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Sent: Saturday, April 16, 2022 11:49 AM

To: Public Comment <PublicComment@carson.org>

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Subject: Public Comment: OSAC meeting 4/18/22, Agenda Item #6: My literature review -- might be applicable to the RCI study?

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These are a lot of reading and a lot to digest. Thought I would give some of you a head start.

Probably not enough time before the OSAC meeting, but valuable to peruse for ongoing and 'future' studies/'management'.

The articles IMHO seem quite relevant to our own OHV project — describe/suggest/offer scientific looks at the impacts of the OHVs on soil/vegetation/fauna/and waterways (ephemeral streams).

Examples of some studies that might be relevant, in content and methodology as well.

Certainly they all validate/emphasize the importance of keeping OHV travel on designated roads and trails, and the negative consequences of ANY cross country travel (no matter how small, and ESPECIALLY over ANY intact soil/vegetation — anathema to ANY land ethics). And they validate negative consequences of travel in waterways/wash channels (even in the rarely flowing ephemeral stream washes).

I don't see any such studies in the reference page of the Final Report on the Prison Hill Recreation Area: A Targeted Geomorphic Review. Unfortunately. I do not see that that study acknowledges the importance of protection of ephemeral streams washes (when dry or wet!) — and impacts of inviting large heavy wide Crawlers to grind up and down and across them (per the Crawlers identifying the routes they wanted included in the plan — per emails from NOHVCC and statements in the Management Plan/Site Assessment/Grant apps).

The below excerpts IMHO apply to our washes — and their value within the PH OHV ecosystem — they validate that water is an important resource in arid environments, even if brief. Seems to me our West Basin washes should have been/should be given much more importance than Open Space, OSAC, RCI or the users give them.

IMHO, my research supports the importance/value of our ephemeral stream washes. I wonder why the RCI References include none of my references in this email? Was there a literature search done? Was there consultation with Natural Resource Specialists who work specifically with/address ephemeral stream washes in OHV areas???? (I have called many BLM, USFS offices — and spoken with several staff on the ground in their areas — and even spoke with one of the authors of one of these studies).

Why weren't ALL the washes and topography on the SW slope studied? — before the Signs of Change 1 and 2 and West Basin Construct projects? Why was Not so Easy Rider not included in the final report?: it runs above an ephemeral stream wash that is being impacted by trespass off this trail, into the head of the wash and the wash itself.

And why wasn't the entire Once is Enough wash included (even though not on the trail plan now — but it DOES have a very definitive OHV trail along its ENTIRE course, from the rock dam off Not so Easy Rider, all the way down the the closed sign at the lower rock dam/basin!!!! — with trespass in and out on fall lines, along its entire length.

Why wasn't the plan brought before the public, OSAC, BOS at any time?? And how will the RCI study be used "to support staff in future planning and decision making"? Is the current evolving trail plan being evaluated by anyone?/RCI. What is RCI's role — present and future?

Too many questions for a 3 minute public comment. Worthy of an Agenda Item (as we have been asking for years). Or a round table discussion (preferably on the ground) — as I asked at the last OSAC meeting? Why is the Working Group not being included — as stated it would be in all the documents and grant applications? (From outset, during, and after!!!).

What is the oversight of this project: professionally and by the public?

1). <https://pubs.usgs.gov/of/2007/1353/report.pdf>

Great comprehensive article. Addresses OHV use, impacts, studies/techniques to monitor/evaluate, and mitigation/restoration techniques. Worth a COMPLETE read.

2). https://www.doi.gov/ocl/hearings/110/OFVManagementOnPublicLands_060508#

Interesting statement and philosophy by former Deputy Director BLM, 2008. He refers to Article #1 above: "My testimony today will highlight the ongoing efforts within the Bureau of Land Management (BLM) to manage off-highway vehicle (OHV) use and will highlight a 2007 United States Geological Survey (USGS) study synthesizing the literature regarding OHV impacts on the land."

From my read, he does not support Open Cross Country except in large designated areas like dunes/playas where there is minimal impact, and where the use is regulated.

"Specifically, the guidance affirmed that continued designation of large areas that remain open to unregulated "cross-country travel" is not a practical management strategy. Instead, field offices are directed to focus OHV travel on designated roads and trails. Field offices still can and have designated open areas, where unrestricted OHV play is permissible..... Open areas are appropriate for intensive OHV use where there are no compelling resource protection needs or public safety issues to warrant limiting cross-country use. Examples of areas open to motorized recreational use include El Mirage OHV Area in the Mojave Desert of California, 12,000 acres of flat lakebed used for land sailing and OHV riding, and Hackberry Lake OHV Area in New Mexico, offering 55,000 acres of rolling dunes used for OHV play. These open areas are extremely important local and regional destinations for OHV play with minimal impact. Closures are sometimes necessary to protect and conserve resources".....

3). https://www.epa.gov/sites/default/files/2015-03/documents/ephemeral_streams_report_final_508-kepner.pdf

This study discusses the vegetation along ephemeral streams and **concludes that the streams with less water, have vegetation the same as surrounding uplands.**

If there is more water, there might be larger and/or different species present. Our ephemeral streams have little water, relatively — so host the same vegetation as the surrounding uplands. Makes sense? So the fact that the RCI states that our washes do not have special or unique species, does not diminish their importance, from my research. The West Basin ephemeral stream washes are still viable surface water courses, that have the positive qualities of ephemeral streams as described in the article. CERTAINLY there is a preponderance of grasses, moss, lichen, algae (esp in the standing water), along these washes — a positive quality of ephemeral streams described in the article. Again, I have photos of this, but don't want to be chastised for making my posts longer. They are available for the asking. This article often interchanges the terms 'ephemeral

stream', with 'intermittent stream', and 'riparian' vegetation — but ultimately identifies the qualities of ephemeral streams separately. Because much of the description is of Arizona (SW) — there is mention of species that we don't have here (succulents). Below I have included some relevant quotes — to our Ephemeral Stream Washes— from the above document. Worth a read and study!?:

"The management of arid and semi-arid lands drained by ephemeral stream channels has a direct impact on the hydrology and geomorphology of the drainage network. Indeed ephemeral streams may be more sensitive to anthropogenic disturbance than perennial streams (Bull, 1997)."

"Biological soil crusts, or cryptobiotic crusts, are a mixture of mosses, algae, microfungi, lichen and cyanobacteria that live on and just below desert soil surfaces. They are usually found in open, undisturbed areas where vegetation is sparse, for example in upland areas adjacent to ephemeral streams. These organic complexes help to stabilize desert soils, hold in soil moisture, fix carbon and nitrogen, and can stimulate plant growth (Belnap, 2003). In some soil types, biological soil crusts can increase infiltration rates. Biological soil crusts can determine the amount, location, and timing of water infiltration into desert soils, which, in turn, determines the type and size of microbial response. Nutrients resulting from this pulse then create a positive feedback as increases in microbial and plant biomass enhance future resource capture or, alternatively, may be lost to the atmosphere, deeper soils, or downslope patches (Belnap et al., 2005)."

"Vegetative communities along ephemeral and intermittent streams provide structural elements of food, cover, nesting and breeding habitat, and movement/migration corridors for wildlife that are not as available in the adjacent uplands. Functional services of these communities include moderating soil and air temperatures, stabilizing channel banks and interfluvies, seed banking and trapping of silt and fine sediment favorable to the establishment of diverse floral and faunal species, and dissipating stream energy which aids in flood control (Howe et al., 2008)."

"Along small desert washes, **vegetation composition and structure overlap considerably with those of the surrounding desert uplands** (Bloss and Brotherson, 1979; Warren and Anderson, 1985)....."

My comment: you state that our West Basin ephemeral stream wash vegetation is not distinct from surrounding upland (as a reason our ephemeral stream washes are not important?)— Apparently, as stated above, washes that have 'limited water availability' do not show vegetation different from surrounding environment: "As water availability increases, the vegetation becomes increasingly distinct from the upland vegetation with respect to physiognomy and species composition.

Vegetation and Morphology:

My comment: the following applies to our washes?:

"Vegetation in ephemeral stream channels plays a key role in resource retention by protecting soils from wind and water erosion, slowing floodwater velocity, and moderating temperatures. Ephemeral stream vegetation also influences biogeochemical cycles by providing leaf litter, and food and cover for wildlife. In some cases, vegetation can intercept rainfall, preventing it from infiltrating into the soil, and influencing the local water balance and ecosystem processes (Owens et al., 2006; Miller, 2005). Vegetation structure and diversity determine wildlife species diversity and abundance, and if a portion of habitat on which a species depends is damaged or destroyed, the breeding population of that species could be lost (Anderson and Ohmart, 1977)."

My comment: the below excerpts apply to our washes:

"Where the washes are undisturbed in their lower reaches, alluvial fans — and in the washes not ridden by OHVs -- vegetation grows in the wash floor i.e. 'channel bed'." Almost all the West Basin washes have vegetation along their banks — except for the most used ones like Mailbox, Gunslinger (except middle Gunslinger), Deathwall, and the Off the Trailer washes. And all have vegetation in their alluvial fans! (where there are few trails through them --- the westernmost designated road that parallels Golden Eagle Lane, is the main one).

The below excerpts also apply to our washes — and their value within their ecosystem — water is an important resource in arid environments, even if brief. Seems to me they should be given much more importance than Open Space, OSAC, RCI or the users give them. My research supports this. I wonder why the RCI References include none of my references in this email?

"Vegetation in arid and semi-arid regions is largely controlled by the availability of water, with flood disturbance and edaphic conditions further shaping plant distribution patterns. Depending on attributes of the particular stream, the highest density of vegetation may occur along the stream bank or within the channel bed (Figure 31). By providing channel and stream bank roughness through standing or downed material, vegetation can influence flow velocities, flow depths, bank and flood plain erosion, and sediment transport and deposition, and can be a major factor contributing both to channel stability and to channel instability (e.g., Heede, 1985). Vegetation along the stream bank stabilizes the soil through the reinforcing nature of their roots, and prevents erosion (Groeneveld and Griepentrog, 1985)."

"Because ephemeral and intermittent stream channels have a higher moisture content and more abundant vegetation than the surrounding areas, they are very important to wildlife."

"The microclimates created in and around ephemeral and intermittent streams are utilized extensively by wildlife, and especially by less mobile species that cannot avoid the harsh desert environment by moving to more favorable microclimates. As a result, these areas generally support the greatest concentrations of wildlife, providing the primary habitat, predator protection, breeding and nesting sites, shade, movement corridors, migration stopover sites, and food sources."

"Ephemeral and intermittent stream channels provide important wildlife movement corridors in arid and semi-arid regions because they contain continuous chains of vegetation that wildlife can utilize for cover and food."

"As previously mentioned, nearly 81 percent of all streams in the six Southwestern states are ephemeral or intermittent (USGS, 2006) and in many watersheds most stream channel reaches are ephemeral or intermittent. From a strictly numerical standpoint, then, the degradation of ephemeral or intermittent streams diminishes ecosystem functions in most southwestern watersheds."

ii. Physical habitat features

"The habitat provided by desert streams contracts and expands dramatically in size due to the extreme variations in flow, which can range from high-discharge floods to periods when surface flow is absent. This spatial variation in habitat or ecosystem size is a fundamental, defining feature of these streams (Stanley et al., 1997)."

"Regardless of whether it is perennial, a stream affects the substrate it flows upon, creating habitat for various species of wildlife. Some physical features of wildlife habitat along ephemeral and intermittent streams include the deposits of river material (sediment and debris), the exposure of rock and subsurface soil layers by erosion, the provision of shade through topographic relief, the creation of microclimatic zones, and the sequestration of moisture and nutrients in alluvium".

"Stream alluvium is often looser than the soils or colluvium of surrounding uplands, which enhances the potential for exploitation by specialized sand-burrowing species of wildlife. Woody debris swept in from the watershed collects in the flood plain and stream channel as flood wrack (brush piles), creating additional

complex, high-value shelters. If the stream incision is deep enough, it may create a cooler canyon environment in which heat and moisture loss are retarded. Bull (1977) noted that ephemeral streams are much more sensitive to climate or anthropogenic disturbance than are perennial streams."

"In arid and semi-arid regions, the functions of ephemeral and intermittent streams must be recognized and appreciated to protect and manage them properly; they must not be relegated to second-class status as compared to wetter systems elsewhere in the U.S."

d. Research Recommendations — (evolving science re the importance of ephemeral stream washes)

"Many of the underlying physical, ecological, and biological processes and linkages in arid and semi-arid region systems are not well understood or documented. This general lack of information specific to ephemeral and intermittent streams in the arid and semi-arid Southwest leaves a wide range of research opportunities."

"Much still needs to be learned about the ecological and hydrological interactions on ephemeral and intermittent streams due to variability and the often highly episodic occurrence of extreme events in these systems. There are unique challenges for work on these desert

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rivers. Sometimes the environments are inhospitable, but arguably the greatest challenge is trying to use short-term projects to understand arid and semi-arid region streams whose variable behavior sometimes demands years of data more than are needed on a mesic river. As noted, ephemeral and intermittent streams constitute the vast majority of drainage ways in the Southwest and they play an integral role in overall watershed function. Future research is needed for both the long-term monitoring of these systems over a range of conditions, and on developing modeling tools that can be applied to large temporal and spatial scales."

8. Conclusions

"When functioning properly, arid and semi-arid region streams provide many of the same services as perennial streams that affect water quality and ecosystem health. These services include landscape hydrologic connections; surface and subsurface water storage and exchange; ground-water recharge and discharge; sediment transport, storage, and deposition; flood plain development; nutrient cycling; wildlife habitat including movement and migration corridors; support for vegetation communities that help stabilize stream banks and provide wildlife services; water supply and water quality filtering or cleansing; and stream energy dissipation associated with high-water flows that reduces erosion and improves water quality (USFWS, 1993; BLM, 1998). In addition, riparian areas associated with ephemeral and intermittent streams help mitigate and control water pollution by removing pollutants and sediment from surface runoff (Sonoran Institute, 2007). Thus, these streams play a significant role in the physical, biological, and chemical integrity of an ecosystem and must be afforded the same importance as other wetter systems in the U.S. in land management decisions."

"In the rapidly developing southwest, land management decisions must employ a watershed- scale approach that addresses overall watershed function and water quality. As shown in this report, ephemeral and intermittent stream systems comprise a large portion of southwestern watersheds, and contribute to the hydrological, biogeochemical, and ecological health of a watershed. Given their importance and vast extent, consideration of the cumulative impacts from anthropogenic uses on these streams is critical in watershed-based assessments and land management decisions to maintain overall watershed health and water quality."

4). https://beaver.utah.gov/DocumentCenter/View/1309/Beaver-CRMP_Final_Amended-121719

Read pages 69-72 for excellent description of ephemeral streams. In this description, the word 'riparian' is also used, to describe the vegetation on the banks of an ephemeral stream. So, 'riparian' is often used in relation to ephemeral stream description/definition — even though not defining them as intermittent or perennial 'riparian' streams. **In the introduction to the Agenda Item, it is said that 'these areas are not considered riparian areas' — devaluing them because of this? The below report speaks to this. Some ephemeral streams have a riparian character (different ecosystem than surrounding uplands) — and others don't. Depending upon the volume and frequency of rainfall. Still, each is a valuable ephemeral stream wash feature within its environment.** This is explained in this article, pages 69:

"4.6 Dry Washes and Ephemeral Streams

I. FINDINGS

"For the purposes of this Resource Management Plan, dry washes and ephemeral streams are defined as: a watercourse or portion of a watercourse which flows briefly in direct response to precipitation in the immediate vicinity, and whose channel is dry for significant periods of time throughout the year. Riparian areas are defined as: the strip of vegetation along an ephemeral, intermittent, or perennial stream, which is of distinct composition and density from the surrounding uplands." (page 69)."

The below quote explains the difference between an ephemeral stream wash w/riparian areas along its bank — and those washes that do NOT have this.

"Generally in Beaver County, dry washes and ephemeral streams do not exhibit dominant riparian vegetation characteristics. Often there is little differentiation between upland vegetation and bank vegetation. Structural, biologic and ecological functions do not exist, **and banks and streambeds are prone to erosion.**" (Maybe **prone to more erosion than those with riparian strips of vegetation along them?**).....

Some other interesting excerpts that seem quite applicable to our ephemeral stream washes — and their importance on the SW slope:

"Dry washes and ephemeral streams are unique in that they lack permanent flow except in response to rainfall events, but may perform the same critical hydrologic functions as perennial streams."

"The variability of flood magnitudes is also much greater for dry washes and ephemeral stream channels as compared to that of perennial stream systems.

Floods in dry washes and ephemeral streams often occur as flash floods, single-peak events, multiple-peak events, and seasonal floods. The highly variable stream flow in ephemeral and dry washes most often occurs as a flash flood, lasting only minutes or hours. Flash floods may occur any time of the year in response to a short-duration high-intensity precipitation event, and after the watershed has received enough precipitation to generate runoff."

"Water flowing in normally dry stream channels is subject to two key forces: (1) gravity that moves the water downslope; and (2) friction between the water and channel boundaries that resists the downslope movement.

These two forces determine, to a large degree, the ability of the water to modify the channel geometry and transport debris. In addition, channel roughness, slope, and depth determine the velocity of the flowing water. Channel slopes in Beaver County are often large, so when flows do occur they have high velocities and consequently significant energy and erosive power. Dissipation of energy in channels can occur due to vegetation, curvature, obstructions, and the size, character and configuration of material in the bed and banks."

"As noted previously, although ephemeral streams do not flow at all times, they still perform the major functions of a stream: the transportation of water, nutrients, and sediment. However, unlike perennial streams that continuously move sediment through the watershed, sediment movement in non-perennial stream channels generally occurs as a pulse in response to

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runoff generated by the short duration, high intensity thunderstorms that are typical of the area."

"By providing channel and streambank roughness through standing or downed material, vegetation can influence flow velocities, flow depths, bank and floodplain erosion, and sediment transport and deposition, and can be a major factor contributing both to channel stability or instability. Vegetation along the streambank stabilizes the soil through the reinforcing nature of its roots, and prevents erosion."

In spite of not being included/"jurisdictional under the CWA" — (that status has changed back and forth over the years) — ephemeral streams — per this study — have value unto themselves (even if they do not communicate/'nexus' with " traditional navigable water of the United States'. However, I wonder if the ephemeral stream washes on the SW slope/West Basin DO communicate with the Carson River Watershed and River (Navigable water of the US)? They are part of the Clear Creek Watershed (per Robb Fellows treatise of 2007) — which communicates with the Carson River Watershed, right? And the water from Off the Trailer is deeply eroding a channel heading towards the Carson River. Go take a walk and look! The wash water probably reaches the floodplain area adjacent to the River — and thus into the ground water table and into the River ultimately? "I am the Carson River Watershed". Perhaps our local Andy Aldax Award Winners could be recruited to do a study here (base of Off the Trailer) — and re how the OHVs are impacting the Golden Eagle Open Space and Carson River at and above the Mexican Dam Open Space (evidence of ongoing trespassing into both areas — visual sightings by Rangers and Open Space Staff and the public, and tire track evidence).

My aside re above:

Below is map of the Clear Creek Watershed, from Robb Fellows article: <https://www.cwsd.org/wp-content/uploads/2016/02/Adopted-Clear-Creek-SW-Program-10-18-07.pdf>. Looks to me like the entire SW facing slope, from the Ridgeline down (nonOHV to at least Heidi/Clearview — and including ALL of the OHV area south to and across the River.....). SO, all the ephemeral stream washes from the first one that is between Not so Easy Rider/Rubber Side up, to and including Off the Trailer (and the Golden Eagle Open Space?) — are within the Clear Creek Watershed. Doesn't that have some significance/importance? And what about ground water communication from Clear Creek Watershed to the Carson River watershed? — if not frank overland flow (Eventually from Off the Trailer if that blocked culvert is not fixed — and remember that much of the water from the Main Road out of the Staging Area AND from the Staging Area was diverted INTO Off the Trailer Wash — to preserve function in the Staging Area and up the main road, to decrease the water flow in those areas with erosion/eroding of the road/gullying and rilling that were identified/addressed in the Signs of Change 1 and 2 project Fall 2019- Winter 2020. This increase in water diversion/flow in Off the Trailer is having adverse effects downstream — violation of CCMC and State NRSs? — and still not resolved 3 years later.....). I would expect that the construction and OHV use on Prison Hill — in this watershed — would have effects that should be professionally evaluated? Per the Objectives listed below: This map also from the above treatise, shows the topography of the Prison Hill washes/west basin, within the Clear Creek watershed.

Stated strategies from the document: I spoke with Robb re my concerns, years ago, but he stated this project was not anything his department was involved with--
(that was prior to the Code Enforcement Complaint sent in — I don't know if that has changed his department's involvement?)

Watershed Management Program Strategies

- Track effective Best Management Practices (BMPs) used in the watershed and utilize the BMPs for future construction projects.
- Evaluate new dirt roadway creation from fire break construction, 4-wheel drive and ATV use.

"Recent guidance from the U.S. EPA and Army Corps of Engineers requires that a significant nexus exist between dry washes or ephemeral stream and a traditional navigable water of the United States for the dry washes or ephemeral streams to be jurisdictional under the CWA. This

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significant nexus evaluation must consider flow characteristics and functions of the tributary to determine if it has a significant effect on the chemical, physical, and biological integrity of downstream traditional navigable waters."

Objectives in Beaver County might be an example for us?:

"II. OBJECTIVES

Beaver County's objectives with regard to dry washes and ephemeral streams are as follows:

1. To restore dry washes and ephemeral streams, especially on undeveloped federal lands, to properly functioning conditions;
2. To make structural and non-structural improvements to degraded dry washes and ephemeral streams;
3. To recognize the role of upland watershed management be recognized and incorporated in dry wash and ephemeral stream restoration; "

Some of the ecosystems of Beaver County have similarities to ours. Upland desert. The recent Jamboree rides were all on designated roads/trails, not in washes and no cross country riding — from my review of the rides offered (in the desert areas).

Also, I did call Keven Whicker, Public Lands Administrator, listed as a contributor on the document ---- years ago when I first became aware of 'ephemeral stream' classifications/ and that our washes qualified. We discussed ephemeral streams, and he was quite sure that what we have here qualify. I believe I remember that he said he helped write the Moab RMP, for the OHVers. He said that in Moab, OHVers are NOT allowed to ride up ANY washes of any kind — or ride cross country. They are sent 45 miles NE, to White Sand Dunes (designated) large Open Area. I called the Moab BLM — and they validated what he said. All their trails are on designated roads and trail, no cross country/open riding, no riding up washes.

I have visited there and stayed in the OHV camping area — and travelled the routes there and in the adjacent environs — and they are exactly what Kevin and BLM described.

5). https://tpwd.texas.gov/publications/pwdpubs/media/pwd_rp_t3200_1081.pdf

This is a comprehensive study of effects of OHVs on vegetation, soil, ephemeral streams. Speaks of mechanical or man induced erosion, can accelerate the natural processes of water and wind erosion. Channelization in vehicle tracks has implications for accelerated erosion. OHVs can induce rilling and glying, more rapidly than other land uses. Tracks of OHVs on erosion sensitive soil surfaces, can form continuous rills and channels which can grow into continuous gullies. OHVs can reduce perennial or annual plant cover and density and the overall above ground biomass: all the more reason to make sure they stay on designated roads and trails — not allowed to ride cross country over intact soil and vegetation, even SMALL areas of such. Discusses all the complications of even a single vehicle pass that can destroy or disrupt many types of plants, microfloral crusts, and soil. Worse in the Summer, as the plant becomes drier and more brittle. Also travel is a key link in the spread of invasive or noxious plants — especially if riding off designated roads and trails. Concern re OHV riding off designated trails in the desert — and across any water channels. Emphasis on the damage when OHVs go off roads/trails, and across vegetation, or in stream wash areas. The OHV Management Plan/Site Assessment refers to closing the area after a certain amount of rainfall (page 17) i.e. "if more than 2 inches of rain within a 24 hour period. Closures shall remain in place if precipitation continues or if there is a greater than 70% chance of precipitation the following day". Also closures for flash floods (which perhaps the high volume and velocity flow in the ephemeral stream washes during a heavy rain, could be called? When I brought up 'closures' for rainfall/wet condition — and said it was addressed on the old kiosk at the Snyder Staging Area — I was scoffed at, and the kiosk was removed a few days later. Interesting. The October storm brought 3.8 inches within 36 hours; I don't know what the inches were for the first 24 hours. I don't know what the rainfall was in the late November and December storms. But Tread Lightly and/or Stay the Trail (CO) refer to not riding in wet areas, because of damage to the soil/vegetation and tires creating water channels. Not addressed for our project.

6).

<https://www.discovermoab.com/atv-riding/>

Information on OHV riding in the Moab BLM area. Moab has OHV riding on their urban interface, as we do (Prison Hill and all the adjacent BLM riding areas). Similar arid desert environment, with lots of red rock — and sand. However, their management is more towards 'sustainable' than ours: no cross country riding or riding in washes, in their trail system. Their BLM RMP is restricted to 'limited' riding ie NO riding anywhere cross country, riding only on designated roads and trails except in the large 1400 acre designated White Wash Sand Dunes Area.

No .9 to 23 acre Open Areas within their local riding areas. Perhaps a good example to follow?

There is a map of the Motorized Travel Routes, on the above website, for the entire Moab Area: "Routes on the following maps are designated in the 2008 Resource Management Plan. No cross-country travel is allowed in the lands administered by the Moab Field Office with the exception of the White Wash Sand Dunes Area (Maps 19 and 20)."

"Routes on the Map are designated in the 2008 Resource Management Plan. All routes not on this map are not designated for motorized travel. Motorized travel on non-designated routes will be subject to fines."

Whitewash Sand Dunes Open OHV Area and Trail System

The White Wash Sand Dunes are located 48 miles northwest of Moab, and 25 miles southeast of Green River. The Sand Dunes themselves are delineated and fenced for open OHV play; cross country travel is allowed only in the open area. Outside this area, there are hundreds of miles of designated roads and trails to be enjoyed. All motorized travel outside the open area must stay on the designated routes. Staying on the designated routes helps keep these routes open for your enjoyment. Damage to adjoining private property has occurred, and is a threat to your continued enjoyment of this area. Staying on designated routes assures that you will not trespass on private property. If you observe any trespassing or damage, do your part to help White Wash and report these actions to the Grand County Sheriff's Department at 435-259-8115 (or 911 for an emergency).

Whitewash Sand Dunes is an approximately **1400 acre open riding area** just south of Green River, Utah. The open area is signed and fenced along the southern boundary to help people know what is legal for riding. Within the open area is white wash itself acting as a main artery for riders. On the south of the wash are the dunes. These dunes, while not the largest in Utah, are unique in that they have many Cottonwood trees growing directly out of the dunes. This creates a beautiful setting for riding and has attracted several movies in recent years to film there. Branching out from the open area are several trails which range from fast open desert riding to techy singletrack hopping up and down ledges and along cliff edges. There is something for everyone.

Please avoid the oil production facilities and the adjoining ranch, and never chase or harass livestock. When going through gates, leave them open or closed as you found them. You must stay on designated roads and trails when riding outside the dune area. These routes are marked with white arrows and/or white paint. Bighorn sheep inhabit this area; riders should avoid stressing these animals by giving them the space they need. The cottonwood trees growing in the White Wash area are quite unique. Please avoid damaging these trees -- give them wide berth to reduce potential for soil compaction.

From: Robyn Orloff <robyn.orloff@icloud.com>

Sent: Sunday, April 17, 2022 1:44 PM

To: Public Comment <PublicComment@carson.org>

Subject: PUBLIC COMMENT OSAC MEETING 4/18/22: AGENDA #6 - PHOTO COMPARISONS

This message originated outside of Carson City's email system. Use caution if this message contains attachments, links, or requests for information.

Below are more photos of the areas listed in Attachments A and B, to complement your photos. The more vegetated green ones were taken in the last 2 weeks. They show how the washes and Open Areas are revegetating themselves with current decreased use/impact (because of the Construction Closures, since early November).

I am submitting a pictorial again, because no one is interested in a site visit with me into the heart of the riding area.

All the below statements are in my humble opinion based on boots on the ground, over years. And dirt biking since last Fall. I am obviously not a natural resource specialist, as many of you are.

But my view of the property over time, to me, reveals impacts that could be prevented and/or reversed.

Lynn Zonge's photos were taken in October, after many months of heavy riding (Spring and Summer). Unfortunate that Lynn was contracted to study only the Ephemeral Streams and Open Areas of the West Basin, and only in a short time span (October). Would it have been valuable, if the study compared October photos and ephemeral stream flow studies — with December rain/snow photos and flow studies (normal December Winter storm vs the 25 year storm in October). Then compare the same areas in Spring, after minimal use -- since Construction Closures started in November 2021! Compare the vegetation on the wash floors/banks/slopes — October vs December vs Feb/March/ April: maybe

at month intervals? Effects of even minimal precipitation are increased ground cover and vegetation! — water is such a resource in our arid desert environment. Wouldn't that tell a more complete story of the area, under different conditions and use. AND, an unexpected opportunity to study the washes when being ridden vs when minimal use (closed) — and comparing the health/condition of the washes/Open Areas in each case.

Also as another aside: in the report of the PH Management Plan (OHV section), the photo monitoring of the OHV area was mentioned. It didn't start until 2020, 5 years after the land transfer from BLM.

A comprehensive baseline study in Fall 2015, and annually from then would have been appropriate and useful? And then studies prior to the Open Areas being signed in 2019 / area promoted starting at an annual NOHVCC convention field day October 2019. And more studies prior release of the trail map 3/11/20? To be compared with the monitoring started by Open Space in June 2020. For an overall more comprehensive comparison?

Another question and concern:

The Interim Map was NEVER brought before the Working Group, the Public, or OSAC or BOS. IMO, from our discussions, Open Space Staff did not even seem knowledgeable about where the routes were, character of the routes and Open Areas, existence even of ephemeral stream washes. Who is overseeing this project? WILL RCI be involved "to support staff in future planning and decision making for the Prison Hill OHV Area?". Per Agenda #6 Background/Issues & Analysis. How and when? ON the ground study of proposed routes? Evaluation and recommendations, ongoing?

And why is this a study of future management — not the present trail system and construction?

Attachment A - page 2:

Below: Lower and Middle Rubber side up. Effects of rainfall on the main trail. Also, disturbed on north facing shoulder and slope of the wash that runs between it and Not so Easy Rider, due to riding off trail down into the wash at that location. Also trespass in the wash, from the 'closed' (but not observed) lateral road between the two Crawler Routes, that crosses the wash. Photos taken Fall 2021.





Below: Lower Rubber Side Up. Volunteers naturalized the area where the out of bounds sign is — before (and after) sign put in — trespass repeatedly up that drainage, crawling the rock there (not on the designated route) — disrupting soil and vegetation. They raked and mulched — repeating it when riders trespassed again. Finally the area is now respected. Riders saw 'the presence' and response to the trespass. And stopped. It looks good now, right?





Below: Citizens (?) also naturalized this lower right area where the road was being widened by riding into the vegetation.

This has stopped the trespass. Note that the Rubber Side Up route is very wide in the upper portion — has left a small swath of vegetation in the widened road.

Disturbance/evidence of riding down into the wash (from left, north) side of this widened section of route. Plan is said to narrow the road, restore the shoulder and slope of the wash there.



Below: Trampling off Not so Easy Rider, at head of wash that runs between it and Rubber Side Up — impacting this wash, erosion, sedimentation downstream, destruction of the resource.

Photos taken Fall 2021.

Does not bring sediment below to Golden Eagle Lane, but its intrinsic natural resources are being impacted, aren't they? i.e. destruction of soil, vegetation, habitat, visual/aesthetics.

Would you allow these disturbances in the NON-OHV areas? Your other Open Spaces? Why allowed in the OHV area?





Destroying the wash course, at the head of the ephemeral stream wash — where the water flows and runs over the high pour off.





Below left: Wash pour off below the head of wash above. Note fall line trail distant left, closed road between Not so easy Rider and Rubber Side up.
Not 'closed' because riders easily and often trespass through the signs and ride across and up/down the wash and slopes there. Photo to right.





Probably need fence continued across this access!?



And riding upstream in the drainage course, in the channel between the granite — towards and INTO the nonOHV area through that north boundary. Riding over the rock slabs or through the one gap in the fence, into the nonOHV area. Gap is to right and left of and through, the destroyed shrub — once full and vital, now just a remnant. Trespass into nonOHV area — with resultant impacts there.





Attachment A - page 3: **MAILBOX.**

Note: one of the drainages of the Mailbox ephemeral stream wash, comes thru the alcove to the left. There is a pour off at the head of the alcove, where water flows from above, cascading in a waterfall to the wash floor. The Mailbox Crawler Route turns left, forward of this wash course.

The Alcove and area going up the slope where the sign is, is OUT OF BOUNDS. I wonder why the OUT OF BOUNDS sign is placed so far up the slope, that is not part of the designated route?

I asked that the sign be moved forward, to protect this alcove — which does show trespass tracks into it (esp dirt bikes). Isn't it a natural resource: grass, moss, lichen, ground cover, low shrubs, wildlife habitat, bird and packrat nests, water source?





Other shots in Mailbox: revegetating during the Construction Closures and some min precipitation.
The white arrows painted on the rocks show the course of the wash. Unobtrusive way to 'sign' the wash routes.



Below: vegetation along the wash, nourished by the infrequent rain/water flow. There WAS vegetation on the other side of the wash, but it has been trampled by Crawlers (6' wide) -- wider than the wash(1' wide here?). This vegetation will be destroyed, in time. Causing more erosion/sedimentation/visual impacts, destroying wildlife habitat?



Result of the Crawlers along course of the wash, over time. Also riding up and down the fall lines shown to left (same to right).

Not closed off at the wash level yet. So still being ridden. This wash has been impacted over time, so might as well keep it in the Crawler invited system.





Below: south slope of Mailbox wash, 'residue' of prior vegetation here. Impacts of Crawler use.
Destroy vegetation and disrupt soil — yields more erosion sedimentation?
No impact?



Attachment A - page 4: **MIDDLE GUNSLINGER**

IMHO this is one of the most special unique sections of ephemeral stream wash. Photo taken a week ago. Coming back, with the Construction Closure rest — and intermittent rainfall, albeit little. Every drop makes a difference? Would you allow destruction of such a special spot, in the nonOHV Open Space properties? Why do we turn a blind eye/deaf ear here? Note the narrow course of the wash (light colored soft DG) and the span of the 6' wide Rock Crawler (impacts to the left, destroying ground cover and shrubber/disrupting soil.



This area is especially beautiful when water is coursing through it.





Would our Open Space Natural Resource Specialist and Trail Manager allow this kind of impact, in our nonOHV Open Spaces?

Mountain bike and e-bike travel? I don't think so. How about a diversion around here???? — keep the Gunslinger Route but divert around this short section somehow.



Evidence of the banks and slopes of this wash being impacted.









Attachment A - page 5: DOUBLE WATERFALL

Note the Double Waterfall eroded into the bedrock, thus the very creative name for this route!

Water flows down from the upper SW slope, around the north side of Ghost Open Area, gathering water/wash branches along its way, to become

Double Waterfall Wash below this pour off feature. The Open Area envelops this feature, is above and to its right.



Sign up above is Open Area Boundary sign, below which riding is allowed anywhere. Note fall line trail up to it — with evidence of branch breakage as riders impact the edges of the fall line trail.



Course of the Double Waterfall Wash, looking upstream towards the waterfall, at base of above fall line slope.



Looking downstream in Double Waterfall wash. Narrow DG ribbon, vegetation on banks/slopes that are impacted by the 6' Crawlers designated for this route. Vegetation has had a chance to reestablish, with the closures and moisture. Photo taken within past 2 weeks.



I think this is the one Crawler Route that should be taken off the map. It travels through Headlight, receiving other wash systems along the way, including Lower Deathwall at its lower end. It then continues out to Golden Eagle Lane. It is one out of 4 Crawler Routes in ephemeral washes. The least impacted. 2 other Crawler routes are on shoulders above a shared wash (between them). 6 Crawler routes total. PLUS the MANY wash Crawler Routes within the 23 acre Open Area "Off the Trailer".

Lower Gunslinger jog:

Main westernmost road crosses Gunslinger lower wash — looking south.



This is a 4 wheel (2 track) designated short 'jog' up this section of wash, then right turn up the trail to the right. Note the density of vegetation in the wash, upstream of this turn, where not disturbed by OHVs. This is what this wash looked like before designated for travel. Probably could revegetate itself, if taken off the map.



'Virgin' wash directly upstream of the 'jog'.



Virgin wash downstream of the jog. Vegetation IN the alluvial fan/terminus of the Gunslinger wash.



Gunslinger continuing downstream.



Terminus of Gunslinger/sediment on Golden Eagle lane.



Consider: remove this short 'jog' from the trail plan. Keep OHVs on the main designated westernmost road. What is rationale for sacrificing this short section of wash?

In a wash that is one of the main drainages on the SW slope, per the RCI report.

Below: Lower Headlight Wash :

Wash below the sign is **2 track/4wheel designated**. That means 65" and 6' wide vehicles can travel it. It is 2-3' wide max in this section.



Impacts from water flow and riding (tracks evident, spanning the width of the wash — wider than the wash course).



Disturbance of the wash, from water flow and OHV use. Use in dry or wet conditions has impact. Note that the wash is still narrower than 65" or 6'. Heavily vegetated along its banks, downstream. Lots of beautiful desert peach. Banks revegetating some during Construction Closure.







Trampling of desert peach and associated vegetation, vehicles wider than wash course.

There IS an established road that runs on the shoulder above this wash, north side (right) that is very wide and can accommodate the OHVs.

It is not the designated trail here, the wash is.

Why impact this resource, when there is a viable alternative?

This wash section hosts coyote dens, rabbit hutches, animal transit (with evidence of prey/predator action/bones/carcasses/hunting!), bird habitat.





Terminus of wash on Golden Eagle Lane: transport of sediment. Certainly water causes erosion in the wash, but isn't erosion further

exacerbated and accelerated by the physical impacts of the OHVs traveling here? What about removing this entire Headlight system from the trail plan.

It is but one wash (beginning at Double Waterfall) and traveling through the Headlight Open Area all the way down to this Lane.

It is one of the main wash systems on the SW slope. Many rock dams and basins have been constructed along its course, to control the downstream sediment flow.

Ghost and Headlight Central Open Area would still be used by the Crawlers — but they are accessible by main designated roads on their north and south sides!

No reason to travel the wash to access the Crawler rocks! The wash could be preserved — AND the rock crawling opps would also be preserved.

Compromise and 'sustainable' vs 'sacrifice'?



ATTACHMENT A - PAGE 6: Lower DEATH WALL designated for Single Track

This wash is continuation of Upper Death Wall Crawler Route — but below Cable Road it is designated 'Single Track only'.

I noticed on Saturday that there are also new orange survey ribbons designating a new single or double track route, through the intact vegetation on sections of the slope/banks of this lower wash — and crossing it.

Plus travel IN the wash per the already designated trail on the Interim Map. There are many many single track routes throughout the entire OHV area.

What about making decisions re which trails are more sustainable vs less?

This is a very pristine wash. Not even a foot wide in some sections, 1-2' in others. Is this a sustainable route or a sacrifice?

There are single track trails up long stretches of some of the washes on the south and SE facing slopes. I have ridden many of them on my dirt bike! Fun and challenging.

Already impacted/widened to easily accommodate a dirt bike -- from use over time. Vegetation lines the trails but is not being ridden over! — riders are respectful of those trails.

How much is enough? Is this Death Wall wash really necessary to impact — or should it be protected?

Shouldn't we be carefully picking and choosing the resources we are impacting?

This project has PLENTY of options, on its almost 900 acres!!!!

The public, Working Group, OSAC, BOS are not involved in the decisions re trail choices.

Are our Open Space Natural Resource Specialist and Trail Manager walking these trails with the Consultant and discussing if they are sustainable?

E= Evaluating from their professional experience and knowledge base? Protecting OUR Carson City unique resource that is the south end of Prison Hill.





Vegetation on banks/slopes.







ATTACHMENT A - PAGE 7: GHOST OPEN AREA

Photos in the RCI report show the vegetation in the Open Area. Mostly bedrock. The residual vegetation will be destroyed, but can't be helped. This is a great Crawler area.

ATTACHMENT A - PAGE 8: Lower HEADLIGHT OPEN AREA — cross country riding on shoulders/slopes/banks/wash within the signed boundaries.

Note sign top right. All terrain in this photo can be impacted by riding. This 2 acres was noted by RCI Study to be intact soil biotic crust and vegetation.

Obviously wash floor and environs are being trampled by the 6' wide crawlers (and wheelers and quads and dirtbikes — whatever OHVs can get down into it from the main designated perimeter trail on its north border.



All this is in the cross country allowed area. Tracks though it willy nilly.





Sign in distance is far boundary. All area in photo is cross country riding allowed.



Shoulder of Open Area, looking S from perimeter boundary road.



You can see the perimeter road to the right. All this vegetation in photo is in the cross country riding area. Some new tracks seen through it. Just designated late Summer 2021. Construction closures soon after. So has not been heavily impacted — YET.



Perimeter boundary road forward right. Road to right corner is lateral road through the Open cross Country area. All the ground cover and vegetation in photo is vulnerable.



More of the cross country area, see wash on left. This slope, shoulder is vulnerable. Sacrifice of intact resources?

As an aside: At the October 2018 question and answer with NOHVCC, Donna I asked if there would be fall line trails/cross country riding/boundaries through rock outcroppings. She was told NO, NO, and NO. Reality on the ground in the project is YES, YES, and YES. The boundary through the rock is at the big outcropping at the Snyder PA and MA entrance. With resultant riding up the draws of the outcropping, causing soil/vegetation disturbance there. See photo right.





















Middle Headlight: above Cable Road, north side: cross country riding allowed through this vegetation, off the perimeter road to left.







Cross country wheelin' crawlin': over dry brush during fire restrictions of no riding off designated road and trails. But this IS allowed in the Open Areas.



ATTACHMENT A - PAGE 9: Below ---OFF THE TRAILER OPEN AREA: inlands of intact vegetation, at least 4 acres documented here, in the RCI report. All the below photos are within the cross country riding area, allowed to be ridden through/over.





Vulnerable to being ridden over. Just a matter of time. Sacrifice? Impacts?









And, in conclusion. The slogan I brought to the project “Don’t Crush the Brush” (from the Alabama Hills restoration project in Lone Pine — multi-use OHV and nonmotorized area) was made into an excellent sign — great graphics — easy to read. However, it is placed at the ENTRANCE to the Off the Trailer Open Space Cross Country riding area. Oxymoron? Don’t crush the Brush BUT you are permitted and invited to ride cross country in all the Open Riding Areas. Confusing? Contradiction? Why not just make this 23 acre Open Riding Area a “Stay on Designated Roads and Trails area” as I stated above — plenty of existing established roads that lead to the Rock Outcroppings. Maybe signage that says to stay on existing roads — except on the bedrock rock slabs and associated denuded areas (where they can ride at will). Why sacrifice the intact soil and vegetation? Is there a natural resource reason for this?

In the Alabama Hills project it is placed at the edges of actual restoration areas or special vegetation areas that are being protected.

Not at the entrance to an area where destruction is invited and permitted!!!!



How about either removing this sign — or changing the designation of this Open Area.

Again, a round table discussion — or better yet a walk and talk on the property, IMHO, would be helpful. To get the OSAC and staff more involved in decision making re this project.

I cannot reconcile the Conclusions of the RCI report (page 6) that the Open Areas 'are mostly bedrock controlled' — with my own boots on the ground experience there.

Based on this pictorial, you might have questions as well.

Ghost and central Headlight are — but not the new 2 acres of Lower Headlight that is documented as intact soil and vegetation. Nor are at least 4 acres of Off the Trailer.

The RCI conclusion states that "vegetation provides soil stability, especially on slopes. The sandy soils are highly susceptible to erosion and are held in place with the vegetation.

The Management practice to minimize new disturbance to vegetated areas is important". Hmmmm, then why is 'Management practice' inviting cross country riding in 6 acres of Open Area, and Crawling in sections of vegetated washes narrower than the vehicle?

"The geomorphology of the area supports OHV use with very limited resource impact"?

Might the depth and breadth of drainage features (rock dams and basins) indicate the degree of impacts by OHVs, in the ephemeral stream washes and Open Cross Country riding areas?

Thank you for reading and listening. My offer always stands, for a site tour.

Robyn Orloff

Carson City Citizen, taxpayer, and advocate for "balancing riders needs while ensuring resource protection" (NOHVCC grant app, FY2018).



Environmental Effects of Off-Highway Vehicles on Bureau of Land Management Lands: A Literature Synthesis, Annotated Bibliographies, Extensive Bibliographies, and Internet Resources

By Douglas S. Ouren, Christopher Haas, Cynthia P. Melcher,
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Conversion Factors

Inch/Pound to SI (International System of Units)

	Multiply	By	To obtain
Length			
	inch (in.)	2.54	centimeter (cm)
	inch (in.)	25.4	millimeter (mm)
	foot (ft)	0.3048	meter (m)
	mile (mi)	1.609	kilometer (km)
	yard (yd)	0.9144	meter (m)
Area			
	square foot (ft ²)	929.0	square centimeter (cm ²)
	square foot (ft ²)	0.09290	square meter (m ²)
	square inch (in ²)	6.452	square centimeter (cm ²)
	square mile (mi ²)	2.590	square kilometer (km ²)
Volume			
	cubic inch (in ³)	16.39	cubic centimeter (cm ³)
	cubic yard (yd ³)	0.7646	cubic meter (m ³)
Mass			
	ounce, avoirdupois (oz)	28.35	gram (g)
	pound, avoirdupois (lb)	0.4536	kilogram (kg)
	ton, short (2,000 lb)	0.9072	megagram (Mg)
	ton, long (2,240 lb)	1.016	megagram (Mg)

SI to Inch/Pound (English System of Units)

	Multiply	By	To obtain
Length			
	centimeter (cm)	0.3937	inch (in.)
	millimeter (mm)	0.03937	inch (in.)
	meter (m)	3.281	foot (ft)
	kilometer (km)	0.6214	mile (mi)
	meter (m)	1.094	yard (yd)
Area			
	square centimeter (cm ²)	0.001076	square foot (ft ²)
	square meter (m ²)	10.76	square foot (ft ²)
	square centimeter (cm ²)	0.1550	square inch (in ²)
	square kilometer (km ²)	0.3861	square mile (mi ²)
Volume			
	cubic centimeter (cm ³)	0.06102	cubic inch (in ³)
	cubic meter (m ³)	1.308	cubic yard (yd ³)
Mass			
	gram (g)	0.03527	ounce, avoirdupois (oz)
	kilogram (kg)	2.205	Pound, avoirdupois (lb)
	megagram (Mg)	1.102	ton, short (2,000 lb)
	megagram (Mg)	0.9842	ton, long (2,240 lb)

Glossary

ATV (All-Terrain Vehicle) Small, motorized 3- or 4-wheeled vehicles specifically designed for off-road use. The American National Standards Institute (ANSI) further defines an ATV as a vehicle that travels on low-pressure tires, with a seat that is straddled by the operator, and with handlebars for steering control. By the current ANSI definition, it is intended for use by a single operator, although a change to include 2-seaters (in tandem) is under consideration. Herein, the definition of ATV coincides with the description above and does not include passenger vehicles, including sport-utility vehicles or 4-wheel-drive jeeps.

fugitive dust Dust raised by mechanical (anthropogenic) disturbance of granular material exposed to and becoming suspended in the air, then carried by wind. Arises from “nonpoint” sources—such as unpaved roads, agricultural tilling operations, aggregate storage piles, and heavy construction—rather than “point” sources—such as confined flow streams discharged to the atmosphere from a stack, vent, or pipe.

indicator threshold For a given land health indicator (or set of indicators), the value(s) at or above which management action may be triggered or required.

land health The condition of natural resource attributes, including soils and site stability, hydrologic function, and biotic integrity.

OHV Defined herein as any civilian off-highway vehicle, including motorcycles, motorized dirt bikes, ATVs (see definition above), snowmobiles, dune buggies, 4-wheel-drive jeeps, sport-utility vehicles, and any other civilian vehicles capable of off-highway, terrestrial travel (including utility vehicles [UTVs] and ATVs with more than 4 wheels).

OHV route Defined herein as any unpaved route created for OHV travel, including single-track paths or trails, two-tracks, and unimproved or improved dirt/gravel roads. Herein, this term is also applied to “rogue” (undesigned or unauthorized) routes created by OHV users in closed or limited areas.

population dynamics Herein, used broadly to include wildlife or vegetation population size, density, and/or distribution (both spatial and temporal); rates of birth/germination, death, and/or survivorship; population gender/age-class structure; population genetics; and/or the rates/directions of change in all these parameters.

right-of-way habitat Habitat provided within the legal description of a given transportation corridor.

sink population For a given metapopulation, a population sink is a local area or habitat where the local population’s reproductive rate is lower than the required replacement rate (in other words, a sink population is eventually extirpated without immigration of individuals from other areas). Population sinks often occur where there is excessive predation pressure and/or poor habitat quality.

source population For a given metapopulation, a population source is a local area or habitat where the local population’s reproductive rate is greater than the required replacement rate. Excess individuals produced from a source population may emigrate to join sink populations, thereby keeping the sink populations from becoming extirpated.

stream order A stream’s order is determined by its confluence with other streams: first-order streams are headwaters, the confluence of two first-order streams forms a second-order stream, the confluence of two second-order streams forms a third-order stream, and so on.

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Executive Summary

This report and its associated appendixes compile and synthesize the results of a comprehensive literature and Internet search conducted in May 2006. The literature search was undertaken to uncover information regarding the effects of off-highway vehicle (OHV) use on land health, or “natural resource attributes,” and included databases archiving information from before OHVs came into existence to May 2006. Information pertaining to socioeconomic implications of OHV activities is included as well. The literature and Internet searches yielded approximately 700 peer-reviewed papers, magazine articles, agency and non-governmental reports, and internet websites regarding effects of OHV use as they relate to the Bureau of Land Management’s (BLM) standards of land health. Discussions regarding OHV effects are followed by brief syntheses of potential indicators of OHV effects, as well as OHV-effects mitigation, site-restoration techniques, and research needs.

Terminology Used in This Report

The BLM has definitions for several road and trail types; however, the OHV literature often uses somewhat different definitions. Whereas all terms are useful within their own contexts, herein the general term “OHV routes” is used to simplify discussions concerning all types of unpaved roads and trails, whether designated or unauthorized, and “roads” or “highways” are used to simplify discussions concerning paved roads. The definition of OHV also varies by agency and author, and to simplify discussions herein, OHV may include off-highway motorbikes, ATVs, dune buggies, snowmobiles, 4-wheel drive jeeps, motorcycles, some types of 4-wheel drive automobiles (including sport-utility vehicles), and any other civilian vehicle specifically designed for off-road travel. OHV type or route/road type are specified if a given discussion warrants and if the literature cited in that discussion specified OHV type or route/road type.

How to Use This Report

Major sections of this document comprise a “manager’s report,” which includes a literature synthesis and related discussions of (1) OHV effects on natural resource attributes and socioeconomics; (2) indicators described in the literature to evaluate/monitor OHV effects on natural resource attributes and could serve as potential indicators in future research or monitoring programs; (3) mitigation and site-restoration techniques used for OHV-use areas; and (4) research and monitoring needs pertaining to OHV-effects. This document also includes extensive bibliographies pertaining to OHV effects on natural resources. It is recommended that readers focus first on the manager’s report, as it provides the basic understanding of OHV effects and potential approaches to researching, monitoring, and/or managing OHV effects. Reading the Executive Summary, the summaries provided in each section, and the conclusion may suffice for those seeking a quick overview. **To facilitate a rapid review, section summaries are placed at the beginning of their respective sections and do not contain in-text citations. For a more in-depth review (with in-text citations), the entire manager’s report should be read.** Appendix 1 provides the extensive bibliographies, and Appendix 2 details the literature/Internet search methods and summarizes the search results (including tables and graphs).

OHV Effects

OHV Effects on Soils and Watersheds

The primary effects of OHV activity on soils and overall watershed function include altered soil structure (soil compaction in particular), destruction of soil crusts (biotic and abiotic) and desert pavement (fine gravel surfaces) that would otherwise stabilize soils, and soil erosion. Indicators of soil compaction discussed in the OHV effects literature include soil bulk density (weight per unit of volume), soil strength (the soil's resistance to deforming forces), and soil permeability (the rate at which water or air infiltrate soil). Generally, soil bulk density and strength increase with compaction, whereas permeability decreases with compaction. As soil compaction increases, the soil's ability to support vegetation diminishes because the resulting increases in soil strength and changes in soil structure (loss of porosity) inhibit the growth of root systems and reduce infiltration of water. As vegetative cover, water infiltration, and soil stabilizing crusts are diminished or disrupted, the precipitation runoff rates increase, further accelerating rates of soil erosion.

OHV Effects on Vegetation

Plants are affected by OHV activities in several ways. As implied above, soil compaction affects plant growth by reducing moisture availability and precluding adequate taproot penetration to deeper soil horizons. In turn, the size and abundance of native plants may be reduced. Above-ground portions of plants also may be reduced through breakage or crushing, potentially leading to reductions in photosynthetic capacity, poor reproduction, and diminished litter cover. Likewise, blankets of fugitive dust raised by OHV traffic can disrupt photosynthetic processes, thereby suppressing plant growth and vigor, especially along OHV routes. In turn, reduced vegetation cover may permit invasive and/or non-native plants—particularly shallow-rooted annual grasses and early successional species capable of rapid establishment and growth—to spread and dominate the plant community, thus diminishing overall endemic biodiversity.

OHV Effects on Wildlife and Habitats: Native, Threatened, and Endangered Species

Habitats for native plants and animals, including endangered and threatened species, are impacted by OHVs in several ways. A salient effect is habitat fragmentation and reduced habitat connectivity as OHV roads and trails proliferate across the landscape. Reduced habitat connectivity may disrupt plant and animal movement and dispersal, resulting in altered population dynamics and reduced potential for recolonization if a species is extirpated from a given habitat fragment. Wildlife is also directly affected by excessive noise (decibel levels/noise durations well above those of typical background noise) and other perturbations associated with OHV activities. Disturbance effects range from physiological impacts—including stress and mortality due to breakage of nest-supporting vegetation, collapsed burrows, inner ear bleeding, and vehicle-animal collisions—to altered behaviors and population distribution/dispersal patterns, which can lead to declines in local population size, survivorship, and productivity.

OHV Effects on Water Quality

The effects of OHV activities on water quality can include sedimentation (deposited solids), turbidity (suspended solids), and pollutants within affected watersheds. Sedimentation increases because compacted soils, disrupted soil crusts, and reduced vegetation cover can lead to increased amounts and velocities of runoff; in turn, this accelerates the rates at which

sediments and other debris are eroded from OHV-use areas and flushed to aquatic systems downslope. Pollutants associated with deposition of OHV emissions and spills of petroleum products may be adsorbed to sediments, absorbed by plant material, or dissolved in runoff; once mobilized, these contaminants may enter aquatic systems.

OHV Effects on Air Quality

Air quality is affected when OHV traffic raises fugitive dust and emits by-products of combustion. Because wind can disperse suspended particulates over long distances, dust raised by OHV traffic can blanket plant foliage and disperse dust-adsorbed contaminants well beyond a given OHV-use area. Primary combustion by-products potentially affecting air quality in OHV-use areas include (but are not limited to) polycyclic aromatic hydrocarbons, sulfur dioxide (SO₂), nitrogen oxides (NO_x), and ozone (O₃). Although leaded gasoline has not been used in the United States since 1996, lead emissions deposited prior to the ban on leaded gasoline may persist for decades and continue impacting ecosystems as wind and water erosion continue to mobilize lead and other contaminants downwind (or downslope) of contaminated soils.

Socioeconomic Implications of OHV Use

For the purposes of this document, the socioeconomics of OHV use include (1) OHV user demands, concerns, and attitudes; (2) the economic effects of OHV use on communities near OHV-use areas; (3) and the effects of OHV use on other land users. Although not one of BLM's land health considerations, the socioeconomic implications of OHV use have significant direct and indirect effects on land health. As the popularity of OHV recreation increases, socioeconomic factors become increasingly important considerations in understanding and mitigating the overall effects of OHV use on land health. OHV recreation can have significant economic value to local communities where and when OHV use is popular; however, the economic costs to those communities remain unknown. OHV use also can lead to conflicts among different land users—both OHV users and people seeking non-motorized forms of recreation—within OHV-use areas and nearby areas. Crowding of designated OHV areas may encourage unauthorized use in closed areas, and adjacent or overlapping use types may cause dissatisfaction or discourage recreation altogether, which can diminish public support for land-management programs.

Potential Indicators (Both Direct and Indirect) for Evaluating and Monitoring OHV Effects

Soil Health and Watershed Condition

- Soil strength
- Soil bulk density
- Soil permeability (rates of air and water infiltration)
- Erosion rate
- Level of sedimentation or turbidity in wetlands
- Surface changes (for example, gully erosion)
- Presence/condition of soil crusts

Vegetation Health

- Plant community composition (including species and structural diversity, ratio of native to non-native or invasive species)
- Abundance of individuals and/or stem density

- Percent vegetation cover
- Plant size
- Growth rate
- Biomass

Habitat Condition and Health of Wildlife Populations (including indirect indicators)

- Habitat patch size and connectivity
- Community composition (including species diversity, ratio of native to non-native or invasive species)
- Population size, density, and trend
- Spatiotemporal distribution of populations
- Survivorship and mortality rates
- Productivity and body mass
- Age-class and gender structure
- Frequency of OHVs passing through a given area and associated wildlife mortalities rates
- Road or trail type and width
- Level (decibels), duration, and timing of traffic noise

Water Quality

- Sedimentation rate
- Levels of turbidity and suspended solids
- Contaminant levels, including petroleum-derived compounds from spills and emissions, such as benzene; ethylbenzene; m-, p-, and o-xylene; toluene; 1,3-butadiene; and lead

Air Quality

- Level of dust particulates
- Particulate levels of OHV emission by-products, such as polycyclic aromatic hydrocarbons, aldehydes, carbon monoxide, nitrogen oxides, ozone, and sulfur oxides

Socioeconomics

- User satisfaction with recreation experiences
- User compliance with OHV (or other) regulations
- User knowledge regarding effects of recreation activities on various aspects of land health
- Distribution and intensity of OHV versus non-motorized recreation and other land uses
- Extent to which unauthorized trails are created and damage to vegetation occurs
- Trends in local economic indicators associated with OHV and non-motorized recreation and other land uses, such as sales of camping equipment, gasoline, restaurants, lodging facilities

Mitigation and Site-Restoration Techniques

Balancing OHV-user preferences with protecting land health and the needs of other land users requires careful study and planning, as well as appropriate management strategies. Prior planning for locating OHV areas before they are opened to the public can preclude undesirable

effects of OHV use and costly site restoration. Once a site has been used, however, trail/area closures, signage, and other visual cues, as well as enforcement and limiting visitor numbers through “rationing,” are among the tools used to preclude additional effects.

Because habitat fragmentation is particularly difficult to repair, planning and management designed to maintain habitat connectivity are crucial to minimize fragmentation. Variation in impacts requires various restoration techniques. Whereas a single OHV pass on a xeric landscape may cause long-lasting damage, a similar single pass on a mesic landscape may require no treatment at all. Restoration approaches may include replacing native soil where erosion has removed the topsoil and exposed the underlying bedrock, seeding with indigenous plants, inoculating soils with native microbes and mycorrhizae, scarifying, and/or mulching. Ultimately, the success of such measures depends on the nature and intensity of the disturbance, topography, soil type, climate, and the ability of land managers to enforce closures and prevent the proliferation of new routes.

Monitoring and Research Needs to Support OHV Management Decisions

Elucidating OHV impacts on soils and watersheds, vegetation, wildlife and their habitats, water and air quality, and/or socioeconomics, whether through monitoring or experimental research studies, will require careful planning and appropriate, rigorous study design. Results of many past ecological studies on the effects of OHVs may be regarded as preliminary, particularly for those that lacked comparable treatment and control sites and site replication. Overall, the reliability and value of monitoring and research results would increase significantly by including a broad range of spatial and temporal scales—from microhabitat to landscape or ecosystem scale, and from short-term (seasonal) to long-term (decades)—within the full range of impacted habitat types represented on BLM lands. The full array of site types also needs evaluation, including designated OHV-use sites, undesignated (rogue) OHV-use sites, unused areas, and restoration sites. Multiple- and simultaneous-assessment techniques that take advantage (and push the advancement) of existing and emerging technologies are needed to fully represent the scale and diversity of OHV impacts on the abiotic and biotic components of affected lands and communities, and to ascertain indicator thresholds as they pertain to BLM’s land health standards. More specifically, monitoring and research needs pertaining to OHV use and impacts include (but are not limited to)

- well-designed monitoring programs and experimental studies that incorporate planned comparisons of treatment (OHV-impacted) and control (unimpacted/reference) sites;
- before and after OHV-impact studies;
- studies at various spatial and temporal scales across all impacted habitat types;
- studies on habitat fragmentation and road-edge effects caused by OHV activities;
- studies on various gradients in OHV disturbance at various distances from OHV routes;
- studies to improve the understanding of the physical and chemical dynamics of soil compaction;
- studies evaluating the effects of erosion, sedimentation, and turbidity at both local (immediately downslope of OHV-affected sites) and landscape (throughout impacted watersheds) scales;
- studies of OHV effects on plant and animal population dynamics;
- simultaneous evaluations of wildlife responses and OHV route-specific variables;
- improvements in techniques for successful site restoration;

- improvements in techniques and technologies for assessing OHV impacts over large areas and long periods of time;
- effectiveness evaluations of various techniques to manage OHV use and its ecological and socioeconomic effects while simultaneously providing the greatest satisfaction among all land users; and
- studies that determine the economic and sociological costs of OHV use.

1.0 Introduction

1.1 Issue Context: Bureau of Land Management Land Health and Off-highway Vehicle Use

1.1.1 Bureau of Land Management Land Health Standards

In the mid-1990s, *Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands* was published to examine the scientific basis and success of methods used by federal agencies to inventory, classify, and monitor rangelands, and to make recommendations for improvements to these methods (Committee on Rangeland Classification, Board on Agriculture, and National Research Council, 1994). Therein, rangeland health was defined as “...the degree to which the integrity of the soil and the ecological processes of rangeland ecosystems are sustained.” In 2001, the BLM published *Rangeland Health Standards*, a process framework for assessing rangeland health via interdisciplinary teams that, at a minimum, would evaluate (1) watershed function; (2) nutrient cycling and energy flow; (3) water quality; (4) habitat for endangered, threatened, proposed, candidate, or special status species; and (5) habitat quality for native plant and animal populations (U.S. Bureau of Land Management, 2001). Subsequently, it was clarified that the term “rangeland” is interchangeable with “land” and that “...‘the rangeland health standards’ really apply to the condition of the land itself regardless of the uses that may influence the health of that land” (U.S. Bureau of Land Management, 2007). In other words, the standards for rangeland health apply to all BLM lands, whether used for grazing, off-highway vehicle (OHV) recreation, or any other use permitted to occur on BLM lands.

The standards of rangeland health establish minimum resource conditions that must be achieved and maintained to ensure the “proper functioning condition” (see Barrett and others, 1995)—both physical and biological—and sustainability of BLM lands. These standards, however, must be relative to the native conditions for a given “reference site,” as native conditions vary widely among sites on BLM lands. For example, the BLM defines healthy soils in northwest California as “exhibit[ing] characteristics of infiltration, fertility, permeability rates, and other functional and physical characteristics that are appropriate to soil type, climate, desired plant community, and land form” (personal communication from M. Karl to V. Josupait, U.S. Bureau of Land Management, Denver, Colorado, May 2001).

The BLM’s technical reference on *Interpreting Indicators of Rangeland Health* recognizes three broad categories of natural resource attributes for assessing land health: (1) soils and site stability, (2) hydrologic function, and (3) biotic integrity (Pellant and others, 2005). Relative to off-highway vehicle (OHV) impacts on ecosystem health, soil/site stability and hydrologic or watershed function pertain (but are not limited) to erosion and extent of surface changes and patterns of water flow, including infiltration. Biotic integrity pertains to community structure and functionality of plants. Within these three categories, overall land health is qualitatively assessed via 17 parameters (or indicators) that indicate the presence, number, extent, percent, and/or depth or height of (1) rills, (2) water flow patterns, (3) erosional pedestals/terraces, (4) bare ground, (5) gullies and gully erosion, (6) wind scoured blowouts and/or depositional areas, (7) litter movement, (8) soil surface resistance to erosion, (9) soil surface structure and content of soil organic matter (SOM), (10) effect of plant community composition and spatial distribution on infiltration and runoff, (11) compaction layer, (12) dominance hierarchy of functional/structural groups in plant communities, (13) mortality and

decadence among plant functional groups, (14) litter cover, (15) expected above-ground annual production, (16) potential invasive species, and (17) perennial plant reproductive capability (Pellant and others, 2005). Many of the indicators listed above may be assessed in terms of the condition and extent of abiotic (chemical) and biotic soil crusts, and soil surfaces of small stones known as “desert pavement,” as they help stabilize soils and/or cycle nutrients through the system. Indicators 1-11 largely pertain to soil/site stability and hydrologic/watershed function, whereas parameters 12-17 are primarily indicators of biotic integrity, although there is overlap among the two groups.

1.1.2 Increasing OHV Use

An important factor affecting the health of BLM lands is the use of OHVs. In 1993, 2,920,000 all-terrain vehicles (ATVs) and off-highway motorcycles were estimated to be in use (Cordell and others, 2005). Between 1995 and 2003, sales of ATVs and off-highway motorcycles tripled, increasing the number of ATVs and off-highway motorcycles in use to 8,010,000 (Cordell and others, 2005). Because the popularity of OHV-based recreation is relatively recent and still increasing (see Matchett and others, 2004), the full range of short- and long-term impacts has yet to be fully realized or understood. Overall, it is clear that OHV use on public lands is and will continue to be an important management issue.

1.2 Objectives, Scope, Organization, and Use of This Report

1.2.1 Objectives

The objectives of this report are twofold. This first is to synthesize the results of a comprehensive literature search on what is currently known about the effects of OHV activities as they relate to the BLM’s land health standards (U.S. Bureau of Land Management, 2001). These discussions include socioeconomic implications of OHV use—including preferences of OHV users, effects of OHV activities on other land users, and the economic impacts of OHV recreation on local economies—because understanding these factors and incorporating that knowledge into management plans and policies will be crucial to management success. The second objective is to discuss the indicators of land health and socioeconomics described in the OHV effects literature, as they have potential usefulness for evaluating or monitoring lands and land users affected by OHV use. This report also contains brief overviews of mitigation approaches, site-restoration techniques, and monitoring and research needs described in the OHV-effects literature.

1.2.2 Geographical Scope

Although the vast majority of literature and other sources consulted address OHV impacts on ecosystems in the western United States, there are a number of useful references that address OHV use or impacts of roads in other parts of the United States and in other countries. Some of these sources have been included to provide additional information not provided elsewhere and/or to broaden the scope and relevance of this document.

1.2.3 Organization

The main body of this document—referred to herein as the “manager’s report” (Executive Summary and Sections 1-7)—includes the literature synthesis of OHV effects; annotated bibliographies that typify the body of research regarding effects of OHV activities on BLM’s land health standards; sections regarding indicators of OHV effects, mitigation and site-

restoration techniques, and monitoring and research needs; and a listing of all literature cited in the manager's report. To facilitate the logical flow of information, the natural resource attributes addressed in BLM's land health standards serve as the underlying organizational structure of all major sections in the report, as indicated by parallel subsection headings pertaining to (1) soils and watersheds, (2) vegetation, (3) habitat for native plants and wildlife, (4) water quality, and (5) air quality. Although not part of the BLM's land health agenda, a sixth subsection has been included in each major section to address the socioeconomic considerations of OHV use, because, ultimately, it is socioeconomic factors (including conflicts among land users, preferences of OHV users, and economics of OHV use) that drive changes in overall land health.

1.2.4 Tips on Navigating This Document

It is recommended that readers focus first on the manager's report, as it provides the basic understanding of OHV effects and possible indicators to use in research, monitoring, and/or management programs. Reading the Executive Summary, subsection summaries, and the overall conclusion may suffice for those seeking a quick overview. **For quick and easy reference, subsection summaries on OHV effects are placed at the top of their respective subsections. In-text citations were purposely left out of all summaries to enhance readability. For a more in-depth, fully cited review, reading the entire manager's report is recommended.**

Appendixes 1 and 2 provide further information and more extensive resources for those needing high levels of detail. The Extensive Bibliographies (Appendix 1) includes the approximately 700 publications and reports uncovered through the literature search (from 1960 to May 2006) that pertain to effects of OHV use. Appendix 2 details the literature- and Internet-search methods and provides tabular and graphical summaries of literature, websites, and associated resources, as they pertain to OHV effects on natural resources and related policies.

1.3 Definitions of OHV Routes/Roads, Vehicles, and Activities

1.3.1 Definitions of Roads and Trails Used in This Report

BLM's *Roads and Trails Terminology* document (U.S. Bureau of Land Management, 2006) defines (1) a road as "a linear route declared a road by the owner, managed for use by low-clearance vehicles having four or more wheels, and maintained for regular and continuous use;" (2) a primitive road as "a linear route managed for use by four-wheel drive or high-clearance vehicles;" and (3) a trail as "a linear route managed for human-powered, stock, or off-highway vehicle forms of transportation or for historical or heritage values." Bolling and Walker (2000) offer more detailed definitions of unpaved roads and trails: (1) graded, improved roads are those from which the topsoil has been removed by bulldozer and characterized by the presence of lateral berms; (2) unimproved roads are those not graded consistently; (3) jeep trails are four-wheel drive tracks impacted only by vehicular traffic and generally characterized by a center berm; and (4) single tracks are severely compacted trails generated by OHVs.

The literature includes numerous reviews on the ecological effects of paved as well as unpaved roads (see Andrews, 1990; Forman and Alexander, 1998; Spellerberg, 1998; Trombulak and Frissell, 2000). Ecosystems of the West, however, are especially vulnerable to OHV-related activities on unpaved (gravel or dirt) roads and trails due to the effects they impose on soils and vegetation, which may take centuries to recover (Webb, 1982; Lovich and Bainbridge, 1999). Furthermore, unpaved roads comprise the majority of OHV routes used throughout public lands in the western United States. Therefore, the primary considerations in this report are unpaved

roads and trails. References and discussions regarding effects of paved roads are not entirely excluded, however, as they often inform the potential scope of OHV effects not otherwise addressed. When necessary to do so, the type of road is specified.

All of terms described above for roads and trails are useful within their own contexts, but to distinguish between them and those used in the OHV literature would unnecessarily complicate discussions herein. Therefore, except where there is a need to specify in more detail, unpaved roads, primitive roads, and unpaved trails, are referred to as “routes,” regardless of their intended purpose or how they are maintained. “Routes” also include unauthorized or “rogue” roads and trails created by OHV users traveling off officially designated roads, primitive roads, and trails. Paved roads are referred to as “roads.”

1.3.2 Definitions of OHVs and OHV Activities Used in This Report

BLM’s *Roads and Trails Terminology* document (U.S. Bureau of Land Management, 2006) defines an OHV as “any motorized vehicle capable of—or designated for—travel on or immediately over land, water, or other natural terrain” (excluding nonamphibious registered motorboats; military, fire, emergency, or law enforcement vehicles used for emergency purposes; official vehicles used expressly by an authorized officer; and military vehicles). Cordell and others (2005) further specify that OHVs may include motorcycles and off-highway motorbikes, ATVs, dune buggies, snowmobiles, most 4-wheel drive automobiles (jeeps, sport utility vehicles), and any other civilian vehicle specifically designed for off-road travel. For the purpose of this document, OHV is defined in accordance with BLM terminology and includes those vehicles listed by Cordell and others (2005), as well as utility vehicles (UTVs) and ATVs with more than 4 wheels.

There are numerous activities and outcomes directly and indirectly associated with OHV use. To simplify discussions of OHV activities herein, the term “OHV activities” largely refers to driving OHVs for recreation. In certain contexts, OHV activities also may include driving and parking vehicles that tow trailers carrying OHVs and loading and unloading OHVs from trailers. Whereas the use of 4-wheel drive jeeps, automobiles, and sport utility vehicles is largely restricted to unpaved roads and jeep trails, the effect of ATVs and off-highway motorcycles extends well beyond them to double- and single-track trails, as well as unauthorized roads and trails. Thus, “OHV activities” may include driving OHVs on authorized roads/routes and on (or creating) unauthorized routes.

2.0 Effects of OHV Travel on Natural Resource Attributes and Socioeconomics

2.1 Scale and Patterns of OHV Activities and Their Effects

Temporal and spatial scales are crucial considerations when evaluating or monitoring effects of any factor on ecosystems (Noon, 2003; Ringold and others, 2003). In discussing OHV effects on desert ecosystems, Brooks and Lair (2005) and Matchett and others (2004) describe the impacts of OHV activities at various spatial and temporal scales. At the highly localized spatial scale, one might find soil compaction taking place within the confines of a single OHV route, the effects of which might be limited to poor infiltration of water and reduced plant cover in the route itself. Brooks and Lair (2005) go on to explain, however, that the cumulative impacts of any one effect at many sites can result in impacts at much greater scales. For example, if

networks of OHV routes criss-cross large areas, the habitat connectivity that previously facilitated animal movements within that landscape may be disrupted (Forman and others, 2003: p. 129-134). Similarly, a single pass by one OHV probably has negligible effects on animal distributions, but if OHV traffic is intense and chronic, animal densities may decline (Reijnen and others, 1995, 1997) as cumulative impacts of this one effect occurring at many sites across a landscape disrupt entire populations. Furthermore, any **direct** effect of OHV use is also likely to have **indirect** effects that go beyond the site of disturbance. For example, reduced plant cover (direct effect) can result in greater rates of erosion in and around an OHV route, which, in turn, might increase sedimentation and turbidity in wetlands downslope of the route (indirect effect). Overall, Brooks and Lair (2005) conclude that effects of OHV use need to be evaluated at appropriate scales, which must take into account the scale at which OHV activities and ecosystem responses occur (Brooks and Lair, 2005). Overall, most, if not all, effects of OHV activities described in sections 2.2 through 2.6 can occur from the very localized and/or ephemeral scale to the landscape and/or long-term scale. By the same token, any direct effect may have a number of indirect effects, the magnitude of which may depend on the spatial and temporal scales at which a direct effect occurs.

At an OHV site in California, Matchett and others (2004) classified OHV routes in terms that describe intensity and pattern of use. First, OHV lines (routes) were categorized as either *dirt* (lines most likely created for or by OHV use) or as *wash* (lines most likely created by water flow, but possibly used by OHVs). They went on to define levels of OHV use that also imply patterns of use: (1) densely tracked reticulate (OHV lines evident in a web-like pattern, but too dense and overlapping to distinguish individually); (2) densely tracked hill-climb (OHV lines evident on slopes, but too dense and overlapping to distinguish individually); (3) densely tracked intersection (OHV lines evident at intersections, but too dense and overlapping to distinguish individually); (4) densely tracked right-of-way (OHV lines evident near pipelines, transmission lines, and highway right-of-ways, but too dense and overlapping to distinguish individually); (5) densely tracked wash (OHV lines evident within washes, but too dense and overlapping to distinguish individually); (6) denuded hill-climb (OHV lines not readily evident on hill-climbs, but the preponderance of densely tracked areas in the vicinity indicate that OHV use was probably high within that area); and (7) denuded staging (OHV routes not readily evident in relatively flat camping areas, but the preponderance of densely tracked areas in the vicinity indicated that OHV use was probably high within that area) (Matchett and others, 2004). Overall, these categories indicate that OHV use often entails many criss-crossing routes as opposed to a single route. They also point out that OHV use may be heaviest on slopes, along right-of-ways, in washes, and in the vicinity of camping facilities.

2.2 OHV Effects on Soils and Watersheds

2.2.1 Section Summary

Important effects of OHV activities on soils and watershed function include soil compaction, diminished water infiltration, diminished presence and impaired function of soil stabilizers (biotic and abiotic crusts, desert pavement), and accelerated erosion rates. Compacted soil inhibits infiltration of precipitation. In turn, soil moisture available to vegetation is diminished, volumes and velocities of precipitation runoff increase, and soil erosion accelerates, leading to the formation of gullies and other surface changes. Additionally, soil compaction may inhibit root growth among plants, in which case organic matter, litter, soil fertility, and vegetative cover are diminished, further exacerbating the soil's susceptibility to erosion. Where

biotic and chemical crusts or other soil stabilizers are disturbed or destroyed, soil erosion from water and wind may increase beyond rates found in undisturbed sites with similar soils and conditions; nutrient-cycling processes also are likely to be disrupted, potentially leading to declines in soil fertility.

2.2.2 Soil Compaction and Reduced Water Infiltration

One of the most common and important effects of OHV activities is soil compaction (Liddle, 1997), which diminishes water infiltration, destroys soil stabilizers (biotic and abiotic crusts, desert pavement), and promotes greater rates of erosion from water and wind. In turn, soil moisture available for plant growth is diminished, precipitation runoff increases in volume and velocity, and soil erosion accelerates, which leads to surface changes, including the formation of rills, gullies, terracettes, and pedestals (Webb and others, 1978; Iverson and others, 1981; Webb, 1982; Hinckley and others, 1983; Wilshire, 1983b). The extent of soil compaction may be measured in terms of soil bulk density, soil strength, and/or permeability. Soil bulk density, calculated as oven-dried soil weight per unit of volume, is typically expressed as g/cm^3 or g/cc . Soil strength, measured as the soil's resistance to deforming forces—or the amount of energy required to break apart aggregates or move implements through the soil—is typically expressed as kg/cm^2 or pounds per square inch (PSI). Soil permeability is the rate at which water (or air) infiltrates the soil, expressed as cm/hr or inches/hr (Leung and Meyer, 2004). Generally, soil bulk density and strength increase with increasing compaction, whereas permeability decreases with increasing compaction (Adams and others, 1982; Webb, 1982; Cole, 1990).

Important factors affecting a soil's susceptibility to compaction include its (1) texture (relative proportions of sand, silt, and clay); (2) structure (the grouping of sand, silt, and clay particles into aggregates), including its porosity (a measure of pore space, which affects the amount of air or water a soil can hold) and aggregate stability (the ability of soil aggregates to resist disruption from outside forces—water in particular); (3) type (series) and depth; and (4) antecedent moisture (the soil's water content prior to compaction). Sandy or clayey soils relatively uniform in texture and structure are less vulnerable to compaction than loamy sands or coarse-textured, gravelly soils characterized by variability in particle size (Lovich and Bainbridge, 1999). In addition, soils with greater water content are more susceptible to compaction than those containing less moisture (Webb, 1982), although even in semi-arid and arid lands soil compaction is problematic because the texture of these soils is slow to recover (Webb, 1982) through natural soil-loosening processes (including shrinking, swelling, drying, wetting, freezing, and thawing).

As the number of vehicle “passes” (one pass is the equivalent of one OHV passing over a given area one time) increases, soil bulk density and soil strength increase and permeability (as indicated by water infiltration rate) decreases (Lovich and Bainbridge, 1999). Soil compaction may become evident after only a few vehicle passes. In fact, Iverson and others (1981) found that soil bulk density increased logarithmically with the number of vehicle passes. Similarly, Adams and others (1982) report that soil strength on routes subjected to a single vehicle pass was 5.3 to 28.4 kg/cm^2 (75.366 to 403.848 PSI) greater (depending on the percent soil moisture) than that of nearby undisturbed soils; after 10 to 20 passes, soil strength was too great (impenetrable) to measure with a penetrometer, indicating that a few passes were enough to cause soil “cementation.” After initial disturbance, the effects of soil compaction can persist for years, even centuries, before natural soil-loosening processes can restore the soil's texture (Webb and Wilshire, 1980; Webb, 1982; Froehlich and others, 1985; Prose, 1985; Lovich and Bainbridge, 1999). For example, one year after impact, a one-pass trail was still faintly visible, as indicated

by slightly more surface gravel and growth of annual plants (the first to grow in disturbed sites) than on surrounding land, and trails impacted by 100 and 200 passes had notable side berms (Prose, 1985).

Other effects of soil compaction include changes to soil horizons and increased compaction in deeper strata. The OHV traffic associated with the annual Johnson Valley-Parker OHV race (1980-1983) near Joshua Tree National Park on the Colorado River compacted 2 to 5 cm (0.8 to 2.0 in) of the underlying vesicular soil horizon (composed of fined-grained, wind-blown material occurring about 20 cm [7.9 in] deep near surface soil horizons, often immediately under desert pavement, and characterized by small pores, or vesicles, of air space; typical of arid regions) and caused excavation (mechanical erosion) of the A and B soil horizons to depths of 20 cm (7.9 in) (Wilshire, 1983a). Prose (1985) found that resistance (to a penetrometer) of soil affected by military maneuvers (including tanks, tracked equipment and personnel carriers, and support vehicles) was 50 percent greater than that of undisturbed soils. Overall, traffic typically causes significant changes to soils, which may take years, if not decades, to recover.

2.2.3 Effects on Soil Stabilizers and Rates of Soil Erosion

A significant effect of soil compaction is the soil's inability to support vegetation after disturbance, thus increasing its susceptibility to erosion (Webb and others, 1978). Soil erosion resulting from soil compaction is caused by two main factors (Hinckley and others, 1983): reduced infiltration rates and destruction of soil stabilizers. Infiltration of water into soils depends, to a large extent, on the soil's porosity, which is reduced by compaction. Soil stabilizers, which are characteristic of undisturbed desert substrates, may include cryptobiotic crusts of lichen, fungi, bacteria, mosses, and/or algae; chemical or mechanical crusts (thin upper coating of clay particles oriented parallel to the surface); and desert pavements (closely packed, interlocking fragments of pebble- and/or cobble-sized rocks from which fine-grained materials have been removed by wind or water erosion) (Lovich and Bainbridge, 1999). Cryptobiotic organisms facilitate accumulation of organic materials and nutrients, including nitrogen and carbon, thereby increasing soil fertility (Johansen, 1993). Since they occur in the soil's upper layer, they also promote water infiltration and enhance retention of soil moisture (Belnap and Gardner, 1993). Their proximity to the surface, however, makes them susceptible to destruction by vehicular and foot traffic.

Cole (1990) documented destruction of cryptogamic soil crusts after only 15 passes by hikers wearing lug-soled boots. Traffic from the Johnson Valley-Parker OHV race mentioned in section 2.2.2 not only destroyed the vesicular soil horizon, it destroyed the overlying desert pavement (Wilshire, 1983a). Webb (1982), who evaluated soil surfaces (shape; another measure of soil compaction) after 1, 10, 100, and 200 motorcycle passes, found changes occurring after the first few passes, although the effects of subsequent passes were more severe due to their cumulative effects: routes subjected to 100 and 200 passes were characterized by berms and lateral edges, and route midlines were 10-30 mm below the level of surrounding undisturbed ground. Once damaged or destroyed, it may take 300-500 years per inch for soil stabilizers to recover or return to their original state (Hudson, 1971).

Typically, undisturbed soil surfaces are very important in controlling the soil's response to precipitation runoff, particularly where the soil surface is covered with fine gravel that overlays soils with large pores (Webb, 1982). In the Mojave Desert, surface runoff was typically five times greater and sediment yield (in runoff) was 10-20 times greater in OHV-impacted areas than in undisturbed areas (Iverson and others, 1981). For various reasons, certain portions of the desert, including dunes, playas, and areas covered with coarse surface material, are fairly

resistant to erosion from runoff (Hinckley and others, 1983), whereas vulnerable areas are those where initial infiltration rates are low, slopes are high, and ratios of surface sand/gravel to smaller particles are low (Iverson and others, 1981). The character of precipitation also influences the susceptibility of denuded soil to erosion; erosion rates are typically greater when rainfall events are of long duration and high intensity (Iverson and others, 1981). Disturbed soils also increase the likelihood of debris eroding from areas disturbed by OHV activities (Lovich and Bainbridge, 1999). Indeed, debris flow has been documented to bury plants growing outside the area impacted (Nakata, 1983).

2.2.4 Annotated Bibliography for OHV Effects on Soils and Watersheds

Adams, J.A., Endo, A.S., Stolzy, L.H., Rowlands, P.G., and Johnson, H.B., 1982, Controlled experiments on soil compaction produced by off-road vehicles in the Mojave Desert, California: *Journal of Applied Ecology*, v. 19, no. 1, p. 167–175.

Under controlled conditions, soil crust properties were measured to determine how rapidly they were altered by passing vehicles. Routes impacted by a single vehicle pass had soil strengths 5.3 to 28.4 kg/cm² (75.366 to 403.848 lb/in² [or PSI], depending on the percent soil moisture) greater than undisturbed soil, indicating that just a single pass can begin to affect soil strength. Mean soil strength on routes exposed to 10 and 20 passes was too high to measure. Drying caused the soil in the slightly compacted track to become much harder (increased soil strength) than the undisturbed soil.

Belnap, Jayne, 1993, Recovery rates of cryptobiotic crusts—inoculant use and assessment methods: *Great Basin Naturalist*, v. 53, no. 1, p. 89–95.

Rates of recovery of cyanobacterial-lichen soil crusts from disturbance were examined. Plots were either undisturbed or scalped, and scalped plots were either inoculated with surrounding biological crust material or left to recover naturally. Natural recovery rates were found to be very slow. Inoculation significantly hastened recovery of the cyanobacterial/green algal component, lichen cover, lichen species richness, and moss cover; even with inoculation, however, lichen and moss recovery was minimal.

Belnap, Jayne, 2002, Impacts of off-road vehicles on nitrogen cycles in biological soil crusts—resistance in different U.S. deserts: *Journal of Arid Environments*, v. 52, no. 2, p. 155–165.

This study was conducted to evaluate short-term impacts of OHVs on lichen cover and the nitrogenase activity (NA) of biological soil crusts on various soil types in the Great Basin, Colorado Plateau, Sonoran, Chihuahuan, and Mojave deserts. Lichen cover was significantly correlated with percent silt in soil (and negatively correlated with percent sand and clay). Disturbance reduced NA at all 26 sites, but significantly at 12; declines were greatest in soils of cooler regions than hotter ones, possibly indicating that non-heterocystic cyanobacterial species are more susceptible to disturbance than heterocystic species. Sandy soils showed greater reduction of NA as sand content increased, while fine-textured soils showed a greater decline as sand content increased. At all sites, higher NA before the disturbance resulted in less impact to NA post-disturbance. These results may be useful in predicting the impacts of off-road vehicles in different regions and different soils.

Cole, D.N., 1990, Trampling disturbance and recovery of cryptogamic soil crusts in Grand Canyon National Park: *Great Basin Naturalist*, v. 50, no. 4, p. 321–325.

Under controlled conditions, cryptogamic soil crusts in Grand Canyon National Park were trampled by hikers to determine how rapidly they were pulverized and how rapidly they recovered. Only 15 passes were required to destroy the structure of the crusts; visual evidence of bacteria and cryptogam cover was reduced to near zero after 50 passes. It took soil crusts one to three years to redevelop, and after 5 years the extensive bacteria and cryptogam cover left little visual evidence of disturbance. Surface irregularity remained low after 5 years, however, suggesting that recovery was incomplete.

Eckert, R.E.J., Wood, M.K., Blackburn, W.H., and Peterson, F.F., 1979, Impacts of off-road vehicles on infiltration and sediment production of two desert soils: *Journal of Range Management*, v. 32, no. 5, p. 394–397.

This project staged a series of controlled motorcycle and 4-wheel drive vehicle passes, followed by simulated rainfall. Two sites were chosen to represent two different soil types. Infiltration rates were lower and sediment yield was higher after soil was disturbed by vehicular traffic. High sediment yield was attributed to reduced infiltration after 10 minutes; the remaining 20 minutes of the test period were characterized by particles being carried away in runoff water.

Folz, R.B., 2006, Erosion from all terrain vehicle (ATV) trails on National Forest lands (abs.): Proceedings of the 2006 American Society of Agricultural and Biological Engineers, Portland, Oregon, July 9–12, 2006: St. Joseph, Michigan, 2006 American Society of Agricultural and Biological Engineers, <http://asae.frymulti.com/abstract.asp?aid=21056&t=2>.

Concern about unmanaged use of all terrain vehicles (ATV) on U.S. Forest Service lands prompted an experimental study to test the relative effects of low-, medium-, and high-disturbance trails (based on traffic levels), as measured by reduced litter/vegetation and the width and wheel-rut depth of trails. Trail condition was assessed and then subjected to simulated rainfall. A negative relationship between levels of ATV traffic and rainfall infiltration was not statistically significant among disturbance levels; however, there were significant differences in infiltration and measures of erosion between undisturbed and disturbed conditions. Data from this study will be used to estimate ATV traffic-induced erosion and make decisions regarding management of ATV use.

Iverson, R.M., Hinckley, B.S., and Webb, R.M., 1981, Physical effects of vehicular disturbances on arid landscapes: *Science*, v. 212, no. 4497, p. 915–917.

In 50 rainfall simulation tests, vehicle-use plots had about five times more runoff and 10–20 times greater sediment yield than adjacent unused plots. In a desert environment, such effects may occur even when use of off-road vehicles is light. Recovery times from vehicular traffic were estimated to be nearly 100 years. Erosion rates were calculated from multivariate statistical analyses using 22 experimental factors. The character of the rainfall was identified as the most important variable in predicting increases in erosion.

Sparrow, S.D., Wooding, F.J., and Whiting, E.H., 1978, Effects of off-road vehicle traffic on soils and vegetation in the Denali Highway region of Alaska: *Journal of Soil and Water Conservation*, v. 33, no. 1, p. 20–27.

This study examined the effects of vehicles on trails. The surface layer of living material was killed on all main trails, although soil morphology was not generally altered except in the surface horizon. Varying amounts of organic matter were lost from the heavily used trails,

depending on slope and vehicle type. Soil depth and drainage were the most important factors influencing the condition of the trail. The greatest effects on soils occurred in poorly drained areas or on loose, gravel-free soils that were highly susceptible to erosion.

Tuttle, M., and Griggs, G., 1985, Accelerated soil erosion at three State Vehicular Recreation Areas: central and southern California, *in* Erosion control: A challenge in our time, proceedings of the 16th annual International Erosion Control Association, February 21–22, 1985, San Francisco, California: San Francisco, California, International Erosion Control Association, p. 105-115.

Soil erosion rates were evaluated at three State Vehicular Recreation Areas, with a particular focus on hillclimbs. The key factors contributing to erosion rates were slope, length of climb, soil type, and weather. Based on monitoring and catchment basin yield, erosion in open areas dedicated to OHV use was 10 to 25 times greater than in undisturbed areas.

Webb, R.H., 1982, Off-road motorcycle effects on a desert soil: *Environmental Conservation*, v. 9, no. 3, p. 197–208.

The effects of controlled motorcycle traffic on a Mojave Desert soil in California were studied in order to quantify soil compaction. Four experimental trails treated with 1, 10, 100, and 200 passes with an off-road motorcycle were established in loamy sand at 6.2 percent (by weight) moisture content. Soil penetration resistance, bulk density, infiltration rate, and response to rainfall were measured for undisturbed soil and the experimental trails immediately after the impact, and soil cores were measured in the laboratory to determine pore-size distributions. Soil bulk density was remeasured one year after the impact to ascertain the amount of recovery. The 1-pass trail had a slight surface indentation with knob imprints from the tires. Along the 100- and 200-pass trails, there were berms and lateral edges, and their centers were 10–30 mm below the level of undisturbed soil adjacent to the trail.

Wilshire, H.G., and Nakata, J.K., 1976, Off-road vehicle effects on California's Mojave Desert: *California Geology*, June 1976, p. 123–132.

This study was designed to evaluate long-term effects of an off-road vehicle race on the desert landscape, in particular the landscape condition after vehicular use (specifically motorcycles), whether or not effects were confined to the areas of direct impact, and how long the physical effects of such activities remained. Visual observations and penetrometer measurements were recorded in five ground types. Soil compaction was the dominant consequence of motorcycle use: penetrometer data revealed decreases in mean penetration depths. Combined with a notable reduction in plant cover, soil compaction significantly increased the potential for erosion. Initial vehicle impact resulted in substantial, immediate mechanical erosion, followed by wind erosion, culminating in the increased potential for water erosion over longer periods of time.

Wilshire, H.G., Nakata, J.K., Shipley, Susan, and Prestegard, Karen, 1978, Impacts of vehicles on natural terrain at seven sites in the San Francisco Bay area: *Environmental Geology*, v. 2, no. 5, p. 295–319.

Vegetation and soil properties were measured at seven sites exposed to off-road vehicle activities. Impacts on loamy soils included greater soil surface strength and bulk density, lower infiltration rates and soil moisture, extended diurnal temperature ranges, and reduced organic

carbon. These effects, combined with the associated loss in vegetative cover, promoted erosion, the rates of which significantly exceeded Federal and local standards, and the increased sediment yield and runoff caused adverse effects on neighboring properties.

2.3 OHV Effects on Vegetation

2.3.1 Section Summary

Relative to plant communities in OHV-impacted areas, those in undisturbed sites are dominated by native plants, invasive species are not increasing, plant growth and reproduction are vigorous, age-classy structures are appropriate to the species, and canopy cover and vertical structure are adequate for dispersing the energy of precipitation runoff and promoting water infiltration. Direct impacts of OHV activities on vegetation include reduced vegetation cover and growth rates, and increased potential for non-native grasses and pioneering species to become established, thus altering vegetation communities. In certain instances, however, the impervious nature of compacted route and paved road surfaces could result in significant runoff that generates greater moisture availability immediately along OHV routes. In turn, this would promote increased vegetation cover and plant abundance than one might find in surrounding areas farther away from OHV routes.

Some important indirect effects of OHV activities on vegetation are tied to soil properties altered by OHV traffic, as soil properties typically influence vegetation growth. OHV roads and trails also create edge habitats, which can generate conditions that promote the encroachment of non-native and invasive plant species. Other indirect effects include increased amounts of airborne pollutants and dust raised by OHV traffic. A blanket of fugitive dust on plant foliage can inhibit plant growth rate, size, and survivorship.

2.3.2 Overall Effects on Vegetation Cover and Community Composition

When soils are severely disturbed, vegetation cover can be reduced significantly (Adams and others, 1982; Prose and others, 1987; Bolling and Walker, 2000) and growth can be impaired (Spencer and Port, 1988; Angold, 1997). As stated in the previous section, even a few passes by vehicles can cause significant changes in soil properties. Adams and others (1982) found reduced cover of desert annuals in tracks created by as few as 1 (on wet loamy sand) to 20 (on dry loamy sand) vehicle passes; the reduction in cover, however, was not due to fewer plants, but to smaller plant sizes. Similarly, Bolling and Walker (2000) found that in OHV routes there were many small individuals of creosote bush (*Larrea tridentata*), but larger plants were few or absent; in control plots, however, there were more large plants and fewer small ones.

Reduced plant sizes are typical where the extent of soil compaction inhibits their roots from penetrating to deeper soil levels. In fact, Adams and others (1982) determined that root growth is precluded at soil strengths of about 20 kg/cm² (284.4 lb/in²). Within tracks made by 1, 3, 10, and 20 vehicle passes, Adams and others (1982) found that annuals with large taproots (for example, pincushion flower [*Chaenactis fremontii*]) decreased, whereas there was significantly greater cover of common Mediterranean grass (*Schismus barbatus*), a non-native grass with a fibrous root system. The fibrous root system of plants that characterized by single cotyledons, such as common Mediterranean grass, allows for easier germination and root growth than is possible for taprooted dicotyledons.

Soil compaction also increases the potential for invasive, non-native annuals and other early successional plants to establish rapidly in OHV routes, whereas native perennials may require at least 5 years to become established (Adams and others, 1982; Prose and others, 1987;

Lovich and Bainbridge, 1999). This is due, in part, to the increased surface moisture availability within the tracks of OHV routes after compaction has reduced the rate of water infiltration, which may favor the rapid germination and growth of non-native and invasive annuals (Adams and others, 1982). In disturbed areas, pioneering species, such as burrobrush (*Ambrosia dumosa* and *Hymenoclea salsola*—now *Ambrosia salsola*; see http://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?3578), often dominate the plant community and typically their percent cover is similar to, or greater than, that of undisturbed areas (Prose and others, 1987). Davidson and Fox (1974) also found that non-native, early-successional species, such as redstem stork's bill (*Erodium cicutarium*) and common Mediterranean grass were common at sites disturbed by OHVs. When comparing vegetation in disturbed versus protected plots, Brooks (1995) found that common Mediterranean grass was the only species with greater biomass in the disturbed plots.

OHV traffic also causes direct impacts to vegetation structures (breakage, smashing), although population-level effects may be difficult to discern in the short term. Overall, the extent of immediate effects increases with the frequency of OHV passes. For example, Webb (1983) found that after a single pass, annual plants on an OHV route remained intact, but most were destroyed after 10 passes. Likewise, a series of studies to evaluate the impacts of OHV traffic on the Federally listed Peirson's milkvetch (*Astragalus magdalenae peirsonii*) indicated that this plant was more likely to occur at sites closed to OHV activity than at OHV sites that have been rested from OHV activity (Groom and others, 2005); however, additional study indicated that the number of reproducing plants (and the seedbank) was adequate to maintain the milkvetch population (Phillips and Kennedy, 2006; for more reports, go to http://www.fws.gov/carlsbad/PMV_Docs.htm). It remains unclear, however, whether research conducted over longer time scales would yield different results.

2.3.3 Edge Effects Along OHV Routes

Roads and trails also create edge habitats (Johnson and others, 1975; Vasek and others, 1975; Adams and Geis, 1983; Andrews, 1990; Holzapfel and Schmidt, 1990; Lightfoot and Whitford, 1991; Reed and others, 1996), resulting in a variety of effects, including changes in vegetation and encroachment of non-native and invasive species (Huey, 1941; Lovich and Bainbridge, 1999). As mentioned in section 2.3.2, the impermeable surfaces of roads and OHV routes shed precipitation, thereby increasing overall moisture availability in the immediate vicinity of the road or route. Additionally, the coarse-textured soils typically found in association with paved roads (roadbed materials laid down prior to paving) permit good water infiltration along road edges (Hillel and Tadmor, 1962); similar conditions may occur along improved gravel routes. The increased moisture availability may promote greater plant vigor along roadsides than in surrounding areas (Johnson and others, 1975), and Angold (1997) indicated that such effects may extend as far as 200 m from road edges. Indeed, several studies have shown that there can be more vegetation cover along roadsides and right-of-ways than in adjacent areas (Johnson and others, 1975; Vasek and others, 1975; Holzapfel and Schmidt, 1990; Lightfoot and Whitford, 1991). Perennial shrubs, in particular, may grow larger and attain greater vigor and density along road edges (Johnson and others, 1975; Lightfoot and Whitford, 1991). Likewise, Johnson and others (1975) found that the standing crop (a measure of primary productivity) was 6 times greater along unpaved roads (17 times greater along paved roads) than it was in nearby undisturbed areas.

The greater vegetation cover typically observed along roadsides also is often due, in part, to greater species richness in those areas (Holzapfel and Schmidt, 1990); however, much of this diversity may be represented by non-native species easily dispersed along roads and trails

(Wilcox, 1989; Tyser and Worley, 1992; Parendes and Jones, 2000). Furthermore, local-scale increases in species richness can be associated with decreases in species richness at the landscape scale, thus creating a relatively impoverished and anthropogenic vegetation community (Holzapfel and Schmidt, 1990). Interestingly, increased vegetation cover along roadsides may attract more invertebrates and other organisms. For example, Lightfoot and Whitford (1991) found that shrubs along a road supported greater numbers of foliage arthropods. What is not clear, however, is whether high densities of animals in roadside habitats represent improved conditions for native fauna or dominance by invasive and/or non-native organisms. Furthermore, high densities do not necessarily represent population sources (that is, where survivorship and productivity are high enough to contribute to the species' overall population); instead, high densities can indicate poor-quality habitat into which subordinate animals may crowd and experience poor survivorship if they cannot find or defend better habitat (population sinks). In other words, density can be a misleading indicator of habitat quality (Van Horne, 1983). It is important to note, however, that the greater vegetation cover along roadsides compared to plots away from roads may be a phenomenon found only in arid environments (Hillel and Tadmor, 1962; Holzapfel and Schmidt, 1990).

Fugitive dust raised by OHV traffic also affects vegetation in the vicinity of roads. Along Alaskan roads heavily traveled by various types of vehicles, Walker and Everett (1987) found significant dust impacts up to 10 m (10.9 yd) from the roadside and dust blankets up to 10 cm (3.9 in) thick on mosses and other vegetation of low stature. Several morphological factors contribute to plant susceptibility to heavy dust loads, including mat or prostrate growth form, lack of a protective stem cortex or leaf cuticle, and intricate branching or closely spaced leaves that tend to trap dust (Walker and Everett, 1987; Spellerberg and Morrison, 1998). Processes that may be affected by dust include photosynthesis, respiration, and transpiration due to blocked stomata and cell destruction (Spellerberg and Morrison, 1998), all of which could result in reduced plant growth, size, productivity, and/or survivorship.

2.3.4 Annotated Bibliography for OHV Effects on Vegetation

Adams, J.A., Stolzy, L.H., Endo, A.S., Rowlands, P.G., and Johnson, H.B., 1982, Desert soil compaction reduces annual plant cover: California Agriculture, v. 36, no. 9–10, p. 6–7.

Soil crust properties and associated changes in vegetation composition were measured under controlled conditions over two 6-month wet seasons to determine how rapidly they were altered by vehicle passes. Reductions in annual plant cover occurred in tracks created by as few as 1 (on wet loamy sand) to 20 vehicle passes (on dry loamy sand). This cover reduction, however, was not due to fewer plants; rather, the plants were smaller, and their size depended on the duration of drying periods, during which the soil strength intensified in impact/track areas. Cover of annuals with large taproots (for example, *Chaenactis fremontii*) decreased in vehicle tracks, whereas the cover of *Schismus barbatus*, a grass with a fibrous root system, was significantly greater in tracks generated by 1, 3, 10, and 20 vehicle passes. It was determined that root growth for plants stops at soil strengths of about 20 kg/cm² (284.4 lb/in² [or PSI]). Soil disturbance also increased the potential for grasses and pioneering annual species to become established, whereas perennial species would take at least 5 years to return. A possible reason for this may be greater water availability in the track.

Angold, P.G., 1997, The impact of a road upon adjacent heathland vegetation—Effects on plant species composition: Journal of Applied Ecology, v. 34, no. 2, p. 409–417.

The effect of a road on heathland vegetation was investigated at five sites adjacent to the main trunk road through the New Forest, Hampshire, United Kingdom, and nine supplementary sites adjacent to five minor roads. There was enhanced growth of vascular plants near the road, notably heather and grasses, which was probably due to nitrogen oxides from vehicle emissions. There was a decrease in the abundance and health of lichens near the road. There was an increase in the abundance of grasses in the heathland near roads, which may be due to the changes in relative competitive ability of plant species under conditions of eutrophication. The extent of the edge effect in the heath was closely correlated with traffic intensity, with a maximum edge effect of 200 m adjacent to a dual carriageway.

Benninger-Traux, M., Vankat, J.L., and Schaefer, R.L., 1992, Trail corridors as habitat and conduits for movement of plant species in Rocky Mountain National Park, Colorado, USA: *Landscape Ecology*, v. 6, no. 4, p. 269–278.

Ground-layer vegetation was sampled along selected trail corridors to determine whether corridors provide habitat for certain species and serve as conduits for species dispersal. Patterns of plant species composition were analyzed in relation to distance from trail edge, level of trail use, and distance from trailheads, junctions, and campgrounds. Species composition was significantly affected by distance from trail edge and level of trail use, as species were favored or inhibited by the corridor, depending upon their growth habits. Species composition also was affected by distance from trailheads. These findings, along with the presence of exotic species, indicate that trail corridors in Rocky Mountain National Park function as habitat and conduits for dispersal of plant species.

Bolling, J.D., and Walker, L.R., 2000, Plant and soil recovery along a series of abandoned desert roads: *Journal of Arid Environments*, v. 46, no. 11, p. 1–24.

To elucidate factors controlling desert succession, soil and vegetation dynamics were examined along roads abandoned for 5, 10, 21, 31, 55 and 88 years in southern Nevada. None of the measured soil or vegetation parameters varied significantly with road age. Differences were found, however, between soils and vegetation on roads compared to those on nearby control sites, and soils differed between roads created by surface vehicular traffic and those made by bulldozing. Studies of recovery following disturbance in deserts must take into account natural patterns of plant and soil heterogeneity and initial disturbance type.

Brooks, M.L., 1995, Benefits of protective fencing to plant and rodent communities of the western Mojave Desert, California: *Environmental Management*, v. 19, no. 1, p. 65–74.

This paper documents the response of plant and small mammal populations to fencing constructed to preclude OHV activities between 1978 and 1979 at the Desert Tortoise Research Natural Area, Kern County, California. Aboveground live annual plant biomass was generally greater inside than outside the fenced plots during April 1990, 1991, and 1992. The non-native grass, *Schismus barbatus*, was a notable exception, producing more biomass in the unprotected area. Forb biomass was greater than that of non-native annual grasses inside the fence during all 3 years of the study. Outside the fence, forb biomass was significantly greater than that of non-native grasses only during spring 1992. Percent cover of perennial shrubs was greater inside the fence than outside, while no significant trend in density was detected. There was also more seed biomass inside the fence, which may have contributed to the greater species diversity and density of Merriam's kangaroo rats (*Dipodomys merriami*), long-tailed pocket mice (*Chaetodipus*

formosus), and southern grasshopper mice (*Onychomys torridus*) in the protected area. These results show that protection from OHV disturbance has many benefits, including greater overall community biomass and diversity.

Holzappel, C., and Schmidt, W., 1990, Roadside vegetation along transects in the Judean Desert: Israel Journal of Botany, v. 39, p. 263–270.

Vegetation was studied on comparable plots along roadsides and in the surrounding area. The uniqueness of roadside vegetation was shown using indices and measurements that allowed comparison along a climatic gradient. Near roads, biomass and species diversity were notably greater than in surrounding areas, and the chorological composition was different, at least under arid conditions. The reasons for these differences are discussed based on investigations of site conditions. Increased water runoff and more favorable soil conditions seem to have had important influences on the vegetation community.

Kutiel, P., Eden, E., and Zhevelev, Y., 2000, Effect of experimental trampling and off-road motorcycle traffic on soil and vegetation of stabilized coastal dunes, Israel: Environmental Conservation, v. 27, no. 1, p. 14–23.

The aim of this study was to assess the response of soil and annual plants of stabilized Mediterranean coastal dunes in Israel to various intensities of short-duration pedestrian and motorcycle traffic. Experimental procedures entailed 0, 20, 50, 100, and 200 straight and 150 turn motorcycle passes. The response of annual plants was assessed by measuring ground cover, height, and species richness and diversity, and soil response was assessed by measuring penetrable depth, organic matter, and moisture content. Motorcycle passage had an immediate significant impact on annual plants at all traffic intensities. The maximum effect on plants was observed in the wheel tracks and in the turn lanes. Mean annual ground cover and height were less sensitive measures than species richness and diversity for determining the overall impact of motorcycles on the area.

Prose, D.V., Metzger, S.K., and Wilshire, H.G., 1987, Effects of substrate disturbance on secondary plant succession—Mojave Desert, California: Journal of Applied Ecology, v. 24, no. 1, p. 305–313.

The effects of substrate disturbance on perennial plant succession in the Mojave Desert were assessed at three military camps abandoned for 40 years. Soil compaction, removal of the top layer of soil, and altered drainage channel density caused significant changes in perennial plant cover, density, and relative species composition. Long-lived species, predominantly *Larrea tridentata*, were dominant in all control areas, but percent cover and density were greatly reduced in areas where substrate alterations were significant. At one camp where substrate alterations were insignificant in disturbed areas, *Larrea* was the dominant species (as it was in the control areas).

Schultink, G., 1977, Impact analysis of off-road-vehicle use on vegetation in the Grand Mere Dune environment: East Lansing, Michigan, Michigan State University, Report no. NASACR155764, 10 p.

A linear regression of percent unvegetated land in OHV-impacted areas versus time for two sample areas indicated that the areas underwent average declines of 1.9 and 5.9 percent per year in vegetation cover. Two factors were assumed to play roles in the difference: the difference

in accessibility and the extent of vegetation fragmented during the first year of the study (one sample area was located closer to potential access points and was more fragmented initially).

Wilshire, H.G., Shipley, Susan, and Nakata, J.K., 1978, Impacts of off-road vehicles on vegetation: Transactions of the North American Wildlife and Natural Resources Conference, v. 43, p. 131–139.

Observations of the impacts of off-road vehicles on soils and vegetation were made at more than 400 sites in seven western states during 3 years. This type of land use had both direct and indirect effects on vegetation. Direct effects included crushing and uprooting plants. Indirect effects included modification of the soil, which affected plants beyond the areas directly impacted by vehicles, and restoration of the plant cover was inhibited. This paper covers the erosional effects on vegetation, depositional effects on vegetation, and the effects of physical and chemical modification of remnant soils on revegetation.

2.4 OHV Effects on Wildlife and Habitats: Native, Threatened, and Endangered Species

2.4.1 Section Summary

The impacts of OHV activities on wildlife and their habitats are numerous and well documented. Networks of roads and trails fragment habitat, reduce patch size, and increase the ratio of edge to interior. This may have serious consequences for area-sensitive species (those that cannot carry out certain aspects of their life cycles without large blocks of habitat or corridors linking habitat patches), predator-prey relationships, and overall population dynamics. In particular, fragmentation and edges created by OHV routes may have strong effects on animal movement patterns. Precluding or inhibiting animal movements effectively diminishes dispersal to and recolonization in other areas, thus increasing the likelihood of local extirpations. Overall, studies demonstrate that even narrow roads (paved and unpaved) and trails can represent significant barriers to the movements of animals. Reluctance to cross even narrow trails similar in width to routes created by OHV travel may alter or preclude the movements of various species. The cumulative effects of OHV-route networks proliferating across the landscape may have serious ecological consequences for species reluctant to cross OHV routes. Where threatened and endangered species are at risk, understanding their particular responses to roads of varying types, widths, use intensities, and habitat contexts is crucial.

OHV routes also generate conditions unlikely to occur in environments unaffected by OHV activity; in turn, these conditions can facilitate range extensions and invasions of non-native and/or opportunistic species. In addition, OHVs can contribute directly to mortality (and possible population declines) of wildlife species through collisions with vehicles, nest destruction, and collapsing burrows. Noise generated by OHVs also has been found to cause inner ear bleeding. In particular, noise may alter animal behaviors, breeding populations, the abilities of some species to detect predators (through auditory cues), and it can stimulate estivating animals to emerge from their underground burrows at inappropriate times. These factors may result in diminished body mass, reduced productivity, and/or poor survivorship.

2.4.2 Loss of Habitat Connectivity: Fragmentation and Barrier Effects

Creating roads and trails (of any kind) diminishes habitat connectivity, increases the proportion of edge to interior habitat, and decreases patch size of habitats (Reed and others, 1996; Forman and others, 2003). In fact, roads, including OHV routes, represent a principal

factor contributing to habitat fragmentation at various scales (Meffe and Carroll, 1997). Furthermore, both paved roads and OHV routes—ranging from 4-lane paved highways to two-track routes less than 3 m (3.3 yards) wide—that separate once-continuous habitat can disrupt the movement and dispersal of many wildlife species between and within habitats (Swihart and Slade, 1984; Brody and Pelton, 1989; Yanes and others, 1995; Lovallo and Anderson, 1996; Clevenger, 1998; Forman and Alexander, 1998; Jackson and Griffen, 1998). In turn, these effects can have consequences for area-sensitive species and may encourage non-native and/or invasive species. Special-status wildlife species known to occur on BLM lands and whose long-term persistence is threatened by habitat fragmentation and diminished habitat connectivity include grizzly bear (*Ursus arctos horribilis*; Gibeau and Herrero, 1998; Servheen and others, 1998), black bear (*Ursus americanus*; Brody and Pelton, 1989), gray wolf (*Canis lupus*; Paquet and Callahan, 1996), mountain lion (*Felis concolor*; Beier, 1993), lynx (*Felis lynx*; Ruediger, 1998), ocelot (*Leopardus pardalis*; Tewes and Blanton, 1998), and desert tortoise (*Gopherus agassizii*; Boarman and Sazaki, 1996). The resulting isolation of subpopulations (Dobson and others, 1999) can promote increased inbreeding and a lack of genetic exchange with other subpopulations, ultimately leading to declines in the genetic diversity required for adaptation to variable conditions and possible founder effects (Hanski and Simberloff, 1997; Hanski, 1999). Another consequence of subpopulation isolation is the reduced potential for recolonization when extirpations occur as a result of localized population fluctuations and catastrophic events (Yanes and others, 1995).

Until recently, only wide, multi-lane, paved roads have been considered significant barriers to animal movements. More recent lines of evidence from fragmentation studies, however, indicate that the ability or willingness of an animal to cross a given road type varies widely by species (Brody and Pelton, 1989; Lovallo and Anderson, 1996). For example, rodents in a desert habitat were found to avoid crossing a 4-lane highway, although they lived alongside the road in the right-of-way vegetation (Garland and Bradley, 1984). Likewise, in forested habitats divided highways wider than 90 m (98.4 yd) served as total barriers to dispersal by small forest mammals (Oxley and others, 1974). However, improved gravel roads have been found to inhibit crossings by mountain lions (*Puma concolor*; van Dyke and others, 1986), and even infrequently traveled, single-lane dirt roads have been found to alter movements by some species (Andrews, 1990). For example, Swihart and Slade (1984) report that prairie voles (*Microtus ochrogaster*) and cotton rats (*Sigmodon hispidus*) were strongly inhibited from crossing a route less than 3 m (3.3 yd) wide and composed of two dirt tracks created by the passing of 10 to 20 vehicles per day. Oxley and others (1974) evaluated small mammal responses to roads and routes ranging from 4-lane paved highways to country gravel roads in forested systems of southeastern Canada and found that they were not willing to cross roads or other routes with a total clearance (the distance between forest margins, including road surfaces and immediately adjacent strips of vegetation kept very short via spraying and/or mowing) of 30 m (32.8 yd) or greater; road surface apparently was unimportant. Likewise in Germany, forest mice (*Apodemus flavicollis*) did not cross roads 6 m (6.6 yd) wide, and very few mice returned to the side of the road from which they were captured after being translocated to the opposite side within the same habitat type (Mader, 1984). Areas characterized by high densities of roads also are characterized by low probabilities that amphibian species will occupy breeding pools (Vos and Chardon, 1998), most likely because the edges were relatively impermeable (whether due to behavioral avoidance or direct mortality) to critical amphibian movements (dispersal, seasonal movements; Gibbs, 1998). On the other hand, some small mammals are known to cross paved and gravel roads (Bakowski

and Kozakiewicz, 1988), particularly where vegetated highway right-of-ways resemble those of adjacent habitats (Wilkins, 1982). These studies indicate that road surface type is not always the critical inhibiting factor; however, it does influence traffic speed, which can directly affect mortality rates (Oxley and others, 1974; Bakowski and Kozakiewicz, 1988).

Invertebrates also may be precluded from crossing various road types, including those considered relatively narrow; again, however, there are species differences that may be influenced by their ecologies and physical capabilities. For example, Samways (1989) found that both “tarred” (paved) and “untarred” roads were almost complete or partial barriers to three species of bush crickets (*Decticus varrucivorus monspeliensis* and *Platycleis fedtschenkoi azami*, both wingless, and *P. tessellate*, the flight range of which is less than [$\leq$] 5m [5.5 yd]), but roads were only minor, very minor, or did not serve as barriers to the movements of six other bush cricket species, five of which can readily fly across roads (flight ranges from <30 to 150 m [32.8–164.0 yd]). On the other hand, Munguira and Thomas (1992) found that wide highways did not affect the movements of butterflies in open populations; movements of butterflies in closed populations, however, were slightly impeded by roads. Other butterfly species may not even attempt to fly across roads (described by authors as two-lane highways and secondary roads), possibly due to the extreme changes in microclimate over roads (including columns of warm air rising above roads; Boer Leffef, 1958, as interpreted and translated by van der Zande, 1980). Mader (1984) reported that in a five-year mark-recapture-release study involving 10,186 carabid beetles representing nine species, three species were never recaptured on the opposite side of study area roads (one- or two-lane paved roads) or parking loops, and the remainder were recaptured across the road only rarely. However, some individuals of a Swedish snail species (*Arianta arbustorum*) that were captured and translocated to the opposite sides of narrow paths or relatively wider roads did return to the capture sides of paths (Baur and Baur, 1990).

2.4.3 Edge Effects

Aside from fragmenting habitat, roads and trails of any kind also create habitat edges (Reed and others, 1996). In many instances, these edge effects extend well beyond the road’s actual footprint and for some species the effects may extend well into the desert interior. Therefore, assessing edge effects of roads and trails on wildlife may entail determining distributions of wildlife in reference to the extent of any one edge effect (Yahner, 1988). Even then there may be an array of factors that vary the distances from roads/trails at which edge effects may be apparent. For example, Nicholson (1978) indicates that metapopulations of desert tortoises may be depleted within 0.8 km (0.5 mi) of highway edges, and von Seckendorff Hoff and Marlow (1997) indicate that this effect may extend as far as 3.5 km (2.2 mi) from the highway edge.

Given the frequent incidence of significant vegetation cover along road edges, many organisms may be attracted to right-of-way habitats. For example, Adams and Geis (1983) found greater small mammal density within interstate right-of-way habitats than in adjacent habitats. Density, however, can indicate habitats sinks to which animals retreat when more desirable habitats are occupied (Van Horne 1983). Alternatively, road edges may serve as ecological traps (Andrews, 1990) that are attractive and replete with necessary resources on the one hand, but impose unusually high mortality rates on the other hand. For example, birds may be attracted to lush roadside vegetation for breeding, nesting, or foraging (Clark and Karr, 1979), but they may be at great risk of mortality due to being hit by vehicles (Mumme and others, 2000). Similarly, avian eggs and nestlings can experience increased mortality due to high rates of predation (Yahner and others, 1989) in edge habitats. As mentioned in the section above, edge effects

along roads can alter or preclude the seasonal movements of amphibians to their breeding pools (Gibbs, 1998; Vos and Chardon, 1998).

In the same ways that travel routes promote increased dispersal of non-native and invasive plant species, they also promote increased distributions of wildlife species otherwise unlikely to be common in a given area; in turn, this exerts additional competitive pressures on native species. Huey (1941) documented pocket gophers (*Thomomys umbrinus*) extending their ranges across the Mojave Desert via roads and canal systems. Although much of the surrounding desert landscape contained soils unsuitable for gophers, the attractive habitat (greater cover of vegetation resulting from increased moisture availability) along roadsides and canals facilitated the spread of these animals (Huey, 1941). An additional important edge effect associated with roads of many types is the presence of utility infrastructures, which can contribute to significantly altered predator-prey relationships along roads. For example, raven species (*Corvus* spp.) have increased their distribution throughout the Mojave Desert, primarily due to the fact that they can perch along utility structures to scan for carcasses on adjacent roads (paved and unpaved) (Knight and Kawashima, 1993), a significant concern in light of the fact that Berry and others (1986) reported ravens as being responsible for 68 and 75 percent of mortality among juvenile desert tortoises on two study plots.

2.4.4 OHV Disturbance and Noise

Vehicular traffic is also a source of noise and other stimuli that have the potential for disturbing wildlife along any type of road or trail (Singer, 1978; van der Zande, 1980; Brattstrom and Bondello, 1983; Bowles, 1995; Reijnen and others, 1995, 1996; Bowles, 1995; Kaseloo and Tyson, 2004). Veen (1973; as interpreted and translated by van der Zande, 1980) found that four shorebird species inhabiting open grassland areas were disturbed within 500–600 m of a “quiet rural road” and within 1600–1800 m of a “busy highway;” van der Zande (1980) reanalyzed Veen’s data and yielded similar results for three of the four species, and went on to conclude that populations of these birds were diminished by as much as 60 percent over those distances. Forman and Alexander (1998) found that noise levels generally increase with traffic intensity, and Reijnen and others (1995, 1997) concluded that traffic noise can lead to significant reductions in breeding bird densities. Larger animals also exhibit responses to the intensity of traffic and traffic noise. Lyren (2001) found that coyotes changed their road-crossing periods in response to changes in traffic intensity throughout the day, and Singer (1978) reported that, in response to the shifting of truck gears, mountain goats ran away from a road edge when the truck was 1 km (0.6 mi) away from them, and they ran away from a lick that was 400 m (437.4 yd) from the road.

Noise emitted from certain types of OHVs can be as high as 110 decibels, which is near the threshold of human pain (Lovich and Bainbridge, 1999). Although sounds from OHV motors are not the loudest anthropogenic sounds, in wildlife habitats they are emitted more frequently than other high-intensity sounds (Brattstrom and Bondello, 1983), and the effect on animals can be significant. For example, sand lizards (*Uma scoparia*) and kangaroo rats (*Dipodomys deserti*) experienced hearing loss that lasted for weeks after being exposed to less than 10 minutes of dune buggy playback recordings played intermittently at lower decibel levels than the animals would have been exposed to in the actual presence of a dune buggy (Brattstrom and Bondello, 1983); subsequently, both species were unresponsive to recordings of predator sounds. In two other studies, kangaroo rats (*Dipodomys spectabilis*) experienced inner ear bleeding when subjected to OHV noise (Berry, 1980b; Bury, 1980). Another issue is the way in which OHV noise (sound pressure) may simulate that of natural sounds (thunder, for example) to which many

animals may be adapted to respond. For example, in response to 30 minutes of taped motorcycle sounds, Brattstrom and Bondello (1983) documented a spadefoot toad (*Scaphiopus couchii*) emerging prematurely (wrong season, absence of rain) from its burrow, most likely because the sound mimicked that of thunder, to which the species would normally respond.

Noise, lights, and other disturbances associated with OHV activities also have the potential for eliciting stress responses from a broad spectrum of wildlife taxa. Indeed, studies have shown that ungulates, birds, and reptiles all experience accelerated heart rates and metabolic function during disturbance events; in turn, animals may be displaced and experience reproductive failure and reduced survivorship (see review in Havlick, 2002). For example, radio-collared mule deer disturbed by ATVs altered their patterns of foraging and spatial use of habitat; deer in undisturbed areas, however, exhibited no such changes (Yarmoloy and others, 1988). In addition, Yarmoloy and others (1988) found that harassment of deer resulted in diminished reproductive output in the following fawning season, whereas deer that were not harassed experienced no change in reproduction.

2.4.5 Wildlife Mortality and Related Issues

Direct wildlife mortality can result from vehicular impact (Harris and Gallagher, 1989; Beier, 1993; Bruinderink and Hazebrook, 1996; Moore and Mangel, 1996), thus removing individuals from populations (Harris and Gallagher, 1989; Forman and Alexander, 1998); thus, habitats containing roads may represent population sinks for any species that commonly attempts to move from one habitat fragment to another by crossing roads (Kline and Swann, 1998). If mortality rates exceed rates of reproduction and immigration, wildlife populations decline (Beier, 1993; Bruinderink and Hazebrook, 1996; Moore and Mangel, 1996; Forman and Alexander, 1998). Previous studies indicate that mortality rates vary widely according to habitat and road or route characteristics (for example, road width, traffic density and speed, adjacent habitat) (Ward, 1982; Bashore and others, 1985; Foster and Humphrey, 1995; Evink and others, 1996, 1998), as well as taxa studied—invertebrates: Seibert and Conover (1991), Munguira and Thomas (1992); reptiles and amphibians: Rosen and Lowe (1994), Ashley and Robinson (1996), Boarman and others (1998), Rudolph and others (1998), Means (1999); birds: Dhindsa and others (1988), Moore and Mangel (1996), Mumme and others (2000); and mammals: Gilbert and Wooding (1996), Romin and Bissonette (1996), Lehnert and Bissonette (1997), Gunter and others (1998), Lyren (2001). Even where the frequency of wildlife mortality is relatively low most of the year, it may increase during certain seasons (Feldhammer and others, 1986; Bruinderink and Hazebrook, 1996) or when traffic frequency increases (McCaffery, 1973). Furthermore, population dynamics can be altered if low mortality rates nonetheless cause disproportionate mortality among specific sex and/or age classes (Beier, 1993; Moore and Mangel, 1996; Mumme and others, 2000).

Several researchers have conducted extensive monitoring at desert OHV sites and undisturbed sites to compare direct effects of OHV activity on mortality and abundance of certain reptile species (Bury and others, 1977; Berry, 1980a; Bury, 1980; Luckenbach and Bury, 1983; Brooks, 1999; Grant, 2005). Of important concern is the susceptibility of desert tortoises to mortality on all types of roads. Berry (1980a) found a link between OHV activity and population declines of the desert tortoise and Couch's spadefoot toad (*Scaphiopus couchii*); numbers of tortoises and active burrows in a 25-ha control plot were significantly greater than in a similar plot exposed to OHV activity, presumably the result of direct mortality from vehicles or the collapsing of burrows caused by OHV traffic (Lovich and Bainbridge, 1999). Additionally, the body masses of subadult and adult tortoises in the control plot were greater than those of

tortoises in the OHV area (Bury and Luckenbach, 1986, cited in Lovich and Bainbridge, 1999). When comparing lizards in OHV-impacted plots to control plots, controls supported 1.8 times more species, 3.5 times more individuals, and 5.9 times more biomass (Luckenbach and Bury, 1983). Similarly, Bury and others (1977) found more reptile species (1.63 times more) and greater reptile abundance (182 percent more individuals) at control sites than at OHV sites. In another study, the remains of 39 tortoises were recorded during three surveys over a 2.5-year period along a 24-km (14.9-mi) section of paved highway in the western Mojave Desert (Boarman and others, 1993). Snakes also experience high rates of mortality in the Mojave Desert due to their strategy for thermoregulation (lying on warm surfaces, such as roads; Sullivan, 1981). Rosen and Lowe (1994), who conducted nighttime snake surveys along a 2-lane paved road in the Sonoran Desert (primarily within Organ Pipe Cactus National Monument), documented a 72 percent rate of snake mortality (104 live, 264 dead); mortality peaked in spring—when snake activity was moderately high and automobile traffic had not yet reached its summer minimum—and during rain events in the monsoon season (July through early September). Overall snake mortality during the entire 4-year study was estimated at 2,383 snakes (13.5 snakes/km/year; 8.1 snakes/mi/year), although actual numbers were likely closer to 4,000.

Densities and species diversity of desert birds and small mammals also have been reported to decrease in areas where OHV use was extensive (Busack and Bury, 1974; Bury and others, 1977; Luckenbach, 1978; Luckenbach and Bury, 1983; Brooks, 1999). Direct and indirect effects of OHVs on these species include breaking shrubs containing nests (nests, eggs, or nestlings destroyed) and diminished cover when shrubs are reduced or eliminated, mortality due to vehicle impact (especially ground-dwelling animals), and collapse of burrows due to OHV traffic (Bury and others, 1977). Bury and others (1977) found greater small mammal species richness (1.25 times greater) and abundance (500 percent more individuals) at control sites than OHV sites. Similarly, Luckenbach and Bury (1983) found 1.5 times more small mammal species, 5.1 times more individuals, and 2.2 times more biomass in control plots than in OHV-impacted plots; the number of desert kangaroo rats recorded in OHV plots was 53 percent lower than the number in control plots. Luckenbach and Bury (1983) found that overall animal activity—as measured by track frequencies—was greater in control areas than it was in OHV-use areas: arthropod tracks were 24 times more abundant, kangaroo rat tracks were 5 times more abundant, kit fox tracks were 2 times more abundant, and cottontail rabbit tracks were 10 times more abundant. Finally, Brooks (1999) found that protected areas in the Desert Tortoise Research Natural Area supported a greater abundance and species richness of birds and lizards than nearby portions of the desert subjected to intense OHV use and past sheep grazing. In one study, however, road mortality did not appear to have detrimental effects on densities of small mammals inhabiting highway right-of-ways, although the authors admit that they could not rule out confounding effects of immigration (Adams and Geis, 1983). In a study of 36 radio-marked flat-tailed horned lizards (*Phrynosoma mcallii*) subjected to high (60 percent OHV track coverage in 60 minutes of riding time), low (30 percent in 20 minutes of riding time), and no (0 percent) impact by OHV traffic in 100 × 100 m (109.4 × 109.4 yd) plots, all survived. At the time of OHV treatment, however, 32 of the lizards were in their hibernation burrows 2–17 cm (0.8–6.7 in) underground (Grant, 2005), and it remains unclear whether soil substrates and vegetation growing above the burrows helped protect the animals from being crushed (21 of the 32 were under shrubs, and 8 burrows were known to have been run over directly by OHVs).

A major indirect effect of OHV activity on vertebrate survivorship is loss of vegetation cover. For all terrestrial vertebrates sampled, including species of conservation concern (desert

kangaroo rat [*Dipodomys deserti*] and fringe-toed lizard [*Uma notata*]), Bury and others (1977) found a positive correlation between the percent canopy cover of creosote bush and species richness, abundance, and biomass. In a study of OHV effects on biota (including herbaceous and perennial plants, arthropods, lizards, and mammals) of the Algodones Dunes area in California, Luckenbach and Bury (1983) detected 9.4 times more cover, and 40 times more overall volume in control plots than in OHV-impacted plots, largely because shrubby perennial cover was greater in control plots. Another indirect effect of OHV activity on wildlife mortality is the proliferation of routes that provide greater access to remote places by hunters, poachers, and people seeking several forms of nonconsumptive recreation (Boyle and Samson, 1985; Andrews, 1990). Boyle and Samson (1985) also report a variety of nonconsumptive recreation impacts on wildlife, including flushing animals off nests; unnecessary energy expenditures; and displacement of animals from food, shelter, and other vital resources. Of particular concern was the increasing access that roads provide for tortoise collectors, which may explain declining trends in tortoise numbers along highways (Boarman and others, 1997).

2.4.6 Annotated Bibliography for OHV Effects on Wildlife and Habitats: Native, Threatened, and Endangered Species

Berry, K.H., 1980, A review of the effects of off-road vehicles on birds and other vertebrates, in DeGraaf, R.M., and Tilghman, N.G., eds., Management of western forests and grasslands for nongame birds—Workshop proceedings, Salt Lake City, Utah, February 11–14, 1980: Ogden Utah, U.S. Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-86, p. 451–467.

A review of the literature on the effects of off-road vehicles revealed that OHV use has significant effects and can reduce numbers, diversity, and biomass of birds and other vertebrates. The degree of impact depends upon amount and intensity of OHV use, habitat type, and sensitivity of the species.

Boarman, W.I., and Sazaki, M., 2006, A highway's road-effect zone for desert tortoises (*Gopherus agassizii*): Journal of Arid Environments, v. 65, no. 1, p. 94–101.

Roads can affect populations of animals directly (vehicle-animal collisions) and indirectly (due to habitat fragmentation and dispersal/proliferation of non-native or predatory species). This study investigated the effect of a 2- to 4-lane highway (with a posted speed limit of 65 mi/hr [105 km/hr] and an average daily traffic intensity of 8500 vehicles) on threatened desert tortoise (*Gopherus agassizii*) populations in the Mojave Desert, California, and attempted to determine the width of the road-effect zone by counting signs of tortoises (shells, tracks, scats, burrows, and pellets) along transects at 0, 400, 800, and 1600 m from and parallel to the edge of a highway. Mean sign count was 0.2/km (0.32/mi) at 0 m (0 yd), 4.2/km (6.72/mi) at 400 m (437.4 yd), 5.7/km (9.12/mi) at 800 m (874.9 yd), and 5.4/km (8.64/mi) at 1600 m (1749.8 yd) from the highway edge. The differences between all distances except 800 and 1600 m (874.9 and 1749.8 yd) were statistically significant, suggesting that tortoise populations in the study area were depressed within a zone extending at least 400 m (437.4 yd) from the highway.

Brattstrom, B.H., and Bondello, M.C., 1983, Effects of off-road vehicle noise on desert vertebrates, in Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, p. 167–206.

This study determined that sand lizards (*Uma scoparia*) and kangaroo rats (*Dipodomys deserti*) suffered hearing loss lasting for weeks after being exposed to less than 10 minutes of playback recordings of dune buggy sounds played intermittently at intensities lower than the average intensity levels actually emitted by OHVs. Such impacts led to the inability of both of these species to respond to recordings of predator sounds. A spadefoot toad (*Scaphiopus couchii*) emerged prematurely from its burrow when exposed to 30 minutes of taped motorcycle sounds.

Brooks, M.L., 1999, Effects of protective fencing on birds, lizards, and black-tailed hares in the western Mojave Desert: Environmental Management, v. 23, no. 3, p. 387–400.

Effects of a protective (fenced) area on birds, lizards, black-tailed hares (*Lepus californicus*), perennial plant cover, and structural diversity of perennial plants were evaluated from spring 1994 through winter 1995 at the Desert Tortoise Research Natural Area (DTNA), in the Mojave Desert, California. Abundance and species richness of birds were greater inside than outside the DTNA; these effects, however, were more pronounced during breeding season and a year of high rainfall than during winter and a year of low rainfall. Nesting activity was also more frequent inside the enclosure. Total abundance and species richness of lizards and individual abundances of western whiptail lizards (*Cnemidophorus tigris*) and desert spiny lizards (*Sceloporus magister*) were greater inside than outside the enclosure. Black-tailed hares generally prefer areas of low perennial plant cover, which may explain why they were more abundant outside than inside the DTNA. Habitat structure may not affect bird and lizard communities as much as availability of food at this desert site, and the greater abundance and species richness of vertebrates inside than outside the DTNA may correlate with abundances of seeds and invertebrate prey.

Bury, R.B., Luckenbach, R.A., and Busack, S.D., 1977, Effects of off-road vehicles on vertebrates in the California desert USA: Wildlife Research Report no. 8, U.S. Fish and Wildlife Service, Washington, D.C., p. 1–23.

This study compared differences in avian diversity, abundance, and biomass in unused and OHV-disturbed sites. Compared to OHV sites, reptile species richness was 1.63 times greater and there were 270 more individuals at control sites. Similarly, mammal species richness was 1.25 times greater and there were 115 more individuals at control sites than at OHV sites. The potential for ground nests of birds to be crushed and incubating birds to abandon nests was greater in areas of high OHV activity. Indirect effects of OHV activity on vertebrates were primarily caused by the loss of vegetation cover. There was a positive correlation between the cover of creosote bush and the total number of species, abundance, and biomass of all terrestrial vertebrates sampled.

Bury, R.B., and Luckenbach, R.A., 2002, Comparison of desert tortoise (*Gopherus agassizii*) populations in an unused and off-road vehicle area in the Mojave Desert: Chelonian Conservation and Biology, v. 4, no. 2, p. 457–463.

This study examined habitat, abundance, and life history features of desert tortoises (*Gopherus agassizii*) on two 25-ha plots in the western Mojave Desert: one unused and one used by OHVs. The unused plot had 1.7 times more live plants, 3.9 times more plant cover, 3.9 times more desert tortoises, and 4.0 times more active tortoise burrows than a nearby area used heavily by OHVs; these between-plot differences were all statistically significant. Furthermore, the few large-sized tortoises in the OHV plot had less body mass than those in the unused area. Although

the scope of this study was limited to one paired-plot comparison, current data suggest that operation of OHVs in the western Mojave Desert results in major reductions in habitat and tortoise numbers, and possibly the body mass of surviving tortoises.

Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: *Environmental Management*, v. 24, no. 3, p. 309–326.

Large areas of the southern California desert ecosystem have been affected by off-highway vehicle use, overgrazing by domestic livestock, agriculture, urbanization, construction of roads and utility corridors, air pollution, military training exercises, and other activities. Secondary contributions to degradation include the dispersal and proliferation of exotic plant species and a higher frequency of anthropogenic fire. Effects of these impacts include alteration or destruction of macro- and micro-vegetation elements, establishment of annual plant communities dominated by exotic species, destruction of soil stabilizers, soil compaction, and increased erosion. This paper provides a broad view of impacts on biota and cites several pertinent studies relative to OHV impacts on wildlife. The authors suggest that given the sensitivity of desert habitats to disturbance and the slow rate of natural recovery, the best management option is to limit the extent and intensity of impacts as much as possible.

Luckenbach, R.A., and Bury, R.B., 1983, Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County, California, USA: *Journal of Applied Ecology*, v. 20, no. 1, p. 265–286.

Algodones Dunes, the largest dune complex in California, contains many unique species; however, it also receives the greatest use by off-road vehicles in California. Studies of paired plots (unused versus OHV-impacted) and animal tracks along sand sweeps clearly demonstrated that OHV activities in the Algodones Dunes significantly reduced the biota. There were marked declines in herbaceous and perennial plants, arthropods, lizards, and mammals in OHV-used areas compared with nearby controls. All sand-adapted species, including several rare or threatened plants, were greatly reduced in habitats where OHVs operate; the biota was affected even by relatively low levels of OHV activity. Areas heavily used by OHVs had virtually no native plants or wildlife.

Rosen, P.C., and Lowe, C.H., 1994, Highway mortality of snakes in the Sonoran Desert of southern Arizona: *Biological Conservation*, v. 68, no. 22, p. 143–148.

A total of 368 snakes (104 live, 264 dead) were recorded over four years on a paved highway during 15,525 km (9,647.2 mi; mostly within Organ Pipe Cactus National Monument, Arizona) of driving along the road to detect amphibians and reptiles during rainfall events or while basking on the warm road surface. During 4 years, an estimated 2,383 snakes were killed on this stretch of pavement, although the actual number killed was probably closer to 4,000.

Webb, R.H., and Wilshire, H.G., 1983, Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, 534 p.

This book discusses the physical and biological effects of OHVs (recreational, mining, and military vehicles) on arid-land ecosystems, including effects on soils, vegetation, and wildlife. It also points out the loss of choices that OHV effects impose on future land users. Actual case studies are presented, complete with practical solutions, detailed planning measures

that can be taken to reduce the adverse effects of OHVs, methods that can be used to rehabilitate the physical systems and vegetation communities of disturbed areas, and management concepts and practices that can be employed in protecting susceptible areas, including regulations and education.

2.5 OHV Effects on Water Quality

2.5.1 Section Summary

The direct effects of OHV activity on aquatic systems have received surprisingly little attention, due, in part, to the fact that OHV-impact research has focused on arid environments, where aquatic systems are seasonal or rare. Nonetheless, there is great potential for OHV activities to affect water quality in arid environs as well as well-watered regions. As described in Sections 2.2 and 2.3, soil properties and vegetation cover may be altered by OHV use; in turn, surface patterns of precipitation runoff (amount, velocity) may be altered, resulting in accelerated rates of erosion and sedimentation and elevated levels of turbidity in affected watersheds. Where slope is a factor, the extensive networks of OHV routes proliferating across landscapes can serve as conduits that direct or alter the direction of surface flows. These conduits may be eroded to form gullies that channel dislodged sediments and contaminants into aquatic ecosystems. Water quality also is adversely affected by OHV-raised dust that settles into aquatic systems.

OHV-dispersed chemicals also may be transported into aquatic systems. The operation of OHV engines, especially 2-stroke engines, can impact water quality through spills and emissions. These contaminants may enter aquatic systems via direct flushing, or they may be adsorbed to sediments and/or absorbed by plant materials, both of which are easily transported to aquatic systems by precipitation runoff or wind. Spill or emission contaminants may include 1,3-butadiene, benzene and ethylbenzene, xylenes, and toluene. Prior to the ban on leaded gasoline, lead levels were high in plants and animals near roads, and although the 1996 ban on leaded gasoline has resulted in dramatic declines in lead levels, it persists in the soil and may be mobilized when soils are eroded into wetlands.

2.5.2 Sedimentation and Turbidity

Areas naturally most susceptible to water-quality problems are those where infiltration rates are low, slopes are steep, the ratio of surface sand and gravel to finer particles is low, and where rainfall events are typically prolonged and intense (Iverson and others, 1981). Altering soil texture, disrupting soil crusts or desert pavement, and reducing vegetation cover can increase the soil's susceptibility to erosion; in turn, rates of sedimentation and turbidity levels can increase and alter the water quality of a given watershed, including streams and rivers, lakes, and small, isolated wetlands, including vernal pools (Forman and others, 2003). Sediments can displace the water-holding volume of a wetland, thus diminishing or eliminating the wetland's hydrological function (Luo and others, 1977). For example, where OHVs had traveled over the soil, Iverson and others (1981) found that surface runoff was 5 times greater and yielded 10-20 times more sediment than where soils were undisturbed.

Where OHV activity occurs, networks of OHV routes proliferate. Wheel cuts and tracks within these networks may serve as water conduits that channel and direct water flow containing sediments and contaminants into aquatic ecosystems (Wemple and others, 1996; Forman and others, 2003, p. 185–197). The generally impervious nature of soils compacted by OHV traffic enhances gully formation in these conduits, thus promoting additional flows of sediments and suspended solids into aquatic systems, effectively extending the drainage network of a given

watershed, and potentially changing the timing of peak runoff flows (Wemple and others, 1996). The presence of OHV-route networks is an important factor in determining the severity of potential sedimentation in nearby aquatic systems. In particular, Wemple and others (1996) found that the drainage ditches along logging roads and the gullies that form below culvert outlets (where drainage flows pass under a road, or cross-drains) on steep slopes served as primary conduits linking surface flows to streams. The extent to which sediments might be carried along these conduits and into aquatic systems depends primarily on the presence of obstructions below cross drains and the spatial intervals between them (Haupt, 1959). In situations where cross drains were positioned at sufficient distances from streams, the drainage discharge infiltrated the soil and did not contribute to sedimentation in streams (Haupt, 1959). In areas characterized by soils with relatively low infiltration rates, such as those compacted by OHV use, transport of sediments over greater distances and into aquatic systems may be substantial.

Furniss and others (2000) describe similar effects of road and/or trail networks across a landscape. In particular, they discuss the continuous “hydrological connections” that facilitate sediment transport between surface flows and waterways. Furniss and others (2000) go on to list ways in which water and associated sediments enter stream systems from roads, including (1) inboard ditches (ditches perpendicular to the road footprint and that bisect the road) delivering runoff to a stream at a road-stream crossing, (2) inboard ditches delivering water to a cross-drain (culvert, dip, waterbar), (3) where sufficient discharge is available to create a gully or sediment plume that extends to the stream channel, (4) roads sufficiently close to streams so that the fillslope (road fill between the outside edge of the road and the base of the fill where it meets the natural ground surface) encroaches on the stream, and (5) landslide scars on the road fill. These connections provide direct routes for accelerated runoff transporting sediments and road-associated contaminants to natural drainage channels.

2.5.3 Dust and Contaminants

Water quality also is adversely affected when fugitive dust and contaminants enter aquatic systems. Emissions from OHVs, particularly those with 2-stroke engines, can include a variety of contaminants, which may settle directly in wetlands or they may be deposited in snow or directly on soils during rain events, from which they may be mobilized into wetlands. Arnold and Koel (2006), who tested snowmelt runoff exposed to significant snowmobile emissions in Yellowstone National Park, detected benzene, ethylbenzene, m- and p-xylene, o-xylene, and toluene, and although all compounds were within the limits set by the U.S. Environmental Protection Agency, it is not clear what the cumulative impacts of these chemicals may be in watersheds. Adams (1975) found that the stamina of brook trout experimentally exposed to elements commonly found in snowmobile emissions, as measured by their ability to swim against the water current, was significantly diminished compared to that of control fish.

Airborne dust—and contaminants adsorbed to dust particles—raised by OHV traffic may eventually settle directly into wetlands (Forman and others, 2003, p. 231–234). The potential for adsorbed contaminants to be carried along with precipitation runoff and into wetlands is also a concern, as are plant materials containing absorbed contaminants. Finally, contaminants may enter aquatic habitats by direct flushing of exposed contaminants (for example, petroleum puddles). Prior to the ban on leaded gasoline, lead levels were high in plants and animals near roads (Daines and others, 1970; Motto and others, 1970; Quarles and others, 1974; Wheeler and Rolfe, 1979). Although the 1996 ban on leaded gasoline has since resulted in dramatic declines

in lead levels along roadsides and in organisms, it persists in the soil and may be mobilized when soils are eroded into wetlands.

2.5.4 Annotated Bibliography for OHV Effects on Water Quality

Adams, E.S., 1975, Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvelinus fontinalis*): Transactions of the American Fisheries Society, v. 104, no. 2, p. 363–373.

Prior to snowmobiling season, hydrocarbon levels in the water of a pond in Maine were undetectable; by the time of ice-out in spring, hydrocarbon levels had reached 10 parts per million (ppm) in the water and 1 ppm in exposed fish. In addition, exposed brook trout fingerlings contained 9 to 16 times more lead than control trout. Brook trout (*Salvelinus fontinalis*) held in aquaria for 3 weeks in melted snow containing three different concentrations of snowmobile exhaust also showed hydrocarbon and lead uptake. Stamina, as measured by the ability to swim against current, was significantly less in trout exposed to snowmobile exhaust than in control fish.

Brabec, E., Schulte, S., and Richards, P.L., 2002, Impervious surfaces and water quality—A review of current literature and its implications for watershed planning: Journal of Planning Literature, v. 16, no. 4, p. 499–514.

This paper focuses on the effect of impervious surfaces on the health of nearby aquatic habitats. Although considerable research has been done to define watershed thresholds of impervious surfaces (beyond which water quality declines), there are numerous flaws in the assumptions and methodologies used. Given refinement of the methodologies, accurate and usable parameters for preventive watershed planning can be developed, including thresholds of impervious surfaces and balances between pervious/impervious surfaces within a watershed.

Brown, K.J., 1994, River-bed sedimentation caused by off-road vehicles at river fords in the Victorian Highlands, Australia: Water Resources Bulletin, v. 30, no. 2, p. 239–250.

This study investigated some of the effects occurring at OHV crossings on two rivers in eastern Australia, where many road crossings occur at low-level fords. It provides a method whereby the amount of sediment redeposited downstream of a ford can be measured. Attention is drawn to the fact that sediment is contributed to rivers by five major processes: the exposure of surfaces, the concentration of surface runoff in wheel ruts, soil compaction and subsequent reduction of water infiltration leading to increased surface runoff, backwash from the vehicle, and undercutting of banks by bow-wave action. The last two of these processes have not been reported previously. Sediment collection experiments in two upland rivers indicated a mean deposition rate at the stream bed of approximately 1,000 g/m² over a period of 30 days.

Furniss, M.J., Flanagan, S.A., and McFadin, B.A., 2000, Hydrologically connected roads—An indicator of the influence of roads on chronic sedimentation, surface water hydrology, and exposure to toxic chemicals: U.S. Forest Service, Stream Systems Technology Center, Rocky Mountain Research Station, Technical Report, 4 p., http://www.stream.fs.fed.us/streamnt/jul100/jul100_2.htm.

This study defines the concept of forest-road drainage as a transport system for sediment into streams and proposes design changes to road drainage that would prevent or minimize this movement. The proportion of road that is hydrologically connected to a stream network may be a useful indicator of the potential for several adverse effects, including (1) the delivery of road-

derived sediments to streams; (2) hydrologic changes associated with subsurface flow interception, concentration, and diversion; (3) increased drainage density; (4) extension of the stream network; and (5) the potential for road-associated spills and chemicals to enter streams.

Hamilton, L.J., 2002, A study of the effects of ORV stream crossings on water quality of two streams located in the Angelina National Forest, Texas—A physicochemical and benthic macroinvertebrate analysis: Masters Abstracts International, v. 40, no. 3, p. 668.

A study was conducted for the U.S. Forest Service to determine whether OHV-based stream crossings affected water quality of two streams located in Texas. The sites differed most in turbidity, total solids, Shannon's diversity index, dissolved oxygen, nitrate, and ratios of Chironomidae:EPT (Ephemeroptera + Plecoptera + Trichoptera, a common indicator of taxonomic richness detected during stream surveys to assess water quality), although there were no significant differences in the physicochemical properties. At one site, however, the upstream and downstream plots differed significantly in terms of two benthic indices—Hilsenhoff's *Biotic Index* and *Ratio of Scrapers to Filtering Collectors*.

Katz, M., Legore, R.S., Weitkamp, D., Cummins, J.M., and Anderson, D., 1972, Effects on freshwater fish: Journal of the Water Pollution Control Federation, v. 44, no. 6, p. 1226–1250.

This is a literature review of the effects of water pollutants on freshwater fish. Topics include (1) tests to determine the lethality of estuarine and some polluted river waters to trout and cyprinids; (2) estimated degrees of river pollution based on bacterial and chemical analysis of water samples; (3) documentation of some effects of municipal wastewater effluents on the water quality, fish populations, and bottom-fauna characteristics of a receiving stream; and (4) observations of the environmental effects of pollutants such as synthetic detergents, industrial wastes, and pesticides.

Roy, A.H., Rosemond, A.D., Leigh, D.S., Paul, M.J., and Wallace, J.B., 2003, Habitat-specific responses of stream insects to land cover disturbance—Biological consequences and monitoring implications: Journal of the North American Benthological Society, v. 22, no. 2, p. 292–307.

This study analyzed the impact of a range of physical and chemical stressors on aquatic insects and tested whether the effects of these stressors differed in three habitat types: riffles, pools, and banks. Riffle assemblages were affected by both physical (for example, streambed mobility) and chemical (specific conductance, nutrient concentration) variables. The density of aquatic insects in pools also was correlated to physical and chemical variables, but there were few relationships with pool or bank richness or bank density. Because relative impacts of disturbance in riffles were greater than in banks, the authors found greater differences between riffle and bank richness in streams with greater sedimentation. The proportion of bank richness (bank richness/bank + riffle richness) increased with finer bed sediment and increased bed mobility. The study also compared richness of facultative taxa (found in multiple habitats) between sites characterized as minimally impacted and sediment-impacted. In riffles, richness of facultative taxa was lower in sediment-impacted than in minimally impacted sites, but was similar for both disturbance groups in banks.

Wheeler, A.P., Angermeier, P.L., and Rosenberger, A.E., 2005, Impacts of new highways and subsequent landscape urbanization on stream habitat and biota: Reviews in Fisheries Science, v. 13, no. 3, p. 141–164.

This paper emphasizes a more thorough consideration of highway impacts and, ultimately, better land-use decisions by conceptualizing road development in three stages: initial construction, road presence, and eventual landscape urbanization. Road construction is characterized by localized physical disturbances, which generally subside through time. In contrast, road presence and landscape urbanization are characterized by persistent physical and chemical impacts. Though not specific to OHV activity, this paper does focus on the fact that landscape urbanization is clearly the greatest threat to stream habitat and biota, as stream ecosystems are sensitive to even low levels (less than 10 percent of a given watershed) of urban development. Researchers know little about the occurrence, loading rates, and biotic responses to specific contaminants in runoff from roads. Also needed is a detailed understanding of how drainage crossings, especially culverts, affect fish populations via constraints on movement and how road networks alter natural regimes (streamflow, temperature).

2.6 OHV Effects on Air Quality

2.6.1 Section Summary

Fugitive dust raised by OHV traffic on unpaved roads/trails can contribute significantly to air-quality problems. Also problematic are OHV emissions, particularly from 2-stroke engines. Currently, many OHVs in use, including off-highway motorbikes and ATVs, run on 2-stroke engines, which do not burn fuel completely and produce significant amounts of airborne contaminants, including nitrogen oxides, carbon monoxide, ozone, aldehydes, and extremely persistent polycyclic aromatic hydrocarbons (PAH), including the suspected human carcinogen, methyl tert-butyl ether (MTBE). Some airborne contaminants settle onto plants or into soils and function as fertilizers, thus causing changes in plant community composition and altering growth rates. The accumulation of emissions contaminants is evident in the tissues of plants and animals exposed to them. Prior to the ban on leaded gasoline, lead also was prevalent in plants and animals near paved roads and other travel routes, and because it persists in the environment, it can still have impacts when contaminated soils are mobilized.

2.6.2 Fugitive Dust Raised by OHV Traffic

Fugitive dust (largely composed of lightweight soil particles, including silt and clay) suspended in the air may impact more total area than any other impact of roads (paved or unpaved; Forman and others, 2003), and it can have significant effects on ecosystems (Westec, 1979). Dust is created and raised into the air as OHVs disturb soil crusts, abrade and pulverize soils, and generate wind currents. Once soil surfaces are disturbed, wind erosion may increase the amount of debris flow (Lovich and Bainbridge, 1999). In 1973, satellite photos detected six dust plumes in the Mojave Desert covering more than 1,700 km² (656.2 mi²); the plumes were attributed to destabilization of soil surfaces resulting from OHV activities (Nakata and others, 1976; Gill, 1996). Along roads in Alaska heavily traveled by various types of vehicles, Walker and Everett (1987) found that dust had buried mosses and very low-statured vegetation in the 10-m-wide area adjacent to each side of the road; dust blankets measured up to 10 cm (3.9 in) deep. Accumulations of dust on vegetation can disrupt photosynthetic and respiration processes, leading to reduced plant growth, reproduction, and survivorship.

2.6.3 Contaminants Associated with OHV Use

Before emissions controls on automobiles became significantly more effective, there was little concern about emissions from small engines; today, however, their relative contribution to

air-quality problems is significant (see <http://www.egr.msu.edu/erl/Small%20Engine%20Emissions.html>). This is because small engines, especially 2-stroke models (many of which are being phased out), do not burn fuels completely; thus, their emissions contain the resulting by-products of incomplete combustion, including nitrogen oxides NO_x, sulfur dioxide (SO₂), carbon monoxide (CO), ozone (O₃), aldehydes, and extremely persistent polycyclic aromatic hydrocarbons (PAH). In fact, a very small, 2-stroke engine running for 2 hours emits the same amount of hydrocarbons as driving 10 cars (of the fuel-burning efficiency produced in 1995) for 250 miles each (http://www.arb.ca.gov/msprog/offroad/sm_en_fs.pdf).

Pollutants emitted from exhaust can cause a variety of impacts on vegetation. Carbon dioxide may function as a fertilizer and cause changes in plant species composition (Bazzaz and Garbutt, 1988; Hunt and others, 1991; Ferris and Taylor, 1995); nitrogen oxides also may function as fertilizers, producing similar effects along roadsides (Falkengren-Grerup, 1986; Holzapfel and Schmidt, 1990; Angold, 1997). Spencer and Port (1988) found that the soluble nitrogen content of perennial ryegrass (*Lolium perenne*) plants growing within 0-6 m (0-6.6 yd) of a paved road than in plants growing more than 6 m (6.6 yd) from the road, which contributed to greater growth rates and fecundity of aphids (*Rhopalosiphum padi*) inhabiting the plants closest to the road. Sulfur dioxide, which can be taken up by vegetation, may result in altered photosynthetic processes (Winner and Atkison, 1986; Mooney and others, 1988).

Several species of Mojave Desert perennials and annuals were fumigated in experimental chambers to determine their sensitivities to SO₂, nitrogen dioxide (NO₂), and O₃; Thompson and others, 1980; Thompson and others, 1984). Creosote bush (*Larrea* sp.), the only perennial species found to be sensitive to SO₂ and NO₂, exhibited leaf injury and reduced growth when exposed to SO₂ and NO₂; however, numerous annuals, including redstem stork's bill (*Erodium cicutarium*) and desert Indianwheat (*Plantago insularis*; extremely sensitive), cleftleaf wildheliotrope (*Phacelia crenulata*; very sensitive), and wooley desert marigold (*Baileya pleniradiata*), exhibited more dramatic effects, including extensive injury and death (Thompson and others, 1980). Another study by Thompson and others (1984) revealed several annual species that are extremely sensitive to SO₂ and O₃, including brown-eyed primrose (*Camissonia claviformes*), Santa Cruz Island suncup (*C. hirtella*), and Nevada cryptantha (*Cryptantha nevadensis*).

OHV emissions also contain a variety of heavy metals, including zinc, copper, nickel, chromium, and lead (National Research Council, 1986). In terms of overall quantity, lead was one of the most significant heavy metals emitted prior to the ban on leaded gasoline in 1996 (Daines and others, 1970; Motto and others, 1970; Quarles and others, 1974; Wheeler and Rolfe, 1979). At least in desert regions, concentrations of lead particulates along roads were positively correlated with traffic volume (Motto and others, 1970). Within 80 m (87.5 yd) of roadsides, Quarles and others (1974) found that lead concentrations diminished notably from road edges (543 and 190 ppm) to 10 m (47 and 5 ppm, respectively) away from the edge; beyond 80 m, accumulations of lead diminished at lower rates. The declining gradient in lead concentrations away from roadsides may have been due, in part, to the direction of surface water flow (Byrd and others, 1983) as soil and other debris to which lead adheres were flushed away by the volume of water that runs off road surfaces. Although lead emissions from gasoline have declined dramatically since control policies were implemented in the 1970s (Forman and others, 2003), it persists in soils and can continue to move through the environment when contaminated soils are dislodged.

2.6.4 Annotated Bibliography for OHV Effects on Air Quality

Agrawal, Y.K., Patel, M.P., and Merh, S.S., 1981, Lead in soils and plants—Its relationship to traffic volume and proximity to highway (Lalbag, Baroda City): *International Journal of Environmental Studies*, v. 16, no. 3–4, p. 222–224.

Accumulations of lead from motor-vehicle exhausts on soils and trees growing along a busy thoroughfare in the Lalbag area of Baroda City were studied. Analysis of soils and tree samples showed that the distribution of emitted lead was influenced by the direction of the prevailing wind. Lead concentrations in plants and soils near the roadside were greater than they were in soils and plants 4–6 m away from the roadside.

Bazzaz, F.A., and Garbutt, K., 1988, The response of annuals in competitive neighborhoods—Effects of elevated CO₂: *Ecology*, v. 69, no. 4, p. 937–946.

Four members of an annual plant community were used to investigate the effects of changing neighborhood complexity and increased carbon dioxide (CO₂) concentration on competitive outcome. Plants were grown in monoculture and in all possible combinations of two, three, and four species in CO₂-controlled growth chambers at CO₂ concentrations of 350, 500, and 700 microliters/liter (μL/L) (1 ppm), with ample moisture and light. Species responded differently to enhanced CO₂ level. The biomass of some species (*Abutilon theophrasti*, for example) increased with increasing CO₂, while that of others (*Amaranthus retroflexus*) decreased with increasing CO₂ concentration. The potential effects of CO₂ on community structure could be profound, particularly at the intermediate levels of CO₂ that are predicted for the first half of the 21st century.

Gish, C.D., and Christensen, R.E., 1973, Cadmium, nickel, lead, and zinc in earthworms from roadside soil: *Environmental Science and Technology*, v. 7, p. 1060–1062.

Cadmium (Cd), nickel (Ni), lead (Pb), and zinc (Zn) in soils and earthworms along two Maryland highways decreased with increasing distance (10, 20, 40, 80, and 160 ft) from the road. Along each highway, metal residues were greater where traffic volume was greater. Correlations between residues in earthworms and soil decreased with decreasing atomic weights (Pb, Cd, Zn, Ni). Metal residues in soils were positively correlated with quantities of soil organic matter. Earthworms accumulated up to 331.4 ppm of Pb and 670.0 ppm of Zn, concentrations that may be lethal to earthworm-eating animals.

Motto, H.L., Daines, R.H., Chilko, D.M., and Motto, C.K., 1970, Lead in soils and plants—Its relationship to traffic volume and proximity to highways: *Environmental Science and Technology*, v. 4, p. 231–237.

Lead concentrations increased with traffic volume and decreased with distance from highways. Much of the lead was present as removable surface contamination on plants, and major effects were limited to the soil surface within 100 ft (30.48 m) of the highway.

Nakata, J.K., Wilshire, H.G., and Barnes, G.C., 1976, Origin of Mojave Desert dust plumes photographed from space: *Geology*, v. 4, p. 644–648.

OHV-raised dust has been an enormous problem in the Mojave Desert, as illustrated by satellite photos that revealed six dust plumes covering more than 1,700 km² (656.4 mi²) of the western Mojave region in January 1973; the dust plumes were attributed to destabilization of ground surfaces, primarily from OHV activity.

Quarles, H.D., Hanawalt, R.B., and Odum, W.E., 1974, Lead in small mammals, plants, and soil at varying distances from a highway: *Journal of Applied Ecology*, v. 11, no. 3, p. 937–949.

Lead particulates were measured at varying distances from three highways. Lead concentrations were greatest within 10 m (10.9 yd) of the highways. Lead concentrations in the soil along two transects dropped from 543 ppm and 190 ppm at the road edge to 47 ppm and 5 ppm 10 m from the road edge. Both plants and animals were susceptible to lead uptake.

Spencer, H.J., and Port, G.R., 1988, Effects of roadside conditions on plants and insects. II. Soil conditions: *Journal of Applied Ecology*, v. 25, no. 22, p. 709–715.

An experiment was done to investigate the performance of plants (*Lolium perenne*) grown in roadside soil. Significantly fewer plants germinated in soil taken 0 to 6 m from the road compared with soil taken 6 m from the road. For a given population size, however, plants grown in soil taken from beside the road attained significantly greater dry weight and significantly greater soluble nitrogen content. Nitrogen oxide emissions, identified as the probable cause of these effects, were absorbed by the roadside soil and subsequently assimilated by the plants.

Thompson, C.R., Olszyk, D.M., Kats, G., Bytnerowicz, A., Dawson, P.J., and Wolf, J.W., 1984, Effects of ozone or sulfur dioxide on annual plants of the Mojave Desert: *Journal of the Air Pollution Control Association*, v. 34, no. 10, p. 1017–1022.

Forty-seven species of annual plants from the Mojave Desert were grown in pots and exposed in open-top field chambers located at Riverside, California, to test their relative sensitivity to SO₂ and O₃. Species differed widely in their response to the pollutants. Three species, *Camissonia claviformis*, *Camissonia hirtella*, and *Cryptantha nevadensis*, were quite sensitive to both pollutants, exhibiting leaf injury when exposed to 0.1 ppm O₃ or 0.2 ppm SO₂. The other species were intermediate in sensitivity, and O₃ sensitivity did not always correspond to SO₂ sensitivity. For 8 of 11 species tested, total sulfur concentration was greater in plants exposed to 0.2 ppm SO₂ than in unexposed plants. *Baileya pleniradiata* and *Perityle emoryi* exhibited the greatest increases in sulfur concentration for exposed versus control plants.

Walker, D.A., and Everett, K.R., 1987, Road dust and its environmental impact on Alaskan taiga and tundra: *Arctic and Alpine Research*, v. 19, no. 4, p. 479–489.

The physical and chemical characteristics and ecological consequences of road dust in arctic regions were reviewed with emphasis on recent information gathered along the Dalton Highway and the Prudhoe Bay Spine in northern Alaska. Enhanced dust-control measures were considered, particularly where the road passes through scenic lichen woodlands, acidophilic tundra, and in calm valleys where dust commonly was a traffic-safety hazard.

Westec Services Inc., 1979, Fugitive dust impacts during off-road vehicle (ORV) events in the California desert: Tustin, California, WESTEC Services, Inc., Technical Report, 40 p.

Results and analysis of dust monitoring for five desert races demonstrated that factors such as distance from the point of generation, soil moisture, soil characteristics, wind, and relative humidity, as well as the type and number of vehicles in the race, had the largest effect on the amount and type of dust, particulate size, how quickly it settled, and the extent of the human health hazard present during the race. Long period (daily) dust-exposure levels were 10 times

greater than the standard, whereas short period (hourly) dust levels were 100 times greater than the standard under adverse conditions near the race activity.

2.7 Socioeconomic Implications of OHV Use

2.7.1 Section Summary

The socioeconomics of OHV use include OHV user demands, concerns, and attitudes; the economic effects of OHV use on communities near OHV-use areas; the economics of managing OHV activities; the effects of OHV use on non-motorized recreators; and the economics of losing ecosystem services. Although not currently addressed through BLM's indicators of rangeland health, natural resource attributes are heavily influenced by socioeconomic factors. Since the mid 1980s, the incidence of OHV use on public lands has increased substantially, and this trend is expected to continue. Moreover, the economic benefits from travel expenditures and the sales of supplies and equipment in communities bordering OHV-use areas generates significant pressure to maintain or increase current levels of OHV activity. As OHV activity increases, however, increasing stress is placed on natural resources, land managers who must monitor and regulate OHV activities, and visitors seeking non-motorized forms of recreation.

2.7.2 Trends in OHV Use and Technology

In a survey of Utah OHV users commissioned by the Utah Department of Natural Resources, Fisher and others (2001) found that public lands are primary destinations among most users; only one quarter of survey respondents took trips to private land. More specifically, BLM land was the primary destination for ATV, motorcycle, and 4 x 4 vehicle users; U.S. Forest Service land was the secondary destination among ATV and 4 x 4 users; and State land was the secondary destination among motorcycle users (Fisher and others, 2001). Increasing OHV use is likely to be accompanied by greater demand for places where OHVs can be used, particularly near urban areas and corridors; as urban populations increase, so do the numbers of recreators on nearby public lands, thereby putting more stress on the landscape (Brooks and Champ, 2006). The increasing demands also pose problems for land managers already balancing the needs of a dynamic land base, often with limited budgets and/or staffing (Brooks and Champ, 2006; Rocky Mountain Research Institute, 2002). These limitations constrain land managers but not OHV use; thus, OHV recreation is largely "unmanaged." In addition, technology advancements in outdoor recreation equipment have led to production of OHVs that easily access lands previously unimpacted by mechanized recreation (Meine, 1998; Ewert and Shultis, 1999). As a result, new problems have arisen for both previously unimpacted areas and backcountry users who now encounter OHVs. Problems potentially arising from a constrained ability to manage lands include resource degradation, displacement of wildlife, and conflict among users, both within and across user types.

2.7.3 Types, Sources, and Effects of OHV User Conflict

Much of the OHV literature addresses conflicts between OHV users and other land users, even those who are not directly affected by OHV users. Researchers have addressed conflict issues by using a variety of tools or models designed to help managers understand and reduce conflicts between or among user groups. Bury and others (1983, p. 401) describe conflict as existing "whenever incompatible activities occur" and offer three elements that contribute to the incompatibility of activities: spatial and temporal proximity, dominance over the environment, and dependence on technology. When the proximity of activities does not result in direct or

indirect (seeing the effects of other uses) encounters among user types, then environmental dominance and technological dependence are more likely to come into play. Dominance over the environment refers to how much an individual feels the need to exert some kind of control over the environment. Dependence on technology can cause conflict when people who retreat to backcountry to seek solace from modern technology clash with those who use technology to enhance their outdoor experiences. Conflict also occurs between land users and land managers. Inconsistent management policies across different land management agencies can cause such conflict, particularly as OHV recreation is ushered from being “unmanaged” to “managed.” On many public lands, trails are currently considered open unless posted as closed, and once a trail has been established by users, it is often considered open for use (Brooks and Champ, 2006).

Graefe and Thapa (2004) outline some of the traditional approaches to examining user conflicts through research, including studies of goal interference (first introduced by Jacob and Shreyer, 1980). Goal interference occurs when a user comes into direct (seeing the conflicting recreation type) or indirect (seeing the *effects* of a recreation type) contact with another user type and is impeded from accomplishing the desired purpose of his or her recreation (Badaracco, 1976). The factors that contribute to goal interference are activity style, resource specificity, mode of experience (whether individuals are focused or unfocused), and tolerance for lifestyle diversity. Another model classifies conflict as either interpersonal conflict or a conflict of social values (Vaske and others, 1995). Interpersonal conflict is similar to goal interference in that a user has a problem with another use type and encounters an individual participating in, or evidence of, that type (hearing OHV noise, for example). Social values conflict occurs regardless of whether or not differing user types encounter one another—just knowing that the other recreation type is permitted may be unacceptable.

In the literature on user conflict, conflict is more often characterized as one-sided than two-sided (Badaracco, 1976; Bury and others, 1983; Watson and others, 1997; Graefe and Thapa, 2004). For example, while backpackers may perceive OHV users as disruptive to their experience, it is less likely that OHV users will find backpackers disruptive to their experience (Jackson and Wong, 1982). Displacement is the most common personal coping mechanism by which conflict is abated (Watson et al, 1997; Graefe and Thapa, 2004). That is, if an individual feels negatively enough about certain recreational activities occurring in the area he/she wishes to use, there is a possibility that the individual will simply forgo recreating in the area altogether, thereby increasing the probability that area managers will gradually lose support from that user base (Watson and others, 1997; Graefe and Thapa, 2004).

2.7.4 OHV Users and Their Preferences

Overall, understanding the social effects of OHV use requires understanding the full array of recreational activities sought and the preferences of both OHV and non-OHV users alike. For example, people engaged in camping may include both OHV and non-OHV users, which can result in dissatisfaction among campers. In a survey of campers that included both OHV and non-OHV users, 66 percent indicated that having a regulated OHV riding area nearby would make their stay more enjoyable because it would reduce the number of riders in other areas and maintain a safer environment for both riders and campers (Bury and Fillmore, 1974). When given a choice between having (1) no motorcycle riding area but permission to ride on campground roads, (2) prohibition of all motorcycle riding, or (3) a nearby motorcycle area and no permission to ride on campground roads, 75 percent of riders and campers surveyed preferred the third alternative (Bury and Fillmore, 1974; riders and campers were socioeconomically similar).

Fisher and others (2001) reported that although 63.2 percent of motorcycle users surveyed did not stop to engage in any other type of recreational activity, almost 60 percent of ATV owners and 75 percent of 4 × 4 vehicle owners did engage in other recreational activities during their trips. Of those OHV users who did stop to engage in additional recreational activities, hiking was the most popular (>75 percent of motorcycle/4 × 4 vehicle users and 20 percent of ATV users). Hunting was the other most common recreational activity among ATV users and the second most common activity among 4 × 4 vehicle users; other recreational activities included fishing, camping, and sightseeing (Fisher and others, 2001).

Overall, the results of the user preference surveys discussed previously reveal a potentially conflicted OHV user base in that the quality of their associated recreational activities could be affected by OHV activities. For example, campers who wish to ride OHVs for additional recreation, but who feel strongly that OHV use should be restricted to designated areas, are likely to feel dissatisfied if other OHV users ride through the campground and/or on hiking trails. Similarly, if OHV use in preferred hunting or fishing areas—or other areas crucial to healthy populations of game and fish species—degrades habitat quality that results in diminished game and fish populations, then OHV riders who also hunt and fish may experience dissatisfaction.

Understanding the social effects of OHV activities (and potential outcomes of OHV activities) also requires determining where OHV users like to go and what their preferences are while riding. For example, in Colorado (where user attitudes are likely relatively moderate), Crimmins (1999) reported that

- 38.5 percent of OHV riders use U.S. National Forest Service land,
- 22.4 percent use private land,
- 18.6 percent use BLM land,
- 6.0 percent use State land,
- 3.4 percent use City or county land, and
- 2.3 percent use National Recreation Areas.

These data indicate that the use of public lands for OHV riding far outweighs that of private lands. Crimmins (1999) further reported OHV user preferences in terms of riding area attributes, which included

- no fee for use (if on public land),
- signs indicating all activities allowed on the trail, and
- locations removed from other human activity.

The least important attributes included

- patrolling by staff of land management agencies or local OHV clubs,
- restrooms, and
- loading ramps (Crimmins, 1999).

When presented with a list of priorities for uses of public funds, OHV users selected

- purchasing right-of-ways for OHV access,
- new OHV trail construction,
- erosion control, and
- OHV trail system planning and maintenance.

The low ranking of management patrols probably indicates that users desire more flexibility regarding where they may ride (Crimmins, 1999). Crimmins (1999) also pointed out that although the availability of facilities ranked low in terms of user preferences, management

agencies nonetheless generally focus on providing facilities and generally report high user demand.

In terms of OHV user preferences for trail types and features, Bury and Fillmore (1974) reported that variation in terrain was the most important factor. The authors' recommendations for an effective OHV area included

- riding areas established near some, but not all, campgrounds;
- trails kept ≥ 600 feet (183 m) from the nearest campground;
- trails ≤ 6 feet (1.83 m) wide; and
- trails that traverse hillsides and include a variety of technical (obstacles, rugged terrain) and non-technical (no obstacles, smooth riding surface) features.

Fisher and others (2001) reported that motorcycle and ATV riders in Utah preferred

- riding off established trails (38.1 and 49.4 percent, respectively),
- double-track trails (12.7 and 17.1 percent),
- single-track trails (12.7 and 4.3 percent),
- moto-cross or ATV courses (9.5 and 15.1 percent), and
- roads (11.1 and 4.3 percent).

The issue of traveling off established trails is a serious concern with respect to natural resource management (Forman and others, 2003; Petersen, 2006); however, areas closed to OHVs and a shortage of designated OHV areas are common complaints among users (Achana, 2005; Fisher and others, 2001; Nelson and others, 2000). For example, in a survey commissioned by the Utah Department of Natural Resources to identify the most important issues affecting OHV use in Utah, 42.3 percent of respondents indicated that "Having enough places to ride" was most important; 8.4 percent indicated "Too many areas closed to OHV use;" and 5.6 percent indicated that "Resource management conservation" was the most important issue (Fisher and others, 2001). In a survey conducted by Nelson and others (2000), 44.6 percent of respondents selected "Do not reduce current trail/route system and OHV access" to indicate the most important thing that should not be changed, and 30.1 percent selected "Develop more trails/routes/area and connections to services" to indicate the most important thing that should be changed. When provided with several OHV-management statements with which to agree or disagree, Crimmins (1999) found that "Most trail closures have been done for good reason" received the highest level of disagreement.

Similar patterns in attitudes and beliefs were revealed through a survey of 336 ATV and motorbike users conducted by the Idaho Department of Parks and Recreation (Achana, 2005). On a scale of 0-7 (from least to most serious), respondents were asked to rank 23 issues of concern to them. Results indicated that the most serious issues of concern (in descending order of seriousness; scores greater than 4) were

- permanent closure of an area the recreator uses most,
- temporary closure of an area the recreator uses most,
- inattentive/careless recreators engaged in motorized recreation,
- litter,
- too many rules and regulations, and
- poor communication of rules and regulations.

Conversely, respondents felt that issues they were not concerned with (in ascending order of seriousness; scores less than 3) were

- too few rules and regulations,

- inadequate facilities at campsites,
- ATV impacts on water,
- motorcycle impacts on water,
- problems with parking availability for OHV-support vehicles,
- lack of suitable campsites,
- ATV impacts on wildlife, and
- some other (unlisted) issue of concern in OHV use areas.

Issues of concern that fell in the middle (in descending order of seriousness) were

- inattentive/careless non-motorized recreators,
- OHVs traveling too fast,
- motorcycle impacts on soil,
- motorcycle impacts on vegetation,
- ATV impacts on vegetation,
- hunters on OHVs off designated roadways and trails,
- ATV impacts on soil,
- motorcycle impacts on wildlife, and
- noise from OHVs.

When asked which of 16 possible factors contributed to creation of unauthorized trails in recreational regions of Idaho, survey respondents selected (from most to least frequently)

- belief that OHV users should be free to go anywhere,
- lack of enough designated places to ride,
- avoidance of crowded designated areas,
- lack of operator experience,
- riding motorcycles for fun,
- treeless terrain,
- riding ATVs for fun,
- using ATVs for hunting access,
- lack of enforcement regulations,
- using motorcycles for hunting access,
- using ATVs for camping,
- inadequate regulation,
- using motorcycles for camping,
- using motorcycles for fishing access,
- using ATVs for fishing access, and
- some other (unlisted) regional resource impact.

Combined, the top three possible factors contributing to creation of unauthorized trails indicate that closures of OHV areas could result in at least local increases in dispersed use. Finally, when presented with a list of four alternatives for creating uniform OHV access requirements to all recreation areas, trails, and roads on Idaho public lands, 53 percent of the respondents selected the alternative “Open to OHVs unless posted as closed by signing,” and 33 percent selected the alternative “Open to OHVs unless posted as closed by signing, designation, or description.” Only 6.1 and 1.0 percent felt that areas should be “Closed to OHVs unless open by signing, designation, or description” or “Closed to OHVs unless open by signing,” respectively (6.7 percent did not respond to this question). These results are consistent with the top possible

factors contributing to creation of unauthorized trails: the belief that OHV users should be free to go anywhere unless posted as closed by signing, designation, or description.

2.7.5 Economic Benefits and Costs of OHV Use

The economic benefits resulting from OHV sales, operation and maintenance, and associated sales and activities have been well documented (American Motorcyclist Association, 1978; Dave Miller Associates, 1981; Reed and Hass, 1989; Dean Runyon Associates, 2000; Nelson and others, 2000). OHV recreation and camping, in particular, can generate significant revenues for local economies through campground fees, grocery sales, eating and drinking in restaurants, and sales associated with operating and maintaining OHVs and support vehicles. In 1999, camping at public campgrounds on local, State, BLM, and U.S. Forest Service lands in California generated \$500 million; an additional \$130 million was spent solely on going to and from the campground and/or home (Dean Runyon Associates, 2000). A study conducted in 1988 by Reed and Hass (1989) indicated that, during a 12-month period in 1987-1988, Colorado OHV users spent \$488.7 million on OHV purchases, operation and maintenance, support equipment (tow trailers, storage sheds, and so on), and travel expenses associated with OHV trips. Nelson and others (2000) reported that, between July 1998 and June 1999, the average Michigan OHV licensee spent \$1,944 on non-trip related purchases, 80 percent of which was for equipment. When extrapolated to the estimated number of licensees in Michigan, Nelson and others (2000) found that this amounted to \$134 million in spending on equipment; a similar extrapolation indicated that \$40 million was spent on local trips.

The literature search conducted for this report, as well as personal communications with experts working in the field of outdoor recreation socioeconomics, revealed no published studies on the socioeconomic costs generated by OHV use. These costs could include the degradation or loss of ecosystem services, the costs of restoring OHV sites, and the loss of revenues from non-motorized recreators who seek alternate areas for recreation where motorized recreation does not occur. Examples of degraded or lost ecosystem services would be the diminished capacity for a given watershed to provide high-quality water, diminished water infiltration into aquifers, and flooding resulting from increased runoff where soils become compacted. Lost constituencies (and associated revenues) could include not only non-motorized recreators, but also hunters and anglers whose primary recreational foci (wildlife and fish) may have undergone population declines due to the effects of OHV use. At this time, however, the true benefit:cost ratio of OHV use remains unknown.

2.7.6 Annotated Bibliography for Socioeconomic Implications of OHV Use

Badaracco, R.J., 1976, ORVs—Often rough on visitors: Parks and Recreation, v. 11, no. 9, p. 32-35, 68-75.

This paper first reviews relevant literature on user conflict and discusses the one-sidedness of conflicts between OHV and non-OHV users, as well as the spatial nature of conflicts that occur when non-OHV users seek solitude and quiet and OHV users seek places for challenge and adventure. The paper then describes the ISD (impairment, suppression, displacement) syndrome: impairment is the diminished enjoyment among non-OHV users when they come into direct or indirect contact with OHV impacts; suppression is reduced participation of the non-OHV group; and displacement is the abandonment of a site impacted by OHV activity. Land planners and managers often misinterpret displacement as disinterest in the abandoned activity and, in so doing, may focus management efforts and other resources on OHV user demands.

Bury, R.L., and Fillmore, E.R., 1974, Design of motorcycle areas near campgrounds—Effects on riders and non riders: College Station, Texas, Department of Recreation and Parks, Texas A & M University, Technical Report, 72 p.

This document analyzes some of the psychological and sociological effects of constructing motorcycle riding areas adjacent to fixed-site campgrounds. It describes rider and camper profiles, rider and camper perceptions of riders, and camper and rider preferences and satisfactions with respect to the proximity and design of riding areas.

Cordell, H.K., Betz, C.J., Green, G., and Owens, M., 2005, Off-highway vehicle recreation in the United States, regions, and states—A national report from the National Survey on Recreation and the Environment (NSRE): U.S. Forest Service, Southern Research Station, Technical Report, 90 p.

This report was prepared for the U.S. Forest Service's National OHV Policy and Implementation Teams. The data from the NSRE were collected between the fall of 1999 and late 2004. The focus of this report is off-highway driving of motor vehicles. The 15 July 2004, U.S. Forest Service draft rule regarding management of motorized vehicle use has increased attention on where and how OHV recreation occurs and is offered. As public land managers are tasked with the responsibility of examining and implementing clear and consistent agency policy, understanding who the OHV recreators are has become ever more important. The growing use of motor vehicles is prompting the Forest Service to revise its management of this use so that the agency can continue to provide opportunities desired by the public, while sustaining National Forest System lands.

Crimmins, T., 1999, Colorado off-highway vehicle user survey—Summary of results: Denver, Colorado, Colorado State Parks, Technical Report.

This report summarizes a State Parks user survey designed to elucidate OHV rider-use patterns, what riders want in a recreation area, enthusiast values and beliefs, use of OHVs in hunting, how the state OHV fund should use the funds collected, and rider perceptions of how OHV funds are used, lands are allocated, and routes are managed.

Dave Miller Associates, 1981, An economic/social assessment of snowmobiling in Maine: Windham, Maine, Dave Miller Associates, Technical Report, 52 p.

This summarizes a user survey covering economics (number of trips, distance traveled, duration, fuel, lodging, equipment) and analyzing the statewide impacts and trends indicated by the responses. (No information on demographics or user perception was gathered.)

Dean Runyan Associates, 2000, Campers in California—Travel patterns and economic impacts: Portland, Oregon, Dean Runyan Associates, Technical Report, 76 p.

This document charts the distribution of camping opportunity according to type of environment and land ownership, tallies the results of a questionnaire distributed to people using public campgrounds, and develops a comprehensive profile of camping travel patterns, demographics, and expenditures. The report provides significant detail on a wide range of camping patterns, such as how many trips, how long and where, a breakdown of the activities pursued by campers once on site, and the ethnic and income classifications of campers. Although not OHV-specific, it shows where OHV recreation fits into the big picture.

Decker, D.J., Krueger, R.A., Bauer, Jr., R.A., Knuth, B.A., and Richmond, M.E., 1996, From clients to stakeholders—A philosophical shift for fish and wildlife management: *Human Dimensions of Wildlife*, v. 1, no. 1, p. 70-82.

This paper begins with a call for wildlife professionals to “adopt and use the term stakeholder,” the development of which they review and the definition of which they indicate as being any citizen potentially affected by or having a vested interest in an issue, program, action, or decision leading to an action. The authors maintain that successful natural resource management in today’s society requires recognizing the array of stakeholders that demand a voice or involvement in decision-making about natural resource management. The authors describe taking a stakeholder approach to planning and decision-making in natural resource management by including all those who might be impacted by natural resource management decisions (the authors focus on fish and wildlife management, but the principle is applied throughout natural resource management). The process entails developing communication strategies for understanding and representing stakeholder concerns, attitudes, and conflicts. The authors maintain that today’s successful professional resource managers need to “...seek a widely recognized image of giving unprejudiced consideration to all significant stakeholder interests in management decisions.”

Fisher, A.L., Blahna, D.J., and Bahr, R., 2001, Off-highway vehicle uses and owner preferences in Utah: Logan, Utah, Institute for Outdoor Recreation and Tourism, Department of Forest Resources, Utah State University, Report no. IORT PR2001-02, 80 p.

This study entailed an OHV user survey to examine owner characteristics, attitudes, and preferences. Respondents were selected at random from Utah OHV registrations and interviewed by telephone. This was a very extensive questionnaire, including the verbatim responses to interviewers’ open-ended questions. Other questions included demographics, vehicle type used, where ridden, distance traveled, types of riding preferred, attitudes toward OHV program fund use, attitudes toward training and safety, and much more.

Jim, C., 1989, Visitor management in recreation areas: *Environmental Conservation*, v. 16, no. 1, p. 19-32.

This paper discusses various visitor-management measures for diminishing or precluding the effects of visitor impacts on natural resources in recreation areas by employing existing recreation-management research on visitor decisions—such as trip duration, difficulty, and desired environment—to suggest ways of dispersing use into patterns that do not result in damage to natural resources. It also examines various management scenarios: signs and maps to direct users into a managed pattern, restricting admission, lotteries, and various rationing/pricing concepts.

Kockelman, W.J., 1983, Management Concepts, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 399-446.

Noise and motorized intrusion were the major impacts of ORVs on non-OHV users. Permitting OHV activity on public land is described as “inefficient” in the goal to provide for multiple uses because the noise, dust, and speed of just one OHV can exclude all other recreators from an area. The author categorizes OHV users as work-related users, recreational users, or

“bad apples.” Work-related users are natural resource managers and utility workers, among others. Recreators are further categorized as casual (value aesthetics more than the challenges of riding) or endurance riders. “Bad apples” are characterized by a complete lack of concern about their impacts and are likely to be noncompliant with regulations.

Nelson, C.M., and Lynch, J.A., 2001, A usable pilot off-road vehicle project evaluation: East Lansing, Michigan, Department of Park, Recreation and Tourism Resources, Michigan State University, Technical Report, 50 p.

This report details the results of an interagency effort to increase compliance with OHV rules in a Michigan State forest. An OHV-rider survey asked for respondents’ perceptions of signs, maps, and trail systems in the pilot area, as well as rider perceptions of any law enforcement contact riders may have had during the study period. The survey also queried each respondent’s understanding of pilot area regulations and offered the opportunity to give open-ended comments. There is also a detailed discussion of the participating law enforcement agencies’ response to the pilot project, including officer concerns, jurisdiction conflicts, workload distribution vs. agency priorities, and an analysis of sign survival in the pilot project areas. Finally, interviews with park manager/grant recipients and discussion of the results in terms of park administration, funding, staffing, and resource protection are provided.

Nelson, C.M., Lynch, J.A., and Stynes, D.J., 2000, Michigan licensed off-road vehicle use and users 1998–99: East Lansing, Michigan, Department of Park, Recreation and Tourism Resources, Michigan State University, Technical Report, 49 p.

This details a survey of randomly selected OHV owners in 1999. In addition to questions about demographics, expenditures, type of OHVs owned, and preferred activities, respondents were queried about their perceptions of specific aspects of the State OHV program. One section is dedicated to comparing this survey with a similar survey from 1988.

Propst, D.B., Shomaker, J.H., and Mitchekkm, J.E., 1977, Attitudes of Idaho off-road vehicle users and managers: Moscow, Idaho, College of Forestry, Wildlife and Range Sciences, University of Idaho, Technical Report, 30 p.

This report provides background information on, and an introduction to OHV use in, the era when it was new and poorly understood, and includes one of the earliest OHV/OSV (over-snow vehicle) user surveys. It compares user and land manager responses in the same survey; both groups were queried about their perceptions of environmental impacts, causes of conflicts, uses of public money for facilities, regulation enforcement, impacts on wildlife, and reasons for pursuing OHV/OSV activities.

3.0 Potential Indicators for Evaluating and Monitoring OHV Effects

3.1 Summary

There are numerous parameters that have the potential for serving as indicators of OHV effects in monitoring or research programs. Every attempt was made to provide an inclusive list of potential indicators of OHV effects described in the OHV effects literature (listed below). Of those listed, some correspond with BLM’s 17 indicators of rangeland health; others are quite different but could provide supplemental data for evaluating or monitoring OHV effects (for

example, erosion and/or sedimentation rates would complement assessments of rill formation and other surface changes) or fill indicator voids (such as those pertaining to wildlife ecology).

(1) Soil health and watershed condition

- Soil strength
- Soil bulk density
- Water infiltration rate
- Permeability
- Erosion and sedimentation rate
- Sedimentation or turbidity in wetlands
- Surface changes (for example, formation of rills, gullies, and terracettes)
- Presence/condition of soil crusts (in some cases: depending on crust type)

(2) Vegetation health

- Plant community composition (including species diversity, ratio of native to non-native or invasive species, structural diversity)
- Abundance of individuals and/or stem density
- Percent vegetation cover
- Plant size
- Growth rate
- Biomass

(3) Habitat condition and health of wildlife populations (direct and indirect)

- Habitat patch size and connectivity
- Wildlife community composition (including species diversity, ratio of native to non-native or invasive species)
- Abundance, density, and distribution
- Population sizes and trends
- Survivorship, productivity, body mass, and roadkill rates
- Age-class and gender structure
- Frequency of OHVs passing through a given area
- Road or trail type and width
- Level (decibels), duration, and timing of traffic noise

(4) Water quality

- Sedimentation rate
- Levels of turbidity and suspended solids
- Contaminants levels, including levels of petroleum-derived compounds from spills (aromatic hydrocarbons in particular)

(5) Air quality

- Dust levels
- Levels of by-products of OHV emissions (including polycyclic aromatic hydrocarbons, carbon monoxide, nitrogen oxides, ozone, and sulfur dioxide)

(6) Socioeconomics (direct and indirect)

- Recreator satisfaction with their recreation (or other) experiences
- Compliance with OHV (or other) regulations
- Knowledge regarding effects of user activities on various aspects of land health

- Mapping the distribution and intensity of OHV versus non-motorized recreation and other land uses,
- Patterns of regulation compliance (as evidenced by creation of unauthorized trails, damage to vegetation, and so on)
- Trends in local economic indicators associated with OHV and non-motorized recreation and other land uses (for example, sales in camping equipment, gasoline, restaurants, lodging facilities)

Specific research questions and management goals—as well as sensitivity to OHV effects and the availability of funding and personnel—will determine the potential efficacy of using any one indicator to evaluate or monitor OHV effects on BLM lands. Qualitative indicators may be most useful for rapid assessments, whereas quantitative indicators may be needed for long-term monitoring. Ultimately, however, implementing an OHV effects monitoring program will require consultation with topical experts and additional research to identify or develop appropriate and efficient indicators and field methods for evaluating and monitoring OHV effects (personal communication from D.A. Pyke to Z.H. Bowen, U.S. Geological Survey, Fort Collins, Colorado, August 2007). Work on developing such indicators is currently underway by rangeland ecologist, D.A. Pyke, U.S. Geological Survey in Corvallis, Oregon.

3.2 BLM's Indicators of Land Health Compared to Indicators of OHV Effects Described in the Literature

In terms of the specific land health attributes assessed, there is some limited correspondence between several indicators of OHV effects described in the literature and some of BLM's 17 qualitative assessment indicators (see Pellant and others, 2005). The area of greatest overlap is that of soil health and watershed condition; there is somewhat less overlap in the area of vegetation health (table 3.1). Attributes addressed in the literature but not by BLM's 17 indicators include wildlife population and habitat health, water and air quality, and socioeconomics. Even indicators that measure the same or similar attributes, however, may differ notably with respect to the scale and scope to which they are or can be applied, or the precision and accuracy they can provide.

The differences between BLM's indicators and those described in the literature do not imply that BLM's indicators are inappropriate for assessing some attributes under some conditions. Rather, they underscore the need for a variety of indicators to meet equally variable needs. For example, qualitative indicators (such as those employed by the BLM) often entail making visual estimates, which may be suitable for rapid assessments by time-limited personnel operating with small budgets; qualitative measurements, however, are subject to observer bias. Research and monitoring studies, on the other hand, generally require quantitative indicators (or strict decision rules to guide data collection for qualitative parameters) that minimize observer bias and maximize statistical precision and accuracy to ensure defensible results and the detection of trends; quantitative measurements, however, can drive up the cost and time requirements of research and monitoring efforts. Therefore, the choice of indicators employed will depend on the specific goals, budgets, sites, and other factors. In some cases, BLM's indicators may be suitable; other cases may require more quantitative indicators. Co-opting indicators from other disciplines also may be extremely useful for revealing OHV effects on land health.

Table 3.1. Indicators emphasized in the literature reviewed for effects of off-highway vehicles (OHV) on land health compared to indicators of land health employed by the U.S. Bureau of Land Management (BLM) (Pellant and others, 2005).

Land health category	Indicators of OHV effects described in reviewed literature	BLM indicators ^a
Soils and watersheds	Soil strength	9,11*
	Soil bulk density	11
	Soil permeability	8,9*,11*
	Water infiltration rate	1,2,3,4,5,8*,9*,10*,11*
	Erosion rate	1,2,3,4,5,6,7,8*,10*
	Sedimentation rate	
	Presence/condition of biotic and abiotic soil crusts	2,4,6,7,8*
Vegetation	Plant species diversity	12*,13,16*
	Ratio of native plants to non-native and/or invasive plants	12,16
	Percent plant cover	4,13,14
	Plant size	11,13,14,15*,17
	Plant growth rate	11*,13,14,15*,17
Wildlife and habitats	Habitat patch size and connectivity (can be expressed as ratio of road edge:habitat area or as native:non-native habitat)	4,12*,16*
	Shape/scope of animal movements relative to roads	
	Wildlife diversity and/or species abundance	
	Ratio of native, endemic wildlife to non-native and/or invasive species	
	Population size and trend	
	Gender/age ratio trend	
	Productivity trend	
	Average body mass for a given age/gender	
	Average survivorship	
	Vehicle-caused mortality rate	
Water quality	Sedimentation rate or depth	
	Amount of suspended solids	
	Turbidity level	
	Level of atmospheric deposition associated with OHV emissions	
	Level of petroleum or its by-products (benzene, ethylbenzene, toluene, xylenes, 1,3-butadiene, lead)	
Air quality	Levels of OHV emission by-products (nitrogen oxides, carbon monoxide, sulfur dioxide, ozone, aldehyde, PAHs ^b)	
	Level of suspended particulates	
	Plant-absorbed level of emissions by-products	

^a 1 = Number and extent of rills.

2 = Presence of water flow patterns.

3 = Number and height of erosional pedestals or terracettes.

- 4 = Bare ground (excluding rock, litter, lichen, moss, plant canopy).
 - 5 = Number of gullies and erosion associated with gullies.
 - 6 = Extent of wind scoured blowouts and/or depositional areas.
 - 7 = Amount of litter movement (description of size and distance expected to travel).
 - 8 = Average soil surface (top few mm) resistance to erosion.
 - 9 = Soil surface structure and content of soil organic matter (to include type of structure and A-horizon color and thickness).
 - 10 = Effect of plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff.
 - 11 = Presence and thickness of compaction layer (usually none).
 - 12 = Functional/structural groups (in descending order of dominance by above-ground production or live foliar cover).
 - 13 = Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence).
 - 14 = Average percent and depth of litter cover.
 - 15 = Expected annual production (this is total above-ground production, not just forage production).
 - 16 = Potential invasive (including noxious) species (native and non-native).
 - 17 = Perennial plant reproductive capability.
- ^b Polycyclic aromatic hydrocarbons.

Ultimately, **any indicator used to evaluate or monitor OHV effects will need a standard value (or range of values) that represents the baseline condition or a threshold value above (or below) which management is triggered.** Ecosystem properties, however, can vary widely across (and within) **spatial scales**. Therefore, selecting an appropriate standard or threshold for any one indicator necessitates an evaluation of the spatial scale(s) at which the associated effect occurs or is likely to affect ecosystem function. For example, OHV-caused sedimentation in a first-order stream might have significant by very localized effects on that stream, but no significant effects downstream; in contrast, OHV-caused sedimentation in a first-order stream might not have significant effects on that stream, but sedimentation in multiple first-order streams may result in significant cumulative downstream effects in second- and third-order streams. Similarly, the **temporal scale** at which ecosystems respond to land uses can vary from short-term (hours) to long-term (decades or longer); thus, it is important to consider temporal scale(s) as indicator standards or thresholds are established. For example, wildlife behaviors may exhibit immediate responses to OHV traffic by moving away from OHV routes; population trends, however, may take several generations to show effects of OHV disturbance, in which case the time required to detect trends will depend on how long it takes for generations turn over. Where OHV effects are not an immediate concern, one could incorporate long-term, annual, qualitative assessments of OHV-use areas, but where effects are of immediate concern, short-term, quantitative assessments may be implemented.

Standards for a given land health indicator can be developed by ascertaining baseline values at control sites under a given set of conditions. Once the baseline values are established, it becomes important to standardize the conditions under which subsequent measurements of that indicator are made. For example, the freezing and thawing of soils tend to decompact soils, and precipitation tends to alter other soil properties; thus, it would be important to monitor soils at similar times of year and under similar soil-moisture conditions.

3.3 Some Potential Indicators for Evaluating and Monitoring OHV Effects

3.3.1 Potential Indicators of OHV Effects on Soils and Watersheds

A major effect of OHV traffic on soil health is compaction—the reduction of a soil's porosity. Potentially useful indicators for monitoring soil compaction include soil strength, soil bulk density, and infiltration rate (or permeability). **Soil strength** is typically measured in terms of the soil surface's resistance to a vertical force exerted by a penetrometer and is expressed as kg/cm^2 (see <http://cropsoil.psu.edu/extension/facts/agfacts63.cfm> for explanations and diagrams of this method). **Soil bulk density** is measured as the ratio of dry solid mass (after soil is oven-dried) to bulk volume of soil and is expressed as g/cm^3 (or Mg/m^3). **Infiltration** or **permeability** is the rate at which the water infiltrates the soil and is expressed as cm/hr . Infiltration tests can be conducted in the field with relatively simple equipment (for a demonstration, see <http://www.grow.arizona.edu/Grow--GrowResources.php?ResourceId=181>); however, many replicates are needed to obtain adequate comparisons, and it takes time for infiltration to occur. Additional resources on the utility of devices and techniques for monitoring soil health include Leung and Meyer (2003) for soil compaction; O'Sullivan and Ball (1982), Hooks and Jansen (1986), Komatsu and others (1988), and Keener and others (1991) for soil strength; and Flint and Childs (1984), Isensee and Luth (1992), Miller and others (2001), and Lowery and Morrison (2002) for soil bulk density. McBrayer and others (1997) and Amezketa Lizarraga and others (2002) describe techniques used to measure infiltration rates. Overall, soil strength and bulk density are the most commonly used indicators of soil compaction in visitor impact studies (Liddle, 1997).

Soil strength, which increases with increasing soil compaction, depends on a number of inherent variables, such as particle size, type of clay mineral, the size/distribution of pores, and aggregate stability. For example, Adams and others (1982) found that soil strength in undisturbed areas of the Mojave Desert ranged between 5.1 kg/cm^2 at 6 percent water content and 21.1 kg/cm^2 at 1.8 percent water content, indicating that soil strength decreases with increasing moisture content. In general, a soil strength of less than 20 kg/cm^2 (284.4 lb/in^2) was indicative of undisturbed terrain, whereas trails intensely used by motorcycles had soil strengths (during wet conditions) that typically ranged from 20 to 60 kg/cm^2 (284.4 to 853.2 lb/in^2) (Adams and others, 1982). When soil strengths exceeded 20 kg/cm^2 (284.4 lb/in^2 ; measured at about field capacity) due to compaction, Grimes and others (1975, 1978) found that root extension of certain plants, including alfalfa (*Medicago sativa*), corn (*Zea mays*), and cotton (*Gossypium hirsutum*), was limited.

Soil bulk density also increases with increasing soil compaction. For example, in the Mojave Desert, Webb (2002) and Caldwell and others (2006) found that bulk densities of undisturbed surface soils ranged from 1.40 to 1.68 g/cm^3 ; however, bulk density increased significantly to 1.80 g/cm^3 at high-disturbance sites (Caldwell and others, 2006). Measuring soil bulk density, however, is time-consuming and difficult in gravelly soils (Webb, 2002), which are typical of many desert sites. Thus, its practicality may vary not only from region to region, but from soil to soil within a region. Infiltration, on the other hand, decreases with increasing soil compaction. In undisturbed desert habitats, Eckert and others (1979) found soil infiltration rates to be 3.2 cm/hr . In the same study, infiltration rates were 15 percent lower where motorcycle (2.7 cm/hr) and 33 percent where truck (2.1 cm/hr) traffic had occurred.

For each of the indicators identified above, it will be crucial to consider soil type and water content when setting standards, as these factors clearly influence overall inherent values of

each parameter. It also is clear that variability in soil type may preclude using a single indicator—much less one standard—for monitoring soil health across all sites. Overall, monitoring soil health would entail measuring soil properties in tracked versus untracked areas of similar soil type and under similar conditions of soil water content. For areas previously unaffected by OHV activities but proposed to become OHV areas, managers may wish to collect predisturbance data on soil properties to serve as a baseline from which trends in soil properties may be assessed over time. An acceptable percent change in soil properties could be selected, and if soil properties were to exceed these threshold values then management actions could be implemented to bring the soil properties back to acceptable values.

A possible method of monitoring surface changes in watersheds might be to establish permanent monitoring sites for repeat photography studies. By standing in the same spot, orienting the camera in the same direction, and using the same focal length for each site visit, sequential photographs would provide a qualitative, relatively easy means of monitoring surface changes due to erosion and OHV tire cuts. Helpful websites that discuss repeat photography (both terrestrial and aerial) include <http://biology.usgs.gov/luhna/chap9.html>, http://www.paztcn.wr.usgs.gov/wyoming/rpt_ground.html, and <http://www.cpluhna.nau.edu/Tools/repeatphotog.htm>. Scientists with the National Science and Technology Center are using close-range (terrestrial or ground-based) photogrammetry techniques and associated tools for producing and interpreting close-range images (less than 300 m, as opposed to aerial photogrammetry distances of more than 300 m) that may be used to document soil crusts, soil erosion, vegetation, and other resources (see <http://www.blm.gov/nstc/prodserv/ST134/pdf/Handout3CloseRange.pdf>).

3.3.2 Potential Indicators of OHV Effects on Vegetation

Some plant responses to OHV activities are preceded by, and result from, OHV effects on soil properties. In other words, soil characteristics, particularly soil compaction, play important roles in the distribution, abundance, growth rate, reproduction, and size of plants. Furthermore, some plant responses are likely to lag behind changes in soil properties, and, by the time effects are detected in plants, site recovery could be more difficult and/or lengthy. As such, it would be important to implement management strategies for maintaining or improving soil condition before plants are affected and no longer provide enough cover to hold soils in place during restoration efforts. Several vegetation parameters, however, have potential value as direct indicators of OHV effects on plant communities.

As mentioned in section 3.3.1, soil compaction results in reduced water infiltration. As a result, overall plant productivity, as measured by **percent plant cover, abundance or stem density, growth rate, biomass, plant height and width, ratio of large:small species, and/or reproductive output** may be diminished (Johnson and others, 1975; Vasek and others, 1975; Adams and others, 1982; Webb, 1983; Prose and others, 1987; Holzapfel and Schmidt, 1990; Lightfoot and Whitford, 1991; Brooks, 1995; Bolling and Walker, 2000). It is important to consider, however, the differential growth habits and responses of plant species to conditions generated by OHV activities; they may be favored or inhibited by OHV effects (Holzapfel and Schmidt, 1990; Angold, 1997). For example, the productivity of some species may increase due to abnormal conditions of moisture availability from runoff near compacted areas and/or where water roadbed materials allow increased infiltration rates (Johnson and others, 1975; Vasek and others, 1975; Holzapfel and Schmidt, 1990; Lightfoot and Whitford, 1991).

To evaluate and monitor plant productivity, researchers often use transect-intercept methods for measuring larger- or site-scale indicators, such as percent cover, and quadrat-based

sub-sampling at random locations along transects for measuring smaller-scale (individual plants) indicators, such as plant size or growth rate. Repeat photography is also potentially useful for monitoring vegetation cover when personnel budgets are limiting, although ground-based repeat photography methods may be more realistic than satellite imaging in terms of staff expertise and funding required (see methods and URLs provided in Section 3.3.1). Satellite imagery, however, can be very effective for ascertaining landscape-scale changes in vegetation cover during long-term studies at selected study sites (Johansen and others, 2007).

Plant community composition or diversity—a parameter that factors relative proportions of each species into species richness—is a commonly used indicator health of a vegetation community (Davidson and Fox, 1974; Adams and others, 1982; Prose and others, 1987; Wilcox, 1989; Tyser and Worley, 1992; Lovich and Bainbridge, 1999; Parendes and Jones, 2000). For example, a plant community comprising 5 individuals each of 10 species and 150 individuals of another (200 total individuals) would be considered depauperate compared to a community comprising 20 individuals each of 10 species (200 total). Native species diversity is further compromised when non-native and/or invasive plants dominate the plant community (Holzapfel and Schmidt, 1990). OHVs caked with mud acquired elsewhere potentially introduce or disperse seeds of non-native and invasive species; thus, OHV-route margins often become populated with exotics and invasives that eventually may spread and outcompete native species at the landscape level. Therefore, an important consideration when evaluating plant species diversity is the presence of non-native and/or invasive species. In other words, although species diversity can be useful for evaluating and monitoring the impacts of OHV activities on vegetation, the ratio of native to non-native and invasive plant species must be taken into account. Monitoring transects oriented perpendicular to OHV travel routes would help identify range expansions beyond the linear routes.

Similar to the precautions issued above for selecting standards of soil health, vegetation characteristics also vary widely according to soil type, slope, aspect, microclimate, and other factors. Ultimately, having baseline data before a site is disturbed, and/or having nearby reference sites not subjected to OHV activity would help differentiate between site-based variations and OHV impacts on vegetation.

3.3.3 Potential Indicators of OHV Effects on Wildlife and Habitats: Native, Threatened, and Endangered Species

The physical imprint of a road or OHV route creates barrier effects that may effectively alter **habitat patch size and connectivity**, which potentially alters or inhibits **animal movements** (Oxley and others, 1974; Mader, 1984; Swihart and Slade, 1984; Samways, 1989; Andrews, 1990; Baur and Baur, 1990; Forman and Alexander, 1998; Jackson and Griffen, 1998). Roads and trails also create edges that can alter wildlife habitat use and movements (Nicholson, 1987; Yahner, 1988; Reed and others, 1996; von Seckendorff Hoff and Marlow, 1997; Gibbs, 1998; Vos and Chardon, 1998), and in many instances these **edge effects** extend well beyond the road's actual footprint into habitat interiors. Unfortunately, both direct and indirect indicators of animal movements and habitat or home-range use can be difficult to measure, simply because populations are mobile and easily affected by many factors besides OHV activity if care is not taken to avoid, or control for, these additional effects. Furthermore, adequate sample sizes and accurate measurements of animal movements generally require capture-mark-release or capture-mark-resight studies, which can be costly in terms of funding for equipment and personnel time. Therefore, evaluating and monitoring movement responses of suitable indicator species or

functional groups to OHV activities and routes might be more efficient than trying to monitor many species. For example, species least likely to cross OHV routes or networks of routes (beetles or small mammals, for example) would be more suitable for studying barrier effects of OHV routes than species inhibited from crossing only multi-lane, paved highways (large ungulates). Ultimately, animal movement studies might be most appropriate in comprehensive, long-term research projects at selected study sites representative of locations and habitats being impacted most by OHV activities. An appropriate measure of edge effects on wildlife may entail studies of spatial distribution relative to distance from OHV routes, as well as density and other population dynamics among target indicator species that require habitat interiors.

Traffic intensity and noise level of OHVs may be useful indirect measures of OHV effects on wildlife behavior and survivorship. If measured, temporal variation in animal activity or presence would need to be considered, as diurnal animals may be more affected by OHV traffic and noise than nocturnal animals if most OHV activity occurs during daylight hours (Ouren and Watts, 2005). Vehicle speed also may be an important parameter to measure, as it can affect mortality rates of animals as they attempt to navigate landscapes where OHV travel is significant. There are technologies available for field monitoring of noise levels and traffic volume and speed (see examples on the Internet at <http://www.jhuapl.edu/ott/technologies/technology/articles/P01254.asp> and <http://www.noisemeters.com/accessories/outdoorkits.asp>), although again it would be more cost-effective to use them in selected study sites for targeted research questions as opposed to broad-scale monitoring programs.

Ideally, any program for monitoring OHV effects on wildlife would include assessments of whether/how wildlife responds to OHV-related factors. If population dynamics were understood *before* the onset of OHV activities, then monitoring any changes that occur afterward could be straightforward if other conditions are held relatively constant. Climate, however, typically makes long-term monitoring of animal population dynamics very complex, and wide-ranging animals may be more difficult to monitor than those with smaller or more restricted movements. Similar to the dynamic ways in which wildlife populations use a given area, OHV use in a given area is also dynamic; if the area affected and the intensity of disturbance enlarges considerably, wildlife may respond as well. These and other factors typically drive up the funding and staffing needs associated with collecting population dynamics data. Thus, to determine thresholds of OHV activity potentially tolerated by wildlife, it may be more realistic to measure long-term changes relative to gradients and changes in OHV activity. Again, careful selection of suitable indicator species, or functional groups, may help increase the effectiveness of monitoring wildlife populations (Lindenmayer, 2000; Noon, 2003, p. 51-55).

To date, there have been few simultaneous studies of OHV use and wildlife responses to OHV activities, but such studies could provide more precise assessments of the relationship between patterns of OHV activity and wildlife responses, particularly behavioral responses to varying traffic patterns, intensity, and total area affected. GPS and satellite technologies could be employed to build Geographic Information System (GIS) data layers of OHV-associated variables, both static (for example, road width) and dynamic (vehicle speed and traffic volume). When overlaid with GPS-based telemetry data layers that map animal movements, one could relate changes in static and dynamic OHV variables to wildlife responses, making these particularly powerful tools for long-term studies aimed at evaluating OHV impacts on wildlife.

3.3.4 Potential Indicators of OHV Effects on Water Quality

The literature on OHV impacts offered little information specific to evaluating or monitoring OHV effects on water or air quality. Based on studies of water quality in other disciplines, however, potentially useful indicators highly relevant to OHV effects would be **sedimentation** and **turbidity**. Sedimentation can be measured in terms of deposition rate or total amount of solids deposited where surface and directed flows enter aquatic systems downslope of OHV-use areas. A useful reference on different methods for measuring sedimentation may be found in Lisle and Eads (1991). Turbidity, which indicates the level of **suspended solids** in water, can be measured easily in the field with a Secchi disk (see <http://www.noble.org/Ag/Wildlife/SecchiDisk/Index.htm>). With respect to monitoring levels of contaminants in water from OHV emissions and fuel or other chemical spills, water samples can be collected and analyzed in laboratory settings; however, this can be costly, and would probably be more suitable for selected, long-term research sites than in broad-scale monitoring programs. Potentially important contaminants to test for in OHV-impacted watersheds could include **benzene; ethylbenzene; m-, p-, and o-xylene; toluene; 1,3-butadiene; and lead** (Forman and others, 2003: p. 205-213; Arnold and Koel, 2006). In addition, nitrogen deposition from nitrogen oxides can affect water quality if nitrogen loading alters the chemical balance of nutrients in aquatic organisms.

Although it has already been stated that, in general, it is important to compare OHV-impacted sites with similar reference (unaffected) sites when evaluating OHV effects, an additional consideration with respect to water quality is to make comparisons within the same drainage. This is because water quality variables can change depending on the geology, adjacent habitat, and hydrology of the area. Thus, an appropriate technique for assessing OHV effects on aquatic systems might be to compare water quality at replicate sites both upstream and downstream of where OHV activities are occurring.

3.3.5 Potential Indicators of OHV Effects on Air Quality

There are several measures of air quality that can be used to assess effects of OHVs, including levels of fugitive dust (**suspended particulates**) and/or **OHV emissions** (including **carbon monoxide, ozone, sulfur dioxide, aldehyde, and polycyclic aromatic hydrocarbons**). Due to the effects of humidity, precipitation, fallout rates of different particle sizes, and wind speed and direction, however, measuring dust levels specific to any one site or set of OHV activities can be difficult. A useful technique for assessing the amount of dust associated with OHV use is to collect PM₁₀ (particulate matter less than 10 microns in diameter, which can pass through the nose and throat and get deep into the lungs) data, as dust is a common component of PM₁₀. Technological advancements continue to provide additional devices useful for monitoring dust and other suspended particulates (Sanders and Addo, 2000)—including satellite imagery (Nakata and others, 1976; Gill, 1996; Stefanov and others, 2001)—although cost becomes a greater factor with increasing sophistication of instruments used. Fox (1986) provides a list of appropriate procedures for measuring and evaluating various air-quality parameters, and the Environmental Protection Agency's National Ambient Air Quality Standards include primary standards (those designed to protect overall public health and the health of "sensitive populations") for carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur oxide levels (see <http://www.epa.gov/air/criteria.html>).

3.3.6 Potential Indicators for OHV Effects on Socioeconomics

Resource planning has been known to take recreation and economic values of OHV use into greater consideration than biological considerations (Adams and Dove, 1989). **Human behaviors, attitudes, and economics**, however, are the ultimate drivers of OHV impacts on natural resources (Decker and others, 1996; Vaske and others, 2001); thus, understanding the socioeconomics of OHV use is crucial to the success of any program designed to address OHV effects, whether they impact natural resources or land users. This includes understanding the economic effects—**both benefits and costs**—of OHV management and use on OHV users, other land users, local businesses, land-management agencies, and ecosystem services.

Bight and others (2003) provide a framework and guidelines for conducting social assessments and identifying/organizing social science data, including measurable indicators (see Chapter 3, p. 21) for use in natural resource planning. Indicators suitable for monitoring the socioeconomic implications of OHV use (human behaviors, attitudes, and economics) may be identified through stakeholder interviews, focus groups, and surveys (mail or telephone); economic assessments; and developing maps depicting areas used for different forms and intensities of recreation (Massachusetts Department of Environmental Management, 1995; Decker and others, 1996; Stokowski and LaPointe, 2000; Nelson and Lynch, 2001; Dillman, 2007). For example, interviews can be designed to elucidate not only OHV impacts on all types of user experiences, but also ways in which those impacts might be mitigated. Trail openings or closures may affect levels of OHV user demand and satisfaction, which could be identified through well-designed survey questions that target OHV users (see Dillman 2007).

Likewise, understanding the effects of OHV site development and regulation compliance first requires monitoring where OHV users like to go and what their preferences are when riding. For example, Nelson and Lynch (2001) conducted a study to determine the effectiveness of OHV areas, the approaches for which included a survey of licensed OHV riders, interviews with key stakeholders about project management, and an assessment of the signs established to identify designated OHV trails. Monitored over time, these indicators could be used as guidelines for adaptive management. Finally, identifying the economic impacts associated with OHV activities and regulations potentially affecting nearby communities may entail economic analyses of businesses and services that cater to outdoor recreators (including OHV users and non-motorized recreators; English and others, 2001). Economic assessments also may be used to determine the financial effects associated with losing ecosystem services, regulation enforcement, resource restoration, and other potential costs of OHV use.

A potentially powerful tool for identifying socioeconomic effects of OHV use would be GIS applications (Massachusetts Department of Environmental Management, 1995; Stokowski and LaPointe, 2000; Kopperoinen and others, 2004). For example, areas considered by recreators as being most important for excluding motorized forms of recreation could be identified by users on a map and then used to develop time-series GIS data layers that illustrate long-term changes in preferences pertaining to land-management actions or other factors. Overlaid with maps that identify areas ecologically most suitable for OHV use, managers also could determine which areas are most likely to be resilient to OHV use and provide OHV user satisfaction.

4.0 Mitigation and Site-Restoration Techniques

4.1 Summary

Mitigation of OHV effects and restoration of OHV-impacted sites requires a range of approaches and techniques. Social science in particular has strong applicability for ameliorating the effects of OHV activities, not only in terms of their impacts on non-motorized recreators and other OHV users, but also in terms of their effects on natural resources, as ultimately human behavior is what drives OHV use and related behaviors. Important tools for managing OHV use, therefore, include not only interviews, surveys, and focus groups, but also strong educational campaigns. Once impacted by OHV use, however, ecosystems may need to be closed and rested, if not restored. Sites with severely compacted soils and/or bedrock exposures due to erosion may need restoration through importation of native soils, scarification, decompaction, stabilization, inoculation with microbes and mycorrhizae, and/or mulching before reseeding and/or planting can be done.

4.2 Mitigation and Site-Restoration Techniques

The OHV literature has addressed many effects of both motorized and non-motorized recreation on components of ecosystem health (Cole, 2004; Stokowski and LaPointe, 2000; Cline and others, 2007), including soils, vegetation and habitat, wildlife behavior and population dynamics, and the quality of water and air. Resource degradation and wildlife disturbance are not uniform, however. Factors influencing the extent and degree of impact include user types and behaviors, the environment's resistance and resilience, and the timing, intensity, and distribution of use (Cole, 2004). Therefore, management and mitigation planning and implementation must take these factors into consideration.

4.2.1 Understanding Land User Preferences and Conflicts

Although addressing ecosystem degradation and user conflicts stemming from OHV use generally requires policy and management considerations (Vancini, 1989), there is the likelihood that one group or another will be dissatisfied with the outcome of any one management decision. Therefore, it is important to promote acceptance of, if not support for, management decisions prior to implementation, because those not accepted are likely to fail in the long run, regardless of how sound the reasoning is behind them (Shindler and others, 2004). One way to potentially improve policy acceptability is to identify, assess, and include all users who may be affected by management decisions and include them in the decision-making process; useful tools for accomplishing this goal include stakeholder and demographic analyses, and arranging stakeholder focus groups (Decker and others, 1996; National Oceanic and Atmospheric Administration, 2005). Basic discussions, such as defining different interpretations of OHV use or seeking consensus on the meaning of OHV use to disparate users, can potentially preclude feelings of marginalization by any given group that could lead to conflict between users and/or between users and managers (Stokowski and LaPointe, 2000).

A baseline understanding of OHV users (including recreators, livestock operators, and energy-development operators) can further help to alleviate conflicts among different users. If users can be classified, even broadly, managers can maximize their efforts by using that information to form relevant management plans and/or communication and education campaigns. For example, understanding the problems that users have with each other, as well as their motivations for recreating, can yield more effective management that placates most, if not

all stakeholder groups, and does not lead to marginalization or displacement of any one group. Often, outdoor recreators of all types have fairly similar goals and reasons for participating in outdoor recreation (Schuett and Ostergren, 2003), including a need to “get away” from the pressures and commotion of everyday life, rejuvenation, and enjoyment of the natural environment. Even when the mechanisms by which those needs are met are not homogeneous among user groups, knowledge of stakeholder preferences can help to improve the management of OHV recreation on public lands.

Managing the social effects of OHV activities and promoting compliance with regulations also require determining where OHV users like to go and what their preferences are when riding (Nelson and Lynch, 2001). Likewise, management must consider the levels of environmental dominance and technology associated with different forms of land use. Once again, GIS data layers could be developed to identify spatial management needs and predict where conflicts may occur. For instance, nature study, an activity characterized by “low dependence on technology and low dominance over the environment,” and OHV touring, which is characterized by “high dependence on technology and high levels of environmental dominance,” need to be segregated spatially to help prevent user conflicts. If it is found on a map grid that two such activities are taking place in adjacent quadrats, there is a high likelihood that recreators who participate in these activities will come into conflict (Bury and others, 1983). Maps of sites suitable for a given activity could be overlaid with user preferences for certain locations or landscape features to further fine-tune planning and mitigation of user conflicts.

Finally, if recreators are made aware of their impacts and understand the implications of those impacts, they may be more willing to take steps that lessen those effects, thereby diminishing the necessary level of managerial monitoring (Vancini, 1989; Anderson and others, 1998). Communication and education campaigns can be difficult, however, due in part to (1) modern-day information overload, increasing the likelihood that recreators will disregard information pertaining to natural resources and recreation, and (2) the fact that managers and designers of education campaigns rarely have a formal knowledge and understanding of persuasion techniques (Absher and Bright, 2004). Assuming that these factors can be surmounted by well-designed educational resources and manager training, education is a crucial first step in alleviating negative perceptions of trail closures and other regulations or management actions. For example, management agencies need to explain the reasons and rationale for closures so that they do not appear arbitrary (Crimmins, 1999). Such educational campaigns may be more successful if they target the many OHV users participating in some other form of outdoor recreation that depends on a healthy ecosystem. Hunting and fishing are two such forms of recreation, and if an OHV area is closed seasonally to protect elk during calving season or fish during spawning season, communicating this to OHV users is likely to elicit more compliance with the closures. When OHV users understand that their hunting and fishing activities may be at stake, they are more likely to respect closures. In closed areas already subjected to high levels of illegal riding, education would be crucial for communicating to users the reasons for the closures and related management actions.

4.2.2 Mitigating OHV Use Effects

Lands managed by BLM are placed into one of three broad types pertaining to OHV-use designation: “open,” “limited,” or “closed.” Within the “limited” category there can be several types of limitations: OHVs can be “limited to existing routes,” “limited to designated routes,” or “limited seasonally” (see

http://www.blm.gov/nhp/news/releases/pages/2000/pr000110_ohv_qa.html). Indeed, trail/area

closures are among the management options available for allowing soils and vegetation to recover from OHV effects or to help preclude localized impacts on air and water quality. However, in areas where OHV effects would be notable with the first few uses and/or generate significant, long-lasting impacts, it would be prudent to consider whether such places are appropriate for OHV use in the first place (Cole and Landres, 1995; Cole, 2004). A well-placed, concentrated system of trails could alleviate the difficulties of enforcement that extend across a large territory (Major, 1987). Spatial models, including GIS data layers, developed for identifying areas most suitable for resisting or recovering rapidly from OHV impacts, or those most suited for concentrated and/or self-monitored OHV use, would be effective tools for establishing OHV sites in appropriate areas and avoiding the need for frequent, long-term closures, expensive restoration actions, and/or the high cost of enforcement monitoring. For example, erosion, sedimentation, and rill or gully formation are much more likely to occur in, and downslope of, OHV-use areas located on or at the top of a slope than in/from a flat site or depressional area lacking watershed outlets. The GIS data layers could, therefore, identify areas to exclude from development for OHV use.

Although trail/area closures may be among the easiest management actions to implement, they may prove difficult to enforce, particularly under a policy of “closed unless posted open.” The enforcement difficulty will depend on the number of trails involved, their locations relative to one another, and the number of enforcement personnel available. In the absence of funding for adequately monitoring regulation compliance, educating the public about the effects of their recreational pursuits may prove more economical and yield self-monitored trail users. In areas affected heavily by recreational activities, however, visitor management may be required (Jim, 1989). “Rationing” is a visitor management strategy that can be used to control the number of visitors over a given area where the available recreational resources are finite and/or unique. If the number of visitors is restricted, their quality of experience may be greater; a drawback of this approach is that the benefit is realized by fewer users (see Dimara and Skuras, 1998). Other strategies may include reserving a permit in advance, a permit lottery system, or implementing user fees that reflect the quality of experience (for example, it may cost more to use a high-use area that offers a high-quality experience than a low-use area that offers a low-quality experience). In many cases, these strategies could help alleviate pressures on law enforcement.

Wildlife is affected by OHV recreation in numerous ways, including displacement caused by human disturbance or direct mortality caused by vehicle-animal collisions (Cole and Landres, 1995; Knight and Cole, 1995; Miller, 1998; Stokowski and LaPointe, 2000; Cline and others, 2007). As OHV-related landscape fragmentation increases, habitat area and required juxtapositions of habitat types that meet the different needs of a given species, as well as adequate cover from disturbance, are diminished. Because the resulting effects may be detrimental to individuals and/or local populations (Knight and Cole, 1995), mitigation and management may be required to protect wildlife. One approach for mitigating the effects of wildlife displacement and disturbance may be to control the spatial and/or temporal proximity of OHV activities to wildlife, especially during critical nesting and breeding times (Gutzwiller, 1995). Again, GIS data layers could be very useful for identifying crucial wildlife areas and ensuring that they are not overlapped, fragmented, or otherwise disturbed by OHV-use areas.

4.2.3 Restoration of OHV-Impacted Areas

Revegetation of natural communities in arid environments is particularly difficult (Wallace and others, 1980) and studies evaluating revegetation have shown varying degrees of success (Graves and others, 1975, 1978; Kay and Graves, 1983; Grantz and others, 1998); thus,

restoration of sites significantly degraded by OHV activity may be needed before sufficient levels of revegetation can take place, particularly if underlying bedrock has become exposed. Webb and others (1978) recommend that soil be imported and stabilized to replace the displaced soil where bedrock has become exposed. Generally, restoring soil horizons for re-establishing microbial communities can be achieved by inoculating soils with native microbes and mycorrhizae (Belnap, 1993; Bolling and Walker, 2000). Bolling and Walker (2000) suggest that decompacting OHV tracks and flattening out the lateral and center berms associated with them may increase the probability of community redevelopment with a more natural surface shape. Recovery of cryptobiotic soils, however, is more complex and may require long periods of time (Wilshire, 1983b; Lovich and Bainbridge, 1999); ultimately, their recovery rate will depend on the degree of soil compaction and the nature and intensity of the initial disturbance (Bolling and Walker, 2000).

To reduce the potential for erosion at restoration sites, it is important to use mulch, stabilization techniques, and/or establish vegetation. Rasor (1976, cited in Webb and others, 1978) suggests that ground cover (such as wire netting) be applied across the restoration site to stabilize soils. Kay and Graves (1983) recommend that seeding with local seed stock begin as the disturbance desists. Revegetation techniques also may include container planting (Grantz and others, 1998), hand seeding (Lovich and Bainbridge, 1999), drill seeding (Kay, 1988), and establishment of visually dominant species, such as creosote bush (*Larrea tridentata*; Kay and Graves, 1983).

5.0 Monitoring and Research Needs

5.1 Summary

More information is needed to help support policy making and land management as they pertain to the natural resources and people affected by OHV policies and management. Research needed to help support policy makers and land managers includes (but is not limited to)

- well-designed studies that incorporate planned comparisons of treatment (OHV-impacted) and control (unimpacted/reference) sites, as well as “before and after OHV-impact” studies;
- studies at various spatial and temporal scales across all impacted habitat types;
- studies on habitat fragmentation and road-edge effects caused by OHV activities;
- studies on effects of various gradients in OHV disturbance and at varying distances from OHV routes;
- studies of OHV effects on plant and animal population dynamics;
- simultaneous evaluations of wildlife responses and OHV route-specific variables;
- studies to improve knowledge about the physical and chemical dynamics of soil compaction;
- studies evaluating the effects of erosion, sedimentation, and turbidity downslope of OHV-affected sites;
- improvements in techniques for successful site restoration;
- improvements in techniques and technologies for assessing OHV impacts over large areas and long time periods;

- studies that evaluate the effectiveness of various techniques to manage OHV use and its ecological and socioeconomic effects while simultaneously providing the greatest satisfaction among all land users; and
- studies that determine the economic and sociological costs of OHV use.

The experimental design of past studies on the ecological effects of OHVs often proved inadequate for providing reliable, defensible results. In particular, use of comparable treatment and control sites with adequate replication has been minimal. To better elucidate OHV effects on wildlife, habitats, and vegetation, there is a need for well-replicated research based on treatments and controls ranging across various spatial and temporal scales within the full range of habitat types represented on BLM lands. In desert ecosystems, for example, the impacts of OHV activities can occur at several spatial and temporal scales (Forman and others, 2003: p. 129-134; Matchett and others, 2004; Brooks and Lair, 2005; see discussion in section 2.1); thus, research conducted across the scale(s) at which OHV activities and ecosystem responses are likely to occur will produce the most reliable information about OHV effects on land health and users of the land (Brooks and Lair, 2005). There also is a need for long-term monitoring of OHV effects at both designated OHV sites and undesignated (rogue use) sites, as well as revegetation sites.

Monitoring and research approaches that take advantage, and push the advancement, of existing and emerging technologies are needed to fully represent the scale and diversity of OHV impacts likely affecting plant and animal populations and communities, and to ascertain indicator thresholds as they pertain to BLM's land health standards. Current technologies, including satellite imagery, GPS, and GIS, among others, would be extremely useful in broadening the scope of OHV-impact research from site-based effects to ecosystems and landscapes. Technology also provides opportunities for better assessing OHV effects on wildlife, vegetation, and other natural resources. Finally, multiple assessments and the simultaneous recording of independent and dependent variables would improve overall results and better inform management decisions.

5.2 Monitoring and Research Needs

Remaining questions about effects of OHVs on ecosystems and people are numerous and varied. Information regarding management approaches for sustaining or restoring resources—from the level of single OHV routes to entire landscapes—to pre-disturbance conditions while still providing for quality OHV experiences is especially sparse. Therefore, the need for solid, well-designed research for supporting management decisions cannot be understated. Based on major unresolved issues and questions raised in the OHV impacts literature, current research needs include (but are not limited to)

- well-designed research capable of producing scientifically sound results by incorporating planned comparisons of treatment (OHV-impacted) and control (unimpacted/reference) sites, as well as studies that take advantage of opportunities to compare “before and after OHV-impacts” at sites that may be slated for—but are not yet impacted by—OHV use;
- studies to evaluate OHV effects on natural resource attributes at various spatial and temporal scales, particularly those appropriate for evaluating and understanding effects occurring at watershed, landscape, and plant and animal population levels;
- studies to improve the overall understanding of habitat fragmentation and road-edge effects caused by OHV activities in OHV-impacted habitat types;

- studies that evaluate effects of OHV activities at various gradients in OHV disturbance levels and at varying distances from OHV routes;
- studies to evaluate how OHV activities and habitat fragmentation affect plant and animal population dynamics;
- simultaneous evaluations of wildlife responses (from individual- to population-level scales) and route-specific variables, including route type and width, and the intensity, noise levels, and speed of traffic;
- studies to improve the understanding of the physical and chemical dynamics, as well as the consequences, of soil compaction, sedimentation, and turbidity downslope of OHV-affected sites;
- improvements in techniques and technologies for assessing OHV impacts over large areas and long periods of time;
- improvements in techniques for successful site restoration;
- studies to determine the economic value of ecosystem goods and services provided by natural resources on or in BLM (and affected) lands and waters; and
- studies to determine the costs of OHV use, including degradation or loss of ecosystem goods and services, loss of supportive constituencies, managing/enforcing regulations of OHV use, and restoring OHV-impacted sites.

5.2.1 Scientifically Rigorous Research Projects

Several studies discussed in this document compared areas impacted (treatment) to areas unimpacted (control) by OHVs. Many studies, however, did not compare treatment and control sites, or the control and treatment sites differed with regard to some major factor (for example, other recreation activities, livestock grazing, logging, or energy-development activities) that could have masked true differences pertaining to OHV effects. In other words, controls in research and monitoring programs provide the necessary frame of reference for identifying true effects of the variable(s) of interest; in turn, identifying true effects will better inform management actions. Therefore, among the greatest research needs pertaining to OHV effects on natural resources are scientifically defensible studies based on planned comparisons of OHV-impacted and unimpacted sites that are otherwise similar in terms of soils, topographies, climatic patterns, plant and animal communities, non-motorized activities, and other potentially confounding factors. This is particularly important for developing appropriate threshold indicator values for sustaining current resource conditions or triggering management actions.

An additional approach to research that can provide informative results is to conduct before-and-after comparisons of sites previously unimpacted by OHV use but slated for future OHV use. Although year-to-year variations in climate and plant or animal population cycles can introduce too much variation in ecological before-and-after data to provide statistically meaningful results, this research approach can provide valuable information when conditions are reasonably similar during each phase of the project. Thus, it would be prudent to take advantage of such opportunities as they come up.

Technologies and tools that could prove very useful in study design and site selection pertaining to OHV effects include satellite imaging and GIS. Although they are still advancing rapidly in terms of their capabilities and utilities, they are nonetheless already very helpful in studies ranging from the site to the landscape scale. Satellite imagery can help locate sites with differing extents of OHV activity, and, when rendered into GIS database layers, they can provide opportunities for repeating imagery over time and evaluating landscape-scale changes. U.S.

Geological Survey scientists, for example, are currently using these tools and technologies to study the effects of energy-development activities in sage-steppe systems on BLM lands in Wyoming (C. Aldridge, pers. comm.).

5.2.2 OHV Effects at Various Spatial and Temporal Scales, Across Habitat Types

Past studies regarding OHV impacts on natural resources have focused primarily on effects at the single route or site level; thus, the overall understanding of landscape-, watershed-, and population-scale effects, including habitat/population fragmentation, is inadequate for managing OHV effects at larger spatial and longer temporal (Boyle and Samson, 1985) scales. Most of what is known pertains to very localized and short-term effects on sub-populations. Even then, past studies evaluating changes in animal densities of sub-populations may have violated basic assumptions of closed-population status. That is, studies that “failed to detect OHV effects on animal densities” may have been confounded by the immigration of new individuals after original individuals experienced poor survivorship due to direct or indirect effects of OHV activities. Mark-recapture studies that take advantage of radio-marking technologies, both in and away from the affected site, can help evaluate the extent to which assumptions of closed versus open populations are upheld or violated.

Research is also needed to better understand the edge effects of roads on different habitats and populations of different species or taxonomic groups. Here again, scale is important. Many past studies have evaluated the effects of traffic in immediately adjacent habitats (road rights-of-way, for example), whereas the effects may be realized well into the habitat interior quite far from travel routes. Thus, study designs that incorporate gradients of distance away from OHV routes or route networks would be crucial.

5.2.3 Research Regarding Effects of OHVs on Animal Populations

Many prior studies of OHV impacts on wildlife have focused on indirect indicators of animal population health, such as distribution and behavior, at the expense of more direct indicators, such as population trend/size, gender and age ratios, and productivity. In part, this is because such data can be significantly more difficult and expensive to collect than behavioral and distribution data. Studies that address possible changes in plant and animal genetics in ecosystems fragmented by OHV roads and trails also are needed. For species that naturally occur at low densities, such as the desert tortoise, bighorn sheep (*Ovis canadensis*), and mountain lion, this is particularly important, as isolation of their populations could more easily lead to localized extinctions.

Understanding direct effects of OHV activities on wildlife populations would be further enhanced by research that evaluates wildlife population dynamics in different habitat types (Bury and others, 1977), at different spatial and temporal scales, and under different conditions (levels) of OHV use. Likewise, research programs that incorporate representative and disparate taxonomic groups would help identify ecosystem-level effects. For example, a given habitat-fragmentation factor (a network of OHV routes) might not have any significant impact on large ungulates, but it might lead to complete loss of genetic diversity among flightless invertebrates. In conjunction with this type of research, it would be important to identify which specific environmental and anthropogenic factors promote or limit the exchange of individuals across OHV-impacted habitat types or landscapes.

Few past studies have employed multiple-assessment or simultaneous survey methods to detect rare or sensitive species that may not be detected through standard monitoring techniques, resulting in biases towards more common and easily detected species and an incomplete

understanding of the community at risk. For example, multiple survey techniques can be used to determine whether changes in species composition are due to changes in detectability across habitat types, times of day or season, geographical area, and abundance. For detecting reptiles and amphibians, researchers could combine noosing, pitfall sampling, night surveys, and road driving surveys. For mammal studies, track, scat, and camera surveys might enhance species detections. Many avian-ecology researchers now use combinations of road driving, point sampling, and mist netting, in addition to double-observer methods, for improving overall survey results.

Studies of OHV effects on wildlife also could be improved through simultaneous recording of independent and dependent variables. For example, many studies relating effects of OHVs on animal populations also lack any measurements of static and dynamic road- and OHV-related variables—such as width and traffic intensity/noise levels (Andrews, 1990)—that may strongly influence species behavior, distribution, abundance, survivorship, and productivity. Given the importance of relationships between these independent and dependent variables, employing long-term monitoring that incorporates their simultaneous measurement would be very helpful (see Andrews, 1990). This type of information would be particularly useful for identifying indicator thresholds that might trigger area closures, re-routing of OHV routes, and/or implementing a restoration project. A variety of technologies and tools now available would be useful in these endeavors, including satellite telemetry, Global Positioning Systems (GPS), infrared photography, pneumatic vehicle counters, and so on.

Finally, there are a number of specific questions that researchers could ask with respect to OHV effects on animal populations. For example, the discussion in section 2.3.3 regarding edge effects of OHV routes raises the question of whether high densities of animals in roadside habitats represent favorable conditions for native fauna or dominance by invasive or non-native organisms and, if the former, whether these habitats are population sources or sinks (see Van Horne, 1983).

5.2.4 Research to Determine Socioeconomic Costs Associated with OHV Use

The literature search conducted for this report yielded no published studies of the economic costs associated with OHV use. Costs could include the degradation or loss of crucial ecosystem goods and services (such as a decline in water quality due to accelerated sedimentation and increased turbidity in wetlands caused by OHV traffic, or the loss of livestock and wildlife forage due to soil compaction caused by OHV traffic), the loss of economic and political support from both OHV users and non-motorized constituencies whose recreation experiences (or other land uses) are degraded by OHV effects, and the costs of managing OHV recreation and restoring sites impacted by OHV traffic. Although the costs of OHV effects may be challenging to assess, there are efforts underway to first identify the economic values of ecosystem goods and services and factor them into economic analyses of human activities. For example, Ducks Unlimited Canada and The Nature Conservancy have co-published a report that calls for the immediate acceleration of “efforts to measure, protect, and enhance the natural capital of Canada,” including the need to “invest in science to measure, value, and monitor ecological goods and services, and develop economic instruments that recognize and protect natural capital, rather than continue to reward its destruction” (Olewiler, 2004). A companion report details the values of goods and services provided by wetlands (Gabor and others, 2004). Similar efforts to place a value on the goods and services provided by lands affected by OHV activities would provide the necessary basis for balancing economic equations of OHV use.

5.2.5 Research to Improve Site Restoration

The success of site restoration ultimately depends on the ability to return soils, including abiotic crusts and desert pavement, vegetation, and biotic crusts to their original condition. Therefore, research is needed to study the mechanisms behind, and mitigation that could diminish, changes in soils. Adams and others (1982) called for research on the disproportionate hardening of only slightly compacted desert soil and whether soil hardening is caused by chemical cementation or by a greater number of interstitial water bonds remaining between soil particles after drying. Webb and others (1978) called for studies that explore the amount of time required for soils to respond to revegetation of OHV sites and develop ways of mitigating changes in soil properties during OHV use. More recently, Bolling and Walker (2000) expressed the need for long-term monitoring and analysis of soil microbial populations. Answers to these and other important questions that elucidate the ways in which systems recover from the effects of OHVs are crucial to the possibility of long-term OHV use without incurring irreparable damage to ecosystems.

6.0 Conclusion

It is apparent from the literature identified and discussed herein that the effects of OHV activities on ecosystems are diverse and potentially profound, if poorly understood. Studies have revealed a variety of effects on soil properties, watersheds, and vegetation resulting from one to multiple passes by OHV vehicles. Likewise, research has shown a variety of OHV effects on both OHV users and non-motorized recreators. Considerably less is known about impacts to wildlife or air and water quality. Whereas the results of past OHV-effects research have been reasonably consistent in demonstrating the nature of OHV effects in the immediate vicinity of single trails and OHV sites, there is a need for stronger emphasis on the cumulative effects—both spatial and temporal—of OHV use. For example, the effects of a single OHV route on a watershed may be greater when it is part of a route network than when it is the only route within the watershed. Furthermore, a network of OHV routes is likely to accommodate more users than a single route. Therefore, route density is an important consideration when evaluating and monitoring OHV effects across a given landscape.

The Council on Environmental Quality's (CEQ) regulations for implementing the National Environmental Policy Act define a cumulative impact as "...the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (Council on Environmental Quality, 1997). In other words, cumulative impacts can result from what may appear on small spatial or temporal scales to be minor, but which become collectively significant when such actions take place over large areas and long periods of time. Moreover, one effect may interact with other effects to generate additional effects that are not apparent when evaluating effects individually.

The concept of cumulative impacts as they relate to OHV activity, therefore, must be applied in a landscape context, as these impacts are not site-specific and may affect adjacent or even more remote habitats and landscapes. For example, dust created from OHV activities can be dispersed to areas far away from habitats directly impacted by OHV activities. Likewise, erosion of soils during heavy rain events may increase sedimentation far downstream of areas directly subjected to OHV activities, and edge or corridor effects of OHV routes may promote widespread dispersal of non-native and invasive species. Thus, there is a need for greater

monitoring and research emphasis on the effects of OHV activities not only in the areas directly subjected to those activities, but across impacted habitat types, watersheds, and landscapes. Overall, monitoring of cumulative impacts is needed at a scale larger than the physical imprint of the OHV-use area. By the same token, economic analyses of OHV use are needed to account for not only the immediate and apparent economic benefits, but also the long-term, large-scale, and ongoing costs associated with OHV use. Without factoring these variables into models of economic impacts, true cost:benefit ratios of OHV use will remain unknown.

7.0 Literature Cited

- Absher, J. D., and Bright, A. D., 2004, Communication research in outdoor recreation and natural resources management, *in* Manfredo, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., *Society and Natural Resources—A summary of knowledge*: Jefferson, Missouri, Modern Litho, p.117–126.
- Achana, F., 2005, 2005 ATV/motorbike user survey: Boise, Idaho, Idaho Department of Parks and Recreation, Report, 37 p.
- Adams, E.S., 1975, Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvelinus fontinalis*): *Transactions of the American Fisheries Society*, v. 104, no. 2, p. 363–373.
- Adams, J.A., Endo, A.S., Stolzy, L.H., Rowlands, P.G., and Johnson, H.B., 1982, Controlled experiments on soil compaction produced by off-road vehicles in the Mojave Desert, California: *Journal of Applied Ecology*, v. 19, no. 1, p. 167–175.
- Adams, L.W., and Geis, A.D., 1983, Effects of roads on small mammals: *Journal of Applied Ecology*, v. 20, no. 2, p. 403–415.
- American Motorcyclist Association, 1979, The economic impact of off-highway motorcycling in southern California and Mexico: Westerville, Ohio, Department of Government Relations, Technical Report, 14 p.
- Amezketta Lizarraga, E., Gazol Lostao, R., and Aragues Lafarga, R., 2002, Development of an automated infiltrometer and its applicability to the field: *Investigacion Agraria Produccion y Proteccion Vegetales*, v. 17, no. 1, p. 131–142.
- Anderson, D.H., Lime, D. W., and Wang, T.L., 1998, Maintaining the quality of park resources and visitor experiences—A handbook for managers: St. Paul, Minnesota, University of Minnesota Extension Tourism Center, TC-777, 149 p.
- Andrews, A., 1990, Fragmentation of habitat by roads and utility corridors—A review: *Australian Zoologist*, v. 26, p. 130–141.
- Angold, P.G., 1997, The impact of a road upon adjacent heathland vegetation—Effects on plants species composition: *Journal of Applied Ecology*, v. 34, no. 2, p. 409–417.

- Arnold, J.L., and Koel, T.M., 2006, Effects of snowmobile emissions on the chemistry of snowmelt runoff in Yellowstone National Park—Final report: Yellowstone National Park, Wyoming, Report YCR-2006-1, Fisheries and Aquatic Sciences Section, Center for Resources, available on the Internet at <http://www.nps.gov/yell/planyourvisit/upload/snmbssnowmelt.pdf> (accessed April 2007).
- Ashley, E.P., and Robinson, J.T., 1996, Road mortality of amphibians, reptiles, and other wildlife on the Long Point Causeway, Lake Erie, Ontario: *The Canadian Field-Naturalist*, v. 110, p. 403–412.
- Bakowski, C., and Kozakiewicz, M., 1988, The effect of forest road on bank vole and yellow-necked mouse populations: *Acta Theriologica*, v. 33, no. 12–25, p. 345–353.
- Barrett, H., Cagney, J., Clark, R., Fogg, J., Gebhardt, K., Hansen, P.L., Mitchell, B., Prichard, D., and Tippy, D., 1995, Riparian area management—Process for assessing proper functioning condition: Denver, Colorado, U.S. Bureau of Land Management, Technical Reference 1737-9, BLM/SC/ST-93/003 + 1737 +REV95.
- Bashore, T.L., Tzilkowski, W.M., and Bellis, E.D., 1985, Analysis of deer-vehicle collision sites in Pennsylvania: *Journal of Wildlife Management*, v. 49, no. 3, p. 769–774.
- Baur, A., and Baur, B., 1990, Are roads barriers to dispersal in the land snail *Arianta arbustorum*? : *Canadian Journal of Zoology*, v. 68, no. 33, p. 613–617.
- Bazzaz, F.A., and Garbutt, K., 1988, The response of annuals in competitive neighborhoods—Effects of elevated CO₂: *Ecology*, v. 69, no. 4, p. 937–946.
- Beier, P., 1993, Determining minimum habitat areas and habitat corridors for cougars: *Conservation Biology*, v. 7, no. 11, p. 94–108.
- Belnap, Jayne, 1993, Recovery rates of cryptobiotic crusts—Inoculant use and assessment methods: *Great Basin Naturalist*, v. 53, no. 1, p. 89–95.
- Belnap, Jayne, 2002, Impacts of off-road vehicles on nitrogen cycles in biological soil crusts—Resistance in different U.S. deserts: *Journal of Arid Environments*, v. 52, no. 2, p. 155–165.
- Belnap, Jayne, and Gardner, J.S., 1993, Soil microstructure in soils of the Colorado Plateau—The role of the cyanobacterium *Microcoleus vaginatus*: *Great Basin Naturalist*, v. 53, no. 1, p. 40–47.
- Benson, P.E., Nokes, W.A., Cramer, R.L., O'Connor, J., Lindeman, W., 1986, Air-quality and noise issues in environmental planning: Washington, D.C., Transportation Research Board and National Research Council Technical Report, 72 p., http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7172765.

- Berry, K.H., 1980a, A review of the effects of off-road vehicles on birds and other vertebrates, *in* DeGraaf, R.M., and Tilghman, N.G., eds., Management of western forests and grasslands for nongame birds—Workshop proceedings, Salt Lake City, Utah, February 11-14, 1980: Ogden Utah, U.S. Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-86, p. 451-467.
- Berry, K.H., 1980b, The effects of four-wheel vehicles on biological resources, *in* Andrews, R.N.L., and Nowak, P., eds., Off-road vehicle use—A management challenge: Washington, D.C., U.S. Office of Environmental Quality, p. 231-233.
- Berry, K.H., Shields, T., Woodman, A.P., Campbell, T., Roberson, J., Bohuski, K., and Karl, A., 1986, Changes in desert tortoise populations at the Desert Tortoise Research Natural Area between 1979 and 1985, Desert Tortoise Council proceedings of symposium, Palmdale, California, March 22-24, 1986: Desert Tortoise Council, p. 100-123.
- Bight, A.D., Coredell, H.K., Hoover, A.P., and Tarranr, M.A., 2003, A human dimensions framework—Guidelines for conducting social assessments: Asheville, North Carolina, U.S. Forest Service, Southern Research Station, 83 p.
- Boarman, W.I., Beigel, M.L., Goodlett, G.C., and Sazaki, M., 1998, A passive integrated transponder system for tracking animal movements: Wildlife Society Bulletin, v. 26, no. 4, p. 886-891.
- Boarman, W.I., and Sazaki, M., 1996, Highway mortality in desert tortoises and small vertebrates—Success of barrier fences and culverts, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30-May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Boarman, W.I., Sazaki, M., Berry, K.H., Goodlett, G.O., Jennings, W.B., and Woodman, A.P., 1993, Measuring the effectiveness of a tortoise-proof fence and culverts—Status report from first field season, Proceedings of the Desert Tortoise Council: Desert Tortoise Council, p. 126-142
- Boarman, W.I., Sazaki, M., and Jennings, W.B., 1997, The effects of roads, barrier fences, and culverts on desert tortoise populations in California, USA, *in* Abbeema, J.V., ed., Proceedings—Conservation, restoration, and management of tortoises and turtles—An international conference, State University of New York, Purchase, New York, July 1993: Orange, New Jersey, New York Turtle and Tortoise Society, p. 54-58.
- Boer Leffe, W. J., 1958, De entomologische waarde van eiken-berkenbos: De Levendc Natuur, v. 61, p. 97-102.
- Bolling, J.D., and Walker, L.R., 2000, Plant and soil recovery along a series of abandoned desert roads: Journal of Arid Environments, v. 46, no. 11, p. 1-24.

- Bowles, A.E., 1995, Responses of wildlife to noise, in Knight, R.L., and Gutzwiller, K.J., eds., *Wildlife and recreationists—Coexistence through management and research*: Washington, D.C., Island Press, p. 109–156.
- Boyle, S.A., and Samson, F.B., 1985, Effects of nonconsumptive recreation on wildlife—A review: *Wildlife Society Bulletin*, v. 13, p. 110–116.
- Brattstrom, B.H., and Bondello, M.C., 1983, Effects of off-road vehicle noise on desert vertebrates, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 167–206.
- Brody, A.J., and Pelton, M.R., 1989, Effects of roads on black bear movements in western North Carolina: *Wildlife Society Bulletin*, v. 17, p. 5–10.
- Brooks, J.J., and Champ, P.A., 2006, Understanding the wicked nature of "unmanaged recreation" in Colorado's Front Range: *Environmental Management*, v. 38, no. 5, p. 784–798, <http://www.springerlink.com/content/ek62272u626u6074/fulltext.pdf>.
- Brooks, M.L., 1995, Benefits of protective fencing to plant and rodent communities of the western Mojave Desert, California: *Environmental Management*, v. 19, no. 1, p. 65–74.
- Brooks, M.L., 1999, Effects of protective fencing on birds, lizards, and black-tailed hares in the western Mojave Desert: *Environmental Management*, v. 23, no. 3, p. 387–400.
- Brooks, M.L., and Lair, Bridget, 2005, Ecological effects of vehicular routes in a desert ecosystem: Henderson, Nevada, U.S. Geological Survey, Western Ecological Research Center, Las Vegas Field Station, Technical Report, 23 p., http://www.dmg.gov/documents/Desert_Road_Ecology_report.pdf (accessed April 4, 2006).
- Bruinderink, G.W.T.A., and Hazebroek, E., 1986, Ungulate traffic collisions in Europe: *Conservation Biology*, v. 10, no. 4, p. 1059–1067.
- Bury, R.B., 1980, What we know and do not know about off-road vehicle impacts on wildlife, in Andrews, R.N.L., and Nowak, P., eds., *Off-road vehicle use—A management challenge*: Washington, D.C., U.S. Office of Environmental Quality, p. 110–122.
- Bury, R.B., and Luckenbach, R.A., 1986, Abundance of desert tortoises (*Gopherus agassizii*) in natural and disturbed habitats: Fort Collins, Colorado, U.S. Fish and Wildlife Service, unpublished draft report.
- Bury, R.B., Luckenbach, R.A., and Busack, S.D., 1977, Effects of off-road vehicles on vertebrates in the California desert USA: Washington, D.C., U.S. Fish and Wildlife Service, *Wildlife Research Reports* no. 8, p. 1–23.

- Bury, R.L., and Fillmore, E.R., 1974, Design of motorcycle areas near campgrounds—Effects on riders and non riders: College Station, Texas, Department of Recreation and Parks, Texas A & M University, Technical Report, 72 p.
- Bury, R.L., Holland, S.M., McEwen, D.N., 1983, Analyzing recreational conflict—Understanding why conflict occurs is requisite to managing that conflict: *Journal of Soil and Water Conservation*, v. 3, no. 5, p. 401-403.
- Busack, S.D., and Bury, R.B., 1974, Some effects of off-road vehicles and sheep grazing on lizard populations in the Mojave Desert: *Biological Conservation*, v. 6, no. 3, p. 179–183.
- Byrd, D.S., Gilmore, J.T., and Lea, R.H., 1983, Effect of decreased use of lead in gasoline on the soil of a highway: *Environmental Science and Technology*, v. 17, p. 121–123.
- Caldewell, T.G., McDonald, E.V., and Young, M.H., 2006, Soil disturbance and hydrologic response at the National Training Center, Fort Irwin, California: *Journal of Arid Environments*, v. 67, no. 3, p. 456-472.
- Clark, W.D., and Karr, J.R., 1979, Effects of highways on red-winged blackbird and horned lark populations: *The Wilson Bulletin*, v. 91, p. 143–145.
- Clevenger, A.P., 1998, Permeability of the Trans-Canada Highway to wildlife in Banff National Park—Importance of crossing structures and factors influencing their effectiveness, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 109–119.
- Cline, R., Sexton, Natalie, and Stewart, S.C., 2007, A human-dimensions review of human-wildlife disturbance—A literature review of impacts, frameworks, and management solutions: Fort Collins, Colorado, U.S. Geological Survey, Open-File Report 2007-1111, 91 p.
- Cole, D.N., 1990, Trampling disturbance and recovery of cryptogamic soil crusts in Grand Canyon National Park: *Great Basin Naturalist*, v. 50, no. 4, p. 321–325.
- Cole, D.N., 2004, Environmental impacts of outdoor recreation in wildlands, *in* Manfredo, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., *Society and natural resources—A summary of knowledge*: Jefferson, Missouri, Modern Litho, p. 107–116.
- Cole, D.N. and Landres, P.B., 1995, Indirect effects of recreation on wildlife, *in* Knight, R.L., and Gutzwiller, K.J., eds., *Wildlife and recreationists—Coexistence through management and research*: Washington, D.C., Island Press, p. 183–202.

- Committee on Rangeland Classification, Board on Agriculture, and National Research Council, 1994, *Rangeland Health—New methods to classify, inventory, and monitor rangelands*: Washington, D.C., National Academy Press.
- Cordell, H.K., Betz, C.J., Green, G., and Owens, M., 2005, *Off-highway vehicle recreation in the United States, regions, and states—A national report from the national survey on recreation and the environment (NSRE)*: U.S. Forest Service, Southern Research Station, Technical Report, 90 p., <http://www.srs.fs.usda.gov/pubs/21307>.
- Cotts, N.R., Redente, E.F., and Schiller, R., 1991, *Restoration methods for abandoned roads at lower elevations in Grand Teton National Park, Wyoming: Arid Soil Research and Rehabilitation*, v. 5, p. 235–249.
- Council on Environmental Quality, 1997, *Considering cumulative effects under the National Environmental Policy Act*: Washington, D.C., Council of Environmental Quality, Technical Report, <http://www.nepa.gov/nepa/ccenepa/ccenepa.htm>.
- Crimmins, T., 1999, *Colorado off-highway vehicle user survey—Summary of results*: Denver, Colorado, Colorado State Parks, Technical Report, <http://www.outdoorlink.com/amtrails/resources/motors/motCoOHVsurvey/html>.
- Daines, R.H., Motto, H., and Chilko, D.M., 1970, *Atmospheric lead—Its relationship to traffic volume and proximity to highways*: *Environmental Science and Technology*, v. 4, no. 4, p. 318–322.
- Dave Miller Associates, 1981, *An economic/social assessment of snowmobiling in Maine: Windham, Maine*, Dave Miller Associates, Technical Report, 52 p.
- Davidson, E.D., and Fox, M., 1974, *Effects of off-road motorcycle activity on Mojave Desert vegetation and soil*: *Madroño*, v. 22, no. 8, p. 381–390.
- Dean Runyan Associates, 2000, *Campers in California travel patterns and economic impacts*: Portland, Oregon, Dean Runyan Associates, Technical Report, 76 p.
- Decker, D.J., Krueger, R.A., Bauer, Jr., R.A., Knuth, B.A., and Richmond, M.E., 1996, *From clients to stakeholders—A philosophical shift for fish and wildlife management*: *Human Dimensions of Wildlife*, v. 1, no. 1, p. 70–82.
- Dhindsa, M.S., Sandhu, J.S., Sandhu, P.S., and Toor, H.S., 1988, *Roadside birds in Punjab (India)—Relation to mortality from vehicles*: *Environmental Conservation*, v. 15, no. 4, p. 303–310.
- Dillman, D.A., 2007, *Mail and telephone surveys—The tailored design method*: New York, John Wiley & Sons, 375 p.

- Dimara, E., and Skuras, D., 1998, Rationing preferences and spending behavior of visitors to a scarce recreational resource with limited carrying capacity: *Land Economics*, v. 74, no. 3, p. 317-327.
- Dobson, A., Ralls, K., Foster, M., Soulé, M.E., Simberloff, D., Doak, D., Estes, J.A., Mills, L.S., Mattson, D., Dizro, R., Arita, H., Ryan, S., Norse, E.A., Noss, R.F., and Johns, D., 1999, Connectivity—Maintaining flows in fragmented landscapes, *in* Soulé, M.E., and Terborgh, J., eds., *Continental Conservation—Scientific foundations of regional reserve networks*: Washington, D.C., Island Press, p. 129–170.
- Gabor, T.S., North, A.K., Ross, L.C.M., Anderson, J.S., and Raven, M., 2004, Natural values—The importance of wetlands and upland conservation practices in watershed management: Stonewall, Manitoba, Ducks Unlimited Canada. Available online at http://www.ducks.ca/conserve/wetland_values/pdf/nvalue.pdf.
- Eckert, R.E.J., Wood, M.K., Blackburn, W.H., and Peterson, F.F., 1979, Impacts of off-road vehicles on infiltration and sediment production of two desert soils: *Journal of Range Management*, v. 32, no. 5, p. 394–397.
- English, B., Menard, J., and Jensen, K., 2001, Estimated economic impacts of off-highway vehicle special events: Knoxville, Tennessee, Agri-Industry Modeling and Analysis Group, Department of Agricultural Economics, University of Tennessee, <http://aimag.ag.utk.edu/pubs/ohveventimpacts.pdf> (accessed May, 2007).
- Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., 1996, Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., 1998, Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98.
- Ewert, A., and Shultis, J., 1999, Technology and backcountry recreation—Boon to recreation or bust for management?: *Technology and Leisure*, v. 70, no. 8, p. 23–31.
- Falkengren-Grerup, U., 1986, Soil acidification and its impact on ground vegetation: *Oecologia*, v. 70, p. 339–347.
- Feldhammer, G.A., Gates, J.E., Harman, D.M., Loranger, A.J., and Dixon, K.R., 1986, Effects of interstate highway fencing on white-tailed deer activity: *Journal of Wildlife Management*, v. 50, no. 4, p. 497–503.
- Ferris, R., and Taylor, G., 1995, Contrasting effects of elevated CO₂ and water deficit on two native herbs: *New Phytologist*, v. 131, no. 4, p. 491–501.

- Fisher, A.L., Blahna, D.J., and Bahr, R., 2001, Off-highway vehicle uses and owner preferences in Utah: Logan, Utah, Institute for Outdoor Recreation and Tourism, Department of Forest Resources, Utah State University, Report no. IORT PR2001-02, 80 p.
- Flint, A.L., and Childs, S., 1984, Development and calibration of an irregular hole bulk density sampler: *Soil Science Society of America Journal*, v. 48, no. 2, p. 374–378.
- Folz, R.B., 2006, Erosion from all terrain vehicle (ATV) trails on National Forest lands (abs.): St. Joseph, Michigan, Proceedings of the 2006 American Society of Agricultural and Biological Engineers, <http://asae.frymulti.com/abstract.asp?aid=21056&t=2>.
- Forman, R.T.T., and Alexander, L.E., 1998, Roads and their major ecological effects: *Annual Review of Ecology and Systematics*, v. 29, p. 207–231.
- Forman, R.T.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V.H., Fahrig, L., France, R., Goldman, C.R., Heanue, K., and others, 2003, *Road ecology—Science and solutions*: Washington, D.C., Island Press, 481 p.
- Foster, M.L., and Humphrey, S.R., 1995, Use of highway underpasses by Florida panthers and other wildlife: *Wildlife Society Bulletin*, v. 23, no. 1, p. 95–100.
- Fox, D.G., 1986, Establishing a baseline/protocols for measuring air quality effects in wilderness: U.S. Forest Service, Rocky Mountain Forest and Range Experimental Station, Technical Report, 85–91 p.
- Froehlich, H.A., Miles, D.W.R., and Robbins, R.W., 1985, Soil bulk density recovery on compacted skid trails in central Idaho: *Soil Science Society of America Journal*, v. 49, p. 1015–1017.
- Furniss, M.J., Flanagan, S.A., and McFadin, B.A., 2000, Hydrologically connected roads—An indicator of the influence of roads on chronic sedimentation, surface water hydrology, and exposure to toxic chemicals: U.S. Forest Service, Stream Systems Technology Center, Rocky Mountain Research Station, Technical Report, 4 p., http://www.stream.fs.fed.us/streamnt/jul100/jul100_2.htm.
- Garland, T., and Bradley, W.G., 1984, Effects of a highway on Mojave Desert rodent populations: *American Midland Naturalist*, v. 111, p. 47–56.
- Gibbs, J.P., 1998, Amphibian movements in response to forest edges, roads, and streambeds in southern New England: *Journal of Wildlife Management*, v. 62, no. 2, p. 584–589.
- Gibeau, M.L., and Herrero, S., 1998, Roads, rails, and grizzly bears in the Bow River Valley, Alberta, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida,

February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 104–108.

- Gilbert, T., and Wooding, J., 1996, An overview of black bear roadkills in Florida 1976–1995, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Gill, T.E., 1996, Eolian sediments generated by anthropogenic disturbances of playas—Human impacts on the geomorphic system and geomorphic impacts on the human system: Geomorphology, v. 17, no. 1–3, p. 207–228.
- Gish, C.D., and Christensen, R.E., 1973, Cadmium, nickel, lead, and zinc in earthworms from roadside soil: Environmental Science and Technology, v. 7, p. 1060–1062.
- Graefe, A.R., and Thapa, B., 2004, Conflict in natural resource recreation, in Manfredo, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., Society and natural resources—A summary of knowledge: Jefferson, Missouri, Modern Litho, p. 209–224.
- Grant, T.J., 2005, Flat-tailed horned lizards (*Phrynosoma mcallii*)—Population size estimation, effects of off-highway vehicles, and natural history: Fort Collins, Colorado, M.S. thesis, Department of Wildlife Biology, Colorado State University, 84 p., http://www.warnercnr.colostate.edu/~doherty/Tyler%20Grant%20M.S.%20Thesis_FINAL.pdf.
- Grantz, D.A., Vaughn, D.L., Farber, R., Kim, B., Zeldin, M., Vancuren, T., and Campbell, R., 1998, Seeding native plants to restore desert farmland and mitigate fugitive dust and PM₁₀: Journal of Environmental Quality, v. 27, p. 1209–1218.
- Graves, W.L., 1978, Revegetation of disturbed sites in the Mojave Desert with native shrubs: California Agriculture, p. 4–5.
- Graves, W.L., Kay, B.L., and Williams, W.A., 1975, Seed treatment of Mojave Desert shrubs: Agronomy Journal, v. 67, p. 773–777.
- Griffiths, M., and Van Schaik, C.P., 1993, The impact of human traffic on the abundance and activity periods of Sumatran rain forest wildlife: Conservation Biology, v. 7, no. 3, p. 623–626.
- Grimes, D.W., Miller, R.J., and Wiley, P.L., 1975, Cotton and corn root development in two field soils of different strength characteristics: Agronomy Journal, v. 67, p. 519–523.
- Grimes, D.W., Sheesley, W.R., and Wiley, P.L., 1978, Alfalfa root development and shoot regrowth in compact soil of wheel traffic patterns: Agronomy Journal, v. 70, p. 955–958.

- Groom, J., McKinney, T., Gant, T., and Winchell, C., 2005, Preliminary 2006 *Astragalus magdalenae* var. *peirsonii* survivorship and demography findings: Carlsbad, California, U.S. Fish and Wildlife Service Field Office, <http://www.fws.gov/carlsbad/Rules/PMV/USFWS%202006%20preliminary%20findings.pdf>.
- Grue, C.E., O'Shea, T.J., and Hoffman, D.J., 1984, Lead concentrations and reproduction in highway-nesting barn swallows [*Hirundo rustica*]: Condor, v. 86, no. 4, p. 383–389.
- Gutzwiller, K.J., 1995, Recreational disturbances and wildlife communities in Knight, R.L., and Gutzwiller, K.J., eds., Wildlife and recreationists—Coexistence through management and research: Washington, D.C., Island Press, p. 169–181.
- Hanski, I., 1999, Metapopulation ecology: New York, Oxford University Press, 324 p.
- Hanski, I., and Simberloff, D., 1997, The metapopulation approach, its history, conceptual domain, and application to conservation, in Hanski, I., Gilpin, M., and Hanski, I., eds., Metapopulation biology—Ecology, genetics, and evolution: San Diego, California, Academic Press, p. 5–26.
- Harris, L.D., and Gallagher, P.B., 1989, New initiatives for wildlife conservation—The need for movement corridors, in Mackintosh, G., ed., Preserving communities and corridors: Washington, D.C., Defenders of Wildlife, p. 11–34.
- Haupt, H.F., 1959, Road and slope characteristics affecting sediment movement from logging roads: Journal of Forestry, v. 57, no. 5, p. 329–339.
- Havlick, D.G., 2002, No place distance—Roads and motorized recreation on America's public lands: Washington, D.C., Island Press, 297 p.
- Hillel, D., and Tadmor, N., 1962, Water regime and vegetation in central Negev Highlands of Israel: Ecology, v. 43, no. 1, p. 33–41.
- Hinckley, B.S., Iverson, R.M., and Hallet, B., 1983, Accelerated water erosion in ORV off-road vehicle-use areas, in Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, p. 81–96.
- Holzapfel, C., and Schmidt, W., 1990, Roadside vegetation along transects in the Judean Desert: Israel Journal of Botany, v. 39, p. 263–270.
- Hooks, C.L., and Jansen, I.J., 1986, Recording cone penetrometer developed in reclamation research: Soil Science Society of America Journal, v. 50, no. 1, p. 10–12.
- Hudson, N.W., 1971, Soil conservation: Ithaca, New York, Cornell University Press, 320 p.
- Huey, L.M., 1941, Mammalian invasion via the highway: Journal of Mammalogy, v. 22, p. 383–385.

- Hunt, R., Hand, D.W., Hannah, M.A., and Neal, A.M., 1991, Response to CO₂ enrichment in 27 herbaceous species: *Functional Ecology*, v. 5, no. 3, p. 410–421.
- Isensee, E., and Luth, H.G., 1992, Continuous recording of soil density: *Landtechnik*, v. 47, no. 9, p. 449–452.
- Iverson, R.M., Hinckley, B.S., and Webb, R.M., 1981, Physical effects of vehicular disturbances on arid landscapes: *Science*, v. 212, no. 4497, p. 915–917.
- Jackson, E.L., and Wong, R.A., 1982, Perceived conflict between urban cross-country skiers and snowmobilers in Alberta: *Journal of Leisure Research*, v. 14, no. 1, p. 47–62.
- Jackson, S.D., and Griffin, C.R., 1998, Toward a practical strategy for mitigating highway impacts on wildlife, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 17–22.
- Jacob, G. R., and Schreyer, R., 1980, Conflict in outdoor recreation—A theoretical perspective: *Journal of Leisure Research*, v. 12, no. 4, p. 368–380.
- Jim, C., 1989, Visitor management in recreation areas: *Environmental Conservation*, v. 16, no. 1, p. 19–32.
- Johansen, J.R., 1993, Cryptogamic crusts of semiarid and arid lands of North America: *Journal of Phycology*, v. 29, no. 22, p. 140–147.
- Johansen, K., Coops, N.C., Gergel, S.E., and Stange, Y., 2007, Application of high spatial resolution satellite imagery for riparian and forest ecosystem classification: *Remote Sensing of Environment*, v. 110, no. 1, p. 29–44.
- Johnson, H.B., Vasek, F.C., and Yonkers, T., 1975, Productivity, diversity and stability relationships in Mojave Desert roadside vegetation: *Bulletin of the Torrey Botanical Club*, v. 102, p. 106–115.
- Kaseloo, P.A., and Tyson, K.O., 2004, Synthesis of noise effects on wildlife populations: Office of Research and Technology Services, Federal Highway Administration, Report no. FHWA–HEP–06–016, 67 p.
- Kay, B.L., 1988, Artificial and natural revegetation of the second Los Angeles aqueduct: *Mojave Revegetation Notes*, no. 24, p. 1–3.

- Kay, B.L., and Graves, W.L., 1983, History of revegetation studies in the California deserts, *in* Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 315–324.
- Keener, K.M., Wood, R.K., Holmes, R.G., and Morgan, M.T., 1991, Soil strength evaluation of sample cores in a field measurement system: St. Joseph, Michigan, American Society of Agricultural Engineers, ASAE Paper No. 91-1526, 10 p.
- Kline, N.C., and Swann, D.E., 1998, Quantifying wildlife road mortality in Saguaro National Park, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 23–31.
- Knight, R.L., and Cole, D.N., 1995, Wildlife response to recreationists, *in* Knight, R.L., and Gutzwiller, K.J., eds., *Wildlife and recreationists—Coexistence through management and research*: Washington, D.C., Island Press, p. 51–69.
- Knight, R.L., and Kawashima, J.Y., 1993, Responses of raven and red-tailed hawk populations to linear right-of-ways: *Journal of Wildlife Management*, v. 57, no. 2, p. 265–271.
- Komatsu, M., Kato, A., and Sakamoto, K., 1988, Study on the automatic measurement system of soil parameters. Development of soil hardness sensor: Tottori, Japan, Tottori University, *Bulletin of the Faculty of Agriculture*, v. 41, p. 39–46.
- Kopperoinen, L., Shemeikka, P.J., and Lindblom, V., 2004, Environmental GIS in the management of visitor flows: Helsinki, Finland, Finnish Environment Institute, Working Papers of the Finnish Forest Research Institute 2, <http://www.metla.fi/julkaisut/workingpapers/2004/mwp002-58.pdf>.
- Lacey, C.A., Lacey, J.R., Fay, P.K., Storey, J.M., and Zamora, D.L., 1997, Controlling knapweed on Montana rangeland: Bozeman, Montana, Montana State University Extension Service, Circular 311.
- Lehnert, M.E., and Bissonette, J.A., 1997, Effectiveness of highway crosswalk structures at reducing deer-vehicle collisions: *Wildlife Society Bulletin*, v. 25, no. 4, p. 809–818.
- Leung, Y.-F., and Meyer, K., 2004, Soil compaction as indicated by penetration resistance—A comparison of two types of penetrometers, *in* Harmon, D., Kilgore, B.M., and Vietzke, G.E. eds., *Protecting our diverse heritage—The role of parks, protected areas, and cultural sites*, *Proceedings of the 2003 George Wright Society / National Park Service Joint Conference*: Hancock, Michigan, The George Wright Society, <http://www.georgewright.org/2003proc.html> (accessed April 2007).
- Liddle, M.J., 1997, *Recreation ecology—The ecological impact of outdoor recreation and ecotourism*: London, Chapman and Hall, 666 p.

- Lightfoot, D.C., and Whitford, W.G., 1991, Productivity of creosotebush foliage and associated canopy arthropods along a desert roadside: *American Midland Naturalist*, v. 125, no. 2, p. 310–322.
- Lindenmayer, D.B., Margules, C.R., and Botkin, D.B., 2000, Indicators of biodiversity for ecological sustainable management: *Conservation Biology*, v. 14, p. 941–950.
- Lisle, T.E., and Eads, R.E., 1991, Methods to measure sedimentation of spawning gravels: Berkeley, California, U.S. Forest Service, Pacific Southwest Research Station, Research Note PSW-411, 7 p., <http://www.fs.fed.us/psw/rsl/projects/water/Lisle91.pdf> (accessed April 2007).
- Lovallo, M.J., and Anderson, E.M., 1996, Bobcat (*Lynx rufus*) home range size and habitat use in northwest Wisconsin: *American Midland Naturalist*, v. 135, no. 2, p. 241–252.
- Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: *Environmental Management*, v. 24, no. 3, p. 309–326.
- Lowery, B., and Morrison, J.E., Jr., 2002, Soil penetrometers and penetrability, in Dane, J., and Topp, C., eds., *Methods of soil analysis, part 4—Physical methods*: Madison, Wisconsin, Soil Science Society of America, p. 363–388.
- Luckenbach, R.A., 1978, An analysis of off- road vehicle use on desert avifaunas: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 43, p. 157–162.
- Luckenbach, R.A., and Bury, R.B., 1983, Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County, California, USA: *Journal of Applied Ecology*, v. 20, no. 1, p. 265–286.
- Luo, H.R., Smith, L.M., Allen, B.L., and Haukos, D.A., 1997, Effects of sedimentation on playa wetland volume: *Ecological Applications*, v. 7, p. 247–252.
- Lyren, L., 2001, Movement patterns of coyotes and bobcats relative to roads and underpasses in the Chino Hills area of southern California: Pomona, California, California State Polytechnic University, Pomona, 127 p.
- Mader, H.J., 1984, Animal habitat isolation by roads and agricultural fields: *Biological Conservation*, v. 29, no. 1, p. 81–96.
- Major, M.J., 1987, Managing off-the-road vehicles—A recurring round of events: *Journal of Forestry*, v. 85, no. 11, p. 37–41.

- Massachusetts Department of Environmental Management, 1995, Report on policy for off-road vehicle use in Massachusetts forests and parks: Boston, Massachusetts, Massachusetts Executive Office of Environmental Affairs.
- Matchett, J.R., Gass, L., Brooks, M.L., Mathie, A.M., Vitales, R.D., Campagna, M.W., Miller, D.M., and Weigand, J.F., 2004, Spatial and temporal patterns of off-highway vehicle use at the Dove Springs OHV Open Area, California: Henderson, Nevada, U.S. Geological Survey, Western Ecological Research Center, 17 p.,
http://www.werc.usgs.gov/lasvegas/pdfs/Matchett_et_al_2004_Spatial%20and%20Temporal%20Patterns%20of%20off-highway.pdf (accessed May 2007).
- McBrayer, M.C., Mauldon, M., Drumm, E.C., and Wilson, G.V., 1997, Infiltration tests on fractured compacted clay: *Journal of Geotechnical and Geoenvironmental Engineering*, v. 123, no. 5, p. 469–473.
- McCaffery, K.R., 1973, Road-kills show trends in Wisconsin deer populations: *Journal of Wildlife Management*, v. 37, no. 2, p. 212–216.
- Means, D.B., 1999, The effects of highway mortality on four species of amphibians at a small, temporary pond in northern Florida, *in* Evink, G.L., Garrett, P., and Zeigler, D., eds., *Proceedings of the third international conference on wildlife ecology and transportation*, Missoula, Montana, September 13–16: Tallahassee, Florida, Florida Department of Transportation, Report no. FL-ER-73-99, p. 125–128.
- Meffe, G.K., and Carroll, R.C., 1997, *Principles of conservation biology*: Sunderland, Massachusetts, Sinauer Associates, Inc., 729 p.
- Meine, C., 1998, Outdoor recreation in the United States—The quiet explosion, *in* *Outdoor recreation—Promise and peril in the new West*: Boulder, Colorado, 19th Annual Summer Conference, Natural Resources Law Center, University of Colorado School of Law and the U.S. Bureau of Land Management.
- Miller, R.E., Hazard, J., and Howes, S., 2001, Precision, accuracy, and efficiency of four tools for measuring soil bulk density or strength: U.S. Forest Service, Pacific Northwest Research Station, Report no. PNW–RP–532, 16 p.
- Miller, S., 1998, Environmental impacts—The dark side of outdoor recreation, *in* *Outdoor recreation—Promise and peril in the New West*: Boulder, Colorado, 19th Annual Summer Conference, Natural Resources Law Center, University of Colorado School of Law and U.S. Bureau of Land Management.
- Mooney, H.A., Kueppers, M., Koch, G., Gorham, J., Chu, C., and Winner, W.E., 1988, Compensating effects to growth of carbon partitioning changes in response to SO₂-induced photosynthetic reduction in radish: *Oecologia*, v. 75, no. 4, p. 502–506.

- Moore, T.G., and Mangel, M., 1996, Traffic related mortality and the effects on local populations of barn owls *Tyto alba*, in Evink, G.L., Garrett, P., Zeigler, D., and Barry, J., eds., Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Motto, H.L., Daines, R.H., Chilko, D.M., and Motto, C.K., 1970, Lead in soils and plants—Its relationship to traffic volume and proximity to highways: *Environmental Science and Technology*, v. 4, p. 231–237.
- Mumme, R.L., Schoech, S.J., Woolfenden, G.W., and Fitzpatrick, J.W., 2000, Life and death in the fast lane—Demographic consequences of road mortality in the Florida scrub-jay: *Conservation Biology*, v. 14, no. 2, p. 501–512.
- Munguira, M.L., and Thomas, J.A., 1992, Use of road verges by butterfly and burnet populations, and the effect of roads on adult dispersal and mortality: *Journal of Applied Ecology*, v. 29, p. 316–329.
- Nakata, J.K., 1983, Off-road vehicular destabilization of hill slopes—The major contributing factor to destructive debris flows in Ogden, Utah, 1979, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 343–353.
- Nakata, J.K., Wilshire, H.G., and Barnes, G.C., 1976, Origin of Mojave Desert dust plume photographed from space: *Geology*, v. 4, p. 644–648.
- Nelson, C.M., and Lynch, J.A., 2001, A usable pilot off-road vehicle project evaluation: East Lansing, Michigan, Department of Park, Recreation and Tourism Resources, Michigan State University, Technical Report, 50 p.
- Nelson, C.M., Lynch, J.A., and Stynes, D.J., 2000, Michigan licensed off-road vehicle use and users 1998–99: East Lansing, Michigan, Department of Park, Recreation and Tourism Resources, Michigan State University, Technical Report, 49 p.
- Nicholson, L., 1978, The effects of roads on desert tortoise populations, in Trotter, M. (ed.), *Proceedings of the 1978 Desert Tortoise Council Symposium*, San Diego, California: Desert Tortoise Council, p. 127–129.
- Noon, B.R., 2003, Conceptual models in monitoring ecological resources, in Busch, D.E., and Trexler, J.C., eds., *Monitoring ecosystems—Interdisciplinary approaches for evaluating ecoregional initiatives*: Washington, D.C., Island Press, p. 27–71.
- Olewiler, N., 2004, The value of natural capital in settled areas of Canada: Stonewall, Manitoba, Ducks Unlimited Canada and the Nature Conservancy of Canada, 36 p. Available online at <http://www.ducks.ca/aboutduc/news/archives/pdf/ncapital.pdf>.

- O'Sullivan, M.F., and Ball, B.C., 1982, A comparison of five instruments for measuring soil strength in cultivated and uncultivated cereal seedbeds: *Journal of Soil Science*, v. 33, no. 4, p. 597–608.
- Ouren, D.S., and Watts, R.D., 2005, Public access management as an adaptive wildlife management tool: Fort Collins, Colorado, U.S. Geological Survey, Open-File Report 2005-1349, 10 p.
- Oxley, D.J., Fenton, M.B., and Carmody, G.R., 1974, Effects of roads on populations of small mammals: *Journal of Applied Ecology*, v. 11, no. 1, p. 51–59.
- Paquet, P., and Callahan, C., 1996, Effects of linear developments of winter movement of gray wolves in the Bow River Valley of Banff National Park, Alberta, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Parendes, L.A., and Jones, J.A., 2000, Role of light availability and dispersal in exotic plant invasion along roads and streams in the H. J. Andrews Experimental Forest, Oregon: *Conservation Biology*, v. 14, no. 1, p. 64–75.
- Pellant, M., Shaver, P., Pyke, D.A., and Herrick, J.E., 2005, Interpreting indicators of rangeland health, version 4—Technical Reference 1734-6: Denver, Colorado, U.S. Bureau of Land Management, National Science and Technology Center, Report no. BLM/WO/ST-00/001+1734/REV05, 122 pp.
- Petersen, T.R., ed., 2006, A road runs through it—Reviving wild places: Boulder, Colorado, Johnson Books, 240 p.
- Phillips, A.M., III, and Kennedy, D.J., 2006, Seed bank and survival of Peirson's milkvetch (*Astragalus magdalenae* var. *peirsonii*) in the Algodones Dunes, California, 2005-06, final report prepared for the American Sand Association: Eckert, Colorado, Botanical and Environmental Consulting, 22 p.
- Powers, R.F., Tiarks, A.E., and Boyle, J.R., 1998, Assessing soil quality—Practicable standards for sustainable forest productivity in the United States, *in* The contribution of soil science to the development of and implementation of criteria and indicators of sustainable forest management: St. Louis, Missouri, Soil Science Society of America, Inc., p. 53–80.
- Prose, D.V., 1985, Persisting effects of armored military maneuvers on some soils of the Mojave Desert: *Environmental Geology and Water Sciences*, v. 7, no. 3, p. 163–170.

- Prose, D.V., Metzger, S.K., and Wilshire, H.G., 1987, Effects of substrate disturbance on secondary plant succession—Mojave Desert, California: *Journal of Applied Ecology*, v. 24, no. 1, p. 305–313.
- Quarles, H.D., Hanawalt, R.B., and Odum, W.E., 1974, Lead in small mammals, plants, and soil at varying distances from a highway: *Journal of Applied Ecology*, v. 11, no. 3, p. 937–949.
- Rasor, R., 1976, Fair share: *American Motorcycle Association News*, August, p. 16–17.
- Reed, P., and Haas, G., 1989, Off highway vehicles in Colorado: estimated recreational use and expenditures: Fort Collins, Colorado, Colorado State University, Department of Recreational Resource and Landscape Architecture, 13 p.
- Reed, R.A., Johnson-Barnard, J., and Baker, W.L., 1996, Contribution of roads to forest fragmentation in the Rocky Mountains: *Conservation Biology*, v. 10, no. 4, p. 1098–1106.
- Reijnen, R., Foppen, R., Braak, C.T., and Thissen, J., 1995, The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads: *Journal of Applied Ecology*, v. 32, no. 1, p. 187–202.
- Reijnen, R., Foppen, R., and Meeuwsen, H., 1996, The effects of traffic on the density of breeding birds in Dutch agricultural grasslands: *Biological Conservation*, v. 75, p. 255–260.
- Reijnen, R., Foppen, R., and Veenbaas, G., 1997, Disturbance by traffic of breeding birds—Evaluation of the effect and considerations in planning and managing road corridors: *Biodiversity and Conservation*, v. 6, no. 4, p. 567–581.
- Ringold, P.L., Mulder, Barry, Alegria, Jim, Czaplewski, R.L., Tolle, Tim, and Burnett, Kim, 2003, Design of an ecological monitoring strategy for the forest plan in the Pacific Northwest, in Busch, D.E., and Trexler, J.C., eds., *Monitoring ecosystems—Interdisciplinary approaches for evaluating ecoregional initiatives*: Washington, D.C., Island Press, p. 73-99.
- Rocky Mountain Research Institute, 2002, Off-road vehicles in Colorado—Facts, trends, recommendations: Nederland, Colorado, Rocky Mountain Research Institute.
- Romin, L.A., and Bissonette, J.A., 1996, Temporal and spatial distribution of highway mortality of mule deer on newly constructed roads at Jordanelle Reservoir, Utah: *Great Basin Naturalist*, v. 56, no. 1, p. 1–11.
- Rosen, P.C., and Lowe, C.H., 1994, Highway mortality of snakes in the Sonoran Desert of southern Arizona: *Biological Conservation*, v. 68, no. 22, p. 143–148.
- Rudolph, D.C., Burgdorf, S.J., Conner, R.N., and Dickson, J.G., 1998, The impact of roads on the timber rattlesnake, (*Crotalus horridus*), in eastern Texas, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife*

- Ecology and Transportation, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 236–240.
- Ruediger, B., 1998, Rare carnivores and highways—Moving into the 21st century, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 10–16.
- Samways, M.J., 1989, Insect conservation and landscape ecology—A case-history of bush crickets (Tettigoniidae) in southern France: *Environmental Conservation*, v. 16, no. 3, p. 217–226.
- Sanders, T.G., and Addo, J.Q., 2000, Experimental road dust measurement device: *Journal of Transportation Engineering*, v. 126, no. 6, p. 530-535.
- Schuett, M.A., and Ostergren, D., 2003, Environmental concern and involvement of individuals in selected voluntary associations: *Journal of Environmental Education*, v. 34, no. 4, p. 30–38.
- Seibert, H.C., and Conover, J.H., 1991, Mortality of vertebrates and invertebrates on an Athens County, Ohio [USA], highway: *Ohio Journal of Science*, v. 91, no. 4, p. 163–166.
- Servheen, C., Walker, J., and Kasworm, W., 1998, Fragmentation effects of high-speed highways on grizzly bear populations shared between the United States and Canada, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 97–103.
- Shindler, B., Brunson, M.W., and Cheek, K.A., 2004, Social acceptability in forest and range management, *in* Manfredo, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., *Society and natural resources—A summary of knowledge*: Jefferson, Missouri, Modern Litho, p. 146–157.
- Singer, F.J., 1978, Behavior of mountain goats in relation to US Highway 2, Glacier Park, Montana: *Journal of Wildlife Management*, v. 42, p. 591–597.
- Smith, W.H., 1976, Lead contamination of the roadside ecosystem: *Journal of the Air Pollution Control Association*, v. 26, p. 753–766.
- Spellerberg, I.F., 1998, Ecological effects of roads and traffic—A literature review: *Global Ecology and Biogeography Letters*, v. 7, no. 5, p. 317–333.

- Spellerberg, I.F., and Morrison, T., 1998, The ecological effects of new roads—A literature review: Wellington, New Zealand, New Zealand Department of Conservation, Technical Report, 55 p.
- Spencer, H.J., and Port, G.R., 1988, Effects of roadside conditions on plants and insects: II. Soil conditions: *Journal of Applied Ecology*, v. 25, no. 22, p. 709–715.
- Stefanov, W.L., Ramsey, M.S., and Christensen, P.R., 2001, Mapping of fugitive dust generation, transport, and deposition in the Nogales, Arizona region using Enhanced Thematic Mapper Plus (ETM+) data: American Geophysical Union, 2001 Spring Meeting, Boston, Massachusetts, May 29–June 2, 2001, abstract no. B32A-10, <http://adsabs.harvard.edu/abs/2001AGUSM...B32A10S> (accessed May 2007).
- Stokowski, P.A., and LaPointe, C.B., 2000, Environmental and social effects of ATVs and ORVs—An annotated bibliography and research assessment: Burlington, Vermont, University of Vermont, School of Natural Resources, 32 p., <http://atfiles.org/files/pdf/ohvbibliogVT00.pdf>.
- Sullivan, B.K., 1981, Distribution and relative abundance of snakes along a transect in California: *Journal of Herpetology*, v. 15, no. 2, p. 247–248.
- Swihart, R.K., and Slade, N.A., 1984, Road crossing in *Sigmodon hispidus* and *Microtus ochrogaster*: *Journal of Mammalogy*, v. 65, no. 2, p. 357–360.
- Tewes, M.E., and Blanton, D.R., 1998, Potential impacts of international bridges on ocelots and jaguarundis along the Rio Grande wildlife corridor, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 135–139.
- Thompson, C.R., Kats, G., and Lennox, R.W., 1980, Effects of SO₂ and/or NO₂ on native plants of the Mojave Desert and Eastern Mojave-Colorado Desert: *Journal of the Air Pollution Control Association*, v. 30, no. 12, p. 1304–1309.
- Thompson, C.R., Olszyk, D.M., Kats, G., Bytnerowicz, A., Dawson, P.J., and Wolf, J.W., 1984, Effects of ozone or sulfur dioxide on annual plants of the Mojave Desert: *Journal of the Air Pollution Control Association*, v. 34, no. 10, p. 1017–1022.
- Trombulak, S.C., and Frissell, C.A., 2000, Review of ecological effects of roads on terrestrial and aquatic communities: *Conservation Biology*, v. 14, no. 1, p. 18–30.
- Tyser, R.W., and Worley, C.A., 1992, Alien flora in grasslands adjacent to road and trail corridors in Glacier National Park, Montana (U.S.A.): *Conservation Biology*, v. 6, no. 2, p. 253–262.

- U.S. Bureau of Land Management, 2001, Rangeland health standards handbook H-4180-1, release 4-107: U.S. Bureau of Land Management, 50 p.,
<http://www.blm.gov/nhp/efoia/wo/handbook/h4180-1.pdf> (accessed April 2007)
- U.S. Bureau of Land Management, 2006, Roads and trails terminology: Denver, Colorado, Technical Note 422. U.S. Bureau of Land Management, Technical Notes
BLM/WO/ST-06/006, 67 p.
- U.S. Bureau of Land Management, 2007, Notice of final action to adopt revisions to the Bureau of Land Management's procedures for managing the NEPA process, chapter 11 of the Department of the Interior's manual part 516: Federal Register, vol. 72, no. 156, part II, p. 45504- 45542.
- Udevitz, M.S., Howard, C.A., Robel, R.J., and Curnutte, B., 1980, Lead contamination in insects and birds near an interstate highway, Kansas: Environmental Entomology, v. 9, no. 1, p. 35–36.
- van der Zande, A.N., Keurs, W.J., and van der Weijden, W.J., 1980, The impact of roads on the densities of four bird species in an open field habitat—Evidence of a long-distance effect: Biological Conservation, v. 18, no. 4, p. 299–321.
- Van Dyke, F.G., Brocke, R.H., and Shaw, H.G., 1986, Use of road track counts as indices of mountain lion presence: Journal of Wildlife Management, v. 50, no. 1, p. 102–109.
- Van Horne, Beatrice, 1983, Density as a misleading indicator of habitat quality: Journal of Wildlife Management, vol. 47, no. 4, p. 893–901.
- Vancini, F.W., 1989, Policy and management considerations for off-road vehicles—Environmental and social impacts: Ithaca, New York, Cornell University, 19 p.
- Vasek, F.C., Johnson, H.B., and Brum, G.D., 1975, Effects of power transmission lines on vegetation of the Mojave Desert: Madroño, v. 23, no. 1, p. 114–130.
- Vaske, J. J., Donnelly, M. P., Wittmann, K., and Laidlaw, S., 1995, Interpersonal versus social-values conflict: Leisure Sciences, v. 17, no. 3, p. 205-222.
- Vaske, J.J, Fulton, D.C., and Manfredo, M.J., 2001, Human dimensions considerations in wildlife management planning, *in* Decker, D.J., Brown, T.L., and Siemer, W.F., eds., Human Dimensions of Wildlife Management in North America: Bethesda, Maryland, The Wildlife Society, p. 91-108.
- Veen, J., 1973, De verstorende van weidevogelpopulaties: Stedeb. en Volkshuisv., 5v. 3, p. 16-26.
- von Seckendorff Hoff, K., and Marlow, R., 1997, Highways and roads are population sinks for desert tortoises, *in* New York Turtle and Tortoise Society, Proceedings—Conservation,

- restoration, and management of tortoises and turtles—An international conference: Orange, New Jersey, New York Turtle and Tortoise Society, p. 482.
- Vos, C.C., and Chardon, J.P., 1998, Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*: *Journal of Applied Ecology*, v. 35, no. 1, p. 44–56.
- Walker, D.A., and Everett, K.R., 1987, Road dust and its environmental impact on Alaskan taiga and tundra: *Arctic and Alpine Research*, v. 19, no. 4, p. 479–489.
- Wallace, A., Romney, E.M., and Hunter, R.B., 1980, The challenge of a desert: revegetation of disturbed desert lands, in Woods, S.L., ed., *Great Basin naturalist memoirs—Soil-plant-animal relationships bearing on revegetation and land reclamation in Nevada Deserts*: Provo, Utah, Brigham Young University, p. 216–225.
- Ward, A.L., 1982, Mule deer behavior in relation to fencing and underpass on Interstate 80 in Wyoming: *Transportation Research Record*, v. 859, no. 8–13.
- Watson, A., Asp, C., Walsh, J. and Kulla, A., 1997, The contribution of research to managing conflict among national forest users: *Trends*, v. 34, no. 3, p. 29–35.
- Webb, R.H., 1982, Off-road motorcycle effects on a desert soil: *Environmental Conservation*, v. 9, no. 3, p. 197–208.
- Webb, R.H., 1983, Compaction of desert soils by off-road vehicles, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 50–79.
- Webb, R.H., 2002, Recovery of Severely Compacted Soils in the Mojave Desert, California, USA.: *Arid Land Research & Management*, v. 16, no. 3, p. 291–305.
- Webb, R.H., Ragland, H.C., Godwin, W.H., and Jenkins, D., 1978, Environmental effects of soil property changes with off road vehicle use: *Environmental Management*, v. 2, no. 3, p. 219–233.
- Webb, R.H., and Wilshire, H.G., 1980, Recovery of soils and vegetation in a Mojave desert ghost town, Nevada, U.S.A.: *Journal of Arid Environments*, v. 3, p. 291–303.
- Wemple, B.C., Jones, J., and Grant, G., 1996, Channel network extension by logging roads in two basins, western Cascades, Oregon: *Water Resources Bulletin*, v. 32, no. 6, p. 1195–1207.
- Wheeler, G.L., and Rolfe, G.L., 1979, The relationship between daily traffic volume and the distribution of lead in roadside soil and vegetation: *Environmental Pollution*, v. 18, p. 265–274.

- Wilcox, D.A., 1989, Migration and control of purple loosestrife (*Lythrum salicaria* L.) along highway corridors: *Environmental Management*, v. 13, no. 3, p. 365–370.
- Wilkins, K.T., 1982, Highways as barriers to rodent dispersal: *Southwestern Naturalist*, v. 27, no. 44, p. 459–460.
- Wilshire, H.G., 1983a, Off-road vehicle recreation management policy for public lands in the United States—A case history: *Environmental Management*, v. 7, no. 6, p. 489–499.
- Wilshire, H.G., 1983b, The impact of vehicles on desert soil stabilizers, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 31–50.
- Winner, W.E., and Atkinson, C.J., 1986, Absorption of air pollutants by plants and consequences: *Trends in Ecology and Evolution*, v. 1, p. 15–18.
- Yahner, R.H., 1988, Changes in wildlife communities near edges: *Conservation Biology*, v. 2, no. 4, p. 333–339.
- Yahner, R.H., Morrell, T.E., and Rachael, J.S., 1989, Effects of edge contrast on depredation of artificial avian nests: *Journal of Wildlife Management*, v. 53, no. 4, p. 1135–1138.
- Yanes, M., Velasco, J.M., and Suárez, F., 1995, Permeability of roads and railways to vertebrates—The importance of culverts: *Biological Conservation*, v. 71, no. 33, p. 217–222.

Appendix 1. Extensive Bibliographies

1.1 OHV Effects on Soils and Watersheds

- Adams, J.A., Endo, A.S., Stolzy, L.H., Rowlands, P.G., and Johnson, H.B., 1982, Controlled experiments on soil compaction produced by off-road vehicles in the Mojave Desert, California: *Journal of Applied Ecology*, v. 19, no. 1, p. 167–175.
- Adams, J.A., Stolzy, L.H., Endo, A.S., Rowlands, P.G., and Johnson, H.B., 1982, Desert soil compaction reduces annual plant cover: *California Agriculture*, v. 36, no. 9–10, p. 6–7.
- Agrawal, Y.K., Patel, M.P., and Merh, S.S., 1981, Lead in soils and plants—Its relationship to traffic volume and proximity to highway (Lalbag, Baroda City): *International Journal of Environmental Studies*, v. 16, no. 3–4, p. 222–224.
- Al-Awadhi, J.I., 2001, Impact of gravel quarrying on the desert environment of Kuwait: *Environmental Geology*, v. 41, no. 3–4, p. 365–371.
- Albrecht, J., and Knopp, T.B., 1985, Off road vehicles—Environmental impact—Management response—A bibliography: Rosemount, Minnesota, Agricultural Experiment Station, University of Minnesota, Miscellaneous Publication, 50 p.
- Amezketta Lizarraga, E., Gazol Lostao, R., and Aragues Lafarga, R., 2002, Development of an automated infiltrometer and its applicability to the field: *Investigacion Agraria Produccion y Proteccion Vegetales*, v. 17, no. 1, p. 131–142.
- Anders, F.J., and Leatherman, S.P., 1987, Disturbance of beach sediment by off-road vehicles: *Environmental Geology and Water Sciences*, v. 9, no. 3, p. 183–189.
- Anders, F.J., and Leatherman, S.P., 1987, Effects of off-road vehicles on coastal foredunes at Fire Island, New York, USA: *Environmental Management*, v. 11, no. 1, p. 45–52.
- Arndt, W., 1996, The effect of traffic compaction on a number of soil properties: *Journal of Agriculture Engineering Research*, v. 11, p. 182–187.
- Becher, H.H., 1985, Compaction of arable soils due to reclamation or off-road military traffic: *Reclamation and Revegetation Research*, v. 4, no. 2, p. 155–164.
- Been, A., 1985, Assessment of damage by wheels of off-road vehicles: Norsk Institutt for Skogforskning, Technical Report, 12 p.
- Beije, H.M., 1986, Effects of military-training activities on soil, vegetation, and fauna: Leersum, Netherlands, Research Institute for Nature Management, p. 95–111.
- Bekker, M.G., 1977, Evaluation of tires in off the road locomotion—Motion resistance and soil compaction: *Zesz Probl Postepow Nauk Roln*, v. 183, p. 111–124.

- Bekker, M.G., 1980, Evaluation of soil/vehicle relationship to lessen damage to forest road and off-road surfaces—A literature and state-of-the-art survey: San Dimas, Mexico, Equipment Development Center, Technical Report, 71 p.
- Belnap, Jayne, 1993, Recovery rates of cryptobiotic crusts—Inoculant use and assessment methods: *Great Basin Naturalist*, v. 53, no. 1, p. 89–95.
- Belnap, Jayne, 1995, Surface disturbances—Their role in accelerating desertification: *Environmental Monitoring and Assessment*, v. 37, no. 1–3, p. 39–57.
- Belnap, Jayne, 2002, Impacts of off-road vehicles on nitrogen cycles in biological soil crusts—Resistance in different U.S. deserts: *Journal of Arid Environments*, v. 52, no. 2, p. 155–165.
- Belnap, Jayne, 2003, The world at your feet—Desert biological soil crusts: *Frontiers in Ecology and the Environment*, v. 1, no. 4, p. 181–189.
- Benoit, O., and Gotteland, P., 2005, Modelling of sinkage tests in tilled soils for mobility study: *Soil and Tillage Research*, v. 80, no. 1–2, p. 215–231.
- Berry, K.H., 1980, A review of the effects of off-road vehicles on birds and other vertebrates, *in* DeGraaf, R.M., and Tilghman, N.G., eds., *Management of western forests and grasslands for nongame birds—Workshop proceedings*, Salt Lake City, Utah, February 11–14, 1980: Ogden Utah, U.S. Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT–86, p. 451–467.
- Bessee, G.B., and Kohl, K.B., 1993, Characterization of CONUS and Saudi Arabian fine-grained soil samples: San Antonio, Texas, Southwest Research Institute Belvoir Fuels and Lubricants Research Facility, Report no. BFLRF294, 80 p.
- Boer, B., 1998, Anthropogenic factors and their potential impacts on the sustainable development of Abu Dhabi's terrestrial biological resources: *International Journal of Sustainable Development and World Ecology*, v. 5, no. 2, p. 125–135.
- Bolling, J.D., and Walker, L.R., 2000, Plant and soil recovery along a series of abandoned desert roads: *Journal of Arid Environments*, v. 46, no. 11, p. 1–24.
- Brainard, J., 1998, Patton Tank marks suggest long recovery: *Science News*, v. 154, no. 6, p. 87.
- Braunack, M.V., 1986, The residual effects of tracked vehicles on soil surface properties: *Journal of Terramechanics*, v. 23, no. 1, p. 37–50.
- Bredberg, C.J., and Waesterlund, I., 1983, Vehicle-caused damage to roots and soil: *Forstwissenschaftliches Centralblatt*, v. 102, no. 2, p. 86–98.
- Brown, A.C., and McLachlan, A., 2002, Sandy shore ecosystems and the threats facing them—Some predictions for the year 2025: *Environmental Conservation*, v. 29, no. 1, p. 62–77.

- Brown, G., and Porembski, S., 2000, Phytogenic hillocks and blow-outs as 'safe sites' for plants in an oil-contaminated area of northern Kuwait: *Environmental Conservation*, v. 27, no. 3, p. 242–249.
- Brown, G., and Schoknecht, N., 2001, Off-road vehicles and vegetation patterning in a degraded desert ecosystem in Kuwait: *Journal of Arid Environments*, v. 49, no. 2, p. 413–427.
- Brown, J., and Grave, N.A., 1979, Physical and thermal disturbance and protection of permafrost: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Report no. CRREL–SR–79–5, 46 p.
- Bulinski, J., 2000, Effect of forward speed and kind of the agricultural aggregates on soil compaction by wheels: *Inżynieria Rolnicza*, v. 6, p. 111–117.
- Burger, J., 1986, The effect of human activity on shorebirds in two coastal bays in northeastern United States: *Environmental Conservation*, v. 13, no. 2, p. 123–130.
- Byrd, D.S., Gilmore, J.T., and Lea, R.H., 1983, Effect of decreased use of lead in gasoline on the soil of a highway: *Environmental Science and Technology*, v. 17, p. 121–123.
- California State Water Resources Control Board, 1980, Lake Tahoe Basin Water Quality Plan, Final Plan: Sacramento, California, California State Water Resources Control Board, Technical Report.
- Call, C.A., Barker, J.R., and McKell, C.M., 1981, Visitor impact assessment of scenic view areas at Bryce Canyon National Park: *Journal of Soil and Water Conservation*, v. 36, no. 1, p. 50–53.
- Canfield, T.R., and Murray, M.J., 1992, Use of finite elements to model soil/track interactions in coupled multi-body dynamic simulations—Is real time simulation feasible: Argonne National Laboratory, Argonne, Illinois, Report no. ANL/CP–76184, 3 p.
- Charman, D.J., and Pollard, A.J., 1995, Long-term vegetation recovery after vehicle track abandonment on Dartmoor, SW England, U.K.: *Journal of Environmental Management*, v. 45, no. 1, p. 73–85.
- Clampitt, C.A., 1993, Effects of human disturbances on prairies and the regional endemic *Aster curtus* in western Washington: *Northwest Science*, v. 67, no. 3, p. 163–169.
- Cole, D.N., 1990, Trampling disturbance and recovery of cryptogamic soil crusts in Grand Canyon National Park: *Great Basin Naturalist*, v. 50, no. 4, p. 321–325.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Annotated bibliography for biologic overview for the Nevada nuclear waste storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832419, 48 p.

- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Biologic overview for the Nevada nuclear waste storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832460, 55 p.
- Davidson, E.D., and Fox, M., 1974, Effects of off-road motorcycle activity on Mojave Desert vegetation and soil: *Madroño*, v. 22, no. 8, p. 381–390.
- Davis, J.N., Baier, J., and McDonald, T., 2004, Assessment of soil amendments for erosion control on off-road vehicle trails, 2004 annual international meeting of the Society for Engineering in Agricultural, Food and Biological Systems, Ottawa, Canada, August 1–4, 2004: St. Joseph, Michigan, American Society of Agricultural Engineers.
- Decker, D.J., Krueger, R.A., Bauer, R.A., Jr., Knuth, B.A., and Richmond, M.E., 1996, From clients to stakeholders—A philosophical shift for fish and wildlife management: *Human Dimensions of Wildlife*, v. 1, no. 1, p. 70–82.
- Deletic, A., Ashley, R., and Rest, D., 2000, Modelling input of fine granular sediment into drainage systems via gully-pots: *Water Research*, v. 34, no. 15, p. 3836–3844.
- Deliman, N.C., 1998, Modeling soil-traction element interaction for off-road mobility assessment with application to virtual environment simulation, American Society of Agricultural Engineers (ASAE) International Meeting, Orlando, Florida, March 8–10, 1998: St. Joseph, Michigan, American Society of Agricultural Engineers.
- Della-Moretta, L.B., and Hodges, H.C., 1986, Off-highway tire/road damage and healing mechanisms: U.S. Department of Agriculture Forest Service Equipment Development Center, Report no. ASAE/TP86/1060, 15 p.
- Duever, M.J., Riopelle, L.A., and McCollom, J.M., 1986, Long term recovery of experimental off-road vehicle impacts and abandoned old trails in the Big Cypress National Preserve: Naples, Florida, National Audubon Society, Technical Report, 56 p.
- Dunn, J.P., Summerfield, C.J., and Johnson, M., 2003, Distribution, seasonal cycle, host plant records, and habitat evaluation of a Michigan threatened insect—The Great Plains spittlebug, *Lepyronia gibbosa* (Homoptera: Cercopidae): *Great Lakes Entomologist*, v. 35, no. 2, p. 121–129.
- Dunnell, C.W., 1980, Protecting and rehabilitating ORV off-road recreational vehicles use areas—Erosion control and management, Wenatchee National Forest, in Andrews, R.N.L., and Nowak, P.F., eds., *Off-road vehicle use—A management challenge*: Washington, D.C., U.S. Department of Agriculture Office of Environmental Quality, p. 100–102.
- Dyke, L.D., 1985, Terrain disturbance due to summer off-road vehicle use in central Keewatin, Northwest Territories, Canada: Ottawa, Ontario, Department of Indian Affairs and Northern Development, Report no. SSC–R71–19/36–1985F, 53 p.

- Eckert, R.E.J., Wood, M.K., Blackburn, W.H., and Peterson, F.F., 1979, Impacts of off-road vehicles on infiltration and sediment production of two desert soils: *Journal of Range Management*, v. 32, no. 5, p. 394–397.
- Erel, Y., 1998, Mechanisms and velocities of anthropogenic Pb migration in Mediterranean soils: *Environmental Research*, v. 78, no. 2, p. 112–117.
- Falkengren-Grerup, U., 1986, Soil acidification and its impact on ground vegetation: *Oecologia*, v. 70, p. 339–347.
- Fang, S., Wentz, S., Gertner, G.Z., Wang, G., and Anderson, A., 2002, Uncertainty analysis of predicted disturbance from off-road vehicular traffic in complex landscapes at Fort Hood: *Environmental Management*, v. 30, no. 2, p. 199–208.
- Fatoki, O.S., 2000, Trace zinc and copper concentrations in roadside vegetation and surface soils—A measurement of local atmospheric pollution in Alice, South Africa: *International Journal of Environmental Studies (UK)*, v. 57, no. 5, p. 501–513.
- Fletcher, J.J., and Lovejoy, S.B., 1986, Off-farm costs of sediment from agricultural lands, *Proceedings of the American Society of Agricultural Engineers, Winter Meeting, Chicago, Illinois*: St. Joseph, Michigan, American Society of Agricultural Engineers.
- Flint, A.L., and Childs, S., 1984, Development and calibration of an irregular hole bulk density sampler: *Soil Science Society of America Journal*, v. 48, no. 2, p. 374–378.
- Folz, R.B., 2006, Erosion from all terrain vehicle (ATV) trails on National Forest lands (abs.): St. Joseph, Michigan, *Proceedings of the 2006 American Society of Agricultural and Biological Engineers*, <http://asae.frymulti.com/abstract.asp?aid=21056&t=2>.
- Foresman, C.L., 1976, Effect of snowmobile traffic on bluegrass (*Poa pratensis*): *Journal of Environmental Quality*, v. 5, no. 2, p. 129–131.
- Freitag, D.R., Green, A.J., and Murphy, N.R., 1964, Normal stresses at the tire-soil interface in yielding soils: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWES-MISC-PAPER-4-629, 34 p.
- Fuchs, E.H., Wood, M.K., Jones, T.L., and Racher, B., 2003, Impacts of tracked vehicles on sediment from a desert soil: *Journal of Range Management*, v. 56, no. 4, p. 342–352.
- Furniss, M.J., Flanagan, S.A., and McFadin, B.A., 2000, Hydrologically connected roads—An indicator of the influence of roads on chronic sedimentation, surface water hydrology, and exposure to toxic chemicals: U.S. Forest Service, Stream Systems Technology Center, Rocky Mountain Research Station, Technical Report, 4 p., http://www.stream.fs.fed.us/streamnt/jul100/jul100_2.htm.

- Gardner, R.B., 1979, Some environmental and economic effects of alternative forest road designs: Transactions of the American Society of Agricultural Engineers, v. 22, no. 1, p. 63–68.
- Geological Society of America, 1977, Impacts and management of off-road vehicles: Boulder, Colorado, Report of the Committee on Environment and Public Policy, Technical Report, 8 p.
- Gilbertson, D., 1983, The impacts of off-road vehicles in the Coorong Dune and Lake Complex of South Australia, in Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, p. 355–373.
- Gillette, D.A., and Adams, J., 1983, Accelerated wind erosion and prediction rates of off-road vehicles, in Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, p. 97–109.
- Gish, C.D., and Christensen, R.E., 1973, Cadmium, nickel, lead, and zinc in earthworms from roadside soil: Environmental Science and Technology, v. 7, p. 1060–1062.
- Gray, J.R., 1977, Kinds and costs of recreational pollution in the Sandia Mountains: New Mexico Agricultural Experiment Station Bulletin, Technical Report, 57 p.
- Green, J.E., and Knight, S.J., 1959, Preliminary study of stresses under off-road vehicles: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWES-MISC-PAPER-4-362, 20 p.
- Griggs, G.B., and Walsh, B.L., 1981, The impact, control, and mitigation of off-road vehicle activity in Hungry Valley, California: Environmental Geology, v. 3, no. 4, p. 229–243.
- Grimes, D.W., Miller, R.J., and Wiley, P.L., 1975, Cotton and corn root development in two field soils of different strength characteristics: Agronomy Journal, v. 67, p. 519–523.
- Grimes, D.W., Sheesley, W.R., and Wiley, P.L., 1978, Alfalfa root development and shoot regrowth in compact soil of wheel traffic patterns: Agronomy Journal, v. 70, p. 955–958.
- Hairsine, P.B., Croke, J.C., Mathews, H., Fogarty, P., and Mockler, S.P., 2002, Modelling plumes of overland flow from logging tracks: Hydrological Processes, v. 16, no. 12, p. 2311–2327.
- Hall, C., and Dearden, P., eds., 1984, The impact of "non-consumptive" recreation on wildlife—An annotated bibliography: Monticello, Illinois, Vance Bibliographies, 45 p.
- Hammitt, W.E., and Cole, D.N., 1987, Wildland recreation—Ecology and management: New York, John Wiley & Sons, 341 p.

- Hansen, D.J., and Ostler, W.K., 2001, Plant-damage assessment technique for evaluating military vehicular impacts to vegetation in the Mojave Desert: Las Vegas, Nevada, Bechtel Nevada, Inc., Report no. DOE/NV /1178613.
- Harrison, R.T., 1980, Environmental impact of off-road motorcycles, in Andrews, R.N.L., and Nowak, P.F., eds., Off-road vehicle use—A management challenge: Washington, D.C., U.S. Department of Agriculture Office of Environmental Quality, p. 266–269.
- Haupt, H.F., 1959, Road and slope characteristics affecting sediment movement from logging roads: *Journal of Forestry*, v. 57, no. 5, p. 329–339.
- Heede, B.H., 1983, Control of rills and gullies in off-road vehicle traffic areas, in Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, p. 245–264.
- Hellstroem, G.B., 1996, Preliminary investigations into recent changes of the Goukamma Nature Reserve frontal dune system, South Africa—With management implications: *Landscape and Urban Planning*, v. 34, no. 3–4, p. 225–235.
- Hinckley, B.S., Iverson, R.M., and Hallet, B., 1983, Accelerated water erosion in ORV off-road vehicle-use areas, in Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, p. 81–96.
- Hirst, R.A., Pywell, R.F., Marrs, R.H., and Putwains, P.D., 2003, The resistance of a chalk grassland to disturbance: *Journal of Applied Ecology*, v. 40, no. 2, p. 368–379.
- Holloway, D.C., Wilson, W.H., and Drach, T.J., 1989, Examination of ATV tire forces generated on clay, grass, and sand surfaces: Warrendale, Pennsylvania, Society of Automotive Engineers, Technical Report, 12 p.
- Holsman, R.H., 2005, Management opportunities and obligations for mitigating off-road vehicle impacts to wildlife and their habitats: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 70, p. 399–417.
- Hooks, C.L., and Jansen, I.J., 1986, Recording cone penetrometer developed in reclamation research: *Soil Science Society of America Journal*, v. 50, no. 1, p. 10–12.
- Hosier, P.E., and Eaton, T.E., 1980, The impact of vehicles on dune and grassland vegetation on a southeastern North Carolina barrier beach: Wilmington, North Carolina, North Carolina University at Wilmington, Report no. UNC–SG–R–164, 13 p.
- Huszar, P.C., and Piper, S.L., 1986, Estimating the off-site costs of wind erosion in New Mexico: *Journal of Soil and Water Conservation*, v. 41, no. 6, p. 414–421.

- Hyatt, J.A., and Gilbert, R., 2000, Lacustrine sedimentary record of human-induced gully erosion and land-use change at Providence Canyon, southwest Georgia, USA: *Journal of Paleolimnology*, v. 23, no. 4, p. 421–438.
- Hyers, A.D., and Marcus, M.G., 1981, Land use and desert dust hazards in central Arizona, in Pewe, T., ed., *Desert dust origin, characteristics, and effect on man*: Boulder, CO, Geological Society of America, Inc., p. 267–280.
- International Society for Terrain-Vehicle Systems, 1984, *Proceedings of the international conference on the performance of off-road vehicles and machines*, Cambridge, England, August 5–11, 1984: International Society for Terrain-Vehicle Systems, 384 p.
- International Society for Terrain-Vehicle Systems, 1994, *Proceedings of the European ISTVS conference (6th), OVK symposium (4th), on off road vehicles in theory and practice*, Vienna, Austria, September 28–30, 1994: International Society for Terrain-Vehicle Systems, 349 p.
- Isensee, E., and Luth, H.G., 1992, Continuous recording of soil density: *Landtechnik*, v. 47, no. 9, p. 449–452.
- Iverson, R.M., 1980, Processes of accelerated pluvial erosion on desert hillslopes modified by vehicular traffic: *Earth Surface Processes*, v. 5, p. 369–388.
- Iverson, R.M., Hinckley, B.S., and Webb, R.M., 1981, Physical effects of vehicular disturbances on arid landscapes: *Science*, v. 212, no. 4497, p. 915–917.
- Johnson, C.W., and Smith, J.P., 1983, Soil loss caused by off-road vehicle use on steep slopes: *Transactions of the American Society of Agricultural Engineers*, v. 26, no. 2, p. 402–405.
- Johnson, R.R., Mills, G.S., and Carothers, S.W., 1990, Creation and restoration of riparian habitat in southwestern arid and semi-arid regions, in Kusler, J.A., and Kentula, M.E., eds., *Wetland creation and restoration—The status of the science*: Covelo, California, Island Press, p. 351–366.
- Jones, R., Horner, D., Sullivan, P., and Ahlvin, R., 2005, A methodology for quantitatively assessing vehicular rutting on terrains: *Journal of Terramechanics*, v. 42, no. 3–4, p. 245–257.
- Karafiath, L.L., 1978, *Track-soil interaction model for the determination of maximum soil thrust*: Bethpage, New York, Grumman Aerospace Corporation, Report no. RE-556, 60 p.
- Kay, B.L., and Graves, W.L., 1983, History of revegetation studies in the California deserts, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 315–324.

- Kay, B.L., and Graves, W.L., 1983, Revegetation and stabilization techniques for disturbed desert vegetation, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 325–340.
- Kay, J., 1981, Evaluating environmental impacts of off-road vehicles: *Journal of Geography*, v. 80, no. 1, p. 10–18.
- Keener, K.M., Wood, R.K., Holmes, R.G., and Morgan, M.T., 1991, Soil strength evaluation of sample cores in a field measurement system: : St. Joseph, Michigan, American Society of Agricultural Engineers, ASAE Paper No. 91-1526, p. 10.
- Kennedy, J.G., Collins, J.G., and Smith, M.H., 1967, Moisture—Strength characteristics of selected soils in Thailand. Volume I—Analyses and application of data: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWES-TR-3-791-VOL-1, 126 p.
- Kert, J., 1992, Remote sensing of off-road vehicle emissions, International conference optical remote sensing and applications to environmental and industrial safety problems, Houston, Texas, April 6–8, 1992.
- Khalaf, F.I., 1989, Desertification and aeolian processes in the Kuwait Desert: *Journal of Arid Environments*, v. 16, no. 2, p. 125–145.
- Knott, J.M., 1978, Reconnaissance assessment of erosion and sedimentation in the Canada de los Alamos Basin, Los Angeles and Ventura Counties, California: U.S. Geological Survey, Open File Report no. 78-873, 49 p.
- Komatsu, M., Kato, A., and Sakamoto, K., 1988, Study on the automatic measurement system of soil parameters. Development of soil hardness sensor: Tottori, Japan, Tottori University, Bulletin of the Faculty of Agriculture, Tottori University, v. 41, p. 39–46.
- Kondolf, G.M., Piegay, H., and Landon, N., 2002, Channel response to increased and decreased bedload supply from land use change—Contrasts between two catchments: *Geomorphology*, v. 45, no. 1–2, p. 35–51.
- Koppel, W., 1988, Dynamic impact on soil structure due to traffic of off-road vehicles, in Drescher, J., Horn, R., and Boodt, M.D., eds., *Impact of water and external forces on soil structure—Selected papers of the 1st Workshop on Soilphysics and Soilmechanics*: Cremlingen-Destedt, Germany, Catena Verlag, p. 113–122.
- Kurczerski, F.E., 2000, History of white pine (*Pinus strobus*)/oak (*Quercus* spp.) savanna in southern Ontario, with particular reference to the biogeography and status of the antenna-waving wasp, *Tachysphex pechumani* (Hymenoptera: Sphecidae): *Canadian Field-Naturalist*, v. 114, no. 1, p. 1–20.

- Kutiel, P., Eden, E., and Zhevelev, Y., 2000, Effect of experimental trampling and off-road motorcycle traffic on soil and vegetation of stabilized coastal dunes, Israel: *Environmental Conservation*, v. 27, no. 1, p. 14–23.
- Kutiel, P., Eden, Z., and Zhevelev, H., 2001, The impact of motorcycle traffic on soil and vegetation of stabilized coastal dunes, Israel: *Journal of Coastal Conservation*, v. 7, no. 1, p. 81–89.
- Lacey, R.M., and Severinghaus, W.D., 1982, Evaluation of lands for off-road recreational four-wheel drive vehicle use: U.S. Department of Commerce Government Reports Announcements and Index National Technical Information Service (NTIS), Technical Report, 1755 p.
- Langdon, A.M., 2000, Mojave Desert soils, plants, and ants—Developing a monitoring strategy for off-highway-vehicles: Pomona, California, California State Polytechnic University, Pomona, 114 p.
- Larney, F.J., Leys, J.F., Mueller, J.F., and McTainsh, G.H., 1999, Dust and endosulfan deposition in a cotton-growing area of northern New South Wales, Australia: *Journal of Environmental Quality*, v. 28, no. 2, p. 692–701.
- Lawson, D.E., 1982, Long-term modifications of perennially frozen sediment and terrain at East Oumalik, northern Alaska: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Technical Report, 44 p.
- Lei, S.A., 2004, Soil compaction from human trampling, biking, and off-road motor vehicle activity in a blackbrush (*Coleogyne ramosissima*) shrubland: *Western North American Naturalist*, v. 64, no. 1, p. 125–130.
- Leis, S.A., Engle, D.M., Leslie, D.M., and Fehmi, J.S., 2005, Effects of short- and long-term disturbance resulting from military maneuvers on vegetation and soils in a mixed prairie area: *Environmental Management*, v. 36, no. 6, p. 849–861.
- Lightfoot, D.C., and Whitford, W.G., 1991, Productivity of creosotebush foliage and associated canopy arthropods along a desert roadside: *American Midland Naturalist*, v. 125, no. 2, p. 310–322.
- Liston, N., Hutt, M., and White, L., 1981, Mobility bibliography: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Report no. CRREL–SR–81–29, 333 p.
- Liston, R.A., Czako, T., Haley, P., Harrison, W.L., and Hanamoto, B., 1966, Mobility environmental research study mobility testing procedures: Warren, Michigan, U.S. Army Tank-Automotive Center—Warren Michigan Land Locomotion Lab, Technical Report, 88 p.
- Lodico, N.J., 1973, Environmental effects of off-road vehicles—A review of the literature: U.S. Office of Library Services, Research Services Branch, Technical Report, 109 p.

- Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: *Environmental Management*, v. 24, no. 3, p. 309–326.
- Luckenbach, R.A., 1978, An analysis of off- road vehicle use on desert avifaunas, *Transactions of the North American Wildlife and Natural Resources Conference*, v. 43, p. 157–162.
- Luckenbach, R.A., 1982, Ecology and management of the desert tortoise (*Gopherus agassizii*) in California: U.S. Fish and Wildlife Service, Technical Report, 37 p.
- Luckenbach, R.A., and Bury, R.B., 1983, Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County, California, USA: *Journal of Applied Ecology*, v. 20, no. 1, p. 265–286.
- Manson, D.A., 1980, Erosion control in Angourie National Park: *Journal of the Soil Conservation Service of New South Wales*, v. 36, no. 1, p. 23–32.
- McBrayer, M.C., Mauldon, M., Drumm, E.C., and Wilson, G.V., 1997, Infiltration tests on fractured compacted clay: *Journal of Geotechnical and Geoenvironmental Engineering*, v. 123, no. 5, p. 469–473.
- McCool, D.K., Dossett, M.G., and Yecha, S.J., 1981, Portable rill meter for field measurement of soil loss, Erosion and sediment transport measurement—Proceedings of the Florence symposium, Florence, Italy, 22-26 June 1981: Washington, D.C., International Association of Hydrological Sciences, p. 479–484.
- Melvin, S.M., Griffin, C.R., and MacIvor, L.H., 1991, Recovery strategies for piping plovers in managed coastal landscapes: *Coastal Management*, v. 19, no. 1, p. 21–34.
- Meyer, K.G., 2002, Managing degraded off-highway vehicle trails in wet, unstable, and sensitive environments: U.S. National Park Service, Report no. PB2005105502, 88 p.
- Miller, P.M., 1968, The application of the visioplasticity method to soft-soil mobility problems: Buffalo, New York, Cornell Aeronautical Laboratory and United States Advanced Research Projects Agency, p. 41.
- Miller, R.E., Hazard, J., and Howes, S., 2001, Precision, accuracy, and efficiency of four tools for measuring soil bulk density or strength: U.S. Forest Service, Pacific Northwest Research Station, Report no. PNW–RP–532, 16 p.
- Misak, R.F., Al-Awadhi, J.M., Omar, S.A., and Shahid, S.A., 2002, Soil degradation in Kabd area, southwestern Kuwait City: *Land Degradation and Development*, v. 13, no. 5, p. 403–415.

- Mize, R., Evans, R.E., MacRoberts, B.R., MacRoberts, M.H., and Rudolph, D.C., 2005, Restoration of pitcher plant bogs in eastern Texas, USA: *Natural Areas Journal*, v. 25, no. 2, p. 197–201.
- Moorhead, D.L., Linkins, A.E., and Everett, K.R., 1996, Road dust alters extracellular enzyme activities in tussock tundra soils, Alaska, U.S.A.: *Arctic and Alpine Research*, v. 28, no. 3, p. 346–351.
- Motto, H.L., Daines, R.H., Chilko, D.M., and Motto, C.K., 1970, Lead in soils and plants—Its relationship to traffic volume and proximity to highways: *Environmental Science and Technology*, v. 4, p. 231–237.
- Nakata, J.K., 1983, Off-road vehicular destabilization of hill slopes—The major contributing factor to destructive debris flows in Ogden, Utah, 1979, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 343–353.
- National Oceanic and Atmospheric Administration, 2005, Understanding the “human dimension” of coastal management using social science, http://maps.csc.noaa.gov/socialscience_2/wheel_stakeholders.htm (accessed April 2007).
- Niedoroda, A., 1978, The geomorphologic effects of off-road vehicles on coastal systems of Cape Cod, Massachusetts: Amherst, Massachusetts, Massachusetts University National Park Service Cooperative Research Unit, Report no. UM–NPSCRU–17, 106 p.
- Noor, M., and Shah, B.H., 1995, Infiltration capacity and soil bulk density differences between grazed area and off-road track at Paya (Kaghan Valley): *Pakistan Journal of Forestry*, v. 45, no. 1, p. 13–18.
- Noren, O., Danfors, B., and Stambeck, A., 1984, Technical systems in energy forestry: Stockholm, Sweden, Statens Energiverk, Report no. STEV–EO–84–4, 145 p.
- Noren, O., Danfors, B., Stambeck, A., and Gutekunst, K., 1982, Technical equipment for the cultivation of energy forest: Uppsala, Sweden, Jordbrukstekniska Institute, Report no. JTI–38, 116 p.
- Nyssen, J., Poesen, J., Moeyersons, J., Luyten, E., Veyret-Picot, M., Deckers, J., Haile, M., and Govers, G., 2002, Impact of road building on gully erosion risk—A case study from the northern Ethiopian Highlands: *Earth Surface Processes and Landforms*, v. 27, no. 12, p. 1267–1283.
- Okello, J.A., 1991, A review of soil strength measurement techniques for prediction of terrain vehicle performance: *Journal of Agricultural Engineering Research*, v. 50, no. 2, p. 129–155.

- O'Sullivan, M.F., and Ball, B.C., 1982, A comparison of five instruments for measuring soil strength in cultivated and uncultivated cereal seedbeds: *Journal of Soil Science*, v. 33, no. 4, p. 597–608.
- Payne, G.F., Leininger, W.D., and Foster, J., 1979, How off-road vehicles affect range quality. When driving across rangelands, it's better to blaze a new trail: Bozeman, Montana, Montana Agricultural Experiment Station, Report, 2 p.
- Perez, F.L., 1991, Particle sorting due to off-road vehicle traffic in a high Andean paramo: *Catena Giessen*, v. 18, no. 3–4, p. 239–254.
- Persico, L.P., Nichols, K.K., and Bierman, P.R., 2005, Tracking painted pebbles—Short-term rates of sediment movement on four Mojave Desert piedmont surfaces: *Water Resources Research*, v. 41, no. 7, p. W07004.07001–W07004.07015.
- Piehl, B.T., Beschta, R.L., and Pyles, M.R., 1988, Ditch-relief culverts and low-volume forest roads in the Oregon Coast Range: *Northwest Science*, v. 62, no. 3, p. 91–98.
- Pinard, M.A., Barker, M.G., and Tay, J., 2000, Soil disturbance and post-logging forest recovery on bulldozer paths in Sabah, Malaysia: *Forest Ecology and Management*, v. 130, no. 1–3, p. 213–225.
- Piper, S., and Huszar, P.C., 1989, Re-examination of the off-site costs of wind erosion in New Mexico: *Journal of Soil and Water Conservation*, v. 44, no. 4, p. 332–334.
- Powers, R.F., Tiarks, A.E., and Boyle, J.R., 1998, Assessing soil quality—Practicable standards for sustainable forest productivity in the United States, *in* The contribution of soil science to the development of and implementation of criteria and indicators of sustainable forest management: St. Louis, Missouri, Soil Science Society of America, Inc., p. 53–80.
- Prose, D.V., 1985, Persisting effects of armored military maneuvers on some soils of the Mojave Desert: *Environmental Geology and Water Sciences*, v. 7, no. 3, p. 163–170.
- Prose, D.V., Metzger, S.K., and Wilshire, H.G., 1987, Effects of substrate disturbance on secondary plant succession—Mojave Desert, California: *Journal of Applied Ecology*, v. 24, no. 1, p. 305–313.
- Qiu, X.D., Ji, X.W., and Zhuang, J.D., 1995, Analysis of desert sand properties related to off-road locomotion: *Transactions of the Chinese Society of Agricultural Engineering*, v. 11, no. 2, p. 11–16.
- Quarles, H.D., Hanawalt, R.B., and Odum, W.E., 1974, Lead in small mammals, plants, and soil at varying distances from a highway: *Journal of Applied Ecology*, v. 11, no. 3, p. 937–949.

- Rafique, S.A., 1994, Effect of grazing management and fertilizer application on vegetation and soil properties of a moist temperate forest range in Siran Valley (Mansehra), NWFP: Pakistan Journal of Forestry, v. 44, no. 1, p. 20–29.
- Raghavan, G.S.V., 1977, Effect of wheel slip on soil compaction: Journal of Agricultural Engineering Research, v. 22, no. 1, p. 79–83.
- Raghavan, G.S.V., McKyes, E., Amir, I., Chasse, M., and Broughton, R.S., 1976, Prediction of soil compaction due to off-road vehicle traffic: Transactions of the American Society of Agricultural Engineers, v. 19, no. 4, p. 610–613.
- Richard, G., Tan, R., and Avery, J., 1977, An implementation plan for suspended particulate matter in the Phoenix area. Volume II. Emission inventory: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Report no. EPA450377021B, 218 p.
- Rickard, W.H., 1988, Natural vegetation at the proposed reference repository location in southeastern Washington: Richland, Washington, Battelle Pacific Northwest Labs, Report no. PNL–6402, 27 p.
- Ross, J.B., and Willison, J.H.M., 1991, Impacts of all-terrain vehicles on bogs and barrens of the Cape Breton Highlands—Proceedings of the International Conference on Science and Management of Protected Areas, Nova Scotia, Canada, 14-19 May 1991: Halifax, Nova Scotia, Canada, p. 533–534.
- Rula, A.A., Freitag, D.R., and Knight, S.J., 1966, Concepts for vehicles for off-road use in remote areas: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWESMISCPAPER4854.
- Rula, A.A., and Nuttall, C.J., 1971, An analysis of ground mobility models (ANAMOB): Vicksburg, Mississippi, U.S. Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWESTRM714, 326 p.
- Samaras, Z., and Zierock, K.H., 1995, Off-road vehicles—A comparison of emissions with those from road transport: Science of the Total Environment, v. 169, p. 249–253.
- Schemnitz, S.D., and Schortemeyer, J.D., 1972, The influence of vehicles on Florida Everglades vegetation: Tallahassee, Florida, Florida State Game and Fresh Water Fish Commission, Report no. DISFEP–74–31, 65 p.
- Schreier, H., and Lavkulich, L.M., 1979, A numerical approach to terrain analysis for off-road trafficability: Photogrammetric Engineering and Remote Sensing, v. 45, no. 5, p. 635–642.
- Schultink, G., 1977, Impact analysis of off-road-vehicle use on vegetation in the Grand Mere Dune environment: East Lansing, Michigan, Michigan State University, Report no. NASACR155764, 10 p.

- Severinghaus, W.D., Riggins, R.E., and Goran, W.D., 1980, Effects of tracked vehicle activity on terrestrial mammals and birds at Fort Knox, Kentucky: Transactions of the Kentucky Academy of Science, v. 41, no. 1–2, p. 15–26.
- Shaaban, S., 1984, Compaction of sand using ordinary off-road vehicles: Cairo, Egypt, Military Technical College, Report no. ADP0042978, 11 p.
- Shay, R., 1979, Management problems in off-road-vehicle recreation, in Ittner, R., Potter, D.R., Agee, J.K., and Anschell, S., eds., Recreational impact on wildlands—Conference proceedings, Seattle, Washington, October 27–29, 1978: U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station and U.S. National Park Service, p. 314–317.
- Shikanai, T., Ueno, M., Hashiguchi, K., Nohse, Y., and Okayasu, T., 1997, A precise measurement of soil deformation under the wheel: Journal of the Japanese Society of Agricultural Machinery, v. 59, no. 2, p. 3–11.
- Shoop, S.A., 1993, Terrain characterization for trafficability: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Report no. CRREL–93–6, 29 p.
- Snyder, C.T., Frickel, D.G., Hadley, R.F., and Miller, R.F., 1976, Effects of off-road vehicle use on the hydrology and landscape of arid environments in central and southern California: U.S. Geological Survey Water Resources Investigations Report no. USGS/WRI–76–99, 52 p.
- Sparrow, S.D., Wooding, F.J., and Whiting, E.H., 1978, Effects of off-road vehicle traffic on soils and vegetation in the Denali Highway region of Alaska: Journal of Soil and Water Conservation, v. 33, no. 1, p. 20–27.
- Spellerburg, I.F., and Morrison, T., 1998, The ecological effects of new roads—A literature review: Wellington, New Zealand, New Zealand Department of Conservation, Technical Report, 55 p.
- Startsev, A.D., and McNabb, D.H., 2000, Effects of skidding on forest soil infiltration in west-central Alberta: Canadian Journal of Soil Science, v. 80, no. 4, p. 617–624.
- Steiner, A.J., and Leatherman, S.P., 1979, An annotated bibliography of the effects of off-road vehicle and pedestrian traffic on coastal ecosystems: U.S. National Park Service Cooperative Research Unit, and University of Massachusetts Amherst, Report no. UMNPSRU45, 88 p.
- Steiner, A.J., and Leatherman, S.P., 1981, Recreational impacts on the distribution of ghost crabs *Ocypode quadrata* Fab.: Biological Conservation, v. 20, no. 2, p. 111–122.
- Stephenson, G., 1999, Vehicle impacts on the biota of sandy beaches and coastal dunes—A review from a New Zealand perspective: Science for Conservation, v. 121, p. 1–14.
- Stinson, B., 1971, An analytical model for predicting cross-country vehicle performance. Appendix E—quantification of the screening effects of vegetation on driver's vision and

- vehicle speed: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWESTR3783, 33 p.
- Stroh, T., 2001, Proposed Collbran rock and soil source project—Wildlife report: U.S. Bureau of Reclamation, Report no. PB2006101846, 28 p.
- Stull, R., Shipley, Susan, Hovanitz, E., Thompson, S., and Hovanitz, K., 1979, Effects of off-road vehicles in Ballinger Canyon, California: *Geology*, v. 7, no. 1, p. 19–21.
- Swanson, G.D., 1971, Studies of dual and tandem rigid wheel performance in sand: Hoboken, New Jersey, Stevens Institute of Technology, Report no. SIT-DL-71-1536, 132 p.
- Tunstall, B.R., and Reece, P.H., 1989, Environmental assessment of the Sunset and Big Desert lands, northwest Victoria, Australia: South, Australia, Australia Commonwealth Scientific and Industrial Research Organization, Division of Water Resources Divisional Report, Clayton Technical Report, 1–85 p.
- Turnage, G.W., 1972, Performance of soils under tire loads. Report 8. Application of test results to tire selection for off-road vehicles: Vicksburg, Mississippi, U.S., Army Engineer Waterways Experiment Station, Report no. AEWES-TR-3-666-8, 164 p.
- Turton, S.M., 2005, Managing environmental impacts of recreation and tourism in rainforests of the wet tropics of Queensland World Heritage Area: *Geographical Research*, v. 43, no. 2, p. 140–151.
- Tuttle, M., and Griggs, G., 1985, Accelerated soil erosion at three State Vehicular Recreation Areas, central and southern California, Erosion control—A challenge in our time—Proceedings of the 16th annual International Erosion Control Association, San Francisco, California, February 21–22, 1985: Steamboat Springs, Colorado, p. 105-115.
- Tuttle, M., and Griggs, G., 1987, Soil erosion and management recommendations at three State Vehicular Recreation Areas, California: *Environmental Geology and Water Sciences*, v. 10, no. 2, p. 111–123.
- Twiss, R., Sidener, J., Bingham, G., Burke, J.E., and Hall, C.H., 1980, Potential impacts of geothermal development on outdoor recreational use of the Salton Sea: Livermore, California, University of California, Livermore, Technical Report, 61 p.
- U.S. Army Corps of Engineers, 1994, Stationing of mechanized or armored combat forces at Fort Lewis, Thurston and Pierce Counties, Washington: U.S. Army Corps of Engineers, Report no. 940045.
- U.S. Army Corps of Engineers, 2001, Fort Bliss mission and master plan—Dona Ana and Otero Counties, New Mexico, and El Paso County, Texas: U.S. Army Corps of Engineers, Report no. 010081.

- U.S. Army Test and Evaluation Command, 1970, Soft-soil vehicle mobility: Aberdeen Proving Ground, Maryland, U.S. Army Report no. MTP-2-2-619, 11 p.
- U.S. Bureau of Land Management, 1984, Proposed Monument resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 840584, 419 p.
- U.S. Bureau of Land Management, 1985, Box Elder resource management plan, Utah: U.S. Bureau of Land Management, Report no. 850448.
- U.S. Bureau of Land Management, 1985, Grand Junction resource area—Resource management plan and environmental impact statement: U.S. Bureau of Land Management, Technical Report, 171 p.
- U.S. Bureau of Land Management, 1985, resource management plan for the Walker Planning Area, Nevada: U.S. Bureau of Land Management, Report no. 850274.
- U.S. Bureau of Land Management, 1985, White Sands resource area management plan, New Mexico: U.S. Bureau of Land Management, Report no. 850387.
- U.S. Bureau of Land Management, 1986, Lander resource management plan, Lander, Wyoming: U.S. Bureau of Land Management, Report no. 860449.
- U.S. Bureau of Land Management, 1986, Little Snake resource management plan, Moffat, Rio Blanco, and Routt Counties, Colorado: U.S. Bureau of Land Management, Report no. 860029.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan and the Eastern San Diego County master framework plan, California: U.S. Bureau of Land Management, Report no. 860432, 138 p.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan, California: U.S. Bureau of Land Management, Report no. 860077.
- U.S. Bureau of Land Management, 1986, resource management plan for the House Range resource area, Juab and Millard Counties, Utah: U.S. Bureau of Land Management, Report no. 860377.
- U.S. Bureau of Land Management, 1986, resource management plan for the Warm Springs resource area, Millard County, Utah: U.S. Bureau of Land Management, Report no. 860395.
- U.S. Bureau of Land Management, 1986, Wilderness Suitability EIS—Grass Creek and Cody resource areas, Bighorn Basin, Wyoming (draft supplement for the Owl Creek Wilderness Study Area): U.S. Bureau of Land Management, Report no. 860168, 40 p.
- U.S. Bureau of Land Management, 1987, Cascade resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 870281, 432 p.

- U.S. Bureau of Land Management, 1987, Medicine Bow-Divide resource areas resource management plan, Rawlins District, Wyoming: U.S. Bureau of Land Management, Report no. 870212.
- U.S. Bureau of Land Management, 1987, North Dakota resource management plan, Dunn and Bowman Counties, North Dakota: U.S. Bureau of Land Management, Report no. 870236, 199 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette and Lincoln Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870077, 347 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette, Teton, Lincoln, and Fremont Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870428, 232 p.
- U.S. Bureau of Land Management, 1987, Proposed resource management plan for the San Juan resource area, Moab District, Utah: U.S. Bureau of Land Management, Report no. 870440.
- U.S. Bureau of Land Management, 1987, Taos resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 870331.
- U.S. Bureau of Land Management, 1987, Washakie resource area resource management plan, portions of Big Horn, Hot Springs, and Washakie Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870395.
- U.S. Bureau of Land Management, 1988, Challis resource area proposed resource management plan, upper Columbia-Salmon Clearwater Districts, Custer and Lemhi Counties, Idaho: U.S. Bureau of Land Management, Report no. 980508.
- U.S. Bureau of Land Management, 1988, Cody resource area resource management plan, Big Horn and Park Counties, Wyoming: U.S. Bureau of Land Management, Report no. 880315.
- U.S. Bureau of Land Management, 1988, Fort Greely national maneuver area and Fort Greely air drop zone, Alaska—Resource management plan: U.S. Bureau of Land Management, Report no. 880276, 138 p.
- U.S. Bureau of Land Management, 1988, Fort Wainwright maneuver area, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 880277, 138 p.
- U.S. Bureau of Land Management, 1988, Pony Express resource management plan, Toole, Utah, and Salt Lake Counties, Utah: U.S. Bureau of Land Management, Report no. 880310, 147 p.
- U.S. Bureau of Land Management, 1988, Uncompahgre Basin resource management plan, Colorado: U.S. Bureau of Land Management, Report no. 880345.

- U.S. Bureau of Land Management, 1988, West Hiline resource management plan, northcentral Montana: U.S. Bureau of Land Management, Report no. 880200, 306 p.
- U.S. Bureau of Land Management, 1988, Wilderness recommendations for the Red Mountain Wilderness study area in the Arcata resource area, California: U.S. Bureau of Land Management, Report no. 880033, 120 p.
- U.S. Bureau of Land Management, 1989, Dixie resource area management plan, Washington County, Utah: U.S. Bureau of Land Management, Report no. 890290, 250 p.
- U.S. Bureau of Land Management, 1989, San Rafael resource management plan, Emery County, Utah: U.S. Bureau of Land Management, Report no. 890240.
- U.S. Bureau of Land Management, 1989, White Sands resource management plan Amendment for McGregor Range, Otero County, New Mexico: U.S. Bureau of Land Management, Report no. 890127.
- U.S. Bureau of Land Management, 1991, Safford District resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 910314, 511 p.
- U.S. Bureau of Land Management, 1991, Three Rivers resource management plan, Harney, Grant, Lake, and Malheur Counties, Oregon: U.S. Bureau of Land Management, Report no. 910335.
- U.S. Bureau of Land Management, 1993, resource management plan and environmental impact statement for the Big Dry resource area, Miles City District, Montana: U.S. Bureau of Land Management, Report no. 930076, 382 p.
- U.S. Bureau of Land Management, 1994, Fort Wainwright, Yukon maneuver area, proposed resource management plan and final environmental impact statement, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 940001, 124 p.
- U.S. Bureau of Land Management, 1994, resource management plan and environmental impact statement for the Grass Creek resource area, Worland District, Wyoming: U.S. Bureau of Land Management, Report, 299 p.
- U.S. Bureau of Land Management, 1998, Judith-Valley-Phillips resource management plan—Chouteau, Fergus, Judith Basin, Petroleum, Phillips, and Valley Counties, Montana (draft supplement to the final environmental impact statement of September 1997): U.S. Bureau of Land Management, Report no. 980149, 51 p.
- U.S. Bureau of Land Management, 1998, Socorro resource area resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 880397, 266 p.

- U.S. Bureau of Land Management, 2000, Federal fluid minerals leasing and development, Otero and Sierra Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000383, 521 p.
- U.S. Bureau of Land Management, 2001, National management strategy for motorized off-highway vehicle use on public lands: U.S. Bureau of Land Management, Report no. PB2001103162, 58 p.
- U.S. Bureau of Land Management, 2003, Farmington resource management plan, San Juan, McKinley, Rio Arriba, and Sandoval Counties, New Mexico: U.S. Bureau of Land Management, Report no. 030143.
- U.S. Bureau of Land Management, 2004, Dillon resource management plan, Beaverhead and Madison Counties, Montana: U.S. Bureau of Land Management, Report no. 040153, 626 p.
- U.S. Bureau of Land Management, and U.S. Forest Service, 1986, Proposed Coronado National Forest land and resource management plan, Arizona and New Mexico: U.S. Bureau of Land Management, and U.S. Department of Agriculture Forest Service, Report no. 860307.
- U.S. Bureau of Reclamation, 2001, Pothole Reservoir resource management plan, Grant County, Washington: U.S. Bureau of Reclamation, Report no. 010518, 567 p.
- U.S. Federal Highway Administration, 1965, Design of roadside drainage channels: U.S. Federal Highway Administration, Report no. FHWAEPD86103, 64 p.
- U.S. Fish and Wildlife Service, 1986, Great Dismal Swamp National Wildlife Refuge master plan, Virginia and North Carolina: U.S. Fish and Wildlife Service, Report no. 860501, 245 p.
- U.S. Forest Service, 1973, Management of South Holston unit: U.S. Forest Service, Report no. USDAFSFESADM7350, 121 p.
- U.S. Forest Service, 1973, Proposed off-road vehicle regulations and administrative instructions: U.S. Forest Service, Report no. USDAFS-FES(ADM)-73-49, 110 p.
- U.S. Forest Service, 1973, Proposed regulations and administrative instructions relating to use of off-road vehicles on National Forest lands: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-49, 22 p.
- U.S. Forest Service, 1973, Unit plan for management of the South Holston unit: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-50, 80 p.
- U.S. Forest Service, 1985, Caribou National Forest and Curlew National Grassland land and resource management plan, Idaho, Utah, and Wyoming: U.S. Forest Service, Report no. 850437.

- U.S. Forest Service, 1986, Chequamegon National Forest, Wisconsin land and resource management plan: U.S. Forest Service, Report no. 860325.
- U.S. Forest Service, 1986, Cleveland National Forest land and resource management plan, Orange, Riverside, and San Diego Counties, California: U.S. Forest Service, Report no. 860209.
- U.S. Forest Service, 1986, Croatan and Uwharrie National Forests land and resource management plan, North Carolina: U.S. Forest Service, Report no. 860218.
- U.S. Forest Service, 1986, National Forests in Alabama land and resource management plan: U.S. Forest Service, Report no. 860095.
- U.S. Forest Service, 1986, Proposed land and resource management plan for Wayne National Forest, Ohio: U.S. Forest Service, Report no. 860426.
- U.S. Forest Service, 1986, Proposed Santa Fe National Forest land and resource management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 860013.
- U.S. Forest Service, 1987, Angeles National Forest land and resource management plan, Los Angeles, Ventura, and San Bernardino Counties, California: U.S. Forest Service, Report no. 870394.
- U.S. Forest Service, 1987, Proposed Apache-Sitgreaves National Forests land and resource management plan, Apache, Coconino, Greenlee, and Navajo Counties, Arizona: U.S. Forest Service, Report no. 870387.
- U.S. Forest Service, 1987, Santa Fe National Forest land management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 870299.
- U.S. Forest Service, 1988, Proposed Kaibab National Forest land and resource management plan, Coconino, Yavapai, and Mohave Counties, Arizona: U.S. Forest Service, Report no. 880109.
- U.S. Forest Service, 1988, Record of decision for USDA, Forest Service—Final environmental impact statement, Allegheny National Forest, Land and resource management plan—Elk, Forest, McKean, and Warren Counties, Pennsylvania: U.S. Forest Service, Technical Report, 41 p.
- U.S. Forest Service, 1989, San Bernardino National Forest land and resource management plan, San Bernardino and Riverside Counties, California: U.S. Forest Service, Report no. 890023.
- U.S. Forest Service, 1990, Cherokee National Forest land and resource management plan, Tennessee, North Carolina, and Virginia (final supplement to the final environmental impact statement of April 1986): U.S. Forest Service, Report no. 900062, 62 p.

- U.S. Forest Service, 1990, Umatilla National Forest land and resource management plan, Oregon and Washington: U.S. Forest Service, Report no. 900237.
- U.S. Forest Service, 1992, Rangeland ecosystem management in the Uinta National Forest, Provo, Utah: U.S. Forest Service, Report no. 920322, 189 p.
- U.S. Forest Service, 1993, Six Rivers National Forest plan, Humboldt, Del Norte, Siskiyou, and Trinity Counties, California: U.S. Forest Service, Report no. 930340.
- U.S. Forest Service, 1994, Revised land and resource management plan for the National Forests and Grasslands in Texas—Angelina, Fannin, Houston, Jasper, Montague, Montgomery, Nacogdoches, Newton, Sabine, San Augustine, San Jacinto, Shelby, Trinity, Walker, and Wise Counties, Texas: U.S. Forest Service, Report no. 940385.
- U.S. Forest Service, 1995, Draft environmental impact statement, Fish Bate analysis area—North Fork Ranger District, Clearwater National Forest, Clearwater County, Idaho: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 1995, Snowy Trail re-route, Ventura County, California: U.S. Forest Service, Report no. 950117, 109 p.
- U.S. Forest Service, 1996, Snowy Trail re-route, Los Padres National Forest, Ventura County, California: U.S. Forest Service, Report no. 960524.
- U.S. Forest Service, 2000, Silver Creek integrated resource project, Emmett Ranger District, Boise National Forest, Boise and Valley Counties, Idaho: U.S. Forest Service, Report no. 000241, 264 p.
- U.S. Forest Service, 2001, Land and resource management plan, Uinta National Forest—Juab, Sanpete, Toole, Utah, and Wasatch Counties, Utah: U.S. Forest Service, Report no. 010142.
- U.S. Forest Service, 2001, Starbucky restoration project, Red River Ranger District, Nez Perce National Forest, Idaho County, Idaho: U.S. Forest Service, Report no. 010274.
- U.S. Forest Service, 2002, Sixshooter project, Emmett Ranger District, Boise National Forest, Gem County, Idaho: U.S. Forest Service, Report no. 020238, 201 p.
- U.S. Forest Service, 2002, Uncompahgre National Forest travel plan revision, Gunnison, Hinsdale, Mesa, Montrose, Ouray, San Juan, and San Miguel Counties, Colorado (final supplement to the final environmental impact statement of April 2000): U.S. Forest Service, Report no. 020131, 92 p.
- U.S. Forest Service, 2002, West Gold project, Sandpoint Ranger District, Idaho Panhandle National Forests, Bonner County, Idaho: U.S. Forest Service, Report no. 020484.

- U.S. Forest Service, 2003, Big Bend Ridge vegetation management project and timber sale, Ashton/Island Park Ranger District, Caribou-Targhee National Forest, Freemont County, Idaho: U.S. Forest Service, Report no. 030225.
- U.S. Forest Service, 2003, Cross-country travel by off-highway vehicles, Apache-Sitgreaves, Coconino, Kaibab, Prescott, and Tonto National Forests, Arizona: U.S. Forest Service, Report no. 030184, 235 p.
- U.S. Forest Service, 2003, Duck Creek-Swains access management project, Cedar City Ranger District, Dixie National Forest, Iron, Garfield, and Kane Counties, Utah: U.S. Forest Service, Report no. 030343, 49 p.
- U.S. Forest Service, 2003, Upper Bear timber sale, Council Ranger District, Payette National Forest, Adams County, Idaho: U.S. Forest Service, Report no. 030319, 478 p.
- U.S. Forest Service, 2004, Duck Creek fuels treatment analysis, Cedar City Ranger District, Dixie National Forest, Kane County, Utah: U.S. Forest Service, Report no. 040535, 240 p.
- U.S. Forest Service, 2004, French Face ecosystem restoration, Ninemile Ranger District, Lolo National Forest, Montana: U.S. Forest Service, Report no. 040336, 184 p.
- U.S. Forest Service, 2005, Dean project area, Bearlodge Ranger District, Black Hills National Forest, Crook County, Wyoming: U.S. Forest Service, Report no. 050212, 192 p.
- U.S. Forest Service, 2005, Final environmental impact statement for the access designation on the Ocala National Forest, Lake, Marion, and Putnam Counties, Florida: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 2005, Gallatin National Forest travel management plan, Gallatin, Madison, Park, Meagher, Sweetgrass, and Carbon Counties, Montana: U.S. Forest Service, Report no. 050231.
- U.S. Forest Service, 2005, Rocky Mountain Ranger District travel management plan, Rocky Mountain Ranger District, Lewis and Clark National Forest, Glacier, Pondera, Teton, and Lewis and Clark Counties, Montana: U.S. Forest Service, Report no. 050236, 386 p.
- U.S. Forest Service, 2006, Hoosier National Forest land and resource management plan—Final environmental impact statement: U.S. Forest Service, Technical Report.
- U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, 1997, George Washington National Forest land and resource management plan, Virginia and West Virginia (final supplement to the Final environmental impact statement of January 1993): U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, Report no. 970046.

- U.S. National Park Service, 1979, Proceedings of the conference on scientific research in the National Parks, San Francisco, California, November 26–30, 1979: Washington D.C., U.S. Forest Service.
- U.S. National Park Service, 1998, Redwood National and State Parks general management plan, Del Norte and Humboldt Counties, California: U.S. National Park Service, Report no. 980290, 474 p.
- U.S. Naval Facilities Engineering Command, 2003, Advanced amphibious assault vehicle, Marine Corps Base Camp Pendleton and San Clemente Range Complex, San Diego County, California: U.S. Naval Facilities Engineering Command, Report no. 030201.
- U.S. Soil Conservation Service, 1990, Erosion, Grand Traverse County, Michigan: U.S. Soil Conservation Service, Technical Report.
- Valentin, C., Poesen, J., and Li, Y., 2005, Gully erosion—Impacts, factors and control: *Catena*, v. 63, no. 2–3, p. 132–153.
- van Der Puy, M.E., 1986, Rating erosion susceptibility, Proceedings of the fourth federal interagency sedimentation conference, Las Vegas, Nevada: Minneapolis, Minnesota, Federal Interagency Sedimentation Project, p. 2–1 to 2–7.
- Walker, D.A., Webber, P.J., Everett, K.R., and Brown, J., 1977, The effects of low-pressure wheeled vehicles on plant communities and soils at Prudhoe Bay, Alaska: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Report no. CRREL–SR–77–17, 50 p.
- Watson, J.J., Kerley, G.I.H., and McLachlan, A., 1996, Human activity and potential impacts on dune breeding birds in the Alexandria Coastal Dunefield: *Landscape and Urban Planning*, v. 34, no. 3–4, p. 315–322.
- Webb, R.H., 1982, Off-road motorcycle effects on a desert soil: *Environmental Conservation*, v. 9, no. 3, p. 197–208.
- Webb, R.H., 1983, Compaction of desert soils by off-road vehicles, *in* Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 50–79.
- Webb, R.H., 2002, Recovery of severely compacted soils in the Mojave Desert, California, USA: *Arid Land Research and Management*, v. 16, no. 3, p. 291–305.
- Webb, R.H., Ragland, H.C., Godwin, W.H., and Jenkins, D., 1978, Environmental effects of soil property changes with off road vehicle use: *Environmental Management*, v. 2, no. 3, p. 219–233.

- Webb, R.H., and Wilshire, H.G., 1983, Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, 534 p.
- Webb, R.H., Wilshire, H.G., and Henry, M.A., 1983, Natural recovery of soils and vegetation following human disturbance, Environmental effects of off-road vehicles-impacts and management in arid regions: New York, Springer-Verlag, p. 279–302.
- Wemple, B.C., Jones, J., and Grant, G., 1996, Channel network extension by logging roads in two basins, western Cascades, Oregon: Water Resources Bulletin, v. 32, no. 6, p. 1195–1207.
- Wester, L., 1994, Weed management and the habitat protection of rare species—A case study of the endemic Hawaiian fern *Marsilea villosa*: Biological Conservation, v. 68, no. 1, p. 1–9.
- Wiedemann, A.M., 1984, Ecology of Pacific Northwest coastal sand dunes—A community profile: Evergreen State College, Olympia, Washington, Report no. FWSOBS8404, 146 p.
- Wilshire, H.G., 1977, Study results of 9 sites used by off-road vehicles that illustrate land modifications: U.S. Geological Survey, Technical Report, 22 p.
- Wilshire, H.G., 1980, Human causes of accelerated wind erosion in California's deserts, *in* Coates, D.R., and Vitek, J.D., eds., Thresholds in geomorphology: London, George Allen and Unwin, p. 415–433.
- Wilshire, H.G., 1983, Off-road vehicle recreation management policy for public lands in the United States—A case history: Environmental Management, v. 7, no. 6, p. 489–499.
- Wilshire, H.G., 1983, The impact of vehicles on desert soil stabilizers, *in* Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles-impacts and management in arid regions: New York, Springer-Verlag, p. 31–50.
- Wilshire, H.G., and Nakata, J.K., 1976, Off-road vehicle effects on California's Mojave Desert: California Geology, June 1976, p. 123–132.
- Wilshire, H.G., Nakata, J.K., Shipley, Susan, and Prestegard, Karen, 1978, Impacts of vehicles on natural terrain at seven sites in the San Francisco Bay area: Environmental Geology, v. 2, no. 5, p. 295–319.
- Wilshire, H.G., Shipley, Susan, and Nakata, J.K., 1978, Impacts of off-road vehicles on vegetation: Transactions of the North American Wildlife and Natural Resources Conference, v. 43, p. 131–139.
- Wilson, J.P., and Seney, J.P., 1994, Erosional impact of hikers, horses, motorcycles, and off-road bicycles on mountain trails in Montana: Mountain Research and Development, v. 14, no. 1, p. 77–88.

- Wolcott, T.G., and Wolcott, D.L., 1984, Impact of off-road vehicles on macroinvertebrates of a mid-Atlantic beach: *Biological Conservation*, v. 29, no. 3, p. 217–240.
- Wright, R.C., and Burns, J.R., 1968, Mobility environmental research study—A quantitative method for describing terrain for ground mobility. Volume 2. Surface compound: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AWES–TR–3–726–2, 99 p.
- Zander, J., Ammer, U., and Breitsameter, J., 1988, Experimental studies on the effect of off-road traffic on topsoil compaction: *Forstwissenschaftliches Centralblatt*, v. 107, no. 2, p. 112–122.
- Ziani, F., and Biarez, J., 1990, Pressure sinkage relationship for tyres on very loose sand: *Journal of Terramechanics*, v. 27, no. 3, p. 167–177.

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- Agrawal, Y.K., Patel, M.P., and Merh, S.S., 1981, Lead in soils and plants—Its relationship to traffic volume and proximity to highway (Lalbag, Baroda City): *International Journal of Environmental Studies*, v. 16, no. 3–4, p. 222–224.
- Ahlstrand, G.M., and Racine, C.H., 1993, Response of an Alaska, U.S.A., shrub-tussock community to selected all-terrain vehicle use: *Arctic and Alpine Research* v. 25, no. 2, p. 142–149.
- Al-Awadhi, J.I., 2001, Impact of gravel quarrying on the desert environment of Kuwait: *Environmental Geology*, v. 41, no. 3–4, p. 365–371.
- Albrecht, J., and Knopp, T.B., 1985, Off road vehicles—Environmental impact—Management response—A bibliography: Rosemount, Minnesota, Agricultural Experiment Station, University of Minnesota, Miscellaneous Publication, 50 p.
- Anders, F.J., and Leatherman, S.P., 1987, Effects of off-road vehicles on coastal foredunes at Fire Island, New York, USA: *Environmental Management*, v. 11, no. 1, p. 45–52.
- Angold, P.G., 1997, The impact of a road upon adjacent heathland vegetation—Effects on plants species composition: *Journal of Applied Ecology*, v. 34, no. 2, p. 409–417.
- Assistant Secretary of Defense (Health and Environment), 1973, Proposed Department of Defense regulation on use of off-road vehicles: U.S. Department of Defense, Report no. ELR0511, 20 p.
- Bazzaz, F.A., and Garbutt, K., 1988, The response of annuals in competitive neighborhoods—Effects of elevated CO₂: *Ecology*, v. 69, no. 4, p. 937–946.
- Beije, H.M., 1986, Effects of military-training activities on soil, vegetation, and fauna: Leersum, Netherlands, Research Institute for Nature Management, p. 95–111.
- Belnap, Jayne, 1995, Surface disturbances—Their role in accelerating desertification: *Environmental Monitoring and Assessment*, v. 37, no. 1–3, p. 39–57.
- Ben Brooks and Associates, Ironhorse Investors Inc, Santa Fe Pacific Railroad Company and U.S. Department of the Interior, Bureau of Land Management, 1998, Hualapai Mountain Land Exchange, Mohave County, Arizona, Report no. 980482, 175 p.
- Benninger-Traux, M., Vankat, J.L., and Schaefer, R.L., 1992, Trail corridors as habitat and conduits for movement of plant species in Rocky Mountain National Park, Colorado, USA: *Landscape Ecology*, v. 6, no. 4, p. 269–278.
- Berry, K.H, 1980, A review of the effects of off-road vehicles on birds and other vertebrates, *in* DeGraaf, R.M., and Tilghman, N.G., eds., *Management of western forests and grasslands for*

- nongame birds—Workshop proceedings: Ogden Utah, U.S. Forest Service, Intermountain Forest and Range Experiment Station, p. 451–467.
- Berry, K.H., 1980, The effects of four-wheel vehicles on biological resources—Soils, vegetation, small animals, management problems, Southwestern United States, *in* Andrews, R.N.L., and Nowak, P.F., eds., Off-road vehicle use—A management challenge: Washington D.C., U.S. Office of Environmental Quality, p. 231–233.
- Boer, B., 1998, Anthropogenic factors and their potential impacts on the sustainable development of Abu Dhabi's terrestrial biological resources: *International Journal of Sustainable Development and World Ecology*, v. 5, no. 2, p. 125–135.
- Bolling, J.D., and Walker, L.R., 2000, Plant and soil recovery along a series of abandoned desert roads: *Journal of Arid Environments*, v. 46, no. 11, p. 1–24.
- Brainard, J., 1998, Patton Tank marks suggest long recovery: *Science News*, v. 154, no. 6, p. 87.
- Brattstrom, B.H., 2000, The range, habitat requirements, and abundance of the orange-throated whiptail, *Cnemidophorus hyperythrus beldingi*: *Bulletin of the Southern California Academy of Sciences*, v. 99, no. 1, p. 1–24.
- Braunack, M.V., 1986, The residual effects of tracked vehicles on soil surface properties: *Journal of Terramechanics*, v. 23, no. 1, p. 37–50.
- Brodhead, J.M.B., and Godfrey, P.J., 1977, Off road vehicle impact in Cape Cod National Seashore—Disruption and recovery of dune vegetation: *International Journal of Biometeorology*, v. 21, no. 3, p. 299–306.
- Brodhead, J.M.B., 1978, Monitoring of Province Lands off-road vehicle impact sites: Amherst, Massachusetts, Massachusetts University and National Park Service Cooperative Research Unit, Report no. UM–NPSCRU–40, 21 p.
- Brodhead, J.M.B., 1979, Remonitoring of province lands off-road vehicle impact sites: Amherst, Massachusetts, Massachusetts University and National Park Service Cooperative Research Unit, Report no. UM–NPSCRU–43, 10 p.
- Brooks, M.L., 1995, Benefits of protective fencing to plant and rodent communities of the western Mojave Desert, California: *Environmental Management*, v. 19, no. 1, p. 65–74.
- Broughton, J.D., and Adder, E.E., 1968, Mobility environmental research study—A quantitative method for describing terrain for ground mobility. Volume IV. Vegetation: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWES–TR–3–726–4, 159 p.

- Brown, G., and Porembski, S., 2000, Phytogenic hillocks and blow-outs as 'safe sites' for plants in an oil-contaminated area of northern Kuwait: *Environmental Conservation*, v. 27, no. 3, p. 242–249.
- Brown, G., and Schoknecht, N., 2001, Off-road vehicles and vegetation patterning in a degraded desert ecosystem in Kuwait: *Journal of Arid Environments*, v. 49, no. 2, p. 413–427.
- Charman, D.J., and Pollard, A.J., 1995, Long-term vegetation recovery after vehicle track abandonment on Dartmoor, SW England, U.K.: *Journal of Environmental Management*, v. 45, no. 1, p. 73–85.
- Clampitt, C.A., 1993, Effects of human disturbances on prairies and the regional endemic *Aster curtus* in western Washington: *Northwest Science*, v. 67, no. 3, p. 163–169.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Annotated bibliography for biologic overview for the Nevada nuclear waste storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832419, 48 p.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Biologic overview for the Nevada nuclear waste storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832460, 55 p.
- Davidson, E.D., and Fox, M., 1974, Effects of off-road motorcycle activity on Mojave Desert vegetation and soil: *Madroño*, v. 22, no. 8, p. 381–390.
- Duever, M.J., Riopelle, L.A., and McCollom, J.M., 1986, Long term recovery of experimental off-road vehicle impacts and abandoned old trails in the Big Cypress National Preserve: Naples, Florida, National Audubon Society, Technical Report, 56 p.
- Dyke, L.D., 1985, Terrain disturbance due to summer off-road vehicle use in central Keewatin, Northwest Territories, Canada: Ottawa, Ontario, Department of Indian Affairs and Northern Development, Report no. SSC–R71–19/36–1985F, 53 p.
- Everett, K.R., Murray, B.M., Murray, D.F., Johnson, A.W., and Linkins, A.E., 1985, Reconnaissance observations of long-term natural vegetation recovery in the Cape Thompson region, Alaska, and additions to the checklist of flora: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Report no. CRREL–85–11, 85 p.
- Falkengren-Grerup, U., 1986, Soil acidification and its impact on ground vegetation: *Oecologia*, v. 70, p. 339–347.
- Fang, S., Wente, S., Gertner, G.Z., Wang, G., and Anderson, A., 2002, Uncertainty analysis of predicted disturbance from off-road vehicular traffic in complex landscapes at Fort Hood: *Environmental Management*, v. 30, no. 2, p. 199–208.

- Fatoki, O.S., 2000, Trace zinc and copper concentrations in roadside vegetation and surface soils—A measurement of local atmospheric pollution in Alice, South Africa: *International Journal of Environmental Studies* (UK), v. 57, no. 5, p. 501–513.
- Felix, N.A., Raynolds, M.K., Jorgenson, J.C., and Dubois, K.E., 1992, Resistance and resilience of tundra plant communities to disturbance by winter seismic vehicles: *Arctic and Alpine Research*, v. 24, no. 1, p. 69–77.
- Ferris, R., and Taylor, G., 1995, Contrasting effects of elevated CO₂ and water deficit on two native herbs: *New Phytologist*, v. 131, no. 4, p. 491–501.
- Frodigh, R.J., 1967, Seasonal change revealed by time-lapse photography: Natick, Massachusetts, Army Natick Labs Earth Sciences Division, Report no. USANLABS-TR-67-34-ES, 61 p.
- Fuchs, E.H., Wood, M.K., Jones, T.L., and Racher, B., 2003, Impacts of tracked vehicles on sediment from a desert soil: *Journal of Range Management*, v. 56, no. 4, p. 342–352.
- Godfrey, P.J., Leatherman, S.P., and Buckley, P.A., 1978, Impact of off-road vehicles on coastal ecosystems, Coastal zone '78—Proceedings of the symposium on technical, environmental, socioeconomic and regulatory aspects of coastal zone management, San Francisco, California, March 14–16, 1978.
- Griggs, G.B., and Walsh, B.L., 1981, The impact, control, and mitigation of off-road vehicle activity in Hungry Valley, California: *Environmental Geology*, v. 3, no. 4, p. 229–243.
- Grimes, D.W., Miller, R.J., and Wiley, P.L., 1975, Cotton and corn root development in two field soils of different strength characteristics: *Agronomy Journal*, v. 67, p. 519–523.
- Grimes, D.W., Sheesley, W.R., and Wiley, P.L., 1978, Alfalfa root development and shoot regrowth in compact soil of wheel traffic patterns: *Agronomy Journal*, v. 70, p. 955–958.
- Griswold, T.L., 1996, A new *Microbembex* endemic to the Algodones Dunes, California (Hymenoptera: Sphecidae): *Pan-Pacific Entomologist*, v. 72, no. 3, p. 142–144.
- Hall, C., and Dearden, P., eds., 1984, The impact of "non-consumptive" recreation on wildlife—An annotated bibliography: Monticello, Illinois, Vance Bibliographies, 45 p.
- Hansen, D.J., and Ostler, W.K., 2001, Plant-damage assessment technique for evaluating military vehicular impacts to vegetation in the Mojave Desert: Las Vegas, Nevada, Bechtel Nevada, Inc., Las Vegas, NV, Report no. DOE/NV /1178613.
- Hillel, D., and Tadmor, N., 1962, Water regime and vegetation in central Negev Highlands of Israel: *Ecology*, v. 43, no. 1, p. 33–41.

- Hirst, R.A., Pywell, R.F., Marrs, R.H., and Putwains, P.D., 2003, The resistance of a chalk grassland to disturbance: *Journal of Applied Ecology*, v. 40, no. 2, p. 368–379.
- Holzapfel, C., and Schmidt, W., 1990, Roadside vegetation along transects in the Judean Desert: *Israel Journal of Botany*, v. 39, p. 263–270.
- Hosier, P.E., and Eaton, T.E., 1980, The impact of vehicles on dune and grassland vegetation on a south-eastern North Carolina barrier beach: Wilmington, North Carolina, North Carolina University at Wilmington, Report no. UNC–SG–R–164, 13 p.
- Hunt, A., Dickens, H.J., and Whelan, R.J., 1987, Movement of mammals through tunnels under railway lines: *Australian Zoologist*, v. 24, no. 2, p. 89–93.
- Iverson, R.M., Hinckley, B.S., and Webb, R.M., 1981, Physical effects of vehicular disturbances on arid landscapes: *Science*, v. 212, no. 4497, p. 915–917.
- Johnson, R.R., Mills, G.S., and Carothers, S.W., 1990, Creation and restoration of riparian habitat in southwestern arid and semi-arid regions, *in* Kusler, J.A., and Kentula, M.E., eds., *Wetland creation and restoration—The status of the science*: Covelo, California, Island Press, p. 351–366.
- Johnson, R.R., and Simpson, J.M., 1988, Desertification of wet riparian ecosystems in arid regions of the North American southwest, *in* Whitehead, E.E., Hutchinson, C.F., Timmermann, B.N., and Varady, R.G., eds., *Arid lands—Today and tomorrow*: Tuscon, Arizona, October 20–25, 1985: Boulder, Colorado, Westview Press, p. 1383–1393.
- Johnston, F.M., and Johnston, S.W., 2004, Impacts of road disturbance on soil properties and on exotic plant occurrence in subalpine areas of the Australian Alps: *Arctic, Antarctic, and Alpine Research*, v. 36, no. 2, p. 201–207.
- Kay, B.L., and Graves, W.L., 1983, Revegetation and stabilization techniques for disturbed desert vegetation, *in* Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 325–340.
- Kay, J., 1981, Evaluating environmental impacts of off-road vehicles: *Journal of Geography*, v. 80, no. 1, p. 10–18.
- Kert, J., 1992, Remote sensing of off-road vehicle emissions, *Proceedings of the optical remote sensing and applications to environmental and industrial safety problems conference*, Houston, Texas, April 6–8, 1992.
- Knisley, C.B., and Hill, J.M., 2001, Biology and conservation of the Coral Pink Sand Dunes tiger beetle, *Cicindela limbata albissima* Rumpff: *Western North American Naturalist*, v. 61, no. 4, p. 381–394.

- Kondolf, G.M., Piegay, H., and Landon, N., 2002, Channel response to increased and decreased bedload supply from land use change—Contrasts between two catchments: *Geomorphology*, v. 45, no. 1–2, p. 35–51.
- Krzsik, A.J., 1994, Desert tortoise at Fort Irwin, California—A federal threatened species: Champaign, Illinois, Construction Engineering Research Lab, Report no. CERLEN9410, 102 p.
- Kurczewski, F.E., 1998, Distribution, status, evaluation, and recommendations for the protection of *Tachysphex pechumani* Krombein, the antennal-waving wasp: *Natural Areas Journal*, v. 18, no. 3, p. 242–254.
- Kurczerski, F.E., 2000, History of white pine (*Pinus strobus*)/oak (*Quercus* spp.) savanna in southern Ontario, with particular reference to the biogeography and status of the antenna-waving wasp, *Tachysphex pechumani* (Hymenoptera: Sphecidae): *Canadian Field-Naturalist*, v. 114, no. 1, p. 1–20.
- Kutiel, P., Eden, E., and Zhevelev, Y., 2000, Effect of experimental trampling and off-road motorcycle traffic on soil and vegetation of stabilized coastal dunes, Israel: *Environmental Conservation*, v. 27, no. 1, p. 14–23.
- Kutiel, P., Eden, Z., and Zhevelev, H., 2001, The impact of motorcycle traffic on soil and vegetation of stabilized coastal dunes, Israel: *Journal of Coastal Conservation*, v. 7, no. 1, p. 81–89.
- Langdon, A.M., 2000, Mojave Desert soils, plants, and ants—Developing a monitoring strategy for off-highway-vehicles: Pomona, California, California State Polytechnic University, Pomona, 114 p.
- Lathrop, E.W., 1983, The effect of vehicle use on desert vegetation, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 153–166.
- Leis, S.A., Engle, D.M., Leslie, D.M., and Fehmi, J.S., 2005, Effects of short- and long-term disturbance resulting from military maneuvers on vegetation and soils in a mixed prairie area: *Environmental Management*, v. 36, no. 6, p. 849–861.
- Lightfoot, D.C., and Whitford, W.G., 1991, Productivity of creosotebush foliage and associated canopy arthropods along a desert roadside: *American Midland Naturalist*, v. 125, no. 2, p. 310–322.
- Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: *Environmental Management*, v. 24, no. 3, p. 309–326.

- Luckenbach, R.A., 1982, Ecology and management of the desert tortoise (*Gopherus agassizii*) in California: U.S. Fish and Wildlife Service, Technical Report, 37 p.
- Meffe, G.K., and Carroll, R.C., 1997, Principles of conservation biology: Sunderland, Massachusetts, Sinauer Associates, Inc., 729 p.
- Misak, R.F., Al-Awadhi, J.M., Omar, S.A., and Shahid, S.A., 2002, Soil degradation in Kabd area, southwestern Kuwait City: Land Degradation and Development, v. 13, no. 5, p. 403–415.
- Mize, R., Evans, R.E., Macroberts, B.R., Macroberts, M.H., and Rudolph, D.C., 2005, Restoration of pitcher plant bogs in eastern Texas, USA: Natural Areas Journal, v. 25, no. 2, p. 197–201.
- Mooney, H.A., Kueppers, M., Koch, G., Gorham, J., Chu, C., and Winner, W.E., 1988, Compensating effects to growth of carbon partitioning changes in response to SO₂-induced photosynthetic reduction in radish: Oecologia, v. 75, no. 4, p. 502–506.
- Motto, H.L., Daines, R.H., Chilko, D.M., and Motto, C.K., 1970, Lead in soils and plants—Its relationship to traffic volume and proximity to highways: Environmental Science and Technology, v. 4, p. 231–237.
- Munger, J.C., Barnett, B.R., Novak, S.J., and Ames, A.A., 2003, Impacts of off-highway motorized vehicle trails on the reptiles and vegetation of the Owyhee Front: Idaho, U.S. Bureau of Land Management Technical Bulletin No. 03-3, http://www.id.blm.gov/techbul/03_03/doc.pdf.
- Noren, O., Danfors, B., and Stambeck, A., 1984, Technical systems in energy forestry: Stockholm, Sweden, Statens Energiverk, Report no. STEV–EO–84–4, 145 p.
- O'Farrell, T.P., 1984, Conservation of the endangered San Joaquin kit fox *Vulpes macrotis mutica* in the Naval Petroleum Reserves, California: Acta Zoologica Fennica, v. 172, p. 207–208.
- Onyeausi, A.E., 1986, Measurements of impact of tourist off-road driving on grasslands in Masai Mara National Reserve, Kenya—A simulation approach: Environmental Conservation, v. 13, no. 4, p. 325–329.
- Parendes, L.A., and Jones, J.A., 2000, Role of light availability and dispersal in exotic plant invasion along roads and streams in the H. J. Andrews Experimental Forest, Oregon: Conservation Biology, v. 14, no. 1, p. 64–75.
- Persico, L.P., Nichols, K.K., and Bierman, P.R., 2005, Tracking painted pebbles—Short-term rates of sediment movement on four Mojave Desert piedmont surfaces: Water Resources Research, v. 41, no. 7, p. W07004.07001–W07004.07015.

- Pinard, M.A., Barker, M.G., and Tay, J., 2000, Soil disturbance and post-logging forest recovery on bulldozer paths in Sabah, Malaysia: *Forest Ecology and Management*, v. 130, no. 1–3, p. 213–225.
- Prose, D.V., Metzger, S.K., and Wilshire, H.G., 1987, Effects of substrate disturbance on secondary plant succession—Mojave Desert, California: *Journal of Applied Ecology*, v. 24, no. 1, p. 305–313.
- Quarles, H.D., Hanawalt, R.B., and Odum, W.E., 1974, Lead in small mammals, plants, and soil at varying distances from a highway: *Journal of Applied Ecology*, v. 11, no. 3, p. 937–949.
- Rickard, C.A., McLachlan, A., and Kerley, G.I.H., 1994, The effects of vehicular and pedestrian traffic on dune vegetation in South Africa: *Ocean and Coastal Management*, v. 23, no. 3, p. 225–247.
- Rickard, W.H., 1988, Natural vegetation at the proposed reference repository location in southeastern Washington: Richland, Washington, Battelle Pacific Northwest Labs, Report no. PNL–6402, 27 p.
- Schemnitz, S.D., and Schortemeyer, J.D., 1972, The influence of vehicles on Florida Everglades vegetation: Tallahassee, Florida, Florida State Game and Fresh Water Fish Commission, Report no. DISFEP–74–31, 65 p.
- Schreiner, B.G., 1963, Speed tests conducted in Canada during Muskeg Trafficability Test Program, August 1962: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWES–MISC–PAPER–4–621, 26 p.
- Schultink, G., 1977, Impact analysis of off-road-vehicle use on vegetation in the Grand Mere Dune environment: East Lansing, Michigan, Michigan State University, Report no. NASACR155764, 10 p.
- Shay, R., 1979, Management problems in off-road-vehicle recreation, *in* Ittner, R., Potter, D.R., Agee, J.K., and Anschell, S., eds., *Recreational impact on wildlands—Conference proceedings*, Seattle, Washington, October 27–29, 1978, U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station and U.S. National Park Service, p. 314–317.
- Sheridan, D., 1979, Off-road vehicles on public land: Washington, D.C., Council on Environmental Quality, Report no. PB86211158, 94 p.
- Shoop, S.A., 1993, Terrain characterization for trafficability: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Report no. CRREL–93–6, 29 p.
- Smith, W.H., 1976, Lead contamination of the roadside ecosystem: *Journal of the Air Pollution Control Association*, v. 26, p. 753–766.

- Snyder, C.T., Frickel, D.G., Hadley, R.F., and Miller, R.F., 1976, Effects of off-road vehicle use on the hydrology and landscape of arid environments in central and southern California: U.S. Geological Survey, Water Resources Investigations Report USGS/WRI-76-99, 52 p.
- Sparrow, S.D., Wooding, F.J., and Whiting, E.H., 1978, Effects of off-road vehicle traffic on soils and vegetation in the Denali Highway region of Alaska: *Journal of Soil and Water Conservation*, v. 33, no. 1, p. 20-27.
- Spellerburg, I.F., and Morrison, T., 1998, The ecological effects of new roads—A literature review: Wellington, New Zealand, New Zealand Department of Conservation, Technical Report, 55 p.
- Spencer, H.J., and Port, G.R., 1988, Effects of roadside conditions on plants and insects: II. Soil conditions: *Journal of Applied Ecology*, v. 25, no. 22, p. 709-715.
- Stanton, E.J., and Kurczewski, F.E., 1999, Notes on the distribution of *Cicindela lepida* Dejean (Coleoptera: Cicindelidae) in New York, Ontario and Quebec: *Coleopterists Bulletin*, v. 53, no. 3, p. 275-279.
- Steiner, A.J., and Leatherman, S.P., 1979, An annotated bibliography of the effects of off-road vehicle and pedestrian traffic on coastal ecosystems: U.S. Department of Agriculture, U.S. National Park Service Cooperative Research Unit, and University of Massachusetts Amherst, Report no. UMNPSRU45, 88 p.
- Stinson, B., 1971, An analytical model for predicting cross-country vehicle performance. Appendix E-Quantification of the screening effects of vegetation on driver's vision and vehicle speed: Vicksburg, Mississippi, U.S. Army Engineer Waterways Experiment Station, Report no. AEWESTR3783, 33 p.
- Thompson, C.R., Olszyk, D.M., Kats, G., Bytnerowicz, A., Dawson, P.J., and Wolf, J.W., 1984, Effects of ozone or sulfur dioxide on annual plants of the Mojave Desert: *Journal of the Air Pollution Control Association*, v. 34, no. 10, p. 1017-1022.
- Tunstall, B.R., and Reece, P.H., 1989, Environmental assessment of the Sunset and Big Desert lands, northwest Victoria, Australia: Clayton South, Australia, Australia Commonwealth Scientific and Industrial Research Organization, Division of Water Resources Divisional Report, Technical Report, p. 1-85.
- Turton, S.M., 2005, Managing environmental impacts of recreation and tourism in rainforests of the wet tropics of Queensland World Heritage Area: *Geographical Research*, v. 43, no. 2, p. 140-151.
- Tuttle, M., and Griggs, G., 1987, Soil erosion and management recommendations at three State Vehicular Recreation Areas, California: *Environmental Geology and Water Sciences*, v. 10, no. 2, p. 111-123.

- Tyser, R.W., and Worley, C.A., 1992, Alien flora in grasslands adjacent to road and trail corridors in Glacier National Park, Montana (U.S.A.). *Conservation Biology*, v. 6, no. 2, p. 253-262.
- U.S. Army Corps of Engineers, 1994, Stationing of mechanized or armored combat forces at Fort Lewis, Thurston and Pierce Counties, Washington: U.S. Army Corps of Engineers, Report no. 940045.
- U.S. Army Corps of Engineers, 1998, McGregor range land withdrawal, Fort Bliss, Otero County, New Mexico: U.S. Army Corps of Engineers, Report no. 980439, 586 p.
- U.S. Army Corps of Engineers, 2001, Fort Bliss mission and master plan—Dona Ana and Otero Counties, New Mexico, and El Paso County, Texas: U.S. Army Corps of Engineers, Report no. 010081.
- U.S. Army Corps of Engineers, and Oklahoma Department of Wildlife Conservation, 1986, Candy Lake, Candy Creek, Osage County, Oklahoma (supplemental information report to the final environmental impact statement of January 1975): U.S. Army Corps of Engineers, Report no. 860246, 4 p.
- U.S. Bureau of Land Management, 1985, Box Elder resource management plan, Utah: U.S. Bureau of Land Management, Report no. 850448.
- U.S. Bureau of Land Management, 1985, Lower Gila South resource management plan, La Paz, Maricopa, Pima, Pinal, and Yuma Counties, Arizona: U.S. Bureau of Land Management, Report no. 850347, 909 p.
- U.S. Bureau of Land Management, 1985, Proposed Two Rivers resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 850409.
- U.S. Bureau of Land Management, 1985, Resource management plan for the Kemmerer resource area, Lincoln, Sublette, Sweetwater, and Uinta Counties, Wyoming: U.S. Bureau of Land Management, Report no. 850532.
- U.S. Bureau of Land Management, 1985, Resource management plan for the Walker Planning Area, Nevada: U.S. Bureau of Land Management, Report no. 850274.
- U.S. Bureau of Land Management, 1985, Rio Puerco resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 850417.
- U.S. Bureau of Land Management, 1985, Two Rivers resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 850137, 163 p.
- U.S. Bureau of Land Management, 1985, White Sands resource area management plan, New Mexico: U.S. Bureau of Land Management, Report no. 850387.

- U.S. Bureau of Land Management, 1985, Yuma District resource management plan, Yuma, La Paz, and Mohave Counties, Arizona, and San Bernardino, Riverside, and Imperial Counties, California: U.S. Bureau of Land Management, Report no. 850358, 310 p.
- U.S. Bureau of Land Management, 1986, Baker resource management plan, Baker County, Oregon: U.S. Bureau of Land Management, Report no. 860150, 129 p.
- U.S. Bureau of Land Management, 1986, Lander resource management plan, Lander, Wyoming: U.S. Bureau of Land Management, Report no. 860449.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan and the Eastern San Diego County Master Framework Plan, California: U.S. Bureau of Land Management, Report no. 860432, 138 p.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan, California: U.S. Bureau of Land Management, Report no. 860077.
- U.S. Bureau of Land Management, 1986, Proposed Baker resource management plan, Vale District, Oregon: U.S. Bureau of Land Management, Report no. 860396.
- U.S. Bureau of Land Management, 1986, resource management plan for the Carlsbad resource area, Eddy, Lea, and Chaves Counties, New Mexico: U.S. Bureau of Land Management, Report no. 860101, 390 p.
- U.S. Bureau of Land Management, 1986, resource management plan for the House Range resource area, Juab and Millard Counties, Utah: U.S. Bureau of Land Management, Report no. 860377.
- U.S. Bureau of Land Management, 1986, resource management plan for the Warm Springs resource area, Millard County, Utah: U.S. Bureau of Land Management, Report no. 860395.
- U.S. Bureau of Land Management, 1986, Shoshone/Sun Valley Wilderness Study, Blaine, Butte, Cama, Custer, Gooding, and Lincoln Counties, Idaho: U.S. Bureau of Land Management, Report no. 860148, 225 p.
- U.S. Bureau of Land Management, 1987, Cascade resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 870281, 432 p.
- U.S. Bureau of Land Management, 1987, North Dakota resource management plan, Dunn and Bowman Counties, North Dakota: U.S. Bureau of Land Management, Report no. 870236, 199 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette and Lincoln Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870077, 347 p.

- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette, Teton, Lincoln, and Fremont Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870428, 232 p.
- U.S. Bureau of Land Management, 1987, Pocatello resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 870333, 132 p.
- U.S. Bureau of Land Management, 1987, Preliminary wilderness recommendations for the Arcata resource area, Eden Valley and Thatcher Ridge Wilderness Study Areas, Ukiah District, Mendocino County, California: U.S. Bureau of Land Management, Report no. 870348, 111 p.
- U.S. Bureau of Land Management, 1987, Proposed Monument resource management plan and Wilderness Study, Idaho: U.S. Bureau of Land Management, Report no. 870248, 162 p.
- U.S. Bureau of Land Management, 1987, Proposed resource management plan for the San Juan resource area, Moab District, Utah: U.S. Bureau of Land Management, Report no. 870440.
- U.S. Bureau of Land Management, 1987, Proposed resource management plan and wilderness recommendations for the Lahontan resource area, Nevada: U.S. Bureau of Land Management, Report no. 870293, 282 p.
- U.S. Bureau of Land Management, 1987, Proposed utility corridor resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 870291, 281 p.
- U.S. Bureau of Land Management, 1987, resource management plan for the Shoshone—Eureka resource area, Nevada—Wilderness recommendations: U.S. Bureau of Land Management, Report no. 870403, 101 p.
- U.S. Bureau of Land Management, 1987, Taos resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 870331.
- U.S. Bureau of Land Management, 1987, Washakie resource area resource management plan, portions of Big Horn, Hot Springs, and Washakie Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870395.
- U.S. Bureau of Land Management, 1987, Winnemucca District wilderness recommendations, Nevada and California: U.S. Bureau of Land Management, Report no. 870342, 581 p.
- U.S. Bureau of Land Management, 1988, Challis resource area proposed resource management plan, upper Columbia-Salmon Clearwater Districts, Custer and Lemhi Counties, Idaho: U.S. Bureau of Land Management, Report no. 980508.
- U.S. Bureau of Land Management, 1988, Cody resource area resource management plan, Big Horn and Park Counties, Wyoming: U.S. Bureau of Land Management, Report no. 880315.

- U.S. Bureau of Land Management, 1988, Fort Greely national maneuver area and Fort Greely air drop zone, Alaska—Resource management plan: U.S. Bureau of Land Management, Report no. 880276, 138 p.
- U.S. Bureau of Land Management, 1988, Fort Wainwright maneuver area, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 880277, 138 p.
- U.S. Bureau of Land Management, 1988, Medicine Bow-Divide resource areas (now Great Divide resource area) resource management plan, Rawlins District, Wyoming: U.S. Bureau of Land Management, Report no. 880325.
- U.S. Bureau of Land Management, 1988, Proposed Las Vegas resource management plan and final environmental impact statement, Clark and Nye Counties, Nevada: U.S. Bureau of Land Management, Report no. 980207.
- U.S. Bureau of Land Management, 1988, Uncompahgre Basin resource management plan, Colorado: U.S. Bureau of Land Management, Report no. 880345.
- U.S. Bureau of Land Management, 1988, Wilderness recommendations for the Red Mountain Wilderness study area in the Arcata resource area, California: U.S. Bureau of Land Management, Report no. 880033, 120 p.
- U.S. Bureau of Land Management, 1989, Dixie resource area management plan, Washington County, Utah: U.S. Bureau of Land Management, Report no. 890290, 250 p.
- U.S. Bureau of Land Management, 1989, Phoenix resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 890012, 240 p.
- U.S. Bureau of Land Management, 1989, Powder River Wilderness suitability study for the Powder River resource area resource management plan, Miles City District, Montana: U.S. Bureau of Land Management, Report no. 890301, 73 p.
- U.S. Bureau of Land Management, 1989, San Pedro River riparian management plan for the San Pedro River EIS Area, Cochise County, Arizona: U.S. Bureau of Land Management, Report no. 890152, 381 p.
- U.S. Bureau of Land Management, 1989, San Rafael resource management plan, Emery County, Utah: U.S. Bureau of Land Management, Report no. 890240.
- U.S. Bureau of Land Management, 1989, Utility corridor proposed resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 890326, 281 p.
- U.S. Bureau of Land Management, 1989, White Sands resource management plan amendment for McGregor Range, Otero County, New Mexico: U.S. Bureau of Land Management, Report no. 890127.

- U.S. Bureau of Land Management, 1990, Bishop resource management plan and environmental impact statement: U.S. Bureau of Land Management, Report no. BLMCAES900011610, 273 p.
- U.S. Bureau of Land Management, 1991, Arizona Strip District resource management plan, Mohave and Coconino Counties, Arizona: U.S. Bureau of Land Management, Report no. 910055, 617 p.
- U.S. Bureau of Land Management, 1991, Safford District resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 910314, 511 p.
- U.S. Bureau of Land Management, 1991, Spokane resource management plan, Washington: U.S. Bureau of Land Management, Report no. 910374, 169 p.
- U.S. Bureau of Land Management, 1992, Proposed Spokane resource management plan amendment and final environmental impact statement: U.S. Bureau of Land Management, Report no. 920286, 181 p.
- U.S. Bureau of Land Management, 1994, Fort Wainwright, Yukon maneuver area, proposed resource management plan and final environmental impact statement, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 940001, 124 p.
- U.S. Bureau of Land Management, 1994, resource management plan and environmental impact statement for the Grass Creek resource area, Worland District, Wyoming: U.S. Bureau of Land Management, Technical Report, 299 p.
- U.S. Bureau of Land Management, 1994, Stateline resource management plan, Clark and Nye Counties, Nevada (draft environmental impact statement and Draft Supplement): U.S. Bureau of Land Management, Report no. 940177.
- U.S. Bureau of Land Management, 1996, resource management plan for the Green River resource area, Rock Springs, Wyoming: U.S. Bureau of Land Management, Report no. 960148.
- U.S. Bureau of Land Management, 1997, Proposed resource management plan/final environmental impact statement for the Roswell resource area, Roswell, New Mexico and proposed resource management plan Amendment/Final environmental impact statement for the Carlsbad resource area, Carlsbad, New Mexico. Volume 1: U.S. Bureau of Land Management, Report no. BLMNMPT970031610V1, 379 p.
- U.S. Bureau of Land Management, 1997, Proposed resource management plan/final environmental impact statement for the Roswell resource area, Roswell, New Mexico and proposed resource management plan Amendment/Final environmental impact statement for the Carlsbad resource area, Carlsbad, New Mexico. Volume 2: U.S. Bureau of Land Management, Report no. BLMNMPT970031610V2, 535 p.

- U.S. Bureau of Land Management, 1998, Draft Caliente management framework plan amendment and environmental impact statement for management of desert tortoise habitat, Lincoln County, Nevada: U.S. Bureau of Land Management, Report no. 980190, 322 p.
- U.S. Bureau of Land Management, 1998, Judith-Valley-Phillips resource management plan—Chouteau, Fergus, Judith Basin, Petroleum, Phillips, and Valley Counties, Montana (draft supplement to the final environmental impact statement of September 1997): U.S. Bureau of Land Management, Report no. 980149, 51 p.
- U.S. Bureau of Land Management, 1999, Final environmental impact statement for management of desert tortoise habitat, Lincoln County, Nevada: U.S. Bureau of Land Management, Report no. 990201, 442 p.
- U.S. Bureau of Land Management, 2000, Federal fluid minerals leasing and development, Otero and Sierra Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000383, 521 p.
- U.S. Bureau of Land Management, 2000, Pinedale anticline oil and gas exploration and development project, Sublette County, Wyoming: U.S. Bureau of Land Management, Report no. 000159, 301 p.
- U.S. Bureau of Land Management, 2001, National management strategy for motorized off-highway vehicle use on public lands: U.S. Bureau of Land Management, Report no. PB2001103162, 58 p.
- U.S. Bureau of Land Management, 2003, Farmington resource management plan, San Juan, McKinley, Rio Arriba, and Sandoval Counties, New Mexico: U.S. Bureau of Land Management, Report no. 030143.
- U.S. Bureau of Land Management, 2004, Dillon resource management plan, Beaverhead and Madison Counties, Montana: U.S. Bureau of Land Management, Report no. 040153, 626 p.
- U.S. Bureau of Land Management, 2004, Jack Morrow Hills coordinated activity plan, Sweetwater, Fremont, and Sublette Counties, Wyoming: U.S. Bureau of Land Management, Technical Report.
- U.S. Bureau of Land Management, 2005, Newmont Mining Company, emigrant project, Elko County, Nevada: U.S. Bureau of Land Management, Report no. 050117, 269 p.
- U.S. Bureau of Land Management, 2006, Coeur d’Alene resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 060002, 347 p.
- U.S. Bureau of Reclamation, 2001, Pothole Reservoir resource management plan, Grant County, Washington: U.S. Bureau of Reclamation, Report no. 010518, 567 p.

- U.S. Department of Defense, 1999, Military training in the Marianas, Guam and the Commonwealth of the Northern Marianas: U.S. Department of Defense, Report no. 990187, 478 p.
- U.S. Department of the Navy, 1973, Off-road vehicle use of Mirror Lake Naval Weapons Center, China Lake, California: U.S. Department of the Navy, Report no. ELR73-1411, 67 p.
- U.S. Federal Highway Administration, 2005, US 33 Nelsonville bypass, city of Nelsonville, Hocking and Athens Counties, Ohio: U.S. Federal Highway Administration, Report no. 050282, 828 p.
- U.S. Fish and Wildlife Service, 1985, Alaska Peninsula National Wildlife Refuge final comprehensive conservation plan, environmental impact statement, and wilderness review: U.S. Fish and Wildlife Service, Technical Report, 426 p.
- U.S. Fish and Wildlife Service, 1986, Great Dismal Swamp National Wildlife Refuge Master Plan, Virginia and North Carolina: U.S. Fish and Wildlife Service, Report no. 860501, 245 p.
- U.S. Forest Service, 1973, Off-road vehicle policy, Hoosier National Forest, Indiana: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-51, 110 p.
- U.S. Forest Service, 1973, Proposed off-road vehicle regulations and administrative instructions: U.S. Forest Service, Report no. USDAFS-FES(ADM)-73-49, 110 p.
- U.S. Forest Service, 1973, Proposed regulations and administrative instructions relating to use of off-road vehicles on National Forest lands: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-49, 22 p.
- U.S. Forest Service, 1973, Unit plan for management of the South Holston unit: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-50, 80 p.
- U.S. Forest Service, 1985, Caribou National Forest and Curlew National Grassland land and resource management plan, Idaho, Utah, and Wyoming: U.S. Forest Service, Report no. 850437.
- U.S. Forest Service, 1985, Kisatchie National Forest land and resource management plan, Louisiana: U.S. Forest Service, Report no. 850414.
- U.S. Forest Service, 1985, Proposed land and resource management plan for the Medicine Bow National Forest and Thunder Basin National Grassland, Wyoming: U.S. Forest Service, Report no. 850523.
- U.S. Forest Service, 1986, Chequamegon National Forest, Wisconsin land and resource management plan: U.S. Forest Service, Report no. 860325.

- U.S. Forest Service, 1986, Cleveland National Forest land and resource management plan, Orange, Riverside, and San Diego Counties, California: U.S. Forest Service, Report no. 860209.
- U.S. Forest Service, 1986, Croatan and Uwharrie National Forests land and resource management plan, North Carolina: U.S. Forest Service, Report no. 860218.
- U.S. Forest Service, 1986, Proposed Land and resource management plan for Wayne National Forest, Ohio: U.S. Forest Service, Report no. 860426.
- U.S. Forest Service, 1987, Angeles National Forest land and resource management plan, Los Angeles, Ventura, and San Bernardino Counties, California: U.S. Forest Service, Report no. 870394.
- U.S. Forest Service, 1987, Proposed Apache-Sitgreaves National Forests Land and resource management plan, Apache, Coconino, Greenlee, and Navajo Counties, Arizona: U.S. Forest Service, Report no. 870387.
- U.S. Forest Service, 1988, Proposed Kaibab National Forest land and resource management plan, Coconino, Yavapai, and Mohave Counties, Arizona: U.S. Forest Service, Report no. 880109.
- U.S. Forest Service, 1989, San Bernardino National Forest land and resource management plan, San Bernardino and Riverside Counties, California: U.S. Forest Service, Report no. 890023.
- U.S. Forest Service, 1991, Corral Mountain timber sale, San Juan National Forest, Archuleta County, Colorado: U.S. Forest Service, Report no. 910124, 59 p.
- U.S. Forest Service, 1992, Norbeck Wildlife Preserve land management plan, Black Hills National Forest, Custer and Pennington Counties, South Dakota (final supplement to the environmental impact statement of July 1989): U.S. Forest Service, Report no. 920352, 92 p.
- U.S. Forest Service, 1992, Rangeland ecosystem management in the Uinta National Forest, Provo, Utah: U.S. Forest Service, Report no. 920322, 189 p.
- U.S. Forest Service, 1992, Sierra National Forest land and resource management plan, Fresno, Madera, and Mariposa Counties, California: U.S. Forest Service, Report no. 920105.
- U.S. Forest Service, 1993, Six Rivers National Forest plan, Humboldt, Del Norte, Siskiyou, and Trinity Counties, California: U.S. Forest Service, Report no. 930340.
- U.S. Forest Service, 1994, Oregon Dunes National Recreation Area management plan, Siuslaw National Forest—Coos, Douglas, and Lane Counties, Oregon: U.S. Forest Service, Report no. 940292.
- U.S. Forest Service, 1994, Revised land and resource management plan for the national forests and grasslands in Texas—Angelina, Fannin, Houston, Jasper, Montague, Montgomery,

Nacogdoches, Newton, Sabine, San Augustine, San Jacinto, Shelby, Trinity, Walker, and Wise Counties, Texas: U.S. Forest Service, Report no. 940385.

U.S. Forest Service, 1995, Draft environmental impact statement, Fish Bate analysis area—North Fork Ranger District, Clearwater National Forest, Clearwater County, Idaho: U.S. Forest Service, Technical Report.

U.S. Forest Service, 1995, East Fork Blacks Fork analysis area, Wasatch-Cache National Forest, Summit County, Utah (final supplement to the final environmental impact statement of July 1992): U.S. Forest Service, Report no. 950294, 49 p.

U.S. Forest Service, 1995, Mendocino National Forest land and resource management plan—Colusa, Glenn, Lake, Mendocino, Tehama, and Trinity Counties, California: U.S. Forest Service, Report no. 950337.

U.S. Forest Service, 1995, Snowy Trail re-route, Ventura County, California: U.S. Forest Service, Report no. 950117, 109 p.

U.S. Forest Service, 1996, Mendenhall Glacier Recreation Area management plan Revision, Chatham area, Juneau Ranger District, Tongass National Forest, Alaska: U.S. Forest Service, Report no. 960205, 279 p.

U.S. Forest Service, 1996, Proposed Revised Land and resource management plan for Francis Marion National Forest, Berkeley and Charleston Counties, South Carolina: U.S. Forest Service, Report no. 960158.

U.S. Forest Service, 1996, Snowy Trail re-route, Los Padres National Forest, Ventura County, California: U.S. Forest Service, Report no. 960524.

U.S. Forest Service, 2001, Land and resource management plan, Uinta National Forest—Juab, Sanpete, Toole, Utah, and Wasatch Counties, Utah: U.S. Forest Service, Report no. 010142.

U.S. Forest Service, 2001, Starbucky restoration project, Red River Ranger District, Nez Perce National Forest, Idaho County, Idaho: U.S. Forest Service, Report no. 010274.

U.S. Forest Service, 2002, Final environmental impact statement amendment to the Land and resource management plan—Management direction for acquired lands in southeastern Oklahoma, Ouachita National Forest, McCurtain County, Oklahoma: U.S. Forest Service, Technical Report.

U.S. Forest Service, 2002, Uncompahgre National Forest travel plan revision, Gunnison, Hinsdale, Mesa, Montrose, Ouray, San Juan, and San Miguel Counties, Colorado (final supplement to the final environmental impact statement of April 2000): U.S. Forest Service, Report no. 020131, 92 p.

- U.S. Forest Service, 2002, West gold project, Sandpoint Ranger District, Idaho Panhandle National Forests, Bonner County, Idaho: U.S. Forest Service, Report no. 020484.
- U.S. Forest Service, 2002, Whiskey Campo resource management project, Mountain Home Ranger District, Boise National Forest, Elmore County, Idaho: U.S. Forest Service, Report no. 020299, 151 p.
- U.S. Forest Service, 2003, Big Bend Ridge vegetation management project and timber Sale, Ashton/Island Park Ranger District, Caribou-Targhee National Forest, Freemont County, Idaho: U.S. Forest Service, Report no. 030225.
- U.S. Forest Service, 2003, Duck Creek–Swains access management project, Cedar City Ranger District, Dixie National Forest, Iron, Garfield, and Kane Counties, Utah: U.S. Forest Service, Report no. 030343, 49 p.
- U.S. Forest Service, 2003, Upper Bear timber sale, Council Ranger District, Payette National Forest, Adams County, Idaho: U.S. Forest Service, Report no. 030319, 478 p.
- U.S. Forest Service, 2004, Duck Creek fuels treatment analysis, Cedar City Ranger District, Dixie National Forest, Kane County, Utah: U.S. Forest Service, Report no. 040535, 240 p.
- U.S. Forest Service, 2004, French Face ecosystem restoration, Ninemile Ranger District, Lolo National Forest, Montana: U.S. Forest Service, Report no. 040336, 184 p.
- U.S. Forest Service, 2005, Dean Project Area, Bearlodge Ranger District, Black Hills National Forest, Crook County, Wyoming: U.S. Forest Service, Report no. 050212, 192 p.
- U.S. Forest Service, 2005, Final environmental impact statement for the access designation on the Ocala National Forest, Lake, Marion, and Putnam Counties, Florida: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 2005, Gallatin National Forest travel management plan, Gallatin, Madison, Park, Meagher, Sweetgrass, and Carbon Counties, Montana: U.S. Forest Service, Report no. 050231.
- U.S. Forest Service, 2005, Rocky Mountain Ranger District travel management plan, Rocky Mountain Ranger District, Lewis and Clark National Forest, Glacier, Pondera, Teton, and Lewis and Clark Counties, Montana: U.S. Forest Service, Report no. 050236, 386 p.
- U.S. Forest Service, 2005, Woodrock project, Tongue Ranger District, Bighorn National Forest, Sheridan County, Wyoming: U.S. Forest Service, Report no. 050112, 201 p.
- U.S. Forest Service, 2006, Hoosier National Forest land and resource management plan—Final environmental impact statement: U.S. Forest Service, Technical Report.

- U.S. Immigration and Naturalization Service, 2004, U.S. Border Patrol activities within the border areas of the Tucson and Yuma Sectors, Arizona (Revision of the Draft environmental impact statement of November 2002): U.S. Immigration and Naturalization Service, Report no. 040479, 487 p.
- U.S. National Park Service, 1979, Proceedings of the conference on scientific research in the National Parks, San Francisco, California, November 26–30, 1979, U.S. Forest Service, Washington D.C.
- U.S. National Park Service, 1991, Big Cypress National Preserve, Collier, Monroe, and Dade Counties, Florida: U.S. National Park Service, Report no. 910386.
- U.S. National Park Service, 1998, Redwood National and State Parks general management plan, Del Norte and Humboldt Counties, California: U.S. National Park Service, Report no. 980290, 474 p.
- U.S. National Park Service, 1999, Big Cypress National Preserve, recreational off-road vehicle management plan—Collier, Dade, and Monroe Counties, Florida (draft supplement to the environmental impact statement of October 1991): U.S. National Park Service, Report no. 990285, 171 p.
- U.S. National Park Service, 2000, Recreational Off-road Vehicle management plan, Big Cypress National Preserve—Collier, Miami-Dade, and Monroe Counties, Florida (final supplement to the final environmental impact statement of October 1991): U.S. National Park Service, Report no. 000275, 619 p.
- Valentin, C., Poesen, J., and Li, Y., 2005, Gully erosion—Impacts, factors and control: *Catena*, v. 63, no. 2–3, p. 132–153.
- Walker, D.A., and Everett, K.R., 1987, Road dust and its environmental impact on Alaskan taiga and tundra: *Arctic and Alpine Research*, v. 19, no. 4, p. 479–489.
- Walker, D.A., Webber, P.J., Everett, K.R., and Brown, J., 1977, The effects of low-pressure wheeled vehicles on plant communities and soils at Prudhoe Bay, Alaska: Hanover, New Hampshire, Cold Regions Research and Engineering Lab, Report no. CRREL–SR–77–17, 50 p.
- Watson, J.J., Kerley, G.I.H., and McLachlan, A., 1996, Human activity and potential impacts on dune breeding birds in the Alexandria Coastal Dunefield: *Landscape and Urban Planning*, v. 34, no. 3–4, p. 315–322.
- Webb, R.H., Wilshire, H.G., and Henry, M.A., 1983, Natural recovery of soils and vegetation following human disturbance, *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 279–302.

- Welch, R., Madden, M., and Doren, R.F., 1999, Mapping the Everglades: Photogrammetric Engineering and Remote Sensing, v. 65, no. 2, p. 163–170.
- Wester, L., 1994, Weed management and the habitat protection of rare species—A case study of the endemic Hawaiian fern *Marsilea villosa*: Biological Conservation, v. 68, no. 1, p. 1–9.
- Whitten, K.R., and Cameron, R.D., 1983, Movements of collared caribou, *Rangifer tarandus*, in relation to petroleum development on the Arctic slope of Alaska: Canadian Field-Naturalist, v. 97, no. 2, p. 143–146.
- Wiedemann, A.M., 1984, Ecology of Pacific Northwest coastal sand dunes—A community profile: Evergreen State College, Olympia, Washington, Report no. FWSOBS8404, 146 p.
- Wilcox, D.A., 1989, Migration and control of purple loosestrife (*Lythrum salicaria* L.) along highway corridors: Environmental Management, v. 13, no. 3, p. 365–370.
- Wilshire, H.G., 1983, Off-road vehicle recreation management policy for public lands in the United States—A case history: Environmental Management, v. 7, no. 6, p. 489–499.
- Wilshire, H.G., and Nakata, J.K., 1976, Off-road vehicle effects on California's Mojave Desert: California Geology, June 1976, p. 123–132.
- Wilshire, H.G., Nakata, J.K., Shipley, Susan, and Prestegaard, Karen, 1978, Impacts of vehicles on natural terrain at seven sites in the San Francisco Bay area: Environmental Geology, v. 2, no. 5, p. 295–319.
- Wilshire, H.G., Shipley, Susan, and Nakata, J.K., 1978, Impacts of off-road vehicles on vegetation: Transactions of the North American Wildlife and Natural Resources Conference, v. 43, p. 131–139.
- Winner, W.E., and Atkinson, C.J., 1986, Absorption of air pollutants by plants and consequences: Trends in Ecology and Evolution, v. 1, p. 15–18.

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- Adams, E.S., 1975, Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvelinus fontinalis*): Transactions of the American Fisheries Society, v. 104, no. 2, p. 363–373.
- Adams, J.A., Stolzy, L.H., Endo, A.S., Rowlands, P.G., and Johnson, H.B., 1982, Desert soil compaction reduces annual plant cover: California Agriculture, v. 36, no. 9–10, p. 6–7.
- Adams, L.W., and Dove, L.E., 1989, Wildlife reserves and corridors in the urban environment—A guide to ecological landscape planning and resource conservation: Columbia, Maryland, National Institute for Urban Wildlife, 91 p.
- Adams, L.W., and Geis, A.D., 1983, Effects of roads on small mammals: Journal of Applied Ecology, v. 20, no. 2, p. 403–415.
- Alaska Pulp Corporation, U.S. Forest Service, and U.S. Army Corps of Engineers, 1994, Ushk Bay timber sale, Alaska Pulp Corporation long-term timber sale Contract, Chatnam Area, Tongass National Forest, Alaska: U.S. Forest Service and U.S. Army Corps of Engineers, Report no. 940408.
- Albrecht, J., and Knopp, T.B., 1985, Off road vehicles—Environmental impact—Management response—A bibliography: Rosemount, Minnesota, Agricultural Experiment Station, University of Minnesota, Miscellaneous Publication, 50 p.
- Algers, B., Ekesbo, I., and Strömberg, S., 1978, The impact of continuous noise on animal health: Acta Veterinaria Scandinavica (Supplementum), v. 67, p. 1–26.
- Andersen, D.E., Rongstad, O.J., and Mytton, W.R., 1986, The behavioral response of red-tailed hawk to military training activity: Journal of Raptor Research, v. 20, p. 65–68.
- Andrews, A., 1990, Fragmentation of habitat by roads and utility corridors—A review: Australian Zoologist, v. 26, p. 130–141.
- Ashley, E.P., and Robinson, J.T., 1996, Road mortality of amphibians, reptiles, and other wildlife on the Long Point Causeway, Lake Erie, Ontario: The Canadian Field-Naturalist, v. 110, p. 403–412.
- Assistant Secretary of Defense (Health and Environment), 1973, Proposed Department of Defense regulation on use of off-road vehicles: U.S. Department of Defense, Report no. ELR0511, 20 p.
- Awbrey, F.T., Hunsaker, D., and Church, R., 1995, Acoustical responses of California gnatcatchers to traffic noise: Inter-noise, v. 65, p. 971–974.

- Bakowski, C., and Kozakiewicz, M., 1988, The effect of forest road on bank vole and yellow-necked mouse populations: *Acta Theriologica*, v. 33, no. 12–25, p. 345–353.
- Baur, A., and Baur, B., 1990, Are roads barriers to dispersal in the land snail *Arianta arbustorum*?: *Canadian Journal of Zoology*, v. 68, no. 33, p. 613–617.
- Becking, R.W., and Hayes, G.L., 1970, Public land policy and the environment—Volume 3, part II (cont'd)—Environmental problems on the public lands—Case studies 9 through 17: Denver, Colorado, Rocky Mountain Center on Environment, Report no. PLLRC29–3, 436 p.
- Beier, P., 1993, Determining minimum habitat areas and habitat corridors for cougars: *Conservation Biology*, v. 7, no. 11, p. 94–108.
- Beier, P., 1996, Metapopulation models, tenacious tracking, and cougar conservation, *in* McCullough, D.R., ed., *Metapopulations and wildlife conservation*: Washington, D.C., Island Press, p. 293–323.
- Belnap, Jayne, 1995, Surface disturbances—Their role in accelerating desertification: *Environmental Monitoring and Assessment*, v. 37, no. 1–3, p. 39–57.
- Belnap, Jayne, 2003, The world at your feet—Desert biological soil crusts: *Frontiers in Ecology and the Environment*, v. 1, no. 4, p. 181–189.
- Ben Brooks and Associates, Ironhorse Investors, Inc., Santa Fe Pacific Railroad Company, and U.S. Bureau of Land Management, 1998, Hualapai Mountain Land Exchange, Mohave County, Arizona: Report no. 980482, 175 p.
- Berry, K.H., 1980, A review of the effects of off-road vehicles on birds and other vertebrates, *in* DeGraaf, R.M., and Tilghman, N.G., eds., *Management of western forests and grasslands for nongame birds—Workshop proceedings*, Salt Lake City, Utah, February 11–14, 1980: Ogden Utah, U.S. Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT–86, p. 451–467.
- Berry, K.H., 1980, The effects of four-wheel vehicles on biological resources, *in* Andrews, R.N.L., and Nowak, P., eds., *Off-road vehicle use: a management challenge*: Washington, D.C., U.S. Office of Environmental Quality, p. 231–233.
- Berry, K.H., Shields, T., Woodman, A.P., Campbell, T., Roberson, J., Bohuski, K., and Karl, A., 1986, Changes in desert tortoise populations at the Desert Tortoise Research Natural Area between 1979 and 1985, *Desert Tortoise Council proceedings of symposium 10 1986*, Palmdale, California, March 22–24, 1986: Desert Tortoise Council, p. 100–123.
- Benson, P.E., Nokes, W.A., Cramer, R.L., O'Connor, J., Lindeman, W., 1986, Air-quality and noise issues in environmental planning: Washington, D.C., Transportation Research Board and National Research Council Technical Report, 72 p.,
http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7172765.

- Bjornlie, D.D., and Garrott, R.A., 2001, Effects of winter road grooming on bison in Yellowstone National Park: *Journal of Wildlife Management*, v. 65, no. 3, p. 560–572.
- Boarman, W.I., Beigel, M.L., Goodlett, G.C., and Sazaki, M., 1998, A passive integrated transponder system for tracking animal movements: *Wildlife Society Bulletin*, v. 26, no. 4, p. 886–891.
- Boarman, W.I., and Sazaki, M., 1996, Highway mortality in desert tortoises and small vertebrates—Success of barrier fences and culverts, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar*, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Boarman, W.I., and Sazaki, M., 2006, A highway's road-effect zone for desert tortoises (*Gopherus agassizii*): *Journal of Arid Environments*, v. 65, no. 1, p. 94–101.
- Boarman, W.I., Sazaki, M., Berry, K.H., Goodlett, G.O., Jennings, W.B., and Woodman, A.P., 1992, Measuring the effectiveness of a tortoise-proof fence and culverts—Status report from first field season, *Proceedings of the Desert Tortoise Council: Desert Tortoise Council*, p. 126–142.
- Boarman, W.I., Sazaki, M., and Jennings, W.B., 1997, The effects of roads, barrier fences, and culverts on desert tortoise populations in California, USA, *in* Abbeema, J.V., ed., *Proceedings—Conservation, restoration, and management of tortoises and turtles—An international conference*, State University of New York, Purchase, New York, July 1993: Orange, New Jersey, New York Turtle and Tortoise Society, p. 54–58.
- Boer, B., 1998, Anthropogenic factors and their potential impacts on the sustainable development of Abu Dhabi's terrestrial biological resources: *International Journal of Sustainable Development and World Ecology*, v. 5, no. 2, p. 125–135.
- Bolling, J.D., and Walker, L.R., 2000, Plant and soil recovery along a series of abandoned desert roads: *Journal of Arid Environments*, v. 46, no. 11, p. 1–24.
- Bond, J., 1971, Noise—Its effect on the physiology and behavior of animals: *Agricultural Science Review*, v. 9, no. 4, p. 1–10.
- Bowles, A.E., 1995, Responses of wildlife to noise, *in* Knight, R.L., and Gutzwiller, K.J., eds., *Wildlife and recreationists—Coexistence through management and research*: Washington, D.C., Island Press, p. 109–156.
- Boyle, S.A., and Samson, F.B., 1985, Effects of nonconsumptive recreation on wildlife—A review: *Wildlife Society Bulletin*, v. 13, p. 110–116.

- Braby, R.J., Shapira, A., and Simmons, R.E., 2001, Successful conservation measures and new breeding records for Damara Terns *Sterna balaenarum* in Namibia: *Marine Ornithology*, v. 29, no. 2, p. 81–84.
- Brattstrom, B.H., 2000, The range, habitat requirements, and abundance of the orange-throated whiptail, *Cnemidophorus hyperythrus beldingi*: *Bulletin of the Southern California Academy of Sciences*, v. 99, no. 1, p. 1–24.
- Brattstrom, B.H., and Bondello, M.C., 1983, Effects of off-road vehicle noise on desert vertebrates, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 167–206.
- Brezonick, M., 1996, Designing for the sound of silence: Diesel Progress Engines and Drives, v. 62, no. 8, p. 4.
- Brillinger, D.R., Preisler, H.K., Ager, A.A., and Wisdom, M.J., 2004, Stochastic differential equations in the analysis of wildlife motion, 2004 Proceedings of the American Statistical Association, section on statistics and the environment, Toronto, Ontario, Canada, August 8–12, 2004: Alexandria, Virginia, American Statistical Association.
- Brody, A.J., and Pelton, M.R., 1989, Effects of roads on black bear movements in western North Carolina: *Wildlife Society Bulletin*, v. 17, p. 5–10.
- Brooks, M.L., 1995, Benefits of protective fencing to plant and rodent communities of the western Mojave Desert, California: *Environmental Management*, v. 19, no. 1, p. 65–74.
- Brooks, M.L., 1999, Effects of protective fencing on birds, lizards, and black-tailed hares in the western Mojave Desert: *Environmental Management*, v. 23, no. 3, p. 387–400.
- Brown, G., and Porembski, S., 2000, Phytogenic hillocks and blow-outs as 'safe sites' for plants in an oil-contaminated area of northern Kuwait: *Environmental Conservation*, v. 27, no. 3, p. 242–249.
- Bruinderink, G.W.T.A., and Hazebroek, E., 1986, Ungulate traffic collisions in Europe: *Conservation Biology*, v. 10, no. 4, p. 1059–1067.
- Buckley, R., and King, N., 2003, Visitor-impact data in a land-management context, in Buckley, R.C., Pickering, D., and Weaver, D.B., eds., *Nature-based tourism, environment and land management*: Wallingford, England, CABI Publishing, p. 89–99.
- Buick, A.M., and Paton, D.C., 1989, Impact of off-road vehicles on the nesting success of hooded plovers *Charadrius rubricollis* in the Coorong region of South Australia: *Emu*, v. 89, no. 3, p. 159–172.
- Bury, R.B., 1980, What we know and do not know about off-road vehicle impacts on wildlife, in Andrews, R.N.L., and Nowak, P., eds., *Off-road vehicle use—A management challenge*: Washington, D.C., U.S. Office of Environmental Quality, p. 110–122.

- Bury, R.B., and Luckenbach, R.A., 2002, Comparison of desert tortoise (*Gopherus agassizii*) populations in an unused and off-road vehicle area in the Mojave Desert: *Chelonian Conservation and Biology*, v. 4, no. 2, p. 457–463.
- Bury, R.B., Luckenbach, R.A., and Busack, S.D., 1977, Effects of off-road vehicles on vertebrates in the California desert USA: Washington, D.C., U.S. Fish and Wildlife Service, Report, Wildlife Research Reports No. 8, p. 1–23.
- Busack, S.D., and Bury, R.B., 1974, Some effects of off-road vehicles and sheep grazing on lizard populations in the Mojave Desert: *Biological Conservation*, v. 6, no. 3, p. 179–183.
- Butcher, J., Majer, J.D., and Unsworth, P., 1989, Bibliography of fauna studies in reclaimed lands, in Majer, J.D., ed., *Animals in primary succession—The role of fauna in reclaimed lands*: New York, Cambridge University Press, p. 451–516.
- Cimon, N.J., and Wisdom, M.J., 2004, Accurate velocity estimates from inaccurate GPS data, Remote sensing for field users—Proceedings of the tenth Forest Service remote sensing applications conference, Salt Lake City, Utah, April 5–9, 2004.
- Clark, W.D., and Karr, J.R., 1979, Effects of highways on red-winged blackbird and horned lark populations: *The Wilson Bulletin*, v. 91, p. 143–145.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Annotated bibliography for biologic overview for the Nevada nuclear waste storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832419, 48 p.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Biologic overview for the Nevada Nuclear Waste Storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832460, 55 p.
- Dahle, J.L., 1983, Research study on the technology for control of environmental noise from off-road haul trucks: San Diego, California, Woodward Associates, Inc., Report no. BUMINESOFR–100–84, 94 p.
- Delaney, D.K., Grubb, T.G., Beiber, P., Pater, L.L., and Reiser, M.H., 1999, Effects of helicopter noise on Mexican spotted owls: *Journal of Wildlife Management*, v. 63, no. 1, p. 60–76.
- Delforce, R.J., Sinden, J.A., and Young, M.D., 1986, Policy preferences and social economic values to resolve pastoralism—Tourism conflicts: *Landscape Planning*, v. 12, no. 4, p. 387–401.
- Dennis, D.F., 1998, Analyzing public inputs to multiple objective decisions on national forests using conjoint analysis: *Forest Science*, v. 44, no. 3, p. 421–428.

- Dhindsa, M.S., Sandhu, J.S., Sandhu, P.S., and Toor, H.S., 1988, Roadside birds in Punjab (India)—Relation to mortality from vehicles: *Environmental Conservation*, v. 15, no. 4, p. 303–310.
- Doak, D., Kareiva, P., and Klepetka, B., 1994, Modeling population viability for the desert tortoise in the western Mojave Desert: *Ecological Applications*, v. 4, no. 3, p. 446–460.
- Dobson, A., Ralls, K., Foster, M., Soulé, M.E., Simberloff, D., Doak, D., Estes, J.A., Mills, L.S., Mattson, D., Dizro, R., Arita, H., Ryan, S., Norse, E.A., Noss, R.F., and Johns, D., 1999, Connectivity—Maintaining flows in fragmented landscapes, *in* Soulé, M.E., and Terborgh, J., eds., *Continental Conservation—Scientific foundations of regional reserve networks*: Washington, D.C., Island Press, p. 129–170.
- Dunn, J.P., Summerfield, C.J., and Johnson, M., 2003, Distribution, seasonal cycle, host plant records, and habitat evaluation of a Michigan threatened insect—The Great Plains spittlebug, *Lepyronia gibbosa* (Homoptera: Cercopidae): *Great Lakes Entomologist*, v. 35, no. 2, p. 121–129.
- Ehrenfeld, J.G., and Schneider, J.P., 1991, *Chamaecyparis thyoides* wetlands and suburbanization—Effects on hydrology, water quality and plant community composition: *Journal of Applied Ecology*, v. 28, no. 2, p. 467–490.
- Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., 1996, Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., 1998, Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98.
- Fatoki, O.S., 2000, Trace zinc and copper concentrations in roadside vegetation and surface soils—A measurement of local atmospheric pollution in Alice, South Africa: *International Journal of Environmental Studies (UK)*, v. 57, no. 5, p. 501–513.
- Feldhammer, G.A., Gates, J.E., Harman, D.M., Loranger, A.J., and Dixon, K.R., 1986, Effects of interstate highway fencing on white-tailed deer activity: *Journal of Wildlife Management*, v. 50, no. 4, p. 497–503.
- Felix, N.A., Raynolds, M.K., Jorgenson, J.C., and Dubois, K.E., 1992, Resistance and resilience of tundra plant communities to disturbance by winter seismic vehicles: *Arctic and Alpine Research*, v. 24, no. 1, p. 69–77.
- Forman, R.T.T., and Alexander, L.E., 1998, Roads and their major ecological effects: *Annual Review of Ecology and Systematics*, v. 29, p. 207–231.

- Foster, M.L., and Humphrey, S.R., 1995, Use of highway underpasses by Florida panthers and other wildlife: *Wildlife Society Bulletin*, v. 23, no. 1, p. 95–100.
- Furniss, M.J., Flanagan, S.A., and McFadin, B.A., 2000, Hydrologically connected roads—An indicator of the influence of roads on chronic sedimentation, surface water hydrology, and exposure to toxic chemicals: U.S. Forest Service, Stream Systems Technology Center, Rocky Mountain Research Station, Technical Report, 4 p.
- Garland, T., and Bradley, W.G., 1984, Effects of a highway on Mojave Desert rodent populations: *American Midland Naturalist*, v. 111, p. 47–56.
- Gibbs, J.P., 1998, Amphibian movements in response to forest edges, roads, and streambeds in southern New England: *Journal of Wildlife Management*, v. 62, no. 2, p. 584–589.
- Gibeau, M.L., and Herrero, S., 1998, Roads, rails, and grizzly bears in the Bow River Valley, Alberta, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 104–108.
- Gish, C.D., and Christensen, R.E., 1973, Cadmium, nickel, lead, and zinc in earthworms from roadside soil: *Environmental Science and Technology*, v. 7, p. 1060–1062.
- Glass, R.L., 1986, Hydrologic conditions in Connors Bog area, Anchorage, Alaska: U.S. Geological Survey, Technical Report, 23 p.
- Godfrey, P.J., and Godfrey, M.M., 1981, Ecological effects of off-road vehicles on Cape Cod: *Oceanus*, v. 23, no. 4, p. 56–57.
- Grant, T.J., 2005, Flat-tailed horned lizards (*Phrynosoma mcallii*)—Population size estimation, effects of off-highway vehicles, and natural history: Fort Collins, Colorado, M.S. thesis, Department of Wildlife Biology, Colorado State University, 84 p., http://www.warnercnr.colostate.edu/~doherty/Tyler%20Grant%20M.S.%20Thesis_FINAL.pdf
- Greene, A.F.C., 1975, The need for cooperative approaches to fish and wildlife management: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 40, p. 133–141.
- Grue, C.E., O'Shea, T.J., and Hoffman, D.J., 1984, Lead concentrations and reproduction in highway-nesting barn swallows [*Hirundo rustica*]: *Condor*, v. 86, no. 4, p. 383–389.
- Gutzwiller, K.J., and Barrow, W.C., 2003, Influences of roads and development on bird communities in protected Chihuahuan desert landscapes: *Biological Conservation*, v. 113, no. 2, p. 225–237.

- Hall, C., and Dearden, P., eds., 1984, The impact of "non-consumptive" recreation on wildlife—An annotated bibliography: Monticello, Illinois, Vance Bibliographies, 45 p.
- Hansen, R.P., Hillhouse, W.A., Willard, B.E., and Burke, H.D., 1970, Public land policy and the environment. Volume 2. Part II—Environmental problems on the public lands. Summary statement and case studies 1 through 8: Denver, Colorado, Rocky Mountain Center on Environment, Report no. PLLRC29–2, 409 p.
- Hanski, I., 1999, Metapopulation ecology: New York, Oxford University Press, 324 p.
- Hanski, I., and Simberloff, D., 1997, The metapopulation approach, its history, conceptual domain, and application to conservation, *in* Hanski, L., Gilpin, M., and Hanski, I., eds., Metapopulation biology—Ecology, genetics, and evolution: San Diego, California, Academic Press, p. 5–26.
- Harris, L.D., and Gallagher, P.B., 1989, New initiatives for wildlife conservation—The need for movement corridors, *in* Mackintosh, G., ed., Preserving communities and corridors: Washington, D.C., Defenders of Wildlife, p. 11–34.
- Hastings, M.C., 1995, Physical effects of noise on fishes, Inter-noise 95, the 1995 International Congress on Noise Control, July 10, 1995, p. 979–984.
- Haupt, H.F., 1959, Road and slope characteristics affecting sediment movement from logging roads: *Journal of Forestry*, v. 57, no. 5, p. 329–339.
- Hayes, D.L., 1991, The all-American canal lining project—A catalyst for rational and comprehensive groundwater management on the United States-Mexico border: *Natural Resources Journal*, v. 31, no. 4, p. 803–827.
- Hendriks, R.W., 1989, Traffic noise attenuation as a function of ground vegetation: California Department of Transportation, Report no. FHWA/CA/TL–89/09, 99 p.
- Hockey, P.A.R., 1983, The distribution, population size, movements and conservation of the African black oystercatcher *Haematopus moquini*: *Biological Conservation*, v. 25, no. 3, p. 233–262.
- Holsman, R.H., 2005, Management opportunities and obligations for mitigating off-road vehicle impacts to wildlife and their habitats: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 70, p. 399–417.
- Holzapfel, C., and Schmidt, W., 1990, Roadside vegetation along transects in the Judean Desert: *Israel Journal of Botany*, v. 39, p. 263–270.
- Hornby, N., and Sheate, W.R., 2001, Sustainable management of recreational off-road vehicles in National Parks in the UK: *Environmental and Waste Management*, v. 4, no. 2, p. 95–106.

- Hosier, P.E., Kochlar, M., and Thayer, V., 1981, Off-road vehicle and pedestrian track effects on the sea-approach of hatchling loggerhead turtles: *Environmental Conservation*, v. 8, no. 2, p. 158–161.
- Huey, L.M., 1941, Mammalian invasion via the highway: *Journal of Mammalogy*, v. 22, p. 383–385.
- Hunt, A., Dickens, H.J., and Whelan, R.J., 1987, Movement of mammals through tunnels under railway lines: *Australian Zoologist*, v. 24, no. 2, p. 89–93.
- Hyers, A.D., and Marcus, M.G., 1981, Land use and desert dust hazards in central Arizona, *in* Pewe, T., ed., *Desert dust—Origin, characteristics, and effect on man*: Boulder, Colorado, Geological Society of America, Inc., p. 267–280.
- Irwin, C.L., Garrett, P., and McDermott, K.P., 2003 *Proceedings of the International Conference on Ecology And Transportation*, Lake Placid, New York, August 24–29, 2003: Raleigh, North Carolina, Center for Transportation and the Environment, North Carolina State University.
- Irwin, C.L., Garrett, P., and McDermott, K.P., 2005, *Proceedings of the 2005 International Conference On Ecology And Transportation*, San Diego, California, August 29–September 2, 1995: Raleigh, North Carolina, Center for Transportation and the Environment, North Carolina State University.
- Jensen, O., 1997, Adaptive strategies in a mountain valley—A case study from Baltistan: Copenhagen, Institute of Geography, University of Copenhagen, 88 p.
- Johnson, R.R., and Simpson, J.M., 1988, Desertification of wet riparian ecosystems in arid regions of the North American southwest, *in* Whitehead, E.E., Hutchinson, C.F., Timmermann, B.N., and Varady, R.G., eds., *Arid lands—Today and tomorrow*, Tuscon, Arizona, October 20–25, 1985: Boulder, Colorado, Westview Press, p. 1383–1393.
- Karanja, G., 2003, Tourism impacts in Masai Mara National Reserve: *IIED Wildlife and Development Series*, v. 14, p. 5–16.
- Kaseloo, P.A., and Tyson, K.O., 2004, Synthesis of noise effects on wildlife populations: U.S. Federal Highway Administration, Office of Research and Technology Services, Report no. FHWA–HEP–06–016, 67 p.
- Kato, T.T., and O'Farrell, T.P., 1986, Biological assessment of the effects of petroleum production at maximum efficient rate, Naval Petroleum Reserve No. 1 (Elk Hills), Kern County, California, on the endangered blunt-nosed leopard lizard, *Gambelia silus*: Goleta, California, EG and G Energy Measurements, Inc., Report no. EGG102822108, 72 p.

- Katz, M., Legore, R.S., Weitkamp, D., Cummins, J.M., and Anderson, D., 1972, Effects on freshwater fish: *Journal of the Water Pollution Control Federation*, v. 44, no. 6, p. 1226–1250.
- Kay, B.L., and Graves, W.L., 1983, Revegetation and stabilization techniques for disturbed desert vegetation, *in* Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 325–340.
- Kellert, S.R., 1980, Activities of the American public relating to animals. Phase II: U.S. Department of Interior Fish and Wildlife Service, Technical Report.
- Khalaf, F.I., 1989, Desertification and aeolian processes in the Kuwait Desert: *Journal of Arid Environments*, v. 16, no. 2, p. 125–145.
- Kline, N.C., and Swann, D.E., 1998, Quantifying wildlife road mortality in Saguaro National Park, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 23–31.
- Knight, R.L., and Gutzwiller, K.J., 1995, *Wildlife and recreationists—Coexistence through management and research*: Washington, D.C, Island Press, 372 p.
- Knight, R.L., and Kawashima, J.Y., 1993, Responses of raven and red-tailed hawk populations to linear right-of-ways: *Journal of Wildlife Management*, v. 57, no. 2, p. 265–271.
- Kurczerski, F.E., 2000, History of white pine (*Pinus strobus*)/oak (*Quercus* spp.) savanna in southern Ontario, with particular reference to the biogeography and status of the antenna-waving wasp, *Tachysphex pechumani* (Hymenoptera: Sphecidae): *Canadian Field-Naturalist*, v. 114, no. 1, p. 1–20.
- Kurczewski, F.E., 1998, Distribution, status, evaluation, and recommendations for the protection of *Tachysphex pechumani* Krombein, the antennal-waving wasp: *Natural Areas Journal*, v. 18, no. 3, p. 242–254.
- Lacey, R.M., Goettel, R.G., Balbach, H.E., and Severinghaus, W.D., 1982, Planning for off-road recreational vehicle use on Army installations: Champaign, Illinois, Construction Engineering Research Lab, Technical Report, 98 p.
- Lacey, R.M., and Severinghaus, W.D., 1982, Evaluation of lands for off-road recreational four-wheel drive vehicle use: U.S. Department of Commerce Government Reports Announcements and Index National Technical Information Service (NTIS), Technical Report, 1755 p.
- Land, D., and Lotz, M., 1996, Wildlife crossing designs and use by Florida panthers and other wildlife in southwest Florida, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds.,

Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.

Langdon, A.M., 2000, Mojave Desert soils, plants, and ants—Developing a monitoring strategy for off-highway-vehicles: Pomona, California, California State Polytechnic University, Pomona, 114 p.

Lehnert, M.E., and Bissonette, J.A., 1997, Effectiveness of highway crosswalk structures at reducing deer-vehicle collisions: *Wildlife Society Bulletin*, v. 25, no. 4, p. 809–818.

Lightfoot, D.C., and Whitford, W.G., 1991, Productivity of creosotebush foliage and associated canopy arthropods along a desert roadside: *American Midland Naturalist*, v. 125, no. 2, p. 310–322.

Lodico, N.J., 1973, Environmental effects of off-road vehicles—A review of the literature: U.S. Office of Library Services, Research Services Branch, Technical Report, 109 p.

Lopez, J.J., and West, N., 1994, Management issues concerning the piping plover and off-road vehicles at Cape Cod National Seashore, Coastal Zone Canada '94—Cooperation in the coastal zone, Halifax, Nova Scotia, Canada, September 1994: Halifax, Nova Scotia, Canada, Ocean Studies, Office of Research Services, A&A, and Dalhousie University.

Lovallo, M.J., and Anderson, E.M., 1996, Bobcat (*Lynx rufus*) home range size and habitat use in northwest Wisconsin: *American Midland Naturalist*, v. 135, no. 2, p. 241–252.

Lovallo, M.J., and Anderson, E.M., 1996, Bobcat movements and home ranges relative to roads in Wisconsin: *Wildlife Society Bulletin*, v. 24, no. 1, p. 71–76.

Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: *Environmental Management*, v. 24, no. 3, p. 309–326.

Luckenbach, R.A., 1978, An analysis of off-road vehicle use on desert avifaunas: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 43, p. 157–162.

Luckenbach, R.A., 1982, Ecology and management of the desert tortoise (*Gopherus agassizii*) in California: U.S. Fish and Wildlife Service, Technical Report, 37 p.

Luckenbach, R.A., and Bury, R.B., 1983, Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County, California, USA: *Journal of Applied Ecology*, v. 20, no. 1, p. 265–286.

- Lyren, L., 2001, Movement patterns of coyotes and bobcats relative to roads and underpasses in the Chino Hills area of southern California: Pomona, California, California State Polytechnic University, Pomona, 127 p.
- Mader, H.J., 1984, Animal habitat isolation by roads and agricultural fields: *Biological Conservation*, v. 29, no. 1, p. 81–96.
- McDonald, P.M., and Plumb, G.E., 1996, Black-footed ferret reintroduction in the Conata Basin/Badlands of southwestern South Dakota: *Rangelands*, v. 18, no. 6, p. 222–224.
- Meffe, G.K., and Carroll, R.C., 1997, *Principles of conservation biology*: Sunderland, Massachusetts, Sinauer Associates, Inc., 729 p.
- Melvin, S.M., Griffin, C.R., and MacIvor, L.H., 1991, Recovery strategies for piping plovers in managed coastal landscapes: *Coastal Management*, v. 19, no. 1, p. 21–34.
- Melvin, S.M., Hecht, A., and Griffin, C.R., 1994, Piping plover mortalities caused by off-road vehicles on Atlantic coast beaches: *Wildlife Society Bulletin*, v. 22, no. 3, p. 409–414.
- Memphis State University, 1971, Effects of noise on wildlife and other animals: U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Report no. NTID300.5, 77 p.
- Mize, R., Evans, R.E., MacRoberts, B.R., MacRoberts, M.H., and Rudolph, D.C., 2005, Restoration of pitcher plant bogs in eastern Texas, USA: *Natural Areas Journal*, v. 25, no. 2, p. 197–201.
- Morgan, M.T., 1993, Nutrition is the key to plight of an ancient survivor, the desert tortoise: *Smithsonian Institution Research Reports*, v. 74, p. 4.
- Mumme, R.L., Schoech, S.J., Woolfenden, G.W., and Fitzpatrick, J.W., 2000, Life and death in the fast lane—Demographic consequences of road mortality in the Florida scrub-jay: *Conservation Biology*, v. 14, no. 2, p. 501–512.
- Munguira, M.L., and Thomas, J.A., 1992, Use of road verges by butterfly and burnet populations, and the effect of roads on adult dispersal and mortality: *Journal of Applied Ecology*, v. 29, p. 316–329.
- Naylor, L.M., 2006, Behavioral responses of Rocky Mountain elk (*Cervus elaphus*) to recreational disturbance: Corvallis, OR, Oregon State University, 103 p.
- Noor, M., and Shah, B.H., 1995, Infiltration capacity and soil bulk density differences between grazed area and off-road track at Paya (Kaghan Valley): *Pakistan Journal of Forestry*, v. 45, no. 1, p. 13–18.

- Noss, R.F., and Cooperrider, A.Y., 1994, Saving nature's legacy—Protecting and restoring biodiversity: Washington, D.C., Island Press, 417 p.
- Noss, R.F., and Csuti, B., 1997, Habitat fragmentation, in Meffe, G.K., and Carroll, C.R., eds., Principles of conservation biology: Sunderland, Massachusetts, Sinauer Associates, Inc., p. 269–304.
- O'Farrell, T.P., 1984, Conservation of the endangered San Joaquin kit fox *Vulpes macrotis mutica* in the Naval Petroleum Reserves, California: Acta Zoologica Fennica, v. 172, p. 207–208.
- O'Farrell, T.P., and Gilbertson, L., 1986, Ecology of the desert kit fox *Vulpes macrotis arsipus* in the Mojave Desert of southern California USA: Bulletin of the Southern California Academy of Sciences, v. 85, no. 1, p. 1–15.
- O'Farrell, T.P., Harris, C.E., Kato, T.T., and McCue, P.M., 1986, Biological assessment of the effects of petroleum production at maximum efficient rate, Naval Petroleum Reserve No. 1 (Elk Hills), Kern County, California, on the endangered San Joaquin kit fox, *Vulpes macrotis mutica*: Goleta, California, EG and G Energy Measurements, Inc., Report no. EGG102822107, 84 p.
- O'Farrell, T.P., and Kato, T.T., 1987, Biological assessment of the effects of petroleum production activities, Naval Petroleum Reserves in California, on the endangered giant kangaroo rat, *Dipodomys ingens*: Goleta, California, EG and G Energy Measurements, Inc., Report no. EGG102822183, 34 p.
- Oxley, D.J., Fenton, M.B., and Carmody, G.R., 1974, Effects of roads on populations of small mammals: Journal of Applied Ecology, v. 11, no. 1, p. 51–59.
- Paquet, P., and Callahan, C., 1996, Effects of linear developments of winter movement of gray wolves in the Bow River Valley of Banff National Park, Alberta, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Trends in addressing transportation related wildlife mortality—Proceedings of the transportation related wildlife mortality seminar, Orlando, Florida, April 30–May 2, 1996: Tallahassee, Florida, State Department of Transportation, Report no. FL-ER-58-96, <http://www.icoet.net/ICOWET/96proceedings.asp>.
- Parendes, L.A., and Jones, J.A., 2000, Role of light availability and dispersal in exotic plant invasion along roads and streams in the H. J. Andrews Experimental Forest, Oregon: Conservation Biology, v. 14, no. 1, p. 64–75.
- Piehl, B.T., Beschta, R.L., and Pyles, M.R., 1988, Ditch-relief culverts and low-volume forest roads in the Oregon Coast Range: Northwest Science, v. 62, no. 3, p. 91–98.
- Power, J.A., and Schuster, E.G., 1975, Off-road vehicle law and Idaho—An ORV planning aid: Moscow, Idaho, University of Idaho, Technical Report, 65 p.

- Preisler, H.K., Ager, A.A., and Wisdom, M.J., 2006, Statistical methods for analysing responses of wildlife to human disturbance: *Journal of Applied Ecology*, v. 43, no. 1, p. 164–172.
- Propst, D.B., Shomaker, J.H., and Mitchevkm, J.E., 1977, Attitudes of Idaho off-road vehicle users and mangers: Moscow, Idaho, College of Forestry, Wildlife and Range Sciences, University of Idaho, Technical Report, 30 p.
- Quarles, H.D., Hanawalt, R.B., and Odum, W.E., 1974, Lead in small mammals, plants, and soil at varying distances from a highway: *Journal of Applied Ecology*, v. 11, no. 3, p. 937–949.
- Rafique, S.A., 1994, Effect of grazing management and fertilizer application on vegetation and soil properties of a moist temperate forest range in Siran Valley (Mansehra), NWFP: Pakistan *Journal of Forestry*, v. 44, no. 1, p. 20–29.
- Reed, R.A., Johnson-Barnard, J., and Baker, W.L., 1996, Contribution of roads to forest fragmentation in the Rocky Mountains: *Conservation Biology*, v. 10, no. 4, p. 1098–1106.
- Reijnen, R., and Foppen, R., 1995, The effects of car traffic on breeding bird populations in woodland. IV. Influence of population size on the reduction of density close to a highway: *Journal of Applied Ecology*, v. 32, no. 3, p. 481–491.
- Reijnen, R., Foppen, R., Braak, C.T., and Thissen, J., 1995, The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads: *Journal of Applied Ecology*, v. 32, no. 1, p. 187–202.
- Reijnen, R., Foppen, R., and Veenbaas, G., 1997, Disturbance by traffic of breeding birds—Evaluation of the effect and considerations in planning and managing road corridors: *Biodiversity and Conservation*, v. 6, no. 4, p. 567–581.
- Rhoads, W.A., Cochrane, S.A., and Williams, M.P., 1979, Status of endangered and threatened plant species on Tonopah Test Range—A survey: Goleta, California, Santa Barbara Research Center, Report no. SAND807035, 126 p.
- Rickard, W.H., 1988, Natural vegetation at the proposed reference repository location in southeastern Washington: Richland, Washington, Battelle Pacific Northwest Labs, Report no. PNL–6402, 27 p.
- Rinne, J.N., Rickel, B., and Hendrickson, D., 1980, A new Gila topminnow locality in southern Arizona: Fort Collins, Colorado, U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Report no. RM-382, 4 p.
- Romin, L.A., and Bissonette, J.A., 1996, Temporal and spatial distribution of highway mortality of mule deer on newly constructed roads at Jordanelle Reservoir, Utah: *Great Basin Naturalist*, v. 56, no. 1, p. 1–11.

- Roni, P., Beechie, T.J., Bilby, R.E., Leonetti, F.E., Pollock, M.M., and Pess, G.R., 2002, A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds: *North American Journal of Fisheries Management*, v. 22, no. 1, p. 1–20.
- Rosen, P.C., and Lowe, C.H., 1994, Highway mortality of snakes in the Sonoran Desert of southern Arizona: *Biological Conservation*, v. 68, no. 22, p. 143–148.
- Rowland, M.M., Wisdom, M.J., Johnson, B.K., and Penninger, M.A., 2005, Effects of roads on elk—Implications for management in forested ecosystems, *in* Wisdom, M.J., ed., *The Starkey Project—A synthesis of long-term studies of elk and mule deer*: Lawrence, Kansas, Alliance Communications Group, p. 42–52.
- Roy, A.H., Rosemond, A.D., Leigh, D.S., Paul, M.J., and Wallace, J.B., 2003, Habitat-specific responses of stream insects to land cover disturbance—Biological consequences and monitoring implications: *Journal of the North American Benthological Society*, v. 22, no. 2, p. 292–307.
- Rudolph, D.C., Burgdorf, S.J., Conner, R.N., and Dickson, J.G., 1998, The impact of roads on the timber rattlesnake, (*Crotalus horridus*), in eastern Texas, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 236–240.
- Ruediger, B., 1998, Rare carnivores and highways—Moving into the 21st century, *in* Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., *Proceedings of the International Conference on Wildlife Ecology and Transportation*, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 10–16.
- Samways, M.J., 1989, Insect conservation and landscape ecology—A case-history of bush crickets (Tettigoniidae) in southern France: *Environmental Conservation*, v. 16, no. 3, p. 217–226.
- Saunders, D.A., Hobbs, R.J., and Margules, C.R., 1991, Biological consequences of ecosystem fragmentation—A review: *Conservation Biology*, v. 5, no. 1, p. 18–32.
- Schipani, S.P., Bruno, R.S., Lattin, M.A., King, B.M., and Patton, D.J., 1998, Quantification of cognitive process degradation while mobile, attributable to the environmental stressors endurance, vibration, and noise: Aberdeen Proving Ground, Maryland, U.S. Army Research Lab, Report no. ARL–TR–1603, 96 p.
- Seibert, H.C., and Conover, J.H., 1991, Mortality of vertebrates and invertebrates on an Athens County, Ohio [USA], highway: *Ohio Journal of Science*, v. 91, no. 4, p. 163–166.

- Servheen, C., Walker, J., and Kasworm, W., 1998, Fragmentation effects of high-speed highways on grizzly bear populations shared between the United States and Canada, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 97–103.
- Sheridan, D., 1979, Off-road vehicles on public land: Washington, D.C., Council on Environmental Quality, Report no. PB86211158, 94 p.
- Singer, F.J., 1978, Behavior of mountain goats in relation to US Highway 2, Glacier Park, Montana: Journal of Wildlife Management, v. 42, p. 591–597.
- Smith, W.H., 1976, Lead contamination of the roadside ecosystem: Journal of the Air Pollution Control Association, v. 26, p. 753–766.
- Spellerburg, I.F., 1998, Ecological effects of roads and traffic—A literature review: Global Ecology and Biogeography Letters, v. 7, no. 5, p. 317–333.
- Spellerburg, I.F., and Morrison, T., 1998, The ecological effects of new roads—A literature review: Wellington, New Zealand, New Zealand Department of Conservation, Technical Report, 55 p.
- Spencer, H.J., and Port, G.R., 1988, Effects of roadside conditions on plants and insects: II. Soil conditions: Journal of Applied Ecology, v. 25, no. 22, p. 709–715.
- Steiner, A.J., and Leatherman, S.P., 1979, An annotated bibliography of the effects of off-road vehicle and pedestrian traffic on coastal ecosystems: U.S. National Park Service Cooperative Research unit and University of Massachusetts Amherst, Report no. UMNPSCRU45, 88 p.
- Steiner, A.J., and Leatherman, S.P., 1981, Recreational impacts on the distribution of ghost crabs *Ocypode quadrata* Fab: Biological Conservation, v. 20, no. 2, p. 111–122.
- Stroh, T., 2001, Proposed Collbran rock and soil source project—Wildlife report: U.S. Bureau of Reclamation, Report no. PB2006101846, 28 p.
- Sullivan, B.K., 2000, Long-term shifts in snake populations—A California site revisited: Biological Conservation, v. 94, no. 3, p. 321–325.
- Swihart, R.K., and Slade, N.A., 1984, Road crossing in *Sigmodon hispidus* and *Microtus ochrogaster*: Journal of Mammalogy, v. 65, no. 2, p. 357–360.
- Tewes, M.E., and Blanton, D.R., 1998, Potential impacts of international bridges on ocelots and jaguarundis along the Rio Grande wildlife corridor, in Evink, G.L., Garrett, P., Zeigler, D., and Berry, J., eds., Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 10–12, 1998: Tallahassee, Florida, Florida

Department of Transportation, Environmental Management Office Report no. FL DOT FL-ER 69-98, p. 135–139.

Trombulak, S.C., and Frissell, C.A., 2000, Review of ecological effects of roads on terrestrial and aquatic communities: *Conservation Biology*, v. 14, no. 1, p. 18–30.

Tshiguvho, T.E., Dean, W.R.J., and Robertson, H.G., 1999, Conservation value of road verges in the semi-arid Karoo, South Africa—Ants (Hymenoptera: Formicidae) as bio-indicators: *Biodiversity and Conservation*, v. 8, no. 12, p. 1683–1695.

Twiss, R., Sidener, J., Bingham, G., Burke, J.E., and Hall, C.H., 1980, Potential impacts of geothermal development on outdoor recreational use of the Salton Sea: Livermore, California, University of California, Livermore, Technical Report, 61 p.

Tyser, R.W., and Worley, C.A., 1992, Alien flora in grasslands adjacent to road and trail corridors in Glacier National Park, Montana (U.S.A.). *Conservation Biology*, v. 6, no. 2, p. 253-262.

U.S. Army Corps of Engineers, 1994, Stationing of mechanized or armored combat forces at Fort Lewis, Thurston and Pierce Counties, Washington: U.S. Army Corps of Engineers, Report no. 940045.

U.S. Army Corps of Engineers, 1998, McGregor range land withdrawal, Fort Bliss, Otero County, New Mexico: U.S. Army Corps of Engineers, Report no. 980439, 586 p.

U.S. Army Corps of Engineers, 2001, Fort Bliss mission and master plan—Dona Ana and Otero Counties, New Mexico, and El Paso County, Texas: U.S. Army Corps of Engineers, Report no. 010081.

U.S. Army Corps of Engineers, and Oklahoma Department of Wildlife Conservation, 1986, Candy Lake, Candy Creek, Osage County, Oklahoma (supplemental information report to the final environmental impact statement of January 1975): U.S. Army Corps of Engineers, Report no. 860246, 4 p.

U.S. Bureau of Land Management, 1984, Book Cliffs resource management plan, Utah: U.S. Bureau of Land Management, Report no. 840541, 534 p.

U.S. Bureau of Land Management, 1984, Proposed Monument resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 840584, 419 p.

U.S. Bureau of Land Management, 1985, Box Elder resource management plan, Utah: U.S. Bureau of Land Management, Report no. 850448.

U.S. Bureau of Land Management, 1985, Grand Junction resource area—resource management plan and environmental impact statement: U.S. Bureau of Land Management, Report, 171 p.

- U.S. Bureau of Land Management, 1985, Lemhi resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 850426.
- U.S. Bureau of Land Management, 1985, Lower Gila South resource management plan, La Paz, Maricopa, Pima, Pinal, and Yuma Counties, Arizona: U.S. Bureau of Land Management, Report no. 850347, 909 p.
- U.S. Bureau of Land Management, 1985, Medicine Lodge Proposed resource management plan, Bingham, Bonneville, Butte, Clark, Fremont, Jefferson, Madison, and Teton Counties, Idaho: U.S. Bureau of Land Management, Report no. 850237.
- U.S. Bureau of Land Management, 1985, Proposed Two Rivers resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 850409.
- U.S. Bureau of Land Management, 1985, resource management plan for the Kemmerer resource area, Lincoln, Sublette, Sweetwater, and Uinta Counties, Wyoming: U.S. Bureau of Land Management, Report no. 850532.
- U.S. Bureau of Land Management, 1985, resource management plan for the Walker Planning Area, Nevada: U.S. Bureau of Land Management, Report no. 850274.
- U.S. Bureau of Land Management, 1985, Rio Puerco resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 850417.
- U.S. Bureau of Land Management, 1985, Two Rivers resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 850137, 163 p.
- U.S. Bureau of Land Management, 1985, White Sands resource area resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 850387.
- U.S. Bureau of Land Management, 1985, Yuma District resource management plan, Yuma, La Paz, and Mohave Counties, Arizona, and San Bernardino, Riverside, and Imperial Counties, California: U.S. Bureau of Land Management, Report no. 850358, 310 p.
- U.S. Bureau of Land Management, 1986, Baker resource management plan, Baker County, Oregon: U.S. Bureau of Land Management, Report no. 860150, 129 p.
- U.S. Bureau of Land Management, 1986, Big Lost/Pahsimeroi Wilderness, Idaho: U.S. Bureau of Land Management, Report no. 860399, 125 p.
- U.S. Bureau of Land Management, 1986, Eastern San Diego County planning unit, California—Preliminary wilderness recommendations: U.S. Bureau of Land Management, Report no. 860388, 195 p.
- U.S. Bureau of Land Management, 1986, Lander resource management plan, Lander, Wyoming: U.S. Bureau of Land Management, Report no. 860449.

- U.S. Bureau of Land Management, 1986, Little Snake resource management plan, Moffat, Rio Blanco, and Routt Counties, Colorado: U.S. Bureau of Land Management, Report no. 860029.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan and the Eastern San Diego County Master Framework Plan, California: U.S. Bureau of Land Management, Report no. 860432, 138 p.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan, California: U.S. Bureau of Land Management, Report no. 860077.
- U.S. Bureau of Land Management, 1986, Proposed Baker resource management plan, Vale District, Oregon: U.S. Bureau of Land Management, Report no. 860396.
- U.S. Bureau of Land Management, 1986, resource management plan for the Carlsbad resource area, Eddy, Lea, and Chaves Counties, New Mexico: U.S. Bureau of Land Management, Report no. 860101, 390 p.
- U.S. Bureau of Land Management, 1986, resource management plan for the House Range resource area, Juab and Millard Counties, Utah: U.S. Bureau of Land Management, Report no. 860377.
- U.S. Bureau of Land Management, 1986, resource management plan for the Warm Springs resource area, Millard County, Utah: U.S. Bureau of Land Management, Report no. 860395.
- U.S. Bureau of Land Management, 1986, Utah statewide wilderness environmental impact statement: U.S. Bureau of Land Management, Report no. 860036.
- U.S. Bureau of Land Management, 1986, Wilderness Suitability EIS—Grass Creek and Cody resource areas, Bighorn Basin, Wyoming (draft supplement for the Owl Creek Wilderness study area): U.S. Bureau of Land Management, Report no. 860168, 40 p.
- U.S. Bureau of Land Management, 1987, Canon City District wilderness study, Colorado: U.S. Bureau of Land Management, Report no. 870444, 238 p.
- U.S. Bureau of Land Management, 1987, Cascade resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 870281, 432 p.
- U.S. Bureau of Land Management, 1987, Glenwood Springs resource area resource management plan, Colorado—Wilderness recommendations: U.S. Bureau of Land Management, Report no. 870421, 168 p.
- U.S. Bureau of Land Management, 1987, Medicine Bow-Divide resource areas resource management plan, Rawlins District, Wyoming: U.S. Bureau of Land Management, Report no. 870212.

- U.S. Bureau of Land Management, 1987, North Dakota resource management plan, Dunn and Bowman Counties, North Dakota: U.S. Bureau of Land Management, Report no. 870236, 199 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette and Lincoln Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870077, 347 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette, Teton, Lincoln, and Fremont Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870428, 232 p.
- U.S. Bureau of Land Management, 1987, Pocatello resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 870333, 132 p.
- U.S. Bureau of Land Management, 1987, Preliminary wilderness recommendations for the Arcata resource area, Eden Valley and Thatcher Ridge Wilderness Study Areas, Ukiah District, Mendocino County, California: U.S. Bureau of Land Management, Report no. 870348, 111 p.
- U.S. Bureau of Land Management, 1987, Proposed Lemhi resource management plan, Lemhi County, Idaho—Eighteenmile Wilderness: U.S. Bureau of Land Management, Report no. 870437, 178 p.
- U.S. Bureau of Land Management, 1987, Proposed Medicine Lodge, Idaho resource management plan—Wilderness recommendations: U.S. Bureau of Land Management, Report no. 870436, 92 p.
- U.S. Bureau of Land Management, 1987, Proposed Monument resource management plan and Wilderness Study, Idaho: U.S. Bureau of Land Management, Report no. 870248, 162 p.
- U.S. Bureau of Land Management, 1987, Proposed resource management plan and wilderness recommendations for the Lahontan resource area, Nevada: U.S. Bureau of Land Management, Report no. 870293, 282 p.
- U.S. Bureau of Land Management, 1987, Proposed resource management plan for the San Juan resource area, Moab District, Utah: U.S. Bureau of Land Management, Report no. 870440.
- U.S. Bureau of Land Management, 1987, Proposed Utility Corridor resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 870291, 281 p.
- U.S. Bureau of Land Management, 1987, Proposed Wilderness Program for the Stafford District Wilderness EIS Area, Cochise, Gila, Graham, and Greenlee Counties, Arizona and Hidalgo County, New Mexico: U.S. Bureau of Land Management, Report no. 870156, 502 p.

- U.S. Bureau of Land Management, 1987, Proposed wilderness program for the Upper Sonoran Wilderness EIS Area, Maricopa, Mohave, Yavapai, and Yuma Counties, Arizona: U.S. Bureau of Land Management, Report no. 870292, 394 p.
- U.S. Bureau of Land Management, 1987, resource management plan for the Elko resource area, Nevada—Wilderness Plan: U.S. Bureau of Land Management, Report no. 870400, 172 p.
- U.S. Bureau of Land Management, 1987, Taos resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 870331.
- U.S. Bureau of Land Management, 1987, Washakie resource area resource management plan, portions of Big Horn, Hot Springs, and Washakie Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870395.
- U.S. Bureau of Land Management, 1987, Wilderness recommendations for the north-central California Wilderness Study Areas: U.S. Bureau of Land Management, Report no. 870058, 115 p.
- U.S. Bureau of Land Management, 1987, Winnemucca District wilderness recommendations, Nevada and California: U.S. Bureau of Land Management, Report no. 870342, 581 p.
- U.S. Bureau of Land Management, 1988, Brothers/Lapine resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 880365.
- U.S. Bureau of Land Management, 1988, Central California Section 202 wilderness study areas wilderness recommendations—Sheep Ridge, Milk Ranch/Case Mountain, and Ventana contiguous wilderness study areas: U.S. Bureau of Land Management, Report no. 880020, 110 p.
- U.S. Bureau of Land Management, 1988, Challis resource area proposed resource management plan, upper Columbia-Salmon Clearwater Districts, Custer and Lemhi Counties, Idaho: U.S. Bureau of Land Management, Report no. 980508.
- U.S. Bureau of Land Management, 1988, Cody resource area resource management plan, Big Horn and Park Counties, Wyoming: U.S. Bureau of Land Management, Report no. 880315.
- U.S. Bureau of Land Management, 1988, Fort Greely National maneuver area and Fort Greely Air Drop Zone, Alaska—Resource management plan: U.S. Bureau of Land Management, Report no. 880276, 138 p.
- U.S. Bureau of Land Management, 1988, Fort Wainwright maneuver area, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 880277, 138 p.
- U.S. Bureau of Land Management, 1988, Medicine Bow-Divide resource areas (now Great Divide resource area) resource management plan, Rawlins District, Wyoming: U.S. Bureau of Land Management, Report no. 880325.

- U.S. Bureau of Land Management, 1988, Pony Express resource management plan, Toole, Utah, and Salt Lake Counties, Utah: U.S. Bureau of Land Management, Report no. 880310, 147 p.
- U.S. Bureau of Land Management, 1988, Proposed Las Vegas resource management plan and final environmental impact statement, Clark and Nye Counties, Nevada: U.S. Bureau of Land Management, Report no. 980207.
- U.S. Bureau of Land Management, 1988, Uncompahgre Basin resource management plan, Colorado: U.S. Bureau of Land Management, Report no. 880345.
- U.S. Bureau of Land Management, 1988, West Hiline resource management plan, northcentral Montana: U.S. Bureau of Land Management, Report no. 880200, 306 p.
- U.S. Bureau of Land Management, 1988, Wilderness recommendations for the Red Mountain Wilderness Study Area in the Arcata resource area, California: U.S. Bureau of Land Management, Report no. 880033, 120 p.
- U.S. Bureau of Land Management, 1988, Wilderness Study Areas in the Rock Springs District, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming (revised draft environmental impact statement): U.S. Bureau of Land Management, Report no. 880359, 175 p.
- U.S. Bureau of Land Management, 1989, Arcata resource management plan, California: U.S. Bureau of Land Management, Report no. 890306, 354 p.
- U.S. Bureau of Land Management, 1989, Dixie resource area management plan, Washington County, Utah: U.S. Bureau of Land Management, Report no. 890290, 250 p.
- U.S. Bureau of Land Management, 1989, Phoenix resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 890012, 240 p.
- U.S. Bureau of Land Management, 1989, Powder River wilderness suitability study for the Powder River resource area resource management plan, Miles City District, Montana: U.S. Bureau of Land Management, Report no. 890301, 73 p.
- U.S. Bureau of Land Management, 1989, San Pedro River riparian management plan for the San Pedro River EIS Area, Cochise County, Arizona: U.S. Bureau of Land Management, Report no. 890152, 381 p.
- U.S. Bureau of Land Management, 1989, San Rafael resource management plan, Emery County, Utah: U.S. Bureau of Land Management, Report no. 890240.
- U.S. Bureau of Land Management, 1989, Utility Corridor Proposed resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 890326, 281 p.

- U.S. Bureau of Land Management, 1989, White Sands resource management plan amendment for McGregor Range, Otero County, New Mexico: U.S. Bureau of Land Management, Report no. 890127.
- U.S. Bureau of Land Management, 1990, Bishop resource management plan and environmental impact statement: U.S. Bureau of Land Management, Report no. BLMCAES900011610, 273 p.
- U.S. Bureau of Land Management, 1990, Rock Springs District wilderness study areas, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming: U.S. Bureau of Land Management, Report no. 900439, 324 p.
- U.S. Bureau of Land Management, 1990, Uncompahgre Basin resource area, Montrose District, Colorado—Wilderness plan: U.S. Bureau of Land Management, Report no. 900175, 175 p.
- U.S. Bureau of Land Management, 1991, Arizona Strip District resource management plan, Mohave and Coconino Counties, Arizona: U.S. Bureau of Land Management, Report no. 910055, 617 p.
- U.S. Bureau of Land Management, 1991, resource management plan for public lands in the state of Nebraska: U.S. Bureau of Land Management, Report no. 910385, 144 p.
- U.S. Bureau of Land Management, 1991, Safford District resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 910314, 511 p.
- U.S. Bureau of Land Management, 1991, Spokane resource management plan, Washington: U.S. Bureau of Land Management, Report no. 910374, 169 p.
- U.S. Bureau of Land Management, 1991, Three Rivers resource management plan, Harney, Grant, Lake, and Malheur Counties, Oregon: U.S. Bureau of Land Management, Report no. 910335.
- U.S. Bureau of Land Management, 1992, Proposed Spokane resource management plan amendment and final environmental impact statement: U.S. Bureau of Land Management, Report no. 920286, 181 p.
- U.S. Bureau of Land Management, 1993, resource management plan and environmental impact statement for the Big Dry resource area, Miles City District, Montana: U.S. Bureau of Land Management, Report no. 930076, 382 p.
- U.S. Bureau of Land Management, 1994, Burley District tiger beetle inventory: U.S. Bureau of Land Management, Report no. BLMTB942, 27 p.
- U.S. Bureau of Land Management, 1994, Fort Wainwright, Yukon maneuver area, proposed resource management plan and final environmental impact statement, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 940001, 124 p.

- U.S. Bureau of Land Management, 1994, resource management plan and environmental impact statement for the Grass Creek resource area, Worland District, Wyoming: U.S. Bureau of Land Management, Report, 299 p.
- U.S. Bureau of Land Management, 1994, Salem District resource management plan and environmental impact statement—Benton, Clackamas, Clatsop, Columbia, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties, Oregon: U.S. Bureau of Land Management, Report no. 940461.
- U.S. Bureau of Land Management, 1994, Stateline resource management plan, Clark and Nye Counties, Nevada (draft environmental impact statement and draft supplement): U.S. Bureau of Land Management, Report no. 940177.
- U.S. Bureau of Land Management, 1996, resource management plan for the Green River resource area, Rock Springs, Wyoming: U.S. Bureau of Land Management, Report no. 960148.
- U.S. Bureau of Land Management, 1996, Sweet Grass Hills resource management plan amendment, Liberty and Toole Counties, Montana: U.S. Bureau of Land Management, Report no. 960243, 179 p.
- U.S. Bureau of Land Management, 1997, Proposed resource management plan/final environmental impact statement for the Roswell resource area, Roswell, New Mexico and proposed resource management plan amendment/final environmental impact statement for the Carlsbad resource area, Carlsbad, New Mexico. Volume 1: U.S. Bureau of Land Management, Report no. BLMNMPT970031610V1, 379 p.
- U.S. Bureau of Land Management, 1997, Proposed resource management plan/Final environmental impact statement for the Roswell resource area, Roswell, New Mexico and proposed resource management plan amendment/final environmental impact statement for the Carlsbad resource area, Carlsbad, New Mexico. Volume 2: U.S. Bureau of Land Management, Report no. BLMNMPT970031610V2, 535 p.
- U.S. Bureau of Land Management, 1997, Roswell and Carlsbad resource areas—Chaves, Curry, DeBaca, Eddy, Guadalupe, Lea, Lincoln, Quay, and Roosevelt Counties, New Mexico: U.S. Bureau of Land Management, Report no. 970072.
- U.S. Bureau of Land Management, 1998, Draft Caliente management framework plan amendment and environmental impact statement for management of desert tortoise habitat, Lincoln County, Nevada: U.S. Bureau of Land Management, Report no. 980190, 322 p.
- U.S. Bureau of Land Management, 1998, Judith-Valley-Phillips resource management plan—Chouteau, Fergus, Judith Basin, Petroleum, Phillips, and Valley Counties, Montana (draft supplement to the Final environmental impact statement of September 1997): U.S. Bureau of Land Management, Report no. 980149, 51 p.

- U.S. Bureau of Land Management, 1998, Socorro resource area resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 880397, 266 p.
- U.S. Bureau of Land Management, 1999, Final environmental impact statement for management of desert tortoise habitat, Lincoln County, Nevada: U.S. Bureau of Land Management, Report no. 990201, 442 p.
- U.S. Bureau of Land Management, 2000, Federal fluid minerals leasing and development, Otero and Sierra Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000383, 521 p.
- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Albuquerque Field Office—Bernalillo, Cibola, McKinley, Rio Arriba, Sandoval, Santa Fe, and Valencia Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000304.
- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Farmington Field Office—McKinley, Rio Arriba, San Juan, and Sandoval Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000302.
- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Las Cruces Field Office—Dona Ana, Grant, Hidalgo, and Luna Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000303.
- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Taos Field Office—Colfax, Harding, Los Alamos, Mora, Rio Arriba, San Miguel, Santa Fe, Taos, and Unison Counties, New Mexico: U.S. Bureau of Land Management, Report no. 00305.
- U.S. Bureau of Land Management, 2001, National management strategy for motorized off-highway vehicle use on public lands: U.S. Bureau of Land Management, Report no. PB2001103162, 58 p.
- U.S. Bureau of Land Management, 2003, Farmington resource management plan, San Juan, McKinley, Rio Arriba, and Sandoval Counties, New Mexico: U.S. Bureau of Land Management, Report no. 030143.
- U.S. Bureau of Land Management, 2004, Dillon resource management plan, Beaverhead and Madison Counties, Montana: U.S. Bureau of Land Management, Report no. 040153, 626 p.
- U.S. Bureau of Land Management, 2004, Jack Morrow Hills coordinated activity plan, Sweetwater, Fremont, and Sublette Counties, Wyoming: U.S. Bureau of Land Management, Technical Report.
- U.S. Bureau of Land Management, 2005, Newmont Mining Company, Emigrant project, Elko County, Nevada: U.S. Bureau of Land Management, Report no. 050117, 269 p.

- U.S. Bureau of Land Management, 2006, Coeur d'Alene resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 060002, 347 p.
- U.S. Bureau of Land Management and U.S. Fish and Wildlife Service, 1992, Cokeville Meadows National Wildlife Refuge Proposal, Lincoln County, Wyoming: U.S. Bureau of Land Management and U.S. Fish and Wildlife Service, Report no. 920230, 123 p.
- U.S. Bureau of Land Management and U.S. Forest Service, 1986, Proposed Coronado National Forest land and resource management plan, Arizona and New Mexico: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 860307.
- U.S. Bureau of Land Management and U.S. Forest Service, 1990, Proposed Cokeville Meadows National Wildlife Refuge, Lincoln County, Wyoming: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 900388, 197 p.
- U.S. Bureau of Land Management and U.S. Forest Service, 2004, North Fork of the South Platte and the South Platte Rivers wild and scenic river study report, Pike and San Isabel National Forests and Comanche and Cimarron National Grasslands, Douglas, Jefferson, Park, and Teller Counties, Colorado: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 040037, 301 p.
- U.S. Bureau of Reclamation, 2001, Pothole Reservoir resource management plan, Grant County, Washington: U.S. Bureau of Reclamation, Report no. 010518, 567 p.
- U.S. Department of Defense, 1999, Military training in the Marianas, Guam and the Commonwealth of the Northern Marianas: U.S. Department of Defense, Report no. 990187, 478 p.
- U.S. Department of the Navy, 1973, Off-road vehicle use of Mirror Lake Naval Weapons Center, China Lake, California: U.S. Department of the Navy, Report no. ELR73-1411, 67 p.
- U.S. Department of the Air Force, 1992, Defense evaluation support activity testing and evaluation program, Kirtland Air Force Base, New Mexico: U.S. Department of the Air Force, Report no. 920325, 487 p.
- U.S. Department of the Air Force Tactical Air Command and U.S. Bureau of Land Management, 1986, Renewed withdrawal of Groom Mountain Range addition to Nellis Air Force bombing and gunnery range, Lincoln County, Nevada: U.S. Department of the Air Force, Tactical Air Command and U.S. Bureau of Land Management, Report no. 860476.
- U.S. Federal Highway Administration, 1965, Design of roadside drainage channels: U.S. Federal Highway Administration, Report no. FHWAEPD86103, 64 p.
- U.S. Federal Highway Administration, 2005, US 33 Nelsonville bypass, city of Nelsonville, Hocking and Athens Counties, Ohio: U.S. Federal Highway Administration, Report no. 050282, 828 p.

- U.S. Fish and Wildlife Service, 1985, Alaska Peninsula National Wildlife Refuge final comprehensive conservation plan, environmental impact statement, and wilderness review: U.S. Fish and Wildlife Service, Technical Report, 426 p.
- U.S. Fish and Wildlife Service, 1985, Becharof National Wildlife Refuge comprehensive conservation plan and wilderness review, Alaska: U.S. Fish and Wildlife Service, Report no. 850193, 268 p.
- U.S. Fish and Wildlife Service, 1986, Great Dismal Swamp National Wildlife Refuge master plan, Virginia and North Carolina: U.S. Fish and Wildlife Service, Report no. 860501, 245 p.
- U.S. Forest Service, 1973, Aquarius Land Use Plan: U.S. Forest Service, Report no. USDAFSFESADM7411, 253 p.
- U.S. Forest Service, 1973, Management of South Holston unit: U.S. Forest Service, Report no. USDAFSFESADM7350, 121 p.
- U.S. Forest Service, 1973, Off-road vehicle policy, Hoosier National Forest, Indiana: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-51, 110 p.
- U.S. Forest Service, 1973, Proposed off-road vehicle regulations and administrative instructions: U.S. Forest Service, Report no. USDAFS-FES(ADM)-73-49, 110 p.
- U.S. Forest Service, 1973, Proposed regulations and administrative instructions relating to use of off-road vehicles on National Forest lands: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-49, 22 p.
- U.S. Forest Service, 1973, Unit plan for management of the South Holston unit: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-50, 80 p.
- U.S. Forest Service, 1985, Caribou National Forest and Curlew National Grassland land and resource management plan, Idaho, Utah, and Wyoming: U.S. Forest Service, Report no. 850437.
- U.S. Forest Service, 1985, Forest land and resource management plan, Mark Twain National Forest, Missouri: U.S. Forest Service, Report no. 850118.
- U.S. Forest Service, 1985, Kisatchie National Forest land and resource management plan, Louisiana: U.S. Forest Service, Report no. 850414.
- U.S. Forest Service, 1985, Proposed land and resource management plan for the Medicine Bow National Forest and Thunder Basin National Grassland, Wyoming: U.S. Forest Service, Report no. 850523.

- U.S. Forest Service, 1986, Chequamegon National Forest, Wisconsin land and resource management plan: U.S. Forest Service, Report no. 860325.
- U.S. Forest Service, 1986, Cleveland National Forest land and resource management plan, Orange, Riverside, and San Diego Counties, California: U.S. Forest Service, Report no. 860209.
- U.S. Forest Service, 1986, Croatan and Uwharrie National Forests land and resource management plan, North Carolina: U.S. Department of Agriculture Forest Service, Report no. 860218.
- U.S. Forest Service, 1986, Land and resource management plan, Chippewa National Forest, Beltrami, Cass, and Itasca Counties, Minnesota: U.S. Forest Service, Report no. 860208.
- U.S. Forest Service, 1986, Mark Twain National Forest land and resource management plan, Missouri: U.S. Forest Service, Report no. 860260.
- U.S. Forest Service, 1986, National Forests in Alabama land and resource management plan: U.S. Forest Service, Report no. 860095.
- U.S. Forest Service, 1986, Proposed Carson National Forest plan, Rio Arriba, Taos, Colfax, and Mora Counties, New Mexico: U.S. Forest Service, Report no. 860447.
- U.S. Forest Service, 1986, Proposed land and resource management plan for Wayne National Forest, Ohio: U.S. Forest Service, Report no. 860426.
- U.S. Forest Service, 1986, Proposed Santa Fe National Forest land and resource management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 860013.
- U.S. Forest Service, 1987, Angeles National Forest land and resource management plan, Los Angeles, Ventura, and San Bernardino Counties, California: U.S. Forest Service, Report no. 870394.
- U.S. Forest Service, 1987, Proposed Apache-Sitgreaves National Forests land and resource management plan, Apache, Coconino, Greenlee, and Navajo Counties, Arizona: U.S. Forest Service, Report no. 870387.
- U.S. Forest Service, 1987, Proposed land and resource management plan for the Coconino Forest, Coconino, Gila, and Yavapai Counties, Arizona: U.S. Forest Service, Report no. 870288.
- U.S. Forest Service, 1987, Santa Fe National Forest land management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 870299.

- U.S. Forest Service, 1988, Proposed Kaibab National Forest land and resource management plan, Coconino, Yavapai, and Mohave Counties, Arizona: U.S. Forest Service, Report no. 880109.
- U.S. Forest Service, 1988, Record of decision for USDA, Forest Service—Final environmental impact statement, Allegheny National Forest, land and resource management plan—Elk, Forest, McKean, and Warren Counties, Pennsylvania: U.S. Forest Service, Technical Report, 41 p.
- U.S. Forest Service, 1989, San Bernardino National Forest land and resource management plan, San Bernardino and Riverside Counties, California: U.S. Forest Service, Report no. 890023.
- U.S. Forest Service, 1990, Cherokee National Forest land and resource management plan, Tennessee, North Carolina, and Virginia (final supplement to the final environmental impact statement of April 1986): U.S. Forest Service, Report no. 900062, 62 p.
- U.S. Forest Service, 1990, Umatilla National Forest land and resource management plan, Oregon and Washington: U.S. Forest Service, Report no. 900237.
- U.S. Forest Service, 1991, Corral Mountain timber sale, San Juan National Forest, Archuleta County, Colorado: U.S. Forest Service, Report no. 910124, 59 p.
- U.S. Forest Service, 1992, Martinez Creek timber sale, San Juan National Forest, Colorado: U.S. Forest Service, Report no. 920275, 75 p.
- U.S. Forest Service, 1992, Norbeck Wildlife Preserve land management plan, Black Hills National Forest, Custer and Pennington Counties, South Dakota (final supplement to the environmental impact statement of July 1989): U.S. Forest Service, Report no. 920352, 92 p.
- U.S. Forest Service, 1992, Rangeland ecosystem management in the Uinta National Forest, Provo, Utah: U.S. Forest Service, Report no. 920322, 189 p.
- U.S. Forest Service, 1992, Sierra National Forest land and resource management plan, Fresno, Madera, and Mariposa Counties, California: U.S. Forest Service, Report no. 920105.
- U.S. Forest Service, 1993, Six Rivers National Forest plan, Humboldt, Del Norte, Siskiyou, and Trinity Counties, California: U.S. Forest Service, Report no. 930340.
- U.S. Forest Service, 1994, Oregon Dunes National Recreation Area management plan, Siuslaw National Forest—Coos, Douglas, and Lane Counties, Oregon: U.S. Forest Service, Report no. 940292.
- U.S. Forest Service, 1994, Revised land and resource management plan for the national forests and grasslands in Texas—Angelina, Fannin, Houston, Jasper, Montague, Montgomery, Nacogdoches, Newton, Sabine, San Augustine, San Jacinto, Shelby, Trinity, Walker, and Wise Counties, Texas: U.S. Forest Service, Report no. 940385.

- U.S. Forest Service, 1995, Draft environmental impact statement, Fish Bate analysis area—North Fork Ranger District, Clearwater National Forest, Clearwater County, Idaho: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 1995, East Fork Blacks Fork analysis area, Wasatch-Cache National Forest, Summit County, Utah (final supplement to the final environmental impact statement of July 1992): U.S. Forest Service, Report no. 950294, 49 p.
- U.S. Forest Service, 1995, Mendocino National Forest land and resource management plan—Colusa, Glenn, Lake, Mendocino, Tehama, and Trinity Counties, California: U.S. Forest Service, Report no. 950337.
- U.S. Forest Service, 1995, Snowy Trail re-route, Ventura County, California: U.S. Forest Service, Report no. 950117, 109 p.
- U.S. Forest Service, 1996, Mendenhall Glacier Recreation Area management plan Revision, Chatham area, Juneau Ranger District, Tongass National Forest, Alaska: U.S. Forest Service, Report no. 960205, 279 p.
- U.S. Forest Service, 1996, Proposed revised land and resource management plan for Francis Marion National Forest, Berkeley and Charleston Counties, South Carolina: U.S. Forest Service, Report no. 960158.
- U.S. Forest Service, 1996, Snowy Trail re-route, Los Padres National Forest, Ventura County, California: U.S. Forest Service, Report no. 960524.
- U.S. Forest Service, 2000, Silver Creek integrated resource project, Emmett Ranger District, Boise National Forest, Boise and Valley Counties, Idaho: U.S. Forest Service, Report no. 000241, 264 p.
- U.S. Forest Service, 2001, Land and resource management plan, Uinta National Forest—Juab, Sanpete, Toole, Utah, and Wasatch Counties, Utah: U.S. Forest Service, Report no. 010142.
- U.S. Forest Service, 2001, Starbucky restoration project, Red River Ranger District, Nez Perce National Forest, Idaho County, Idaho: U.S. Forest Service, Report no. 010274.
- U.S. Forest Service, 2002, Final environmental impact statement amendment to the land and resource management plan—Management direction for acquired lands in southeastern Oklahoma, Ouachita National Forest, McCurtain County, Oklahoma: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 2002, Uncompahgre National Forest travel plan revision, Gunnison, Hinsdale, Mesa, Montrose, Ouray, San Juan, and San Miguel Counties, Colorado (final supplement to the final environmental impact statement of April 2000): U.S. Forest Service, Report no. 020131, 92 p.

- U.S. Forest Service, 2002, West Gold Project, Sandpoint Ranger District, Idaho Panhandle National Forests, Bonner County, Idaho: U.S. Forest Service, Report no. 020484.
- U.S. Forest Service, 2002, Whiskey Campo resource management project, Mountain Home Ranger District, Boise National Forest, Elmore County, Idaho: U.S. Forest Service, Report no. 020299, 151 p.
- U.S. Forest Service, 2003, Big Bend Ridge vegetation management project and timber Sale, Ashton/Island Park Ranger District, Caribou-Targhee National Forest, Freemont County, Idaho: U.S. Forest Service, Report no. 030225.
- U.S. Forest Service, 2003, Duck Creek–Swains access management project, Cedar City Ranger District, Dixie National Forest, Iron, Garfield, and Kane Counties, Utah: U.S. Forest Service, Report no. 030343, 49 p.
- U.S. Forest Service, 2003, Upper Bear timber sale, Council Ranger District, Payette National Forest, Adams County, Idaho: U.S. Forest Service, Report no. 030319, 478 p.
- U.S. Forest Service, 2004, Duck Creek fuels treatment analysis, Cedar City Ranger District, Dixie National Forest, Kane County, Utah: U.S. Forest Service, Report no. 040535, 240 p.
- U.S. Forest Service, 2004, French Face ecosystem restoration, Ninemile Ranger District, Lolo National Forest, Montana: U.S. Forest Service, Report no. 040336, 184 p.
- U.S. Forest Service, 2005, Dean project area, Bearlodge Ranger District, Black Hills National Forest, Crook County, Wyoming: U.S. Forest Service, Report no. 050212, 192 p.
- U.S. Forest Service, 2005, Final environmental impact statement for the access designation on the Ocala National Forest, Lake, Marion, and Putnam Counties, Florida: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 2005, Gallatin National Forest travel management plan, Gallatin, Madison, Park, Meagher, Sweetgrass, and Carbon Counties, Montana: U.S. Forest Service, Report no. 050231.
- U.S. Forest Service, 2005, Rocky Mountain Ranger District travel management plan, Rocky Mountain Ranger District, Lewis and Clark National Forest, Glacier, Pondera, Teton, and Lewis and Clark Counties, Montana: U.S. Forest Service, Report no. 050236, 386 p.
- U.S. Forest Service, 2005, Woodrock project, Tongue Ranger District, Bighorn National Forest, Sheridan County, Wyoming: U.S. Forest Service, Report no. 050112, 201 p.
- U.S. Forest Service, 2006, Hoosier National Forest land and resource management plan—Final environmental impact statement: U.S. Forest Service, Technical Report.

- U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, 1997, George Washington National Forest land and resource management plan, Virginia and West Virginia (final supplement to the final environmental impact statement of January 1993): U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, Report no. 970046.
- U.S. Immigration and Naturalization Service, 2004, U.S. Border Patrol activities within the border areas of the Tuscon and Yuma Sectors, Arizona (revision of the draft environmental impact statement of November 2002): U.S. Immigration and Naturalization Service, Report no. 040479, 487 p.
- U.S. National Park Service, 1991, Big Cypress National Preserve, Collier, Monroe, and Dade Counties, Florida: U.S. National Park Service, Report no. 910386.
- U.S. National Park Service, 1998, Redwood National and State Parks general management plan, Del Norte and Humboldt Counties, California: U.S. National Park Service, Report no. 980290, 474 p.
- U.S. National Park Service, 1999, Big Cypress National Preserve, recreational off-road vehicle management plan—Collier, Dade, and Monroe Counties, Florida (draft supplement to the environmental impact statement of October 1991): U.S. National Park Service, Report no. 990285, 171 p.
- U.S. National Park Service, 2000, Recreational Off-road vehicle management plan, Big Cypress National Preserve—Collier, Miami-Dade, and Monroe Counties, Florida (final supplement to the Final environmental impact statement of October 1991): U.S. National Park Service, Report no. 000275, 619 p.
- U.S. Naval Facilities Engineering Command, 2003, Advanced amphibious assault vehicle, Marine Corps Base Camp Pendleton and San Clemente Range Complex, San Diego County, California: U.S. Naval Facilities Engineering Command, Report no. 030201.
- Udevitz, M.S., Howard, C.A., Robel, R.J., and Curnutte, B., 1980, Lead contamination in insects and birds near an interstate highway, Kansas: *Environmental Entomology*, v. 9, no. 1, p. 35–36.
- van der Zande, A.N., Keurs, W.J., and Van Der Weijden, W.J., 1980, The impact of roads on the densities of four bird species in an open field habitat—Evidence of a long-distance effect: *Biological Conservation*, v. 18, no. 4, p. 299–321.
- Vos, C.C., and Chardon, J.P., 1998, Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*: *Journal of Applied Ecology*, v. 35, no. 1, p. 44–56.
- Warburton, M., Fisher, R., and Hathaway, S., 2004, Anza-Borrego Desert State Park amphibian survey, 2000-2002: U.S. Geological Survey, Report no. PB2005105820, 44 p.

- Ward, A.L., 1982, Mule deer behavior in relation to fencing and underpass on Interstate 80 in Wyoming: Transportation Research Record, v. 859, no. 8–13.
- Watson, J.J., Kerley, G.I.H., and McLachlan, A., 1996, Human activity and potential impacts on dune breeding birds in the Alexandria Coastal Dunefield: Landscape and Urban Planning, v. 34, no. 3–4, p. 315–322.
- Welch, R., Madden, M., and Doren, R.F., 1999, Mapping the Everglades: Photogrammetric Engineering and Remote Sensing, v. 65, no. 2, p. 163–170.
- Wemple, B.C., Jones, J., and Grant, G., 1996, Channel network extension by logging roads in two basins, western Cascades, Oregon: Water Resources Bulletin, v. 32, no. 6, p. 1195–1207.
- Wester, L., 1994, Weed management and the habitat protection of rare species—A case study of the endemic Hawaiian fern *Marsilea villosa*: Biological Conservation, v. 68, no. 1, p. 1–9.
- Wheeler, A.P., Angermeier, P.L., and Rosenberger, A.E., 2005, Impacts of new highways and subsequent landscape urbanization on stream habitat and biota: Reviews in Fisheries Science, v. 13, no. 3, p. 141–164.
- Whitten, K.R., and Cameron, R.D., 1983, Movements of collared caribou, *Rangifer tarandus*, in relation to petroleum development on the Arctic slope of Alaska: Canadian Field-Naturalist, v. 97, no. 2, p. 143–146.
- Wiedemann, A.M., 1984, Ecology of Pacific Northwest coastal sand dunes—A community profile: Evergreen State College, Olympia, Washington, Report no. FWSOBS8404, 146 p.
- Wilcox, B., and Murphy, D., 1985, Conservation strategy—The effects of fragmentation on extinction: The American Naturalist, v. 125, no. 6, p. 879–997.
- Wild Utah Project, 1999, A literature review of the effects of off-road vehicles on desert biota, with emphasis on Utah BLM lands: Wild Utah Project, Salt Lake City, Utah, Report, 24 p.
- Wilkins, K.T., 1982, Highways as barriers to rodent dispersal: Southwestern Naturalist, v. 27, no. 44, p. 459–460.
- Williams, D.C., and Campbell, F., 1988, How the Bureau of Land Management designates and protects areas of critical environment concern—A status report, with a critical review by the Natural Resources Defense Council: Natural Areas Journal, v. 8, no. 4, p. 231–237.
- Wilshire, H.G., 1983, Off-road vehicle recreation management policy for public lands in the United States—A case history: Environmental Management, v. 7, no. 6, p. 489–499.

- Wilshire, H.G., Shipley, Susan, and Nakata, J.K., 1978, Impacts of off-road vehicles on vegetation: Transactions of the North American Wildlife and Natural Resources Conference, v. 43, p. 131–139.
- Wisdom, M.J., Ager, A.A., Preisler, H.K., Cimon, N.J., and B.K. Johnson, 2005, Effects of off-road recreation on mule deer and elk, *in* Wisdom, M.J., ed., The Starkey project—A synthesis of long-term studies of elk and mule deer: Lawrence, Kansas, Alliance Communications Group, p. 67–80.
- Wisdom, M.J., Cimon, N.J., Johnson, B.K., Garton, E.O., and Thomas, J.W., 2005, Spatial partitioning by mule deer and elk in relation to traffic, *in* Wisdom, M.J., ed., The Starkey project—A synthesis of long-term studies of elk and mule deer: Lawrence, Kansas, Alliance Communications Group, p. 53–66.
- Wisdom, M.J., Rowland, M.M., Johnson, B.K., and Dick, B.L., 2005, Overview of the Starkey Project—Mule deer and elk research for management benefits, *in* Wisdom, M.J., ed., The Starkey Project—A synthesis of long-term studies of elk and mule deer: Lawrence, Kansas, Alliance Communications Group, p. 17–28.
- Wolcott, T.G., and Wolcott, D.L., 1984, Impact of off-road vehicles on macroinvertebrates of a mid-Atlantic beach: Biological Conservation, v. 29, no. 3, p. 217–240.
- Wyatt, R.L., 1988, Implications of illegal off-road vehicle activity on the Cherokee Wildlife Management Area, Unicoi County, Tennessee: Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies, v. 42, p. 533–539.
- Yahner, R.H., 1988, Changes in wildlife communities near edges: Conservation Biology, v. 2, no. 4, p. 333–339.
- Yahner, R.H., Morrell, T.E., and Rachael, J.S., 1989, Effects of edge contrast on depredation of artificial avian nests: Journal of Wildlife Management, v. 53, no. 4, p. 1135–1138.
- Yanes, M., Velasco, J.M., and Suárez, F., 1995, Permeability of roads and railways to vertebrates—the importance of culverts: Biological Conservation, v. 71, no. 33, p. 217–222.

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- Adams, E.S., 1975, Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvelinus fontinalis*): Transactions of the American Fisheries Society, v. 104, no. 2, p. 363–373.
- Al Awadhi, J.I., 2001, Impact of gravel quarrying on the desert environment of Kuwait: Environmental Geology, v. 41, no. 3–4, p. 365–371.
- Anders, F.J., and Leatherman, S.P., 1987, Disturbance of beach sediment by off-road vehicles: Environmental Geology and Water Sciences, v. 9, no. 3, p. 183–189.
- Assistant Secretary of Defense (Health and Environment), 1973, Proposed Department of Defense regulation on use of off-road vehicles: U.S. Department of Defense, Report no. ELR0511, 20 p.
- Balades, J.D., Legret, M., and Madiec, H., 1995, Permeable pavements—Pollution management tools: Water Science and Technology, v. 32, no. 1, p. 49–56.
- Bannister, E.N., 1979, Impact of road networks on southeastern Michigan lakeshore drainage: Water Resources Research, v. 15, no. 6, p. 1515–1520.
- Barrett, H., Cagney, J., Clark, R., Fogg, J., Gebhardt, K., Hansen, P.L., Mitchell, B., Prichard, D., and Tippy, D., 1995, Riparian area management—Process for assessing proper functioning condition: Denver, Colorado, U.S. Bureau of Land Management, Technical Reference 1737-9, BLM/SC/ST-93/003 + 1737 +REV95.
- Beasley, G., and Kneale, P.E., 2003, Investigating the influence of heavy metals on macro-invertebrate assemblages using Partial Canonical Correspondence Analysis (pCCA): Hydrology and Earth System Sciences, v. 7, no. 2, p. 221–233.
- Becking, R.W., and Hayes, G.L., 1970, Public land policy and the environment—Volume 3, part II (cont'd)—Environmental problems on the public lands—Case studies 9 through 17: Rocky Mountain Center on Environment, Denver, CO, Report no. PLLRC29–3, 436 p.
- Belnap, Jayne, 1995, Surface disturbances—Their role in accelerating desertification: Environmental Monitoring and Assessment, v. 37, no. 1–3, p. 39–57.
- Ben Brooks and Associates, Ironhorse Investors, Inc., Santa Fe Pacific Railroad Company, and U.S. Bureau of Land Management, 1998, Hualapai Mountain Land Exchange, Mohave County, Arizona: Report no. 980482, 175 p.
- Bjornlie, D.D., and Garrott, R.A., 2001, Effects of winter road grooming on bison in Yellowstone National Park: Journal of Wildlife Management, v. 65, no. 3, p. 560–572.

- Brabec, E., Schulte, S., and Richards, P.L., 2002, Impervious surfaces and water quality—A review of current literature and its implications for watershed planning: *Journal of Planning Literature*, v. 16, no. 4, p. 499–514.
- Brodbeck, C.J., McDonald, T., Baier, J., and Taylor, S., 2004, Background water quality analysis from the Kentuck off-road vehicle trails, in *Proceedings*, 2004 annual international meeting of the Society for Engineering in Agricultural, Food and Biological Systems, Ottawa, Canada, August 1–4, 2004: St. Joseph, Michigan, American Society of Agricultural and Biological Engineers.
- Brown, A.C., and McLachlan, A., 2002, Sandy shore ecosystems and the threats facing them—Some predictions for the year 2025: *Environmental Conservation*, v. 29, no. 1, p. 62–77.
- Brown, G., and Porembski, S., 2000, Phytogenic hillocks and blow-outs as 'safe sites' for plants in an oil-contaminated area of northern Kuwait: *Environmental Conservation*, v. 27, no. 3, p. 242–249.
- Brown, G., and Schoknecht, N., 2001, Off-road vehicles and vegetation patterning in a degraded desert ecosystem in Kuwait: *Journal of Arid Environments*, v. 49, no. 2, p. 413–427.
- Brown, K.J., 1994, River-bed sedimentation caused by off-road vehicles at river fords in the Victorian Highlands, Australia: *Water Resources Bulletin*, v. 30, no. 2, p. 239–250.
- Buckley, R., and King, N., 2003, Visitor-impact data in a land-management context, in Buckley, R.C., Pickering, D., and Weaver, D.B., eds., *Nature-based tourism, environment and land management*: Wallingford, England, CABI Publishing, p. 89-99.
- California State Water Resources Control Board, 1980, Lake Tahoe Basin water quality plan, final plan: Sacramento, California, California State Water Resources Control Board, Technical Report.
- Coats, R.N., and Miller, T.O., 1981, Cumulative silvicultural impacts on watersheds—A hydrologic and regulatory dilemma: *Environmental Management*, v. 5, no. 2, p. 147–160.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Annotated bibliography for biologic overview for the Nevada Nuclear Waste Storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832419, 48 p.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Biologic overview for the Nevada nuclear waste storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832460, 55 p.
- Colwill, D.M., Peters, C.J., and Perry, R., 1984, Water quality of motorway runoff: Crowthorne, England, Transport and Road Research Laboratory, Report no. TRRL/SR-823, 28 p.

- Davidson, E.D., and Fox, M., 1974, Effects of off-road motorcycle activity on Mojave Desert vegetation and soil: *Madroño*, v. 22, no. 8, p. 381–390.
- Dawson, K.J., 1985, Natural area planning for recreational use transition: *Landscape Planning*, v. 12, no. 2, p. 111–123.
- Deletic, A., Ashley, R., and Rest, D., 2000, Modelling input of fine granular sediment into drainage systems via gully-pots: *Water Research*, v. 34, no. 15, p. 3836–3844.
- Eckert, R.E.J., Wood, M.K., Blackburn, W.H., and Peterson, F.F., 1979, Impacts of off-road vehicles on infiltration and sediment production of two desert soils: *Journal of Range Management*, v. 32, no. 5, p. 394–397.
- Fang, S., Wente, S., Gertner, G.Z., Wang, G., and Anderson, A., 2002, Uncertainty analysis of predicted disturbance from off-road vehicular traffic in complex landscapes at Fort Hood: *Environmental Management*, v. 30, no. 2, p. 199–208.
- Furniss, M.J., Flanagan, S.A., and McFadin, B.A., 2000, Hydrologically connected roads—An indicator of the influence of roads on chronic sedimentation, surface water hydrology, and exposure to toxic chemicals: U.S. Forest Service, Stream Systems Technology Center, Rocky Mountain Research Station, Technical Report, 4 p.
- Glass, R.L., 1986, Hydrologic conditions in Connors Bog area, Anchorage, Alaska: U.S. Geological Survey, Technical Report, 23 p.
- Greene, A.F.C., 1975, The need for cooperative approaches to fish and wildlife management: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 40, p. 133–141.
- Hairsine, P.B., Croke, J.C., Mathews, H., Fogarty, P., and Mockler, S.P., 2002, Modelling plumes of overland flow from logging tracks: *Hydrological Processes*, v. 16, no. 12, p. 2311–2327.
- Hamilton, L.J., 2002, A study of the effects of ORV stream crossings on water quality of two streams located in the Angelina National Forest, Texas—A physicochemical and benthic macroinvertebrate analysis: *Masters Abstracts International*, v. 40, no. 3, p. 668.
- Hansen, R.P., Hillhouse, W.A., Willard, B.E., and Burke, H.D., 1970, Public land policy and the environment. Volume 2. Part II—Environmental problems on the public lands—Summary statement and case studies 1 through 8: Denver, Colorado, Rocky Mountain Center on Environment, Report no. PLLRC29–2, 409 p.
- Haupt, H.F., 1959, Road and slope characteristics affecting sediment movement from logging roads: *Journal of Forestry*, v. 57, no. 5, p. 329–339.

- Hayes, D.L., 1991, The all-American canal lining project—A catalyst for rational and comprehensive groundwater management on the United States-Mexico border: *Natural Resources Journal*, v. 31, no. 4, p. 803–827.
- Hillel, D., and Tadmor, N., 1962, Water regime and vegetation in central Negev Highlands of Israel: *Ecology*, v. 43, no. 1, p. 33–41.
- Hinckley, B.S., Iverson, R.M., and Hallet, B., 1983, Accelerated water erosion in ORV off-road vehicle-use areas, in Webb, R.H., and Wilshire, H.G., eds., *Environmental effects of off-road vehicles—Impacts and management in arid regions*: New York, Springer-Verlag, p. 81–96.
- Hutton, M., and Symon, C., 1986, The quantities of cadmium, lead, mercury and arsenic entering the U.K. environment from human activities: *Science of the Total Environment*, v. 57, p. 129–150.
- Iverson, R.M., 1980, Processes of accelerated pluvial erosion on desert hillslopes modified by vehicular traffic: *Earth Surface Processes*, v. 5, p. 369–388.
- Johnson, R.R., Mills, G.S., and Carothers, S.W., 1990, Creation and restoration of riparian habitat in southwestern arid and semi-arid regions, in Kusler, J.A., and Kentula, M.E., eds., *Wetland creation and restoration—The status of the science*: Covelo, California, Island Press, p. 351–366.
- Johnston, F.M., and Johnston, S.W., 2004, Impacts of road disturbance on soil properties and on exotic plant occurrence in subalpine areas of the Australian Alps: Arctic, Antarctic, and Alpine Research, v. 36, no. 2, p. 201–207.
- Katz, M., Legore, R.S., Weitkamp, D., Cummins, J.M., and Anderson, D., 1972, Effects on freshwater fish: *Journal of the Water Pollution Control Federation*, v. 44, no. 6, p. 1226–1250.
- Knott, J.M., 1978, Reconnaissance assessment of erosion and sedimentation in the Canada De Los Alamos Basin, Los Angeles and Ventura Counties, California: U.S. Geological Survey, Open File Report no. 78–873, 49 p.
- Kondolf, G.M., Piegay, H., and Landon, N., 2002, Channel response to increased and decreased bedload supply from land use change—Contrasts between two catchments: *Geomorphology*, v. 45, no. 1–2, p. 35–51.
- Koppel, W., 1988, Dynamic impact on soil structure due to traffic of off-road vehicles, in Drescher, J., Horn, R., and Boodt, M.D., eds., *Impact of water and external forces on soil structure—Selected papers of the 1st Workshop on Soilphysics and Soilmechanics*: Cremlingen-Destedt, Germany, Catena Verlag, p. 113–122.
- Kurczerski, F.E., 2000, History of white pine (*Pinus strobus*)/oak (*Quercus* spp.) savanna in southern Ontario, with particular reference to the biogeography and status of the antenna-

waving wasp, *Tachysphex pechumani* (Hymenoptera: Sphecidae): Canadian Field-Naturalist, v. 114, no. 1, p. 1–20.

Lewis, O., 1969, Arid lands and their future, in Bender, G.L., ed., Future environments of arid regions of the southwest, contribution no. 12, American Association for the Advancement of Science Committee on Desert and Arid Zone Research symposium, Colorado Springs, Colorado, May 7-10, 1969: Washington, D.C., American Association for the Advancement of Science, Committee on Desert and Arid Zone Research, p. 33–38.

Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: Environmental Management, v. 24, no. 3, p. 309–326.

Melvin, S.M., Griffin, C.R., and MacIvor, L.H., 1991, Recovery strategies for piping plovers in managed coastal landscapes: Coastal Management, v. 19, no. 1, p. 21–34.

Mize, R., Evans, R.E., MacRoberts, B.R., MacRoberts, M.H., and Rudolph, D.C., 2005, Restoration of pitcher plant bogs in eastern Texas, USA: Natural Areas Journal, v. 25, no. 2, p. 197–201.

Morgan, M.T., 1993, Nutrition is the key to plight of an ancient survivor, the desert tortoise: Smithsonian Institution Research Reports, v. 74, p. 4.

Nicola, N.C., and Lovich, J.E., 2000, Preliminary observations of the behavior of male, flat-tailed horned lizards before and after an off-highway vehicle race in California: California Fish and Game, v. 86, p. 208–212.

O'Farrell, T.P., and Kato, T.T., 1987, Biological assessment of the effects of petroleum production activities, Naval Petroleum Reserves in California, on the endangered giant kangaroo rat, *Dipodomys ingens*: Goleta, California, EG and G Energy Measurements, Inc., Report no. EGG102822183, 34 p.

Okello, J.A., 1991, A review of soil strength measurement techniques for prediction of terrain vehicle performance: Journal of Agricultural Engineering Research, v. 50, no. 2, p. 129–155.

Paschka, M.G., Ghosh, R.S., and Dzombak, D.A., 1999, Potential water-quality effects from iron cyanide anticaking agents in road salt: Water Environment Research, v. 71, no. 6, p. 1235–1239.

Perdikaki, K., and Mason, C.F., 1999, Impact of road run-off on receiving streams in eastern England: Water Research, v. 33, no. 7, p. 1627–1633.

Persico, L.P., Nichols, K.K., and Bierman, P.R., 2005, Tracking painted pebbles—Short-term rates of sediment movement on four Mojave Desert piedmont surfaces: Water Resources Research, v. 41, no. 7, p. W07004.07001–W07004.07015.

- Piehl, B.T., Beschta, R.L., and Pyles, M.R., 1988, Ditch-relief culverts and low-volume forest roads in the Oregon Coast Range: *Northwest Science*, v. 62, no. 3, p. 91–98.
- Rickard, W.H., 1988, Natural vegetation at the proposed reference repository location in southeastern Washington: Richland, Washington, Battelle Pacific Northwest Labs, Report no. PNL–6402, 27 p.
- Rinne, J.N., Rickel, B., and Hendrickson, D., 1980, A new Gila topminnow locality in southern Arizona: Fort Collins, Colorado, U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Report no. RM-382, 4 p.
- Robinson, E., 1999, A geology of the road: *Geology Today*, v. 15, no. 3, p. 110–113.
- Roy, A.H., Rosemond, A.D., Leigh, D.S., Paul, M.J., and Wallace, J.B., 2003, Habitat-specific responses of stream insects to land cover disturbance—Biological consequences and monitoring implications: *Journal of the North American Benthological Society*, v. 22, no. 2, p. 292–307.
- Samaras, Z., and Zierock, K.H., 1995, Off-road vehicles—A comparison of emissions with those from road transport: *Science of the Total Environment*, v. 169, p. 249–253.
- Schemnitz, S.D., and Schortemeyer, J.D., 1972, The influence of vehicles on Florida Everglades vegetation: Tallahassee, Florida, Florida State Game and Fresh Water Fish Commission, Report no. DISFEP–74–31, 65 p.
- Schultink, G., 1977, Impact analysis of off-road-vehicle use on vegetation in the Grand Mere Dune environment: East Lansing, Michigan, Michigan State University, Report no. NASACR155764, 10 p.
- Severinghaus, W.D., Riggins, R.E., and Goran, W.D., 1979, Effects of tracked vehicle activity on terrestrial mammals and birds at Fort Knox, KY (special report): *Transactions of the Kentucky Academy of Science*, v. 41, no. 1–2, p. 15–26.
- Snyder, C.T., Frickel, D.G., Hadley, R.F., and Miller, R.F., 1976, Effects of off-road vehicle use on the hydrology and landscape of arid environments in central and southern California: U.S. Geological Survey, Water Resources Investigations Report no. 76–99, 52 p.
- Sparrow, S.D., Wooding, F.J., and Whiting, E.H., 1978, Effects of off-road vehicle traffic on soils and vegetation in the Denali Highway region of Alaska: *Journal of Soil and Water Conservation*, v. 33, no. 1, p. 20–27.
- Steiner, A.J., and Leatherman, S.P., 1981, Recreational impacts on the distribution of ghost crabs *Ocypode quadrata* Fab: *Biological Conservation*, v. 20, no. 2, p. 111–122.
- Tunstall, B.R., and Reece, P.H., 1989, Environmental assessment of the Sunset and Big Desert lands, northwest Victoria, Australia: Clayton South, Australia, Australia Commonwealth

Scientific and Industrial Research Organization, Division of Water Resources Divisional Report, Report, 1–85 p.

Turton, S.M., 2005, Managing environmental impacts of recreation and tourism in rainforests of the wet tropics of Queensland World Heritage Area: *Geographical Research*, v. 43, no. 2, p. 140–151.

Tuttle, M., and Griggs, G., 1985, Accelerated soil erosion at three state vehicular recreation Areas, central and southern California, *Erosion control— A challenge in our time*, proceedings of the 16th annual International Erosion Control Association, February 21–22, 1985, San Francisco, California: San Francisco, California, International Erosion Control Association, p. 105-115.

Tuttle, M., and Griggs, G., 1987, Soil erosion and management recommendations at three state vehicular recreation Areas, California: *Environmental Geology and Water Sciences*, v. 10, no. 2, p. 111–123.

Twiss, R., Sidener, J., Bingham, G., Burke, J.E., and Hall, C.H., 1980, Potential impacts of geothermal development on outdoor recreational use of the Salton Sea: Livermore, California, University of California at Livermore, Technical Report, 61 p.

U.S. Air Force, 1992, Defense evaluation support activity testing and evaluation program, Kirtland Air Force Base, New Mexico: U.S. Air Force, Report no. 920325, 487 p.

U.S. Air Force Tactical Air Command and U.S. Bureau of Land Management, 1986, Renewed withdrawal of Groom Mountain Range addition to Nellis Air Force bombing and gunnery range, Lincoln County, Nevada: U.S. Department of the Air Force, Tactical Air Command and U.S. Bureau of Land Management, Report no. 860476.

U.S. Army Corps of Engineers, 1994, Stationing of mechanized or armored combat forces at Fort Lewis, Thurston and Pierce Counties, Washington: U.S. Army Corps of Engineers, Report no. 940045.

U.S. Army Corps of Engineers, 2001, Fort Bliss mission and master plan—Dona Ana and Otero Counties, New Mexico, and El Paso County, Texas: U.S. Army Corps of Engineers, Report no. 010081.

U.S. Army Corps of Engineers, and Oklahoma Department of Wildlife Conservation, 1986, Candy Lake, Candy Creek, Osage County, Oklahoma (supplemental information report to the final environmental impact statement of January 1975): U.S. Army Corps of Engineers, Report no. 860246, 4 p.

U.S. Bureau of Land Management, 1984, Book Cliffs resource management plan, Utah: U.S. Bureau of Land Management, Report no. 840541, 534 p.

- U.S. Bureau of Land Management, 1984, Camping on the public lands: U.S. Bureau of Land Management, Report no. PB85204907, 5 p.
- U.S. Bureau of Land Management, 1984, Proposed Monument resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 840584, 419 p.
- U.S. Bureau of Land Management, 1985, Grand Junction resource area—Resource management plan and environmental impact statement: U.S. Bureau of Land Management, Report, 171 p.
- U.S. Bureau of Land Management, 1985, Lower Gila South resource management plan, La Paz, Maricopa, Pima, Pinal, and Yuma Counties, Arizona: U.S. Bureau of Land Management, Report no. 850347, 909 p.
- U.S. Bureau of Land Management, 1985, Medicine Lodge proposed resource management plan, Bingham, Bonneville, Butte, Clark, Fremont, Jefferson, Madison, and Teton Counties, Idaho: U.S. Bureau of Land Management, Report no. 850237.
- U.S. Bureau of Land Management, 1985, resource management plan for the Kemmerer resource area, Lincoln, Sublette, Sweetwater, and Uinta Counties, Wyoming: U.S. Bureau of Land Management, Report no. 850532.
- U.S. Bureau of Land Management, 1985, resource management plan for the Walker planning Area, Nevada: U.S. Bureau of Land Management, Report no. 850274.
- U.S. Bureau of Land Management, 1985, White Sands resource area resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 850387.
- U.S. Bureau of Land Management, 1986, Baker resource management plan, Baker County, Oregon: U.S. Bureau of Land Management, Report no. 860150, 129 p.
- U.S. Bureau of Land Management, 1986, Big Lost/Pahsimeroi Wilderness, Idaho: U.S. Bureau of Land Management, Report no. 860399, 125 p.
- U.S. Bureau of Land Management, 1986, Eastern San Diego County planning unit, California—Preliminary wilderness recommendations: U.S. Bureau of Land Management, Report no. 860388, 195 p.
- U.S. Bureau of Land Management, 1986, Lander resource management plan, Lander, Wyoming: U.S. Bureau of Land Management, Report no. 860449.
- U.S. Bureau of Land Management, 1986, Little Snake resource management plan, Moffat, Rio Blanco, and Routt Counties, Colorado: U.S. Bureau of Land Management, Report no. 860029.
- U.S. Bureau of Land Management, 1986, Proposed Baker resource management plan, Vale District, Oregon: U.S. Bureau of Land Management, Report no. 860396.

- U.S. Bureau of Land Management, 1986, resource management plan for the Carlsbad resource area, Eddy, Lea, and Chaves Counties, New Mexico: U.S. Bureau of Land Management, Report no. 860101, 390 p.
- U.S. Bureau of Land Management, 1986, Utah statewide wilderness environmental impact statement: U.S. Bureau of Land Management, Report no. 860036.
- U.S. Bureau of Land Management, 1986, Wilderness Suitability EIS—Grass Creek and Cody resource areas, Bighorn Basin, Wyoming (draft supplement for the Owl Creek Wilderness Study Area): U.S. Bureau of Land Management, Report no. 860168, 40 p.
- U.S. Bureau of Land Management, 1987, Medicine Bow-Divide resource areas resource management plan, Rawlins District, Wyoming: U.S. Bureau of Land Management, Report no. 870212.
- U.S. Bureau of Land Management, 1987, North Dakota resource management plan, Dunn and Bowman Counties, North Dakota: U.S. Bureau of Land Management, Report no. 870236, 199 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette and Lincoln Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870077, 347 p.
- U.S. Bureau of Land Management, 1987, Pocatello resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 870333, 132 p.
- U.S. Bureau of Land Management, 1987, Proposed Lemhi resource management plan, Lemhi County, Idaho—Eighteenmile Wilderness: U.S. Bureau of Land Management, Report no. 870437, 178 p.
- U.S. Bureau of Land Management, 1987, Proposed Medicine Lodge, Idaho resource management plan—Wilderness recommendations: U.S. Bureau of Land Management, Report no. 870436, 92 p.
- U.S. Bureau of Land Management, 1987, Proposed resource management plan for the San Juan resource area, Moab District, Utah: U.S. Bureau of Land Management, Report no. 870440.
- U.S. Bureau of Land Management, 1987, Proposed utility corridor resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 870291, 281 p.
- U.S. Bureau of Land Management, 1987, Washakie resource area resource management plan, portions of Big Horn, Hot Springs, and Washakie Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870395.

- U.S. Bureau of Land Management, 1988, Brothers/Lapine resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 880365.
- U.S. Bureau of Land Management, 1988, Challis resource area proposed resource management plan, upper Columbia-Salmon Clearwater Districts, Custer and Lemhi Counties, Idaho: U.S. Bureau of Land Management, Report no. 980508.
- U.S. Bureau of Land Management, 1988, Cody resource area resource management plan, Big Horn and Park Counties, Wyoming: U.S. Bureau of Land Management, Report no. 880315.
- U.S. Bureau of Land Management, 1988, Fort Greely national maneuver area and Fort Greely air drop done, Alaska—Resource management plan: U.S. Bureau of Land Management, Report no. 880276, 138 p.
- U.S. Bureau of Land Management, 1988, Fort Wainwright maneuver area, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 880277, 138 p.
- U.S. Bureau of Land Management, 1988, Medicine Bow-Divide resource areas (now Great Divide resource area) resource management plan, Rawlins District, Wyoming: U.S. Bureau of Land Management, Report no. 880325.
- U.S. Bureau of Land Management, 1988, Pony Express resource management plan, Toole, Utah, and Salt Lake Counties, Utah: U.S. Bureau of Land Management, Report no. 880310, 147 p.
- U.S. Bureau of Land Management, 1988, Proposed Las Vegas resource management plan and final environmental impact statement, Clark and Nye Counties, Nevada: U.S. Bureau of Land Management, Report no. 980207.
- U.S. Bureau of Land Management, 1988, Uncompahgre Basin resource management plan, Colorado: U.S. Bureau of Land Management, Report no. 880345.
- U.S. Bureau of Land Management, 1988, West Hiline resource management plan, northcentral Montana: U.S. Bureau of Land Management, Report no. 880200, 306 p.
- U.S. Bureau of Land Management, 1988, Wilderness study areas in the Rock Springs District, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming (revised Draft environmental impact statement): U.S. Bureau of Land Management, Report no. 880359, 175 p.
- U.S. Bureau of Land Management, 1989, Dixie resource area management plan, Washington County, Utah: U.S. Bureau of Land Management, Report no. 890290, 250 p.
- U.S. Bureau of Land Management, 1989, Phoenix resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 890012, 240 p.

- U.S. Bureau of Land Management, 1989, San Pedro River riparian management plan for the San Pedro River EIS Area, Cochise County, Arizona: U.S. Bureau of Land Management, Report no. 890152, 381 p.
- U.S. Bureau of Land Management, 1989, San Rafael resource management plan, Emery County, Utah: U.S. Bureau of Land Management, Report no. 890240.
- U.S. Bureau of Land Management, 1989, Utility corridor proposed resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 890326, 281 p.
- U.S. Bureau of Land Management, 1990, Bishop resource management plan and environmental impact statement: U.S. Bureau of Land Management, Report no. BLMCAES900011610, 273 p.
- U.S. Bureau of Land Management, 1990, Rock Springs District wilderness study areas, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming: U.S. Bureau of Land Management, Report no. 900439, 324 p.
- U.S. Bureau of Land Management, 1991, Arizona Strip District resource management plan, Mohave and Coconino Counties, Arizona: U.S. Bureau of Land Management, Report no. 910055, 617 p.
- U.S. Bureau of Land Management, 1991, resource management plan for public lands in the state of Nebraska: U.S. Bureau of Land Management, Report no. 910385, 144 p.
- U.S. Bureau of Land Management, 1991, Safford District resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 910314, 511 p.
- U.S. Bureau of Land Management, 1991, Three Rivers resource management plan, Harney, Grant, Lake, and Malheur Counties, Oregon: U.S. Bureau of Land Management, Report no. 910335.
- U.S. Bureau of Land Management, 1994, Fort Wainwright, Yukon maneuver area, proposed resource management plan and final environmental impact statement, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 940001, 124 p.
- U.S. Bureau of Land Management, 1994, resource management plan and environmental impact statement for the Grass Creek resource area, Worland District, Wyoming: U.S. Bureau of Land Management, Report, 299 p.
- U.S. Bureau of Land Management, 1994, Salem District resource management plan and environmental impact statement—Benton, Clackamas, Clatsop, Columbia, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties, Oregon: U.S. Bureau of Land Management, Report no. 940461.

- U.S. Bureau of Land Management, 1996, resource management plan for the Green River resource area, Rock Springs, Wyoming: U.S. Bureau of Land Management, Report no. 960148.
- U.S. Bureau of Land Management, 1996, Sweet Grass Hills resource management plan amendment, Liberty and Toole Counties, Montana: U.S. Bureau of Land Management, Report no. 960243, 179 p.
- U.S. Bureau of Land Management, 1997, Proposed resource management plan/final environmental impact statement for the Roswell resource area, Roswell, New Mexico and proposed resource management plan Amendment/final environmental impact statement for the Carlsbad resource area, Carlsbad, New Mexico. Volume 1: U.S. Bureau of Land Management, Report no. BLMNMPT970031610V1, 379 p.
- U.S. Bureau of Land Management, 1997, Proposed resource management plan/final environmental impact statement for the Roswell resource area, Roswell, New Mexico and proposed resource management plan amendment/final environmental impact statement for the Carlsbad resource area, Carlsbad, New Mexico. Volume 2: U.S. Bureau of Land Management, Report no. BLMNMPT970031610V2, 535 p.
- U.S. Bureau of Land Management, 1998, Judith-Valley-Phillips resource management plan—Chouteau, Fergus, Judith Basin, Petroleum, Phillips, and Valley Counties, Montana (draft supplement to the final environmental impact statement of September 1997): U.S. Department of Interior Bureau of Land Management, Report no. 980149, 51 p.
- U.S. Bureau of Land Management, 1998, Socorro resource area resource management plan, New Mexico: U.S. Department of Interior Bureau of Land Management, Report no. 880397, 266 p.
- U.S. Bureau of Land Management, 2000, Federal fluid minerals leasing and development, Otero and Sierra Counties, New Mexico: U.S. Department of Interior Bureau of Land Management, Report no. 000383, 521 p.
- U.S. Bureau of Land Management, 2000, Pinedale Anticline Oil and Gas Exploration and Development Project, Sublette County, Wyoming: U.S. Department of Interior Bureau of Land Management, Report no. 000159, 301 p.
- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Albuquerque Field Office—Bernalillo, Cibola, McKinley, Rio Arriba, Sandoval, Santa Fe, and Valencia Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000304.
- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Farmington Field Office—McKinley, Rio Arriba, San Juan, and Sandoval Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000302.

- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Las Cruces Field Office—Dona Ana, Grant, Hidalgo, and Luna Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000303.
- U.S. Bureau of Land Management, 2000, Riparian and aquatic habitat management in the Taos Field Office—Colfax, Harding, Los Alamos, Mora, Rio Arriba, San Miguel, Santa Fe, Taos, and Unison Counties, New Mexico: U.S. Bureau of Land Management, Report no. 00305.
- U.S. Bureau of Land Management, 2001, National management strategy for motorized off-highway vehicle use on public lands: U.S. Bureau of Land Management, Report no. PB2001103162, 58 p.
- U.S. Bureau of Land Management, 2004, Dillon resource management plan, Beaverhead and Madison Counties, Montana: U.S. Bureau of Land Management, Report no. 040153, 626 p.
- U.S. Bureau of Land Management, 2005, Newmont Mining Company, Emigrant project, Elko County, Nevada: U.S. Bureau of Land Management, Report no. 050117, 269 p.
- U.S. Bureau of Land Management and U.S. Fish and Wildlife Service, 1992, Cokeville Meadows National Wildlife Refuge proposal, Lincoln County, Wyoming: U.S. Bureau of Land Management and U.S. Fish and Wildlife Service, Report no. 920230, 123 p.
- U.S. Bureau of Land Management and U.S. Forest Service, 1986, Proposed Coronado National Forest land and resource management plan, Arizona and New Mexico: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 860307.
- U.S. Bureau of Land Management and U.S. Forest Service, 1990, Proposed Cokeville Meadows National Wildlife Refuge, Lincoln County, Wyoming: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 900388, 197 p.
- U.S. Bureau of Land Management and U.S. Forest Service, 2004, North Fork of the South Platte and the South Platte Rivers wild and scenic river study report, Pike and San Isabel National Forests and Comanche and Cimarron National Grasslands, Douglas, Jefferson, Park, and Teller Counties, Colorado: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 040037, 301 p.
- U.S. Bureau of Reclamation, 2001, Pothole Reservoir resource management plan, Grant County, Washington: U.S. Bureau of Reclamation, Report no. 010518, 567 p.
- U.S. Federal Highway Administration, 2005, US 33 Nelsonville bypass, city of Nelsonville, Hocking and Athens Counties, Ohio: U.S. Department of Transportation, Federal Highway Administration, Report no. 050282, 828 p.
- U.S. Fish and Wildlife Service, 1986, Great Dismal Swamp National Wildlife Refuge master plan, Virginia and North Carolina: U.S. Fish and Wildlife Service, Report no. 860501, 245 p.

U.S. Forest Service, 1973, Off-road vehicle policy, Hoosier National Forest, Indiana: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-51, 110 p.

U.S. Forest Service, 1973, Proposed off-road vehicle regulations and administrative instructions: U.S. Forest Service, Report no. USDAFS-FES(ADM)-73-49, 110 p.

U.S. Forest Service, 1973, Proposed regulations and administrative instructions relating to use of off-road vehicles on National Forest lands: U.S. Forest Service, Report no. USDAFS-DES(ADM)-73-49, 22 p.

U.S. Forest Service, 1985, Caribou National Forest and Curlew National Grassland land and resource management plan, Idaho, Utah, and Wyoming: U.S. Forest Service, Report no. 850437.

U.S. Forest Service, 1985, Kisatchie National Forest land and resource management plan, Louisiana: U.S. Forest Service, Report no. 850414.

U.S. Forest Service, 1985, Proposed land and resource management plan for the Medicine Bow National Forest and Thunder Basin National Grassland, Wyoming: U.S. Forest Service, Report no. 850523.

U.S. Forest Service, 1986, Cleveland National Forest land and resource management plan, Orange, Riverside, and San Diego Counties, California: U.S. Forest Service, Report no. 860209.

U.S. Forest Service, 1986, Croatan and Uwharrie National Forests land and resource management plan, North Carolina: U.S. Forest Service, Report no. 860218.

U.S. Forest Service, 1986, National Forests in Alabama Land and resource management plan: U.S. Forest Service, Report no. 860095.

U.S. Forest Service, 1986, Proposed Carson National Forest plan, Rio Arriba, Taos, Colfax, and Mora Counties, New Mexico: U.S. Forest Service, Report no. 860447.

U.S. Forest Service, 1986, Proposed Santa Fe National Forest land and resource management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 860013.

U.S. Forest Service, 1987, Angeles National Forest land and resource management plan, Los Angeles, Ventura, and San Bernardino Counties, California: U.S. Forest Service, Report no. 870394.

U.S. Forest Service, 1987, Environmental impact statement for the Apache-Sitgreaves National Forests Plan: U.S. Forest Service, Report, 392 p.

- U.S. Forest Service, 1987, Santa Fe National Forest land management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 870299.
- U.S. Forest Service, 1988, Proposed Kaibab National Forest land and resource management plan, Coconino, Yavapai, and Mohave Counties, Arizona: U.S. Forest Service, Report no. 880109.
- U.S. Forest Service, 1988, Record of decision for USDA, Forest Service—Final environmental impact statement, Allegheny National Forest, land and resource management plan—Elk, Forest, McKean, and Warren Counties, Pennsylvania: U.S. Forest Service, Technical Report, 41 p.
- U.S. Forest Service, 1989, San Bernardino National Forest land and resource management plan, San Bernardino and Riverside Counties, California: U.S. Forest Service, Report no. 890023.
- U.S. Forest Service, 1990, Cherokee National Forest land and resource management plan, Tennessee, North Carolina, and Virginia (final supplement to the final environmental impact statement of April 1986): U.S. Forest Service, Report no. 900062, 62 p.
- U.S. Forest Service, 1990, Umatilla National Forest land and resource management plan, Oregon and Washington: U.S. Forest Service, Report no. 900237.
- U.S. Forest Service, 1991, Corral Mountain timber sale, San Juan National Forest, Archuleta County, Colorado: U.S. Forest Service, Report no. 910124, 59 p.
- U.S. Forest Service, 1992, Martinez Creek timber sale, San Juan National Forest, Colorado: U.S. Forest Service, Report no. 920275, 75 p.
- U.S. Forest Service, 1992, Norbeck Wildlife Preserve land management plan, Black Hills National Forest, Custer and Pennington Counties, South Dakota (final supplement to the environmental impact statement of July 1989): U.S. Forest Service, Report no. 920352, 92 p.
- U.S. Forest Service, 1992, Rangeland ecosystem management in the Uinta National Forest, Provo, Utah: U.S. Forest Service, Report no. 920322, 189 p.
- U.S. Forest Service, 1993, Six Rivers National Forest plan, Humboldt, Del Norte, Siskiyou, and Trinity Counties, California: U.S. Forest Service, Report no. 930340.
- U.S. Forest Service, 1994, Oregon Dunes National Recreation Area management plan, Siuslaw National Forest—Coos, Douglas, and Lane Counties, Oregon: U.S. Forest Service, Report no. 940292.
- U.S. Forest Service, 1994, Revised Land and resource management plan for the national forests and grasslands in Texas—Angelina, Fannin, Houston, Jasper, Montague, Montgomery, Nacogdoches, Newton, Sabine, San Augustine, San Jacinto, Shelby, Trinity, Walker, and Wise Counties, Texas: U.S. Forest Service, Report no. 940385.

- U.S. Forest Service, 1995, Draft environmental impact statement, Fish Bate analysis area—North Fork Ranger District, Clearwater National Forest, Clearwater County, Idaho: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 1995, Mendocino National Forest land and resource management plan—Colusa, Glenn, Lake, Mendocino, Tehama, and Trinity Counties, California: U.S. Forest Service, Report no. 950337.
- U.S. Forest Service, 1995, Snowy Trail re-route, Ventura County, California: U.S. Forest Service, Report no. 950117, 109 p.
- U.S. Forest Service, 1996, Snowy Trail re-route, Los Padres National Forest, Ventura County, California: U.S. Forest Service, Report no. 960524.
- U.S. Forest Service, 2000, Silver Creek integrated resource project, Emmett Ranger District, Boise National Forest, Boise and Valley Counties, Idaho: U.S. Forest Service, Report no. 000241, 264 p.
- U.S. Forest Service, 2001, Land and resource management plan, Uinta National Forest—Juab, Sanpete, Toole, Utah, and Wasatch Counties, Utah: U.S. Forest Service, Report no. 010142.
- U.S. Forest Service, 2001, Starbucky restoration project, Red River Ranger District, Nez Perce National Forest, Idaho County, Idaho: U.S. Forest Service, Report no. 010274.
- U.S. Forest Service, 2002, Final environmental impact statement Amendment to the Land and resource management plan—Management direction for acquired lands in southeastern Oklahoma, Ouachita National Forest, McCurtain County, Oklahoma: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 2002, Sixshooter project, Emmett Ranger District, Boise National Forest, Gem County, Idaho: U.S. Forest Service, Report no. 020238, 201 p.
- U.S. Forest Service, 2002, Uncompahgre National Forest travel plan revision, Gunnison, Hinsdale, Mesa, Montrose, Ouray, San Juan, and San Miguel Counties, Colorado (final supplement to the final environmental impact statement of April 2000): U.S. Forest Service, Report no. 020131, 92 p.
- U.S. Forest Service, 2002, West Gold project, Sandpoint Ranger District, Idaho Panhandle National Forests, Bonner County, Idaho: U.S. Forest Service, Report no. 020484.
- U.S. Forest Service, 2002, Whiskey Campo resource management project, Mountain Home Ranger District, Boise National Forest, Elmore County, Idaho: U.S. Forest Service, Report no. 020299, 151 p.

- U.S. Forest Service, 2003, Big Bend Ridge vegetation management project and timber sale, Ashton/Island Park Ranger District, Caribou—Targhee National Forest, Freemont County, Idaho: U.S. Forest Service, Report no. 030225.
- U.S. Forest Service, 2003, Upper Bear timber sale, Council Ranger District, Payette National Forest, Adams County, Idaho: U.S. Forest Service, Report no. 030319, 478 p.
- U.S. Forest Service, 2004, French Face ecosystem restoration, Ninemile Ranger District, Lolo National Forest, Montana: U.S. Forest Service, Report no. 040336, 184 p.
- U.S. Forest Service, 2005, Dean Project Area, Bearlodge Ranger District, Black Hills National Forest, Crook County, Wyoming: U.S. Forest Service, Report no. 050212, 192 p.
- U.S. Forest Service, 2005, Rocky Mountain Ranger District travel management plan, Rocky Mountain Ranger District, Lewis and Clark National Forest, Glacier, Pondera, Teton, and Lewis and Clark Counties, Montana: U.S. Forest Service, Report no. 050236, 386 p.
- U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, 1997, George Washington National Forest land and resource management plan, Virginia and West Virginia (final supplement to the final environmental impact statement of January 1993): U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, Report no. 970046.
- U.S. National Park Service, 1991, Big Cypress National Preserve, Collier, Monroe, and Dade Counties, Florida: U.S. National Park Service, Report no. 910386.
- U.S. National Park Service, 1998, Redwood national and state parks general management plan, Del Norte and Humboldt Counties, California: U.S. National Park Service, Report no. 980290, 474 p.
- U.S. National Park Service, 1999, Big Cypress National Preserve, recreational off-road vehicle management plan—Collier, Dade, and Monroe Counties, Florida (draft supplement to the environmental impact statement of October 1991): U.S. National Park Service, Report no. 990285, 171 p.
- U.S. National Park Service, 2000, Recreational Off-road Vehicle management plan, Big Cypress National Preserve—Collier, Miami-Dade, and Monroe Counties, Florida (final supplement to the final environmental impact statement of October 1991): U.S. National Park Service, Report no. 000275, 619 p.
- U.S. Soil Conservation Service, 1990, Erosion, Grand Traverse County, Michigan: U.S. Soil Conservation Service, Technical Report.
- Vogt, G., 1979, Adverse effects of recreation on sand dunes—A problem for coastal zone management: *Coastal Zone Management Journal* New York, v. 6, no. 1, p. 37–68.

- Warburton, M., Fisher, R., and Hathaway, S., 2004, Anza-Borrego Desert State Park amphibian survey, 2000-2002: U.S. Geological Survey, Report no. PB2005105820, 44 p.
- Watson, J.J., Kerley, G.I.H., and McLachlan, A., 1996, Human activity and potential impacts on dune breeding birds in the Alexandria Coastal Dunefield: *Landscape and Urban Planning*, v. 34, no. 3–4, p. 315–322.
- Welch, R., Madden, M., and Doren, R.F., 1999, Mapping the Everglades: *Photogrammetric Engineering and Remote Sensing*, v. 65, no. 2, p. 163–170.
- Wemple, B.C., Jones, J., and Grant, G., 1996, Channel network extension by logging roads in two basins, western Cascades, Oregon: *Water Resources Bulletin*, v. 32, no. 6, p. 1195–1207.
- Wester, L., 1994, Weed management and the habitat protection of rare species—A case study of the endemic Hawaiian fern *Marsilea villosa*: *Biological Conservation*, v. 68, no. 1, p. 1–9.
- Wheeler, A.P., Angermeier, P.L., and Rosenberger, A.E., 2005, Impacts of new highways and subsequent landscape urbanization on stream habitat and biota: *Reviews in Fisheries Science*, v. 13, no. 3, p. 141–164.
- Wilson, J.P., and Seney, J.P., 1994, Erosional impact of hikers, horses, motorcycles, and off-road bicycles on mountain trails in Montana: *Mountain Research and Development*, v. 14, no. 1, p. 77–88.
- Wolcott, T.G., and Wolcott, D.L., 1984, Impact of off-road vehicles on macroinvertebrates of a mid-Atlantic beach: *Biological Conservation*, v. 29, no. 3, p. 217–240.
- Zamora, D., and Porter, M.D., 2000, Improved equipment for sampling dissolved oxygen at levee-pond commercial aquaculture facilities: *North American Journal of Aquaculture*, v. 62, no. 4, p. 311–315.

1.5 OHV Effects on Air Quality

- Adams, E.S., 1975, Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvelinus fontinalis*): Transactions of the American Fisheries Society, v. 104, no. 2, p. 363–373.
- Agrawal, Y.K., Patel, M.P., and Merh, S.S., 1981, Lead in soils and plants—Its relationship to traffic volume and proximity to highway (Lalbag, Baroda City): International Journal of Environmental Studies, v. 16, no. 3–4, p. 222–224.
- Al-Awadhi, J.I., 2001, Impact of gravel quarrying on the desert environment of Kuwait: Environmental Geology, v. 41, no. 3–4, p. 365–371.
- Andrews, A., 1990, Fragmentation of habitat by roads and utility corridors—A review: Australian Zoologist, v. 26, p. 130–141.
- Angold, P.G., 1997, The impact of a road upon adjacent heathland vegetation—Effects on plants species composition: Journal of Applied Ecology, v. 34, no. 2, p. 409–417.
- Bazzaz, F.A., and Garbutt, K., 1988, The response of annuals in competitive neighborhoods—Effects of elevated CO₂: Ecology, v. 69, no. 4, p. 937–946.
- Benson, P.E., Nokes, W.A., Cramer, R.L., O'Connor, J., Lindeman, W., 1986, Air-quality and noise issues in environmental planning: Washington, D.C., Transportation Research Board and National Research Council Technical Report, 72 p., http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7172765.
- Berry, K.H., 1980, The effects of four-wheel vehicles on biological resources—Soils, vegetation, small animals, management problems, Southwestern United States, in Andrews, R.N.L., and Nowak, P.F., eds., Off-road vehicle use—A management challenge: Washington D.C., U.S. Office of Environmental Quality, p. 231–233.
- Bishop, G.A., Morris, J.A., and Stedman, D.H., 2001, Snowmobile contributions to mobile source emissions in Yellowstone National Park: Environmental Science and Technology, v. 35, no. 14, p. 2874–2881.
- Boer, B., 1998, Anthropogenic factors and their potential impacts on the sustainable development of Abu Dhabi's terrestrial biological resources: International Journal of Sustainable Development and World Ecology, v. 5, no. 2, p. 125–135.
- Brown, G., and Porembski, S., 2000, Phytogenic hillocks and blow-outs as 'safe sites' for plants in an oil-contaminated area of northern Kuwait: Environmental Conservation, v. 27, no. 3, p. 242–249.
- Byrd, D.S., Gilmore, J.T., and Lea, R.H., 1983, Effect of decreased use of lead in gasoline on the soil of a highway: Environmental Science and Technology, v. 17, p. 121–123.

- Cadle, S.H., Belian, T.C., Black, K.N., Minassian, F., Natarajan, M., Tierney, E.J., and Lawson, D.R., 2005, Real-world vehicle emissions—A summary of the 14th Coordinating Research Council on Road Vehicle Emissions Workshop: Journal of the Air and Waste Management Association, v. 55, no. 2, p. 130–146.
- Cadle, S.H., Croes, B.E., Minassian, F., Natarajan, M., Tierney, E.J., and Lawson, D.R., 2004, Real-world vehicle emissions—A summary of the 13th Coordinating Research Council on Road Vehicle Emissions Workshop: Journal of the Air and Waste Management Association v. 54, no. 1, p. 8–23.
- Dennis, D.F., 1998, Analyzing public inputs to multiple objective decisions on national forests using conjoint analysis: Forest Science, v. 44, no. 3, p. 421–428.
- Dolfay, M.F., 1980, Methods of improving the management of four-wheel vehicles Wenatchee National Forest, in Andrews, R.N.L., and Nowak, P.F., eds., Off-road vehicle use—A management challenge: Washington, D.C., U.S. Office of Environmental Quality, p. 259–261.
- Dunnell, C.W., 1980, Protecting and rehabilitating ORV off-road recreational vehicles use areas—Erosion control and management, Wenatchee National Forest, in Andrews, R.N.L., and Nowak, P.F., eds., Off-road vehicle use—A management challenge: Washington, D.C., U.S. Office of Environmental Quality, p. 100–102.
- Falkengren-Grerup, U., 1986, Soil acidification and its impact on ground vegetation: Oecologia, v. 70, p. 339–347.
- Ferris, R., and Taylor, G., 1995, Contrasting effects of elevated CO² and water deficit on two native herbs: New Phytologist, v. 131, no. 4, p. 491–501.
- Fox, D.G., 1986, Establishing a baseline/protocols for measuring air quality effects in wilderness: U.S. Forest Service, Rocky Mountain Forest and Range Experimental Station, Technical Report, 85–91 p.
- Gish, C.D., and Christensen, R.E., 1973, Cadmium, nickel, lead, and zinc in earthworms from roadside soil: Environmental Science and Technology, v. 7, p. 1060–1062.
- Grue, C.E., O'Shea, T.J., and Hoffman, D.J., 1984, Lead concentrations and reproduction in highway-nesting barn swallows [*Hirundo rustica*]: Condor, v. 86, no. 4, p. 383–389.
- Harrison, R.T., 1980, Environmental impact of off-road motorcycles, in Andrews, R.N.L., and Nowak, P.F., eds., Off-road vehicle use—A management challenge: Washington, D.C., U.S. Office of Environmental Quality, p. 266–269.
- Holzapfel, C., and Schmidt, W., 1990, Roadside vegetation along transects in the Judean Desert: Israel Journal of Botany, v. 39, p. 263–270.

- Hunt, A., Dickens, H.J., and Whelan, R.J., 1987, Movement of mammals through tunnels under railway lines: *Australian Zoologist*, v. 24, no. 2, p. 89–93.
- Kay, J., 1981, Evaluating environmental impacts of off-road vehicles: *Journal of Geography*, v. 80, no. 1, p. 10–18.
- Kean, A.J., Sawyer, R.F., and Harley, R.A., 2000, A fuel-based assessment of off-road diesel engine emissions (1995): *Journal of the Air and Waste Management Association*, v. 50, no. 11, p. 1929–1939.
- Khalaf, F.I., 1989, Desertification and aeolian processes in the Kuwait Desert: *Journal of Arid Environments*, v. 16, no. 2, p. 125–145.
- Larney, F.J., Leys, J.F., Mueller, J.F., and McTainsh, G.H., 1999, Dust and endosulfan deposition in a cotton-growing area of northern New South Wales, Australia: *Journal of Environmental Quality*, v. 28, no. 2, p. 692–701.
- Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: *Environmental Management*, v. 24, no. 3, p. 309–326.
- Mitchell, G., 2005, Forecasting environmental equity—Air quality responses to road user charging in Leeds, UK.: *Journal of Environmental Management*, v. 77, no. 3, p. 212–226.
- Mooney, H.A., Kueppers, M., Koch, G., Gorham, J., Chu, C., and Winner, W.E., 1988, Compensating effects to growth of carbon partitioning changes in response to SO₂-induced photosynthetic reduction in radish: *Oecologia*, v. 75, no. 4, p. 502–506.
- Motto, H.L., Daines, R.H., Chilko, D.M., and Motto, C.K., 1970, Lead in soils and plants—Its relationship to traffic volume and proximity to highways: *Environmental Science and Technology*, v. 4, p. 231–237.
- Nash, A.E.K., 1980, Nature aesthetics, the public interest, and ORV off-road recreational vehicles users' perspectives, *in* Andrews, R.N.L., and Nowak, P.F., eds., *Off-road vehicle use—A management challenge*: Washington, D.C., U.S. Office of Environmental Quality, p. 12–77.
- Nicholes, G.E., 1980, A foundation for problem solutions—Off-road recreational vehicles, user attitudes, management problems, *in* Andrews, R.N.L., and Nowak, P.F., eds., *Off-road vehicle use—A management challenge*: Washington, D.C., U.S. Office of Environmental Quality, p. 103–109.
- Payne, G.F., Leininger, W.D., and Foster, J., 1979, How off-road vehicles affect range quality. When driving across rangelands, it's better to blaze a new trail: Bozeman, Montana, Montana Agricultural Experiment Station, Technical Report, 2 p.

- Quarles, H.D., Hanawalt, R.B., and Odum, W.E., 1974, Lead in small mammals, plants, and soil at varying distances from a highway: *Journal of Applied Ecology*, v. 11, no. 3, p. 937–949.
- Samaras, Z., and Zierock, K.H., 1995, Off-road vehicles—A comparison of emissions with those from road transport: *Science of the Total Environment*, v. 169, p. 249–253.
- Schade, G.A.J., 1980, Four-wheel vehicle user's perspective, *in* Andrews, R.N.L., and Nowak, P.F., eds., *Off-road vehicle use—A management challenge*: Washington, D.C., U.S. Office of Environmental Quality.
- Smith, W.H., 1976, Lead contamination of the roadside ecosystem: *Journal of the Air Pollution Control Association*, v. 26, p. 753–766.
- Spencer, H.J., and Port, G.R., 1988, Effects of roadside conditions on plants and insects: II. Soil conditions: *Journal of Applied Ecology*, v. 25, no. 22, p. 709–715.
- Thompson, C.R., Olszyk, D.M., Kats, G., Bytnerowicz, A., Dawson, P.J., and Wolf, J.W., 1984, Effects of ozone or sulfur dioxide on annual plants of the Mojave Desert: *Journal of the Air Pollution Control Association*, v. 34, no. 10, p. 1017–1022.
- Tocher, S.R., 1980, Four-wheel vehicles—Summary management on public lands, *in* Andrews, R.N.L., and Nowak, P.F., eds., *Off-road vehicle use—A management challenge*: Washington, D.C., U.S. Office of Environmental Quality, p. 286–289.
- U.S. Army Corps of Engineers, 1994, Stationing of mechanized or armored combat forces at Fort Lewis, Thurston and Pierce Counties, Washington: U.S. Army Corps of Engineers, Report no. 940045.
- U.S. Army Corps of Engineers, 2001, Fort Bliss mission and master plan—Dona Ana and Otero Counties, New Mexico, and El Paso County, Texas: U.S. Army Corps of Engineers, Report no. 010081.
- U.S. Bureau of Land Management, 1985, Grand Junction resource area—Resource management plan and environmental impact statement: U.S. Bureau of Land Management, Report, 171 p.
- U.S. Bureau of Land Management, 1986, Baker resource management plan, Baker County, Oregon: U.S. Bureau of Land Management, Report no. 860150, 129 p.
- U.S. Bureau of Land Management, 1986, Lander resource management plan, Lander, Wyoming: U.S. Bureau of Land Management, Report no. 860449.
- U.S. Bureau of Land Management, 1986, Proposed Baker resource management plan, Vale District, Oregon: U.S. Bureau of Land Management, Report no. 860396.
- U.S. Bureau of Land Management, 1986, Utah statewide wilderness environmental impact statement: U.S. Bureau of Land Management, Report no. 860036.

- U.S. Bureau of Land Management, 1987, North Dakota resource management plan, Dunn and Bowman Counties, North Dakota: U.S. Bureau of Land Management, Report no. 870236, 199 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette and Lincoln Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870077, 347 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette, Teton, Lincoln, and Fremont Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870428, 232 p.
- U.S. Bureau of Land Management, 1988, Challis resource area proposed resource management plan, upper Columbia-Salmon Clearwater Districts, Custer and Lemhi Counties, Idaho: U.S. Bureau of Land Management, Report no. 980508.
- U.S. Bureau of Land Management, 1988, Cody resource area resource management plan, Big Horn and Park Counties, Wyoming: U.S. Bureau of Land Management, Report no. 880315.
- U.S. Bureau of Land Management, 1988, Pony Express resource management plan, Toole, Utah, and Salt Lake Counties, Utah: U.S. Bureau of Land Management, Report no. 880310, 147 p.
- U.S. Bureau of Land Management, 1988, Proposed Las Vegas resource management plan and final environmental impact statement, Clark and Nye Counties, Nevada: U.S. Bureau of Land Management, Report no. 980207.
- U.S. Bureau of Land Management, 1988, Uncompahgre Basin resource management plan, Colorado: U.S. Bureau of Land Management, Report no. 880345.
- U.S. Bureau of Land Management, 1988, Wilderness study areas in the Rock Springs District, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming (revised Draft environmental impact statement): U.S. Bureau of Land Management, Report no. 880359, 175 p.
- U.S. Bureau of Land Management, 1989, Dixie resource area management plan, Washington County, Utah: U.S. Bureau of Land Management, Report no. 890290, 250 p.
- U.S. Bureau of Land Management, 1989, San Rafael resource management plan, Emery County, Utah: U.S. Bureau of Land Management, Report no. 890240.
- U.S. Bureau of Land Management, 1989, White Sands resource management plan Amendment for McGregor Range, Otero County, New Mexico: U.S. Bureau of Land Management, Report no. 890127.

- U.S. Bureau of Land Management, 1990, Rock Springs District wilderness study areas, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming: U.S. Bureau of Land Management, Report no. 900439, 324 p.
- U.S. Bureau of Land Management, 1991, Safford District resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 910314, 511 p.
- U.S. Bureau of Land Management, 1994, Stateline resource management plan, Clark and Nye Counties, Nevada (draft environmental impact statement and draft supplement): U.S. Bureau of Land Management, Report no. 940177.
- U.S. Bureau of Land Management, 1998, Socorro resource area resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 880397, 266 p.
- U.S. Bureau of Land Management, 2000, Pinedale anticline oil and gas exploration and development project, Sublette County, Wyoming: U.S. Bureau of Land Management, Report no. 000159, 301 p.
- U.S. Bureau of Land Management, 2001, National management strategy for motorized off-highway vehicle use on public lands: U.S. Bureau of Land Management, Report no. PB2001103162, 58 p.
- U.S. Bureau of Land Management, 2004, Dillon resource management plan, Beaverhead and Madison Counties, Montana: U.S. Bureau of Land Management, Report no. 040153, 626 p.
- U.S. Bureau of Land Management, 2004, Jack Morrow Hills coordinated activity plan, Sweetwater, Fremont, and Sublette Counties, Wyoming: U.S. Bureau of Land Management, Technical Report.
- U.S. Bureau of Land Management, 2005, Newmont Mining Company, Emigrant project, Elko County, Nevada: U.S. Bureau of Land Management, Report no. 050117, 269 p.
- U.S. Bureau of Reclamation, 2001, Pothole Reservoir resource management plan, Grant County, Washington: U.S. Bureau of Reclamation, Report no. 010518, 567 p.
- U.S. Fish and Wildlife Service, 1986, Great Dismal Swamp National Wildlife Refuge master plan, Virginia and North Carolina: U.S. Fish and Wildlife Service, Report no. 860501, 245 p.
- U.S. Forest Service, 1973, Proposed off-road vehicle regulations and administrative instructions: U.S. Forest Service, Report no. USDAFS–FES(ADM)–73–49, 110 p.
- U.S. Forest Service, 1973, Proposed regulations and administrative instructions relating to use of off-road vehicles on national forest lands: U.S. Forest Service, Report no. USDAFS–DES(ADM)–73–49, 22 p.

- U.S. Forest Service, 1985, Kisatchie National Forest land and resource management plan, Louisiana: U.S. Forest Service, Report no. 850414.
- U.S. Forest Service, 1985, Proposed land and resource management plan for the Medicine Bow National Forest and Thunder Basin National Grassland, Wyoming: U.S. Forest Service, Report no. 850523.
- U.S. Forest Service, 1986, Land and resource management plan, Chippewa National Forest, Beltrami, Cass, and Itasca Counties, Minnesota: U.S. Forest Service, Report no. 860208.
- U.S. Forest Service, 1986, Proposed Santa Fe National Forest land and resource management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 860013.
- U.S. Forest Service, 1987, Proposed Apache-Sitgreaves National Forests land and resource management plan, Apache, Coconino, Greenlee, and Navajo Counties, Arizona: U.S. Forest Service, Report no. 870387.
- U.S. Forest Service, 1987, Proposed land and resource management plan for the Coconino Forest, Coconino, Gila, and Yavapai Counties, Arizona: U.S. Forest Service, Report no. 870288.
- U.S. Forest Service, 1987, Santa Fe National Forest land management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 870299.
- U.S. Forest Service, 1989, San Bernardino National Forest land and resource management plan, San Bernardino and Riverside Counties, California: U.S. Forest Service, Report no. 890023.
- U.S. Forest Service, 1993, Six Rivers National Forest plan, Humboldt, Del Norte, Siskiyou, and Trinity Counties, California: U.S. Forest Service, Report no. 930340.
- U.S. Forest Service, 1994, Revised land and resource management plan for the national forests and grasslands in Texas—Angelina, Fannin, Houston, Jasper, Montague, Montgomery, Nacogdoches, Newton, Sabine, San Augustine, San Jacinto, Shelby, Trinity, Walker, and Wise Counties, Texas: U.S. Forest Service, Report no. 940385.
- U.S. Forest Service, 1995, Mendocino National Forest land and resource management plan—Colusa, Glenn, Lake, Mendocino, Tehama, and Trinity Counties, California: U.S. Forest Service, Report no. 950337.
- U.S. Forest Service, 1995, Snowy Trail re-route, Ventura County, California: U.S. Forest Service, Report no. 950117, 109 p.
- U.S. Forest Service, 1996, Snowy Trail re-route, Los Padres National Forest, Ventura County, California: U.S. Forest Service, Report no. 960524.

- U.S. Forest Service, 2001, Land and resource management plan, Uinta National Forest—Juab, Sanpete, Toole, Utah, and Wasatch Counties, Utah: U.S. Forest Service, Report no. 010142.
- U.S. Forest Service, 2001, Starbucky restoration project, Red River Ranger District, Nez Perce National Forest, Idaho County, Idaho: U.S. Forest Service, Report no. 010274.
- U.S. Forest Service, 2002, Sixshooter project, Emmett Ranger District, Boise National Forest, Gem County, Idaho: U.S. Forest Service, Report no. 020238, 201 p.
- U.S. Forest Service, 2002, West Gold project, Sandpoint Ranger District, Idaho Panhandle National Forests, Bonner County, Idaho: U.S. Forest Service, Report no. 020484.
- U.S. Forest Service, 2002, Whiskey Campo resource management project, Mountain Home Ranger District, Boise National Forest, Elmore County, Idaho: U.S. Forest Service, Report no. 020299, 151 p.
- U.S. Forest Service, 2003, Big Bend Ridge vegetation management project and timber sale, Ashton/Island Park Ranger District, Caribou-Targhee National Forest, Fremont County, Idaho: U.S. Forest Service, Report no. 030225.
- U.S. Forest Service, 2003, Upper Bear timber sale, Council Ranger District, Payette National Forest, Adams County, Idaho: U.S. Forest Service, Report no. 030319, 478 p.
- U.S. Forest Service, 2004, French Face ecosystem restoration, Ninemile Ranger District, Lolo National Forest, Montana: U.S. Forest Service, Report no. 040336, 184 p.
- U.S. Forest Service, 2005, Dean project area, Bearlodge Ranger District, Black Hills National Forest, Crook County, Wyoming: U.S. Forest Service, Report no. 050212, 192 p.
- U.S. Forest Service, 2005, Woodrock project, Tongue Ranger District, Bighorn National Forest, Sheridan County, Wyoming: U.S. Forest Service, Report no. 050112, 201 p.
- U.S. Forest Service, 2006, Hoosier National Forest land and resource management plan—Final environmental impact statement: U.S. Forest Service, Technical Report.
- U.S. Naval Facilities Engineering Command, 2003, Advanced amphibious assault vehicle, Marine Corps Base Camp Pendleton and San Clemente Range Complex, San Diego County, California: U.S. Naval Facilities Engineering Command, Report no. 030201.
- Udevitz, M.S., Howard, C.A., Robel, R.J., and Curnutte, B., 1980, Lead contamination in insects and birds near an interstate highway, Kansas: *Environmental Entomology*, v. 9, no. 1, p. 35–36.
- Walker, D.A., and Everett, K.R., 1987, Road dust and its environmental impact on Alaskan taiga and tundra: *Arctic and Alpine Research*, v. 19, no. 4, p. 479–489.

Westec Services Inc., 1979, Fugitive dust impacts during off-road vehicle (ORV) events in the California desert: Tustin, California, WESTEC Services, Inc., Technical Report, 40 p.

Winner, W.E., and Atkinson, C.J., 1986, Absorption of air pollutants by plants and consequences: Trends in Ecology and Evolution, v. 1, p. 15–18.

1.6 Socioeconomic Implications of OHV Use

- Absher, J.D., and Bright, A.D., 2004, Communication research in outdoor recreation and natural resources management, *in* Manfredo, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., *Society and Natural Resources—A summary of knowledge*: Jefferson, Missouri, Modern Litho, p.117–126.
- Achana, F., 2005, 2005 ATV/motorbike user survey: Idaho Department of Parks and Recreation, Technical Report, 37 p.
- Alaska Pulp Corporation, U.S. Forest Service, and U.S. Army Corps of Engineers, 1994, Ushk Bay timber sale, Alaska Pulp Corporation long-term timber sale Contract, Chatnam Area, Tongass National Forest, Alaska: U.S. Forest Service and U.S. Army Corps of Engineers, Report no. 940408.
- American Motorcyclist Association, 1979, The economic impact of off-highway motorcycling in southern California and Mexico: Westerville, Ohio, Department of Government Relations, Technical Report, 14 p.
- Bannister, E.N., 1979, Impact of road networks on southeastern Michigan lakeshore drainage: *Water Resources Research*, v. 15, no. 6, p. 1515–1520.
- Bight, A.D., Coredell, H.K., Hoover, A.P., and Tarranr, M.A., 2003, A human dimensions framework—Guidelines for conducting social assessments: Asheville, North Carolina, U.S. Forest Service, Southern Research Station, 83 p.
- Bjornlie, D.D., and Garrott, R.A., 2001, Effects of winter road grooming on bison in Yellowstone National Park: *Journal of Wildlife Management*, v. 65, no. 3, p. 560–572.
- Boyle, S.A., and Samson, F.B., 1985, Effects of nonconsumptive recreation on wildlife—A review: *Wildlife Society Bulletin*, v. 13, p. 110–116.
- Brooks, J.J., and Champ, P.A., 2006, Understanding the wicked nature of “unmanaged recreation” in Colorado’s Front Range: *Environmental Management*, v. 38, no. 5, p. 784–798, <http://www.springerlink.com/content/ek62272u626u6074/fulltext.pdf>.
- Brown, A.C., and McLachlan, A., 2002, Sandy shore ecosystems and the threats facing them—Some predictions for the year 2025: *Environmental Conservation*, v. 29, no. 1, p. 62–77.
- Buckley, R., 2004, *Environmental impacts of ecotourism*: Wallingford, England, CABI Publishing, 389 p.
- Buckley, R., 2004, Environmental impacts of motorized off-highway vehicles, *in* Buckley, R., ed., *Environmental impacts of ecotourism*: Wallingford, England, CABI Publishing, p. 83–97.

- Buckley, R., and King, N., 2003, Visitor-impact data in a land-management context, *in* Buckley, R.C., Pickering, D., and Weaver, D.B., eds., *Nature-based tourism, environment and land management*: Wallingford, England, CABI Publishing, p. 89-99.
- Burger, J., 1986, The effect of human activity on shorebirds in two coastal bays in northeastern United States: *Environmental Conservation*, v. 13, no. 2, p. 123–130.
- Bury, R.L., and Fillmore, E.R., 1974, Design of motorcycle areas near campgrounds—Effects on riders and non riders: College Station, Texas, Department of Recreation and Parks, Texas A & M University, Technical Report, 72 p.
- Bury, R.L., Holland, S.M., and McEwen, D.N., 1983, Analyzing recreational conflict—Understanding why conflict occurs is requisite to managing that conflict: *Journal of Soil and Water Conservation*, v. 3, no. 5, p. 401–403.
- Bury, R.L., Wendling, R.C., and McCool, S.F., 1976, Off-road recreation vehicles—A research summary, 1969–1975: College Station, Texas, Texas Agricultural Experiment Station, Technical Report.
- Call, C.A., Barker, J.R., and McKell, C.M., 1981, Visitor impact assessment of scenic view areas at Bryce Canyon National Park: *Journal of Soil and Water Conservation*, v. 36, no. 1, p. 50–53.
- Cole, D.N., 2004, Environmental impacts of outdoor recreation in wildlands, *in* Manfredi, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., *Society and natural resources—A summary of knowledge*: Jefferson, Missouri, Modern Litho, p. 107–116.
- Cole, D.N. and Landres, P.B., 1995, Indirect effects of recreation on wildlife, *in* Knight, R.L., and Gutzwiller, K.J., eds., *Wildlife and recreationists—Coexistence through management and research*: Washington, D.C., Island Press, p. 183–202.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Annotated bibliography for biologic overview for the Nevada nuclear waste storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832419, 48 p.
- Collins, E., O'Farrell, T.P., and Rhoads, W., 1982, Biologic overview for the Nevada Nuclear Waste Storage investigations, Nevada Test Site, Nye County, Nevada: Goleta, California, EG and G, Inc., Report no. EGG11832460, 55 p.
- Cordell, H.K., Betz, C.J., Green, G., and Owens, M., 2005, Off-highway vehicle recreation in the United States, regions, and states—A national report from the national survey on recreation and the environment (NSRE): U.S. Forest Service, Southern Research Station, Technical Report, 90 p.

- Council on Environmental Quality, 1997, Considering cumulative effects under the National Environmental Policy Act: Washington, D.C., Council on Environmental Quality, Technical Report, <http://www.nepa.gov/nepa/ccenepa/ccenepa.htm>.
- Crimmins, T., 1999, Colorado off-highway vehicle user survey—Summary of results: Denver, Colorado, Colorado State Parks, Technical Report.
- Dave Miller Associates, 1981, An economic/social assessment of snowmobiling in Maine: Windham, Maine, Dave Miller Associates, Technical Report, 52 p.
- Dawson, K.J., 1985, Natural area planning for recreational use transition: Landscape Planning, v. 12, no. 2, p. 111–123.
- Dean Runyan Associates, 2000, Campers in California travel patterns and economic impacts: Portland, Oregon, Dean Runyan Associates, Technical Report, 76 p.
- Duever, M.J., Riopelle, L.A., and McCollom, J.M., 1986, Long term recovery of experimental off-road vehicle impacts and abandoned old trails in the Big Cypress National Preserve: Naples, Florida, National Audubon Society, Technical Report, 56 p.
- Ewert, A., and Shultis, J., 1999, Technology and backcountry recreation—Boon to recreation or bust for management?: Technology and Leisure, v. 70, no. 8, p. 23–31.
- Fisher, A.L., Blahna, D.J., and Bahr, R., 2001, Off-highway vehicle uses and owner preferences in Utah: Logan, Utah, Institute for Outdoor Recreation and Tourism, Department of Forest Resources, Utah State University, Report no. IORT PR2001–02, 80 p.
- Graefe, A.R., and Thapa, B., 2004, Conflict in natural resource recreation, *in* Manfredo, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., Society and natural resources—A summary of knowledge: Jefferson, Missouri, Modern Litho, p. 209–224.
- Gray, J.R., 1977, Kinds and costs of recreational pollution in the Sandia Mountains: New Mexico Agricultural Experiment Station Bulletin, Technical Report, 57 p.
- Gutzwiller, K.J., 1995, Recreational disturbances and wildlife communities *in* Knight, R.L., and Gutzwiller, K.J., eds., Wildlife and recreationists—Coexistence through management and research: Washington, D.C., Island Press, p. 169–181.
- Hall, C., and Dearden, P., eds., 1984, The impact of "non-consumptive" recreation on wildlife—An annotated bibliography: Monticello, Illinois, Vance Bibliographies, 45 p.
- Heede, B.H., 1983, Control of rills and gullies in off-road vehicle traffic areas, *in* Webb, R.H., and Wilshire, H.G., eds., Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, p. 245–264.

- Hendon, W.C., 1991, The wilderness as a source of recreation and renewal—Who uses it? what are their characteristics? their other interests? their preferences?: *American Journal of Economics and Sociology*, v. 50, no. 1, p. 105–112.
- Hosier, P.E., and Eaton, T.E., 1980, The impact of vehicles on dune and grassland vegetation on a southeastern North Carolina barrier beach: Wilmington, North Carolina, North Carolina University at Wilmington, Report no. UNC–SG–R–164, 13 p.
- Hosier, P.E., Kochlar, M., and Thayer, V., 1981, Off-road vehicle and pedestrian track effects on the sea-approach of hatchling loggerhead turtles: *Environmental Conservation*, v. 8, no. 2, p. 158–161.
- Iverson, R.M., Hinckley, B.S., and Webb, R.M., 1981, Physical effects of vehicular disturbances on arid landscapes: *Science*, v. 212, no. 4497, p. 915–917.
- Jim, C., 1989, Visitor management in recreation areas: *Environmental Conservation*, v. 16, no. 1, p. 19–32.
- Jim, C.Y., 1987, Trampling impacts of recreationists on picnic sites in a Hong Kong county park: *Environmental Conservation*, v. 14, no. 2, p. 117–127.
- Kant, H., and Sood, K.G., 1974, A study on off-road transportation by tractors: *Indian Forester*, v. 100, no. 5, p. 327–341.
- Karanja, G., 2003, Tourism impacts in Masai Mara National Reserve: IIED Wildlife and Development Series, v. 14, p. 5–16.
- Kato, T.T., and O’Farrell, T.P., 1986, Biological assessment of the effects of petroleum production at maximum efficient rate, Naval Petroleum Reserve No. 1 (Elk Hills), Kern County, California, on the endangered blunt-nosed leopard lizard, *Gambelia silus*: Goleta, California, EG and G Energy Measurements, Inc., Report no. EGG102822108, 72 p.
- Kay, J., 1981, Evaluating environmental impacts of off-road vehicles: *Journal of Geography*, v. 80, no. 1, p. 10–18.
- Kirkpatrick, J.B., 2001, Ecotourism, local and indigenous people, and the conservation of the Tasmanian Wilderness World Heritage Area: *Journal of the Royal Society of New Zealand*, v. 31, no. 4, p. 819–829.
- Knight, R.L., and Cole, D.N., 1995, Wildlife response to recreationists, in Knight, R.L., and Gutzwiller, K.J., eds., *Wildlife and recreationists—Coexistence through management and research*: Washington, D.C., Island Press, p. 51–69.
- Koeppel, W., and Strauss, C., 1984, Areal evaluation of vehicle mobility: Frankfurt, Germany, Battelle Institute, Technical Report, 20 p.

- Landsberg, J., Logan, B., and Shorthouse, D., 2001, Horse riding in urban conservation areas—Reviewing scientific evidence to guide management: *Ecological Management and Restoration*, v. 2, no. 1, p. 36–46.
- Lewis, O., 1969, Arid lands and their future, in Bender, G.L., ed., *Future environments of arid regions of the southwest*, contribution no. 12, American Association for the Advancement of Science Committee on Desert and Arid Zone Research symposium, Colorado Springs, Colorado, May 7-10, 1969: Washington, D.C., American Association for the Advancement of Science, Committee on Desert and Arid Zone Research, p. 33–38.
- Losos, E., Hayes, J., Phillips, A., Alkire, C., and Wilcove, D., 1993, Taxpayers double burden—Federal resource subsidies and endangered species: Missoula, Montana, The Wilderness Society's Bolle Center for Ecosystem Management, Technical Report, 95 p.
- Lovich, J.E., and Bainbridge, D., 1999, Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration: *Environmental Management*, v. 24, no. 3, p. 309–326.
- Lucas, R.C., 1978, Impact of human pressure on parks, wilderness, and other recreation lands, *Sourcebook on the environment—A guide to the literature*: Chicago, University of Chicago Press, p. 221–239.
- Luckenbach, R.A., 1978, An analysis of off-road vehicle use on desert avifaunas: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 43, p. 157–162.
- Major, M.J., 1987, Managing off-the-road vehicles—A recurring round of events: *Journal of Forestry*, v. 85, no. 11, p. 37–41.
- Matchett, J.R., Gass, L., Brooks, M.L., Mathie, A.M., Vitales, R.D., Campagna, M.W., Miller, D.M., and Weigand, J.F., 2004, Spatial and temporal patterns of off-highway vehicle use at the Dove Springs OHV open area, California: U.S. Geological Survey, Report, 17 p.
- Meyer, K.G., 2002, Managing degraded off-highway vehicle trails in wet, unstable, and sensitive environments: U.S. Department of Interior, National Park Service, Report no. PB2005105502, 88 p.
- Meyer, K.G., 2002, Proposed best management practices for OHV/ATV trail management in Alaska: U.S. National Park Service Rivers Trails and Conservation Assistance Program, Technical Report, 19 p.
- Mitchell, G., 2005, Forecasting environmental equity—Air quality responses to road user charging in Leeds, UK.: *Journal of Environmental Management*, v. 77, no. 3, p. 212–226.
- Moorhead, D.L., Linkins, A.E., and Everett, K.R., 1996, Road dust alters extracellular enzyme activities in tussock tundra soils, Alaska, U.S.A.: *Arctic and Alpine Research*, v. 28, no. 3, p. 346–351.

- Mortensen, C.O., 1989, Visitor use impacts within the Knobstone Trail corridor: *Journal of Soil and Water Conservation*, v. 44, no. 2, p. 156–159.
- Muleski, G.E., Garmen, G., and Cowherd, C., 1994, Surface coal mine emission factor field study: Kansas City, Missouri, Midwest Research Institute, Report no. EPA/454/R95/010, 167 p.
- Nelson, C.M., and Lynch, J.A., 2001, A usable pilot off-road vehicle project evaluation: East Lansing, Michigan, Department of Park, Recreation and Tourism Resources, Michigan State University, Technical Report, 50 p.
- Nelson, C.M., Lynch, J.A., and Stynes, D.J., 2000, Michigan licensed off-road vehicle use and users—1998–99: East Lansing, Michigan, Department of Park, Recreation and Tourism Resources, Michigan State University, Technical Report, 49 p.
- Noake, D.W., 1967, Camping as a factor in the ecological impact of tourism and recreation: *International Union Conservation*, p. 224–229.
- Noe, F.P., Hammitt, W.E., and Bixler, R.D., 1995, Park user perceptions of resource and use impacts under varied situations in three National Parks: *Journal of Environmental Management*, v. 49, no. 3, p. 323–336.
- Nova Scotia Voluntary Planning Task Force on Off-Highway Vehicles, 2003, Off-highway vehicles in Nova Scotia: Nova Scotia Voluntary Planning Task Force on Off-Highway Vehicles, Technical Report, 12 p.
- O'Farrell, T.P., 1984, Conservation of the endangered San Joaquin kit fox *Vulpes macrotis mutica* in the Naval Petroleum Reserves, California: *Acta Zoologica Fennica*, v. 172, p. 207–208.
- O'Farrell, T.P., Harris, C.E., Kato, T.T., and McCue, P.M., 1986, Biological assessment of the effects of petroleum production at maximum efficient rate, Naval Petroleum Reserve No. 1 (Elk Hills), Kern County, California, on the endangered San Joaquin kit fox, *Vulpes macrotis mutica*: Goleta, California, EG and G Energy Measurements, Inc., Report no. EGG102822107, 84 p.
- O'Farrell, T.P., and Kato, T.T., 1987, Biological assessment of the effects of petroleum production activities, Naval Petroleum Reserves in California, on the endangered giant kangaroo rat, *Dipodomys ingens*: Goleta, California, EG and G Energy Measurements, Inc., Report no. EGG102822183, 34 p.
- Pelton, C., 1987, A computer program for hill-shading digital topographic data sets: *Computers and Geosciences*, v. 13, no. 5, p. 545–548.

- Propst, D.B., Shomaker, J.H., and Mitchekkm, J.E., 1977, Attitudes of Idaho off-road vehicle users and mangers: Moscow, Idaho, College of Forestry, Wildlife and Range Sciences, University of Idaho, Technical Report, 30 p.
- Radforth, J.R., 1978, Higher travel speeds for off-road logging vehicles: Pointe-Claire, Quebec, Forest Engineering Research Institute of Canada, Report no. TR-22, 23 p.
- Reed, P.C., and Haas, G.E., 1989, Off highway vehicles in Colorado—Estimated recreational use and expenditures: Fort Collins, Colorado, Colorado State University, Department of Recreation Resources and Landscape Architecture, Technical Report, 15 p.
- Rhoads, W.A., Cochrane, S.A., and Williams, M.P., 1979, Status of endangered and threatened plant species on Tonopah Test Range—A survey: Goleta, California, Santa Barbara Research Center, Report no. SAND807035, 126 p.
- Rickard, C.A., McLachlan, A., and Kerley, G.I.H., 1994, The effects of vehicular and pedestrian traffic on dune vegetation in South Africa: *Ocean and Coastal Management*, v. 23, no. 3, p. 225–247.
- Rocky Mountain Research Initiative, 2002, Off-road vehicles in Colorado—Facts, trends, recommendations: Nederland, Colorado, Rocky Mountain Research Initiative, http://www.rmri.org/rmri_full_report.pdf.
- Ross, J.B., and Willison, J.H.M., 1991, Impacts of all-terrain vehicles on bogs of the Cape Breton Highlands, Nova Scotia, Canada, Science and the management of protected areas—proceedings of an international conference held at Acadia University, Nova Scotia, Canada, 14-19 May 1991: Woldville, Nova Scotia, Canada, Acadia University, p. 533–534.
- Schuett, M.A., and Ostergren, D., 2003, Environmental concern and involvement of individuals in selected voluntary associations: *Journal of Environmental Education*, v. 34, no. 4., p. 30–38.
- Sheridan, D., 1979, Off-road vehicles on public land: Council on Environmental Quality, Report no. PB86211158, 94 p.
- Shields, F.D., Cooper, C.M., Knight, S.S., Jr., and Moore, M.T., 2003, Stream corridor restoration research—A long and winding road: *Ecological Engineering*, v. 20, no. 5, p. 441–454.
- Shindler, B., Brunson, M.W., and Cheek, K.A., 2004, Social acceptability in forest and range management, *in* Manfredo, M.J., Vaske, J.J., Bruyere, B.L., Field, D.R., and Brown, P.J., eds., *Society and natural resources—A summary of knowledge*: Jefferson, Missouri, Modern Litho, p. 146–157.

- Siddharthan, R.V., Sebaaly, P.E., El-Desouky, M., Strand, D., and Huft, D., 2005, Heavy off-road vehicle tire–pavement interactions and response: *Journal of Transportation Engineering*, v. 131, no. 3, p. 239–247.
- Sorenson, S., Kalivoda, M., Vacarro, R., Trozzi, C., and Samaras, Z., 1997, Data structure for estimating emissions from non-road sources: Lyngby, Denmark, Technical University of Denmark, Lyngby Institute, Report no. DTUETEO9702, 73 p.
- Steiner, A.J., and Leatherman, S.P., 1981, Recreational impacts on the distribution of ghost crabs *Ocypode quadrata* Fab: *Biological Conservation*, v. 20, no. 2, p. 111–122.
- Stephenson, G., 1999, Vehicle impacts on the biota of sandy beaches and coastal dunes—A review from a New Zealand perspective: *Science for Conservation*, v. 121, p. 1–14.
- Stohlgren, T.J., and Parsons, D.J., 1992, Evaluating wilderness recreational opportunities—Application of an impact matrix: *Environmental Management*, v. 16, no. 3, p. 397–403.
- Stokowski, P.A., and LaPointe, C.B., 2000, Environmental and social effects of ATVs and ORVs—An annotated bibliography and research assessment: Burlington, Vermont, University of Vermont, School of Natural Resources, 32 p.
- Stynes, D.J., Nelson, C.M., and Lynch, J.A., 1988, State and regional economic impacts of snowmobiling in Michigan: East Lansing, Michigan, Department of Park, Recreation and Tourism Resources, Michigan State University, Technical Report, 31 p.
- Swim, F.F., 1971, Bicycling and bicycle trails. A trails and trail based activities bibliography: U.S. Office of Library Services, Report no. BIB24, 38 p.
- Turton, S.M., 2005, Managing environmental impacts of recreation and tourism in rainforests of the wet tropics of Queensland World Heritage Area: *Geographical Research*, v. 43, no. 2, p. 140–151.
- Twiss, R., Sidener, J., Bingham, G., Burke, J.E., and Hall, C.H., 1980, Potential impacts of geothermal development on outdoor recreational use of the Salton Sea: Livermore, California, University of California, Livermore, Technical Report, 61 p.
- U.S. Army Corps of Engineers, 1998, McGregor range land withdrawal, Fort Bliss, Otero County, New Mexico: U.S. Army Corps of Engineers, Report no. 980439, 586 p.
- U.S. Army Corps of Engineers, 2001, Fort Bliss mission and master plan—Dona Ana and Otero Counties, New Mexico, and El Paso County, Texas: U.S. Army Corps of Engineers, Report no. 010081.
- U.S. Bureau of Land Management, 1984, Proposed Monument resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 840584, 419 p.

- U.S. Bureau of Land Management, 1985, Box Elder resource management plan, Utah: U.S. Bureau of Land Management, Report no. 850448.
- U.S. Bureau of Land Management, 1985, Grand Junction resource area—Resource management plan and environmental impact statement: U.S. Bureau of Land Management, Technical Report, 171 p.
- U.S. Bureau of Land Management, 1985, Medicine Lodge Proposed resource management plan, Bingham, Bonneville, Butte, Clark, Fremont, Jefferson, Madison, and Teton Counties, Idaho: U.S. Bureau of Land Management, Report no. 850237.
- U.S. Bureau of Land Management, 1985, Proposed Two Rivers resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 850409.
- U.S. Bureau of Land Management, 1985, Two Rivers resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 850137, 163 p.
- U.S. Bureau of Land Management, 1985, Yuma District resource management plan, Yuma, La Paz, and Mohave Counties, Arizona, and San Bernardino, Riverside, and Imperial Counties, California: U.S. Bureau of Land Management, Report no. 850358, 310 p.
- U.S. Bureau of Land Management, 1986, Baker resource management plan, Baker County, Oregon: U.S. Bureau of Land Management, Report no. 860150, 129 p.
- U.S. Bureau of Land Management, 1986, Lander resource management plan, Lander, Wyoming: U.S. Bureau of Land Management, Report no. 860449.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan and the Eastern San Diego County master framework plan, California: U.S. Bureau of Land Management, Report no. 860432, 138 p.
- U.S. Bureau of Land Management, 1986, Proposed 1985 amendments to the California desert conservation area plan, California: U.S. Bureau of Land Management, Report no. 860077.
- U.S. Bureau of Land Management, 1986, Proposed Baker resource management plan, Vale District, Oregon: U.S. Bureau of Land Management, Report no. 860396.
- U.S. Bureau of Land Management, 1986, resource management plan for the House Range resource area, Juab and Millard Counties, Utah: U.S. Bureau of Land Management, Report no. 860377.
- U.S. Bureau of Land Management, 1986, Utah statewide wilderness environmental impact statement: U.S. Bureau of Land Management, Report no. 860036.

- U.S. Bureau of Land Management, 1986, Wilderness suitability EIS—Grass Creek and Cody resource areas, Bighorn Basin, Wyoming (draft supplement for the Owl Creek wilderness study area): U.S. Bureau of Land Management, Report no. 860168, 40 p.
- U.S. Bureau of Land Management, 1987, Glenwood Springs resource area resource management plan, Colorado—Wilderness recommendations: U.S. Bureau of Land Management, Report no. 870421, 168 p.
- U.S. Bureau of Land Management, 1987, Medicine Bow-Divide resource areas resource management plan, Rawlins District, Wyoming: U.S. Bureau of Land Management, Report no. 870212.
- U.S. Bureau of Land Management, 1987, North Dakota resource management plan, Dunn and Bowman Counties, North Dakota: U.S. Bureau of Land Management, Report no. 870236, 199 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette and Lincoln Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870077, 347 p.
- U.S. Bureau of Land Management, 1987, Pinedale resource area resource management plan, Sublette, Teton, Lincoln, and Fremont Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870428, 232 p.
- U.S. Bureau of Land Management, 1987, Preliminary wilderness recommendations for the Arcata resource area, Eden Valley and Thatcher Ridge wilderness study areas, Ukiah District, Mendocino County, California: U.S. Bureau of Land Management, Report no. 870348, 111 p.
- U.S. Bureau of Land Management, 1987, Proposed Monument resource management plan and Wilderness Study, Idaho: U.S. Bureau of Land Management, Report no. 870248, 162 p.
- U.S. Bureau of Land Management, 1987, Proposed resource management plan and wilderness recommendations for the Lahontan resource area, Nevada: U.S. Bureau of Land Management, Report no. 870293, 282 p.
- U.S. Bureau of Land Management, 1987, Proposed utility corridor resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 870291, 281 p.
- U.S. Bureau of Land Management, 1987, Proposed wilderness program for the Stafford District wilderness EIS Area, Cochise, Gila, Graham, and Greenlee Counties, Arizona and Hidalgo County, New Mexico: U.S. Bureau of Land Management, Report no. 870156, 502 p.
- U.S. Bureau of Land Management, 1987, Proposed wilderness program for the Upper Sonoran wilderness EIS Area, Maricopa, Mohave, Yavapai, and Yuma Counties, Arizona: U.S. Bureau of Land Management, Report no. 870292, 394 p.

- U.S. Bureau of Land Management, 1987, resource management plan for the Shoshone-Eureka resource area, Nevada—Wilderness recommendations: U.S. Bureau of Land Management, Report no. 870403, 101 p.
- U.S. Bureau of Land Management, 1987, Taos resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 870331.
- U.S. Bureau of Land Management, 1987, Washakie resource area resource management plan, portions of Big Horn, Hot Springs, and Washakie Counties, Wyoming: U.S. Bureau of Land Management, Report no. 870395.
- U.S. Bureau of Land Management, 1987, Wells resource area wilderness recommendations, Bluebell, Goshute Peak, South Pequop, and Bad Lands Wilderness Study Areas, Elko County, Nevada: U.S. Bureau of Land Management, Report no. 870267, 224 p.
- U.S. Bureau of Land Management, 1987, Wilderness recommendations for Clark County, Nevada: U.S. Bureau of Land Management, Report no. 870108, 346 p.
- U.S. Bureau of Land Management, 1987, Wilderness recommendations for the northcentral California wilderness study areas: U.S. Bureau of Land Management, Report no. 870058, 115 p.
- U.S. Bureau of Land Management, 1988, Brothers/Lapine resource management plan, Oregon: U.S. Bureau of Land Management, Report no. 880365.
- U.S. Bureau of Land Management, 1988, Central California section 202 wilderness study areas wilderness recommendations—Sheep Ridge, Milk Ranch/Case Mountain, and Ventana contiguous WSA'S: U.S. Bureau of Land Management, Report no. 880020, 110 p.
- U.S. Bureau of Land Management, 1988, Challis resource area proposed resource management plan, upper Columbia-Salmon Clearwater Districts, Custer and Lemhi Counties, Idaho: U.S. Bureau of Land Management, Report no. 980508.
- U.S. Bureau of Land Management, 1988, Cody resource area resource management plan, Big Horn and Park Counties, Wyoming: U.S. Bureau of Land Management, Report no. 880315.
- U.S. Bureau of Land Management, 1988, Fort Greely national maneuver area and Fort Greely air drop zone, Alaska—resource management plan: U.S. Bureau of Land Management, Report no. 880276, 138 p.
- U.S. Bureau of Land Management, 1988, Fort Wainwright maneuver area, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 880277, 138 p.
- U.S. Bureau of Land Management, 1988, Pony Express resource management plan, Toole, Utah, and Salt Lake Counties, Utah: U.S. Bureau of Land Management, Report no. 880310, 147 p.

- U.S. Bureau of Land Management, 1988, Proposed Las Vegas resource management plan and final environmental impact statement, Clark and Nye Counties, Nevada: U.S. Bureau of Land Management, Report no. 980207.
- U.S. Bureau of Land Management, 1988, Uncompahgre Basin resource management plan, Colorado: U.S. Bureau of Land Management, Report no. 880345.
- U.S. Bureau of Land Management, 1988, Wilderness study areas in the Rock Springs District, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming (revised Draft environmental impact statement): U.S. Bureau of Land Management, Report no. 880359, 175 p.
- U.S. Bureau of Land Management, 1989, Arcata resource management plan, California: U.S. Bureau of Land Management, Report no. 890306, 354 p.
- U.S. Bureau of Land Management, 1989, Dixie resource area management plan, Washington County, Utah: U.S. Bureau of Land Management, Report no. 890290, 250 p.
- U.S. Bureau of Land Management, 1989, San Pedro River riparian management plan for the San Pedro River EIS area, Cochise County, Arizona: U.S. Bureau of Land Management, Report no. 890152, 381 p.
- U.S. Bureau of Land Management, 1989, San Rafael resource management plan, Emery County, Utah: U.S. Bureau of Land Management, Report no. 890240.
- U.S. Bureau of Land Management, 1989, Utility corridor proposed resource management plan, Alaska: U.S. Bureau of Land Management, Report no. 890326, 281 p.
- U.S. Bureau of Land Management, 1989, White Sands resource management plan amendment for McGregor Range, Otero County, New Mexico: U.S. Bureau of Land Management, Report no. 890127.
- U.S. Bureau of Land Management, 1990, Bishop resource management plan and environmental impact statement: U.S. Bureau of Land Management, Report no. BLMCAES900011610, 273 p.
- U.S. Bureau of Land Management, 1990, Rock Springs District wilderness study areas, Fremont, Lincoln, Sublette, and Sweetwater Counties, Wyoming: U.S. Bureau of Land Management, Report no. 900439, 324 p.
- U.S. Bureau of Land Management, 1991, Arizona Strip District resource management plan, Mohave and Coconino Counties, Arizona: U.S. Bureau of Land Management, Report no. 910055, 617 p.

- U.S. Bureau of Land Management, 1991, Safford District resource management plan, Arizona: U.S. Bureau of Land Management, Report no. 910314, 511 p.
- U.S. Bureau of Land Management, 1991, Spokane resource management plan, Washington: U.S. Bureau of Land Management, Report no. 910374, 169 p.
- U.S. Bureau of Land Management, 1991, Three Rivers resource management plan, Harney, Grant, Lake, and Malheur Counties, Oregon: U.S. Bureau of Land Management, Report no. 910335.
- U.S. Bureau of Land Management, 1992, Proposed Spokane resource management plan amendment and final environmental impact statement: U.S. Bureau of Land Management, Report no. 920286, 181 p.
- U.S. Bureau of Land Management, 1994, Fort Wainwright, Yukon maneuver area, proposed resource management plan and final environmental impact statement, Fairbanks North Star Borough, Alaska: U.S. Bureau of Land Management, Report no. 940001, 124 p.
- U.S. Bureau of Land Management, 1994, resource management plan and environmental impact statement for the Grass Creek resource area, Worland District, Wyoming: U.S. Bureau of Land Management, Technical Report, 299 p.
- U.S. Bureau of Land Management, 1994, Salem District resource management plan and environmental impact statement—Benton, Clackamas, Clatsop, Columbia, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties, Oregon: U.S. Bureau of Land Management, Report no. 940461.
- U.S. Bureau of Land Management, 1994, Stateline resource management plan, Clark and Nye Counties, Nevada (draft environmental impact statement and draft supplement): U.S. Bureau of Land Management, Report no. 940177.
- U.S. Bureau of Land Management, 1997, Roswell and Carlsbad resource areas—Chaves, Curry, Debaca, Eddy, Guadalupe, Lea, Lincoln, Quay, and Roosevelt Counties, New Mexico: U.S. Bureau of Land Management, Report no. 970072.
- U.S. Bureau of Land Management, 1998, Judith-Valley-Phillips resource management plan—Chouteau, Fergus, Judith Basin, Petroleum, Phillips, and Valley Counties, Montana (draft supplement to the final environmental impact statement of September 1997): U.S. Bureau of Land Management, Report no. 980149, 51 p.
- U.S. Bureau of Land Management, 1998, Socorro resource area resource management plan, New Mexico: U.S. Bureau of Land Management, Report no. 880397, 266 p.
- U.S. Bureau of Land Management, 2000, Federal fluid minerals leasing and development, Otero and Sierra Counties, New Mexico: U.S. Bureau of Land Management, Report no. 000383, 521 p.

- U.S. Bureau of Land Management, 2003, Farmington resource management plan, San Juan, McKinley, Rio Arriba, and Sandoval Counties, New Mexico: U.S. Bureau of Land Management, Report no. 030143.
- U.S. Bureau of Land Management, 2004, Dillon resource management plan, Beaverhead and Madison Counties, Montana: U.S. Bureau of Land Management, Report no. 040153, 626 p.
- U.S. Bureau of Land Management, 2005, Newmont Mining Company, Emigrant project, Elko County, Nevada: U.S. Bureau of Land Management, Report no. 050117, 269 p.
- U.S. Bureau of Land Management, 2006, Coeur d'Alene resource management plan, Idaho: U.S. Bureau of Land Management, Report no. 060002, 347 p.
- U.S. Bureau of Land Management and U.S. Forest Service, 1986, Proposed Coronado National Forest land and resource management plan, Arizona and New Mexico: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 860307.
- U.S. Bureau of Land Management and U.S. Forest Service, 2004, North Fork of the South Platte and the South Platte Rivers wild and scenic river study report, Pike and San Isabel National Forests and Comanche and Cimarron National Grasslands, Douglas, Jefferson, Park, and Teller Counties, Colorado: U.S. Bureau of Land Management and U.S. Forest Service, Report no. 040037, 301 p.
- U.S. Bureau of Reclamation, 2001, Pothole Reservoir resource management plan, Grant County, Washington: U.S. Bureau of Reclamation, Report no. 010518, 567 p.
- U.S. Department of the Air Force, 1992, Defense evaluation support activity testing and evaluation program, Kirtland Air Force Base, New Mexico: U.S. Air Force, Report no. 920325, 487 p.
- U.S. Federal Highway Administration, 2005, US 33 Nelsonville bypass, city of Nelsonville, Hocking and Athens Counties, Ohio: U.S. Federal Highway Administration, Report no. 050282, 828 p.
- U.S. Fish and Wildlife Service, 1985, Alaska Peninsula National Wildlife Refuge final comprehensive conservation plan, environmental impact statement, and wilderness review: U.S. Fish and Wildlife Service, Technical Report, 426 p.
- U.S. Fish and Wildlife Service, 1986, Great Dismal Swamp National Wildlife Refuge master plan, Virginia and North Carolina: U.S. Fish and Wildlife Service, Report no. 860501, 245 p.
- U.S. Forest Service, 1973, Management of South Holston unit: U.S. Forest Service, Report no. USDAFSFESADM7350, 121 p.

- U.S. Forest Service, 1985, Kisatchie National Forest land and resource management plan, Louisiana: U.S. Forest Service, Report no. 850414.
- U.S. Forest Service, 1985, Proposed Land and resource management plan for the Medicine Bow National Forest and Thunder Basin National Grassland, Wyoming: U.S. Forest Service, Report no. 850523.
- U.S. Forest Service, 1986, Chequamegon National Forest, Wisconsin land and resource management plan: U.S. Forest Service, Report no. 860325.
- U.S. Forest Service, 1986, Cleveland National Forest land and resource management plan, Orange, Riverside, and San Diego Counties, California: U.S. Forest Service, Report no. 860209.
- U.S. Forest Service, 1986, Croatan and Uwharrie National Forests land and resource management plan, North Carolina: U.S. Forest Service, Report no. 860218.
- U.S. Forest Service, 1986, Environmental impact statement for the Coronado National Forest plan: U.S. Forest Service, Technical Report, 275 p.
- U.S. Forest Service, 1986, Environmental impact statement, Gila National Forest plan: U.S. Forest Service, Technical Report, 347 p.
- U.S. Forest Service, 1986, Land and resource management plan, Chippewa National Forest, Beltrami, Cass, and Itasca Counties, Minnesota: U.S. Forest Service, Report no. 860208.
- U.S. Forest Service, 1986, National Forests in Alabama land and resource management plan: U.S. Forest Service, Report no. 860095.
- U.S. Forest Service, 1986, Proposed land and resource management plan for Wayne National Forest, Ohio: U.S. Forest Service, Report no. 860426.
- U.S. Forest Service, 1986, Proposed Santa Fe National Forest land and resource management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 860013.
- U.S. Forest Service, 1987, Environmental impact statement for the Apache-Sitgreaves National Forests Plan: U.S. Forest Service, Technical Report, 392 p.
- U.S. Forest Service, 1987, Environmental impact statement, Santa Fe National Forest plan: U.S. Forest Service, Technical Report, 366 p.
- U.S. Forest Service, 1987, Proposed Apache-Sitgreaves National Forests land and resource management plan, Apache, Coconino, Greenlee, and Navajo Counties, Arizona: U.S. Forest Service, Report no. 870387.

- U.S. Forest Service, 1987, Proposed land and resource management plan for the Coconino Forest, Coconino, Gila, and Yavapai Counties, Arizona: U.S. Forest Service, Report no. 870288.
- U.S. Forest Service, 1987, Santa Fe National Forest land management plan, Mora, San Miguel, Santa Fe, Sandoval, Los Alamos, and Rio Arriba Counties, New Mexico: U.S. Forest Service, Report no. 870299.
- U.S. Forest Service, 1988, Proposed Kaibab National Forest land and resource management plan, Coconino, Yavapai, and Mohave Counties, Arizona: U.S. Forest Service, Report no. 880109.
- U.S. Forest Service, 1988, Record of decision for USDA, Forest Service—Final environmental impact statement, Allegheny National Forest, Land and resource management plan—Elk, Forest, McKean, and Warren Counties, Pennsylvania: U.S. Forest Service, Technical Report, 41 p.
- U.S. Forest Service, 1989, San Bernardino National Forest land and resource management plan, San Bernardino and Riverside Counties, California: U.S. Forest Service, Report no. 890023.
- U.S. Forest Service, 1990, Cherokee National Forest land and resource management plan, Tennessee, North Carolina, and Virginia (final supplement to the final environmental impact statement of April 1986): U.S. Forest Service, Report no. 900062, 62 p.
- U.S. Forest Service, 1990, Umatilla National Forest land and resource management plan, Oregon and Washington: U.S. Forest Service, Report no. 900237.
- U.S. Forest Service, 1991, Corral Mountain timber sale, San Juan National Forest, Archuleta County, Colorado: U.S. Forest Service, Report no. 910124, 59 p.
- U.S. Forest Service, 1992, Martinez Creek timber sale, San Juan National Forest, Colorado: U.S. Forest Service, Report no. 920275, 75 p.
- U.S. Forest Service, 1992, Sierra National Forest land and resource management plan, Fresno, Madera, and Mariposa Counties, California: U.S. Forest Service, Report no. 920105.
- U.S. Forest Service, 1993, Six Rivers National Forest plan, Humboldt, Del Norte, Siskiyou, and Trinity Counties, California: U.S. Forest Service, Report no. 930340.
- U.S. Forest Service, 1994, Oregon Dunes National Recreation Area management plan, Siuslaw National Forest—Coos, Douglas, and Lane Counties, Oregon: U.S. Forest Service, Report no. 940292.
- U.S. Forest Service, 1994, Revised land and resource management plan for the national forests and grasslands in Texas—Angelina, Fannin, Houston, Jasper, Montague, Montgomery, Nacogdoches, Newton, Sabine, San Augustine, San Jacinto, Shelby, Trinity, Walker, and Wise Counties, Texas: U.S. Forest Service, Report no. 940385.

- U.S. Forest Service, 1995, Draft environmental impact statement, Fish Bate analysis area—North Fork Ranger District, Clearwater National Forest, Clearwater County, Idaho: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 1995, East Fork Blacks Fork analysis area, Wasatch-Cache National Forest, Summit County, Utah (final supplement to the final environmental impact statement of July 1992): U.S. Forest Service, Report no. 950294, 49 p.
- U.S. Forest Service, 1995, Mendocino National Forest land and resource management plan—Colusa, Glenn, Lake, Mendocino, Tehama, and Trinity Counties, California: U.S. Forest Service, Report no. 950337.
- U.S. Forest Service, 1996, Proposed revised land and resource management plan for Francis Marion National Forest, Berkeley and Charleston Counties, South Carolina: U.S. Forest Service, Report no. 960158.
- U.S. Forest Service, 2000, Silver Creek integrated resource project, Emmett Ranger District, Boise National Forest, Boise and Valley Counties, Idaho: U.S. Forest Service, Report no. 000241, 264 p.
- U.S. Forest Service, 2002, Sixshooter project, Emmett Ranger District, Boise National Forest, Gem County, Idaho: U.S. Forest Service, Report no. 020238, 201 p.
- U.S. Forest Service, 2002, Uncompahgre National Forest Travel Plan Revision, Gunnison, Hinsdale, Mesa, Montrose, Ouray, San Juan, and San Miguel Counties, Colorado (final supplement to the final environmental impact statement of April 2000): U.S. Forest Service, Report no. 020131, 92 p.
- U.S. Forest Service, 2002, Whiskey Campo Resource Management Project, Mountain Home Ranger District, Boise National Forest, Elmore County, Idaho: U.S. Forest Service, Report no. 020299, 151 p.
- U.S. Forest Service, 2003, Big Bend Ridge vegetation management project and timber sale, Ashton/Island Park Ranger District, Caribou-Targhee National Forest, Freemont County, Idaho: U.S. Forest Service, Report no. 030225.
- U.S. Forest Service, 2003, Cross-country travel by off-highway vehicles, Apache-Sitgreaves, Coconino, Kaibab, Prescott, and Tonto National Forests, Arizona: U.S. Forest Service, Report no. 030184, 235 p.
- U.S. Forest Service, 2003, Duck Creek—Swains access management project, Cedar City Ranger District, Dixie National Forest, Iron, Garfield, and Kane Counties, Utah: U.S. Forest Service, Report no. 030343, 49 p.

- U.S. Forest Service, 2004, Duck Creek fuels treatment analysis, Cedar City Ranger District, Dixie National Forest, Kane County, Utah: U.S. Forest Service, Report no. 040535, 240 p.
- U.S. Forest Service, 2004, French Face ecosystem restoration, Ninemile Ranger District, Lolo National Forest, Montana: U.S. Forest Service, Report no. 040336, 184 p.
- U.S. Forest Service, 2005, Dean project area, Bearlodge Ranger District, Black Hills National Forest, Crook County, Wyoming: U.S. Forest Service, Report no. 050212, 192 p.
- U.S. Forest Service, 2005, Final environmental impact statement for the access designation on the Ocala National Forest, Lake, Marion, and Putnam Counties, Florida: U.S. Forest Service, Technical Report.
- U.S. Forest Service, 2005, Gallatin National Forest travel management plan, Gallatin, Madison, Park, Meagher, Sweetgrass, and Carbon Counties, Montana: U.S. Forest Service, Report no. 050231.
- U.S. Forest Service, 2005, Rocky Mountain Ranger District travel management plan, Rocky Mountain Ranger District, Lewis and Clark National Forest, Glacier, Pondera, Teton, and Lewis and Clark Counties, Montana: U.S. Forest Service, Report no. 050236, 386 p.
- U.S. Forest Service, 2005, Woodrock project, Tongue Ranger District, Bighorn National Forest, Sheridan County, Wyoming: U.S. Forest Service, Report no. 050112, 201 p.
- U.S. Forest Service, 2006, Hoosier National Forest land and resource management plan—Final environmental impact statement: U.S. Forest Service, Technical Report.
- U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, 1997, George Washington National Forest land and resource management plan, Virginia and West Virginia (final supplement to the final environmental impact statement of January 1993): U.S. Forest Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, Report no. 970046.
- U.S. National Park Service, 1998, Redwood National and State Parks general management plan, Del Norte and Humboldt Counties, California: U.S. National Park Service, Report no. 980290, 474 p.
- U.S. National Park Service, 1999, Big Cypress National Preserve, recreational off-road vehicle management plan—Collier, Miami-Dade, and Monroe Counties, Florida (draft supplement to the environmental impact statement of October 1991): U.S. National Park Service, Report no. 990285, 171 p.
- U.S. National Park Service, 2000, Recreational off-road vehicle management plan, Big Cypress National Preserve—Collier, Miami-Dade, and Monroe Counties, Florida (final supplement to the final environmental impact statement of October 1991): U.S. National Park Service, Report no. 000275, 619 p.

- Vancini, F.W., 1989, Policy and management considerations for off-road vehicles—Environmental and social impacts: Ithaca, New York, Cornell University, 19 p.
- Watson, A., Asp, C., Walsh, J. and Kulla, A., 1997, The contribution of research to managing conflict among national forest users: *Trends*, v. 34, no. 3, p. 29–35.
- Webb, R.H., and Wilshire, H.G., 1983, Environmental effects of off-road vehicles—Impacts and management in arid regions: New York, Springer-Verlag, 534 p.
- Weeden, R., 1976, On consumptive users—A myth: *Alaska Conservation Review*, v. 17, no. 3, p. 15.
- Wilshire, H.G., Nakata, J.K., Shipley, Susan, and Prestegaard, Karen, 1978, Impacts of vehicles on natural terrain at seven sites in the San Francisco Bay area: *Environmental Geology*, v. 2, no. 5, p. 295–319.
- Wilshire, H.G., Shipley, Susan, and Nakata, J.K., 1978, Impacts of off-road vehicles on vegetation: *Transactions of the North American Wildlife and Natural Resources Conference*, v. 43, p. 131–139.
- Wolcott, T.G., and Wolcott, D.L., 1984, Impact of off-road vehicles on macroinvertebrates of a mid-Atlantic beach: *Biological Conservation*, v. 29, no. 3, p. 217–240.

Appendix 2. Search Methods and Results of Off-Highway Vehicle Effects Literature and Internet Resources

2.1 Methods

2.1.1 Literature Search

From May 10–26, 2006, a comprehensive literature search was conducted to encapsulate the current knowledge on effects of off-highway vehicle (OHV) activities as it pertains to natural resource attributes addressed by the Bureau of Land Management's (BLM) land health standards (U.S. Bureau of Land Management, 2001; Pellant and others, 2005). The search was conducted through 33 electronic literature databases available at Colorado State University's (CSU) library (table 2.1) and search engines available on the Internet. The databases searched encompassed all major, and some minor, sources of relevant literature, including professional, peer-reviewed journal papers and technical reports/articles published in magazines representing the industrial sector and non-governmental conservation organizations.

Search terms used included "OHV," "off-highway vehicle," "ORV," or "off-road vehicle" combined with terms representing the BLM's land health standards, including soil health and watershed condition, nutrient cycling, wildlife health and habitat quality for native plants and animals (especially for species of special status), water quality, and air quality (table 2.1). In addition, searches were conducted on the socioeconomics of OHV use. Within each database searched, all search terms were applied to the 26 topic areas (see footnote 1 associated with table 2.1) listed in CSU's library database subject list. Relevant citations also were gleaned from highly relevant reports and journal articles. All relevant citations identified were grouped by land-health categories to build extensive bibliographies for each land-health category. If a given citation was relevant to more than one land-health category, it was listed in each of the related bibliographies.

2.1.2 Internet Search

Specific goals of the Internet search were to (1) identify websites and other Internet resources provided by the BLM and U.S. Forest Service (FS) regions 2 (time constraints limited this search to Colorado), 3, and 4; (2) classify OHV-related Internet websites by focus/intent and resource type; and (3) report on highly relevant websites. Two primary products were subsequently developed: (1) a thesaurus (table 2.2) of search topics and terms related to OHV effects, and (2) a list of significant BLM and FS resources and corresponding Internet websites. The thesaurus was developed to identify Internet-based resources regarding OHVs and the types of OHV effects. All possible combinations of search terms were used, but any one search string depended on the search engine used. Although *FirstGov* is a good search engine for finding government publications and reports, it limits search results to 100. In contrast, *Google* returns up to 1000 results, and its filter may be used to constrain searches to a specific type of website (for example, ".gov"); however, *Google* is unable to employ multiple exclusion criteria to exclude irrelevant websites (for example, it cannot specify "NOT FS" and NOT BLM") whereas *FirstGov* does handle multiple exclusion criteria. In other words, *Google* was searched with an OHV term combined with an impact term while limiting any one search to "BLM," "EPA" (U.S. Environmental Protection Agency), "FS" (U.S. Forest Service), "NPS" (U.S. National Park Service), or "USGS" (U.S. Geological Survey) sites. Then *FirstGov* was searched with the same

Table 2.1. Search terms used and publication years included when using search engines and 33 electronic literature databases at Colorado State University’s library to assemble an extensive bibliography of literature on effects of off-highway vehicles.

Database searched (for publications years) ¹	Search term										
	Air quality	Benefits	Domestic livestock grazing	Erosion	Noise	Soil impacts	Travel and transportation management	Visual impacts	Vegetation impacts	Water quality	Wildlife impacts
AGRICOLA EBSCO (1970-2006)	X		X	X		X			X	X	X
AGRICOLA National Agricultural Library (1970-2006)	X		X	X		X			X	X	X
Agricultural and Environmental Biotechnology Abstracts (1993-2006)	X			X	X	X	X		X	X	X
Agricultural Sciences (in Cambridge Scientific Abstracts) (compilation of multiple databases ²)	X		X	X		X			X	X	X
Animal Behavior Abstracts (1982-2006)		X	X		X						X
Applied Science and Technology Abstracts (1983-2006)	X			X	X	X	X	X		X	
ASFA 1: Biological Sciences and Living Resources (1971-2006)					X				X		X

Database searched (for publications years) ¹	Search term										
	Air quality	Benefits	Domestic livestock grazing	Erosion	Noise	Soil impacts	Travel and transportation management	Visual impacts	Vegetation impacts	Water quality	Wildlife impacts
ASFA 2: Ocean Technology, Policy & Non-Living Resources (1971-2006)	X			X		X	X	X			
ASFA 3: Aquatic Pollution and Environmental Quality (1990-2006)	X			X	X	X	X	X		X	
BioEngineering Abstracts (1993-2006)				X		X	X				
Biological Abstracts (1969-2006)			X						X		X
Biological Sciences (1982-2006)			X						X		X
Biological Sciences (in Cambridge Scientific Abstracts) (compilation of multiple databases ²)			X						X		X
Biology Digest (1989- 2006)									X		X
Biotechnology and Bioengineering Abstracts (1982-2006)				X		X	X				
CAB Abstracts Archive (1900-1973)											X
Ecology Abstracts (1969-2006)		X	X						X	X	X

Database searched (for publications years) ¹	Search term										
	Air quality	Benefits	Domestic livestock grazing	Erosion	Noise	Soil impacts	Travel and transportation management	Visual impacts	Vegetation impacts	Water quality	Wildlife impacts
EIS: Digests of environmental impact statements (1985- 2006)							X				
Engineering Index (1884-2006)				X		X	X				
Environmental Engineering Abstracts (1990-2006)				X		X	X				
Environmental Sciences & Pollution Management (compilation of multiple databases ²)	X			X	X	X	X				
Forest Service database (dates not indicated)			X	X		X	X		X	X	X
Geobase (1980-2006)				X		X					
Human Population & Natural Resource Management (1995- 2006)			X				X				
Plant Management Network (compilation of multiple databases ²)									X		
Plant Science (1994- 2006)									X		
Pollution Abstracts (1981-2006)	X				X		X				

Database searched (for publications years) ¹	Search term										
	Air quality	Benefits	Domestic livestock grazing	Erosion	Noise	Soil impacts	Travel and transportation management	Visual impacts	Vegetation impacts	Water quality	Wildlife impacts
Pollution Management & Environmental Sciences (in Cambridge Scientific Abstracts) (compilation of multiple databases ²)	X				X		X				
Threatened and Endangered Species System (dates not indicated)									X	X	X
Toxicology Abstracts (1981-2006)	X					X					
Water Resources Abstracts (1967-2006)										X	
Wildlife & Ecology Studies Worldwide (1935-2006)											X
Zoological Record (1978-2006)											X

¹Topic areas searched in databases included biology, botany, civil engineering, construction management, earth resources, ecology, engineering, environment, environmental health, fishery, fisheries, forestry, forest science, geology, hydrology, life sciences, natural resource recreation, tourism, natural sciences, physical sciences, plant science, plant pathology, rangeland ecosystem science, soil and crop sciences, toxicology, water resources, weed science, wildlife, wildlife biology, zoology.

²Dates vary by database.

Table 2.2. Search topics and their associated search terms used in searching the Internet for publications and documents pertaining to off-highway vehicle effects and policies.

Search topic	Search term(s)
Off-highway vehicle	OHV Off-road vehicle Off-road vehicles
Air quality	Air quality
Benefits	Benefits
Domestic livestock grazing	Domestic livestock grazing
Erosion	Erosion
Human dimension	Human dimension Human dimensions
Noise	Noise
Soil impact	Soil impact Soil impacts
Transportation management	Transportation management
Travel	Travel
Vegetation impact	Vegetation impact Vegetation impacts
Visual impact	Visual impact Visual impacts
Water quality	Water quality
Wildlife impact	Wildlife impact Wildlife impacts

terms while excluding “BLM,” “EPA,” “FS,” “NPS,” “USGS,” and “.com” domains, which captured websites representing individual States, military agencies, and other non-commercial entities.

After the Internet searches were conducted, each website identified were reviewed (limited to 2 minutes per website) and assigned a relevance-class code (relevance to OHV effects and policies; table 2.3). Websites classified as H (highly relevant), R (relevant), or S (slightly relevant) were further categorized by focus area (table 2.4). All BLM and FS regions 2 (Colorado only), 3, and 4 websites were included in the results tallies; websites containing news releases, specific flora assessments, and BLM Resource Advisory Council meetings were omitted. Highly relevant websites were selected for presentation.

2.2 Results

2.2.1 Literature Resources

The literature search, and additional sources uncovered outside of the formal search, yielded approximately 700 citations, a number of which overlap in terms of their relevance to categories of land health (table 2.5).

Table 2.3. Relevance class codes and definitions pertaining to Internet websites found to contain information regarding off-highway vehicle effects and policies.

Relevance class	Definition
H	Highly relevant—high-quality resources related directly to OHV impacts; generally included number of OHV trail miles and visitor days, or reasons why OHVs excluded from specific locations; includes OHV strategy/plan documents or public communication sites on OHV recreation areas
R	Relevant—targeted mention of OHV but not as specific or detailed as a highly relevant site
S	Slightly relevant—mention of OHV but with few supporting statements or details
U	Unrelated—no or minimal OHV content
Z	Unable to access, page would not load, URL has changed, page loads but is empty of content
ZDup	Content duplicate of previous entry

Table 2.4. Focus areas and definitions of Internet websites found to contain information regarding off-highway vehicle effects and policies.

Focus area	Definition
Administration	Information sourced from the Federal level
Citizen input	Site contains or informs about public comments on OHV use
EIS	Site contains a draft or final environmental impact statement (EIS) or environmental assessment (EA)—attempt was to keep this category to sites related to actions up through completion of a management plan although there is some overlap with the next category due to title ambiguity
Impact	Site focus was measurement of impact
Legal	Response to appeals regarding travel management plans or EIS documents
Manual	Site containing a handbook or manual
Management plan	Sites with completed management plans or actions stemming from implementation of a management plan; includes monitoring, revision of plans, assessment for roadless areas, and road analyses
Monitoring	Usually annual reports of monitoring activity prescribed by a management plan
Press	Site with information in the form of a press release or media announcement
Road guide	Sites intended to provide public information about OHV and recreation site use; includes descriptions, trail maps, event calendars, safety, licensing and regulation, and closure information

Table 2.5. Number of relevant publications found, and publication dates included, in a literature search on effects of off-highway vehicle activity as they pertain to the U.S. Bureau of Land Management's land health standards.

Land health category	No. citations	Years included
Soils	314	1959-2006
Air quality	104	1970-2006
Water quality	218	1959-2005
Vegetation	326	1962-2006
Wildlife	387	1970-2006
Land users	211	1967-2006

2.2.2 Internet Resources

The Internet search yielded nearly 30,000 State and Federal government websites, of which 8,693 were unique (a single HTML page or .pdf file); 23 percent ($n = 1,998$) were BLM websites, 55 percent ($n = 4,817$) were FS websites, and 7 percent ($n = 568$) were NPS websites (table 2.6). FS regions 2 (Colorado only), 3, and 4 together represented 12 percent of the websites. Of the 8,693 unique sites, 2,495 were visited and reviewed (29 percent) using the methods described above. All search term combinations returned at least 100 results, and some returned as many as 3,700 (table 2.6).

Of the unique websites identified, only 13% ($n = 335$) were classified as highly relevant; 15 percent were relevant, 22 percent were slightly relevant, and 50 percent were unrelated/not available (figure 2.1). Forty-seven percent of those classified as highly relevant were BLM sites, and 53 percent were FS sites. The majority of highly relevant sites (68 percent) were dedicated to environmental impact statements (EIS) or management plans (figure 2.2). Only two percent of the highly relevant sites focused on measuring or monitoring the effects of OHV activities. When all sites were considered, a slightly higher percentage of sites (approximately 5 percent) included monitoring or impact assessment (figure 2.3).

Key similarities between highly relevant BLM and FS websites (figures 2.4 and 2.5) included equal emphasis on road guides (about 12 percent of sites) and little emphasis on monitoring and impacts (0 and 1 percent for BLM, respectively; 1 and 1 percent for FS, respectively). The BLM sites had slightly greater emphasis on EISs and management plans (73 percent) than did FS sites (65 percent). Interestingly, 10 percent of the FS sites concerned legal issues—primarily appeals to decisions—whereas no material of this type was found on BLM websites. This may be due to an agency decision of what type of material is posted to the Internet or it may be a result of a difference in EIS/management plan implementation status between the two agencies. Table 2.8 presents examples of five highly ranked web sites (if available) from BLM and/or FS Region 2 for each of the focus areas.

Table 2.6. Search results, by topic, for all Internet websites pertaining to off-highway vehicle effects and policies (n = 22,990).

Search topic	Results
Air quality	3,040
Benefits	3,081
Domestic livestock grazing	373
Erosion	3,228
Human dimension(s)	241
Noise	2,650
Soil impact(s)	461
Transportation management	453
Travel	3,726
Vegetation impact(s)	155
Visual impact(s)	1,392

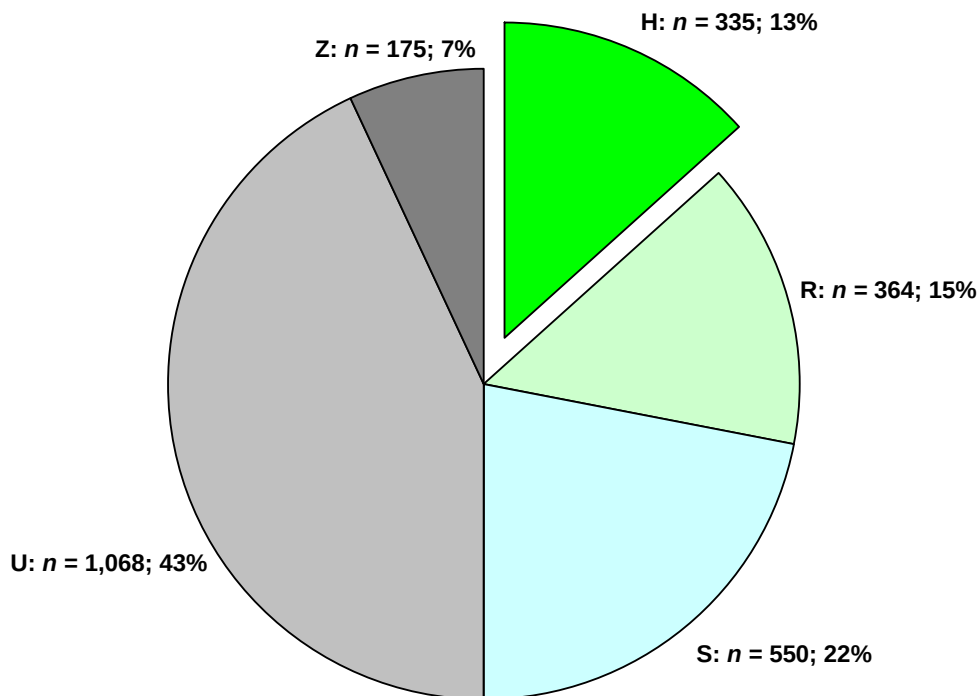


Figure 2.1. Breakdown of unique Internet websites (n = 2,495) classified as “highly relevant” (H), “relevant” (R), “slightly relevant” (S), and “unrelated/unavailable” (U, Z) to off-highway vehicle effects and policies.

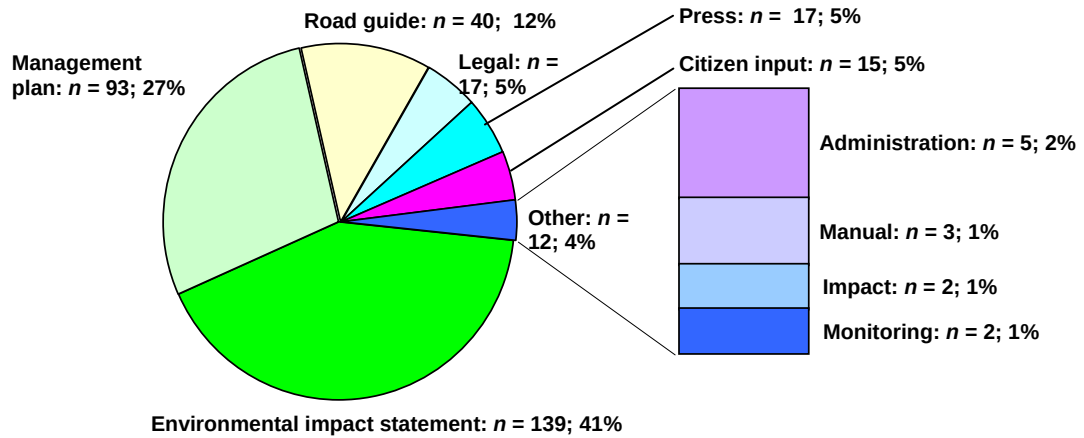


Figure 2.2. Focus areas of Internet websites (n = 333) classified as highly relevant to off-highway vehicle effects and policies.

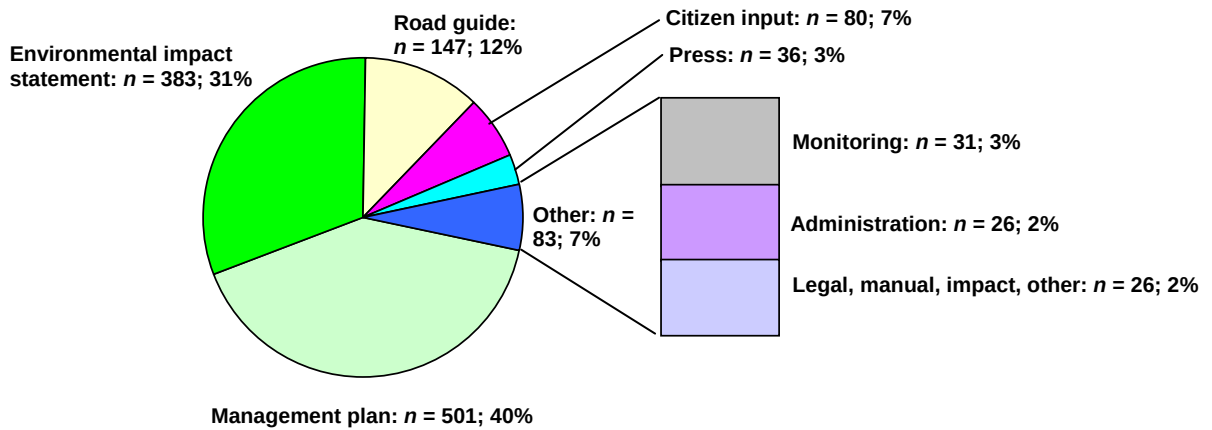


Figure 2.3. Focus areas for all Internet websites (n = 1,230) classified as highly relevant, relevant, and somewhat relevant to off-highway vehicle effects and policies.

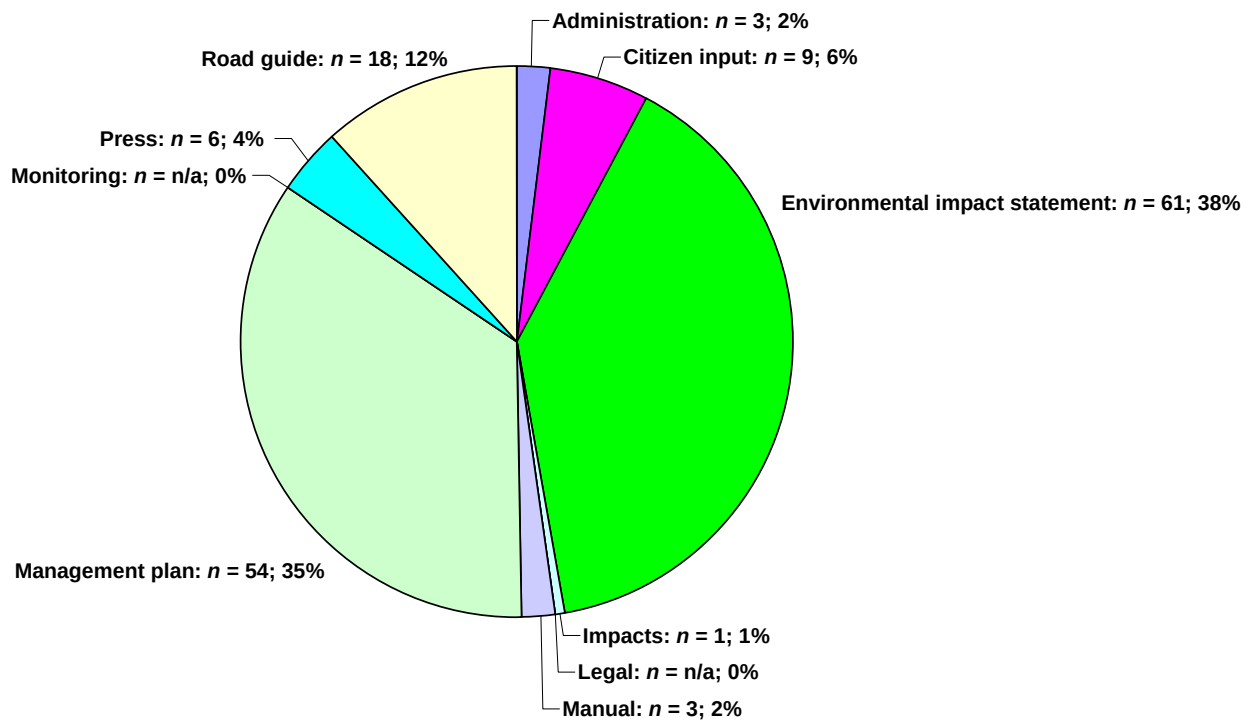


Figure 2.4. Focus areas of U.S. Bureau of Land Management Internet websites (n = 155) classified as highly relevant, relevant to off-highway vehicle effects and policies.

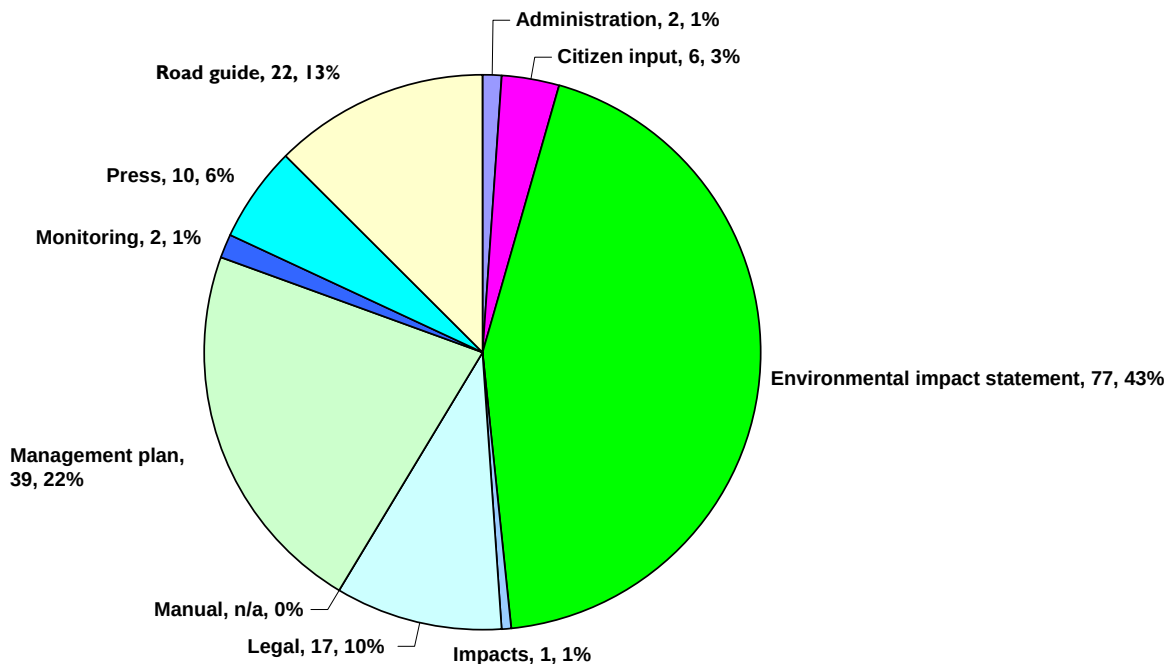


Figure 2.5. Focus areas of U.S. Forest Service (regions 2 [Colorado only], 3, and 4 only) Internet websites (n = 176) classified as highly relevant to off-highway vehicle effects and policies.

The large percentage of highly relevant websites assigned to the EIS and management plan categories indicate that OHV impact is an important topic to both the BLM and FS. The relatively small number of agency sites that address assessment or monitoring of OHV effects suggests that assessment or monitoring of OHV effects may be important topics for future website development. EISs and management plans do not focus on providing quantitative measures for determining the suitability of OHV trails (aside from the problem of trail redundancy for a given area); a trail-management plan of “fewer but better” seemed to be the approach in most plans, although a few plans specified that areas with a high degree of slope are unsuitable for trails. Almost no plans addressed OHV-related dust or noise problems, although some addressed areas of significant erosion by moving trails.

Overall, there appear to be more FS than BLM websites dealing with OHV management and related issues, including monitoring and the legal response to approved plans. Although road management plans are being developed for many land units by both the BLM and FS, only a few of these plans include OHV travel as an aspect of road management. The BLM, however, has produced a nation-wide OHV strategy, and Montana, Wyoming, and Idaho also have prepared state OHV management strategies. In general, policy appears to be taking the form of management plan implementation (such as closing areas due to muddy conditions or fire risk rather than making specific policy statements).

Table 2.7. Internet websites classified as highly relevant, by focus area and source, pertaining to off-highway vehicle effects and policies.

Focus/ source¹	Title and URL
Administration	
BLM	BLM National Management Strategy for Motorized Off-Highway Vehicle Use http://www.fs.fed.us/recreation/programs/ohv/blm_strategies.pdf
FS-R2	Recreation, Wilderness, and Related Resource Management WO Amendment 2300-94-3 http://www.fs.fed.us/cdt/admin.htm
Environmental impact statement	
BLM	Environmental Assessment EA No.: AZ-020-04-0115 for the Arizona Association of Four-Wheel Drive Clubs 2004 4x4 Jamboree http://www.blm.gov/ca/publish/etc/medialib/blm/az/pdfs/nepa/library/4wd.Par.7790.File.dat/ASA4WDC-Jamboree-EA.pdf
BLM	Environmental Assessment: DARPA Grand Challenge http://www.blm.gov/ca/pdfs/barstow_pdfs/darpa/chapter_3_affected_environment.pdf
BLM	Final environmental impact statement for the Imperial Sand Dunes Recreation Area Management Plan and Proposed Amendment to the California Desert Conservation Plan 1980 http://www.blm.gov/ca/pdfs/elcentro_pdfs/FinalEISandRAMP/FinalEIS.pdf
BLM	Red Rock 4-Wheelers Jeep Safari and Fall Campout 5-Year Permit Renewal http://www.blm.gov/ut/st/en/info/newsroom/2006/01/blm_renews_jeep_safari.html
FS-R2	Decision Notice and Finding of No Significant Impact for the Clear/Crazy Designated Motorized Trail System, Powder River Ranger District, Bighorn National Forest http://www.fs.fed.us/r2/bighorn/projects/projectfiles/clearcrazy/clear_crazy_fonsi_032005.pdf
FS-R2	Scoping Document for the Hunt Mountain Travel Management Plan, Medicine Wheel/Paintrock Ranger District, Bighorn National Forest http://www.fs.fed.us/r2/bighorn/projects/projectfiles/hunt_mtn_carea/scoping_carea.pdf
FS-R3	Munds Park Roads and Trails Project: Environmental Assessment http://www.fs.fed.us/r3/coconino/nepa/2004/munds-drft-ea-final-9_24_04.pdf

Focus/ source¹	Title and URL
Impact	
BLM	Air Quality Baseline and Analysis Report, Price Field Office, Price, Utah http://www.blm.gov/utah/price/pricerm/documents/Baseline_and_Analysis_Report.pdf
FS-R2	Anthropogenic Influences Used in Conducting Multiple Scale Aquatic, Riparian, and Wetland Ecological Assessments for the USDA Forest Service – Rocky Mountain Region, Report 2 http://www.fs.fed.us/r2/projects/scp/arw/protocols/anthropogenicinfluencesusedinconductingmultiplescale.pdf
Wildlands	Resource website that provides publications on PHV effects, restoration, enforcement, policy, and other related issues and materials http://www.wildlandscpr.org/resources
Legal	
FS-R2	Recommendation Memorandum for Uncompagre Travel Management Plan, July 13, 2000 http://www.fs.fed.us/r2/projects/nepa/appeal-decisions/2000/gmug/uncompahgre_travel_39.htm
FS-R2	Recommendation Memorandum for Gunnison Interim Travel Restrictions, July 13, 2001 http://www.fs.fed.us/r2/projects/nepa/appeal-decisions/2001/gmug/gunntrvl_16.htm
FS-R2	Recommendation Memorandum for Uncompahgre Travel Management Plan, June 18, 2002 http://www.fs.fed.us/r2/projects/nepa/appeal-decisions/2002/gmug/tvl_mgmt_23.htm
FS-R2	Recommendation Memorandum for Uncompahgre Travel Management Plan, June 19, 2002 http://www.fs.fed.us/r2/projects/nepa/appeal-decisions/2002/gmug/tvl_mgmt_24.htm
FS-R2	Recommendation Memorandum for Radial Mountain Travel Management Environmental Assessment, Sept. 13, 2001 http://www.fs.fed.us/r2/projects/nepa/appeal-decisions/2001/mbr/radial_mtn_25.htm
Manual	
BLM	Western Oregon Plan Revisions: Proposed Planning Criteria and State Director Guidance http://www.blm.gov/or/plans/wopr/files/PlanningCriteriaDocument.pdf
BLM	Interpreting Indicators of Rangeland Health http://www.blm.gov/nstc/library/pdf/1734-6rev05.pdf
BLM	Biological Soil Crusts: Ecology and Management http://www.blm.gov/nstc/library/pdf/CrustManual.pdf
Management plan	
FS-R2	U.S. Forest Service, Travel Management: New Rule http://www.fs.fed.us/r2/recreation/travel_mgmt/

Focus/ source¹	Title and URL
FS-R2	Decision Notice & Finding of No Significant Impact, Grand Mesa Travel Management, December 1, 2003, Delta And Mesa Counties, Colorado http://www.fs.fed.us/r2/gmug/policy/gm_travel/fonsi_dec2003.pdf
FS-R2	Roads Analysis Report: Medicine Bow National Forest http://www.fs.fed.us/r2/mbr/projects/roads/adobepdf/medbow/mbnf_rds_analysis_final.pdf
FS-R2	Roads Analysis Report: Routt National Forest http://www.fs.fed.us/r2/mbr/projects/roads/adobepdf/routt/routt_rap_final.pdf
FS-R2	Travel Management Rule, Implementation Safety, Rocky Mountain Region http://www.fs.fed.us/r2/recreation/travel_mgmt/references/Final_TravelMgmtStrategy.pdf
Monitoring	
FS-R2	Forest Plan Monitoring and Evaluation Reports, Arapaho and Roosevelt National Forests and Pawnee National Grassland http://www.fs.fed.us/r2/arnf/projects/forest-planning/monitoring/
OHV road guide	
BLM	Killpecker Sand Dunes Open Play Area, BLM Wyoming Rock Springs Field Office, Wyoming http://www.wy.blm.gov/rsfo/rec/dunes.htm
BLM	Dunes OHV Area, Farmington Field Office, New Mexico http://www.nm.blm.gov/recreation/farmington/dunes_ohv_area.htm
BLM	Lark Canyon, El Centro Field Office, California http://www.ca.blm.gov/elcentro/larkcany.html
FS-R2	OHV, Pike & San Isabel National Forests, Cimarron & Comanche National Grasslands, South Park Ranger District, Colorado http://www.fs.fed.us/r2/psicc/sopa/roads.shtml
FS-R2	Rampart Range Motorized Recreation Area, Pike & San Isabel National Forests, Cimarron & Comanche National Grasslands, South Platte Ranger District, Colorado http://www.fs.fed.us/r2/psicc/spl/spl_ohv.shtml
FS-R2	OHV, Arapaho & Roosevelt National Forests, Sulphur Ranger District, Colorado http://www.fs.fed.us/r2/arnf/recreation/ohv/srd/stillwaterpass-grandlake.shtml

¹ BLM = U.S. Bureau of Land Management; FS = U.S. Forest Service; R = region (Region 2 limited to Colorado)

Off-Highway Vehicle Management On Public Lands

Statement of

Henri Bisson, Deputy Director

Bureau of Land Management

Before the Senate Energy and Natural Resources

Off-Highway Vehicle Management on Public Lands

June 5, 2008

Introduction

Thank you for inviting me to testify regarding motorized recreational use on the public lands. My testimony today will highlight the ongoing efforts within the Bureau of Land Management (BLM) to manage off-highway vehicle (OHV) use and will highlight a 2007 United States Geological Survey (USGS) study synthesizing the literature regarding OHV impacts on the land. The BLM manages public lands to sustain the health, diversity, and productivity for the use and enjoyment of present and future generations.

OHV Use on BLM-Managed Public Lands

The BLM strives to preserve and protect resources for use and enjoyment of future generations while meeting the need for motorized recreational access today. With more than 57 million people living within 25 miles of BLM administered public lands, motorized recreation on these 258 million acres of public land is managed consistent with the multiple-use mandate of the Federal Land Policy and Management Act of 1976 (FLPMA). Wise management of OHVs and balancing the needs of all the users of the public

lands is a continuing challenge.

This challenge has been building over time. What was once the vast and spacious public land of the West that few knew about and fewer actively used for recreational purposes has now become something quite different. Today, with the suburban sprawl of many western cities and the increased pressure for more outdoor recreational opportunities, the BLM has had to adjust its management of these lands to ensure their health for future generations.

Challenges

Some facts and figures help to illustrate the reality of our management challenges: OHV use has been a major recreational activity across the West for the past four decades. The BLM-administered public lands will host 58 million recreation visits from across the country and other nations this year, a number that has nearly doubled in the last 25 years. Many of these visitors will be responsibly riding ATVs or motorcycles. The Motorcycle Industry Council conservatively estimates there are four times more OHVs in the West than there were a decade ago.

The extensive network of roads and trails, now primarily associated with motorized and non-motorized recreation use, has largely been inherited from historical access patterns dating back nearly 200 years. The majority of roads and trails in use today were originally developed for trade, mineral exploration, ranching, forestry and many other purposes.

The combined effect of population increase in the West, unauthorized user-created roads, explosive growth in the use of OHVs, advances in motorized technology, and intense industry marketing have generated increased social conflicts and resource impacts on the public land. The BLM faces many challenges--protecting resources, minimizing user conflicts, safeguarding visitor safety, and providing reasonable and appropriate access.

Over the last decade, increasing recreational demand has led to an increase in legislation, litigation and intense public interest regarding BLM's management of OHV travel. The United States Geological Survey (USGS) and others have conducted considerable research on the impacts from OHV use on western arid and forested lands. Research continues on the impacts of OHV use. A synthesis of available scientific literature related to the effects of OHV use is available as a USGS Open-File Report ([USGS OFR 2007-1353](#), "Environmental Effects of Off-Highway Vehicles on Bureau of Land Management Lands: A Literature Synthesis, Annotated Bibliographies, Extensive Bibliographies, and Internet Resources"). The report was compiled by the USGS with funding from the BLM National Science and Technology Center.

BLM is addressing travel management as part of a comprehensive approach that considers public access needs for all modes of transportation. BLM has sought extensive public participation and input to designate a travel network that is thoughtfully designed and properly managed and makes the best use of resources. Public participation is essential to the BLM planning process and serves to improve communication, develop enhanced understanding of different perspectives, and identify solutions to issues and problems.

Additionally, in order to help address increased use of BLM lands, the 2009 Budget proposes directing approximately \$8 million from field offices experiencing little or no population growth to field offices in or adjacent to expanding communities. Recreation and law enforcement are among the programs in which these funding shifts will occur.

BLM Management and Policy

In 2001, the BLM issued its *National Management Strategy for Motorized OHV Use on Public Lands* to improve our management of this recreation activity. This strategy sets comprehensive direction for planning and managing motorized recreational use in full compliance with Executive

Orders, existing regulations, and policy guidance. Through the planning and travel management process, public lands are designated as “open”, “limited”, or “closed” to OHV use. Open areas are areas where all types of vehicle use are permitted at all times, anywhere in the area. Limited areas are lands where OHV use is restricted at certain times or use is only authorized on designated routes, and closed areas are lands where OHV use is prohibited. This 2001 strategy recognizes motorized recreational use as a legitimate use of public land wherever it is compatible with established resource management objectives.

Building on this strategy, in 2005 the BLM issued a revised “Land Use Planning Handbook,” which included specific guidance for “Comprehensive Travel and Transportation Management.” It ensures that all new land use plans developed by the BLM will address public access, travel management and OHV area designations. These land use plans guide the management of all of the 258 million acres for which the BLM is responsible.

Finally, in December 2007, the BLM sent guidance to its field offices to further clarify travel management decisions in the planning process. Specifically, the guidance affirmed that continued designation of large areas that remain open to unregulated “cross-country travel” is not a practical management strategy. Instead, field offices are directed to focus OHV travel on designated roads and trails. Field offices still can and have designated open areas, where unrestricted OHV play is permissible. Additionally, this guidance addresses route planning, inventory and evaluation, innovative partnerships, user education, mapping, signing, and law enforcement. The guidance will result in establishing rational and well-analyzed travel networks, permitting OHV users with continued opportunity to recreate on public lands.

With the completion of new or updated plans, the amount of land designated as limited has increased and the number of acres of open areas has decreased. For example, in the Ely, Nevada, Resource Management

Plan (RMP) (2008), the number of acres open to cross-country OHV use declined from 9.8 million acres to zero acres under the preferred management alternative. More than a million acres in the District are closed to OHV use. The closed areas consist of congressionally designated wilderness and Wilderness Study Areas, which is in accordance with the Wilderness Act of 1964 and FLPMA. OHV use on the remaining 10.3 million acres in the planning area is limited to designated roads and trails. This particular area also benefits from a congressionally designated trail system for OHV users.

Open areas have been retained in other RMPs where historical OHV play areas have existed for many years and resource conflicts are minimal. Open areas are appropriate for intensive OHV use where there are no compelling resource protection needs or public safety issues to warrant limiting cross-country use. Examples of areas open to motorized recreational use include El Mirage OHV Area in the Mojave Desert of California, 12,000 acres of flat lakebed used for land sailing and OHV riding, and Hackberry Lake OHV Area in New Mexico, offering 55,000 acres of rolling dunes used for OHV play. These open areas are extremely important local and regional destinations for OHV play with minimal impact.

Closures are sometimes necessary to protect and conserve resources or for public safety in a particular area. Closures can be very controversial. The BLM frequently attempts to work with affected or interested parties to reach agreement on options to address a particular challenge before issuing notices of motorized travel restrictions or temporary closures. Most closures remain in effect until conditions change, impact is reduced or a new decision is addressed in a plan.

For example, to protect public health and safety from exposure to asbestos the BLM issued a temporary closure on 31,000 acres of public land within the Clear Creek Management Area in California on May 1, 2008. The temporary closure order was issued simultaneously with the Environmental

Protection Agency's (EPA) release of the final Asbestos Exposure and Human Health Risk Assessment. The findings of the assessment indicate that the asbestos exposures that EPA measured at CCMA are high and that many of the recreation activities authorized by the BLM pose excess lifetime cancer risks above the EPA's acceptable risk. This closure will remain in effect until the signing of a Record of Decision of the Resource Management Plan for the Clear Creek area. The RMP will incorporate the results of the EPA Assessment and analyze alternatives to minimize and reduce the human health risk from exposure to asbestos from visitor use to ensure public health and safety.

As part of the BLM's commitment to implementing its land use plans and protecting resources, the agency deploys 195 law enforcement rangers and 56 special agents across the public lands, about 1 for every 1.2 million acres. High-use recreation areas, such as sand dunes in Southern California, Utah, Idaho and Nevada, continue to be a challenge, especially on long holiday weekends and during major events, and are a primary focus of BLM law enforcement. Imperial Sand Dunes in California typically has more than 150,000 visitors during winter holidays such as Thanksgiving, New Year's and President's Day. Over the New Year's weekend this year, law enforcement issued 630 citations, arrested 25 individuals. Emergency Medical Services responded to 129 calls. The BLM works closely with local law enforcement agencies on patrols, safety, enforcement and emergency medical responses. We greatly benefit from the strong support of many County Sheriffs and State Highway Patrol organizations throughout the West. The use of short-term work details of BLM officers from other states and officers from other agencies, as well as continued support from local law enforcement agencies through assistance agreements, has proven invaluable.

Partnerships

The vast majority of OHV users are responsible riders. They share the

BLM's commitment to the protection of natural and cultural resources and leave no lasting trace on the land. Working with local, state and national OHV groups, we have improved our ability to inform, train and educate the riding public. Partner organizations such as *Tread Lightly!* and *Leave No Trace* have worked to develop and disseminate stewardship education materials and have worked with industry to encourage responsible use marketing and messaging.

Collaboration with our stakeholders and partners continues to be a crucial piece of BLM's OHV management strategy. In Colorado, OHV groups have stepped forward to assist in the education of OHV users by promoting responsible recreation use. The Stay the Trail program, a joint project between the Colorado Off-Highway Vehicle Coalition and Federal agencies, reinforces and highlights responsible OHV use and seeks to reduce irresponsible use, thus minimizing resource damage. In Oregon, partnerships have formed between user groups, local and state governments and Federal agencies to cooperatively manage OHV use by jointly developing and implementing education, enforcement and trail maintenance programs. This has allowed for more effective use of limited resources to reduce irresponsible use, thus minimizing resource damage. In Idaho, BLM partners with the state Fish and Game agency to implement the CARE/SHARE program to build awareness and user ethics regarding public access across private lands or ranching allotments.

I would like to share with you some before-and-after photos of restoration work being done in Southern California with the Student Conservation Association and the BLM. The projects are primarily focused on restoring areas defined by travel management implementation decisions. The emphasis is to protect the habitat of several endangered species, including the desert tortoise, as well as to ensure the viability of the designated travel network. As you can see, the efforts have been a success. By using a variety of techniques, including vertical mulching and re-texturing the ground surface to erase the impacts, these crews are successfully restoring

habitat and rehabilitating degraded trails to prevent erosion.

The BLM is dedicated to improving the health of the land by reducing OHV impacts. Defining a rational network of roads and trails on over 258 million acres of land is an enormously complex task. Over the next decade, the BLM will work with the public to continue mapping the West's public access travel networks. The BLM will continue to prioritize and target resources and funding to develop and implement travel management plans.

Through public land user education, law enforcement, resource monitoring, public-private partnerships, and continued public involvement in the land-use planning process, the BLM will move closer toward this goal.

Thank you again for the opportunity to testify on this significant issue. I would be happy to answer any questions.



BEAVER COUNTY, UTAH RESOURCE MANAGEMENT PLAN

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INTRODUCTION

Plan Process and Methodology

The purpose of this County Resource Management Plan (“CRMP”) is to amend the Beaver County General Plan and to address issues related to public and private lands. It is intended, to the maximum extent allowed by law, to establish criteria, policies, and requirements to be followed in the various state and federal land planning processes and to provide consistency across agency boundaries while preserving and enhancing Beaver County’s custom, culture, resources, and socioeconomic base.

The information used as the basis for this plan was obtained from various state and federal agencies, experts in various natural resources, public participation, and independent research. After this plan was completed and recommended, the Beaver County Planning and Zoning Commission held a public hearing on the proposed plan on May 16, 2017. The Beaver County Planning and Zoning Commission then forwarded the plan to the Beaver County Commissioners. On June 6, 2017, the Beaver County Commissioners held another public hearing and formally adopted the plan by ordinance 2017-03.

County History and Culture

Natural resources in Beaver County have been explored and documented as far back as the Dominguez-Escalante Expedition in the late 18th Century. Archaeological discoveries have chronicled Beaver County’s history going back as far as 10,000 years, showing that Beaver County has been home to a variety of peoples and civilizations who utilized the abundant natural resources to survive. Beaver County’s modern day inhabitants still rely heavily on these same resources in order to sustain a high quality of life. As such, it’s indisputable that Beaver County’s culture and history is directly and inextricably tied to its natural resources.

The earliest settlers of Beaver County came from Parowan in April 1856. The settlers built log cabins along the Beaver River, utilizing the river to help cultivate a successful agricultural system. These settlers brought with them the livestock they relied on for food, labor and transportation. Parley P. Pratt, a Mormon leader, passing through the area six years earlier, wrote: “This is an excellent place for an extensive settlement.” The grassy meadows and sloughs flanking the Beaver River would provide prime grazing and hay for their livestock. The mountains and desert valleys would provide additional grazing forage to support the agriculture-based settlement. By the 1880’s, large numbers of cattle and sheep were being raised in Beaver County, as it became a center for livestock production in southwestern Utah. As the settlement grew, a town was established in the spring of 1858. The town and the river were named for the many beaver dams found here. Agriculture, including high quality grazing lands, still plays a prominent role in Beaver County’s culture and economy. A variety of crops are produced for

local and outside consumption. Although the dairy industry's impact on the local economy is not as great as it has been in the past, the dairy industry is deeply rooted in Beaver County's history and culture and existing dairy operations provide jobs to many of the County's citizens.

In addition to agriculture, mineral explorers discovered lead in Beaver County in 1852. In 1858, recovery mines were built. In 1859, under the direction of Brigham Young, Isaac Grundy, Jesse Smith, Tarlton Lewis and Wm. Barton and others were sent to establish mining operations. The mine was originally called the Spanish Mine, was later renamed the Rollins Mine, and is now known as the Lincoln Mine. This mine was one of the first documented mines in Utah. That same year, the miners established a city near the mine, aptly named Minersville. Developers attempted to use lead mined from the Lincoln Mine to produce bullets, but an unidentified element in the material made it impossible. It was later discovered that this material was silver. This discovery would make Beaver County famous.

In 1875, two prospectors discovered a silver rich ore body and immediately staked a claim. After selling the claim to a bankrupt financier who promoted the mine venture, silver production exploded and the boomtown of Frisco sprung up and became one of the wildest mining camps in the west. The history of Frisco and the Horn Silver Mine is one of the most drama filled and riveting tales of the old west, literally reading like pulp fiction. By 1879, the Horn Silver was being called the richest silver mine in the world. By 1885, the Horn Silver Mine had shipped some 25,000 tons of ore and produced an estimated \$60,000,000 in zinc, copper, lead, silver and gold.

The Cactus Mine, located on the west side of the San Francisco Mountains, was discovered in 1870 and became one of the earliest mines in the district. Mining operations struggled for thirty years until 1900, when Samuel Newhouse bought the property. A wealthy entrepreneur, Newhouse had formerly financed the copper mine at Bingham Canyon and understood the mining business. With enough capital to make the mine productive, business began to boom. Initially, the mining camp was known as Tent Town for its temporary dwellings, but by 1905, the eponymous town of Newhouse had sprung up with many permanent structures, including a restaurant, library, livery stable, hospital, stores, hotel, opera house and dance hall. Samuel Newhouse kept tight control over his company town that was much smaller and quieter than the nearby town of Frisco, with public drunkenness strictly forbidden.

Shauntie was another mining camp that developed into a bustling boomtown. One of at least a half dozen camps in the Star District around 1870, Shauntie was the only camp with fresh water and quickly became the center for smelting in the district. In 1876 the town was completely destroyed by fire, but by 1877, only a year later over 40 buildings had been erected, including saloons, a hotel and a post office.

Shenendoah, Fortuna and many other mining camps developed into towns of various sizes in the heyday of mining in the county. These mining towns are abandoned now, but they demonstrate the importance of the mining industry in the history of early Beaver County. All this activity attests to the value of natural resource development and the socio-economic impacts from the mining industry. It was because of the mining industry that the telegraph and railroad were brought to southern Utah.

Energy development and natural resource extraction continue to be key to Beaver County's economy, supporting a multitude of local jobs, industries and activities. The entire region is a mineralogist's paradise, with opportunities to collect over 123 recognized mineral specimens, some of which are exclusively unique to this area. Beaver County is certainly a geological crossroad and is incomparable in its diversity of mineralogic, tectonic and stratigraphic activity.

County Resources and Character

Beaver County is 90 miles in length from east to west and 30 miles wide north to south, encompassing approximately 2,568 square miles. It is crossed by a number of short and mineral rich mountain ranges oriented generally on a north-south axis. The Beaver River originates in the County with which it shares a name and flows in a north-westerly direction eventually disappearing into Millard County at the southern end of the Great Basin drainage area.

The average growing season is 106 days and the mean temperature is 47 degrees Fahrenheit. Generally, the climate is temperate and not subject to extreme heat or cold. There are four well-defined seasons. The sun shines an average of 320 days each year. Precipitation averages 11.65 inches annually in Beaver Valley and 8.5 inches in the Milford area. Snowfall and wells provide additional water in what is otherwise a dry region. In Beaver Valley, June 10 generally marks the end of late frosts, while September 25 is generally the first of the early frosts. The Minersville area is protected from early and late frosts by breezes from Minersville Canyon to the east, providing a longer growing season. The Minersville area experiences late frosts before May 20, while early frosts occur after October 5. These conditions make Beaver County highly suitable for agriculture and grazing.

Overview of Main Concerns

In adopting this CRMP, Beaver County seeks to address two main concerns. First, Beaver County has found that it has not been fully engaged in coordination with the state and federal land management agencies in the planning and decision making processes that have direct and substantial effects on its citizens. Beaver County adopts this plan in order to set forth clear policies and guidelines that must be recognized by land management agencies when engaging in

planning and land management decision-making. Second, Beaver County has found that many land use plans and decisions are highly politicized, heavily influenced by special interest groups and often mischaracterize the realities of public land usage in Beaver County. Land management agencies have not fully accounted for the social and economic impacts that their planning and management decisions have on Beaver County and have made little or no effort to mitigate those undesirable impacts. With this plan, Beaver County seeks to ensure that the customs, culture, history, and economy of Beaver County is protected in planning and land use decisions moving forward. These concerns are addressed in greater detail throughout this CRMP.

LEGAL BASIS FOR COUNTY RESOURCE MANAGEMENT PLANNING

The authority for Beaver County, and all other counties in the State of Utah, to implement plans for the management of natural resources comes directly from state law. Utah Code § 17-27a-401(1) provides that "each county shall prepare and adopt a comprehensive, long-range general plan," which addresses, among other concerns: (a) present and future needs of the county; and (b) the growth and development of all or any part of the land within the unincorporated portions of the county. The law gives the county the authority to define the local customs, local culture, and the components necessary for the county's economic stability. *See* Utah Code §17-27a-401(4).

The statute also states that the plan shall serve "as a basis for communicating and coordinating with the federal government on land and resource management issues." Utah Code § 17-27a-401. In furtherance of this directive, "[t]he general plan shall contain a resource management plan for the public lands, as defined in Section 63L-6-102, within the county." Utah Code § 17-27a-401(3)(a). The legislature identified resources, programs, and policies that must be addressed within the resource management plan. *See* Utah Code § 17-27a-401(3)(b)(i)-(xxviii). Counties may obtain access to certain data gathered and held by state agencies that may be of assistance in the county's planning process. *See* Utah Code § 17-27a-402.

While the legislature recognized the county's important role in managing land and resources within its borders, the authority to plan does not give the county any direct jurisdiction over lands owned by the state or federal governments. *See* Utah Code §17-27a-304.

Federally owned land in Utah is primarily managed through the Bureau of Land Management ("BLM") and the United States Forest Service ("USFS"). Both the BLM and the USFS are required to engage in land and natural resource planning, following the procedures outlined in federal statutes and regulations. These plans directly affect the use and development of natural resources within Beaver County.

The BLM is required, pursuant to the Federal Land Policy and Management Act of 1976 ("FLPMA"), to "develop, maintain, and ... revise land use plan which provide by tracts or areas for the use of [BLM] lands." 43 U.S.C. § 1712(a). The USFS is also required to do the same for "land and resource management plans for units of the [USFS]." 16 U.S.C. § 1604(a).

The BLM has a statutory mandate to coordinate their land and natural resource activities with the land use planning and management programs of State and local governments where the lands affected by those activities are located. 43 U.S.C. § 1712(c)(9). To fulfill this obligation,

the BLM must keep apprised of State and local land use plans, provide for meaningful public involvement of State and local government officials, and assist in resolving inconsistencies with federal and State and local plans. *Id.* BLM land use plans “***shall be consistent with State and local plans to the maximum extent [the State and local plans are] consistent with Federal law and the purposes of [FLPMA].***” *Id.* (emphasis added). So long as State and local plans are consistent with the Federal laws and regulations applicable to federal lands, BLM land use plans “will adhere to the terms, conditions, and decisions of officially approved and adopted resource related plans” of State and local governments. 43 C.F.R. § 1610.3-1.

The USFS also has a statutory mandate within the National Forest Management Act (NFMA) of 1976, to coordinate their land and natural resource plans with the corresponding plans of State and local governments. *See* 16 U.S.C. § 1604(a). The USFS “must provide opportunities for the coordination of Forest Service planning efforts . . .” 36 C.F.R. 219.9. The USFS is required to “discuss any inconsistency” between land use and natural resource plans and “any approved State or local plan and laws.” If any inconsistencies exist, the plan must “describe the extent to the [USFS] would reconcile its proposed action with the plan or law.” 40 C.F.R. § 1506.2(d).

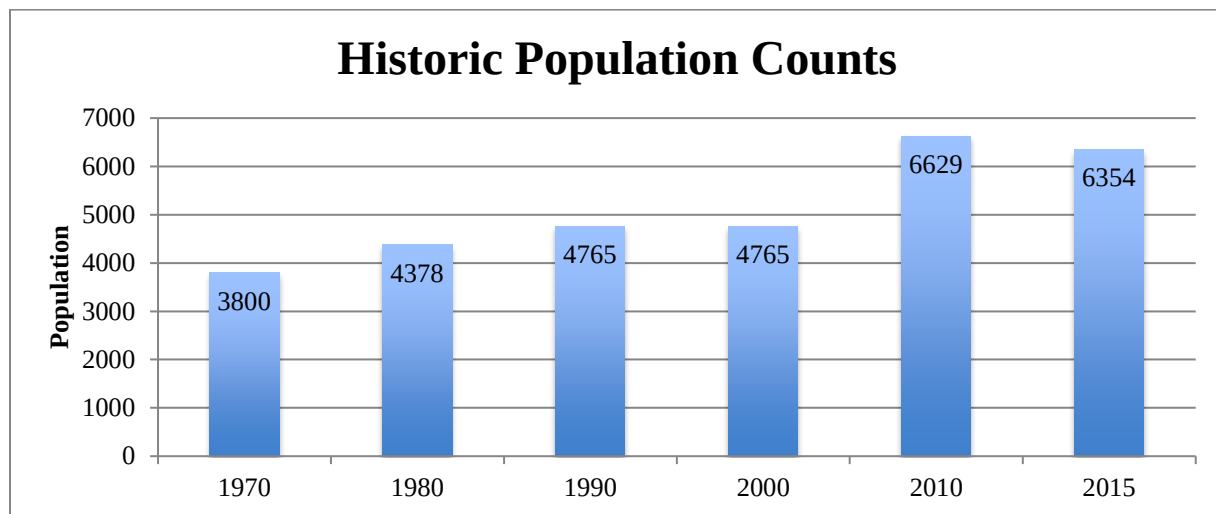
SOCIAL-ECONOMIC LINKAGES

Nearly 80% of the land in Beaver County is owned or managed by the federal government. The lack of private land ownership means that the social and economic viability of Beaver County is dependent on the access and use of public land. All public land use decisions have a substantial impact on the citizens of Beaver County. Beaver County's social and economic connection to public lands is evidenced in the following indicators:

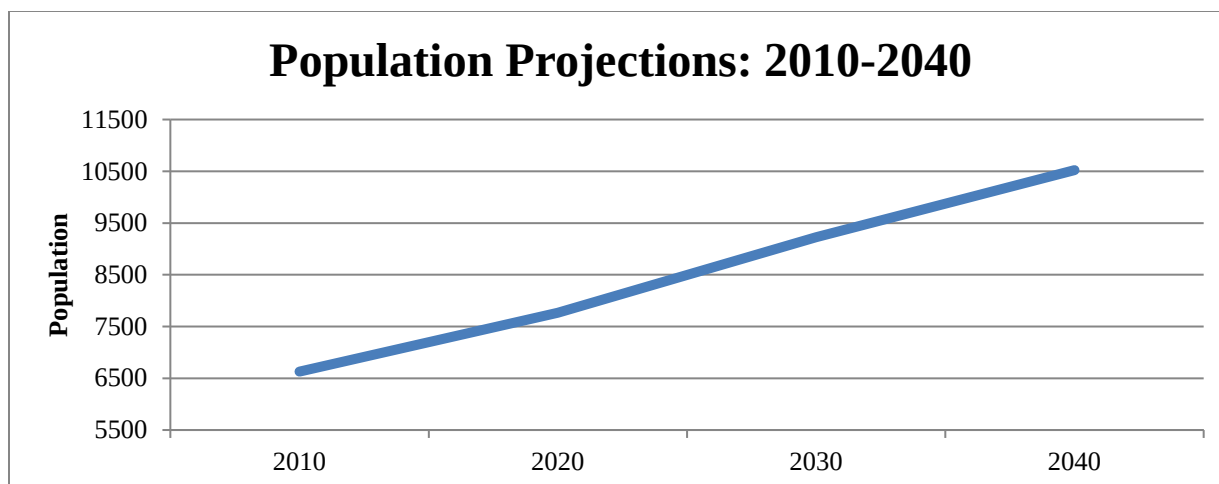
Demographics

1. Population Change

While the population of Beaver County increased by 139% between 2000 and 2010, the overall population decreased by 4% between 2010 and 2015. However, Beaver County is projected to undergo steady growth over the next few decades.

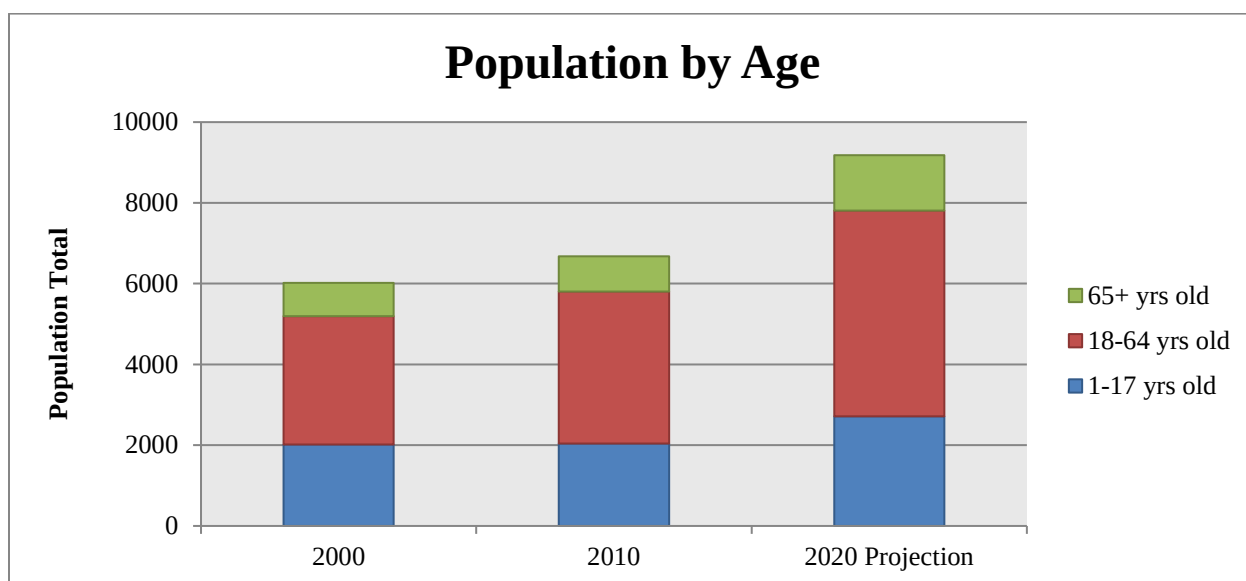


Source: U.S. Census Bureau



Source: U.S. Census Bureau

2. Age Groups



Source: Bureau of Economic and Business Research

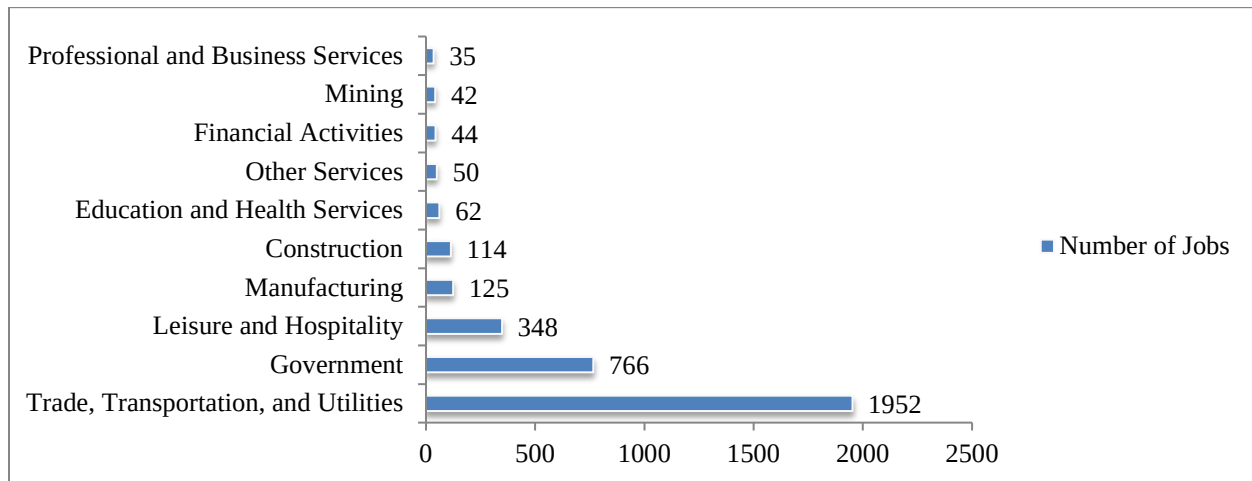
3. Most Populous Cities

Most Populous Cities in Beaver County	
City/Town	Population
Beaver	3,112
Milford	1,409
Minersville	907

Source: U.S. Census Bureau, 2010 Census

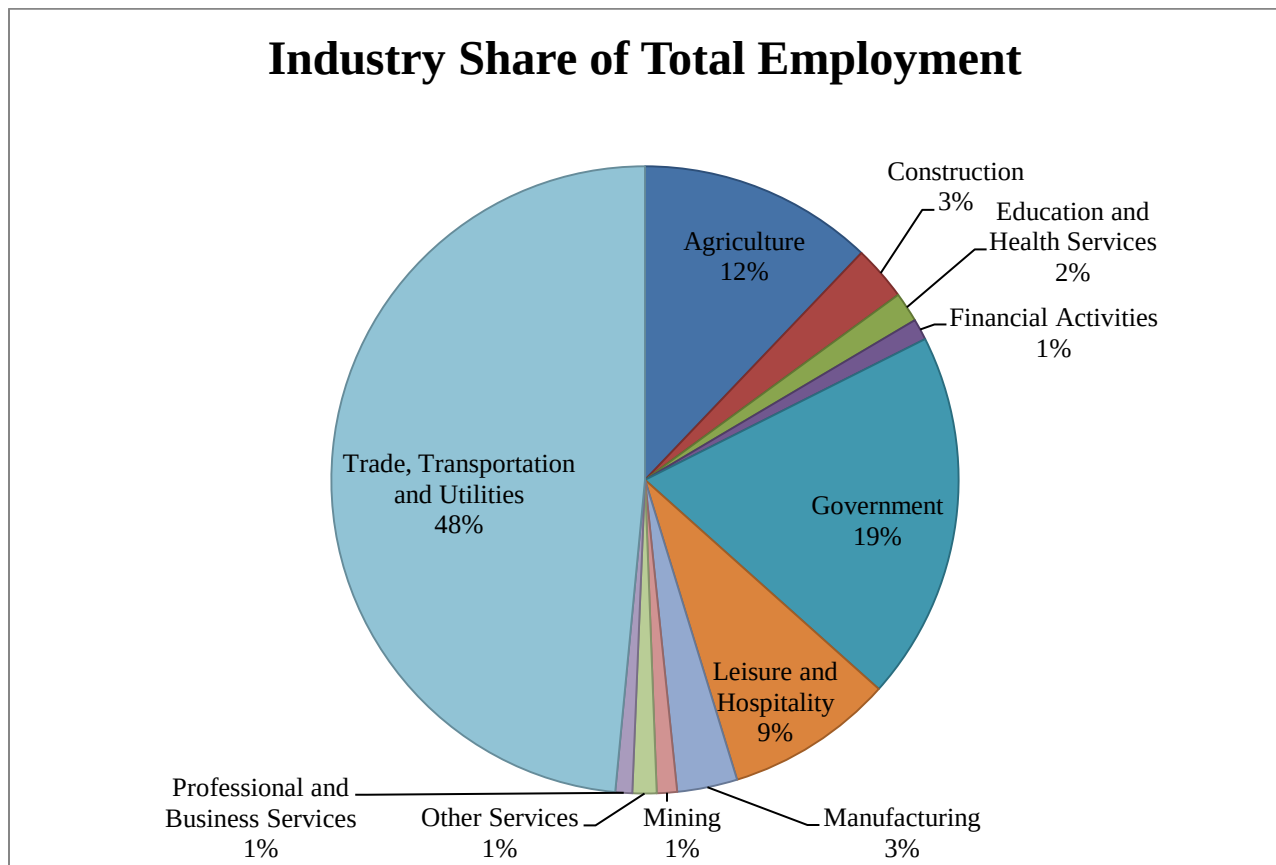
Employment

1. Nonagricultural Employment



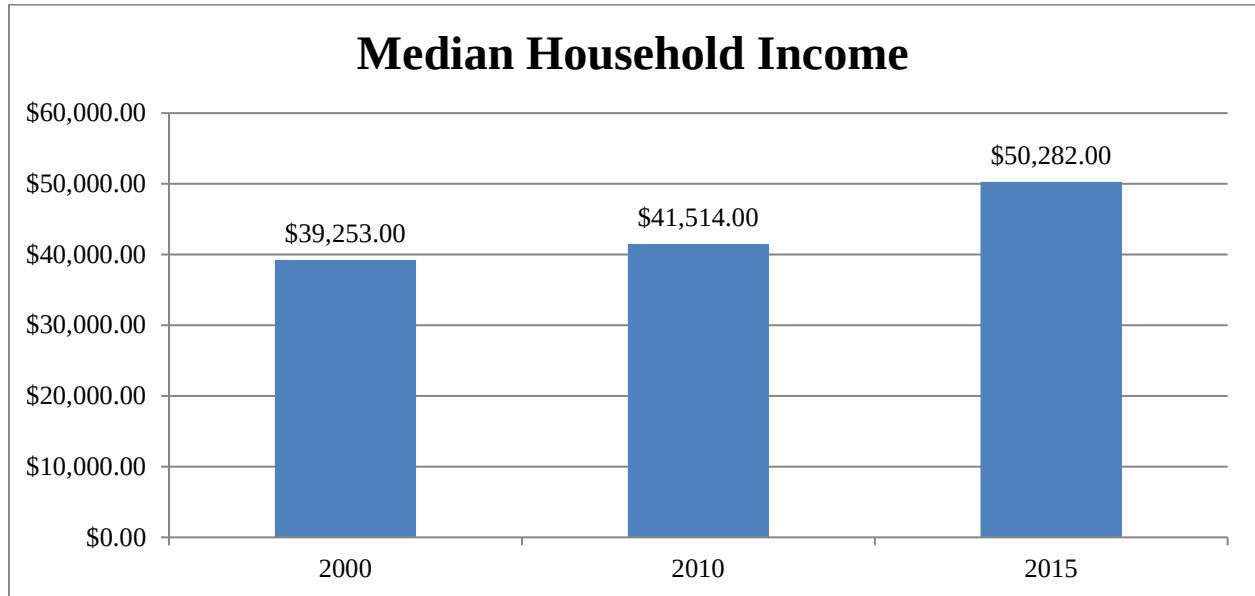
Source: Utah Department of Workforce Services

2. Industry Share of Total Employment



Source: Utah Department of Workforce Services

3. Median Household Income



Sources: U.S. Census Bureau

CURRENT RESOURCE MANAGEMENT SETTING

Beaver County's heritage is directly tied to the natural resources found within its borders, as set forth in the Culture and History section above. Further, given the limited private land ownership in Beaver County, the county's social and economic reliance on these resources is just as important today as it was when the county was first settled. As such, the current management of public lands in Beaver County is of great concern to its citizenship.

Federal and state agencies that manage public lands largely ignore Beaver County's input and desires in the development of land use plans and decisions. The invitation to participate in federal agency planning is mostly symbolic and typically comes after much of the planning and development stages are complete. Beaver County is frequently invited to offer comments on agency actions, but commenting on the action does not equate to meaningful participation.

Issues of Resource Management Conflict and Concern and Need for Change

- 1. Partnerships:** Beaver County has found that planning and management agencies have not taken sufficient steps to cultivate a meaningful cooperative partnership with Beaver County and at times do not inform Beaver County of the initiation of planning and decision making processes. A lack of communication and sharing of information has impaired the ability to establish effective partnerships.
- 2. Planning Timelines:** When Beaver County is provided with an opportunity to participate, it comes at a time when the majority of the planning work has been conducted or decisions have been made. Often, Beaver County has different policies and unique perspectives on particular issues not possessed by the agency. Without a meaningful opportunity to share these policies and perspectives, plans and management decisions mischaracterize land and resources conditions in Beaver County and implement actions that have a profoundly negative impact on the county.
- 3. Direct Impacts:** While Beaver County recognizes that public lands belong to the public as a whole, planning and management agencies have not given enough consideration to the direct and substantial impact their planning and management decisions have on the citizens of Beaver County. This results in plans and decisions that are often times harmful to the local economy and culture of the County.
- 4. Local Economic Impact:** Planning and management agencies have not considered the impact of specific plans and decisions on the economy of Beaver County to the extent necessary to maintain Beaver County's social and economic viability. Agencies should

fully address the social and economic impacts of any agency action on Beaver County. Plans and management decisions should mitigate any negative impacts of the action on Beaver County. The plan or decision should explicitly describe those mitigation measures.

5. **Planning Resources:** Planning and management agencies have failed to keep Beaver County adequately involved regarding the initiation of planning and decision making activities. Beaver County would like these agencies to take a more active role in fostering communication with the County during all planning and decision-making processes in consideration of Beaver County's limited resources.

DESIRED RESOURCE MANAGEMENT SETTING

Meaningful involvement in public land planning, decisions, and management is a priority for Beaver County. This is reflected in the following policy statements, goals, objectives, and monitoring procedures:

1. **Partnerships:** Beaver County will become a formal partner with management agencies supported by cooperative agreements.
2. **Planning Timelines:** Cooperative agreements with management agencies will be contingent on the inclusion of language that guarantees that Beaver County will have meaningful involvement through the entirety of planning and decision making processes, including the scoping process.
3. **Direct Impacts:** The cooperative agreements will require that the policies and specific input of Beaver County be given weighted and regular consideration in making each planning and management decision.
4. **Local Economic Impact:** Beaver County will only support public land plans and decisions that result in a sustainable net benefit to the local economy. Cooperative agreements with management agencies will require agencies to thoroughly analyze potential impacts to Beaver County's economy.
5. **Planning Resources:** Beaver County has limited resources that can be dedicated to protecting their rights to participate in land use planning and management decisions. Management agencies should take a more active role in communicating with Beaver County at each stage of the planning or decision-making process. Beaver County will designate an individual or committee as the point of contact for each agency. That individual or entity will report to the County Commission on the involvement of Beaver County in planning and management decisions. If necessary, this individual or committee will recommend changes to the CRMP's desired management setting including policies, goals and objectives.

1. LAND USE

I. FINDINGS

Locally elected governments and elected officials have far ranging and important responsibilities to their constituents, described by state statutes as protecting their “health, safety and welfare.” That responsibility includes interacting with federal agencies on all issues impacting the local community, County or conservation district(s). Adoption of “local land use plans” or “resource management plans” set local policy regarding the use and management of federal lands and the adoption of federal policies, programs, and other types of federal decision-making and give local governments a stronger voice in coordinating with federal agencies. These local land use policies are not zoning policies and do not regulate the use of private lands. This plan is intended to protect the local citizens’ use of federal and public lands and resources.

Federal agencies and departments are mandated by various federal statutes to engage local governments in federal decision-making that will impact the local land use, management of natural resources, the citizens, and the local tax base. Federal agency consideration of a local land use plans, resource management plans, and other “officially adopted policy” plays a key role in the success of coordination of local, state and federal entities and with consistency review under the National Environmental Policy Act (“NEPA”).

These land use or resource plans are separate and different from county “general plans” which counties use to determine zoning, public services and facilities, transportation, etc. General plans apply to land that is largely within the county’s jurisdiction and are based upon specific state authorization. By contrast, many rural counties officially adopt a separate land use plan or natural resource management plan that contains policies relating to surrounding public lands and reflects the local government’s position on how to best manage those lands. These local plans also describe the local economy or tax base as well as local “customs and cultures” which federal agencies are required to consider and reconcile any inconsistencies between the local plans and any federal land use plans.

Rural counties’ socioeconomic well-being, health, safety, and culture can be strongly impacted by the management of the surrounding federal or public lands. Moreover, courts have clearly recognized that county governments are generally required by state law to use their authority to protect the economic, social, and general well-being of the people and resources that are within their jurisdictions. The development of this land use plan is to ensure the local socioeconomic well-being, the culture and customs of the constituents, and natural resource health are considered in federal decisions.

Statutory Requirements for Federal Agencies

The National Environmental Policy Act (NEPA)

NEPA applies to “every major Federal action significantly affecting the quality of the human environment[.]” See 42 U.S.C. § 4332(2)(C). When the federal government spends any amount of money for almost any action, NEPA compliance is required. There are several ways local governments participate in the NEPA process. First, as part of a federal agency’s “consistency review” process in an EIS, any inconsistencies with local plans must be addressed and described. The EIS should also describe how the federal agency would reconcile its proposed action with the local plan. See 40 C.F.R. §§ 1506.2(d). Second, local governments are invited to participate in the NEPA process as “cooperating agencies” due to their “special expertise.” A local government’s special expertise is defined as the authority granted under state statute to protect the health, safety and welfare of its citizens.

Federal Land Policy and Management Act (FLPMA)

FLPMA, which governs the BLM, provides detailed requirements for “coordination” and “consistency” with local land use plans. FLPMA states:

To the extent consistent with laws governing the administration of the public lands, coordinate the inventory, planning and management activities for such lands with the land use planning and management programs of other Federal departments and agencies of the State and local governments within which the lands are located . . .

43 U.S.C. § 1712 (emphasis added).

FLPMA further requires, to the extent practical, the BLM must stay apprised of local land use plans, assure that local plans germane to the development of BLM land use plans are given consideration, and to the extent practical, BLM must assist in resolving inconsistencies between local and BLM land use plans. The BLM must also provide for meaningful involvement of local governments in the development of BLM land use programs, regulations, and decisions. Additionally, FLPMA requires BLM land use plans be consistent with local land use plans, provided that achieving consistency does not result in violating federal law.

Utah Code §§ 63J-8-103 and 63L-8-104 define state participation in managing public lands and require consistency between federal and state plans. Section 63J-8-103 states:

In view of the requirement in FLPMA, 43 U.S.C. Sec. 1712, that BLM must work through a planning process that is coordinated with other federal, state, and local planning efforts before making decisions about the present and future uses of

public lands, the requirement in FLPMA, 43 U.S.C. Sec. 1714 that BLM may not withdraw or otherwise designate BLM lands for specific purposes without congressional approval, and requirement in the Forest Service Multiple-Use Sustained Yield Act of 1960, 16 U.S.C. Sec. 528, that lands within the national forests be managed according to the principles of multiple use, and in view of the right which FLPMA, the National Environmental Policy Act, 42 U.S.C. Sec. 4321 et seq. and the Federal Advisory Committee Act, 5 U.S.C. Appendix 2, give to state and local governments to participate in all BLM and Forest Service efforts to plan for the responsible use of BLM and Forest Service lands and the requirement that BLM and Forest Service coordinate planning efforts with those of state and local government, the state [and Beaver County] adopts the following policy for the management of the subject lands[.]

Pursuant to the proper allocation of governmental authority between the several states and the federal government, the implementation of congressional acts concerning the subject lands must recognize the concurrent jurisdiction of the states and accord full recognition to state interpretation of congressional acts, as reflected in state law, plans, programs, and policies, insofar as the interpretation does not violate the Supremacy Clause, U.S. Constitution, Article VI, Clause 2.

National Forest Management Act (NFMA)

NFMA governs the USFS, and requires the agency to “coordinate” with local land use plans:

[T]he Secretary of Agriculture shall develop, maintain, and, as appropriate, revise land and resource management plans for units of the National Forest System, coordinated with the land and resource management planning processes of State and local governments and other Federal agencies. . .

16 U.S.C. § 1604(a) (emphasis added).

The fact that the USFS is directed to “coordinate” with local governments implies, by its plain meaning, that the USFS must engage in a process that involves more than simply “considering” the plans and policies of local governments; it must attempt to achieve compatibility between USFS plans and local land use plans.

Governor’s Consistency Review Process

State Governors are entitled to a separate consistency review of BLM land use plans, revisions, and amendments. 43 C.F.R. § 1610.3-2 provides an opportunity for the Governor to review all proposed plans to identify any inconsistencies with State or local plans. If the

Governor's comments result in changes to the plan, the public should be re-engaged in the process.

Federal Data Quality Act

To the greatest extent possible, data should drive all land use planning decisions. The Federal Data Quality Act ("FDQA") provides policy and procedural guidance to federal agencies to ensure and maximize the "quality, objectivity, utility, and integrity" of information disseminated by federal agencies. As required by OMB guidelines, all federal agencies producing information, or "data", must meet basic quality standards, including influential scientific information representing the views of the agency cannot be disseminated until it has been "peer reviewed" by qualified specialists.

Federal agency Resource Management Plans ("RMPs") form the basis for every action and approved use on the public lands. The BLM, Forest Service and other agencies prepare RMPs for areas of public lands, called planning areas, which may be a local or sub-regional jurisdiction. Planning emphasizes a collaborative environment in which local, state, and tribal governments, the public, user groups, and private industry work with federal agencies to identify appropriate uses of the public lands. Plans are periodically revised as changing conditions and resource demands require.

RMPs are used by land management agencies to accomplish the following:

- a. Allocate resources and determine appropriate uses for the public lands;
- b. Develop a strategy to manage and protect resources; and
- c. Establish systems to monitor and evaluate the status of resources and effectiveness of management practices over time.

Beaver County has established an ongoing planning process to ensure that federal RMPs remain consistent with applicable laws, regulations, orders, and policies. In addition, Beaver County demands that federal plans be consistent, to the maximum extent allowed by law, with this CRMP. This process will involve cooperative assessment, decision-making, implementation, monitoring, and evaluation efforts. There will also be ongoing adjustment through maintenance, amendment, and revision. This process allows for continued refinement to respond to new issues and ever-changing circumstances.

Beaver County is 90 miles in length from east to west and 30 miles wide from north to south, with an area of 2,568 square miles. Beaver County land ownership is 77% Federal, 12.6% Private, and 10.1% State Trust Lands. Land use is 0.4% residential, 0.25% commercial, and 3.5% agricultural. Cultivated cropland accounts for approximately 32,000 acres or 1.9% of the land in the county. Much of the federal land is used for recreation, grazing, wildlife habitat,

timber, mining and energy development. Private land is primarily used for residential neighborhoods, community developments, agriculture and commercial business.

For approximately 160 years, Beaver County's residents have relied on the use of public lands as part of their livelihood and heritage. Many residents still derive their living in some degree from the natural resources obtained from public land or the use of those lands. These lands and their resources cannot be separated from the custom, culture, quality of life and economic well-being of Beaver County. Agriculture, livestock grazing, mining, recreation, tourism and timber industries are the lifeblood of Beaver County and all require access to and the use of public lands.

II. OBJECTIVES

Beaver County's objectives with regard to land use are as follows:

1. To ensure that federal lands are managed for multiple uses as mandated in the Multiple Use Sustained Yield Act and other federal law. This approach places an emphasis on striking a balance in land use planning among the competing values of recreation, grazing, timber, watershed protection, fish and wildlife, mining and energy. Efforts should be made to protect critical wildlife habitat, watersheds, scenery, and important natural resources. Efforts should also be made to allow for greater utilization of the land in the areas of recreation, grazing, timber, mining and energy development;
2. To encourage the development of new facilities, paths, trails and other recreational features that encourage recreational activity on public lands. Where appropriate, the use and installation of signs and interpretive devices should be made available. Roads and trails are necessary for recreation and emergency services and should be left open; and
3. To ensure the wise use, conservation and protection of public lands and their resources, including well-planned management strategies.

III. POLICIES AND GUIDELINES

Private Property Rights

1. It is the policy of Beaver County, consistent with Section 63J-8-104(j) of the Utah Code, that federal land management agencies shall manage lands under their jurisdiction so as to not interfere with the property rights of private landowners as follows:

- a. Beaver County recognizes that there are parcels of private fee-title land located adjacent to or surrounded by federal lands;
- b. Federal land management policies and standards shall not interfere with the property rights of any private landowner to enjoy and engage in uses and activities on an individual's private property consistent with County zoning and land use laws; and
- c. A private landowner, or a guest or client of a private landowner, should not be denied the right of motorized access to the landowner's property.

Public Lands

- 2. Public lands shall be managed for multiple uses, sustained yield, the prevention of waste of natural resources, and to protect the health, safety and welfare of the citizens of the county.
- 3. Public lands shall be properly managed for fish, wildlife, livestock production, timber harvest, recreation, energy production, mineral extraction and the preservation of natural, scenic, scientific and historical values.
- 4. State and federal agencies shall develop and implement management plans and decisions that facilitate land and resource use allocation that supports the specific plans, programs and policies of state and local governments.
- 5. Management plans shall be designed to produce and provide the forage, food, fiber and minerals necessary to meet future economic needs and community growth and expansion.
- 6. Management plans shall also meet the recreation needs of the citizens of Beaver County and its visitors. Opportunities for new facilities, paths and trails shall be encouraged.
- 7. Local federal land agencies shall provide to Beaver County, on a regular basis, a list of yearly activities and plans scheduled to occur within the county.
- 8. Beaver County shall have the opportunity for meaningful involvement in public land planning before the general public and to have meaningful involvement prior to the selection of a preferred alternative.
- 9. Counties may request that monitoring or studies occur to determine the effects that land and resource management plans have on the local economy. Counties are allowed to define what constitutes "community or economic stability."

10. All management plans and decisions must insure that special designations do not influence the use of resources on lands not listed or designated.
11. Beaver County opposes the imposition of areas of critical environmental concern (“ACEC’s”), National Conservation Areas, or Visual Resource Management (“VRM”) classifications as substitutes for wilderness inventory units, or as means to displace valid surface occupying multiple use activities.
12. Restrictions placed on any resource must be based on trend analysis and only imposed after a complete documentation of that analysis.
13. Lands designated open for specific uses should be available on a timely basis. If such use is not covered in a resource management plan, then it will be analyzed in a separate document or by amendment to the RMP. Extended delays or no action will not be used as a method to accomplish management goals.
14. Beaver County opposes the use of a buffer zone management philosophy that dictates land use practices and influences decisions beyond the scope and boundaries of the specific land use designation or management prescription. Differences of opinion between the state's plans and policies on use of the subject lands and any proposed decision concerning the subject lands pursuant to federal planning or other federal decision making processes should be mutually resolved between the authorized federal official, including federal officials from other federal agencies advising the authorized federal official in any capacity, and the governor of Utah.
15. The subject lands managed by the BLM are to be managed to the basic standard of preventing undue and unnecessary degradation of the lands, as required by FLPMA. A more restrictive management standard should not apply except through duly adopted statutory or regulatory processes wherein each specific area is evaluated pursuant to the provisions of the BLM's planning process and those of the NEPA.
16. The subject lands should not be segregated into separate geographical areas for management that resembles the management of wilderness, wilderness study areas, wildlands, lands with wilderness characteristics, or the like.
17. The BLM and the USFS should make plans for the use of the subject lands and resources subject to their management pursuant to statutorily authorized processes, with due regard for the provisions of the NEPA, by:
 - a. Recognizing that the duly adopted Resource Management Plan or Forest Service equivalent is the fundamental planning document, which may be revised or amended from time to time;

- b. Avoiding and eliminating any form of guidance or policy that has the effect of prescreening, segregating, or imposing any form of management requirements upon any of the subject lands and resources prior to any of the planning processes subject to Subsection [\(e\)\(1\)](#); and
 - c. Avoiding and eliminating all forms of planning that parallel or duplicate the planning processes subject to Subsection [\(e\)\(1\)](#).”
18. The BLM and USFS land use plans should produce planning documents consistent with state and local land use plans to the maximum extent consistent with federal law and FLPMA's purposes, by incorporating the state's land use planning and management program for the subject lands that preserve traditional multiple use and sustained yield management on the subject lands to:
- a. Achieve and maintain in perpetuity a high-level annual or regular periodic output of agricultural, mineral, and various other resources from the subject lands;
 - b. Support valid existing transportation, mineral, and grazing privileges in the subject lands at the highest reasonably sustainable levels;
 - c. Produce and maintain the desired vegetation for watersheds, timber, food, fiber, livestock forage, wildlife forage, and minerals that are necessary to meet present needs and future economic growth and community expansion in each county where the subject lands are situated without permanent impairment of the productivity of the land;
 - d. Meet the recreational needs and the personal and business-related transportation needs of the citizens of each county where the subject lands are situated by providing access throughout each such county;
 - e. Meet the needs of wildlife, provided that the respective forage needs of wildlife and livestock are balanced according to the provisions of Subsection 63J-4-401(6)(m);
 - f. Protect against adverse effects to historic properties, as defined by 36 C.F.R. Sec. 800;
 - g. Meet the needs of community economic growth and development;
 - h. Provide for the protection of existing water rights and the reasonable development of additional water rights; and
 - i. Provide for reasonable and responsible development of electrical transmission, broadband internet, and energy pipeline infrastructure on the subject lands.”

2. ENERGY, MINING, MINERAL & GEOLOGICAL RESOURCES

2.1 Mining and Mineral & Geological Resources

This section describes the major mineral occurrences in Beaver County, the general locations of known deposits, the quality and/or size of the mineral deposit and the potential for future development of these resources. The potential for any development is based on current estimates of market value, demand, and economic viability and is subject to change.

I. FINDINGS

Beaver County has a responsibility to its citizens to protect and expand the tax base and increase economic activity in order to provide a good standard of living, to provide a quality environment for the enjoyment and use of its citizens (including protection of local values and lifestyles), to represent the interests of its residents in coordinating with other local, state and federal agencies in planning, management and regulatory activities. In fulfilling that responsibility, it is important that the County's mineral and geological resources are fully utilized.

Mineral resources are divided into 4 defined categories in federal permitting; (1) locatable minerals (e.g., copper, gold, iron, and silver); (2) mineral materials or salable minerals (e.g., sand, gravel, stone and pumice); (3) solid leasable minerals (e.g., coal, phosphate, sodium and potassium); and (4) fluid minerals (e.g., oil and gas and geothermal resources).

1. Locatable Minerals

Locatable minerals in Beaver County principally include gold, silver, copper, lead, zinc, and iron, and several industrial minerals and gemstones. Uncommon varieties of sand, gravel, limestone, marble and other building stones may also fall under the category of locatable minerals.

The BLM manages the Mining Law program on the federal mineral estate including authorizing and permitting mineral exploration, mining and reclamation actions. Areas with high potential for locatable mineral development are shown on Map 1.

Locatable mineral exploration and extraction has been a significant and economically important part of the history of Beaver County. The Marysvale-Pioche Mineral belt, one of the three great metallogenic provinces in Utah, covers most of Beaver County. There have been 23 distinct mining districts and at least 4 additional unorganized districts identified in the county that leave a testament to the historic significance of mining and the rich mineral resources found

here. The most productive districts have been the San Francisco Mountains, Beaver Lake Mountains, Rocky Range and Star districts, which were substantial producers of lead, silver and copper, with lesser amounts of zinc and gold. The famous Horn Silver Mine, a bonanza-grade lead and silver deposit, and the associated mining town of Frisco was one of the richest known silver deposits of its time.

Beaver County contains the largest known deposit of what is arguably the most rare gemstone in the world, the red variety of beryl. Current mineral exploration and development focuses primarily on copper and gold resources, but there is excellent potential for other base and precious metal resource development.

All locatable mineral exploration and development activities that disturb the surface of a mining claim (or site) on BLM administered land, requires prior acceptance or authorization and the necessary permits which are obtained through the local BLM field office. Additionally, the Utah Division of Oil, Gas and Mining (“DOGM”) regulates the exploration and development of coal, oil and gas, and minerals within the state. State policies, regulations and permitting affect all private and state lands and are applied in conjunction with federal law on federally owned lands. Approximately 80 percent of mining surface disturbances lie on private lands that were patented into private ownership under the patenting provisions of the General Mining Law. Subject to valid existing rights, the patenting provision is currently unavailable due to a Congressional moratorium.

Copper

Utah is the second largest copper producer in the United States, trailing only Arizona. The largest source of copper in the state is the Bingham District in northern Utah. In Beaver County, the largest deposits of copper are associated with Oligocene, calc-alkaline, intrusive centered mining districts northwest of Milford, including the Beaver Lake, Rocky Range, and San Francisco mining districts. The three districts combined have produced more than 3 million tons of ore (both on private and BLM-administered land), yielding 0.88 percent to 1.4 percent copper. Development potential for copper is high, and there are currently two Plans of Operations for copper.

Gemstones

The primary gemstone of interest in the county is red beryl. The only economic deposit of red beryl in the world is mined at the Ruby Violet mine in the southern Wah Wah Mountains. An estimated 60,000 carats of red beryl, 10 percent of which is facetable, has been produced at the site in the last 25 years. There is currently one Plan of Operations and one notice for red beryl and there is high potential for future development.

Although previous large-scale developments have not been realized, small-scale

development will continue to occur with larger-scale development certainly possible at the Ruby Violet mine.

Gold and Silver

Utah is the third leading producing state for silver and the fourth leading producing state for gold in the United States. Most of Utah's production occurs in the Bingham, Tintic, and Park City districts. The Escalante and Gold Springs Districts are the leading producers of gold and silver in the district in nearby Iron County. There are currently no Plan of Operations or notices for gold and silver in Beaver County. Most of the historic silver claims have been played out and the gold claims haven't produced as significantly as surrounding districts with most production coming as a byproduct of copper mining. The potential for gold and silver development in the county is low to moderate for gold deposits in the Fortuna and Newton districts and silver in the San Francisco, Star and White Mountain districts.

Iron

Utah ranks fifth in the nation in iron ore production, most of which occurs in nearby Iron County in the Iron Springs mining district, which is the most productive iron district in the western United States. Beaver County has low to moderate potential for iron ore production in the Blue and Wah Wah Mountains.

Kaolinite

Kaolinite is a soft, earthy clay mineral that is generally the product of hydrothermal alteration of rhyolitic rocks. Kaolinite has a wide variety of applications, including medicine, ceramics, food additives, and cosmetics. Kaolinite produced in this area is primarily used in cement.

The primary deposits of kaolinite are at Blawn Mountain and White Mountain. There is one Plan of Operations on BLM-administered land in this area. Development potential at known mines and prospects is high.

Lead and Zinc

Utah is the second largest producer of lead and fourth largest producer of zinc in the Nation. Most of the lead and zinc production in the county occurred in the San Francisco and Star mining districts. Development potential in these districts is low to medium given minimal production of these resources in recent years. There are no notices or Plans of Operations on BLM-administered land in the area.

Uncommon Variety Minerals

Uncommon variety minerals include certain varieties of marble and limestone. Common

varieties of marble and limestone are disposed of as salable minerals and are discussed in the *Mineral Materials* section. The BLM determines a variety is uncommon and subject to the General Mining Law case by case based on certain judicially and administratively defined characteristics (BLM 2012g). At present, there are two notices for uncommon variety marble and two Plans of Operations for uncommon variety limestone on BLM-administered land.

Perlite

Perlite, a form of lightweight aggregate, is volcanic in origin and has a variety of industrial and domestic applications. Most of the known occurrences of perlite in the county are in the Mineral Mountains with the most substantial perlite deposit being at the Schoo Mine. Development potential in this area is high.

Tungsten

Tungsten is a hard, rare metal primarily used in the production of alloys, steels, and other hard materials. Production of tungsten in Utah has primarily been driven by brief periods of high tungsten prices as a result of high demand during war years (BLM 2011b). Tungsten can primarily be found in the Rocky Range, Granite, Lincoln, and Star mining districts in Beaver County. Development potential for tungsten is moderate.

Uranium

Utah is a major producer of uranium in the United States, but almost all production (98 percent) in the state occurs on the Colorado Plateau in southeastern Utah. In Beaver County, historical mining has produced nearly 20,000 tons of ore, yielding approximately 40 tons of triuranium octoxide (U_3O_8), a form of yellowcake. There are currently no notices or Plans of Operations for uranium mining in the county and development potential remains low.

Molybdenum

Utah is the third leading molybdenum producing state in the U.S. Although there has been no recorded molybdenum production in Beaver County, there are several known deposits with moderate to high development potential over the long term, namely in the Pine Grove mining district.

Miscellaneous Minerals

Other locatable commodities in Beaver County include barite, fluorite/fluorspar, high-calcium limestone and high-magnesium dolomite, gypsum, sulfur and mercury. These mineral resources are present, and several have been mined historically in the past, however, either because they occur in limited quantities or are difficult to extract, or due to other current market forces, they are unlikely candidates for commercial development. These resources could be

produced on a small scale or for local uses.

Forecast

Historically, the economics of locatable mineral resources, particularly the base metals, have been cyclical, reflecting periods of strong demand and limited supplies followed by oversupply and weaker demand. Renewable energy components are driving the rare earth mineral demand worldwide. Demand and prices for precious metals, like gold and silver, is enhanced by periods of general social, political, and economic uncertainties and unrest. Most locatable mineral commodities trade in the worldwide marketplace, so price and demand can be dictated by world events. At present, a substantial marketplace factor is the economic expansion of China and its enormous demand for a wide variety of mineral commodities. This economic growth is forecast to continue to control demand for all of the base metals.

Beginning in 2005, strong market demand allowed the copper mine operation west of Milford to go into production. Known copper resources in the Beaver Lake Mountains will allow for continued development and expansion into the foreseeable future, provided market prices remain strong. As of August 2016, a decrease in copper prices has idled the copper operation west of Milford.

The dominant area for future locatable mineral development in Beaver County will center on the known copper deposits and surrounding area from the Rocky Range to the San Francisco Mountains. Outside this area, smaller scale mineral development in the western half of the county has excellent potential as long as land access remains open in the higher potential areas.

2. Salable Minerals

Salable minerals, also referred to as mineral materials, known to be present in the County include common-variety deposits of sand, gravel, cinders and aggregate, and lesser amounts of building stones. *See Maps 2-4.*

Rock used for crushed stone and railroad ballast is present at the Twin Mountain quarry northwest of Milford and dominates all other mineral material sales within the county. This quarry, which is located on leased BLM land, began operations in 1997. Since 1997 through 2015, this operation has produced and sold 8.5 million tons of crushed, washed railroad ballast rock to the Union Pacific Railroad and has produced and sold 1.4 million tons of reject fines, by-product crushed rock, and rip-rap boulders to the Union Pacific Railroad, Beaver County and other commercial entities. The quarry has produced an average of 500,000 tons of ballast each year. The total revenue that has been generated from these products since operations began is approximately \$50,000,000.

Sand and gravel resources are widespread throughout the County, primarily in Quaternary alluvial deposits. Given the abundance of sand and gravel resources, accessibility and proximity to end use is the primary driver of the location of development. There are an estimated 80 sand and gravel pits and prospects in the county, and most of them are along major transportation corridors (BLM 2011b). Sand and gravel pits range in size from one acre to as much as 100 acres in size. Most of the larger pits are on private or state land located along the Interstate 15 corridor while smaller gravel pits located on BLM-administered land are dispersed throughout the county. Beaver County and Utah Department of Transportation (“UDOT”) rely on fill material, sand, gravel and cinders for construction and maintenance of state and county roads obtained from material site ROWs and free use permits from the BLM.

Building-stone resources, such as marble and limestone, which are commonly used for landscaping and other decorative purposes, are present in the county and actively mined at a number of locations, although to a lesser extent than crushed rock and sand and gravel resources. Common clay resources and lapidary material are also present in the area, but the development potential for these resources is generally low, and there has been limited historical mining of these resources.

Forecast

Market demand for mineral materials in general mirrors the overall economic wellbeing and growth of the local and regional economies. The low unit value of mineral material commodities typically makes their cost-effective extraction dependent on transportation costs, resulting in localized supply and demand. Certain markets, such as railroad operations, with ready transportation, allow for sales into a regional market. In the immediate future, the demand for mineral materials will likely remain soft, reflecting the general depressed conditions for infrastructure, commercial and residential growth in southwestern Utah. However, longer-term needs could expand with the growth of local economies. For example, heightened development of Cedar City or cities to the south could increase material sales.

There are large quantities of salable mineral reserves estimated in the County, therefore a sustainable level of mineral resources is available to meet any expected future demand.

Development potential for crushed stone and ballast is high at existing quarries, however, limited historical development elsewhere in the area suggests future development will likely not expand substantially beyond current levels. Development potential of sand and gravel is high at existing pits and prospects in host formations within a few miles of major transportation corridors. Similar to crushed stone and ballast, development of sand and gravel resources is expected to continue at current levels. Continued mining of building stone at existing quarries will likely remain similar to current levels, with a lower potential for exploration and development outside existing quarries.

3. Solid Leasable Minerals

Solid leasable minerals include, but are not limited to, coal, phosphate, oil shale, sodium, and potassium. The Mineral Leasing Act of 1920 and its 1926 and 1927 amendments provide for exploration for and extraction of these minerals.

The only known solid leasable minerals in the area are potassium resources in alunite mineralization in the west-central portion of the County. Areas with high potential for solid leasable mineral development are shown on Map 5. There is currently no production of the alunite resources in the County and no current or pending solid mineral leases filed with the BLM.

Potash could be produced through the processing of known alunite deposits in the County. The largest alunite deposit in the County is in the southern Wah Wah Mountains near Blawn Wash. However, due to the economics of processing, there is currently no production of alunite in this area or anywhere else in the United States. Processing alunite requires a substantial investment in infrastructure, which market conditions have so far rendered unfeasible.

Historically, although potassium sulfate has never been produced from alunite in this area, alunite was mined east of Beaver near Marysville during World War I as a source of potassium fertilizer, but the operation did not survive post-war economic conditions. There have been no other known successful commercial operations for alunite extraction in this part of the country. During the 1970s, a mining company identified several deposits of alunite in the area, including the Blawn Wash deposit, and developed a mine plan for part of the deposit. In 1977, the BLM issued an environmental statement for the project, but due to market conditions and high investment costs the project was unsuccessful.

After the increase in potash prices in 2008, two companies filed applications for potassium prospecting permits for prospecting known alunite resources on BLM-administered public lands in Iron and Beaver counties. One of the companies planned a drilling program to further explore the Blawn Wash deposit and the Pine Valley deposit north of Bible Springs, but due to a weakened and unstable market, these applications were withdrawn in 2014. Alunite resources with the highest development potential and the best prospects for producing potash, are on State Trust Lands located north of Blawn Mountain. In early 2017, an updated pre-feasibility technical report, which downsized earlier proposed operations to reduce capital costs, now calls for 250,000 tons per year of potassium sulfate and 600,000 tons per year of sulfuric acid to be produced from this area.

Forecast

The current and projected future market value for potassium sulfate could encourage interest in the acquisition of potassium leases on known alunite deposits. Beaver County contains one of the largest known alunite resources in the world and the best portions of this resource are

on state-owned lands. Potash extraction from alunite, while technically and economically feasible, requires extensive supporting infrastructure, which currently do not exist in this area. The high capital cost of providing the infrastructure remains the principal hurdle to the development of the resource.

4. Fluid Leasable Minerals

Fluid leasable minerals are comprised of oil and natural gas and geothermal resources. This section describes only oil and gas resources in the county; see the *Energy Resources* section for a discussion of geothermal resources.

Beaver County has 1,292,566 acres of federal oil and gas mineral ownership, 16,039 acres of which underlie state or private surface ownership (1.2 percent) in the split-estate ownership scenario. There are 360,872 acres of state and private land in the county with mineral rights vested.

There has been very limited exploration and development for oil and gas in the county. There have been no areas identified that are commercially capable of producing oil and gas on federal, state, or private land and there are currently no producing oil and gas fields. Although exploration for oil and gas resources has been ongoing since the mid twentieth century, no measurable quantity of oil and gas has ever been produced in the county. However, interest in the region's geology has prompted operators to continue to drill exploratory wells and collect seismic data in hopes of finding economically viable reserves.

A total of 6 wells were drilled in Beaver County between 1974 and 2008 (BLM 2016). No oil and gas (including coalbed natural gas) has ever been produced in the County and none of the wells produced any evidence of oil or gas. All of the wells were plugged and abandoned.

Interest in oil and gas exploration in the local area is currently low compared to other areas in Utah or the West, as evidenced by a low number of exploration authorizations. No competitive bids were placed for seven oil and gas lease parcels offered for sale in Iron County on May 24, 2011. However, a small number of Applications for Permit to Drill ("APDs"), possibly relating to the discovery of oil in the Sevier Frontal play (to the northeast of the planning area), were submitted in 2008. Two of these wells were drilled prior to permit expiration, and both were subsequently plugged and abandoned.

Forecast

Very light to moderate leasing and exploration interest in Beaver County is expected due to the geologic potential for undiscovered resources. Improved technology for finding oil and gas, better understanding of petroleum systems, and higher energy prices and dwindling domestic supplies could promote more industry interest in exploring the area. However, interest in

drilling exploratory wells is expected to remain low until there is a discovery. If a new field is discovered, there would be high interest levels for drilling and a widespread intensive exploration effort would ensue.

The Utah Geological Survey estimates that over the next 20 years, Southwest Utah could see drilling of 16 new wildcat wells for oil and gas, and the acquisition of up to 1,500 miles of seismic data (BLM 2011b). A considerable number of seismic surveys have been performed in this area since the 1970s. Additional future seismic surveys are anticipated when exploration interest in this area returns due to a nearby oil and gas discovery, increased oil and gas demand, or increased interest in wildcat exploration in the oil and gas industry. Because of the absence of areas with high development potential in the Cedar City District planning area, the BLM did not develop a detailed Reasonably Foreseeable Development scenario for oil and gas. Oil and gas development potential in the Basin and Range physiographic province characteristic of the planning area is very low, as evidenced by the corresponding low industry interest in this area to date.

II. OBJECTIVES

Beaver County's objectives with regard to mining and mineral/geological resources are as follows:

1. To foster mineral development within the County in a manner that fulfills Beaver County's responsibility to its citizens to protect and expand the tax base and economic activity to provide a high standard of living;
2. To protect the viability of mineral development opportunities within the County;
3. To support oil and gas leasing on public lands without burdensome stipulations; and
4. To demand that land management agencies streamline permitting processes.

III. POLICIES AND GUIDELINES

1. Beaver County believes that a mining industry is essential to the economic and physical well-being of the County and State.
2. Beaver County supports the wise use, conservation and protection of public lands and demands that public lands shall be managed for multiple use, sustained yield.
3. All available and recoverable solid, fluid and gaseous mineral resources in the county shall be seriously considered for contribution or potential contribution to the economy of Beaver County. Portions of Beaver County that are known to have reasonable

mineral potential shall be open to leasing, drilling, and other access with reasonable stipulations and conditions, including mitigation, reclamation, and bonding measures where necessary, that will protect the land against unnecessary damage and degradation to other significant resource values.

4. Existing federal oil and gas leasing conditions and restrictions shall not be modified, waived, or removed unless the lease conditions or restrictions are no longer necessary or effective.
5. Existing lease restrictions that are no longer necessary or effective shall be modified, waived or removed.
6. Restrictions against surface occupancy shall be eliminated, modified or waived where reasonable.
7. Federal land management agencies shall achieve and maintain at the highest reasonably sustainable levels, a continuing yield of energy, hard rock, and nuclear resources in those subject lands with economically recoverable amounts of such resources consistent with Utah Code § 63J-8-104.
8. Beaver County shall foster, encourage and promote the development of oil and natural gas resources in a manner that prevents the waste of those resources consistent with Utah Code § 40-6-1.
9. Applications for permission to drill that meet the standard qualifications, including reasonable and effective mitigation and reclamation requirements, shall be expeditiously processed and granted.
10. Any moratorium that may exist against the issuance of qualified mining patents and oil and gas leases, and any barriers that may exist against developing unpatented mining claims and filing for new claims, shall be carefully evaluated for removal.
11. Transportation and access routes to and across federal lands, including all rights-of-way vested under R.S. 2477, prescriptive easements and Title V are vital to the economy and to the quality of life in the County and must provide, at a minimum, a network of roads throughout the resource planning area that provides for movement of people, goods and services across public lands.
12. All federal land management plans with mineral development provisions applicable to lands in the county, shall have an environmental impact statement that clearly demonstrates:
 - a. That the planning agency has considered and evaluated the mineral and energy

potential in all areas of the planning area as if the areas were open to mineral development under standard lease agreements;

- b. The planning agency has evaluated any management plan prescription for its impact on the areas baseline mineral and energy potential;
 - c. That the development provisions do not unduly restrict access to public lands for mineral exploration and development;
 - d. The authorized planning agency has analyzed all proposed mineral lease stipulations and considered adopting the least restrictive necessary to protect against damage to other significant resource values; and
 - e. That the authorized planning agency evaluated mineral lease restrictions to determine whether to waive, modify or make exceptions to the restrictions on the basis that they are no longer necessary or effective.
13. Beaver County calls upon the federal agencies who administer lands within the County to:
- a. Fully cooperate and coordinate with the county to develop, amend, and implement land and resource management plans and to implement management decisions that are consistent with the purposes, goals, and policies described in this section to the maximum extent allowed under federal law;
 - b. Expedite the processing, granting and streamlining of mineral and energy leases and applications to drill, extract, and otherwise develop all existing energy and mineral resources located in the county;
 - c. Allow continued maintenance and necessary development of roads, power lines, pipeline infrastructure, and other utilities necessary to achieve the goals, purposes and policies described in this section;
 - d. Refrain from any planning decisions and management actions that will undermine, restrict or diminish the goals, purposes and policies of Beaver County as stated in this resolution; and
 - e. Refrain from implementing a policy that is contrary to the goals and purposes described in this resolution.

2.2 Energy Resources

This section describes the major energy resources found in Beaver County with current and potential energy development.

I. FINDINGS

Beaver County has a responsibility to its citizens to protect and expand the tax base and promote economic activity to raise the standard of living and provide necessary services to citizens and visitors. The development of energy resources boosts economic growth, contributing to the fulfillment of this responsibility. Beaver County has become a primary location for the development of energy resources in the State of Utah with development of wind, solar, biomass, geothermal and hydroelectric power.

1. Wind Energy

There are currently 102 turbines that harness wind energy in Beaver County. 80 of those turbines are located on private land with the remainder located on state and federal land. The eastern edge of the Great Basin, which reaches across Beaver, Iron and Millard counties, has the greatest potential for utility-scale wind power in Utah. Phase I of the Milford Wind Corridor Project is located in Beaver County and produces 204 Megawatts (“MW”) of wind energy.

According to studies done by the DOE National Renewable Energy Laboratory, there is high potential for wind energy throughout the central portion of Beaver County, while surrounding areas have moderate potential.

A 2009 study by the Utah Renewable Energy Zones (“UREZ”) Task Force showed multiple wind energy zones in Beaver County with sufficient average wind speeds to be developable. Four zones (two large and two small) were determined to have high development potential. See Map 6.

Having sustained high average wind speeds in proximity to large power transmission lines is necessary for development of wind energy. Beaver County is situated to take advantage of these development opportunities with its consistent wind speeds and the fortuitous location of its existing transmission infrastructure. Additional hi-capacity transmission lines are already being added to supply this energy to high demand urban markets.

2. Solar Energy

Beginning in 2003, the BLM and Department of Energy (“DOE”) initiated a series of Programmatic Environmental Impact Statements (“PEIS”) regarding renewable energy

development in western states. A solar energy PEIS was completed in 2012 and designated 19 solar energy zones (“SEZ”) in six western states. Two of the three SEZs in Utah are located in Beaver County: the Wah Wah Valley SEZ and the Milford Flats South SEZ. *See* Map 7. In addition to the SEZ’s, the BLM considers areas outside the SEZ as Variance Areas, or potential exclusion areas for utility-scale solar energy development. A Final Rule was published in the Federal Register clarifying the process for wind and solar development on BLM public lands. In 2009, the UREZ Task Force also conducted a study on solar energy and found that there were many areas in Beaver County suitable for solar energy development. *See* Map 8.

The solar energy sector has eclipsed wind, hydroelectric, geothermal and biomass combined. Beaver County currently has nine solar developments producing 258 MW of electricity, equating to 30% of Utah’s projected 847 MW of solar output in 2017. The planned 80 MW Milford 1 Solar project is still awaiting construction.”

Project	Location	Output	Size
Granite Peak	East of Milford	3 MW	18 Ac
Milford 2	East of Milford	3 MW	24 Ac
South Milford	Milford Flat	3.8 MW	24 Ac
Laho	Milford Flat	3 MW	18 Ac
Milford Flat	Milford Flat	3 MW	18 Ac
Greenville	West of Greenville	2.2 MW	13 Ac
Escalante I	North of Milford	80 MW	628 Ac
Escalante II	North of Milford	80 MW	550 Ac
Escalante III	North of Milford	80 MW	650 Ac

Potential for solar energy development in Beaver County remains high in areas near large transmission lines that cross the Milford Valley.

3. Geothermal Energy

Geothermal power is cost-effective, reliable, and sustainable and is environmentally friendly. *See* Map 9 showing sources of geothermal energy in Beaver County. There are three geothermal electric plants operating in the state of Utah, and all are located in Beaver County.

The Blundell Geothermal Power Plant at Roosevelt Hot Springs northeast of Milford has been in continuous operation since 1984. Production wells exceed 520°F with a depth range of

2,100 to 6,000 feet. The Blundell Plant produces 44.8 MW of electricity. There are plans to expand the plant to increase capacity by 30 MW.

The Sulphurdale Plant built near Cove Fort in 1985, has been in continuous operation since 2013. The production wells tap a shallow vapor dominated resource at depths ranging from 1,100 to 1,200 feet. The plant currently has the capacity to produce 25 MW. Planned expansions will increase capacity to up to 40 MW.

The Thermo Hot Springs geothermal plant, located west of Minersville, began operations in March of 2009. It currently produces 14 MW of electricity, which is contracted to the city of Anaheim, California.

UREZ found that the Sevier Thermal Area, located on the east side of the Great Basin, of which the three geothermal power plants are a part, contains an estimated 1,900 MW of potential energy from both “identified” and “undiscovered” sources. The potential for additional production here is high and would be highly beneficial to Beaver County.

4. Biomass Energy

Bioenergy is the use of biomass, such as food crops, grassy and wood plants, residues from agriculture or forestry, algae and organic components, to generate electricity. Beaver County’s biomass is primarily composed of residues from forest restoration projects that improve wildlife habitat, increase forest and rangeland health and reduces the risk of wildfire. Much of the biomass is made up of pinyon-juniper woodland, the encroachment of which has led to the degradation of habitats throughout Beaver County.

Biomass projects typically take place on federal land where the BLM has entered into stewardship contracts with small businesses, communities and non-profit organizations to take on restoration projects while harvesting biomass. Estimates of existing biomass resources are expressed in tons per acre (“TPA”) of yield. The yield level in TPA is divided into three categories of potential: low (0 to 5 TPA), medium (5 to 20 TPA), and high (more than 20 TPA). An assessment of biomass resource potential for the public lands administered by the BLM’s Cedar City Field Office showed that 51.8 percent of the land had low potential, 44.4 percent had medium potential and only 3.8 percent had high yield potential. Since there are more and more complex limitations on biomass energy production, the potential for future development in this area is low.

5. Hydroelectric Power

Beaver County has three hydroelectric power stations located on the Beaver River and a small plant located on the Mammoth canal diversion. Beaver City Electric, Light & Water owns these plants, which are operated by Beaver City. These power plants generate revenue for Beaver City while providing affordable energy to the community. The four stations have the capacity to produce 9,200,000 kW of power annually, supplying 50% of the total power consumption of Beaver City. When all stations are running at peak capacity, these plants can produce up to 66% of Beaver City's power needs. Even during seasonal low water flow, the plants are a stable and efficient power source for the community.

These aging power plants do not currently possess the capacity to generate all of Beaver City's electricity needs and must be supplemented by other sources. Because hydroelectric power is cheap, efficient and sustainable, additional developments and/or renovations should be seriously considered.

II. OBJECTIVES

Beaver County's objectives with regard to energy resources are as follow:

1. To fulfill its responsibilities to its citizens including:
 - a. To protect and expand the tax base and promote economic activity that provides a high standard of living;
 - b. To provide the necessary county services for its residents and visitors;
 - c. To provide a quality environment for the enjoyment and use of its citizens, including protection of local values and lifestyles;
 - d. To represent the interests of its residents in coordinating the planning, management and regulatory activities of other local, state and federal agencies; and
 - e. To protect the private property rights of its citizens including their ability to make choices concerning the development of resources on their land in harmony with community plans and zoning ordinances;
2. To take a more central role in the planning, management, and regulatory activities of federal, state and local agencies;
3. To demand that public land management agencies produce and maintain desirable vegetation for watershed protection, healthy timber, wildlife forage and livestock forage that is necessary to meet present and future needs and future economic growth and community expansion without permanent impairment of the productivity of the

land; and

4. To enhance and expand hydroelectric energy production on the Beaver River.

III. POLICIES AND GUIDELINES

1. Beaver County supports the wise use, conservation and protection of public lands and their resources, including well-planned management prescriptions. It is the County's position that public lands be managed for multiple uses, sustained yield, the prevention of natural resource waste and the protection of cultural and historic uses. It is important to the county economy that public lands be properly managed for fish and wildlife, livestock production, timber harvest, recreation, energy production, mineral extraction and the preservation of natural, scientific and historical values.
2. Transportation and access routes to and across federal lands, including all rights-of-way vested under R.S. 2477, prescriptive easements and Title V are vital to the economy and to the quality of life in the Beaver County. Land managers must provide, at a minimum, a network of roads throughout the resource planning area that provides for movement of people, goods and services across public lands.
3. Beaver County supports the development of energy resources on public lands, subject to valid existing rights.
4. Beaver County supports and defends public grazing rights; any removal, denial or termination of existing grazing rights must be justly compensated.
5. Beaver County has a policy of No-Net-Loss of grazing annual unit months ("AUMs") on public lands. Any changes in grazing use shall only be the temporary suspension of AUM's due to drought or other natural occurrences and shall be based on monitoring data of at least five (5) years.
6. Beaver County supports the expansion and enhancement of hydroelectric energy production and development, specifically on the Beaver River. Beaver County will explore opportunities to allow for increasing the benefits of hydroelectric power to its communities. Beaver County will also oppose any current or future law banning or limiting hydroelectric energy production.
7. Beaver County will take any and all appropriate actions to protect private property rights and the use of those lands, pursuant to county zoning ordinances.
8. All federal land management plans and actions pertaining to energy development on public lands in the county, shall have an environmental impact statement that clearly demonstrates:

- a. That the planning agency has considered and evaluated all existing permits, rights and cultural uses on those lands selected for utility-scale development or other right of way (“ROW”) applications; that mitigation strategies will address the loss of any permitted uses, including potential economic losses to permittees.
 - b. The planning agency has evaluated mitigation measures for grazing allotments affected by a proposed energy development; that vegetation treatments are proposed for the affected allotment to enhance forage and protect against AUM loss;
 - c. That the development does not unduly restrict access to public lands for historic and permitted uses;
 - d. The authorized planning agency has analyzed all structures, water improvements, ROW’s, range improvements and other resources prior to approving any proposed energy development; and has endeavored to select the least invasive locations to protect against damage or impairment to improvements and loss to significant resource values.
9. Beaver County calls upon the federal agencies who administer lands within the county to:
- a. Account for all existing rights and permitted uses of the land;
 - b. Mitigate any loss of forage. The mitigation strategy must include grazing AUMs;
 - c. Account for range improvements in any scoping or NEPA process;
 - d. Have all NEPA analysis completed and mitigations approved before any rangeland is taken out of production.;
 - e. Fully cooperate and coordinate with the County to develop, amend, and implement land and resource management plans and to implement management decisions that are consistent with the purposes, goals, and policies described in this section to the maximum extent allowed under federal law;
 - f. Maintain and enhance desired plant communities that benefit watersheds, wildlife, water quality, recreation, and sustainable livestock grazing;
 - g. Allow continued maintenance and necessary development of roads, power lines, pipeline infrastructure, and other utilities necessary to achieve the goals, purposes and policies described in this section;

- h. Refrain from any planning decisions and management actions that will undermine, restrict or diminish the goals, purposes and policies of Beaver County as stated in this resolution; and
- i. Refrain from implementing any policy that is contrary to the goals and purposes described in this resolution.

3. AGRICULTURE

3.1 Agriculture

I. FINDINGS

Agriculture, by definition, is the cultivation of plants and animals for the production of food, fiber, fuel and other products. Beaver County has been an agriculture-based economy since the first Mormon settlers arrived in the Beaver Valley in 1856 to farm and raise livestock in the abundant green meadows. For 160 years, the social customs, culture and character of the County have been founded on agriculture and the natural resources that support it. Founded in 1870 by livestock growers, the town of Milford soon became a shipping hub for livestock when the railroad arrived in 1880 enabling cattle and sheep to be quickly shipped to Salt Lake City. The Milford Valley became the crop production center for the area with its broad flat landscape and a supply of water from the Beaver River.

The 2012 Census of Agriculture indicates there are 277 farms or ranches in Beaver County occupying 190,000 acres of private land. The average farm size is 686 acres and the average land value is \$1,997 per acre. The average farm is valued at \$1,370,000. Of the county's 1,657,656 total acreage, agriculture activity occupies 11.5% of the land. The County had 37,000 acres of cropland, of which 32,000 acres were irrigated and harvested. Alfalfa is the dominant crop with 125,000 tons produced. Corn is the second leading crop with 284,400 bushels of grain and 35,000 tons of silage produced.

Beaver County leads all counties in Utah in total market value of agricultural products at \$288.5 million as well as total livestock revenues valued at \$266.9 million. This is primarily attributable to the commercial hog production facilities in the County. In cattle production, there were over 21,000 head of cows in the county, of which 13,000 were raised for the beef market. The number of dairy cows has fallen to about 700 in 2012.

Cattle numbers have declined in recent years in Beaver County due in small part to the recent downward trend in beef prices. Additionally, Federal agencies have been reducing AUMs on public land grazing allotments while simultaneously, wild horse populations have surged above appropriate management levels, depleting available forage. Once a mainstay in Beaver County, dairy farms have nearly disappeared in the County. Where there were once dozens of dairies, now only 2 remain operational with only a few hundred head of cows.

The agricultural trends over the past 25 years indicate the total amount of agricultural land has remained relatively stable in Beaver County as very little land is being lost to residential

development. Statewide, farmland is declining as urbanization expands and land values soar. In Beaver County, the number of farms is increasing, but the average size of each farm is diminishing. The amount of irrigated cropland has fluctuated over the years, depending on markets and weather patterns, however, more land is being irrigated with sprinkler systems, and increasing crop yields while conserving precious water resources.

Although Beaver County has only marginal cropland, water is the limiting factor for growing crops. Because of the arid landscape and climate, irrigation is a necessity and finite water resources limit the potential crop production capability of available farmland. Small gains in production will invariably come from investments to incorporate more closed irrigation systems. On the other hand, commercial hog production is well established in Beaver County and further growth and expansion are planned, providing a huge economic benefit to the county.

Although the majority of jobs in Beaver County are government, trade and service related, agriculture continues to play a very significant roll. The 2012 Census of Agriculture indicated that 66% of farmers/ranchers derived their primary living from their agricultural operations. A 2015 report by Headwaters Economics indicated that 15% of the employment in Beaver County was farm or agriculture jobs, compared to only 1.4% nationally.

Grasshoppers and Mormon crickets do considerable damage to agricultural crops and gardens. The Utah Department of Agriculture and Food (“UDAF”) in conjunction with U.S. Department of Agriculture (“USDA”) Animal and Plant Health Inspection Service (“APHIS”) surveys and monitors the yearly populations of these insects. An annual report is published by UDAF showing population trends and locations of infestation problems. APHIS oversees the control of grasshoppers and Mormon crickets on public land.

The legal protection of fertile agricultural lands is important to preserve those lands for continued production from future development and degradation. The Agriculture Protection Act passed by the Utah Legislature was aimed at: (1) protecting landowners from unreasonable restrictions from state and local agencies on farm structures and practices; (2) protect landowners from nuisance lawsuits; (3) serve notice to prospective home buyers of the protected status of farming operations nearby; and (4) protect landowners from zoning changes.

The Utah Farmland Assessment Act (“UFAA”), or “Greenbelt Act,” was passed to give property tax relief to those lands and properties associated with agricultural production. This legislation was aimed at agricultural land retention through lower assessed tax rates. These open “green spaces” make communities more desirable and livable and improve air quality while limiting urban sprawl.

Many County zoning ordinances and laws are designed to protect agricultural use of the

land by limiting residential dwellings and developments from infringing on valuable open space prioritized for agriculture and farming. Every residential or commercial development that builds on agricultural land, displaces that land forever from agricultural use. Each residential home built re-allocates a measure of water for domestic use that is ultimately taken away from the water available for agriculture.

II. OBJECTIVES

Beaver County's objectives with regard to agriculture are as follows:

1. To preserve and protect the agricultural lifestyle, heritage, culture and rural character of the County;
2. To actively coordinate with federal and state agencies to foster management goals and decisions that are favorable to the County's agricultural industry;
3. To take action to encourage responsible stewardship of water and rangeland resources to foster a strong agriculture based economy; and
4. To adopt policies and principles that promote local agriculture to increase the state's food security while decreasing its dependence on imported food and produce.

III. POLICIES AND GUIDELINES

1. It is the policy of Beaver County that prime, fertile lands and soils, vital to agricultural production, shall be preserved and protected. Agricultural zoning regulations are important to that cause and shall be judiciously enforced.
2. Beaver County encourages the use of efficient and well-maintained irrigation delivery systems to preserve precious water resources.
3. Beaver County will support and promote efforts to control grasshoppers and Mormon crickets where feasible, and encourages USDA APHIS to continue treating these insects on public lands.
4. Agricultural and residential lands are not natural "historic" habitat for prairie dogs. Utah prairie dogs shall be removed from private lands and relocated on suitable federal lands. No prairie dogs shall be translocated within 5 miles of cultivated agricultural lands or residential areas.
5. Livestock grazing on federal lands shall be preserved in furtherance of Beaver County's no-net-loss of AUMs policy.

6. The UDWR must make efforts to mitigate agricultural damage from wildlife and shall maintain wildlife populations at objective population levels.
7. The use of tools including, but not limited to, livestock grazing, chemical treatments, and mechanical control is critical to protecting ecosystem health from invasive species and noxious weeds.
8. Farms and ranches constitute small business under the Regulatory Flexibility Act and shall be duly identified, analyzed and disclosed in NEPA documents.
9. Beaver County encourages land management agencies to maximize vegetative treatment efforts on public lands. The use of WRI funding to treat rangelands and the resultant forage increases shall be duly apportioned to livestock AUMs.
10. Beaver County opposes grazing buyouts, or any attempt to retire grazing AUMs. Permittee retired AUMs shall be re-allocated to other qualified grazers.
11. Beaver County opposes converting surface water shares to groundwater, which places greater demand on depleted groundwater resources.
12. Beaver County supports wildland fire use on rangelands and encourages prescribed burns where appropriate.
13. Managed livestock grazing is an appropriate management tool for both revegetation and fuel reduction.
14. The custom, culture and heritage of farms, ranches and agriculture shall be analyzed and disclosed in all NEPA reviews and land use plans.

3.2 Livestock and Grazing

I. FINDINGS

Livestock are defined as domesticated animals raised in an agricultural setting to create food, fiber, labor, or other products. Grazing is defined as a method of feeding whereby domestic livestock consume plant material and convert it into meat, milk, and other products. The practice of raising livestock and grazing animals is considered part of agriculture. Livestock and grazing are part of the culture, history and economic base of Beaver County. With over 77% of the land in Beaver County under Federal control, grazing on public land is vital to the agricultural industry of the county.

The first Mormon pioneers to settle in the Beaver area came from Parowan in 1856, bringing with them the livestock they relied on for food, labor and transportation. Parley P. Pratt, a Mormon leader, passing through the area six years earlier, wrote: “This is an excellent place for an extensive settlement.” The grassy meadows and sloughs flanking the Beaver River would provide prime grazing and hay for their livestock. The mountains and desert valleys would provide additional grazing forage to support the agriculture-based settlement. By the 1880’s, large numbers of cattle and sheep were being raised in Beaver County as it became a center for livestock production in southwestern Utah.

Throughout the early settlement period of Utah, as well as the western frontier in general, livestock grazing on federal or “public” land was undertaken without restriction. Cattle and sheep flourished on the verdant mountain grasses and livestock numbers soared. However, with the unregulated grazing came problems. Overgrazing, particularly by large sheep herds, denuded the land in many areas, causing erosion and watershed disasters. There were constant conflicts between livestock owners over the use of the land and who owned the rights to graze where and when. In response to these problems, Congress passed the Taylor Grazing Act in 1934, which led to the creation of grazing districts in which grazing use was apportioned and regulated. The Division of Grazing was created within the Interior Department to administer the grazing districts. This division later became the U.S. Grazing Service and was headquartered in Salt Lake City. In 1946, the Grazing Service was merged with the General Land Office to become the BLM. Similar legislation was later passed under the name Granger-Thye Act (1950) to regulate grazing on the National Forest System lands.

With the passage of the Taylor Grazing Act came new management structure for regulating grazing and protecting natural resources. To control animal movement and enhance grazing activity, fencing and water developments were put in place. Forage surveys were implemented to balance resource demands with range productivity and carrying capacity. The ranchers who utilized the land had a greater vested interest in their stewardship of those lands as grazing rights were created. But by the 1960’s, regulation of public lands began to tighten as ever more restrictive federal policies were enacted and management goals began to change. New laws such as the NEPA, the ESA, NFMA, and FLPMA diverted management attention away from grazing and forage production to the “environmental protection” concerns raised by special interests groups. The result has been endless environmental studies, a backlog of litigation, ongoing bureaucratic delays, heavily prioritized management of riparian areas, sensitive species and special land status designations, and far less emphasis on range improvement activities and forage production. With the passage of FLPMA, BLM’s mission was altered to require overprotection of the public lands rather than utilization. However, FLPMA did not repeal the Taylor Grazing Act.

Today, federal agencies regulate livestock grazing in a manner aimed at achieving and maintaining health of the land and sustaining resources. To achieve desired conditions, the

agencies use forest and rangeland health standards as a guide. Standards describe specific conditions needed for long term sustainability, such as the presence of streambank vegetation and adequate canopy cover. Guidelines are developed to direct management strategies that achieve or maintain healthy lands and ecosystems as defined by the standards. Grazing management strategies designed to attain these standards may include periodic rest, rotation or deferment from specific allotment usage, water developments, and vegetation treatments that increase forage production.

After the passage of the Taylor Grazing Act, the Grazing Service, through advisory boards, created an adjudication process to determine where, when and what type of livestock grazing could occur on public rangelands. To receive an allotment through this process, the stockman had to have (1) “commensurate base property” on which he could graze his livestock when they were not using federal lands, (2) have an economically viable livestock operation and (3) be members of the local community and support the local economic stability of the community.

Current authorized grazing levels were established from 1940 to 1965, during which time the BLM completed livestock forage inventories to establish estimated grazing capacity. These levels have been adjusted over the years to accommodate fluctuations in production capabilities and use by other species. Livestock grazing is regulated by the use of AUMs. This terminology refers to the amount of forage needed to sustain one cow or five sheep for one month. 100 AUM’s would equate to 100 cows for one month or 10 cows grazing for 10 months. Since 1940, data from the BLM indicates that grazing AUM’s for livestock have been reduced by more than two-thirds, from 2,749,000 down to only 675,000 AUM’s in 2009. Almost as dramatic, AUM loss on Forest Service lands over the same time period has been reduced by half. These reductions in AUM’s from the federal agencies are a result of burgeoning regulatory restrictions, modified terms and conditions on grazing permits, inflexibility within federal policies and numerous rangeland factors including: uncontrolled pinyon/juniper expansion, noxious weed invasion, altered fire regimes, reduction in the sheep industry, expansion of wildlife populations and the over-population of wild horses, etc. A new modern threat is the effort of special interest groups to eliminate grazing on public lands through aggressive marketing, lobbying, and litigation.

During the 2006 Utah legislative session, in response to these declines in grazing, the Rangeland Improvement Act was passed (HB 145). The bill provided for the establishment of a State Grazing Advisory Board and six regional advisory boards to improve the grassroots voice of both private and public land grazers. A new division was then established within the Utah Department of Agriculture and Food, known as the Utah Grazing Improvement Program (“GIP”). The mission of GIP is to “improve the productivity, health and sustainability of our rangelands and watersheds.” The GIP program operates under the basic belief that “well planned and managed livestock grazing is the most important landscape scale tool for maintaining healthy rangelands, watersheds, and wildlife habitats” and that “healthy rangelands contribute to

a healthy livestock industry and productive rural economies.”

Grazing is one of the earliest and most important uses of public lands in Beaver County. This activity continues to be an important use on those same lands today. “Livestock Grazing in Utah: History and Status”, a 2008 study of grazing in the state of Utah by the governors Public Lands Policy Coordinating Office showed that livestock and livestock products accounted for 93.7% of the total agricultural cash receipts in Beaver County, the highest in the state. This study gave clear evidence of the importance of public land grazing to individual livestock producers and the industry as whole, by showing 1) the number of animals raised by permit holders was much larger than those without permits, 2) ranching operations having permits were more dependent on livestock production than those without, 3) permittee operations commonly involved more than one family while non-permittee operations were single-family businesses, 4) most livestock operations were multi-generational family businesses, especially permittee based operations, 5) livestock producers buy and sell locally, impacting local economies more directly than other business, 6) grazing public lands reduced producers’ dependency on hay as a source of feed, 7) livestock grazing has a positive influence on fire suppression, 8) the cattle industry has become the dominant sector in Utah agriculture.

II. OBJECTIVES

Beaver County’s objectives with regard to livestock and grazing are as follows:

1. To fulfill Beaver County’s responsibility to its citizens to protect and preserve livestock grazing on public lands as an important historic, cultural and economic activity;
2. To maintain the AUM’s at current levels and encourage increases as range conditions provide;
3. To improve range conditions through vegetation treatments and proper management, allowing for an appropriate increase in livestock grazing;
4. To demand that federal agencies manage for multiple use and sustained yield as mandated by federal law;
5. To encourage the proper use of monitoring systems and insist that agencies refrain from their misuse in issuing non-compliance responses; and
6. To demand proper management of wild horse populations as directed by federal law and county policy.

III. POLICIES AND GUIDELINES

1. Environment:

- a. It is the County's policy that rangelands should be classified according to their productive potential. Ecological sites are the most widely accepted basis for this and shall be used as the basis for interpreting monitoring data, management planning and assessing rangeland health.
- b. It is the County's policy that land managers shall give high priority to completion of soil surveys where lacking. Soil surveys are very useful as a basis for identifying and mapping ecological sites, predicting erosion, identifying adapted species, etc.
- c. Any adjustments to stocking rates must be based on monitoring of actual stocking, utilization, and trends in range vegetation and soil. Livestock carrying capacity is not a biological constant. Therefore, the "stock and monitor" approach (synonymous with adaptive management) shall be pursued.
- d. Turnout dates on seasonal ranges must be flexible and determined as part of a year round plan to meet the needs of the rangeland, livestock and other uses, not rigid "range readiness" requirements.
- e. Federal agencies shall manage public lands for multiple use and sustained yield, including maximizing forage resources for grazing.
- f. Noxious and invasive species shall be controlled or eradicated.
- g. Locally led planning efforts, such as resource management plans, should be used to ensure all resources and uses are protected.
- h. Soils and range site data should be used to create site-specific objectives in resource management plans.
- i. Land managers shall maintain and enhance desired plant communities that benefit watersheds, water quality, wildlife, livestock, and achieve rangeland health standards.
- j. Seed mixes for all reclamation efforts must be beneficial to both livestock and wildlife and developed on a site-specific basis.
- k. Temporary fences should be removed as soon as they are eligible for removal, unless they are converted and utilized as range improvements in consultation

with permittees.

- l. Permittees shall be given a clear explanation of the standards and guidelines used in the assessment of rangeland health, and shall have meaningful involvement in reviewing monitoring data and assessing rangeland health.
 - m. Adaption of livestock grazing management to meet management objectives, policies or guidelines for threatened or endangered species must be based on sound scientific information and relevant to the local area.
2. Monitoring:
 - a. Proper resource monitoring systems shall be developed and implemented for forage utilization on all allotments, as agreed to by permittees.
 - b. Utilization and stubble height measurements are management tools useful for grazing management, analyzing grazing patterns, interpreting cause and effect relationships and helping interpret monitoring data. They are not, however, management objectives.
 - c. Stubble height measurements may be used as “trigger indicators” of grazing pressure to help guide livestock pasture moves, as agreed upon by the permittee. However, use of trigger indicators does not mean livestock must be removed immediately to avoid exceeding the stubble height limit, nor shall they be used for issuance of non-compliance rulings in violation of the terms and conditions of the Term Grazing Permit or Annual Operating Instructions.
 - d. Utilization and/or stubble height “standards” are not management objectives and shall not be used in land use or resource management plans.
 - e. If stubble height measurements are used as a guideline in grazing plans or AOIs, they must be clear and detailed in specifying the location, time, method, and species of plants on which measurements will be based; specific directions shall be given on whether one key species, several key species or all forage plants are measured; the selection of designated monitoring areas must be agreed to by permittees. All ground rules for measurements must be clearly spelled out.
 - f. Attributes measured in monitoring systems must have a known relationship to desired conditions and management objectives and be capable of objective observation or measurement.
 - g. Monitoring methods chosen shall be appropriate to the type of vegetation to be measured, seasonal application and effectiveness of use.

- h. Unless random sampling is used, monitoring site locations shall be agreed upon by permittees.
 - i. Monitoring systems and the interpretation of data should be carried out only by those people with adequate training and experience in the local area.
 - j. Monitoring data must be repeatable. By definition, monitoring is comparing data collected at two or more times to detect changes as a measure of external influence. Data is unusable unless the collection methodology can be repeated.
 - k. When range monitoring data is collected from “key areas” or important ecological sites, chosen to represent the effects of grazing, the information shall not be extrapolated to represent the allotment as a whole. Stubble height measurements collected within an allotment shall not be used for establishing range trends, to assess rangeland health or to influence management actions.
 - l. Monitoring systems shall be developed to separate resource use by species (e.g., wild horses, wildlife, or livestock) to inform management decisions. If a resource problem is occurring, the source of the problem must be positively identified in order to tailor a proper management response.
3. Rangeland Improvement Projects:
- a. Vegetation treatments shall be applied to encroaching and undesirable species in range projects such as pinyon/juniper, Russian olive, Halogeton and Rabbit Brush.
 - b. Federal agencies shall restore and enhance forest and rangelands to a condition that supports the suspended, existing and potential increase of AUMs for those lands.
 - c. Utilize native and non-native seed mixtures in vegetation treatments that are appropriate to management objectives, are adapted to the site conditions and are highly resistant to and/or competitive with invasive and noxious weeds.
 - d. Agencies shall coordinate with permittees to identify and prioritize where range improvement funds are spent, based on allotment category and need.
 - e. Range improvements must be kept functional or maintained in a timely manner, whether by the grazing permittee or the responsible agency.
 - f. Land managers shall prioritize reseeding and noxious weed control within areas burned by fire.

- g. Encourage the development of a Programmatic Categorical Exclusion for the allowance of specific range improvements to be installed in a timely manner.
 - h. Beaver County opposes any acquisition of water rights by the BLM or USFS in the course of authorizing range improvements.
4. Permits/AUMs:
- a. Beaver County strongly advocates no-net-loss of AUMs.
 - b. Adaptive grazing programs shall be created that allow permittees to respond to changes in forage availability and climate variability such as on/off dates, extended shoulder dates, intensity, duration, pasture rest and rotation schedules.
 - c. It is the County's policy that all term grazing permit renewals, including allotment improvements, will be processed in a timely manner.
 - d. Categorical Exclusions for term grazing permit renewals should be used when (1) renewal of the permit is under substantially the same terms and conditions as the existing permit; (2) monitoring data shows that the allotment is at or making substantial progress toward meeting rangeland health standards; and (3) no extraordinary circumstances exist such as conflicting uses, threatened species, special status lands, etc.
 - e. Permanent retirement of any grazing allotment is unacceptable.
 - f. Suspended AUMs should be analyzed and reinstated as expeditiously as possible, within a period not to exceed 3 years .
 - g. Vacant allotments should be prioritized for NEPA analysis to provide availability for livestock grazing.
 - h. Adaptive management practices for grazing should be developed in term grazing permits to allow for fuel load reductions, particularly in cheatgrass infestations or other heavy understory.
 - i. Rested or other available allotments should be temporarily assigned to permittees whose grazing permits have been suspended because of fire or other resource disrupting activities.
5. Reduction in AUMs:
- a. Beaver County's policy is that there shall be no-net-loss in AUMs. Grazing reductions or suspended AUM's caused by degraded range conditions shall be

restored as resource conditions allow.

- b. Livestock grazing should be returned to pre-fire levels when post-fire monitoring data shows objectives have been met, or the site potential has been achieved.
 - c. Changes in class of livestock and permit transfers should be completed without reductions in AUMs and in a timely manner.
 - d. Reductions in domestic livestock grazing AUM's to provide additional forage for another species over its population objective (i.e., wild horses above appropriate management levels ("AMLs")) is unacceptable.
 - e. AUMs on federal lands shall not be reduced unless documented resource conditions show failure to meet rangeland health standards for 5 consecutive years.
- 6. It is the policy of Beaver County that the guiding principle for managing livestock is adaptive management, i.e. clearly defining objectives, developing strategies to achieve objectives, consistent monitoring, and adjustment as needed. This approach provides flexibility in allotment rotations, on/off dates, duration, intensity, etc.
 - 7. Beaver County formally recognizes the historic significance of livestock grazing and its value as a cultural resource.
 - 8. Wild horses shall be managed in strict conformance with existing laws. Populations shall be limited to established AML's, anything over AML is considered excess.
 - 9. Beaver County encourages vegetation treatments and habitat enhancement projects on the Mountain Home allotment for wild horse use, in order to reduce grazing conflicts on adjoining active allotments.
 - 10. Pursuant to the Endangered Species Act (Sec 4(b)(2)) any agency declaring critical habitat must take into consideration the economic impact, and any other relevant impact, of specifying any particular area as critical habitat, including impacts to grazing.
 - 11. Beaver County calls upon the federal agencies who administer lands in the county to:
 - a. Fully cooperate and coordinate with the County to develop, amend, and implement land and resource management plans and to implement management decisions that are consistent with the purposes, goals, and policies described in this plan to the maximum extent allowed under federal law;
 - b. Follow existing laws and policies pertaining to wild horse management on lands they administer;

- c. Refrain from any planning decisions and management actions that will undermine, restrict or diminish the goals, purposes and policies of Beaver County as stated in this resolution; and
 - d. Coordinate with the County as a cooperating agency on all applicable land use plans and NEPA analysis.
12. Land managers shall take actions and make decisions that are designed to achieve the following conditions:
- a. Range/Watershed Condition: Upland rangelands shall have vegetation cover and composition which will insure sustained productivity considering site potential and historical impacts; Range and watershed health is determined based on best available science and experience without reference to intended uses; Assessment of range/watershed condition is based on establishing the kind and amount of vegetation that will furnish soil protection and useful vegetation production considering the potential of the site, not necessarily restoring “natural” conditions.
 - b. Water quality: Water quality meets State standards that reflect appropriate uses and local potential to meet standards.
 - c. Noxious Weeds: Noxious and invasive weed infestations are detected early and controlled by chemical, mechanical, or biological means.
 - d. Desert Shrub: Desert shrub types (greasewood, blackbrush, salt desert shrub, etc.) are managed to maintain a dominance of shrubs with a good understory of perennial grasses and forbs (depending on site potential). Invasive annuals are absent or of minor extent.
 - e. Big Sagebrush: Big sagebrush (Basin, Wyoming and Mountain Big Sagebrush) are manage to maintain a good understory of perennial grasses and forbs with an overstory of big sagebrush and browse shrubs (on appropriate sites). Invasive annuals are absent or of minor importance. Prescribed grazing and periodic brush treatments are used to prevent loss of the perennial understory and complete dominance of mature sagebrush. Landscapes exhibit a diverse mix of sagebrush communities ranging from almost all perennial grass and forbs to moderately dense stands of sagebrush, depending on treatments applied and the time since treatment. Sites having the potential to support productive sagebrush/grass communities have pinyon/juniper completely removed or reduced to a minor component depending on site-specific management objectives.
 - f. Pinyon-Juniper: Pinyon and juniper (PJ) is eliminated or reduced on any site that has the potential to support grassland, sagebrush grassland, or other vegetation

types more useful in terms of watershed condition and resource outputs, unless it has been determined, on a site specific basis that PJ does not jeopardize watershed condition and add to the combined resource outputs and values on the site. On sites where PJ occurs that do not have potential for good perennial grass and shrub cover, or where technology is lacking to establish such cover by reasonable efforts, PJ stands are maintained in an open canopy state when possible to prevent catastrophic wildfire and stand replacement with invasive annuals.

- g. Aspen: Aspen stands have a good understory of forage plants for livestock and wildlife; encroachment of coniferous trees is controlled.
- h. Ponderosa Pine: Ponderosa pine stands are maintained in an open condition that will support a good understory of perennial grasses and browse plants and periodic low intensity fire. Encroachment of shrubs or excessive density of pine reproduction that can support stand replacing crown fires is prevented.
- i. Mixed Conifer: Mixed conifer stands are prevented from invading other forest types or mountain grasslands.
- j. Riparian: Riparian areas are managed to prevent excessive erosion and deposition of sediment and impaired water quality that results, with recognition that these processes may have begun in the past due to natural and/or human caused factors and may continue far into the future regardless of the management applied.

References:

BLM. 1999. Utilization studies and residual measurements. Interagency Technical Reference 1734-3.

Burkhardt, J. Wayne. 1997. Grazing utilization limits: an ineffective management tool. *Rangelands* 19:8-9.

Clary, Warren P. and Wayne C. Leininger. 2000. Stubble height as a tool for management of riparian areas. *Journal of Range Management* 53:562-573.

Cleary, C. Rex, Sheila Anderson, Don Henderson, and John McLain. 2008. Viewpoints: The quandary over short-term indicators. *Rangelands* 30:37-39.

Frost, William E., E. Lamar Smith, and Phil R. Ogden. 1994. Utilization guidelines. *Rangelands* 16:256-259.

Holechek, J.L., R.D. Pieper, and C.H. Herbel. 2000. Range management: principles and practices. Fourth Edition. Prentice Hall.

Holechek, Jerry and Dee Galt. 2004. More on stubble height guidelines. *Rangelands* 26:3-7

Laycock, W. A. 1998. Variation in utilization estimates caused by differences among methods, years, and observers. In: *Stubble Height and Utilization Measurements: Uses and Misuses*, Western Regional Coordinating Committee 40; Oregon State University Station Bulletin 682

McKinney, Earl. 1997. It may be utilization, but is it management? *Rangelands* 19(3)4-7.

Rasmussen, G. A. 1998. Interpretation of utilization and long-term frequency measurements for rangeland management. In: *Stubble Height and Utilization Measurements: Uses and Misuses*. Western Regional Coordinating Committee 40; Oregon State University Station Bulletin 682

Sanders, K.D. 1998. Utilization standards: the quandary revisited. In: *Stubble Height and Utilization Measurements: Uses and Misuses*. Western Regional Coordinating Committee 40; Oregon State University Station Bulletin 682

University of Idaho Stubble Height Review Team. 2004. University of Idaho stubble height study report. Moscow, Id, USA: University of Idaho Forest, Wildlife & Range Experiment Station Contribution No. 986. 26 p.

3.3 Water Rights & Irrigation

I. FINDINGS

Water Rights:

Utah is one of the driest states in the nation, and water is one of Beaver County's most precious natural resources. Water in Beaver County is a scarce resource, and needs to be developed to the maximum extent possible to promote productive and enjoyable harmony between man and his environment. Beaver County's water supplies have been carefully managed through established law, and developing any significant new supplies may be difficult and costly.

As set forth in Section 73-1-1 of the Utah Code, all waters of the state are owned exclusively by the state in trust for its citizens. These waters are subject to appropriation for beneficial use; and are essential to the future prosperity of the County and the quality of life within the county. As set forth in Section 73-1-3, this beneficial use shall be the basis, the measure and the limit of all rights to the use of water in the state. A "water right" is a right to divert water from its natural source to use it beneficially. The defining elements of a typical water right will include:

- A defined nature and extent of beneficial use;

- A priority date;
- A defined quantity of water allowed for diversion;
- A specified point of diversion and source of water; and
- A specified place of beneficial use.

The State of Utah will consider issuance of a water right after analysis of several factors, including the following:

- The availability of unappropriated water at the source;
- The proposed appropriation will not impair existing water rights;
- The proposed appropriation of water is physically and economically feasible at the location;
- The proposed appropriation is not monopolistic or based on speculation;
- Whether the proposed appropriation is in the public interest and promotes public welfare; and
- Whether the proposed appropriation will adversely affect the natural stream environment or public recreation.

The State of Utah has the right to develop and use its entitlement to interstate rivers for the benefit of all citizens. All water rights desired by the federal government must be obtained through the state water appropriation system.

Irrigation:

Agriculture is part of Beaver County's culture and heritage, and is vital to community and socioeconomic stability. Beaver County contains approximately 139,000 acres in farms or ranches, with an average size of 544 acres. The County also has about 52,000 acres in cropland, of which 36,000 are irrigated. Today, crops are mostly irrigated with sprinkler systems, though historically they were irrigated using the original "flooding" irrigation method. In 2010, the U.S. Geological Survey indicated 44.4 million gallons of water were being pumped from groundwater sources for irrigation per day. 33.4 million gallons a day were from surface water sources, or flood irrigated. The sprinkler systems irrigated 24,000 acres, but only 9,000 acres were flood irrigated. Irrigation is a necessary component of agriculture, however, water must be protected and conserved through land management practices and irrigation delivery systems must be more efficient.

II. OBJECTIVES

Beaver County's objectives with regard to water rights and irrigation are as follows:

1. To retain adequate water to meet its diverse current and future needs;

2. To demand that federal, state, and local entities come to a definitive resolution of federal reserved water rights consistent with the provisions of this RMP.
3. To demand that the State of Utah resolve issues regarding ownership of water rights on federal lands for wildlife, livestock, and other authorized purposes;
4. To demand that land managers recognize Beaver County as the primary headwaters of the Beaver River and actions in Beaver County impact numerous activities downstream;
5. To ensure that the flow of current and future irrigation waters across federal lands are unimpeded and efficient;
6. To ensure that appropriate irrigation related resources are added to the County's list of historic and cultural resources and landmarks;
7. To stop the encroachment of pinyon-juniper woodlands, undesirable riparian vegetation, and cheatgrass, all of which negatively impact water quality, quantity, and irrigation resources in Beaver County and for downstream users; and
8. To oppose plans and/or policies on federal lands that limit development of, or access to, water and irrigation resources.

III. POLICIES AND GUIDELINES

1. Beaver County will coordinate with federal, state, and local entities on a definitive resolution of federal reserved water rights consistent with the provisions of this plan. Beaver County also desires that the State of Utah resolve issues regarding ownership of water rights on federal lands for wildlife, livestock, and other authorized purposes.
2. Utah State Water Laws of Prior Appropriation Doctrine and Beneficial Use are recognized as the legal basis for perfecting all water rights for the use of all water within Beaver County.
3. Privately held water rights shall be protected from federal and/or state encroachment or coerced acquisition. Beaver County opposes any movement toward nationalization or federal control of Utah water rights and water resources.
4. State water right filings held by individuals, culinary water districts, or corporations are a private property right that may be sold, exchanged, or held separately from the land by any entity.

5. Any proposed sale, lease or exchange of water rights involving a public land management agency shall address the interests of Beaver County and such sale must include appropriate mitigation.
6. Water development must be prioritized over other multiple use/sustained yield activities unless otherwise approved by the Beaver County Commission.
7. Water related issues shall be coordinated with Beaver County and managed consistent with Beaver County's RMP to the maximum extent allowed by law. Issues associated with federal reserved water rights should be resolved in accordance with law and consistent with this RMP.
8. Irrigation should be preserved, improved, and enhanced, and federal land managers should support the improvement of irrigation on private lands through appropriate actions on federal lands.
9. Land managers implement avoidance, minimization and mitigation techniques and best management practices to support irrigation while allowing appropriate multiple use/sustained yield activities to proceed.
10. All federal agency actions shall recognize legal canal and ditch easements and rights-of-way.
11. Many artificial riparian areas or wetlands are created by fugitive water from irrigation systems. Creation or maintenance of an artificial wetland is contrary to the intent of conservation; Beaver County does not accept or recognize these artificial wetlands or riparian zones in environmental assessments or NEPA studies.
12. Beaver County will cooperate and coordinate with water companies, irrigation companies, conservation districts, state agencies, federal agencies and other partners to manage and develop current and future irrigation and water resources.
13. NEPA analysis for projects that impact irrigation resources shall include detailed socio-economic impacts to irrigators, especially small farmers, water companies and municipalities. Provisions of the Regulatory Flexibility Act will serve as a model for such analysis.
14. Consistent with ecologic site descriptions and based on a 10 year rolling average, land managers shall restore a sufficient amount of Class II and Class III pinyon-juniper woodlands to desirable native and/or non-native sagebrush or grassland communities in order to protect, preserve, improve, and enhance irrigation resources in Beaver County.

3.4 Noxious Weeds

I. FINDINGS

Utah Code Title 4, Chapter 17 (the “Utah Noxious Weed Act”) provides for the control of noxious weeds in Utah. Utah Administrative Code R68-9, effective January 1, 2017, designates the weeds named below, as “noxious” for the State of Utah. A “Noxious Weed” is as any plant deemed to be especially injurious to public health, crops, livestock, land, or other property. Pursuant to Utah Code §§ 4-2-2(k) and 4-17-3, the Commissioner of Agriculture and Food may designate weeds as noxious and undertake control and containment actions.

Class 1A: Declared noxious and invasive weeds found in surrounding states, which are not known to exist in Utah, but pose a significant risk of invasion to the state and should be considered as a very high priority.

Common crupina	Crupina vulgaris
African rue	Peganum harmala
Small bugloss	Anchusa arvensis
Mediterranean sage	Salvia aethiopis
Spring millet	Milium vernale
Syrian beancaper	Zygophyllum fabago
Ventenata (North Africa grass)	Ventenata dubia
Plumeless thistle	Carduus acanthoides
Malta starthistle	Centaurea melitensis

Class 1B: Early Detection Rapid Response (EDRR): Declared noxious, non-native invasive weeds in the State of Utah with very limited distribution, but pose a serious threat to the state and should be considered as a very high priority.

Camelthorn	Alhagi maurorum
Garlic mustard	Alliaria petiolata
Purple starthistle	Centaurea calcitrapa
Goatsrue	Galega officinalis
African mustard	Brassica tournefortii
Giant reed	Arundo donax
Japanese knotweed	Polygonum cuspidatum
Blueweed (Vipers bugloss)	Echium vulgare
Elongated mustard	Brassica elongata
Common St. Johnswort	Hypericum perforatum
Oxeye daisy	Leucanthemum vulgare
Cutleaf vipergrass	Scorzonera laciniata

Class 2: Control. Declared noxious, non-native invasive weeds, found in the State of Utah, that pose a threat and should be considered a high priority. Class 2 weeds are widely distributed throughout state but are considered controllable.

Leafy spurge	<i>Euphorbia esula</i>
Medusahead	<i>Taeniatherum caput-medusae</i>
Rush skeletonweed	<i>Chondrilla juncea</i>
Spotted knapweed	<i>Centaurea stoebe</i>
Purple loosestrife	<i>Lythrum salicaria</i>
Squarrose knapweed	<i>Centaurea virgata</i>
Dyers woad	<i>Isatis tinctoria</i>
Yellow starthistle	<i>Centaurea solstitialis</i>
Yellow toadflax	<i>Linaria vulgaris</i>
Diffuse knapweed	<i>Centaurea diffusa</i>
Black henbane	<i>Hyoscyamus niger</i>
Dalmation toadflax	<i>Linaria dalmatica</i>

Class 3: Containment. Declared noxious non-native invasive weeds to the State of Utah. Class 3 weeds are widely distributed throughout the State and may be considered beyond eradication. County efforts should be directed at controlling expansion as these weeds pose a threat to the agricultural industry and agricultural products.

Russian knapweed	<i>Acroptilon repens</i>
Houndstongue	<i>Cynoglossum officinale</i>
Perennial pepperweed	<i>Lepidium latifolium</i> (Tall whitetop)
Phragmites (Common reed)	<i>Phragmites australis</i> ssp.
Saltcedar (Tamarisk)	<i>Tamarix ramosissima</i>
Hoary cress	<i>Cardaria</i> spp.
Canada thistle	<i>Cirsium arvense</i>
Poison hemlock	<i>Conium maculatum</i>
Musk thistle	<i>Carduus nutans</i>
Quackgrass	<i>Elymus repens</i>
Jointed goatgrass	<i>Aegilops cylindrica</i>
Bermudagrass	<i>Cynodon dactylon</i>
Perennial Sorghum (Johnson grass)	<i>Sorghum halepense</i> and <i>Sorghum alnum</i>
Scotch thistle	<i>Onopordum acanthium</i>
Field bindweed (Wild Morning-glory)	<i>Convolvulus</i> spp.
Puncturevine (Goats head)	<i>Tribulus terrestris</i>

Class 4: Prohibited. Declared noxious and invasive weeds, not native to the State of Utah, that pose a threat to the state through the retail sale or propagation in the nursery and greenhouse

industry. Prohibited noxious weeds are annual, biennial, or perennial plants that the commissioner designates as having the potential or are known to be detrimental to human or animal health, the environment, public roads, crops, or other property.

Cogongrass (Japanese blood grass)	<i>Imperata cylindrica</i>
Myrtle spurge	<i>Euphorbia myrsinites</i>
Dames Rocket	<i>Hesperis matronalis</i>
Scotch broom	<i>Cytisus scoparius</i>
Russian olive	<i>Elaeagnus angustifolia</i>

Utah Administrative Rule R68-9-2 states, “[e]ach county in Utah may have different priorities regarding specific State designated Noxious Weeds and is therefore able to reprioritize these weeds for their own needs.” Each county may also declare a “County Noxious Weed” in addition to the State list.

Weeds Beaver County Has Designated as Noxious

Bull Thistle	<i>Cirsium vulgare</i>

Utah Code § 4-17-4 provides for a “County Weed Control Board” appointed by the county legislative body of 3 to 5 members, and that 2 of those members be farmers or ranchers whose primary source of income is from agriculture. Members are appointed to four-year terms of office. Pursuant to Utah Code § 4-17-5, this county weed control board is given responsibility, under direction of the county legislative body, for formulation and implementation of a county-wide coordinated noxious weed control program designed to prevent and control noxious weeds in the county. Utah Code § 4-17-6 further provides for a “Weed Control Supervisor” to carry out the directives of the weed control board and to implement the weed control program within the county.

Utah Administrative Code R68-9-5 requires that: “[t]he Board of County Commissioners of each county, with the aid of their county Weed Board and their County Weed Supervisor, shall submit an ‘Annual Progress Report of County Noxious Weed Control Program’ to the Commissioner of Agriculture and Food by January 15 of each year, covering the activities of the previous calendar year.”

Utah Administrative Rule R68-9-6 requires the County Weed Board to post “General Notice to Control Noxious Weeds” in at least three public places within the county and be published in one or more newspapers of general circulation throughout the county, on or before May 1 of each year. Such public notice shall state that it is the duty of every property owner to control and prevent the spread of noxious weeds on any land in his possession or control.

Utah Administrative Code R68-9-6 also directs the County Weed Board, after

determining that weed control measures are required to control noxious weeds on a particular property, to cause an “Individual Notice to Control Noxious Weeds” to be served upon the owner or person in possession, giving specific instructions on when and how the noxious weeds are to be controlled within a specified period of time. The individual notice shall also inform the property owner or operator of legal action which may be taken against him if he fails to comply with the notice.

Pursuant to the Federal Noxious Weed Act (7 U.S.C. § 2814), federal agencies have the authority and responsibility to manage undesirable plants and noxious weeds on federal and public lands. Each federal agency has a designated weed specialist and weed control program.

Noxious weeds are a significant problem in Beaver County and have been the focus of considerable effort for many years. Scotch thistle, which is prevalent throughout much of the County, has been identified as a primary problem. Hoary cress is also widely spread across the County including in many alfalfa crops. Saltcedar and Russian olive have invaded most waterways. Houndstongue, Black Henbane, Canada thistle, Musk Thistle, Spotted Knapweed, Perennial Pepperweed, Puncturevine and Poison Hemlock have all invaded Beaver County and obtained strong footholds. Russian Knapweed, Squarrose Knapweed and Diffuse Knapweed have been found in small isolated locations and are being treated with the expectation of eradication. Recently, the new invader Cutleaf Vipergrass was discovered in the Pine Creek area and control measures are being prescribed. The highest concentration of weeds in the County are centralized around the Beaver valley, being dispersed by major transportation routes and stream irrigation among other factors.

Large utility projects, including transmission lines and gas pipeline disturbances, are especially vulnerable to noxious weed infestations. Noxious weeds are introduced through vehicles transporting seeds from outside locations. Disturbance to the soil and destruction of native plant communities leaves the site susceptible to invasion from invasive plants. When projects are finished, required vegetation seedings are applied and forgotten, but are frequently unsuccessful due to low soil moisture or other conditions. These sites may become infested with noxious weeds or undesirable monocultures like halogeton, white horehound or rabbit brush. Disturbed sites must be monitored for several years until desired vegetation has successfully reestablished.

Wild fire and prescribed fire treatment areas are highly vulnerable to noxious weed invasion. The heat from fire tends to stimulate seed germination of many noxious weeds while sterilizing many desirable plant seeds. Locations where fire has spread across the landscape need extra attention from land managers to monitor and control invasive noxious weeds.

Beaver County has struggled to maintain an active weed board through the years where active board participation is vitally needed. Another problem is coordinating among countless private land owners and federal land management agencies that manage public land interspersed

with private property ownership. Cooperative Weed Management Areas (“CWMA”) were first introduced in neighboring states, and have been advocated in Utah to address the management hurdles that come with cross-jurisdictional collaboration. A Beaver County CWMA was formed in 2006 between Beaver County and various federal land management agencies. These partnerships were very helpful in coordinating efforts to combat weeds in the years following its inception. However, following personnel changes in key positions within the group, this working group has since fallen into inactivity.

II. OBJECTIVES

Beaver County’s objectives with regard to noxious weeds are as follows:

1. To fulfill its responsibility to its citizens to protect lands, crops and livestock from the harmful and costly invasion of noxious weeds by preventing their introduction, establishment and spreading;
2. To maintain an active and functioning County Weed Control Board which shall formulate a weed control program or a plan prioritizing control efforts of noxious weeds in the County, post General Notices to control noxious weeds, and when appropriate, issue individual notices to control noxious weeds;
3. To increase public education on the imminent dangers, legal responsibilities and effective methods of controlling noxious weeds;
4. To seek and maintain CWMA’s, which are integral to the coordination and collaboration of planning, financing, and orchestrating weed control activities and projects in the local area among partnering local, state and federal agencies;
5. To promote integrated pest management principles to prevent, contain and control noxious weed problems including mapping, biocontrol and early detection, rapid response;
6. To obtain sources of funding to contribute to the County’s efforts in weed control, including state and federal grants; and
7. To ensure that all large-scale utility projects and other significant habitat disturbing activities implement bonding and/or permitting measures that require weed detection, chemical control mechanisms, post project habitat restoration and on-going monitoring.

III. POLICIES AND GUIDELINES

1. Beaver County shall organize and maintain a County Weed Control Board.

2. Beaver County shall appoint a Weed Control Supervisor to implement the weed control program.
3. Beaver County shall encourage and support the creation of CWMA's for collaboration in weed control efforts.
4. The Beaver County Weed Control Board and Weed Control Supervisor shall utilize Integrated Pest Management principles in the weed control program.
5. Promote noxious weed awareness through public outreach and education.
6. All large-scale utility projects shall have bonding measures and/or permitting that require noxious weed control, post project rehabilitation, including seeding with appropriate native and non-native grasses, and 3 years of monitoring afterwards to prevent establishment of undesirable monocultures. Restoration efforts must utilize native and non-native grasses and forage plants while preventing establishment of noxious weeds as well as undesirable invasive plants such as Halogeton, White Horehound and Rabbit brush.
7. Beaver County calls upon the federal agencies who administer lands within the county to:
 - a. Fully cooperate and coordinate with the county to develop, amend, and implement land and resource management plans and to implement management decisions that are consistent with the purposes, goals, and policies described in this section to the maximum extent allowed under federal law;
 - b. Follow existing laws and rules pertaining to noxious weed control on lands they administer;
 - c. Coordinate with the County Weed Board and participate in applicable CWMA's;
 - d. Maintain and enhance desired plant communities that benefit watersheds, water quality, wildlife, livestock, recreation, and are weed free;
 - e. Utilize native and non-native seed mixtures in vegetation treatments that are appropriate to management objectives, are adapted to the site conditions and are highly resistant to and/or competitive to invasive and noxious weeds;
 - f. Prioritize wild fire and prescribed burn areas for reseeding and noxious weed monitoring;
 - g. Support federal, state and local weed associations, partnerships and coalitions;
 - h. Refrain from any planning decisions and management actions that will

undermine, restrict or diminish the goals, purposes and policies of Beaver County as stated in this resolution; and

- i. Refrain from implementing a policy that is contrary to the goals and purposes described in this resolution.

4. WATER RESOURCES

Water is one of the most important natural resources in Beaver County. More than 77% of Beaver County is federal land, and of the remaining 23%, only 12.6% is private land, most of which is concentrated in valley bottoms and along watercourses. Consequently, almost all surface water and the majority of watersheds are located on federal land. Beaver County is home to 5 major sub-basin watersheds: Beaver Bottoms-Upper Beaver, Hamlin-Snake Valleys, Pine Valley, Sevier Lake and a small portion of Escalante Desert. The Beaver Bottoms-Upper Beaver and Sevier Lake watersheds develop surface waters that flow north and eventually terminate at Sevier Lake in Millard County. The Sevier, Pine Valley and Hamlin-Snake Valley watersheds are associated with the Basin and Range physiographic region. The Beaver Bottoms-Upper Beaver receives the highest annual precipitation in the County creating numerous perennial streams.

The Beaver River and its tributaries are the major sources of surface water in Beaver County. The Beaver River is fed mainly by snowmelt and groundwater discharge from nearby mountains and is augmented by rainfall, especially during the late summer monsoon season. The Beaver River starts in the Tushar Mountains and flows westerly for about 30 miles as a perennial stream through the Beaver Valley to the Escalante Desert. The river turns north and continues for about 80 miles as an ephemeral wash past Milford into Millard county, where it joins the Sevier River and empties into Sevier Lake. The Beaver River watershed drains about 2,466 square miles, the majority being desert. The Rocky Ford Dam obstructs the river in its lower reaches, forming Minersville Reservoir. This reservoir is used for irrigation for Minersville and the Milford Flat. According to the U.S. Geological Survey's National Water Information System, there were roughly 32,000 acres irrigated in the county in 2010.

Rainfall in Beaver County is not adequate for most commonly grown crops, and is generally the limiting factor for vegetative cover on state and federal lands. Supplemental irrigation is required to obtain acceptable crop yields, and most irrigation water is diverted from the rivers and streams and stored in ponds and reservoirs. Minersville Reservoir, the most prominent storage facility, provides substantial irrigation resources in the area. In addition, many smaller reservoirs have been built in the Tushar Mountains for storage and water regulation.

Beaver County is in a closed basin, meaning none of the water ever flows into an ocean. Instead, streams drain into ephemeral washes and playas on valley floors, or infiltrate the stream channel. The few major rivers and streams in the area are mostly supported by snow runoff from mountain ranges in the Fishlake National Forest. Most streams east of Interstate 15 are diverted and dewatered for municipal and agricultural uses as soon as they leave public lands. Numerous

smaller streams drain from BLM-administered lands in the southern and western portions of the planning area.

Streams are mostly ephemeral and are fed either by groundwater, precipitation in the form of rain or snow, or a combination of the two. Streams also are fed by seasonal precipitation during summer monsoons that can bring localized and often intense thunderstorms from mid-July through mid- September. Streams not utilized for municipal and agricultural purposes typically drain into ephemeral washes and playas on valley floors, or are lost to infiltration into the stream channel.

Springs are fed by groundwater that reaches the surface naturally. When a spring produces enough output, it forms a stream. Rivers, streams, and springs in the County generally support a riparian or small wetland component, given that the duration of available surface or subsurface water allows for the establishment of wetland vegetation. There are numerous small springs widely scattered across the planning area, generally located on valley margins or mountain blocks. Springs are typically categorized as being lotic (flowing) or lentic (static). Small streams can be associated with lotic springs. These small springs and seeps are extremely important for their riparian values, as wildlife habitat, and as water sources for wildlife.

4.1 Hydrology

Hydrology is the science that encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle. The water cycle is a continuous process by which water is purified by evaporation and transported from the earth's surface to the atmosphere and back. All the physical, chemical and biological processes involving water as it travels its various paths in the atmosphere, over and beneath the earth's surface and through growing plants, are part of this hydrologic cycle. There are many pathways the water may take in this continuous cycle, whether falling as rain or snow, frozen for millennia in glaciers, percolating through soil into underground aquifers, flowing from wells or springs, traveling to the ocean by river, transpired by plants, or evaporating from the earth's surface, whether long or short, it is all part of the cycle.

The supply of water available for our use is limited by nature. Although there is plenty of water on earth, it is not always in the right place, at the right time and of the right quality. The challenge becomes, how do we use and store the water so necessary for our daily life while solving water quality concerns as those uses we derive from it frequently lower its quality or purity.

I. FINDINGS

Beaver County is an arid environment. Even in mountainous areas of the County which receive relatively higher volumes of precipitation, water is in limited supply. Generally, eastern Beaver County contains higher elevation mountains and receives more annual precipitation than the western portion of the County. Typically, mountain and forested areas have sufficient vegetative cover and ground litter to allow for the collection of precipitation, especially during the spring when snowmelt occurs gradually. However, where encroaching pinyon and juniper have been allowed to invade and replace historic sagebrush and grassland ecosystems, vegetative cover is lost and consequently, precipitation evaporates more quickly.

The western portion of the county is characterized by sparse vegetation, sandier soils, and desert-like conditions. Intense late summer rain storms often result in flash flood conditions with attendant sediment transport and erosion. Many, if not most, of the watercourses are ephemeral washes with little or no riparian vegetation. Over the past several years, storm runoff intensity appears to have increased. There has been little to no human development in the area, but banks are not stabilized, and streambeds are often subject to downcutting. As a result, sediment transport is at unacceptable levels and is impacting water quality. Further, many of the watercourses in dryer portions of the County are infested with invasive weeds, which replace desirable vegetation and dominate limited water resources.

The utility of all lands in the county, whether public or private, are fully dependent on water flows from watersheds or underground sources for their productivity. The rivers and streams flowing from watersheds on public lands supply important water for municipal, industrial, agricultural and recreational use. As set forth in Utah Code 63-38d-401 (5)(c), “the waters of the state are the property of the citizens of the state, subject to appropriation for beneficial use, and are essential to the future prosperity of the state and the quality of life within the state.”

The U.S. Geological Survey publishes a National Water Information System that provides data on water usage by county. Based on the latest data from 2010, 5,520 of Beaver County’s 6,629 residents (83%) were served by municipal or public water systems. Those public water systems delivered an average of 2.38 million gallons of water per day. Domestic use was rated at 272 gallons per person per day. Industrial use was rated at .81 million gallons per day, down from 1.41 million gallons per day in 2005 and 1.82 million gallons per day in 2000.

The Utah Division of Natural Resources (“DNR”) manages a program called the Watershed Restoration Initiative (“WRI”). This partnership based program focuses on three ecosystem values: (1) wildlife and biological diversity; (2) water quality and yield; and (3) opportunities for sustainable uses of natural resources. WRI is a bottoms-up initiative where

project planning, review, and ranking occur at a local level. Regional teams elect their own leaders, establish focus areas, review, score and rank project proposals, and assist members in implementing projects. Through WRI funding and matching funds from contributing partners, state and private organizations and individuals have assisted federal agencies in treating millions of acres across the state of Utah.

II. OBJECTIVES

Beaver County's objectives with regard to hydrology are as follows:

1. To demand that land management agencies significantly increase implementation of projects that improve vegetative cover, streambank stabilization, water detention, and eradication of undesirable invasive species;
2. To ensure that vegetative resources be managed in a condition that will provide sufficient cover and litter to protect the soil surface from excessive wind and water erosion, reduce bare ground, promote infiltration, detain surface flow, and reduce soil moisture loss by evaporation. This includes making provisions for a) increasing the percentage of vegetated ground; b) reducing the percentage of undesirable, invasive or noxious vegetation in relation to desired plant communities; and c) restoring or enhancing of perennial, intermittent and ephemeral watercourses to properly functioning condition;
3. To demand that land managers to prioritize structural and non-structural projects and best management practices that are designed to reduce stormwater volume, peak flows, and/or nonpoint source pollution through evapotranspiration, infiltration, detention, hydrograph extension, and filtration;
4. To demand that land managers implement structural and non-structural perennial, intermittent and ephemeral stream stabilization projects that reduce stream sedimentation and erosion while enhancing riparian areas, wetlands, and vegetation for wildlife and livestock; and
5. To demand that land managers coordinate programmatic agreements, best management practices, and prioritization schedules for improving hydrologic functions and conditions within Beaver County.

III. POLICIES AND GUIDELINES

1. Section 63J-8-104 of the Utah Code states that federal land management agencies shall manage the watershed on federal lands to achieve and maintain water resources at the highest reasonably sustainable levels as follows:

- a. Adhere to the policies, goals, and management practices set forth in Subsection 63J-4-401(6)(m) of the Utah Code;
 - b. Deter unauthorized cross-country off highway vehicle (“OHV”) use in the subject lands by establishing a reasonable system of roads and trails in the subject lands for the use of an OHV, as closing the subject lands to all OHV use will only spur increased and unauthorized use; and
 - c. Keep open any road in the subject lands that historically has been open to OHV use as identified on respective county road maps.
2. Federal land managers shall implement projects to increase native and non-native vegetative ground cover percentages to acceptable levels.
3. Watersheds shall be managed to preserve the quality and quantity of water for current and future uses.
4. Any proposed agency action must include an analysis of the effects on water quality, stream flow, amount of water yields, and timing of those yields. Any proposed action or non-action that results in a decrease in water quality, quantity or flow, or changes the timing of flows in negative way shall be opposed.
5. Any proposed agency action must be analyzed for impacts to water resource and management facilities, such as dams, reservoirs, delivery systems, culinary systems, and monitoring facilities, etc., located on or downstream from land covered by the proposal.
6. Livestock grazing and other multiple uses are compatible with watershed management.
7. Wild & Scenic Rivers and Wilderness designations limit the development and use of important water resources; Beaver County is opposed to any such designations.
8. Beaver County supports the wise use and conservation of important water resources and encourages new storage facilities, improved delivery systems, proper treatment measures and enhanced protection of water resources.
9. Enhanced programmatic agreements and best management practices associated with prescribed and wildland fire should be implemented to protect hydrologic functions and conditions in Beaver County.

10. Adequate access to water facilities, reservoirs, water lines, developments and other important structures must be protected and maintained.
11. Unless otherwise approved by Beaver County and consistent with ecologic site conditions, the following minimum objectives are established when lands experience prescribed or wildland fire:
 - a. Retain sufficient ground cover after the burn with recruitment to adequate ground cover before the first rainy season following the burn;
 - b. Do not reduce perennial and intermittent channel shading more than necessary, or by an amount that will take more than three years to recover;
 - c. “Burn” and/or “feeder” piles will not be made in channels or swales within the area occupied when the bank full width is doubled;
 - d. Burned piles within riparian areas will be left “messy” in order to retain sediment on site;
 - e. Ignitions will not occur within 15 feet of riparian areas;
 - f. Any firelines created during burning operations will follow *The Five-D System for Effective Fireline Waterbars* (Hauge et al., 1979);
 - g. Firelines that need to cross-riparian areas will do so perpendicular to the channel and should not have more than 40 feet of hydrologic connectivity;
 - h. Cupped fire lines should have water gaps every 20 feet to allow captured water to exit; and
 - i. Existing disturbance areas, such as roads and trails, should be used to the extent possible as fire lines.
12. Unless consistent with ecologic site conditions and approved by Beaver County, the following minimum objectives are established when lands experience mechanical treatments:
 - a. Retain adequate ground cover or pre-treatment level ground cover over the treatment area;

- b. Mechanical equipment should not cross live streams or those channels supporting riparian vegetation except at designated crossing sites. Every effort to use existing crossings should be made;
 - c. Crossings at watercourses should be as close to perpendicular to the channel as possible to limit the area of disturbance;
 - d. Hydrologic connectivity of crossings should be limited to 20 feet on either side of the stream course wherever possible;
 - e. Any sediment or debris pushed into the channel to facilitate a crossing shall be removed as soon as is practical. The disturbed area will be rehabilitated to reduce erosion within the channel. Such rehabilitative efforts may include adding mulch, slash or debris from the project area to reduce flow and erosion potential;
 - f. Mechanical treatments should occur on the contour as much as practical;
 - g. Mechanical equipment should be limited to areas where slopes are less than 35%. Stretches of 100 feet or less on slopes of up to 40% may be treated to achieve desired objectives; and
 - h. Mechanical equipment should not operate when the soil has high moisture content, or when equipment is creating ruts deeper than nine inches in muddy soil.
13. Unless otherwise approved by Beaver County and consistent with ecologic site conditions, the following minimum objectives are established when lands are treated:
- a. No sediment or slash will be introduced into stream channels. Inadvertently introduced material shall be removed, except where greater damage would occur during removal than would exist if the material remained untouched;
 - b. Roads, paths, ways, and trails shall be maintained, restored, or improved to a condition equal to or better than that which existed at the start of the project;
 - c. Project related damage to roads and their drainage features shall be repaired before the next rain or the close of the construction season, whichever is sooner;
 - d. Fueling of drip torches and other equipment shall not occur within riparian areas.

4.2 Surface Waters

I. FINDINGS

Surface water can be generally described as a river, stream, waterbody, reservoir, lake, pond, or spring. Rivers and streams in natural channels are classified as being perennial, intermittent, or ephemeral. Important rivers and streams in Beaver County include the Beaver River, North Creek, South Creek, Indian Creek, and their tributaries. These streams are fed mainly by snowmelt and groundwater discharge from nearby mountains, and are augmented by rainfall, especially during the late summer monsoon season. Rainfall in Beaver County is not adequate for the most commonly grown crops, and is generally the limiting factor for vegetative cover on state and federal lands. Minersville Reservoir is the major irrigation reservoir in the area. Many smaller reservoirs have been built in the area, but they are used mainly for water regulation, rather than large-scale storage.

Over the past 50 years, ecological conditions associated with many of Beaver County's surface waters have declined. The declines are particularly pronounced on federal lands where pinyon-juniper woodlands have been allowed to encroach on more desirable sagebrush and grassland communities, where seeding maintenance and vegetation projects have been neglected and where undesirable riparian vegetation has not been controlled. Often, these conditions occur in sandier soils where sparse vegetative cover is inadequate to prevent soil erosion accompanying intense precipitation events.

Land managers often incorrectly cite human influences as the primary cause for the ecologic decline. However, much of the decline is attributable to the loss of historic sagebrush and grassland vegetative communities, especially in lower elevations with sandier soils and in site specific areas to wild horses that have not been managed according to law. In fact, modification and pollution of surface-water, wetlands, riparian habitats, seeps, and springs are more influenced by vegetative cover, prescribed fire, and wildland fire than by mitigated impacts from residential, commercial and urban development, roadway and bridge construction, oil and gas development, livestock grazing, hydroelectric, wind and solar energy development, geothermal exploration and plant development, pipeline and transmission line construction, and other human activities.

Most human use of the water from rivers, streams, and waterbodies in Beaver County is for agricultural purposes. Historically, numerous small springs, seeps and mesic areas were widely scattered across the County, often located on valley margins or mountain blocks, but extended throughout various landforms. The small springs and seeps were extremely important for their riparian values, as wildlife habitat, and as drinking water for domestic livestock and wildlife.

Many of these springs have dried over the last several decades as a result of encroaching pinyon-juniper woodlands and invasion of undesirable riparian vegetation. Where pinyon-juniper woodlands in the region have been restored to sagebrush and grassland communities, the springs and seeps are returning and providing water for a variety of wildlife. When needed, the water resources are protected from livestock and wildlife trampling by exclosures and off stream watering practices.

Watersheds on public lands often supply water to communities in Beaver County. Surface water is generally used for irrigation purposes, but watershed health and surface water quality and quantity can also impact groundwater resources that are used for municipal domestic water supply. Actions on public lands in these watersheds are likely to affect such factors as water quality and quantity, erosion rates, and groundwater recharge. There is currently a high degree of interest regarding surface water and other water resources.

II. OBJECTIVES

Beaver County's objectives with regard to surface waters are as follows:

1. To demand that federal, state and local entities to cooperate and coordinate surface water management to optimize water quantity, quality, and beneficial use;
2. To re-evaluate surface waters in Beaver County to verify that their designated beneficial use is consistent with hydrologic and environmental conditions;
3. To classify upland soil loss due to lack of desired vegetative ground cover as the primary source of nonpoint pollution in Beaver County;
4. To demand that land managers preserve, enhance, improve, or optimize surface water resources through active management, especially watershed restoration and an increase in desirable native and non-native vegetative ground cover;
5. To ensure that the regulatory control of surface waters under the Clean Water Act be recognized and implemented; and
6. To ensure that adequate ground cover be retained after prescribed or wildland fire with recruitment to a suitable amount of ground cover before the first rainy season following the burn.

III. POLICIES AND GUIDELINES

1. Land managers need to recognize authorities granted to local governments under the Clean Water Act in managing surface waters within their jurisdictions. Federal agencies are subject to and must comply with state, tribal, interstate, and local requirements respecting the control and abatement of water pollution. *See* 33 U.S.C. § 1323. The CWA's regulations (40 C.F.R. part 131, *et seq.*) describe state responsibilities for developing, reviewing, revising, and approving water quality standards, which may be more stringent than those required by federal regulation, and include designation of uses of waters, establishment of water quality criteria, and adoption of an anti-degradation policy.
2. Land managers need to comply with the cooperation and coordination requirements of federal laws, regulations, rules, and manuals (e.g. BLM Manual 7240 and Forest Service Manual 2532) regarding state and local direction of water resource management issues.
3. Until such time as state and federal agencies can coordinate surface water management plans with Beaver County, the provisions of this plan must control maintenance, mitigation, enhancement, and improvement of surface water resources in Beaver County.
4. Consistent with federal, state, and local water quality programs, federal actions shall include at least one alternative that incorporates a science-based watershed approach for water quality protection and restoration, including assessment methods, monitoring and reduction of non-point pollution through vegetative restoration.
5. Priorities for improving water quality in the Beaver River watershed are: 1) enhance desirable upland and riparian vegetative cover; 2) eliminate undesirable riparian vegetation; and 3) enhance channel bank vegetation, riparian forest buffers and herbaceous cover, streambank protection, and channel stabilization.
6. In priority wildlife management areas, new water developments shall be allowed if it is demonstrated, among other benefits, that the improved water resources will benefit the prioritized species.
7. Until such time as total maximum daily loads are determined for individual perennial, intermittent, and ephemeral streams in Beaver County, land managers shall control non-point source pollution, including sediment, by: a) optimizing desirable upland, riparian, aquatic, and wetland vegetation; b) restoring invasive pinyon-juniper woodlands to desirable sagebrush semi-desert grasslands, based on a suitable timeframe ; c) eliminating noxious weeds and undesirable riparian vegetation; and d) using desirable non-native

biological equivalents when soil retention and vegetative performance is better than native species.

4.3 Ditches and Canals

I. FINDINGS

Beaver County's development of canals and ditches paralleled that of other communities in Utah. Ditches and irrigation canals were dug in and around agricultural interests near communities and in outlying valleys. The small amount of private land and the rugged, remote nature of many of the federal lands limited the extent to which ditches and canals could be constructed. However, natural conveyance systems such as riverbeds, creeks and streams, were used to transport water from natural sources and storage facilities to locations where water was regulated and allowed to enter the developed distribution system. Most populated areas of Beaver County and associated agricultural activities had ditches and canals constructed early in the community's development, and they remained relatively unchanged for approximately 100 years. During these years, ditches and canals served dual purposes of conveying irrigation water and providing an outlet for dispersing flood waters resulting from monsoon storms and heavy spring runoff common to the area.

In the latter third of the 20th century, improved techniques and construction methods led to the conversion of earth-lined ditches to lined canals and pipelines. Although more efficient in the use of water, the developments resulted in many historic ditches falling into disrepair and the loss of flood control capabilities. Many of the larger conveyance networks have remained operational and continue to provide service, while many of the smaller facilities associated with individual farms and irrigation companies have been replaced by pipelines.

In Utah, like most parts of the arid West, water often must be conveyed a long distance between the source and the place of use. Accordingly, there are numerous ditches, canals, and pipelines that cross one party's private property in order to convey water to another private party. The party receiving water from the ditch, canal, or pipeline generally has an easement, either by prescription or by an express grant of easement. Whether prescriptive or express, the easement includes the right to maintain the ditch, canal, or pipeline.

In Utah, there have been several situations where ditches or canals have failed. These failures have not only caused property and infrastructure damage, but injury and loss of life. U.C.A. 73-5-7 authorizes the State Engineer to inspect canals and ditches and order necessary repairs to protect public safety. The State Engineer is also required to inventory and maintain a database of all open, human made water conveyance systems prior to July 1, 2017. Section 73-10-33 of the Utah Code requires ditch or canal operators to prepare a management plan which

includes a map of facilities and slope instability locations, shows proof of liability insurance, has a plan for maintenance and emergency response measures, provides financial sourcing and determines the potential effects of storm water flows. The State Engineer's inventory is incorporated by reference.

II. OBJECTIVES

Beaver County's objectives with regard to canals and ditches are as follows:

1. To ensure that ditches and canals be maintained to perform dual functions of water conveyance and flood control;
2. To ensure that appropriate authorizations to be executed to preserve the function of ditches and canals on federal lands;
3. To recognize ditches and canals as important historic and current cultural resources; and
4. To preserve and enhance ditches and canals to benefit man and his environment and to permit the unimpeded flow of water.

III. POLICIES AND GUIDELINES

1. Beaver County supports efforts by irrigation companies, water conservancy districts, and others to protect, facilitate, and improve the efficient supply of water.
2. Private ditches and canals may be used for flood control when the need exists.
3. All federal agency actions shall recognize legal canal and ditch easements and ROWs.

4.4 Rivers and Streams

I. FINDINGS

Beaver County is bisected by numerous small rivers, streams, and tributaries flowing from the mountainous sections of the County. These streams are fed by springs and snow melt.

The Beaver River flows generally from east to west and has its origins in the Tushar Mountains within the Fishlake National Forest. Major contributions of the Beaver River are withdrawn for irrigation and storage purposes along the southeastern portion of its course. The Beaver River becomes an ephemeral stream in the northern portion of its route prior to entering

Millard County. Additional streams in the area include Indian Creek, Pine Creek, South Creek, and the north and south forks of North Creek.

The Hamlin Valley, Pine Valley and Wah Wah Valley sub-basins in western Beaver County are part of the Great Salt Lake Basin, the largest and least populated basin in Utah. The lack of human population in this area is due to the scarcity of water resources. It is composed of salty playa bottoms, and includes some of the most arid lands in the western United States. Only a few small streams are present in this area of Beaver County, whose waters generally infiltrate the streambed before ever reaching the valley floor.

The Beaver River watershed is fed from mountain snowmelt and runoff, and late summer thundershowers. Rivers and streams make up a very small percentage of the land base, but are influenced by conditions in their much larger watersheds. There are no known point sources that discharge directly into Beaver County's rivers and streams.

Pollution in Beaver County's rivers and streams is primarily a result of erosional sediments from insufficient or undesirable vegetative ground cover. Discharge from human developments is controlled by either implementation of stormwater regulations applied to municipalities and communities or implementation of best management practices on sparsely placed developed uses of federal lands.

II. OBJECTIVES

Beaver County's objectives with regard to rivers and streams are as follows:

1. To more aggressively manage vegetation in its rivers, streams and associated watersheds, to optimize and protect water resources;
2. To reclassify impaired waters in the Beaver River to include only those tributaries with native targeted fish populations and conditions suitable for cold-water fisheries;
3. To replace class II and Class III pinyon-juniper woodlands with desirable vegetative communities to reduce erosion and impacts on the County's rivers and streams;
4. To control undesirable riparian vegetation and aquatic noxious plants in all of Beaver County's public land rivers and streams and their associated riparian zones, especially in impaired waters of the Beaver River Watershed;
5. To seek additional structural improvements, such as dams, reservoirs, and impoundments, as well as non-structural improvements must be constructed to improve the efficiency of Beaver County's rivers and streams;

6. To demand that land managers to improve desirable vegetative cover to reduce stream sedimentation and protect water resources; and
7. To demand that land managers and landowners continue efforts to reduce nutrient loading in streams and water bodies.

III. POLICIES AND GUIDELINES

1. The beneficial use of Beaver County's rivers and streams should be maximized through protection and development of water quantity and quality, and through more aggressive vegetative management in watersheds and other areas impacting rivers and streams.
2. Land managers should be consistent with Beaver County's plans, programs, and policies for resources impacting rivers and streams, including actions for vegetation, water quality, pinyon-juniper reduction, fish and wildlife, livestock grazing, special status species, soil resources, and others, to the maximum extent allowed by law.
3. Wild, scenic, and recreational river evaluations and designations should be consistent with Beaver County's criteria, plans, programs, and policies.
4. Law enforcement and emergency medical services, solid waste collection services, human waste collection services, and the general public must be given increased access to Beaver County's rivers and streams—especially those on public lands.
5. Beavers should be transplanted only to areas approved by the Beaver County Commission, where such transplantation will not detrimentally impede the free flow of water.
6. Land managers shall recognize Beaver County's jurisdictional role over rivers and streams, and shall comply with the County's plans, programs and policies to the maximum extent allowed by law.
7. Demand that the restoration of native plant communities and the eradication of invasive and noxious plant species, especially Tamarisk, are the top priority of state and federal land managers in planning and decision making regarding rivers and streams in Beaver County.
8. Waters in Beaver County should meet the water quality standards set forth in state and federal law, as applicable.
9. Beaver County recognizes the "Recreational Use of Public Water on Private Property" law (H.B. 141) as passed by the 2010 Utah Legislature. Beaver County also respects and

defends the private property rights of those landowners whose property lies beneath or adjacent to the water, against trespass or vandalism.

4.5 Flood Plains and River Terraces

I. FINDINGS

Historically, towns in rural Utah have been built in close proximity to rivers and their floodplains, where water was readily available for irrigation and landforms were conducive to agriculture. Beaver County is no exception, as communities in the County have been located near rivers. Early on, pioneers recognized the problems associated with locating homes and structures too close to flood prone rivers, but in recent years an increased desire for recreational homes and riverfront property has resulted in added pressure to make floodplains available for development.

In cooperation with local government, the Federal Emergency Management Agency (“FEMA”) manages development in flood prone areas through the National Flood Insurance Program (“NFIP”). The program typically focuses on the delineation of the 100-year flood zone, also known as the Special Flood Hazard Area. Where a detailed study of a waterway has been done, the 100-year floodplain will also include the floodway, the critical portion of the floodplain which includes the stream channel and any adjacent areas that must be kept free of encroachments that might block flood flows or restrict storage of flood waters.

Communities in Beaver County generally participate with FEMA in managing floodplains, and often adopt more stringent requirements for human development in the floodplain. However, maps are not always accurate, and alterations of the watershed upstream of the point in question can potentially affect the ability of the watershed to handle water, potentially affecting the levels of periodic floods. Additionally, the maps are rarely revisited, and are frequently ineffective at accurately predicting areas of flooding or flood levels. Notwithstanding, developments in floodplains and on river terraces on private lands should be adequately managed through local planning and zoning ordinances and local building codes.

Impacts to floodplains and river terraces on developed state and federal lands are similar to controls used in community and private settings. Best management practices are employed to mitigate any detrimental effects, so limited human developments associated with authorized multiple use activities have little to no effect on floodplains and river terraces.

Large expanses of undeveloped federal land in Beaver County are not afforded similar protection. Passive land management, conversion of historical vegetative communities to noxious and invasive plant communities, increased bare ground, altered fire regimes, and other factors have resulted in modified watersheds and degraded upland conditions. Some estimates

indicated uplands comprise as much as 95% of the federal lands not occupied by water bodies in Beaver County. Degradation in dominant uplands, largely as a result of encroaching conifers, has resulted in increased surface flows and expanding flooding in remote floodplains. Sparsely vegetated sandy soils have responded with increased erosion, downcutting of primary channels and steepening of banks. These unstable conditions are characteristic of formative floodplains that have not reached equilibrium.

Impacts associated with upland induced, unstable floodplains are exacerbated by natural hydrologic cycles typical of the Colorado Plateau. Flooding generally occurs from two distinct events: spring runoff from melting snowpacks, and intense summer thundershowers. While either event can trigger flooding, the dynamics of each are different. Snowmelt is a relatively predictable occurrence dependent on the amounts of winter snowpack and the timing of rising spring temperatures. Large accumulations of snowpack melting in the spring contribute to some localized flooding, usually in the larger drainage basins. In contrast, summer cloudbursts cause site specific and localized flooding events in otherwise dry washes and canyons. While both types of events can have profound impacts on the floodplains and hydrologic systems, thunderstorms often occur in soils that are more susceptible to erosion and create incised channels without functioning floodplains.

Wildland and prescribed fire are secondary causes of flooding. When vegetation is burned, soils are exposed to erosion. Debris flows below fire scars are a considerable risk until vegetation is reestablished. Planning for revegetation through seeding and other mitigation efforts after fires are addressed in resources management documents and in agency practices.

For the most part, flooding is a natural process that supports channel maintenance, ecological processes, and riparian vegetation. However, flooding in areas without properly functioning floodplains has the opposite effect of widening banks and decreasing the hydrologic grade.

II. OBJECTIVES

Beaver County's objectives with regard to flood plains and river terraces are as follows:

1. To restore floodplains, especially on undeveloped federal lands, to properly functioning conditions;
2. To engage in coordinated, strategic planning to restore uplands, floodplains, native plants and vegetation, and to improve rangeland health;

3. To recognize the role of upland watershed management and incorporate them in floodplain management and restoration activities;
4. To make structural and non-structural improvements to degraded uplands to: (a) replace Class II and Class III pinyon-juniper woodlands with desirable historic vegetative communities; (b) reduce runoff; and (c) reduce the amount of bare ground;
5. To install check dams be installed to arrest downcutting and to restore natural stream grade;
6. To make the analysis and approval processes for floodplain restoration as categorical exclusions under NEPA. Corps of Engineers and other federal agency should be reduced to the minimum required under law;
7. To implement active management and restoration projects on federal lands to restore sinuosity, vegetation, and floodplain function which mimic the natural hydrologic system; and
8. To demand that land managers restore a desirable amount of non-functioning floodplains to properly functioning condition.

III. POLICIES AND GUIDELINES

1. Long term hydrologic function should be prioritized over short term ground disturbance.
2. A coordinated, strategic plan recognizing the condition of Beaver County's floodplains, especially on undeveloped federal land, does not exist. Land managers shall include a coordinated floodplain restoration and improvement program in agency resource management plans during the next regular planning cycle, or prior to January 2021, whichever occurs first.
3. Land managers shall prioritize management actions on activities that improve the productivity of resources and resource uses under their management control. Restoration of invasive conifers to desirable vegetative communities, maintenance of seedings, vegetation projects to reduce bare ground, appropriate use of prescribed fire and response to wildfire, structural projects to restore floodplains to historical topographic and ecological conditions, and other pro-active solutions shall be implemented prior to prescriptive actions associated with climate change.

4. Land managers, especially of undeveloped federal lands, shall implement an active program of structural and non-structural improvements to deficient floodplains, river terraces and associated watersheds— including uplands— to protect a) harmony between man and his environment, b) resources and resource uses, c) enjoyment of resources by current and future generations, d) rangeland health, e) water quality, and f) the County’s custom, culture, heritage, and socio-economic stability.
5. Where land managers are unable to restore a desirable amount of non-functioning floodplain due to associated substandard upland conditions, floodplain restoration may be postponed for up to three years.
6. Active floodplain management and restoration, especially on undeveloped federal lands, must be implemented to restore sinuosity, vegetation, and floodplain function. These implementations should mimic natural hydrologic conditions on an adequate amount of the non-functioning floodplains prior to 2040.
7. Analysis and approval processes for floodplain restoration shall be simplified to the maximum extent allowed by law, and shall be authorized as categorical exclusions under NEPA wherever possible. Corps of Engineers and other federal agency involvement shall be eliminated or reduced to the minimum required under law.

4.6 Dry Washes and Ephemeral Streams

I. FINDINGS

For the purposes of this Resource Management Plan, dry washes and ephemeral streams are defined as: *a watercourse or portion of a watercourse which flows briefly in direct response to precipitation in the immediate vicinity, and whose channel is dry for significant periods of time throughout the year.* Riparian areas are defined as: *the strip of vegetation along an ephemeral, intermittent, or perennial stream, which is of distinct composition and density from the surrounding uplands.*

Dry washes and ephemeral streams are the defining characteristic of many public land watersheds in Beaver County, especially in the western portions of the County, outside high precipitation forests and densely vegetated lands. Individual washes and ephemeral stream segments are not generally examined in isolation for landscape level planning purposes. However, site-specific projects often rely on the impacts associated with individual watercourses.

Dry washes and ephemeral streams are found across the Earth's land surface in arid and semiarid regions that are commonly referred to as "drylands." Approximately one-third of the Earth's land surface is classified as arid or semi-arid, including significant portions of Beaver County. These lands are characterized by low and highly variable annual precipitation, where evapotranspiration exceeds precipitation. Riparian ecosystems associate with dry washes and ephemeral streams, occupying a very small portion of the landscape. Yet, they may exert substantial influence on hydrologic, geomorphic, and ecological processes of a watershed.

Dry washes and ephemeral streams are unique in that they lack permanent flow except in response to rainfall events, but may perform the same critical hydrologic functions as perennial streams. Although arid and semi-arid region streams perform the same functions as perennial streams, their hydrology and sediment transport characteristics cannot be reliably predicted. This is due to a much higher degree of spatial and temporal variability in hydrologic processes, and also in the resulting erosion and sedimentation processes than are higher than near perennial streams. Desert environments typically produce more runoff and erosion per unit area than do temperate regions for a given intensity of rainfall due to sparse vegetation cover and poorly developed soils with little organic matter. The variability of flood magnitudes is also much greater for dry washes and ephemeral stream channels as compared to that of perennial stream systems.

Floods in dry washes and ephemeral streams often occur as flash floods, single-peak events, multiple-peak events, and seasonal floods. The highly variable stream flow in ephemeral and dry washes most often occurs as a flash flood, lasting only minutes or hours. Flash floods may occur any time of the year in response to a short-duration high-intensity precipitation event, and after the watershed has received enough precipitation to generate runoff.

Water flowing in normally dry stream channels is subject to two key forces: (1) gravity that moves the water downslope; and (2) friction between the water and channel boundaries that resists the downslope movement. These two forces determine, to a large degree, the ability of the water to modify the channel geometry and transport debris. In addition, channel roughness, slope, and depth determine the velocity of the flowing water. Channel slopes in Beaver County are often large, so when flows do occur they have high velocities and consequently significant energy and erosive power. Dissipation of energy in channels can occur due to vegetation, curvature, obstructions, and the size, character and configuration of material in the bed and banks.

As noted previously, although ephemeral streams do not flow at all times, they still perform the major functions of a stream: the transportation of water, nutrients, and sediment. However, unlike perennial streams that continuously move sediment through the watershed, sediment movement in non-perennial stream channels generally occurs as a pulse in response to

runoff generated by the short duration, high intensity thunderstorms that are typical of the area. These thunderstorms often result in flash floods and yield rapidly rising runoff. Normally dry channels tend to have deep sediments that are mostly sands and gravels, with widely scattered shrubs that are resistant to violent floodwaters. The unconsolidated sediments can be easily mobilized during flows, unlike the clay bedded, vegetated or armored channels in perennial streams. These deep sediments cause large bed and bank losses in the downstream direction, resulting in reduced flow volume and velocity over the length of the stream, and subsequent deposition of bed load materials and coarser suspended sediments. In simple terms, dry washes and ephemeral streams are usually erosive and unstable.

Generally in Beaver County, dry washes and ephemeral streams do not exhibit dominant riparian vegetation characteristics. Often there is little differentiation between upland vegetation and bank vegetation. Structural, biologic and ecological functions do not exist, and banks and streambeds are prone to erosion.

Vegetation in arid and semi-arid regions is largely controlled by the availability of water, with flood disturbance and soil conditions further shaping plant distribution patterns. Depending on attributes of the particular dry watercourse, the highest density of vegetation may occur along the streambank or within the channel bed. By providing channel and streambank roughness through standing or downed material, vegetation can influence flow velocities, flow depths, bank and floodplain erosion, and sediment transport and deposition, and can be a major factor contributing both to channel stability or instability.

Vegetation along the streambank stabilizes the soil through the reinforcing nature of its roots, and prevents erosion. In dry washes and ephemeral stream channels, vegetation may establish on sand bars, and subsequently initiate the formation of various depositional features such as small current shadows, bars, benches, ridges, or islands. Spatially extensive assemblages of any plant species have the potential to alter geomorphology and geomorphic processes through disturbance of sedimentary deposits, alteration of nutrient or fire cycles, and patterns of succession.

The goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, and to prevent pollution of those waters. Historically, major desert washes have sometimes been considered to be jurisdictional under the CWA. However, as a result of Supreme Court decisions, the definition of the nation's waters or jurisdictional waters of the United States under the CWA has required additional clarification, specifically with respect to tributaries that are "not relatively permanent" (i.e. dry washes and ephemeral streams). Recent guidance from the U.S. EPA and Army Corps of Engineers requires that a significant nexus exist between dry washes or ephemeral stream and a traditional navigable water of the United States for the dry washes or ephemeral streams to be jurisdictional under the CWA. This

significant nexus evaluation must consider flow characteristics and functions of the tributary to determine if it has a significant effect on the chemical, physical, and biological integrity of downstream traditional navigable waters.

II. OBJECTIVES

Beaver County's objectives with regard to dry washes and ephemeral streams are as follows:

1. To restore dry washes and ephemeral streams, especially on undeveloped federal lands, to properly functioning conditions;
2. To make structural and non-structural improvements to degraded dry washes and ephemeral streams;
3. To recognize the role of upland watershed management be recognized and incorporated in dry wash and ephemeral stream restoration;
4. To make structural and non-structural improvements to degraded uplands to a) replace Class II and Class III pinyon-juniper woodlands with desirable historic vegetative communities, b) reduce runoff, and c) reduce the amount of bare ground;
5. To install check dams to arrest downcutting, and to restore natural stream grade in dry washes and ephemeral streams;
6. To make the analysis and approval processes for dry wash and ephemeral stream restoration categorical exclusions under NEPA; and
7. To demand that land managers restore to properly functioning condition a desirable amount of non-functioning dry washes and ephemeral streams per year.

III. POLICIES & GUIDELINES

1. Coordinate with federal and state entities on strategic plans to restore dry washes and ephemeral streams, and to improve rangeland health.
2. Corps of Engineers and other federal agency involvement must be reduced to the minimum required under law. Dry washes and ephemeral streams must be recognized as outside of the Corps of Engineers jurisdiction.

4.7 Groundwater

I. FINDINGS

Groundwater is Beaver County's principal reserve of fresh water, and represents much of its potential future water supply. Groundwater on federal lands is a major contributor to flow in many streams and rivers, and it has a strong influence on the health and diversity of plant and animal species in forests, rangelands, grasslands, riparian areas, lakes, wetlands, and springs. It also provides drinking water for all of the public water systems, and is connected to many of the private water systems in Beaver County.

As of 2010, the U.S. Geological Survey indicated 1100 residents of Beaver County utilized self-supplied culinary water from groundwater sources. These wells supplied approximately 190,000 gallons of water per day, or about 171 gallons per person per day. The municipalities in Beaver County provide nearly 2.4 million gallons of culinary water per day, all of which comes from groundwater sources, either from springs or wells.

Awareness of groundwater's importance, the need for safe drinking water, and requirements to maintain healthy ecosystems are increasing. Many of the concerns about groundwater resources on private and public lands center around dependability of long term supply, depletion of groundwater storage, reductions in streamflow, potential loss of groundwater-dependent ecosystems, and changes in groundwater quality. The effects of human activities common to more populated areas, land subsidence, and saltwater intrusion are not applicable to Beaver County. Contamination from landfills, septic tanks, leaky underground gas tanks, and from overuse of fertilizers and pesticides is prevented and controlled through various federal, state, and local regulatory mechanisms.

Groundwater wells in the County are utilized primarily for culinary water and crop irrigation. With virtually no oil and gas development in Beaver County, there are no concerns over potential groundwater contamination from those sources. However, E. Coli and other bacterial contaminants were discovered in Milford Flat wells in the fall of 1998. The sewer lagoons from the valley's hog farms were suspected of being the source of the contamination. The Utah Department of Environmental Quality began a year-long study, finding: (1) There was no compelling data to support the contention that ground water was contaminated; (2) there was no data to support the contention that the bacteria originated in the Circle 4 sewer lagoons; (3) there was no data to suspect the Beaver River as the source; (4) data did not indicate septic seepage as the source; and (5) data strongly suggested the bacterium stemmed from pipes in the well apparatus.

The Utah State Engineer manages potential drawdown of groundwater resources. As of March 19, 1997, Most of the Sevier River Basin was closed to all new appropriations. All new groundwater development is to be based on the acquisition and changing of existing valid water rights, from surface sources like direct flow and reservoir storage, to underground sources. As of January 1, 2017, areas of western Beaver County are “Open” status, signifying unappropriated water is available in the aquifer system.

Ground water is a valuable commodity, and its use is increasingly important. Federal lands contain substantial ground water resources, for which stewardship and protection are mandated by various congressional acts. Many other natural resources rely on ground water, and could be damaged or destroyed if that water were depleted or contaminated. Generally, groundwater resources in Beaver County are relatively deep and have little impact on surface resources. However, overuse of ground water may impact streams, wetlands, riparian areas, forest stands, meadows, grasslands, seeps, springs, and livestock and wildlife watering holes on a site-specific basis. Reduced water-table levels near the earth’s surface can impact biota that depend on ground water, particularly in riparian and wetland ecosystems.

Groundwater quality is highly variable, and is dependent on the location of the aquifer formation, potential pollutants, and the recharge mechanism. Groundwater quality is classified by the Utah Water Quality Board based primarily on the amount of total dissolved solids (“TDS”). Lower amounts of TDSs indicate higher water quality. Potential pollution from private lands has been reduced in recent years with greater knowledge, conversion of flood to sprinkler irrigation, and added emphasis on groundwater quality. Limited development and pollution sources on federal lands suggests a low risk, except for wildland and prescribed fire, which still have the potential to affect groundwater and primary sources of culinary water in the County.

II. OBJECTIVES

Beaver County’s objectives with regard to groundwater are as follows:

1. To preserve, improve, and develop groundwater resources for the use of man while supporting multiple use/sustained yield principles;
2. To develop inventories of the quantity and quality of ground water on federal land to provide the information necessary to appraise their value, and to provide for appropriate stewardship of ground water resources, especially in landscape level planning;
3. To demand that land managers ensure that adequate groundwater resources are available for authorized purposes, and to support local communities;

4. To demand that land managers prevent or minimize adverse impacts to groundwater resources through appropriate vegetative treatments that optimize forest and rangeland health;
5. To recognize humans as a subset of groundwater dependent fauna, and development of resources for their use should be given priority;
6. To demand that land managers optimize forest and rangeland health and vegetative cover as a means of preserving and protecting groundwater resources;
7. To recognize that watersheds that are the source of supply for community and culinary water systems, and wishes that they be managed for resistance and resilience to fire; and
8. To establish the following minimum standards when lands experience prescribed or wildland fire:
 - a. Retain adequate ground cover after the burn with recruitment to a suitable amount of ground cover before the first rainy season following the burn;
 - b. Do not reduce perennial and intermittent channel shading to a less than desirable amount of the natural range of variability or by an amount that will take more than three years to recover;
 - c. “Burn” and/or “feeder” piles will not be made in channels or swales within the area occupied when the bank full width is doubled;
 - d. Burned piles within riparian areas will be left “messy” in order to retain sediment on site;
 - e. Ignitions will not occur within 15 feet of riparian areas;
 - f. Any firelines created during burning operations will follow *The Five-D System for Effective Fireline Waterbars* (Hauge et al., 1979);
 - g. Fire lines that need to cross riparian areas will do so perpendicular to the channel and should not have more than 40 feet of hydrologic connectivity;
 - h. Cupped fire lines should have water gaps every 20 feet to allow captured water to exit; and

- i. Existing disturbance areas, such as roads and trails, should be used to the extent possible as fire lines.

III. POLICIES AND GUIDELINES

1. Land managers must comply with federal, state, and local requirements for wellhead protection and sole source aquifer use. Managers also must ensure all public water systems on their lands comply with applicable groundwater regulations.
2. Land managers must protect ecological processes and biodiversity of groundwater dependent ecosystems by a) maintaining natural patterns of recharge and discharge by minimizing disruption to ground water levels that are critical for ecosystems; b) not polluting or causing significant changes in ground water quality; and c) rehabilitating degraded ground water systems where possible.
3. Land managers must manage groundwater dependent ecosystems under principles of multiple use/sustained yield, while emphasizing protection and improvement of soil, water, and vegetation.
4. Based on site-specific characteristics of water, geology, flora, and fauna, land managers must identify, inventory, and determine boundaries of groundwater dependent ecosystems as part of land use planning processes.

4.8 Wetlands

I. FINDINGS

A wetland is a land area that is saturated with water, permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. Wetlands have been defined in many different ways by different entities, however, the U.S. Army Corps of Engineers (Corps) and the Environmental Protection Agency (EPA) jointly define wetlands as: “Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that do under normal circumstances support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.” This definition of wetlands is the most relevant to local land managers and planners because the Corps and the EPA are the agencies that have legal jurisdiction over wetlands, including those wetlands on private property.

Prolonged saturation with water leads to chemical changes in wetland soils, which in turn

affect the kinds of plants that can grow in wetlands. Some wetlands are easy to recognize because the water sits on the land surface for much of the year. Other wetlands exist due to saturation of the soil by groundwater and can be difficult to identify. Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance.

According to the National Wetlands Priority Conservation Plan (“NWPCP”) of the USFWS (1989), wetlands are considered to be lands in transition zones between aquatic and terrestrial systems where the land is covered by shallow water or the water table is usually near or at the ground surface. Wetlands are critical components of healthy regional ecosystems. They provide essential habitat for many species of fish and wildlife, as well as important resting places for migrating birds. They can also control floods and erosion, purify wastewater and recharge groundwater. The NWPCP is intended to assist public agencies and the private sector with identifying wetlands warranting priority consideration for protection.

Under Section 404 of the Clean Water Act, the Corps is the legal authority designated to issue permits for all activities that involve wetlands, including: placement of fill or dredge material in a wetland, ditching activities, levee, dam or dike construction, mechanized land clearing, land leveling and road construction.

The U. S. Fish and Wildlife Service provides a wetlands interactive map of the United States, including Beaver County. The National Wetlands Inventory map (available at <http://www.fws.gov/wetlands/>) provides County staff and the public with the general location of areas with wetland characteristics.

Beaver County has very limited water resources due to its arid climate. Nearly all of the surface water in the county is used for municipal and agricultural purposes. The National Wetlands Inventory map identifies many so-called wetlands in the county that rarely have water or saturated soils typical of a wetland feature. Many of these mapped wetland locations are historic and indicative of conditions prior to modern settlement and diversion for beneficial purposes. Nevertheless, activities affecting these wetland areas are regulated by the U.S. Army Corps of Engineers.

II. OBJECTIVES

Beaver County’s objectives with regard to wetlands are as follows:

1. To protect precious water resources, including legitimate wetland areas for water purification, groundwater recharge, flood control, and wildlife habitat; and

2. To prioritize private property rights and to strengthen those rights by pursuing legislation that will change, undo, or overhaul burdensome federal regulations and policies that lack merit or local application.

III. POLICIES AND GUIDELINES

1. Beaver County believes that protection of natural wetlands, as defined in the Clean Water Act, benefits the environment and is ecologically prudent.
2. The U.S. Army Corps of Engineers, as the permitting authority for development of wetland areas, shall be judicious and cautious in weighing the benefits of wetland preservation against the development needs of Beaver County and its citizens; those development sites subject to permitting, must meet the criteria for soils, vegetation and hydrology pursuant to the Clean Water Act (Sec 404) to be considered a wetland.
3. Beaver County opposes the wetland delineations as currently mapped by the National Wetlands Inventory map, where those areas that have been without surface water or saturated soils for multiple years and do not conform to the definition of wetlands should be removed from such maps and exempted from wetlands policy restrictions.
4. Beaver County supports only those true wetland areas that have natural water sources that inundate or saturate the soil on an annual basis and actually function as wetlands.
5. Land managers shall not make restrictive plans, actions or management policies for areas as wetlands unless they conform to the definition of wetlands as given by the EPA and U.S. Army Corps of Engineers.

4.9 Water Quality

I. FINDINGS

Beaver County contains some of the most sparsely populated lands in Utah and has very limited industrial and municipal development. 77% of the land is under federal ownership, and only 13% is held by private interests. Consequently, population growth and the development of urban/urbanized areas and industries which have major influences on water quality do not exist. Point source discharges are controlled by state and local regulations; and overall water quality is within established standards. Industrial and municipal discharges are almost entirely limited to municipalities. Containment structures (lagoons) are located in Beaver City, Minersville and Milford. Other communities rely on private wastewater systems. No point source discharge issues are known to exist in Beaver County. However, private lagoons exist for large agricultural industries.

Nonpoint source discharges are also characteristic of rural, sparsely populated areas. Relatively few perennial streams and water bodies exist in Beaver County. Several water resources in the County have been identified on the state's list of 303(d) impaired waters including: Beaver River, Minersville Reservoir, Puffer Lake, Kents Lake, and LeBaron Reservoir. Points of concern include total phosphorous, noxious aquatic plants (algae), riparian habitat modification, dissolved oxygen, and temperature. TMDL reports, which include water quality data and implementation plans typically carried out by various federal, state, and local governments and private cooperators, have been prepared for these waters. Sedimentation and nutrient loading are common problems in Beaver County's impaired waters.

In addition to point and nonpoint pollution sources that are commonly recognized as impacting perennial waterbodies, Beaver County is also impacted by pollution from ephemeral streams. Stormwater runoff is generated from rain and snowmelt events that flow over land and do not soak into the ground. The runoff picks up pollutants like organic debris and dirt/sediment that can harm rivers, streams, and lakes. Concentrated flows also cause damage to ephemeral streambanks and dry washes, threatening rangeland health and stability. Although detailed empirical data is not available, runoff intensity has notably increased over the past few decades. Larger and more damaging runoff events have taken place, and sediment and debris flows have increased proportionally. Together, they can cause changes in hydrology and water quality that result in habitat modification and loss, increased flooding, decreased aquatic biological diversity, and increased sedimentation and erosion. The benefits of effective stormwater runoff control and management of ephemeral watercourses include: protection of wetlands, riparian and aquatic ecosystems, improved quality of receiving waterbodies, conservation of soil resources, and improved range/land forest health.

To protect water quality and associated resources from point and nonpoint pollution, stormwater controls, known as best management practices ("BMPs"), have been implemented by various agencies. These BMPs filter out pollutants and/or prevent pollution by controlling it at its source. The State of Utah and local governments are authorized under the Clean Water Act to implement permitting and management actions, including BMPs to protect water quality and water resources.

Another form of non-point source pollution is hydrologic modification. This term refers to activities that affect the natural pathways of surface water and streambank erosion. Although these activities do not appear to be forms of pollution, they nevertheless are considered to be part of the non-point source pollution problem. Many rivers and streams have natural flood control areas, such as oxbows, adjacent wetlands, and riparian zones. When these areas are modified or removed, significant changes in the ecological functions of surrounding lands are likely to occur. Channel modifications, even when occurring naturally, frequently degrade instream and riparian

habitat for fish and wildlife. Other impacts include erosion and the reduction of the system's ability to filter pollutants. Similarly, upland vegetative modifications, especially adjacent to riparian areas and wetlands can change surface hydrology and reduce natural buffers.

II. OBJECTIVES

Beaver County's objectives with regard to water quality are as follows:

1. To take an active role in water quality management by developing plans, regulations, ordinances, and best management practices surrounding water quality issues;
2. To ensure that any NEPA analysis includes a specific and cumulative impact analysis of Class II and Class III pinyon-juniper woodlands on water quality;
3. To ensure that management of water bodies in Beaver County are coordinated, re-evaluated and are consistent with this plan;
4. To demand that land managers actively manage water bodies in a manner that provides for increased forage production that reduces sedimentation in, and hydrologic modification of, Beaver County's perennial, intermittent, and ephemeral water resources;
5. To ensure that soils in Beaver County, consistent with ecologic site descriptions, produce a suitable amount of their potential by 2025 and show increasing improvement of their potential by 2050;
6. To demand that land managers recognize that storm water management approaches that rely solely on peak flow storage have not usually targeted pollution reduction and only treat sediments after they have entered the watercourse. Upland vegetative productivity and cover also need to be enhanced and optimized with appropriate native and non-native seed mixes;
7. To demand that, consistent to the maximum extent allowed by law, land managers: (a) reduce impacts to water quality by complying with the provisions of Beaver County's Resource Management Plan; or (b) as approved by Beaver County, develop and implement a cooperative and coordinated water quality management plan prior to the first day of their 2020 fiscal year; and
8. To develop policies, goals, objectives and best management practices for forest and rangelands to reduce sediment and debris in the County's watercourses.

III. POLICIES AND GUIDELINES

1. Beaver County will cooperate and coordinate with the State of Utah to review and revise Total Maximum Daily Loads (“TMDLs”) for hydrologic units listed on the 303(d) list of impaired streams.
2. Beaver County will coordinate with the Utah Division of Water Quality to re-evaluate and refine beneficial use designations of Beaver County’s water bodies.
3. It is the policy of Beaver County that water-quality testing guidelines should be established by the State of Utah and not by the federal government. At a minimum, testing requirements should be modified to fit local necessity and circumstances.
4. Beaver County supports expanded livestock grazing adaptive management including extended on/off dates, intense seasonal grazing to control invasive species and vegetation based use criteria. Unless coordinated with and approved by Beaver County, livestock grazing restrictions shall not be implemented until water quality prioritizations and provisions outlined in this plan are completed.
5. Land managers shall control water runoff from disturbed or developed sites and shall control soil erosion from undeveloped sites through implementation of provisions contained in the CRMP. With concurrence of the Beaver County Commission, land managers may implement alternate provisions that have been coordinated with the County and are demonstrated to advance the findings, policies, goals, and objectives of the CRMP.
6. Surface disturbing activities within withdrawn Drinking Water Source Protection Zones may be allowed if the disturbance does not degrade water resources and best management practices are implemented.
7. Proper disposal, other beneficial use and appropriate surface discharge of produced water from new activities on public land is allowed if mitigation measures and/or best management practices are implemented to address impacts from the produced water.
8. Beaver County supports an integrated approach to stormwater management without negatively impacting existing resource levels and uses. Based on existing conditions, current technology, acreages in need of improvement, effectiveness of potential actions, and other factors, Beaver County adopts the following prioritization to improve water quality:

- a. Optimization of upland vegetative cover through restoration, improvement and enhancement of desirable native and non-native vegetative communities, including restoration of Class II and Class III to sagebrush / semi-desert grasslands, especially in areas of accelerated erosion;
- b. Development, enhancement and expansion of detention areas, lakes, ponds, wetlands, riparian areas, grade structures, and mesic conditions to slow stormwater and reduce erosion;
- c. Maintenance of existing biologic soil communities where it is scientifically and statistically demonstrated their positive impact on water quality exceeds benefits from optimizing vegetative cover by more than 20%;
- d. Modification of existing Best Management Practices for oil & gas leasing, mining, timber harvesting, recreation, OHV use, roads, travel designations, livestock grazing and other multiple use/sustained yield activities.

5. RECREATION AND TOURISM

I. FINDINGS

Recreation and tourism resulting from Beaver County's unique character, history, and culture plays a critical role in the local economy. The importance of this sector continues to increase with the growing number of tourists attracted to National Parks and Recreation Areas in and around Beaver County. According to the Utah Department of Workforce Services, leisure and hospitality jobs had a 17.4% non-agricultural industry share in 2015, ranking 13th out of Utah's 29 counties. According to the Utah State Tax Commission, in 2015, travel-related tax revenues totaled approximately \$343,178. As with most counties in Utah, recreational and tourism activity fluctuates by season, with visitation high during summer months and lower during winter months. However, Beaver County can increase recreation and tourism during "off-seasons," and in general, by increasing public awareness of recreational opportunities and other attractions that Beaver County has to offer.

Beaver County offers many world-class outdoor recreation opportunities. The majestic Tushar Mountain Range marks the eastern boundary of Beaver County. The range includes two of the highest mountains in the state, Delano Peak (12,173 feet) and Mount Belknap (12,139 feet). In addition to breathtaking hiking and backpacking trails, Beaver County has mountain biking opportunities, including a mountain traversing bike race each summer. Horse riding and packing trails and ATV trails are numerous and popular. The Tushar Mountains do not just offer summer activities, skiing, snowmobiling and ice fishing are very popular winter activities enjoyed by many locals and visitors. The large granite rock formations of the Mineral Mountains provides an adventurous wonderland for exploring as well as highly technical climbing and rappelling opportunities for more advanced climbers. Frisco Peak has been the destination for hang gliders who are bold enough to launch off the steep precipice into the rising desert thermals.

Beaver County is also known for its high quality hunting and fishing opportunities. Beaver County is home to many huntable species including big game, waterfowl, and predators. The trophy-class elk and deer found in Beaver County are highly sought after and a prized resource. Minersville Reservoir is managed to produce trophy-sized trout, wipers and smallmouth bass. The high mountain lakes and streams of the Tushar Mountains have Rainbow, Brown, Cutthroat, and Tiger trout varieties.

Beaver County is also a hotspot for "rockhounds" who are drawn to Beaver County's plentiful deposits of desirable minerals. Many geological tourists travel to the Mineral Mountains, a short distance from Milford and Minersville, to find deposits of smoky quartz, feldspar and many other prized gems.

People come to Beaver County from all over the country to ride on the Paiute ATV trail. This world-class trail system traverses several counties in southwestern Utah, including Beaver County. There are many other popular OHV riding areas scattered across the county for exploring as well. The Mineral Mountains are a fascinating location to explore on OHV's and draw many riders here each year.

As nearly 80% of all land in Beaver County is federally owned and/or managed, many recreational activities that provide a significant economic stimulus to Beaver County are reliant on reasonable access to public lands for recreational purposes. When public lands are managed strictly for the purpose of preservation, and not for multiple uses, Beaver County suffers real and direct economic harm.

In addition to classic outdoor recreation options, Beaver County also offers attractions of the historic variety. Beaver County has a diverse history that includes Native American inhabitants, famous explorers, western outlaws, Mormon settlers, military personnel, and mineral prospectors. The famous outlaw Butch Cassidy was born in Beaver and Philo T. Farnsworth, the inventor of the television, was born in Manderfield. Visitors to Beaver city can visit the Historic Territorial Courthouse and see the Philo T. Farnsworth statue and Farnsworth family cabin.

Tourists can also explore Beaver County's numerous ghost towns. The most infamous of these sites is Frisco, which in the late 19th century was one of the wildest mining camps in the west. Frisco once had 21 saloons, gambling halls, a red light district, and frequent shootouts.

Beaver County has many exciting and unique recreational and tourist attractions that are not well known, even among Utahns. Recreational activities in Beaver County are not limited to summer months and tourism should remain strong during all seasons. Increased land access and advertising will increase tourism in the County and will strengthen the local economy.

II. OBJECTIVES

Beaver County's objectives with regard to recreation and tourism are as follows:

1. To draw more visitors to the County and to raise awareness of the diverse recreational opportunities within the County; and
2. To ensure that public lands are managed in a manner that provides for multiple uses including recreational activities such as OHV use.

III. POLICIES AND GUIDELINES

1. It is the policy of Beaver County to support outdoor recreation on public lands as part of a balanced plan of economic growth and quality of life.
2. Beaver County, through its Tourism and Outdoor Recreation department, in conjunction with the travel council, will work to increase recreational opportunities and marketing.
3. Public land management agencies must manage public lands in a manner that allows for multiple use; singular uses, including recreational activities, shall not be used to dictate land management policies or decisions.
4. Public land agencies shall not discriminate against one kind of recreational activity in favor of another.
5. Public land agencies, including the BLM and USFS must coordinate and consult closely with Beaver County in any decision-making affecting recreational resources within the county. Public land agencies must provide for early and meaningful involvement of Beaver County, especially with regard to special designations that may limit recreational opportunities on public lands.
6. Beaver County will encourage private sector development of recreational facilities and services using development incentives where feasible and appropriate.
7. Beaver County will seek partnerships with public land agencies and stakeholders with the purpose of improving and maintaining trails (hiking, cycling, OHV) within the County.
8. Beaver County will take all necessary actions to protect access to public lands. This includes historic rights to access federal lands with the regard to recreational activities.
9. Wildlife hunting, trapping, and fishing should continue at levels determined by the Utah Wildlife Board and the Utah Division of Wildlife Resources in consultation with Beaver County.

6. FIRE MANAGEMENT

I. FINDINGS

Wildland fire plays an integral role in forest and rangeland systems in Beaver County. Both wildfires and prescribed fires help maintain healthy ecosystems and vegetation. In a properly functioning ecosystem, frequent low intensity fires would remove dead and old-age vegetation. However, limitations on logging and grazing practices over the past several decades as well as the invasion of exotic and noxious species, have resulted in more dense and less diverse wildlands and the accumulation of large amounts of woody debris and increased fuel load. These conditions have created the severe wildfires that Utah has experienced over the past several years. These unusually intense wildfires threaten the wellbeing of the land, citizens, and property. It is vital to maintain appropriate fire management policies and plans.

Every year, hundreds of wildfires burn on private, state, and federal land in Utah. Fires occurring on federal and tribal lands are managed by the USFS, BLM, NPS, USFWS, and the Bureau of Indian Affairs. Over the past few decades, the federal government has implemented multiple policies designed to more quickly and effectively manage wildland fires. In 2000, the National Fire Plan (“NFP”) was developed to ensure that fire managers meet sufficient preparedness standards, establish long and short term restoration efforts, reduce fuels in high risk area, and to identify plans to maintain ecosystem health by eliminating harmful and invasive insect and plant species. The Healthy Forests Restoration Act (“HFRA”), which became law in 2003, sped up the reduction of hazardous fuel by allowing timber harvests on National Forest land and streamlining the permitting process by including a list of categorical exclusions from the environmental impact assessment process. Both the NFP and HFRA mandated coordination with state and local governments.

However, litigation concerning environmental rules and regulations has hindered the effectiveness of these federal policies and programs. The litigation and other efforts to neuter the effectiveness of federal programs have contributed to continued long-term buildup of volatile fuels and post-fire restoration efforts that allow for the spread of invasive and harmful species.

Wildfires that occur on state and private lands that are not inside city limits are managed by the Utah Division of Forestry, Fire & State Lands, and are coordinated through County Fire Wardens. County Fire Wardens work with federal agencies and local fire departments to coordinate suppression efforts. Beaver County has three fire stations, one each in the incorporated areas of Beaver, Milford, and Minersville. The fire departments are administered through Special Service District #1 (Beaver), serving the east side of Beaver County, and Special Service District #2 (Milford & Minersville), serving the western half of the

County.

The Districts have been actively engaged in applying fire preventative measures set forth in the 2006 Utah Wildland-Urban Interface (WUI) Code. These measures include removing ladder fuels, creating firebreaks, and applying set-backs to appropriate levels for surrounding cover. Wildland-urban interface refers to the transition zone between unoccupied land and human development prone to wildfire. Over the last twenty-five years, tens of thousands of homes and cabins have been built in Utah's wildlands. Approximately 137,000 acres of Utah wildland has been developed for housing. This trend is likely to continue at an accelerated rate. According to a Profile of Development and the Wildland-Urban Interface produced using Headwaters Economics' Economic Profile System, as of 2010, Beaver County ranked 11th out of 29 counties in Utah in current risk of wild fire in wildland-urban interface areas. Given the increased threat to individuals and property, additional policies, programs, and actions are needed.

Beaver County finds that land managers have not sufficiently utilized certain strategies in managing wildland fire on public lands. Undesirable shrub cover has been allowed to linger in high-risk areas. Reducing shrub cover in dense strands or maintaining open stands of shrubs with a good understory of perennial grasses, forbs, and low shrubs can reduce the damaging effects of wildfire, make wildfire control more effective, and help reduce invasion of noxious weeds. Dense strands of shrubs (e.g. sagebrush, pinyon-juniper) may have a lower risk of burning than grasslands but the intensity of fires is increased due to higher amounts of fuel that increase temperature and duration of fires. Although most grasses and many shrubs are adapted to periodic fire, extreme fire intensity can kill even these plants, leaving the burned site barren and subject to invasion by noxious weeds that can spread rapidly into unoccupied land.

Historically, livestock grazing has no doubt been a factor in reducing incidences of wildfire. However, livestock grazing has not been widely used by land management agencies as a primary tool in fire management. This is due, in part, to litigation concerning federal programs designed to increase grazing as a fire preventive tool. However, studies have shown that grazing at 30-80% utilization can provide fuel reductions that are sustainable while maintaining the ecological integrity of the land. Similarly, local timber industry has not had sufficient access to public land for the purpose of clearing out standing dead timber. Not only would these activities benefit the Beaver County economy, but they would also decrease the risk of wildfire.

II. OBJECTIVES

Beaver County's objectives with regard to fire management are as follows:

1. To fulfill its responsibility to protect the health, safety and welfare of its citizens and visitors by ensuring that prescribed wildland fire is properly used in a manner that is beneficial to Beaver County;
2. To actively coordinate with federal, state, and local agencies in implementing fire management plans and policies; and
3. To demand that land managers utilize all available means of reducing forest fuel such as grazing and timber harvesting.

III. POLICIES AND GUIDELINES

1. It is the policy of Beaver County to continue cooperating with the Utah Division of Forestry, Fire and State Lands to address wildfire issues in Beaver County.
2. Beaver County supports all efforts to reduce the potential for resource damage associated with wildfires on public lands.
3. Fire-damaged areas on public lands within Beaver County shall be re-vegetated with seedings as soon as possible following a fire event.
4. Land managers must coordinate with Beaver County in all decision making and actions related to fire and fuels management affecting Beaver County including providing the County with information related to prescribed burns, in conformity with federal law.
5. Prescribed burns should be avoided on weekends and holidays when Beaver County anticipates an influx of tourists.
6. Beaver County will create a local interdisciplinary working group to assist with the implementation of the Federal Wildland Fire Management Policy that includes at least one member from the County.
7. The use of tools including, but not limited to, livestock grazing, chemical, and other mechanical control is critical to protecting ecosystem health from invasive species after fire events.
8. The reduction of fuels through silviculture and livestock grazing is a necessary practice.
9. Long-term (i.e. 20 years) timber harvest leases, based on local market value, are important to allow private industry to take the financial risk and make an investment in the infrastructure necessary to maintain the timber industry and forest health in the County.
10. Increased timber harvests should be analyzed in the next forest plan update to improve

the economic viability of logging in the County and improve forest condition.

11. Treat insect outbreaks as emergencies. Forest insect management should focus on altering stand condition that factor-in insects and include all methods to reduce or prevent insect infestations including, but not limited to, salvage and sanitation cutting, spraying, biological control, prescribed burning, etc. to prevent widespread tree mortality.
12. Beaver County supports prescribed wildland fire use on rangelands and encourages prescribed burns where appropriate.
13. Managed livestock grazing is an effective management tool for both revegetation and fuel reduction.
14. Livestock grazing should be returned to pre-fire levels when post-fire monitoring data shows objectives have been met, or have been achieved to the extent possible based on site potential.
15. Adaptive management practices for grazing shall be developed and included in term grazing permits to allow for flexible forage utilization and fuel load reduction on allotments with dense understory foliage or in areas with heavy cheatgrass infestations.
16. The development of measurable, achievable objectives should be used in all Emergency Stabilization and Rehabilitation (ESR) plans and management decisions, based on site potential.
17. Vacant grazing allotments should be assigned to permittees affected by fire or other resource concerns as quickly as possible to minimize the economic disruption to permittees.
18. The removal of pinyon-juniper infestations throughout Beaver County is necessary to decrease wildfire potential and improve upland habitat conditions.
19. Post-fire monitoring should be completed as soon as allowed by the fire closure decision to determine if reseeding objectives have been met. If objectives have not been met, land managers should complete a determination regarding the likelihood of the objective being met without additional resources and continued closure.
20. State and local agencies will participate in identification of geographic-based or criteria-based areas where restorative actions are needed on private, state and federal lands.
21. Beaver County will provide and promote the education of communities and property owners in the wildland-urban interface regarding fuels mitigation, creating defensible space and fuel breaks and meeting other standards in the current Utah WUI Code.

22. Beaver County will enforce WUI code standards for subject lands in the county.
23. Federal land management agencies are responsible to reduce the risk of harmful wildland fires on federal lands adjacent to wildland-urban interface areas.

7. LAND ACCESS

7.1 Land Access

I. FINDINGS

Access to public lands has always been crucial and necessary in Beaver County. Over 77% of the county (over 1,265,500 acres) is under federal land ownership. Access to land, water and natural resources is critical to the residents of this county for their livelihoods, recreation and way of life. The economy of Beaver County is likewise tied to public lands and access to the available natural resources. Local municipalities rely on water from public land watersheds to sustain those communities. Ranchers, miners, hunters, hikers, outdoor enthusiasts and many others rely on access to public lands and the opportunities found there.

However, access to public lands continues to dwindle as increasingly more roads are closed by federal agencies and greater pressure is applied by special interest groups to place wilderness designations on existing lands. Travel management planning processes that result in road closures or efforts to manage for wilderness suitability or other restricted use designations will severely impact or halt land access and natural resource use and harm local economic viability.

Travel throughout Beaver County occurs in many forms. Motorized travel includes both on-highway and OHVs. OHVs include motorcycles, three-wheelers, all-terrain vehicles (“ATVs”), side-by-side vehicles and snowmobiles. Non-motorized travel includes hiking, backpacking, cycling, skiing, and equestrian travel. The BLM and USFS have undertaken travel planning processes in recent years. These plans address motorized and non-motorized vehicle use and road closures for each agency.

Commonly known as R.S. 2477, rights-of-way for travel across federal lands were recognized by Congress in 1866 with what may be the shortest statute on record: “the right-of-way for the construction of highways across public lands not otherwise reserved for public purposes is hereby granted.” This statute was repealed in 1976 with the passage of FLPMA, but the existing rights remained in place. Beaver County maintains approximately 623 miles of class “B” roads across public lands with varying levels of use and surface treatments. In addition, there are over 750 miles of roads in Beaver County that have been identified, reviewed, documented and inventoried for inclusion in the county road system as qualifying for RS 2477 right-of-way claim status. Many additional roads exist in the county road system that may, or may not qualify, pursuant to further review and evaluation.

The BLM must follow numerous federal laws regarding management of transportation and travel on public lands. For example, the Wilderness Act of 1964 prohibits motor vehicles

in wilderness areas except in emergency situations. FLPMA is the overarching document that pertains to all of the BLM's management responsibilities. FLPMA directs the BLM, with regard to travel on public lands, to balance public access and multiple uses with the protection and preservation of the quality of the lands and its resources to be able to be enjoyed by the public for many years to come. Travel management and road access on BLM lands are determined through the land use management planning process. NEPA dictates that certain federal projects and land use decisions (including decisions related to opening and closing BLM roads) must go through an environmental review process. The BLM's Cedar City Field Office is currently (2017) undertaking a travel management planning process to review all roads in the planning area, identifying which will remain open and which should be closed. Various management alternatives will be presented for public comment prior to a final Record of Decision.

In 2005, the Forest Service issued a Travel Management Rule requiring national forests to designate open roads. All prior legal motorized use on non-designated routes became illegal. See 36 C.F.R. Parts 212, 251, 261, and 295. The Fishlake National Forest finalized its motorized travel plan and OHV route designation project in December 2006, and the plan was implemented in 2007. The old travel plan relied on an "open unless signed or mapped closed" enforcement scheme which was deemed too complicated to interpret and difficult to administer. New user created routes proliferated without closed signs to halt further use, which exacerbated conditions, particularly in sensitive resource areas. The management of Forest Service roads and trails under the new Motorized Travel Plan switches to an explicit designated use only system where travel is limited to only those roads and trails signed and mapped as open and for specific uses and/or vehicle type. Multiple roads and numerous trails were closed and decommissioned from use after this action.

II. OBJECTIVES

Beaver County's objectives with regard to land access are as follows:

1. To protect Beaver County citizen's vested rights of access to all publicly owned areas of the County through its duly appointed planning and zoning commissions and full board of county commissioners.

III. POLICIES AND GUIDELINES

1. Public rights-of-way established under RS 2477 are not negotiable and cannot be subjugated or taken by any state or federal agency. They are vested property rights duly recognized in federal and state law.
2. RS 2477 is a property right claim of the public for transportation routes that cannot be

given or taken away by any federal agency. Beaver County acknowledges that in 1866, Congress granted access across federal land not otherwise reserved. The evidence of acceptance of that grant is the Beaver County Transportation Map, renderings of historic documents, and the public's continued presence on and use of these routes.

3. RS 2477 rights-of-way may include, and are not limited to, horse paths, cattle trails, irrigation canals, waterways, ditches, pipelines or other means of water transmission and their attendant access for maintenance, wagon roads, jeep trails, logging roads, homestead roads, mine to market roads and all other ways established and held consistent with Utah Code § 72-5-104 and in use prior to October 22, 1976.
4. Title V grants to local county governments or the States are in perpetuity. Nothing in Title V gives the Secretary of the Interior authority to arbitrarily close a road or a corridor once it is granted except by cooperation and coordination with the government entity holding the grant. In applying for a right-of-way, or other use of lands under Title V of FLPMA, consistent with Utah Code § 72-3-108, Beaver County does not relinquish its right to the land, its use or property ownership under RS 2477 or any other law, regulation or Act.
5. All rights of Beaver County and the State of Utah in and to such roads, ways and routes may be revoked only in compliance with Utah Code § 72-5-105 and by formal action of the Board of County Commissioners of Beaver County to abandon such route as a public way, pursuant to Utah Code § 72-3-108.
6. All necessary action will be taken to protect access to public land. It is the policy of Beaver County to use reasonable administrative and legal measures to protect and preserve valid existing rights-of-ways granted by Congress under R.S. 2477 and to support and work in conjunction with the State of Utah to redress cases where those rights are not recognized or are impaired.
7. The historic right to access federal lands in the pursuit of mining, energy development, ranching, farming, logging, recreational activities, motorized vehicle use, hunting and other historic uses, and those roads used by law enforcement and emergency medical services in the protection of residents and visitors, is critical to the health, safety and economic viability of Beaver County.
8. Beaver County will identify and inventory public access roads and will engage in meaningful participation with federal and state land management agencies in all decision making processes.
9. Beaver County has undertaken efforts over the past several years to identify and map the location of all Class B and Class D roads that are legitimately part of the County's

transportation system. This map is expressly adopted and incorporated into this policy as the county road system. This map includes, but is not limited to all roads claimed by Beaver County pursuant to R.S. 2477 for roads across BLM lands. It is expected that the BLM will conform the travel management planning provisions of the Resource Management Plan to be consistent with this map, as required by FLPMA in Section 1712(c)(9). It is also expected that when such mapping is completed for areas under the stewardship of the U.S. Forest Service, that the Forest Service will conform the transportation provisions of its forest plans to be consistent with such map.

10. Transportation and access routes to and across federal lands, including all rights-of-way vested under R.S. 2477, are vital to the economy and to the quality of life in the County, and must provide at a minimum, a network of roads throughout the resource planning area that provides for:
 - a. Movement of people, goods, and services across public lands;
 - b. Reasonable access to a broad range of resources and opportunities throughout the county, including livestock operations and improvements, solid, fluid, and gaseous mineral operations, recreational opportunities, search and rescue needs, public safety needs, and access to wood products;
 - c. Access to federal lands for people with disabilities and the elderly; and
 - d. Access to State lands and School and Institutional Trust Lands, to accomplish the purposes of those lands.
11. The access and transportation needs of the County shall be considered, evaluated and analyzed in the land use planning process. No roads, trails, rights-of-way, easements or other traditional access for the transportation of people, products, recreation, energy or livestock may be closed, abandoned, withdrawn, or have a change or use without full public disclosure and analysis.
12. Access to all water related facilities such as dams, reservoirs, delivery systems, monitoring facilities, livestock water and handling facilities, etc., must be maintained. This access must be economically feasible with respect to the method and timing of such access.
13. Beaver County supports administrative access for permittees on closed or restricted roads when necessary for allotment access; Public land agencies shall accommodate livestock permit holders, resource developers and managers who have legitimate need to enter specific areas on public lands.
14. Beaver County opposes any additional evaluation of national forest system lands as

“roadless” or “un-roaded” beyond the forest service’s second roadless area review evaluation and opposes efforts by agencies to specially manage those areas in a way that:

- a. Closes or decommissions existing roads unless multiple parallel roads exist running to the same destination and state and local governments consent to close or decommission the extraneous roads;
- b. Permanently bans travel on an existing roads;
- c. Excludes or diminishes traditional multiple-use activities, including grazing and proper forest harvesting;
- d. Interferes with the enjoyment and use of valid, existing rights, including water rights, local transportation plan rights, R.S. 2477 rights, grazing allotment rights, and mineral leasing rights; or
- e. Prohibits development of additional roads reasonably necessary to pursue traditional multiple-use activities.

15. Beaver County calls upon the federal agencies who administer lands within the County to:

- a. Keep open to motorized travel any road in the subject lands that is part of Beaver County’s duly adopted transportation system;
- b. Provide that R.S. 2477 rights-of-way be fully recognized by the BLM;
- c. Provide that a county road may be temporarily closed or permanently abandoned, only by authorized statutory action of the county or state;
- d. Provide that the BLM and the USFS recognize and not unduly interfere with the County’s ability to maintain and repair roads and, where reasonably necessary, make improvements to the roads; and
- e. Recognize that additional roads and trails may be needed in the subject lands from time to time, to facilitate reasonable access to important resources and to allow for planned growth and economic development.

7.2 Wilderness and Other Special Land Designations

This section describes the findings, objectives, policies and guidelines regarding special designations of land within Beaver County. Federal land designations are described as follows:

Wilderness Areas are tracts of federally owned land that Congress has designated for special protection and management due to their wilderness characteristics. *See* 16 U.S.C. §1131(a)-(b). Congress provides only broad guidelines and no detailed standards for making such a designation. The land must be “an area where the earth and its community of life are untrammelled by man,” meaning there are no man made habitats and or “permanent improvements.” *See* 16 U.S.C. § 1131(c). Wilderness Areas must also: (1) be “affected primarily by the forces of nature, with the imprint of man’s work substantially unnoticeable;” (2) possess “outstanding opportunities for solitude or a primitive and unconfined type of recreation;” (3) contain at least 5,000 acres of land “or is of sufficient size as to make practicable its preservation and use in an unimpaired condition;” and (4) “may also contain ecological, geological, or other features of scientific, educational, scenic, or historic value.” *Id.*

The Wilderness Act of 1964 established the National Wilderness Preservation System, to be managed by the USFS, National Park Service (“NPS”), and the USFWS. At the passage of the act, USFS lands previously deemed as “wilderness” or “wild” were given protection as Wilderness Areas (“WA”). Further, the Secretary of Agriculture was given 10 years to inventory Forest Service lands for areas classified as primitive, to determine their suitability or non-suitability as wilderness, and present those findings to the President. The President would then make recommendations to Congress for designation as wilderness areas in the Wilderness Preservation System. *See* 16 U.S.C. §1131 and 1132.

The passage of FLPMA in 1976 added the BLM as a wilderness management agency to the Wilderness Act. Under Sec. 603(a), the Secretary of Interior was given 15 years to inventory all BLM roadless areas of 5000 acres or more for lands containing wilderness characteristics as defined in the Wilderness Act. The lands identified under the Section 603 review were designated as Wilderness Study Areas (“WSA”). This designation will remain in place until the WSA is designated as a Wilderness Area or Congress releases the land from WSA status.

Additionally, the Section 603 review required the U.S. Geological Survey and U.S. Bureau of Mines to inventory all areas identified with wilderness characteristics for mineral

values. Pursuant to this provision in FLPMA, all mining, livestock grazing and mineral leasing would continue in the manner and degree at the time of the acts passage in 1976. In other words, despite future wilderness designation, these activities were grandfathered in wherever identified, even if they impair wilderness characteristics. *See Rocky Mountain Oil and Gas Association v. Watt*, 696 F.2d 734 (10th Cir. 1982).

In the early 1990's, Secretary of the Interior Bruce Babbitt, ordered an additional review and inventory of BLM land to identify areas that contained some wilderness characteristics. This "re-inventory", as it became known, was less stringent and driven by political motivation. Numerous lawsuits were filed over this action with the courts finding that the wilderness recommendation process had ended and that no additional recommendations could be forwarded to Congress. However, the courts also ruled that federal agencies could continue to inventory resources, including wilderness characteristics as part of a land use planning process under Section 201 of FLPMA. These lands have been designated as "Lands with Wilderness Characteristics" ("LWC").

Similarly, in January of 2001, the Roadless Area Conservation Rule was adopted into regulation by the USFS. These lands were labeled *Inventoried Roadless Areas* ("IRA"). The identification of IRA's went beyond the acreage deemed suitable for proposal to Congress for designation as wilderness and ignored earlier court rulings over re-inventory action. The new rule imposed management restrictions on IRA's that contradicted the multiple use and sustained yield management that previously applied to these areas. Roads were closed, timber harvesting halted and traditional use was impaired. The USFS has managed these areas in an overly restrictive manner, similar to wilderness, without Congress ever designating it for inclusion in the Wilderness Preservation System.

FLPMA states that, in creating and revising land use plans, agencies must "give priority to designation and protection of areas of critical environmental concern." 43 U.S.C. § 1712(c)(3). However, in order to designate land as an *Area of Critical Environmental Concern* ("ACEC"), the agency must show that "special management attention is required (when such areas are developed or used or where no development is required) to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources or other natural systems or processes, or to protect life and safety from natural hazards." 43 U.S.C. § 1702(a). *See also* Section 7.4 of this plan.

Other special designations include *National Parks*, *National Monuments*, and *National Conservation Areas*. None of these special designated areas exist in Beaver County.

I. FINDINGS

During the 1970s, both the USFS and the BLM conducted reviews and inventoried federal land across the country, including Beaver County, as required by statute. The USFS submitted their recommendations for Wilderness Area designation in 1974. The BLM submitted their recommendations in 1991. The USFS did not recommend any land for Wilderness Area designation in their original review. As of January 2017, Congress has not designated any land in Beaver County as a Wilderness Area.

However, during the initial inventory conducted by the BLM in the 1980's, approximately 11,047 acres of land in Beaver County was classified as WSA. These include the White Rocks Range WSA (*See Map 10*) and the Wah Wah Mountains WSA (*See Map 11*).

The White Rocks WSA does not meet the requirements necessary for consideration as a Wilderness Area and Congress should release it from WSA classification. The White Rocks WSA only encompasses 3,767 acres, failing to meet the statutory requirement of 5,000 acres. Further, the land is not untouched by man. The area encompassed many roads and right of ways that were ignored by the BLM. The land also includes multiple water resource developments including springs, riparian enclosures, stock dams and linear water line disturbances.

The Wah Wah WSA does not contain a sense of solitude as it is situated next to Highway 21, which emits noise from vehicle traffic. Additionally, other roads run alongside and through the WSA showing that man's impact is clearly established.

The USFS designated 70,900 acres of land within the Fishlake National Forest located in Beaver County as Inventoried Roadless Area. Like, the two WSAs, the alleged IRA does not meet the statutory criteria to be considered for a wilderness designation. Man's impact is clearly visible throughout the area including roads, right of ways, and water resource developments. *See Map 12.*

In many cases, designation of land as a Wilderness Area or WSA has a negative impact on the local economy, culture and use of that land. Most air pollution in Beaver County comes from biogenic sources. Wilderness designations prevent responsible vegetative treatments that limit pollution from biogenic sources. Wild fire is another major contributor to air pollution in Beaver County. Wilderness designations limit responsible timber harvest and effective fire response that reduces the risk and impact of wild fire.

In addition to air quality concerns, wilderness designations have a negative impact on water resource development. Wilderness designations prevent installation of pipelines, springs, hydro-power operations, and reservoir construction. Wilderness designations impair the public's access to necessary and important water resources.

Finally, restrictions on Wilderness Areas and WSAs prohibit energy development on those lands. Beaver County's economy still relies on energy development within its borders.

There are currently no national parks, national monuments, or national conservation areas within Beaver County. Beaver County finds that there are no areas of land that should be withdrawn for such a designation.

II. OBJECTIVES

Beaver County's objectives with regard to wilderness and other special designations are as follows:

1. To protect and expand the tax base and increase economic activity in the County; to provide a quality standard of living for the citizens of the County, including protection of local values and customs;
2. To represent the interests of the residents of the County through coordinating with federal land management agencies in planning, management and regulatory activities;
3. To limit wilderness designations within Beaver County to only those lands that clearly and unmistakably fit within the statutory criteria implemented by Congress;
4. To retain land usage and access that is beneficial to the citizens of Beaver County; and
5. To protect the multiple use and sustained yield standard prescribed by FLPMA and NFMA.

III. POLICIES AND GUIDELINES

1. To the extent that they do not exist, pursue agreements with the BLM, USFS or other relevant agencies guaranteeing that Beaver County will be consulted with prior to and during any land review, inventory, or recommendation that may lead to a special designation. Beaver County will demand that federal agencies provide Beaver County with a meaningful voice in the designation process in furtherance of the objectives set forth herein.
2. To the extent that they do not exist, pursue agreements with the BLM, USFS or other relevant agencies guaranteeing that Beaver County will be consulted with prior to and during creation of LWC, WSA, or IRA designations, management policies or procedures.
3. Congress has established clear and precise criteria for lands proposed for wilderness designation. Beaver County insists on holding agencies to those standards when land use planning inventories are undertaken and special designations are proposed.

4. The USFS, BLM, and other relevant federal agencies shall utilize the findings of Beaver County and the State of Utah regarding the character of the land within its borders and whether that land is appropriate for special designation.
5. Beaver County will work with Utah's Congressional Delegation to draft legislation that calls for the release of those lands that do not clearly and unmistakably fall within the relevant statutory definitions of special designation status.
6. Beaver County shall oppose any and all legislation that may unnecessarily restrict land use related areas with or without special designations that negatively impacts the citizens of Beaver County.
7. The County will identify, manage, and protect existing roads and rights of way held by Beaver County that fall within federally owned land near or within areas with special designations. Ensure that these roads and rights of way are included in the BLM's Cedar City Field Office Resource Management Plan, and Fishlake National Forest's Forest Management Plan.
8. The County will identify and protect existing rights, including water rights, which benefit Beaver County in any area that possess special designations.
9. Pursuant to Section 603 of FLPMA, all existing mining activities, mineral developments and grazing practices in place, prior to any WSA designation in the county, shall continue unabated.
10. Federal agencies must comply with relevant federal and state law in the management of areas with special designations.
11. Beaver County will pursue any and all sources of federal or state financial support that lessens Beaver County's financial burden in providing law enforcement, search and rescue, emergency medical, and solid and human waste collection and disposal services associated with areas with special designations.
12. All land that has not been designated by Congress as a Wilderness Area should be managed in accordance with the policies, guidelines, and principles set forth in this plan. Public land should be managed in a manner that maximizes the benefit to Beaver County citizens. This includes accessibility for mineral development, grazing and recreational activities.
13. It is Beaver County's policy and practice to oppose and terminate all designations and classifications referenced in this section, together with any other designation or classification that has the purpose or effect of reducing traditional multiple use and sustained yield and access to energy and mineral development, motorized travel,

grazing, timber and other active vegetation management, or any other traditional multiple use on public lands.

7.3 Wild and Scenic Rivers

I. FINDINGS

The Wild and Scenic Rivers Act of 1968 (“WSRA”) (16 U.S.C. §§ 1271 et seq.) established a National Wild and Scenic Rivers System to protect rivers and their immediate environments for the benefit and enjoyment of present and future generations, to preserve selected rivers in their free-flowing condition, and to protect water quality and fulfill other vital conservation purposes. Uses compatible with the management goals of a particular river are allowed for under the WSRA, recognizing expected changes moving forward. The intent of Congress was to create a national system of protected rivers that co-existed with use and appropriate development. Therefore, any future development must ensure the river’s free flow and protect its “outstandingly remarkable resources.”

Congress, in passing the WSRA, declared that “the established national policy of dam and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes.” Section 5(d)(1) of the act directs federal agencies to consider the potential for national wild, scenic, and recreational river areas in all planning regarding the use and development of water and related resources. The WSRA (16 U.S.C. § 1273 (b)) provides the following standards for classifying, designating and administering certain rivers as wild, scenic or recreational:

- (1) Wild river areas: Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, and watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.
- (2) Scenic river areas: Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.
- (3) Recreational river areas: Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

Section 1274(d)(1) provides for comprehensive management plans to be developed by the Federal agency charged with administration of the specific river segment, which shall address resource protection, development of lands and facilities, user capacities, and other management practices necessary to achieve the purposes of the Act. This includes establishing boundaries for management of the river, which shall include an average of not more than 320 acres of land per mile on both sides of the river, or generally accepted as lands within one-quarter mile from the high water mark.

Wild and Scenic River designations have long lasting effects, both positive and negative, on the future use of the stream, water resource and surrounding lands. Some of the potential effects of wild and scenic river designations include:

- No new dams can be constructed on the designated rivers;
- The nation's premiere rivers are preserved indefinitely;
- The only water resource development projects allowed are those projects that have no direct or adverse effects on the free flow, water quality, or outstandingly remarkable values for which the river was designated; and
- Mining and mineral leasing will be further limited in areas near designated rivers, subject to existing rights and management goals and regulations.

The USFS conducted an environmental analysis in 2007 to evaluate the suitability of 86 river segments on the National Forests in Utah for recommendation for inclusion in the National Wild and Scenic Rivers System. The area affected by this study included National Forest System lands on the Ashley, Dixie, Fishlake, Manti-La Sal, and Uinta-Wasatch-Cache National Forests in Utah. The river segments selected on the Fishlake National Forest included Salina Creek in Sevier County, Fish Creek in Sevier and Piute Counties, Corn Creek in Millard County, and Pine Creek/Bullion Falls in Piute County. No river segments were recommended for streams in Beaver County.

However, within the BLM's draft RMP (2016) for the Cedar City Field Office, Birch Creek in Beaver County was identified in the list of alternatives for inclusion as a candidate for a wild and scenic river designation. No other streams on BLM lands in Beaver County were proposed for Wild and Scenic River designation.

II. OBJECTIVES

Beaver County's objectives with regard to wild and scenic rivers are as follows:

1. To have meaningful involvement in federal land management planning involving water and stream designations to protect local interests. In addition, local municipalities, water

companies, ditch and irrigation companies and other water users are encouraged to participate as well;

2. To participate as a cooperating agency in all applicable federal agency actions affecting the county to ensure that reasonable and practical management solutions affecting water and stream designations are obtained;
3. To ensure environmental protections be balanced with local values and economic needs;
4. To prevent needless prohibitions on future uses of any designated stream that may impact water resource needs of county residents. Beaver County will seek to limit the adverse effects on economic growth and prosperity that may be hampered by a Wild and Scenic River designation;
5. To limit the adverse effects of land management decisions on federal lands that stray from the policy of multiple use and sustained yield;
6. To increase clarity and transparency in defining impacts to local communities, water users and citizens; and
7. To prevent Wild and Scenic River designations on streams and water courses that are necessary for municipal and agricultural needs or that lack outstanding and remarkable features or are already protected by other federal actions.

III. POLICIES AND GUIDELINES

1. Pursuant to Section 1276(c), Federal agencies must pursue the study of any potential river designation in close cooperation with the affected State and local government; including Beaver County.
2. Pursuant to Section 63J-4-401 of the Utah Code, it is the policy of Beaver County that support for the addition of a river segment to the Wild and Scenic Rivers System shall be withheld until:
 - a. It is clearly demonstrated that water is present and flowing at all times. Dry washes or stream segments below dams and other controls, and other stream segments that have been physically altered by human activity should not be considered, even in the eligibility stage;
 - b. It is clearly demonstrated that the required water-related value is considered outstandingly remarkable within a region of comparison consisting of one of three physiographic provinces in the state, and that the rationale and justification for the conclusions shall be disclosed;

- c. It is clearly demonstrated that the inclusion of each river segment is consistent with the plans and policies of the state and the county or counties where the river segment is located as those plans and policies are developed according to Subsection (3) of Section 63J-4-401;
- d. The effects of the addition upon the local and state economies, agricultural and industrial operations and interests, outdoor recreation, water rights, water quality, water resource planning, and access to and across river corridors in both upstream and downstream directions from the proposed river segment have been evaluated in detail by the relevant federal agency;
- e. It is clearly demonstrated that the provisions and terms of the process for review of potential additions have been applied in a consistent manner by all federal agencies;
- f. The rationale and justification for the proposed addition, including a comparison with protections offered by other management tools, is clearly analyzed within the multiple-use mandate, and the results disclosed;
- g. It is clearly demonstrated that the federal agency with management authority over the river segment, and which is proposing the segment for inclusion in the National Wild and Scenic River System will not use the actual or proposed designation as a basis to impose management standards outside of the federal land management plan;
- h. It is clearly demonstrated that the terms and conditions of the federal land and resource management plan containing a recommendation for inclusion in the National Wild and Scenic River System Fully disclaims the use of the recommendation as a reason or rationale for an evaluation of impacts by proposals for projects upstream, downstream, or within the recommended segment;
- i. It is clearly demonstrated that the agency with management authority over the river segment commits to not use any actual or proposed designation as a basis to impose Visual Resource Management Class I or II management prescriptions that do not comply with the provisions of Subsection (8)(t) of Section 63J-4-401; and
- j. It is clearly demonstrated that including the river segment and the terms and conditions for managing the river segment as part of the National Wild and Scenic River System will not prevent, reduce, impair, or otherwise interfere with:

- i. The state and its citizens' enjoyment of complete and exclusive water rights in and to the rivers of the state as determined by the laws of the state; or
 - ii. Local, state, regional, or interstate water compacts to which the state or any county is a party.
3. The conclusions of all studies related to potential additions to the National Wild and Scenic Rivers System, 16 U.S.C. §§ 1271 et seq., shall be submitted to the state for review and action by the Legislature and Governor, and the results, in support of or in opposition to, are included in any planning documents or other proposals for addition and are forwarded to the United States Congress.
4. Beaver County insists that minor streams (e.g. Birch Creek) do not merit special designation, as they are not preeminent rivers meeting regional or national designation standards, as intended by the law.
5. Any proposed stream designations for inclusion in the Wild and Scenic Rivers System must show unequivocally that they contain outstandingly remarkable values on a regional scale.
6. Wild and Scenic River designations shall not be implemented when streams and riparian areas have existing protective measures in place under federal land management regulations.
7. Federal agencies shall not manage streams or watercourses as if they were wild and scenic rivers without congressional designation.

7.4 Areas of Critical Environmental Concern (ACECs)

INTRODUCTION

ACECs are specifically designated areas where special management attention is required to protect relevant and important historic, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes from irreparable damage, or to protect life and safety from natural hazards. As of January 2016, there are no ACECs in Beaver County. ACECs are being proposed by the BLM on limited areas of public lands where special management attention is assumed to be needed to protect or preserve outstanding, sensitive resources that were subject to imminent, irreparable damage from a verifiable threat. The ACEC proposals incorrectly considered excessively large parcels of land where the purported resources are described in the

most general terms and where resources could not be specifically mapped, identified or accurately described. Efforts have also been made to disguise wilderness proposals as ACECs contrary to settlement agreements reached between the State of Utah and the United States government and inconsistent with federal planning regulations and local land use plans.

The FLPMA defines an ACEC as an area within the public lands where special management attention is required to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources or other natural systems or processes, or to protect life and safety from natural hazards. Other than these broad statements in the law there is very little objective criteria for establishing an ACEC. To date, agency determinations have been speculative at best. To some degree, ACECs have been used as an attempt to create wilderness where it did not exist or to implement prescriptive management action on large blocks of public land. The criteria for evaluating areas for protection under federal guidelines gives broad speculation to what is important and relevant resources by using terms loosely defined as “scenic” or “cultural”. These Relevant and Important values must be clearly identifiable, articulated, mapped and distinctly characterized.

I. FINDINGS

FEDERAL RESTRICTIONS ON DESIGNATING ACEC's

Federal law mandates that the BLM "shall manage the public lands under principles of multiple use and sustained yield, in accordance with land use plans ..., except where a tract of land has been dedicated to specific uses according to any other provisions of law it shall be managed in accordance with such law." 43 U.S.C. 1732(a); *see also* 43 U.S.C. 1701(a)(7) ("goals and objectives be established by law as guidelines for public land use planning, and that management be on the basis of multiple use and sustained yield unless otherwise specified by law") and 43 U.S.C. 1712(c)(1) (BLM in developing and revising land use plans "shall - use and observe the principles of multiple use and sustained yield set forth in this and other applicable law").

While the BLM must give priority to the designation and protection of areas of ACECs when developing and revising land use plans, 43 U.S.C. 1712(c)(1), *still Federal law gives the BLM no authority to designate an ACEC unless it meets the definitional requirements of the Federal Land Policy Management Act of 1976 (FLPMA), 43 U.S.C. 1702(a), which states:*

The term "areas of critical environmental concern" means areas within the public lands where special management attention is required (when such areas are developed or used or where no development is required) to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and

wildlife resources or other natural systems or processes, or to protect life and safety from natural hazards. 43 U.S.C. 1702(a).

The strict statutory criteria for specialized ACEC designation must be read in light of the fact that FLPMA already generally mandates protection of all public lands against "unnecessary or undue degradation":

In managing the public lands the Secretary [BLM] shall, by regulation or otherwise, take any action necessary to prevent unnecessary or undue degradation of the lands. 43 U.S.C. 1732(b).

FLPMA's "unnecessary and undue degradation" general protection standard, coupled with FLPMA's "sustained yield" general management standard, mean that an ACEC special designation is valid *only* "where special management attention is required" *above and beyond* application of those general standards. In addition, there are numerous other laws and policies currently in place to protect special resources, i.e., Endangered Species Act (16 U.S.C 1531-1973) along with associated species specific recovery plans, Bald and Golden Eagle Protection Act (16 U.S.C 668-669c), Utah Greater Sage-Grouse Proposed Land Use Amendment and Environmental Impact Statement – 2015, etc. In short, the area must *require* special management attention above and beyond the FLPMA general standards of protection mentioned above, and the protections provided by existing laws, policies and guidelines.

ACEC special designation is appropriate only if required to prevent, not just any damage to relevant values, but damage that is "*irreparable*." 43 U.S.C. 1702(a). Moreover the values to be protected must be "*important*," on a regional scale, meaning they possess "qualities of more than just local significance and worth, consequence, meaning, distinctiveness, or cause for concern." 43 CFR 1610.7-2(a)(2).

Moreover, ACEC special designation is appropriate in areas only "when such areas are developed or used or where no development is required." 43 U.S.C. 1702(a).

STATE CODE POLICY RESTRICTIONS ON ACEC DESIGNATIONS ARE CONSISTENT WITH FEDERAL LAW RESTRICTIONS

In support of the foregoing Federal statutory requirements, the State of Utah has adopted the following policy in Utah State Code regarding ACECs: Pursuant to Utah Code 63J-4-401(8)(c), the State does not support a proposed ACEC designation unless it is clearly demonstrated that:

- (i) All the definitional requirements of 43 U.S.C. 1702 are met;
- (ii) The proposed designation and management prescriptions are limited in geographic size and scope to the minimum necessary to specifically protect and prevent

irreparable damage to the relevant and important values identified;

(iii) The proposed area is either already developed or used or no development is required;

(iv) The proposed area contains relevant and important historic, cultural or scenic values, fish or wildlife resources, or natural processes which are unique or substantially significant on a regional basis;

(v) The regionally important values, resources or processes have been analyzed for *irreparable damage* and the analysis describes the rationale for any special management attention required to protect, or prevent irreparable damage to the values, resources, processes, or hazards;

(vi) The proposed designation is consistent with the plans and policies of the state and of the county where the proposed designation is located;

(vii) The proposed designation will not be applied redundantly over existing protections provided by other state and federal laws, and will not be applied where not needed in addition to those specified by the other state and federal laws;

(viii) The difference between special management attention required for an ACEC and normal multiple-use management has been identified and justified, and any determination of irreparable damage has been analyzed and justified for short and long-term horizons; and

(ix) The proposed designation:

(A) Is not a substitute for a wilderness suitability recommendation.

(B) Is not a substitute for managing non-WSA areas inventoried for wilderness characteristics.

(C) Is not an excuse or justification to apply de facto wilderness management standards.

NONE OF THE AREAS IN BEAVER COUNTY MEET THE CRITERIA FOR SPECIAL ACEC DESIGNATION

To Beaver County's knowledge, recent ACEC public nominations in the Beaver County portion of the BLM Cedar City Field Office planning area, made in conjunction with the RMP revision process, include:

- Frisco Charcoal Kilns - 936 acres for Cultural, Historic Mining Town
- Great Basin Core - portion of 550,625 acres for Wildlife (shared with Iron County)
- Mineral Mountains - 81,489 acres for Scenic, Cultural/Wildlife

- Mineral Mountains Obsidian - 23,276 acres for Cultural
- Pine Valley-Utah Prairie Dog (UPD) - portion of 97,667 acres for Wildlife (shared with Iron County)
- Ponderosa Pine - 41,592 acres for Forestry - Ponderosa Pine
- South Central Utah - portion of 273,250 acres for Wildlife (shared with Iron County)
- South Wah Wah - 35,458 acres for Cultural, Scenic and Wildlife
- Beaver River - 3,311 acres for Cultural
- Tushar Slope - portion of 82,284 acres for Cultural (shared with Iron County)

Beaver County approves none of the ACECs nominated in paragraph 8 above, because none of them meet the required criteria.

For all nominated ACECs set forth in paragraph 8 above, Beaver County finds that each such nominated ACEC:

- (i) Fails to contain relevant values that are uniquely or substantially important on a regional basis;
- (ii) Exceeds the geographic size and scope necessary to specifically protect and prevent irreparable damage to relevant and important values, even if any were identified to exist there;
- (iii) Fails to pertain to areas that are either already developed or used or no development is required, for purposes of 43 U.S.C. 1702(a);
- (iv) Fails to be demonstrated as required to protect any such values from *irreparable damage*;
- (v) Fails to be demonstrated as necessary above and beyond FLPMA's general "undue and unnecessary degradation" and "sustained yield" management standards.
- (vi) Is applied redundantly over existing protections provided by other state and federal laws;
- (vii) Appears (if nominated by pro-wilderness NGOs) to be merely a substitute

for a wilderness suitability recommendation, and/or for managing non-WSA areas inventoried for wilderness characteristics; and/or an excuse to otherwise apply de facto wilderness management standards;

(viii) Otherwise fails to meet all the ACEC definitional requirements of 43 U.S.C. 1702; and

(ix) Is not consistent with this, Beaver County's plan for ACECs.

Beaver County also finds that:

- (i) Large blocks of land described with general values (cultural, geologic, scenic, etc.) do not qualify for ACEC consideration. Only those values that are specific, identifiable, and articulable with the associated threats or hazards clearly identified shall be considered for ACEC designation.
- (ii) There is no consistent BLM criteria for evaluating relevant important values associated with ACEC consideration. Beaver County has developed criteria for relevant evaluation of important resource concerns, and finds that it is the most accurate and comprehensive criteria available when considering the customs, culture, socioeconomic base and public land usage in Beaver County.
- (iii) Agencies that have not included Beaver County in all aspects of the ACEC consideration process (public notice, scoping, comment evaluation, criteria development, relevant important value evaluation, boundary determination, etc.), have failed to include the county as a cooperating agency at the earliest possible date and have not complied with the mandates of FLPMA.
- (iv) There are no ACECs within Beaver County as of January 2016 and the designation of ACECs contrary to the criteria established in this plan without concurrence of the Beaver County Commission is inconsistent with the county's plan and violates federal and state law.

II. OBJECTIVES

Beaver County's objectives with regard to ACECs are as follows:

1. To demand that the BLM reject and decline all pending nominated ACECs on public lands in Beaver County, whether set forth in paragraph 8 of the above findings or otherwise, in its 2016 (projected) revised BLM Cedar City Field Office RMP; and
2. To ensure that land areas and resources represented by, and identified in, all other nominated ACECs are managed according to the multiple use and sustained yield management standard and the undue and unnecessary degradation protection standard of FLPMA, with no special ACEC designations.

III. POLICIES AND GUIDELINES

1. Beaver County supports and adopts as its own policy, all of the Federal law restrictions and State of Utah policy restrictions governing the designation of ACECs.
2. Under those restrictions all pending nominated ACECs on public lands in Beaver County, whether set forth in paragraph 8 of the above findings or otherwise, fail to qualify for designation as valid ACECs by the BLM in its 2016 (projected) revised BLM Cedar City Field Office RMP.
3. Under Beaver County's policy, no showing has been made that any of the nominated areas possess resource values of unique and significant regional importance, or that ACEC special designation is required to prevent irreparable damage to such values, that current laws, policies and guidelines don't already provide.
4. Beaver County specifies the following relevant-important criteria to be used when analyzing areas for ACEC designation:
 - a. Important resources are of rare, unique, exemplary and significant quality deserving of special designation, protection and land use restrictions. They must be outstanding, remarkable, one-of-a-kind resources that deserve special management when compared to other similar resources in the region;
 - b. Historic/Cultural Resources: An activity, business, district, building, structure, object or site may qualify as a *Relevant/Important Historical/Cultural* resource if it is located within the official boundaries of the county, is approved by the County Commission, has been the subject of a Class 3 inventory or equivalent and at least 95% of the designated area meets one or more of the following minimum criteria:

- i. The resource is of sufficient value that it is a site for public or private facilities that enhance the interpretive opportunities of the public. Parks, museums, monuments, businesses and other permanent designations qualify under this criterion. Examples for comparison within the region include, but are not limited to: Parowan Gap Petroglyph site, Fremont Indian State Park, Old Iron Town Ruins, etc.;
 - ii. The resource is of sufficient value that it requires paid or volunteer staff to assist with the interpretation and/or protection of the resource. The presence of on-site guides, hosts, rangers, guards, specialists or other staff with a minimum of 500 hours per year qualifies cultural resources for this criterion. Examples in the region include but are not limited to: Mormon Handcart sites, Grand Gulch, Defiance House, etc.;
 - iii. The resource is of sufficient value that it is the subject of guided or self-guided tours promoted by land management agencies or private businesses and has a minimum visitation of 200 visits per month during a defined peak season to qualify under this criterion. Examples include but are not limited to: Kanarrville Falls, Cedar Mesa, Kane Gulch, Cowboy Cave, etc.;
 - iv. The resource is of sufficient renown that its location and nature are well known and recognizable throughout the region. Resources that have been the subject of not less than 10 statewide mass media feature articles or programs qualify for this criterion. Examples include: Range Creek, Nine Mile Canyon, Mormon Handcart Sites, Hole-in-the-Rock, etc.; and
 - v. The Relevant/Important nature of the resource value has been shown and demonstrated, by a preponderance of evidence, to the Beaver County Commission in a public hearing, that special protection is justified and warranted.
- c. Scenic Resources: Scenic resources qualify as Relevant/Important if they can be graphically described with identifiable limits and meet all of the following criteria:
- i. It is located within the official boundaries of the county;
 - ii. It is designated as a Class “A” Scenery or equivalent. (See Appendix 2);
 - iii. It has a Scenic Quality Rating of 28 or greater. (See Appendix 1);

- iv. It has a land form rating of 5 or equivalent. (See Appendix 1);
 - v. It has a color rating of 5 or greater. (See Appendix 1);
 - vi. It has a scarcity rating of 5 or greater. (See Appendix 1);
 - vii. It is renowned throughout the region;
 - viii. It is the primary destination for more than 2,400 visitors per year as verified by actual visitor counts; and
 - ix. All of the proposed land for designation meets all of the criteria.
- d. Fish and Wildlife: Outstandingly remarkable fish and wildlife values are those populations that are rare, special or regionally significant. Although it may include special status species, a special status specie designation in and of itself does not meet the outstandingly remarkable and relevant threshold. The minimum criteria required for this resource value:
- i. It is on the threatened or endangered species list and is the only population of the species within the region of comparison;
 - ii. It is on the threatened or endangered species list and comprises at least 80% of the known population in existence, of the species;
 - iii. It is documented and shown that the existing federal and state laws, recovery plans, policies and guidelines for protection of the species in question are deemed inadequate and insufficient, and it is determined that unless a special ACEC is granted, the species will be decimated. A thorough analysis must be conducted on existing federal and state laws, recovery plans, policies, etc. to identify where they are failing, and how a special ACEC designation will reverse the trend; and
 - iv. It is shown and proven by a preponderance of evidence to the Beaver County Commission that an ACEC is necessary and appropriate for the protection of a select species.
- e. Natural Systems or Processes: In accordance with the laws that govern nature, i.e. natural orders, laws or processes; Characteristic of nature, the natural growth of

animals, plants and organisms; Conforms to the order, laws and methods nature has defined; Existing in nature or created by the forces of nature. Humans, by our very existence are a part of nature and as such, we have an impact on the world around us. This is no different than a colony of ants building an ant hill or a beaver creating a pond by damming a stream. There are a small contingent of people who want to disregard this notion in favor of the belief that any and all anthropogenic activity is unnatural and destructive and anomalous to nature. This belief completely disregards man's entire existence. Therefore, the natural activities of man to build roads, till the land, dig holes, cut down trees or the myriad of activities mankind is engaged in, is in fact, natural and necessary. The degree to which we are destructive to nature and disrupt natural processes is the point in question. The criterion for creating an ACEC to protect Natural Systems and Processes must meet all of the following requirements:

- i. The Natural System or Process must be endemic to the county and its intrinsic value must be regionally significant;
 - ii. There must be quantifiable evidence that the threat to the Natural Process or System is of a serious nature with irreversible consequences without the protections afforded by an ACEC;
 - iii. It must be clearly shown that existing state and federal laws, policies and guidelines are insufficient to protect the Natural System or Process or to mitigate the threats to it;
 - iv. There must be a preponderance of evidence shown to the County Commission that land management protections are necessary and appropriate through the creation of an ACEC to mitigate pending threats to a Natural Process or System;
 - v. Any ACEC proposal must have clearly defined boundaries that coincide with the actual threats exhibited to a Natural Process or System that have been deemed to cause irreversible harm. A blanket coverage of the entire system/process goes beyond the need and intent of ACECs; and
 - vi. At least 80% of the statewide occurrence of the natural system or process occurs in the proposed ACEC.
- f. Natural Hazards: The occurrences of Natural Hazards that threaten human life and safety are widely varied in how and where they might occur. Natural hazards in

this context are much more than precipitous landscape features that exist in remote locations. The need for an ACEC to afford protections from identified hazards must meet the following criterion:

- i. The Natural Hazard is of significant size and scope that local resources cannot mitigate it sufficiently, completely or in a timely manner;
- ii. The Natural Hazard cannot be mitigated through other measures or efforts of the federal land management agency, county and/or state;
- iii. The Natural Hazard has a defined area or mapped location that identifies the problem boundary, origin and/or area of potential effect;
- iv. Any ACEC proposal would be limited geographically to the specific area where a change in land management policy would be highly likely to prove beneficial to the safety and welfare of those potentially affected;
- v. The hazardous site is a destination of renown within the region, causing individuals or groups of people to seek out and travel to the location without a comprehension of the potential danger;
- vi. There is a history of harm or danger to the uninformed public demonstrated by calls to emergency services on more than one occasion from the site in question;
- vii. There is a preponderance of evidence presented to the County Commission that a hazard to human safety exists and that an ACEC designation would provide the best protection and mitigate the problem.

7.5 Broadband Access

I. FINDINGS

As high-speed internet connections become an increasingly critical asset for economic development, education, healthcare, public safety, and general quality of life, it is essential to address the development of broadband infrastructure throughout Beaver County. The need for reliable broadband is growing as rapidly as the tech industry and therefore, federal, state and local governments must work with broadband providers collaboratively to prepare for the

growing need. Broadband infrastructure needs to be deployed with the capacity to adapt for evolving technologies. Land managers play an important role in streamlining that process.

The Utah Broadband Outreach Center (“Outreach Center”) in the Governor’s Office of Economic Development provides an up-to-date map displaying residential broadband speeds throughout Utah, including Beaver County (broadband.utah.gov/map). The map indicates where coverage is offered by service providers and can be filtered by individual provider, speed, technology type, and populated areas. This map can serve as a helpful tool for businesses in scouting locations for various facilities as it provides information concerning broadband availability, utilities, transportation, workforce, recreation, and health care facilities. The Outreach Center can also provide custom mapping upon request.

As the majority of public land in Beaver County is federally owned or managed, federal land management agencies also play a critical role in successful broadband deployment. It is important for these agencies to approach planning in a methodical and efficient way so that underserved county residents gain access to broadband, public lands are minimally disturbed, and service providers can engage in deploying services that benefit the county. However, providers have found it difficult to interact with federal land managers, particularly when it comes to permitting. These issues have resulted in delays that have sometimes lasted more than a year. Giving this authority to transportation agencies would expedite the process by limiting the time consuming and redundant reviews currently performed by federal land management agencies. Further, while some agencies are making progress towards centralizing this information, providers still lack a complete inventory that they and local governments can access for planning purposes. Making this data publicly available will allow providers and communities to undertake meaningful broadband planning efforts.

By expanding coverage into underserved areas, Beaver County can make itself a more desirable location for employers, providing more employment opportunities for the citizen workforce, increasing quality of life, and diversifying the local economy.

II. OBJECTIVES

Beaver County’s objectives with regard to broadband access are as follows:

1. To implement best practices that encourage broadband investment that will increase the economic viability of the County;
2. To coordinate with the Outreach Center to identify and utilize opportunities to expand broadband coverage;
3. To make broadband planning a priority in public land decision making and planning; and

4. To streamline permitting to encourage broadband deployment.

III. POLICIES AND GUIDELINES

1. Beaver County recognizes the Outreach Center as a resource in planning efforts as they relate to expanding broadband coverage in Beaver County and strengthening the local economy.
2. Beaver County will implement the following best management practices to encourage broadband investment:
 - a. Use the residential and economic development maps available through the Outreach Center to help assess community wide access and identify areas of need;
 - b. Set goals to prioritize communities with the lowest business and residential average speeds and work with broadband providers in those areas to determine strategies to improve services. These areas should be evaluated in terms of wired (cable, DSL, fiber), fixed wireless, and mobile broadband coverage;
 - c. Implement money and time saving practices such as:
 - i. Identify which existing poles and conduits are owned by local governments or other owners and make them easily available to providers when possible.
 - ii. Ensure broadband provider access to existing publically owned infrastructure.
 - iii. Work with broadband providers to coordinate fiber installation with regular utility and road maintenance by informing them of opportunities where they can install services.
 - d. Identify likely corridors to connect underserved areas and powered cellular communications sites to expand mobile service and create a streamlined process to allow providers to install services;
 - e. Coordinate with key stakeholders on infrastructure deployment, which can be achieved using the following strategies:
 - i. Form a Joint Utility Committee (JUC) where county and city officials, developers and other utilities meet with broadband providers to coordinate planning efforts. For example, providers should be given the opportunity to incorporate broadband infrastructure into future developments as part of the approval process.
 - ii. Designate a broadband development liaison to notify providers of opportunities to install services.

- iii. Create a permitting or public works department database to track projects and notify providers of opportunities to access poles, open trenches, and conduits.
 - iv. Hold regular meetings with local leaders and telecommunications companies to discuss projects. Public officials should consider asking providers about future areas of development and collaborate on reducing barriers to entry.
 - v. Maintain open and friendly relationships with providers.
- f. Create broadband-friendly policies and planning documents, with considerations including:
 - i. Zoning laws that encourage deployment, with added requirements for broadband consideration during new construction and new developments.
 - ii. Codified collaboration between public agencies, private providers, and end users.
 - iii. Standards of construction that can assist with issues that arise based on unknown variables in the right-of-way.
 - iv. Streamlined local permitting with predictable timelines, reduced regulatory barriers, and centralized communication between local planning offices.
 - v. Less expensive rights-of-way fees in areas lacking sufficient broadband in order to incentivize broadband providers into underserved areas.
- 3. Federal land managers should make data publicly available including locations of federal assets, tower locations, areas that have undergone environmental review under NEPA, and visitation statistics by recreation areas. Federal land managers should maintain an online inventory and map of federal assets that the county can utilize in broadband planning efforts as has been recommended by the U.S. Broadband Opportunity Counsel established by President Obama in 2014.
- 4. Federal land managers should implement the following best management practices with regard to broadband development:
 - a. Map and evaluate designated communications sites that can be used for telecommunications infrastructure, and work with providers to identify future communications sites;
 - b. Prioritize designated communications sites for development based on need in the area;
 - c. Collaborate with Beaver County, other local governments, and land management

agencies to designate broadband corridors that would connect communications sites, communities, cell tower sites, schools, libraries, government facilities and other areas of economic activity; and

- d. Actively collaborate with service providers to encourage development in underserved areas by streamlining, accelerating, and consolidating permitting for designated locations. County leaders, with the help of the State of Utah Broadband Outreach Center, can help recruit providers to build infrastructure in these prioritized areas.
5. Federal planning efforts should also consider how to best leverage different existing facilities. Wireless broadband, or “over the top” broadband, in combination with wired connections greatly increase the broadband capacity in any given area. Wireless towers and access points are also a necessary feature for emergency communications on federal lands. Wireless towers must be connected with fiber, making concurrent planning necessary. The following considerations should be made when planning for wireless broadband on public lands:
 - a. Plan to integrate fiber and wireless broadband by deploying fiber to the edge of wilderness and special designation areas to maximize coverage;
 - b. Plan for inconspicuous wireless tower locations that won’t intrude on views or add additional intrusion to views;
 - c. Feed fiber to tower locations or future tower locations when deploying fiber for other projects (e.g., highway construction and maintenance, new developments, etc.) to save costs and time.
 6. Federal permitting should be streamlined to allow broadband providers access to open conduits. Permit streamlining can be accomplished through the following actions:
 - a. Identify areas where permitting could be streamlined, particularly easing permitting restrictions in previously disturbed areas. Proposed fiber installation along existing highways should be permitted on an accelerated pace. These disturbed corridors would face only minor temporary impacts. Such corridors often already have underground and overhead utility lines, making fiber deployment even less impactful;
 - b. Allow for state Departments of Transportation to permit the installation of fiber optic lines or empty conduit within the constructed roadway prism (to include the improved surface, shoulder, and immediate constructed drainage) of any federal or state highway, or local road that qualifies and receives maintenance funding under the Federal Highway Administration (FHWA) federal-aid program. These qualifying projects should be exempted from NEPA review or granted categorical exclusions;
 - c. Highway easements across federal lands should be defined to include broadband service providers;

- d. Make the Utah Department of Transportation (UDOT) the permitting agency for providers wishing to build or access conduits along the highway;
- e. Increase hiring of staff responsible for telecommunications permitting.

7.6 Utility Corridors

I. FINDINGS

Utility corridors are preferred routes that co-locate multiple linear utility ROWs and are generally adjacent to existing highways or county roads. Utilities in these corridors may include electric transmission and distribution powerlines, gas, water pipelines, and communication lines such as telephone or cable. The existence and continued maintenance of utility corridors and the respective transmission lines is vital to the health, safety, welfare and economic success of all communities. Drivers for development in utility corridors include population growth, residential and commercial development, demand and delivery of energy resources, increased reliability of infrastructure, and improvements to aging infrastructure. As the federal government manages approximately 78% of the land in Beaver County, it is important that federal and other land managers allow for land access for the purpose of building, expanding, and maintaining utility corridors.

Currently, several large high capacity power lines conduct electricity through Beaver County through a corridor running north to south through the Milford Valley and into Iron County. Gas pipelines also transect the Milford Flat diagonally through a corridor from the East side of the Milford Valley heading Southwesterly.

As Beaver County continues to see an influx of large scale energy developments seeking to take advantage of our quality wind, solar and geothermal resources, additional utility corridors will be necessary to access areas with high energy development potential while excluding remaining tracts of land to preserve the existing natural resources. A new utility corridor is especially needed along State Road 21 where there is a high potential for wind, solar, and mineral development in the Wah Wah Valley. The lack of an existing corridor in this area will be a hindrance to future development. Furthermore, project developers have found that siting proposed transmission lines in existing corridors might not always be feasible to achieve the necessary transfer capacity rating from Western Utility Coordinating Council, as placing lines too close to one another can limit transfer capacity of a utility line. As such, new energy

corridors that connect into existing substations would serve future population growth and facilitate new renewable energy sources. Allowing for the designation of new utility corridors is consistent with the various federal land management agency's mandates to manage public lands for multiple uses.

II. OBJECTIVES

1. Beaver County will identify and establish utility corridors throughout the County to facilitate future energy development while protecting the health, safety, and welfare of the community and preserving the natural resources within the county.

III. POLICIES AND GUIDELINES

1. The BLM and other land management entities must actively consult and coordinate with Beaver County in all land management planning, decision making, or other activities for the purpose of allowing for construction, expansion, and maintenance of utility corridors.
2. Land managers must, with regard to all planning, decisions, and other activities, take into account existing utility corridors and areas that are suitable for new utility corridors and ensure that those lands remain suitable for this use.
3. Beaver County will recognize existing utility corridors as well as identify and map future utility corridors to service the needs of energy development in the county in the most appropriate and logical locations.
4. Beaver County, by ordinance, has designated a 1000 foot utility corridor, located 500 feet on either side of SR-21 from the TransWest Express powerline to the Millard County Line.
5. Land Management Agencies shall allow new transmissions lines to be placed adjacent to existing lines in recognized utility corridors.
6. All existing utility corridors must be maintained for proper transmission and flow of electricity or other utility source. Land Management Agencies must allow for authorized personnel to adequately access and address all maintenance needs.

7. New utility corridors may be needed in the future where potential energy sources are discovered or developed. Beaver County will strive to accommodate those needs where possible, by identifying appropriate areas for new utility corridors within the county.
8. Beaver County recognizes the gas pipelines across the Milford Flat as a functional utility corridor.

8. CULTURAL, HISTORICAL & PALEONTOLOGICAL RESOURCES

I. FINDINGS

Cultural resources are sensitive, irreplaceable objects and sites important to Beaver County's history and heritage. Cultural resources are objects or places that give evidence of human activity, occupation and use, which are important for scientific or historic value and meaning. Cultural resources include locations, sites, structures, objects, relics, artifacts and remains. They offer insight into traditional cultural, social or religious life of specific ethnic or cultural groups. Archaeological resources are a subset of cultural resources and defined as "any material remains of human life or activities that are at least 100 years of age, and that are of archaeological interest."

A paleontological resource is any fossilized remains, traces or imprints of organisms, preserved in or on the earth's crust, which provides information about the history of life on earth.

The National Park Service ("NPS") categorizes cultural resources in the following groups: archeological resources, cultural landscapes, structures, museum objects, or ethnographic resources. The National Historic Preservation Act ("NHPA") further recognizes five types of historic or prehistoric property: districts, sites, buildings, structures, and objects. See 54 U.S.C. § 300308. Pursuant to NHPA, these categories are used in the National Register of Historic Places ("NRHP").

Archeological resources are the remains of past human activity and records documenting the analysis of those remains. Archeological resources can be used to shed light on societal organization, human behavior, and the evolution of ideas over time. Examples of archeological resources include stratified layers of household debris, weathered pages of a field notebook, and laboratory records of pollen analysis.

Cultural landscapes are settings humans have created in the natural world including fences, watercourses, buildings, formal gardens, cattle ranches, cemeteries and pilgrimage routes to village squares. They reveal fundamental ties between people and the land – ties based on the need to grow food, form settlements, and engage in recreation.

Structures include dwellings, fences & repositories, roads & bridges, vehicles, tools & machines, signs & monuments that demonstrate human productive ability and artistic sensitivity.

Museum Objects are manifestations and records of behavior and ideas that span the breadth of

human experience and depth of natural history. They are evidence of technical development and scientific observation, of personal expression and curiosity about the past, of common enterprise and daily habits. Museum objects may include a butterfly collection, woven fragments of a prehistoric sandal, the walking cane of an American president, a blacksmith's tools, the field notes of a marine biologist, fossilized dinosaur bones, business journals, household furnishings or even love letters bound with a faded ribbon.

Ethnographic resources are basic expressions of human culture and form the basis for continuity of cultural systems and ongoing development of cultural resources. Cultural systems encompass tangible and intangible resources including traditional arts and native languages, religious beliefs and subsistence activities. Ethnographic resources support some of these traditions: special places in the natural world, structures with historic associations, and natural materials. An ethnographic resource might be a riverbank used as a ceremonial or recreation site, a schoolhouse associated with cultural or historic education, sea grass needed to make baskets, a particular tool or method to accomplish a task, or traditional use of a road or area by a particular group of people. Management of ethnographic resources acknowledges that culturally diverse groups have their own ways of viewing the world and a right to maintain their traditions.

In response to legislative requirements including Section 106 of NHPA, formal inventories are conducted in anticipation of site-specific surface disturbing projects. Additionally, academic institutions have performed some research projects. However, detailed inventories have not been conducted on all lands in the County. Intensive cultural resource inventories meeting Utah Class III standards (i.e. 15 meter transect intervals) have only been completed on a small percentage of the lands in Beaver County. It is believed that cultural resource densities range from non-existent to more than 100 sites per square mile in certain locations. Based on Beaver County's size, tens of thousands of cultural resources may exist within the County limits. Additionally, untold ethnographic resources and artifacts exist in Beaver County.

Within Beaver County, a total of 114 cultural resource sites are listed in the State Historic Preservation Office ("SHPO") database. Current SHPO records for Beaver County indicate that 111 buildings & structures, 1 district and 2 archaeological resources are listed in the NRHP. In addition, one cultural resource is nominated for listing and 1,765 resources have been evaluated as being National Register quality.

II. OBJECTIVES

Beaver County's objectives with regard to cultural, historical, or paleontological resources are as follows:

1. To protect and expand the tax base and level of economic activity in order to provide a

good standard of living, to provide a quality environment for the enjoyment and use of its citizens including protection of local values and lifestyles, to represent the interests of its residents in coordinating with other local, state and federal agencies concerning planning, management and regulatory activities, and provide necessary county services for its residents and visitors;

2. To protect its cultural resources from damage and removal in a manner that maximizes the resources' intrinsic, scientific, educational and economic value; and
3. To increase research and visitation for the purpose of studying and enjoying cultural resources.

III. POLICIES AND GUIDELINES

1. Beaver County will encourage federal land management agencies to continue to seek out, identify, record and catalogue cultural resources within Beaver County. Ensure that all state and federal laws are complied with upon the discovery and identification of new cultural resources.
2. Beaver County shall oppose the closure of any road, path, way or trail that has not been shown to have negatively impacted existing cultural resources.
3. Where feasible, Beaver County will provide opportunities for the public to study and enjoy cultural resources within the County.
4. To the extent they do not exist, Beaver County will pursue agreements with the BLM, USFS, and other federal agencies that guarantee Beaver County will be consulted with prior to and during any decision making process affecting cultural resources within its borders. Beaver County will demand that federal land management agencies provide Beaver County with a meaningful voice in the decision making process in the furtherance of the objectives set forth herein.

9. FISH & WILDLIFE

This section describes the findings, objectives, policies and guidelines regarding the management of fish and wildlife within Beaver County. Topics addressed within this section include: wildlife, fisheries, predator control, threatened, endangered and sensitive species, and wild horses.

9.1 Fish and Fisheries

I. FINDINGS

As many as 20 species of fish can be found in Beaver County including varieties of bass, chub, and trout. Proper population and fishery management is important to the overall environmental, social, and economic well-being of Beaver County. Beaver County has a responsibility to its citizens to protect and expand the tax base and increase economic activity in order to provide a high standard of living, to provide a quality environment for the enjoyment and use of its citizens (including protection of local values and lifestyles), to represent the interests of its residents in coordinating with other local, state and federal agencies in planning, management and regulatory activities. State and federal agencies have ignored Beaver County in making management plans and decision regarding fish and aquatic habitats that impact Beaver County directly. The lack of consultation with Beaver County has resulted in plans and decisions that do not address the needs and concerns of the county.

Management plans and actions have focused on the negative impact of human surface disturbing activities, even though the overall impact of such activities has been limited. Degradation of fisheries in Beaver County have stemmed from the loss of historic vegetative communities with the encroachment of pinyon-juniper woodlands, Tamarisk and Russian Olive, and failure to control invasive aquatic species.

The encroachment of Tamarisk, or Saltcedar, has invaded streambanks, ditches and riparian areas throughout the Southwest. This deciduous shrub or small tree grows in dense, nearly impenetrable thickets displacing native vegetation such as willows and cottonwood. Tamarisk increases alkalinity in the surrounding soil through its natural processes, effectively altering the ecosystem. Tamarisk collects river sediment that narrows and channelizes streams, creates flooding and limits use of waterways. It provides poor habitat for wild animals and birds and has no food value for wildlife species.

Degradation of fisheries in Beaver County has also occurred as a result of failure to prevent the spread of invasive aquatic species. The discovery of quagga mussels in nearby waters threatens to be a concern to Beaver County's lakes and management actions are required to address this issue. Of greater concern to Beaver County is the parasite known as *Myxobolus*

cerebralis which causes whirling disease in trout, salmon, whitefish, and grayling. While this parasite is rare in Utah, it has been found in two of Beaver County's top fisheries: the Beaver River and Minersville Reservoir. To maintain the quality of local fisheries, it is imperative to eradicate this parasite from county waters.

II. OBJECTIVES

Beaver County's objectives with regard to fish and fisheries are as follows:

1. To become more directly involved in important decision-making concerning the management of fish and fisheries in the county, including the introduction or re-introduction of fish species into Beaver County waters; and
2. To ensure that fish and fisheries are managed in a manner that maximizes the benefit to the environmental, social, and economic needs of its citizens.

III. POLICIES AND GUIDELINES

1. To the extent that they do not exist, Beaver County will pursue agreements with the state and federal agencies guaranteeing that Beaver County will be consulted with prior to and during any decision-making or planning concerning fish or fishery management. The agreements will guarantee that fish or other aquatic species will not be introduced or re-introduced into Beaver County without the express approval of the Beaver County Commission.
2. Beaver County shall support and assist in drafting legislation that requires approval of the Beaver County Commission before a state or federal agency introduces or re-introduces a fish or aquatic species into Beaver County.
3. Beaver County demands that the restoration of native plant communities and the eradication of invasive and noxious plant species, especially Tamarisk, are the top priority of state and federal land managers in planning and decision making regarding habitats affecting fisheries in Beaver County.
4. Beaver County demands that all planning and management decisions prioritize the environmental, social, and economic needs of Beaver County.
5. Waters in Beaver County should meet the water quality standards set forth in state and federal law, as applicable.
6. Beaver County recognizes the "Recreational Use of Public Water on Private Property" law (H.B. 141) as passed by the 2010 Utah Legislature; we also respect and defend the

private property rights of those landowners whose property lies beneath or adjacent to the water, against trespass or vandalism.

7. Beaver County will increase efforts to eradicate invasive aquatic species and organisms, specifically *Myxobolus cerebralis*, which are harmful to fish and fisheries in Beaver County.

9.2 Wildlife

I. FINDINGS

Beaver County is home to a wide variety of wildlife that play an important role in the environmental, social, and economic condition of the county. While it is important to recognize the needs of these different species of wildlife, these needs are secondary to the needs of the citizens of Beaver County. Beaver County has a responsibility to protect and expand the tax base and promote economic activity in order to raise the standard of living and provide necessary services to citizens and visitors, to provide a quality environment for the enjoyment and use of its citizens (including protection of local values and lifestyles), and to represent the interests of its residents in coordinating with other local, state and federal agencies in planning, management and regulatory activities.

Under Utah Code § 23-14-1, the Utah Division of Wildlife Resources (“UDWR”) is the wildlife authority for the state of Utah, with all powers, duties rights and responsibilities for wildlife management within the state with the exception of species listed under the federal Endangered Species Act, which are managed by the U.S. Fish and Wildlife Service (“USFWS”), and nuisance wildlife and commercially raised fish and wildlife (coyotes, raccoons, elk and commercial aquaculture) are controlled and regulated by the Utah Department of Agriculture. Under Section 2 of that chapter, a Wildlife Board is appointed to direct policy and enact regulations and rules governing how wildlife is managed in the state. The UDWR is then responsible to implement and enforce those rules and regulations. Public input is gathered through Regional Advisory Councils (“RACs”) who provide recommendations to the Wildlife Board on a regular basis. General public input is valuable in determining wildlife management goals, but the input of Beaver County is essential to protect local values, interests and economic vitality. Beaver County has often been ignored by state and federal agencies in the wildlife management process to the detriment of its residents. Livestock grazing rights are often minimized or ignored in wildlife management goals that significantly impact the local economy. Lack of coordination has also led to spurious habitat designations within the county in various planning documents, undermining property rights and hampering effective wildlife management.

Wildlife Management Plans are developed for specific species identifying population, sex ratios and age objectives and overall guidance and direction for management of the species. The UDWR must then follow that guidance and direction in managing those species. A committee

made up of the Wildlife Board, RAC, UDWR, federal agencies and numerous groups and stakeholders develops these plans. The plans are approved for a specific period of time, at which point they are reviewed and updated. Management plans are developed for wild turkey, chukar, greater sage-grouse, mule deer, elk, moose, pronghorn, mountain goat, bighorn sheep, prairie dogs, beaver, otter, black bear, cougar, bobcat and wolf.

Wildlife species found in Beaver County include big game, upland game, migratory birds, raptors, small mammals, predators, and some special designation species discussed in section 1.9.4.

Mule deer are the most abundant big game animal and can be found in a variety of habitats throughout Beaver County. Mule deer feed on forbs, grasses, and shrubs. Shrubs are the primary food source during the fall and winter months. They are generally migratory, moving between high elevation summer and low elevation winter ranges.

Pronghorn are also common in Beaver County on open and flat terrain. Pronghorn feed primarily on forbs during spring and summer months and shrubs during winter.

Rocky Mountain Elk are present in Beaver County year round. Large concentrations are found in the southwestern part of the county on the Indian Peak range and in the Tushar Mountains. Elk are adept at traveling significant distances and will move from one mountain range to another causing population swings that require constant adaptive management.

Bighorn Sheep were once abundant throughout the state as evidenced by their prevalence in ancient rock art, but were nearly extirpated after the arrival of early white settlers. Beaver County has no populations of wild sheep. There are numerous areas suitable as sheep habitat, characterized by rugged mountains with steep talus slopes and remote canyons, but not all suitable habitats are good potential transplant locations due to human encroachment, domestic livestock grazing and other factors. Mineral development in bighorn sheep habitat is also a major cause of habitat loss. Bighorn sheep are considered one of the most sought after and highly prized big game animals in North America and demand for hunting opportunities far exceeds current availability. The UDWR, in accordance with Utah Code 23-14-21, will continue to look for opportunities to transplant sheep to appropriate new locations in the state, which may include Beaver County.

Rocky Mountain Goats are obligate occupants of the highest alpine environments with precipitous cliffs necessary for escape cover. The peaks of the Tushar Mountains in eastern Beaver County are suitable habitat despite this animal not being native to this area. Mountain goats were first transplanted into Beaver County in 1986 with 7 goats. In 1988 17 more were added. This herd has successfully expanded its population to the point it is now used as a seed herd to start new populations in other areas. In order to properly manage mountain goats, it is critical that biologists have all possible management tools available to them, including the use of

aircraft for surveys, research and transplanting projects. Any future wilderness designations around existing populations would likely inhibit these activities.

Upland game birds found in Beaver County include the greater sage-grouse, dusky grouse, mourning dove, ring-necked pheasant, Rio Grande and Merriam's wild turkey, and chukar partridge. Habitat conditions and population fluctuation for these species is dependent on annual climate patterns. Warm, dry spring weather correlates to increases in populations while cold wet weather may depress population numbers.

Beaver County is also part of the flyway pattern of a variety of migratory bird species, including numerous hunt-able species of waterfowl. Human development in Beaver County has not had a significant impact on the migratory routes or habitats of these species, and in fact, human water developments are the primary source of waterfowl habitat in the county.

Beaver County is home to a few species of raptors including hawks, eagles, owls, and falcons. These raptors are protected species. Raptors serve as an indicator of environmental quality because of their position at the top of their respective food chain. There are a variety of suitable raptor habitats throughout Beaver County.

A host of small mammals can be found in Beaver County including furbearer species like the gray fox, kit fox, red fox, bobcat, raccoon, badger, ringtail, spotted skunk, striped skunk, American marten, weasels, mink and beaver. Furbearer populations are managed pursuant to state regulations.

Black bears are native to and common in Beaver County. They live in year-round habitats in the eastern part of the state. Black bear observations usually occur at elevations between 7,000 and 10,000 feet. Black bears are omnivores and hibernate for 5 to 7 months over winter.

Cougars, or mountain lions, are found all over Beaver County, but rarely observed. Their movements typically mirror those of mule deer, their primary prey. Cougar populations are closely monitored and are hunted on a limited basis.

Definitive studies have not been conducted on other wildlife species known to exist in Beaver County. These species include varieties of rodents, bats, amphibians, reptiles, and invertebrates.

Agencies categorize important habitats with terms such as "critical", "crucial" or "priority". Federal law defines "critical habitat" under the Endangered Species Act as "a specific geographical area that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection". Critical habitat may include areas that are not currently occupied but will be necessary for the recovery of the species. "Crucial habitat" has no regulatory or legal meaning, nevertheless, agencies frequently

assign this moniker to high value areas used by a species in part or all of its natural life cycle, such as “crucial deer winter range”. If “crucial” habitat is lost, those individuals living in that location may be displaced or die off, but regionally the species is unaffected. “Priority Habitat” is neither critical nor crucial, but agencies have given special management prescriptions to those lands where important species may live, impairing all other uses of that land which may be deemed impactful to the species in question. All these habitat designations have been used in the management of public lands in ways detrimental to other species, the principle of multiple use, granted ROW’s, private property rights, land access and historic use of that land. These prescriptive areas are notoriously imprecise, inaccurately mapped and/or broadly defined which has consequential impacts on nearby uses and assets. Buffer zones are frequently applied to important habitat features that may include areas completely unnecessary, unused or inconsequential to the survival of that species, yet heavily impacting other important uses.

II. OBJECTIVES

Beaver County’s objectives with regard to wildlife are as follows:

1. To be more directly involved in important decision-making concerning the management of wildlife, specifically regarding the introduction or re-introduction of wildlife species into Beaver County; and
2. To ensure that wildlife is managed in a manner that maximizes the benefit to the environmental, social, and economic needs of its citizens. This includes giving livestock grazing priority in the allocation of forage.

III. POLICIES AND GUIDELINES

1. Beaver County will pursue agreements with the state and federal agencies, ensuring that Beaver County will be included in any decision-making or planning process concerning wildlife management within the county.
2. No wildlife species shall be introduced or re-introduced into Beaver County without the express approval of the Board of County Commissioners.
3. Definitions used for wildlife habitat, such as “crucial”, “critical” or “priority” must accurately reflect the precise value and regional importance of such habitat. Habitats which are deemed of such high importance must also be accurately mapped and have ground-truthing to establish the true nature and extent of that habitat.
4. Beaver County will support and assist in drafting legislation that requires approval of the Beaver County Commission before a state or federal agency introduces or re-introduces a wildlife species into Beaver County.

5. Wildlife management plans shall be site specific when dealing with imperiled species, crucial habitats or when adverse impacts or problems persist.
6. Wildlife habitat and range reseeding projects must employ a mix of desirable native and non-native seeds that optimize forage requirements, range health and productivity.
7. The UDWR shall manage wildlife species at the objective levels set forth in the respective species management plans. If populations are above objective levels, the UDWR shall execute immediate action to reach objective levels within three years.
8. Wildlife population objective levels within Beaver County shall not be adjusted upwards due to increased forage from vegetation treatments without an equivalent or equitable adjustment to AUM numbers in the grazing allotment plans and NEPA analysis on shared public lands.
9. Beaver County supports wildlife management policies and practices that minimize impacts on agriculture and livestock grazing.
10. Land management agencies shall take actions to control and eradicate harmful and invasive noxious weeds and aggressively treat pinyon-juniper encroachment on habitats which benefit wildlife.
11. Beaver County opposes the closures of roads, paths, ways, or trails that have not been shown to have a significant negative impact on wildlife, critical habitat or their natural lifecycle processes.
12. Livestock grazing must be prioritized in the allocation of available forage on public lands.
13. Beaver County supports the responsible use of pesticides that do not negatively impact wildlife.
14. Agencies shall use adaptive management strategies in managing wildlife and their habitats.
15. All agencies shall increase efforts to accurately identify and map the “critical”, “crucial” or “priority” habitats of wildlife in Beaver County, especially for sensitive and endangered species.
16. Beaver County will assist state and federal agencies in data collection to ensure that planning decisions concerning wildlife accurately reflect species and habitat conditions in Beaver County.
17. Given the importance of wildlife and hunting to the local custom, culture and heritage

of Beaver County, hunting shall be preserved and protected as a traditional wildlife management tool.

9.3 Threatened, Endangered, and Sensitive Species

I. FINDINGS

Since the ESA (16 U.S.C. § 1531, *et seq.*) was passed in 1973, there have been over 2000 species listed and given protection under the law while only 28 species have been delisted due to successful recovery efforts. A success rate of a mere 1% over four decades of protections, indicates there needs to be serious reform to the policies employed under the ESA. The USFWS administers the ESA with minimal oversight and no perceivable public accountability. This large federal agency frequently acts with impunity towards property owners whenever threatened species are identified on their land, or worse, classifying that land as critical habitat, thereby halting nearly all future use or development. With scores of examples of bureaucratic strong-arming of landowners, the colloquial adage “shoot, shovel and shut up” has become a preemptive and common reaction to the presence of a threatened species on one’s property.

Once a species of plant or animal becomes federally listed, the range of options for managing public lands where that species occur narrows substantially. With the existing avenue to petition the USFWS for listing species believed to be imperiled, the ESA has become a weapon for special interest groups who seek to close roads, halt grazing, end timber harvest, prohibit energy exploration and stop mineral extraction on public lands. This onslaught, under the guise of conservation, sidesteps the normal electoral and public participation processes while manipulating public sentiment through emotional argument rather than sound science. These attempts to place restrictions on public land usage will result in devastating impacts to rural economies.

Designations under the ESA have become indefinite or permanent in many cases, instead of temporary actions in order to build up populations. This results in specific species being listed over certain geographic regions despite having a thriving population overall. Those regions are then subject to ecological imbalance when one protected species is given absolute immunity with no mitigation available. A successful species recovery should be delisted and returned to State management. It is irrational and places an undue burden on rural communities to list a species under the ESA in peripheral regions of its habitat when that species is abundant and flourishing within its core habitat.

The freedom to manage species in a way that best suits the county is lost once the USFWS issues an affirmative listing decision. In response to stiff regulatory controls, subversive actions to prevent habitat designations have been detrimental to many species

recovery efforts. While no studies have been done to show the negative impacts of the ESA, many believe that finding a way to reduce the many grievances and heavy regulatory burdens imposed would provide better widespread and effective protection of endangered species. No one seeks the loss of rare plants or wildlife, but having to deal with the procedural difficulties, diminished flexibility and increased costs associated with species listings under the ESA has had adverse consequences.

The ESA defines endangered as any species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. A candidate species is a species under consideration for official listing.

A sensitive species is a species facing one or more threats to its population or habitats, which needs special management attention to reduce the likelihood of a future threatened or endangered status. The term “sensitive species” is used by the state and land management agencies to denote those species in need of protection or special management attention, but the term is somewhat ubiquitous and may vary in its meaning between agencies and may, or may not, include listed species. “Species of concern” is a more generic term that refers to those species needing management attention, but does not generally include those species listed under the ESA.

Special status species is the term that Beaver County chooses to identify the wildlife and plant species collectively, that the County considers to be threatened, endangered or worthy of special actions to recover or maintain populations. While each species has value and plays an important role in maintaining ecological integrity, the practical reason for protective action is to eliminate the possibility of a species becoming listed under the Endangered Species Act (ESA). Determining Beaver County’s Special Status Species is a fundamental first step in addressing special status species management. Sources used to identify the County’s Special Status Species List are:

Utah Sensitive Species List The Utah Sensitive Species List was prepared by the Utah Division of Wildlife Resources (UDWR) pursuant to State of Utah Administrative Rule R657-48 and includes “all wildlife species for which there is credible scientific evidence to substantiate a threat to continued population viability.” Species on this list are identified as “Wildlife Species of Concern.” Included are fish, amphibians, reptiles, birds, mammals and mollusks designated as any of the following:

1. Federal candidate species (as determined by the USFWS);
2. Federal threatened species (as determined by the USFWS);

3. Federal endangered species (as determined by the USFWS);
4. Conservation agreement species (subject to official conservation agreements between the U. S. Government and the State of Utah); and
5. Utah wildlife species of concern (species where the State of Utah has determined that conservation actions be taken to preclude their listing as candidate, threatened or endangered).

The Utah Sensitive Species List and a list of sensitive species in Beaver County can be viewed at dwrcdc.nr.utah.gov/ucdc/ViewReports/sslist.htm. All Utah Sensitive Species that occur in Beaver County are considered to be Beaver County Special Status Species.

Utah Wildlife Action Plan The DWR's Utah Wildlife Action Plan's list identifies "Species of Greatest Conservation Needs." The Wildlife Action Plan analysis focused on three fundamental factors: 1) the likelihood of an ESA listing, 2) the consequences of listing, and 3) the potential for influencing a listing. For a description of how the species of greatest conservation needs were determined see the Wildlife Action Plan (wildlife.utah.gov/Utah.WAP.pdf). All Beaver County species identified in the Wildlife Action Plan are considered to be Beaver County Special Status Species.

Candidate, Threatened and Endangered Species in Beaver County: Candidate, threatened and endangered species listed by the U.S. Fish and Wildlife Service under the ESA as being present in Beaver County. As of January 2017, only the Utah Prairie Dog (*Cynomys parvidens*) is listed under the ESA as a threatened wildlife species. No candidate or endangered species are found.

Candidate, Threatened and Endangered Plants in Beaver County: Plant species that the USFWS has listed as endangered or threatened or has designated as candidate species that are native to and are known to be present in the County. Beaver County has three ESA listed plant species, Frisco buckwheat, Frisco clover, and Ostler's peppergrass which are all candidate species.

Federal Land Management Agency Sensitive Species The Bureau of Land Management and the U. S. Forest Service maintain sensitive wildlife species and sensitive plant species lists. Additionally, the Forest Service has a list of management indicator species (MIS) that, while not necessarily sensitive or vulnerable, do represent the types of species present in various vegetation associations, and the Forest Service considers them worthy of special management attention. A comparison of BLM and Forest Service sensitive species for Beaver County indicates that all of these species are also on one of the two State lists described above. Consequently, there is no

need to duplicate the State's species by including BLM or Forest Service sensitive species on the County list of special status species.

Conservation Agreement Species Conservation agreement species refers to wildlife and fish species that are the subject of intergovernmental management agreements. In Beaver County, two fish and one bird are listed. All conservation agreement species are included on the Beaver County list of Special Status Species.

Incidental Occurrence It is possible that a species identified in one or another sensitive species list, but not identified as occurring in Beaver County, may be found temporarily in Beaver County as individuals wander or pass through incidentally. These species are not included in the Beaver County List of Special Status Species.

Nonessential Experimental Populations. Under section 10(j) of the ESA, the Secretary may designate a population established outside the species current range as an "experimental population" as an avenue to authorize activities that would otherwise be prohibited. These introductions are classified as either "essential" or "non-essential" based on the perceived importance to the species overall recovery. Regulatory restrictions are not as intrusive for a nonessential experimental population compared to the regulations for non-experimental populations. Introduced and nonessential experimental populations will be included in Beaver County's list of special status species on a case-by-case basis.

To summarize, Beaver County Special Status Species includes:

1. Native wildlife and plant species known to regularly be present in Beaver County that the USFWS has listed as endangered (FWSE), threatened (FWST) or designated as a candidate species (FWSC), except for experimental populations;
2. Native wildlife species identified on Utah Sensitive Species List as "Wildlife Species of Concern" and that the State recognizes as occurring in Beaver County (WSC);
3. Wildlife species classified as conservation agreement species and known to be present in Beaver County (CAS);
4. Wildlife species identified in the Utah Wildlife Action plan as "Species of Greatest Conservation Needs" and that the State recognizes as occurring in Beaver County (USCN); and
5. Wildlife species identified by federal agencies as special status are included in Beaver County's management when identified on Utah's list of Wildlife Species of Concern or Species of Greatest Conservation Needs. They are included in the chart below to facilitate consistency

and coordination as BLM Sensitive Species (BLMSS) and Forest Service Sensitive Species (FSSS).

Based on the factors described above, the following species are considered Beaver County Special Status Species:

Common Name	Scientific Name	Status	Group
American Three-toed Woodpecker	<i>Picoides dorsalis</i>	WSC	Bird
American White Pelican	<i>Pelecanus erythrorhynchos</i>	WSC	Bird
Bald Eagle	<i>Haliaeetus leucocephalus</i>	WSC	Bird
Big Free-tailed Bat	<i>Nyctinomops macrotis</i>	WSC	Mammal
Bonneville Cutthroat Trout	<i>Oncorhynchus clarkia</i> Utah	CAS	Fish
Burrowing Owl	<i>Athene cunicularia</i>	WSC	Bird
Dark Kangaroo Mouse	<i>Microdipodops megacephalus</i>	WSC	Mammal
Ferruginous Hawk	<i>Buteo regalis</i>	WSC	Bird
Fringed Myotis	<i>Myotis thysanodes</i>	WSC	Mammal
Frisco Buckwheat	<i>Eriogonum soredium</i>	FWSC	Plant
Frisco clover	<i>Trifolium friscanum</i>	FWSC	Plant
Greater Sage-grouse	<i>Centrocercus urophasianus</i>	WSC	Bird
Hamlin Valley Pyrg	<i>Pyrgulopsis hamlinensis</i>	FWSC	Mollusk
Kit Fox	<i>Vulpes macrotis</i>	WSC	Mammal
Least Chub	<i>Iotichthys phlegethontis</i>	WSC	Fish
Long-billed Curlew	<i>Numenius americanus</i>	WSC	Bird
Northern Goshawk	<i>Accipiter gentilis</i>	CAS	Bird
Ostler's Peppergrass	<i>Lepidium ostleri</i>	FWSC	Plant
Pygmy Rabbit	<i>Brachylagus idahoensis</i>	WSC	Mammal
Short-eared Owl	<i>Asio flammeus</i>	WSC	Bird
Southern Leatherside Chub	<i>Lepidomeda aliciae</i>	WSC	Fish
Spotted Bat	<i>Euderma maculatum</i>	WSC	Mammal
Townsend's Big-eared Bat	<i>Corynorhinus townsendi</i>	WSC	Mammal
Utah Prairie-dog	<i>Cynomys parvidens</i>	FWST	Mammal
Western Toad	<i>Bufo boreas</i>	WSC	Amphibian

As seen in the chart above, the current Beaver County Special Status Species list contains 25 species. There are 4 candidate species and one threatened species with no endangered species currently inhabiting Beaver County. Among the many species on this list are a select few that deserve additional attention and specific planning efforts to ensure their viability or to detail the findings that may be of concern to the county. There are also a few species not on the list that deserve special mention as well.

Southwestern Willow Flycatcher: Listed as an endangered species in the state of Utah, and the Yellow-billed Cuckoo, a candidate species, are on the Utah Sensitive Species list but not in Beaver County. These species are often used by special interest groups as rationale to bring suit

against timber harvest plans, watershed restoration, or other rangeland vegetation projects. As these species are not known to inhabit Beaver County, such actions are unjustified.

California condor, listed as endangered, was introduced into the Grand Canyon of Arizona as a non-essential experimental population. The USFWS includes Beaver County in its list of counties where the population is “known to or is believed to occur” even though Beaver County is not historic habitat and is far from the introduction site. The Condor is included on the DWR list of Species of Greatest Conservation Needs (as an endangered species), but is not on the Wildlife Species of Concern list. As a non-native species to Beaver County, introduced to a new location not far from the county, any siting or occurrence would realistically be transitory or temporary. Therefore, the California condor is not included on the Beaver County special status species list. The presence of the California condor has impacted neighboring counties in varying ways, including the push to require expensive lead-free ammunition by hunters going afield in condor habitat.

Northern Goshawk, a conservation agreement species, is another species of concern. The goshawk is widespread throughout Utah, including Beaver County, inhabiting mature forests areas. Because of the special status of the bird, forest management prescriptions are severely hampered by their presence. Logging and prescribed fire regiments are severely curtailed wherever Northern goshawks occur, affecting forest health standards and local economies.

Greater Sage-grouse have been the focus of intense scrutiny over the past decade. This grouse inhabits 11 western states and Canada with population estimates of over half a million birds. Yet, because of the general downward population trend and the increasing expansion of civilization into historic habitat necessary for its survival, the sage-grouse was listed as a candidate species by the USFWS. Most of the controversy centers around using the declining sage-grouse population as the nexus for obstructing energy exploration, mining and grazing on public lands by environmental opponents of these activities. Because of the scrutiny placed on this bird by environmentalists and the USFWS, despite the abundant population across the western U.S., States were compelled to take aggressive proactive measures to insure the sage-grouse did not become listed.

On February 14, 2013, the State of Utah adopted an updated Conservation Plan for Greater Sage-grouse. Utah’s plan is designed to protect high-quality habitat, enhance impaired habitat and restore converted habitat in Utah, to support a portion of the range-wide population of greater sage-grouse necessary to eliminate threats and negate the need for the listing of the species under the provisions of the federal Endangered Species Act. The plan is designed to eliminate the threats facing the sage-grouse while balancing the economic and social needs of the residents of Utah through a coordinated effort which provides for incentive-based programs for private, local government and School and Institutional Trust Lands Administration (“SITLA”)

lands and reasonable and cooperative regulatory programs on other state and federally managed lands. Implementation of the Plan requires a cooperative effort among local, state and federal agencies, working in concert with private interests.

The biological pillars of sage-grouse conservation include protection of habitat which provides for the year-round life-cycle needs of the species, focused attention on those conditions necessary to ensure recruitment and perpetuation of the population within the aggregate state population, and enhancement/improvement of sage-grouse habitat that has been impaired or altered, through restoration and rehabilitation activities.

On September 22, 2015, a status review by the USFWS reached a determination that the Greater sage-grouse, despite long-term population declines, remained relatively abundant and well-distributed across the species' 173-million acre range. This decision was made in large part, because of the conservation efforts of the multiple states, key agency partners and private landowners. Individual states prepared and enacted conservation plans and the BLM/USFS finalized land use plan amendments to provide increased protection of sage-grouse habitat. The USFWS will continue to monitor population trends and conservation efforts of the Greater sage-grouse.

Beaver County adopted the Utah Sage Grouse Conservation Plan as a county plan and supports the conservation efforts and policies contained therein. As of January 2017, Utah has spent \$5 million annually on sage-grouse conservation, restored 1.2 million acres of habitat and has protected 94% of the sage-grouse habitat in the state. Reports indicate that sage-grouse populations are currently increasing throughout the state.

Utah Prairie-dog. This southern Utah sub-species of prairie-dog is currently listed as threatened. The efforts of the State of Utah and several affected counties to delist this species has prompted heavy interest in translocating the rodents to new locations. Beaver County is the focus of several relocation sites, however, the county a section has been included in this plan restricting where prairie-dogs may be released in order to protect citizens and agricultural properties. See Section 9.3.1.

Gray Wolf. The Gray wolf currently introduced into the Northern Rocky Mountains is not the same subspecies that historically inhabited the state of Utah. There is further controversy over the endangered status of wolves in Utah while all across the northern tier of the continent, wolves are prolific and abundant with no listing status. This contradicts the stated definition of endangered as "any species which is in danger of extinction throughout all or a significant portion of its range . . ." Beaver County has been the site of a recent wolf incident and in the interest of protecting the citizens of this county and their domestic animals and livestock, a specific section dedicated to wolf management is included in the plan. See Section 9.4.1.

Least Chub. The USFWS received a petition to list the least chub as threatened or endangered, but in August of 2014 they issued a finding that the listing was not warranted and removed it from candidate status.

Hamlin Valley Pyrg. This small snail was part of two separate petitions to list over 200 species in the western U.S. by environmentalist organizations starting in 2007. As of January 2017, the USFWS has not issued a finding and it remains under review as a candidate species.

All of the species on Beaver County's List are being managed for recovery or sustainability by the State and federal agencies and are subject to various recovery plans and conservation strategies. All ESA listed species will have documented Recovery Plans prepared by the USFWS. All conservation agreement species have Conservation Agreements, which are similar to Recovery Plans but not as detailed. Other Beaver County Special Status Species generally do not have specific management plans. However, they are typically considered in Resource Management Plans prepared by Forest Service and BLM units within Beaver County.

II. OBJECTIVES

Beaver County's objectives with regard to threatened, endangered, and sensitive species are as follows:

1. To protect the health, safety, welfare and private property rights, to improve the standard of living and to strengthen economic vitality;
2. To preserve and protect sensitive species and their habitat;
3. To amend, rewrite or repeal the Endangered Species Act with legislation that protects those species that truly need it, while giving greater flexibility and relief to property owners and land managers in protecting and enhancing critical habitats;
4. To become more actively involved in land management planning through coordination with federal and State agencies with regards to actions and policies involving threatened, endangered and sensitive species;
5. To support adaptive resource management that maintains multiple use and sustained yield on public lands;
6. To enact a common simplified and unified definition between agencies for designating and describing special status species;
7. To encourage the use of the best available science in species management, recovery

plans and species listings;

8. To remove the assignment of developed lands (e.g., housing developments, commercial developments, cultivated agricultural lands, etc.) from critical or crucial habitat designation; and
9. To demand an analysis of potential impacts must be provided for any introduction/reintroduction and full mitigation measures must be approved which constrain, limit, curb or restrict those species to the boundaries set forth in original plans. Introductions/reintroductions often grow beyond the stated boundaries and intended scope of recovery efforts, resulting in detrimental impacts to surrounding area economies, life style, culture and heritage.

III. POLICIES AND GUIDELINES

1. Beaver County will take the following actions concerning Sensitive Species/Species of Concern:
 - a. Support creating a unified definition for species of concern across agencies;
 - b. Support the use of credible data or information that agencies (BLM, USFS) use on which to base a decision that a species should be designated a “species of concern” or “sensitive” beyond criteria provided in their respective handbooks;
 - c. Oppose the management of non-ESA listed species (sensitive species, species of concern) as though they are protected by the rules of the Endangered Species Act;
 - d. Support delisting of any species with insufficient, unsupported, or questionable data not meeting the minimum criteria for its listing or protection level;
 - e. Management plans shall not be created for single species and should be consistent with multiple use mandates;
 - f. The County should be involved in the sensitive species/species of concern review process, including the determination of which species are included;
 - g. The County should be involved in the establishment of recovery objectives for species of concern (e.g. Greater Sage-grouse) and the development of management actions to move species off the list of concern. Once recovery objectives have been reached, those species should be immediately removed

from the list of concern; and

- h. Support the development of local solutions (e.g., habitat management plans or conservation plans) to keep a species from being listed under ESA.
- 2. Beaver County will take the following actions concerning Threatened or Endangered Species:
 - a. The County shall be a cooperating agency and participate in coordination with federal agencies in rulemaking, including any NEPA analysis related to the designation of critical habitat and development of recovery plans;
 - b. Require the full analysis of economic impacts on all proposed critical habitat designations or species management plans, and the inclusion of the County's participation in this analysis;
 - c. Support cooperation between private landowners and federal agencies to reduce the risk of listing under ESA;
 - d. Oppose the introduction or reintroduction of listed species into Beaver County, unless the County Commission deems no harm will come to the County, or that terms and conditions are approved that will guarantee no disruption of current land uses;
 - e. Should an agreement not be reached on a potential introduction or reintroduction, and a species is introduced anyway, demand the introduction be classified as a non-essential or experimental population;
 - f. Participate as a cooperating agency in all decisions and proposed actions which affect Beaver County regarding sensitive, threatened or endangered species; the introduction or reintroduction of listed species; habitat conservation plans; conservation agreements or plans; and candidate conservation agreements;
 - g. Support the development of recovery plans within 18 months of a species listing, including clear objectives to be reached in order for delisting to occur;
 - h. Require the petition of the immediate delisting of a species when population or recovery plan objectives have been met;
 - i. Oppose management actions increasing the population of any listed species in the County without an approved recovery plan; and
 - j. Require the continued use of existing valid permits and lease rights on lands with listed species wherever possible.

3. Beaver County will take appropriate actions to conserve and aid recovery of endangered species within the county, consistent with stated county goals and objectives.
4. Beaver County will support efforts to protect and preserve threatened and endangered species using incentives and cooperative agreements entered into by private property owners or lessees and the authorized management agency.
5. Beaver County will encourage and support the amending or revision of the ESA.
6. Single-species management in all planning efforts should be avoided and in favor of planning the focuses on multiple uses of lands and resources, as required by federal law.
7. Restrictions on land use associated with special status species shall be removed from lands that do not contain: (a) current viable populations or (b) high value critical habitat.
8. Management actions and recovery plans must be based on current habitats and conditions, not a perceived native condition or potential future condition.
9. Recovery plans must provide for indicators that track the progress of a species recovery or plan effectiveness and identify the point at which recovery has been accomplished.
10. Critical habitat designations and species recovery plans are based on local populations and site-specific habitat conditions; Human developments shall be excluded from critical habitat designation.
11. Special status species conservation and recovery shall be managed in concert with traditional multiple use/sustained yield policies on public lands.
12. Special status species recovery habitats shall not be designated near human developments, housing areas, cultivated fields or commercial/utility developments.
13. Beaver County opposes the designation of potential habitat as critical habitat unless quantifiable data showing when and how features necessary for species recovery will be achieved on the property.
14. The Utah Wildlife Action Plan shall be used as a principal guide for implementing conservation strategies and species recovery plans in Beaver County.
15. The Utah Sage Grouse Conservation Plan, as the source for the county plan, shall be used as the principle guide for implementing conservation strategies and recovery plans for sage-grouse in Beaver County.

16. All non-essential, experimental populations, temporary or transient individuals, or introduced species shall not receive consideration for special status species protections or recovery efforts.
17. A census shall be taken annually for special status species in Beaver County by the responsible agency. When annual counts are reported as zero for 5 consecutive years, that species is deemed to no longer exist in Beaver County.
18. Conservation agreements need to be reviewed and revised through coordination to be in consistency with Beaver County's plans and policies.
19. Land must be removed from priority, critical or other habitat designations when they do not contain populations of those species for which they are being designated.
20. Lands must be removed from priority, critical, crucial or other habitat designations when they are in conflict with human developments, agricultural lands or commercial/utility developments.
21. Beaver County supports the control of predators and zoonotic and vector borne diseases negatively impacting special status, candidate, or listed species.
22. Beaver County opposes the concept of buffer zones or setbacks for the protection of threatened, endangered or sensitive species.
23. Introductions/reintroductions must be constrained, limited and restricted to the scope and boundaries set forth in release plans; Mitigation strategies shall be approved for any species release that exceeds or overruns those boundaries.
24. The County does not believe that it was the intention of the Act to restore all original habitats formerly occupied by a specific species, or to reintroduce a species back to all former habitats, but only the amount needed to allow for species recovery and continued viability.
25. Devaluation of private property from habitat designations under the ESA is considered a "taking" and must be compensated, including under the 5th Amendment to the U.S. Constitution.
26. Beaver County calls upon the federal agencies that administer lands within the county to:
 - a. Fully cooperate and coordinate with the county to develop, amend, and implement land and resource management plans and to implement management decisions that are consistent with the purposes, goals, and policies described in

this section to the maximum extent allowed under federal law;

- b. Maintain and enhance desired plant communities that benefit watersheds, wildlife, livestock, recreation, and other beneficial uses;
- c. Utilize native and non-native seed mixtures in vegetation treatments that are appropriate to management objectives, are adapted to the site conditions and are highly resistant to and/or competitive to invasive and noxious weeds;
- d. Avoid attempts to circumvent responsible land management practices, to close roads, suspend grazing AUM's, and other actions under the pretense of sensitive species protections without clear scientific evidence and reason.
- e. Provide copies of legal descriptions showing the exact boundaries of all designated or proposed critical habitats in Beaver County.
- f. Provide a completed exclusion analysis for all lands within Beaver County.
- g. Provide annual reports to Beaver County Commission on population counts and trends, habitat restorations or improvements, and other important management actions taken pursuant to threatened or endangered species in Beaver County.
- h. Refrain from any planning decisions and management actions that will undermine, restrict or diminish the goals, purposes and policies of Beaver County as stated in this resolution; and
- i. Refrain from implementing a policy that is contrary to the goals and purposes described in this resolution.

9.3.1 Prairie Dog Management

I. FINDINGS

In *People for Ethical Treatment of Property Owners v. U. S. Fish and Wildlife Service*, 57 F.Supp.3d 1337, 1346 (D. Utah 2014), [hereinafter “*PETPO*”], U.S. District Court Judge Dee Benson ruled that, “Congress has no authority to regulate takes of Utah prairie dogs on non-federal land. . . . Although the Commerce Clause authorizes Congress to do many things, it does not authorize Congress to regulate takes of a purely intrastate species that has no substantial effect on interstate commerce. Congress similarly lacks authority through the Necessary and Proper Clause because the regulation of takes of Utah prairie dogs is not essential or necessary to the ESA's economic scheme [;]”

The ruling effectively repealed rule 4(d) of the Endangered Species Act (ESA) as it relates to Federal regulation of the take of Utah prairie dogs on non-federal lands in Utah. Under the decision, State law now regulates the take of Utah prairie dogs on private, State and local government lands. However, the ruling does not apply to Utah prairie dogs on protected private and federal lands.

Beaver County is defined as a cooperating agency with the Federal government under 40 CFR § 1508.8 and 43 CFR § 1601.0-5.

Under Utah Code Ann. § 17-53-318(2), Beaver County “is considered to have special expertise: . . . (ii) in a matter related to federal land development and planning, the implementation of a federal resource management plan, and other related federal land management actions; (iii) regarding whether a federal land development and plan, resource management plan, or other related federal land management action is consistent with an adopted county general plan; and, (iv) on a subject matter for which it has statutory responsibility, including a subject matter related to the health, safety, welfare, custom, culture, or socioeconomic viability of a county.”

Utah Code Ann. § 17-53-318(3) directs that “A county through its governing body or a person designated by the governing body may participate in efforts to coordinate and make consistent the federal agency resources management plan or other related management action with the general plan as provided in: (a) the Federal Land Policy Management Act of 1976, 43 U.S.C. § 1701, et seq.; (b) 16 U.S.C. § 1604; or, (c) any other federal law or rule that provides for coordination and consistency with local government plans and policies.”

In keeping with the Federal District Court ruling in *PETPO*, *supra*, the Utah Division of Wildlife Resources (“UDWR”) has developed the Utah Prairie Dog Management Plan for Non-federal Lands.

The plan has identified a portion of Beaver County as historic range for the Utah Prairie Dog, and having documented recovery objectives for the species will include translocation to suitable habitats.

Utah Code Ann § 23-13-14(3) dictates: “A person who knowingly and without lawful authority imports, transports, or releases a live species of wildlife that the person knows is listed as threatened or endangered, or is a candidate to be listed under the Endangered Species Act, 16 U.S.C. § 1631, et seq., with the intent to establish the presence of that species in an area of the state not currently known to be occupied by a reproducing population of that species is guilty of a third degree felony.”

Utah Code Ann. § 23-14-21(2) states: “The [Utah Division of Wildlife Resources] shall: (a) consult with the landowner in determining the suitability of a site for the transplant of a species; (b) prepare a list of proposed sites for the transplant of species; [and,] (c) provide notification of proposed sites for the transplant of species to: (i) local government officials having jurisdiction over areas that may be affected by a transplant . . .”

Utah Code Ann. § 17-53-223(1)(a) directs as follows: “A county legislative body may: (a) pass all ordinances and rules and make all regulations, not repugnant to law, necessary for carrying into effect or discharging the powers and duties conferred by this title, and as are necessary and proper to provide for the safety, and preserve the health, promote the prosperity, improve the morals, peace, and good order, comfort, and convenience of the county and its inhabitants, and for the protection of property in the county.”

The Legislative Body of Beaver County hereby finds that the presence of the Utah prairie dog in surrounding counties has had a substantial impact on the prosperity, socioeconomic viability, and protection of property of those counties, and that translocation of any Utah prairie dogs into Beaver County from surrounding areas, or translocation within Beaver County from mapped and occupied habitat to unoccupied habitat, will have a similar detrimental impact upon Beaver County.

The USFWS’s Utah Prairie Dog Final Revised Recovery Plan (2012) has speciously identified the entire boundary of Beaver County as historic habitat in direct contrast to the studies of G. D. Collier, et al. (Collier, 1975) (Pizzimenti & Collier, 1975) (Allen, 1905) and have specified a recovery unit boundary covering a majority of the county with no valid scientific evidence to support this demarcation.

The basis for much of the claim that the majority of Beaver County was historically occupied by the Utah Prairie Dog comes from an overly vague map by N. Hollister (Hollister, 1916) and a frequently cited report by a high school student (Hardy, 1937) which evidences the lack of scientific proof of the presumptive range historically occupied in the county.

In the exhaustive research done by G. D. Collier on Utah Prairie dogs from 1972-1975, in preparation for the U.S. Fish and Wildlife Service’s ESA listing, there were no Utah Prairie Dogs found in Beaver County (Collier, 1975). Additionally, the historic distribution of the prairie dog in Beaver County from 1920-1972 was completely conjectural based upon extensive interviews with local farmers, ranchers and others with no scientific credentials (Collier, 1975).

There are known to be Townsend ground squirrels throughout the Milford Flat area of Beaver County which have existed here prior to human settlement, which questions the validity of un-credentialed claims of prairie dogs in the area based on potential misidentification of these

similar species (Collier, 1975); Furthermore, the rarity in which these two species intermingle, owing to their differing adaptabilities to arid habitats, serves to undermine the hypothesis of prairie dogs historically inhabiting this area.

A prairie dog specimen was collected in Pine Valley, Beaver County Utah, in a museum expedition of 1904 (Allen, 1905), confirming their existence in this location only.

II. OBJECTIVES

Beaver County's objective with regard to prairie dog management is as follows:

1. To protect the health, safety and welfare of its citizens and to protect private property from the destruction and damage caused by prairie dog burrowing and feeding activities.

III. POLICIES AND GUIDELINES

1. Beaver County refutes the claim that Utah Prairie Dogs historically inhabited large portions of the county. The citations used to support the argument that prairie dogs were abundant throughout the county are lacking in proof or scientific evidence and are based purely on hypothesis and conjecture.
2. Beaver County acknowledges the historic habitat that has been occupied and documented within the southern end of Pine Valley by the Utah Prairie Dog, and knowing this, they are to inhabit nowhere else in Beaver County.
3. Beaver County opposes any efforts to transplant prairie dogs into the county outside of that area mapped and deemed historic habitat by the county. The area that has been mapped by the County, and accepted as historic habitat, will be recognized for the species *Cynomys parvidens*.
4. The mapped and occupied habitat in the southern part of Pine Valley shall be recognized as habitat for the species *Cynomys parvidens*, while preserving all existing uses, in accordance with applicable State and Federal law and regulation. See Map 13.
5. In accordance with applicable State and Federal law and regulation, translocation shall be prohibited by the U.S. Fish and Wildlife service, the Utah Division of Wildlife Resources, or any other State or Federal agency desiring to move or translocate Utah Prairie Dogs into or within Beaver County unless approval is first obtained from the Board of County Commissioners prior to the movement or translocation of prairie dogs into or within any portion of the boundaries of the County.

9.4 Predator Control

I. FINDINGS

Across the United States, wildlife habitat has substantially changed as human populations have expanded and land has been transformed to meet varying human needs. These human uses and needs may compete with the needs of wildlife or attract wildlife and have inherently increased the potential for conflicts between wildlife and people.

Wildlife damage management, a specialized field within the wildlife management profession, is the science of reducing damage or problems caused by wildlife. It is recognized as an integral part of modern wildlife management (Berryman, 1991).

The U.S. Department of Agriculture (“USDA”) Wildlife Services (“WS”) program, a division of APHIS, is the federal agency authorized by Congress to conduct wildlife damage management to protect American agriculture, industrial and natural resources, property and human health and safety from damage associated with wildlife (Animal Damage Control Act, 1931). WS responds to requests for assistance when valued resources are lost, damaged, or threatened by wildlife. As requested, WS cooperates with land management agencies (e.g. BLM and USFS) and wildlife management agencies (e.g. UDWR and USFWS), and the Utah Department of Agriculture and Food to effectively and efficiently reduce wildlife damage. Aerial hunting of wildlife that damage livestock is authorized under the Airborne Hunting Act of 1971 and allows WS to pursue wildlife damaging livestock from fixed-wing or rotor operated aircraft. States also can permit private individuals to hunt coyotes from the air through a permitting process, which in Utah is managed through the UDAF.

The Utah Wildlife Services (“WS-Utah”) program is a cooperative effort between the USDA and UDAF. The state authority for the program is found in Title 4, Chapter 23 of the Utah Code. Under that code, the state has created a nine member board to oversee the state role in predator damage management as directed in the Agricultural and Wildlife Damage Prevention Act. Most of WS-Utah’s activities are spent on predator damage management, but other activities include monitoring animal and bird disease outbreaks and threatened and endangered species protection.

Species in Utah that cause repeated damage to resources include coyotes, red fox, mountain lions, black bears, raccoons, and striped skunks. Other predators that cause localized damage include swift fox, bobcat, badger, mink, feral cats and free roaming dogs.

Livestock predation causes significant economic loss to livestock owners. Without effective predator management to protect livestock, predation would be higher (Howard & Shaw, 1978) (Collinge & Maycock, 1997). In Utah, coyotes account for an annual average of 65% of

confirmed livestock kills. Mountain lions account for an annual average of 14% of losses and black bears average 21% of annual losses.

Livestock are an important component of the local economies throughout the state. UDAF estimated Utah statewide predation losses of sheep and lambs at \$4,529,000 in 2014. It must be noted that these losses occurred with a predator damage management program in place, losses would have been much greater without this program. Although direct losses of livestock to predation are economically significant, actual indirect costs are also significant. The threat from predators' increases costs imposed on livestock producers from mitigation efforts including confinement, increased fencing, early weaning, choice of grazing areas, increased feed costs, stress from harassment, hired herders, guard animals, noise devices, lights and others.

Private landowners who suffer damage to their livestock, including cattle, sheep, goats, horses, mules, turkeys and swine, from predators such as bear, wolf or mountain lion are entitled to seek compensation through the Wildlife Damage Compensation Act (See Utah Code 23-24-1).

The UDWR recognizes predator management as an important tool available to division staff when needed. Although predator management can be controversial, it is important under certain circumstances for the effective management of predator and prey populations.

If predator populations are limiting UDWR's ability to reach other wildlife management objectives, wildlife officials may choose to implement predator management plans, such as those for mule deer. This plan directs financial resources (\$600,000 annually) to the USDA-Wildlife Services for coyote control, specifically to help reduce populations in areas where deer fawn survival is low. Coyotes are not considered a protected species in Utah and a bounty program was also instituted as part of the effort to bolster dwindling mule deer numbers. In addition, targeted efforts using hunters and trappers cooperatively hired through Wildlife Services and UDAF for removal of coyotes from specific areas and during prescribed seasons are also used in this effort.

The UDWR is also working to limit the impact of cougars on Utah's deer herds, while maintaining a healthy cougar population statewide. Cougar harvest has been liberalized where mule deer or bighorn sheep populations fall below population management objectives. Currently the UDWR has programs to control certain predators in specific wildlife management situations, including:

- Ravens, coyotes, red foxes and badgers that prey on sage-grouse and their eggs;
- Raccoons and red foxes that prey on waterfowl and their eggs;
- Cougars that prey on adult mule deer or bighorn sheep; and
- Coyotes that prey on mule deer or pronghorn fawns.

Utah's Mule Deer Protection Act (S.B. 245) was passed in 2012 to appropriate funds for coyote control. The Utah Legislature set aside \$500,000 from the General Fund to administer the program, track harvest and participation, and finance the bounty program, which replaced bounty programs formerly administered by counties.

Two additional wildlife species can at times cause predatory problems in Utah: black bears and wolves. Both of these species are managed under specific plans (Utah Black Bear Management Plan and Utah Wolf Management Plan), although wolves do not currently present predator-management challenges to Utah wildlife managers at this time. Wolves do not currently inhabit Beaver County, although a transient individual was taken in the county. Senate Bill 36 directed UDWR to prevent any wolf pack from establishing in the delisted portion of the state. USDA-Wildlife Services have the authority to resolve livestock depredation incidents involving wolves in this area. For the remainder of the state, wolves continue to be classified as a federally endangered species and under USFWS authority.

In 2013, the UDWR published a conservation plan for Greater Sage-grouse, identifying 11 Sage-grouse Management Areas ("SGMA") throughout the state, including the Bald Hills and Hamlin Valley in Beaver County. These management areas were identified as the most important and high-value areas for intensive Sage-grouse conservation efforts. The UDWR conservation plan identifies eleven categories of threats to greater sage-grouse populations in Utah. Predation has been identified in Utah's plan as a "key threat" in most of those SGMA's. Studies have shown predators were responsible for nearly 100% of the chick mortality in sage grouse. (Burkepile, Reese, & Connelly, 2001). Significant predation was also documented by red fox in another study suggesting red fox populations should be discouraged in sage-grouse habitats (Bunnell & Flinders, 1999). Studies have consistently shown that removing predators had a large, positive effect on hatching success and increased autumn densities of grouse.

Predator control programs that protect livestock, wildlife, and agricultural crops and protect health and human safety are beneficial to Beaver County and its citizens. Prevention or control of wildlife damage, which often includes removal of the animals responsible for the damage, is an essential and responsible part of wildlife management.

II. OBJECTIVES

Beaver County's objectives with regard to predator control are as follows:

1. To coordinate with UDWR and other agencies involving predator control, to ensure an adequate predator management program;
2. To protect livestock and other domestic animals from predatory animals;
3. To protect and preserve the use of management tools and equipment in local and state policies for flexible and efficient predator control by professionals, agency staff and

licensed sportsmen;

4. To continue the protection of mule deer and support actions that strengthen populations;
5. To obtain financial relief for depredating livestock losses; and
6. To demand that wildlife management agencies actively manage all wildlife populations, including predators.

III. POLICIES AND GUIDELINES

1. Beaver County will seek coordination with UDWR and federal agencies concerning predator control programs and management of predators;
2. Beaver County supports and encourages the continuance of the Predator Damage Management program offered by Utah Wildlife Services (UDAF and USDA WS);
3. Beaver County supports the Animal Damage Compensation Act and fair compensation for livestock losses;
4. Beaver County supports the Mule Deer Protection Act and the bounty program offered for coyote control;
5. Beaver County discourages any attempts to place protected status on coyotes;
6. Beaver County supports all legitimate management tools used in animal damage control and predator management by agencies and sportsmen including: foothold traps, snares, ground shooting, aerial shooting, trained dogs, denning, and the use of M-44's and DRC-1339 by Wildlife Services personnel;
7. Beaver County demands that state and federal agencies prioritize predator control in the management of Greater Sage-grouse, including DRC-1339 treated eggs for crow and raven control;
8. Beaver County encourages the removal of protected status from Ravens;
9. Beaver County demands that UDWR promptly respond to, and remove, aggressive predators involved in potentially dangerous incidents or encounters, especially those involving animals habituated to human activities or developments, or those frequenting recreation areas or human habitations;
10. Beaver County will seek any and all actions necessary to prevent wolves from inhabiting Beaver County;
11. Beaver County demands that Rocky Mountain Gray Wolves be delisted statewide and that the Utah Wolf Management Plan be implemented;
12. Beaver County will continue to support predator control programs that are beneficial to

its citizens and help maintain appropriate wildlife populations within the county.

9.4.1 Wolf Management

I. FINDINGS

The Southern Rocky Mountain wolf (*Canis lupus youngi*) (Goldman, 1937) was a subspecies of wolf that was found over southeastern Idaho, southwestern Wyoming, northeastern Nevada, Utah, western and central Colorado, northwestern Arizona and northwestern New Mexico (Allen, 1942). It was a valid subspecies (Wozencraft, 2005) that is now considered extinct.

The Northern Rocky Mountain wolf (*Canis lupus irremotus*) (Goldman, 1937) was a subspecies of wolf native to the northern Rocky Mountains, from northwestern Wyoming northward through western Montana and eastern Idaho into southern Alberta. The U. S. Fish and Wildlife Service in 1980, in their draft recovery plans to reestablish wolves into the Northern Rocky Mountains, chose the Mackenzie Valley wolf (*Canis lupus occidentalis*), also known as the Northwestern wolf. These wolves were viewed as a synonymous subspecies to the Northern Rocky Mountain Wolf *C. l. irremotus*, because of their overlapping habitat in Alberta, Canada. Rather than trying to locate and reestablish any remaining true Northern Rocky Mountain wolves, the USFWS used the plentiful Canadian wolves (*C. l. occidentalis*) in their recovery effort.

The Mexican wolf (*Canis lupus baileyi*), also known as the lobo, was a subspecies of wolf native to southeastern Arizona, southern New Mexico, western Texas and northern Mexico. It is the smallest and most endangered of the gray wolf subspecies, having been nearly extirpated from the wild by the mid 1900's. After being listed under the Endangered Species Act in 1976, five wild wolves were captured alive in Mexico and used to create a breeding program. These five wolves constituted the known population of Mexican wolves at that time. On January 16, 2015 the U. S. Fish and Wildlife Service finalized a rule listing the Mexican wolves as a separate entity under the ESA and revised the regulations for the nonessential experimental population under 10(j), placing this subspecies under endangered species status. The Mexican Wolf Recovery Plan called for the reestablishment of at least 100 wolves in their historic range. A study released by U. S. Fish and Wildlife shows a minimum population of 109 wolves as of 2014 in southwest New Mexico and southeast Arizona.

Despite all evidence to the contrary, the U. S. Fish and Wildlife Service chose to release a non-native subspecies of wolf into the northern Rocky Mountains. This wolf is unquestionably not native to Utah and is a larger specimen than the native Southern Rocky Mountain subspecies that once roamed this state. Further, the Mexican subspecies was selectively identified and given

Endangered species status, despite the often cited concern over obvious inbreeding and lack of DNA diversity or a potential hybrid mixing in its blood lines. The Mexican wolf's habitat never extended into Utah, yet there are currently planning efforts by wolf advocates to push for these wolves to expand their territory into Utah.

Wolves are currently listed as endangered under the Endangered Species Act throughout the greater portion of the state of Utah; The U.S. Fish and Wildlife Service has acknowledged that Utah is not critical to the recovery of wolves.

The USFWS has refused to approve, deny or comment on the Utah Wolf Management Plan, prepared by the State of Utah Division of Wildlife Resources in anticipation of the wolf getting delisted within the state. The State has formally requested in writing, on multiple occasions, that the service delist the wolf throughout Utah. The service has failed to acknowledge or otherwise respond to any and all requests by the State.

Under Utah Code Ann. § 23-29-201(1), “[t]he division shall contact the service upon discovering a wolf in any area of the state where wolves are listed as threatened or endangered under the Endangered Species Act and request immediate removal of the animal from the state; (2) The division shall manage wolves to prevent the establishment of a viable pack in all areas of the state where the wolf is not listed as threatened or endangered under the Endangered Species Act until the wolf is completely delisted under the act and removed from federal control in the entire state.”

It is the policy of the state to legally advocate and facilitate the delisting of wolves in Utah under the Endangered Species Act and place wolf management authority under state control.

Under Utah Code Ann. § 17-53-318(2), Beaver County “is considered to have special expertise: . . . (ii) in a matter related to federal land development and planning, the implementation of a federal resource management plan, and other related federal land management actions; (iii) regarding whether a federal land development plan, resource management plan, or other related federal land management action is consistent with an adopted county general plan; and, (iv) on a subject matter for which it has statutory responsibility, including a subject matter related to the health, safety, welfare, custom, culture, or socioeconomic viability of a county.”

Utah Code Ann. § 17-53-318(3) directs as follows: “A county through its governing body or a person designated by the governing body may participate in efforts to coordinate and make consistent the federal agency resource management plan or other related management action with the general plan as provided in: (a) the Federal Land Policy Management Act of 1976, 43 U.S.C.

§ 1701, et seq.; (b) 16 U.S.C. § 1604; or, (c) any other federal law or rule that provides for coordination and consistency with local government plans and policies.”

Utah Code Ann § 23-13-14(3) dictates: “A person who knowingly and without lawful authority imports, transports, or releases a live species of wildlife that the person knows is listed as threatened or endangered, or is a candidate to be listed under the Endangered Species Act, 16 U.S.C. § 1631, et seq., with the intent to establish the presence of that species in an area of the state not currently known to be occupied by a reproducing population of that species is guilty of a third degree felony.”

Utah Code Ann. § 23-14-21(2) states the following: “The [UDWR] shall: (a) consult with the landowner in determining the suitability of a site for the transplant of a species; (b) prepare a list of proposed sites for the transplant of species; [and,] (c) provide notification of proposed sites for the transplant of species to: (i) local government officials having jurisdiction over areas that may be affected by a transplant . . .”

Utah Code Ann. § 17-53-223(1)(a) directs as follows: “A county legislative body may: (a) pass all ordinances and rules and make all regulations, not repugnant to law, necessary for carrying into effect or discharging the powers and duties conferred by this title, and as are necessary and proper to provide for the safety, and preserve the health, promote the prosperity, improve the morals, peace, and good order, comfort, and convenience of the county and its inhabitants, and for the protection of property in the county.”

II. OBJECTIVES

Beaver County’s objectives with regard to wolf management are as follows:

1. To protect the citizens of this county from unwanted dangerous predators that threaten the health, safety, welfare, customs, culture and socioeconomic viability of Beaver County; and
2. To support any effort to delist wolves throughout the state of Utah where they are currently listed as an endangered species.

III. POLICIES AND GUIDELINES

Beaver County's planned policies and guidelines for accomplishing the foregoing objectives are as follows:

1. The Legislative Body of Beaver County hereby finds that the presence of wolves in surrounding states has had a substantial impact on livestock operations, local communities, domestic animals, and big game populations, and that the introduction of any wolves into Beaver County from surrounding areas will have a similar detrimental impact upon Beaver County.
2. The Legislative Body of Beaver County asserts that this County is not part of the historic range of the Mexican Gray Wolf (*Canis lupus baileyi*) and prohibits their introduction into this County.
3. The Legislative Body determines that the Canadian Gray Wolf subspecies *Canis Lupus Occidentalis* that has been transplanted into Montana, Idaho and Wyoming is not native to Beaver County and its introduction is likewise prohibited.
4. The Legislative Body of Beaver County supports the Utah Division of Wildlife Resources and their management of wolves under the state wolf management plan.

References:

- Allen, G. M. (1942). *Extinct and Vanishing Mammals of the Western Hemisphere*. Lancaster, Pa: The Intelligencer Printing Co.
- Berryman, J. H. (1991). Animal damage management: responsibilities of various agencies and the need for coordination and support. . *Proceedings of the Eastern Wildlife Damage Control Conference*. 5/12/2014 .
- Bunnell, K. D., & Flinders, J. T. (1999). *Restoration of sage grouse in Strawberry Valley, Utah 1998-99 report to Utah Reclamation Mitigation and Conservation Commission*. Provo, Utah: Brigham Young University.
- Burkepile, N. A., Reese, K. P., & Connelly, J. W. (2001). Mortality patterns of sage grouse chicks in southeast Idaho. *Annual meeting of the Idaho Chapter of The Wildlife Society*. Boise.
- Collinge, M. D., & Maycock, C. L. (1997). *Cost-Effectiveness of Predator Damage Management Efforts to Protect Sheep in Idaho*. Great Plains Wildlife Damage Control Workshop Proceedings.
- Goldman, E. A. (1937). The Wolves of North America. *Journal of Mammalogy* , 37-40.
- Howard, V. W., & Shaw, R. E. (1978). *Preliminary assessment of predator damage to the sheep industry in southeastern New Mexico*. Las Cruces, New Mexico: Agricultural Experiment Station., New Mexico State University,.
- Wozencraft, W. C. (2005). *Mammal Species of the World: A Taxonomic and Geographic Reference (3rd ed.)*. Baltimore: The Johns Hopkins University Press.

9.5 Wild Horses

I. FINDINGS

STATUTORY REQUIREMENTS

Large numbers of unbranded and unclaimed horses roam in Beaver County on public lands administered by the United States Secretary of Interior through the Bureau of Land Management (BLM). These animals are known and referred to as wild free-roaming horses. *See* 16 U.S.C. 1331(b). Many of these animals wander from time to time onto private and State owned lands in Beaver County.

Congress asserted jurisdiction over wild free-roaming horses and burros pursuant to the Wild Free-Roaming Horses and Burros Act of 1971 (Public Law 92-195 and subsequent amendments), codified at 16 United States Code Sections 1331-1340. Congress charged the BLM and the Forest Service each to manage wild horses and burros found on the public lands they each administer. While no wild, free roaming burros occur in Beaver County, the wild free-roaming horses in Beaver County are found on lands administered by the BLM.

Despite the BLM's management authority over wild free-roaming horses and burros in Beaver County, Congress in the Wild Free-Roaming Horses and Burros Act of 1971 ("WFRHBA"), 16 U.S.C. 1331, *et. seq.*, and FLPMA, 43 U.S.C. 1701, *et. seq.*, have issued a series of mandates to the BLM.

Under the WFRHBA, the BLM shall remove excess wild free-roaming horses and burros from public land areas where overpopulation is determined to exist. 16 U.S.C. 1333(b)(2). The term "excess" is statutorily defined as animals which have been removed or which must be removed from an area "in order to preserve and maintain a thriving natural ecological balance and multiple-use relationship in that area". *Id.* The BLM must determine the AML of wild horses and burros in an area and use removal, destruction and other options to achieve AML. *See* 16 U.S.C. 1333(b)(1). Thus, in the practical application of the WFRHBA, an "overpopulation" of wild horses and burros occurs in an area, for which the BLM shall remove "excess animals" from the area, whenever the count of wild horses and burros in the area reaches and threatens to exceed the area's AML. In short, anything above AML is considered "excess" and must be removed. As the population of wild free roaming horses approaches AML, the trigger point for doing an EA and NEPA documents in preparation to remove excess animals is reached when the population reaches 85% of AML.

The BLM shall remove wild free-roaming horses or burros that stray on privately owned land if the private land owner so informs the BLM in writing. *See* 16 U.S.C. 1334.

The BLM shall "to the extent consistent with the laws governing the administration of the public lands [namely the Wild Free-Roaming Horses and Burros Act of 1971] coordinate the inventory, planning, and management activities [for wild free-roaming horses and burros] with the land use planning and management programs of [Beaver County]." 43 U.S.C. 1712(c)(9); and

"Land use plans of the BLM [for wild free-roaming horses and burros] under this section shall be consistent with [Beaver County's plan for the same animals] to the maximum extent [the Secretary of Interior] finds consistent with Federal Law [namely the WFRHBA] and the purposes of this Act [meaning FLPMA]." 43 U.S.C. 1712(c)(9).

Beaver County's plan to manage wild free-roaming horses and burros is consistent in every respect with the WFRHBA as amended and FLPMA as amended. Therefore, Beaver County expects maximum adherence by the BLM to this, Beaver County's plan for wild free-roaming horses and burros.

The WFRHBA requires the BLM:

a. To designate and maintain given areas for the protection and preservation of wild horses and burros to be managed "in a manner that is designed to achieve and maintain a thriving natural ecological balance on the public lands;" 16 U.S.C. 1333(a); and

b. To keep current inventories of wild free-roaming horses and burros in the given areas to determine:

- If overpopulations exist;
- Whether actions should be taken to remove excess animals;
- How to best achieve appropriate management levels (AML) whether through removal, destruction of excess animals, or other options such as sterilization or natural population controls. 16 U.S.C. 1333(b)(1).

The WFRHBA requires the BLM to "immediately remove excess animals" from a given area "so as to achieve appropriate management levels" (AML) if the BLM determines on best available information that an overpopulation exists and action is necessary to remove excess animals in the given area. 16 U.S.C. 1333(b)(2). Again AML, particularly upper AML, is the point that defines when wild horses and burros reach a stage of "excess animals" that need to be removed. Such removal of excess wild free-roaming horses shall proceed in the following order and priority:

- a. Destroy old, sick or lame animals in the most humane manner possible;
- b. Capture and remove for private maintenance such number of excess animals for which a demand exists for adoption under qualified, humane care;
- c. Destroy additional excess animals in the most humane and cost efficient manner possible.

See 16 U.S.C. 1333(b)(2)(A)-(C).

The WFRHBA also requires the BLM to sell without limitation all excess animals in excess of 10 years of age and all excess animals that have been offered unsuccessfully for adoption at least 3 times, until all excess animals offered are sold or the appropriate management level has been attained. *See* 16 U.S.C. 1333(e).

The WFRHBA does not expressly prohibit the BLM from utilizing sterilization and fertility programs for wild free-roaming horses and burros. However, the WFRHBA does not excuse the BLM from adhering to its capture/removal/destroy responsibilities under 16 U.S.C. 1333(b) and 1333(e) just because it engages in such sterilization and fertility programs.

The WFRHBA requires the BLM to remove wild free-roaming horses or burros who stray onto privately owned land if the private land owner so informs the BLM in writing. *See* 16 U.S.C. 1334.

The WFRHBA authorizes the BLM to enter into cooperative agreements with landowners, the State of Utah and Beaver County with respect to wild free-roaming horses and burros. *See* 16 U.S.C. 1336.

The WFRHBA does not authorize the BLM to relocate wild free-roaming horses and burros to areas of the public lands where they do not presently exist. 16 U.S.C. 1339. No wild free roaming burros occurred in Beaver County at the passage of the WFRHBA, nor do they occur at the present time.

REGULATORY REQUIREMENTS

The BLM's management of wild free-roaming horses and burros and the establishment of herd management areas ("HMAs") are done in accordance with approved BLM land use plans. *See* 43 CFR 4710.1. When HMAs are established, the BLM must inventory and monitor herd and habitat characteristics, 43 CFR 4710.2, consider the AML of the herd, and prepare a herd management area plan for each HMA. *See* 43 CFR 4710.3-1. The BLM is required by rule to limit the animals' distribution to the HMAs. *See* 43 CFR 4710.4.

BLM by rule allows for closing or limiting certain public lands areas to all or a particular kind of domestic livestock grazing *if necessary* to (1) provide habitat for wild free-roaming horses and burros, (2) to implement herd management actions, or (3) protect the animals from disease, harassment or injury. See 43 CFR 4710.5. Moreover this provision must be applied consistent with the additional BLM rule that management for wild horse and burro values "shall be at the minimum level necessary to attain the objectives identified in approved land use plans and herd management area plans." 43 CFR 4710.4.

HMA's, THEIR AML's, AND THEIR MANAGEMENT, GATHER AND REMOVAL PLANS

There are currently five BLM HMA's and one BLM herd area ("HA") situated wholly or partially in Beaver County. See Map 14. The names of these HMA's and HA (in alphabetical order) and the current BLM determined AML for each area are as follows:

- Bible Spring HMA *	AML 30-60
- Blawn Wash (HA)	AML 0
- Chokecherry HMA	AML 0-30
- Four Mile* HMA	AML 30-60
- Frisco HMA	AML 30-60
- Sulphur HMA	AML 165-250

* Part of the so-called Bible Spring Complex in Beaver and Iron Counties, for which the collective AML is 80-170

The Sulphur HMA is currently supposed to be managed according to the 1987 Sulphur Wild Horse Herd Management Area Plan and the 2010 Wild Horse Gather Plan For The Sulphur Herd Management Area Capture, Treat, and Release Plan, DOI-BLM-UT-C010-2010-0048-EA.

The Bible Spring and Four Mile HMA's are currently supposed to be managed according to the 2005 Bible Springs, Blawn Wash, Four Mile, and Tilly Creek Wild Horse Appropriate Management Level Assessment and the 2014 Bible Spring Complex Wild Horse Gather and Removal and Fertility Treatment Plan, DOI-BLM-UT-C010-2014-0035-EA.

The Chokecherry HMA is currently supposed to be managed according to the 2010 Eagle, Chokecherry, and Mt. Elinor Herd Management Areas Wild Horse Gather Plan, DOI-BLM-NV-L020-2010-0045-EA as tiered into the 1993 Pinyon MFP and 2008 BLM Ely District ROD and Approved RMP.

The Frisco HMA is currently supposed to be managed according to the 2012 Frisco Herd Management Area Plan and Gather Plan, DOI-BLM-UT-C010-2012-0018-EA.

The Blawn Wash HMA has been removed from wild horse management activity. Currently, the State of Utah School and Institutional Trust Lands Administration (SITLA) holds 25,970 acres of land in the HMA, comprising 43% of the area, but also producing 70% of the available forage. Wild horses managed by the BLM could not be excluded from the SITLA lands without fencing across very treacherous terrain. This option was determined to be too expensive and unworkable. Therefore, the Blawn Wash HMA will be managed for 0 AML.

BLM'S FAILURE TO FOLLOW APPLICABLE STATUTES, RULES AND HMA MANAGEMENT, GATHER AND REMOVAL PLANS

The BLM has not adhered to its legal duty to keep wild horses within AMLs. For purposes of the WFRHBA, "overpopulations" of "excess animals" chronically exist and persist far in excess of AML in all five active HMAs (more than double in some areas) and "action is necessary to remove excess animals in" those HMAs.

For purposes of the WFRHBA the BLM has not adhered to its legal duty to remove excess wild free-roaming horses from HMAs in Beaver County by first destroying old, sick or lame animals in the most humane manner possible; next capturing and selling without limitation all excess animals in excess of 10 years old; next capturing and removing for private maintenance such number of excess animals for which a demand exists for adoption under qualified, humane care; next by selling without limitation all excess animals that have been offered unsuccessfully for adoption at least 3 times; and next by destroying additional excess animals in the most humane and cost efficient manner possible. By not adhering to their removal mandate by the WFRHBA, BLM continues to cause conflicts with private landowners by allowing excess wild horses to wander onto private lands.

For purposes of the WFRHBA and applicable BLM rules, the BLM has purported to reduce various local livestock operators' permitted grazing forage, expressed as AUMs, in order to accommodate the exploding wild free-roaming horse populations. Such BLM grazing reductions are not necessary to implement any herd management plan or provide more wild free-roaming horse habitat. Rather, they were ordered because the BLM arbitrarily plans to *continue to fail to follow* its own herd management plans thereby destroying existing habitat.

For purposes of the WFRHBA the BLM has failed to manage wild free-roaming horses in the five active HMAs in Beaver County so as to achieve a thriving natural ecological balance and multiple-use relationship in those areas.;

For purposes of the WFRHBA and applicable BLM rules, the BLM has failed to act in a reasonably prompt manner to remove wild free-roaming horses from private lands upon notice

from the land owners and from State lands managed by SITLA and DNR. The BLM has also neglected to keep wild free-roaming horses off of federally managed lands outside the HMAs.

The failings cited in the preceding paragraphs are due to the following:

- a. The BLM does not utilize euthanasia as legally required except for injured animals;
- b. The BLM does not put aged and unadoptable animals up for sale or euthanasia as legally required, but holds and feeds them in contracted pasture or other holding facilities for the remainder of their lives at great taxpayer expense;
- c. The BLM does not realistically deal with the fact that the demand for adopting wild horses and adoption rates are low and continue to decline due to high feed costs, onerous adoption rules and selective demand for young workable horses or horses of the old Spanish barbed lineage.
- d. The BLM does not realistically deal with the fact that the unwanted, unadoptable horses it keeps are estimated to exceed 50 thousand in number, costing the BLM over \$40 million annually to care for and feed;
- e. The BLM arbitrarily adopts the attitude of reducing established grazing levels first, rather than remove excess wild free-roaming horses, in order to preserve ecological balance;
- f. The BLM does not set realistic and reasonable funding priorities to provide for legally required wild horse gathers except for "emergency situations;"
- g. Even when funding for gathers is available, because pasture and holding facilities are full to capacity and overflowing with un-adopted/unsold/undestroyed animals illegally held in perpetuity, the BLM perpetually delays and altogether cancels wild horse gathers in the face of critical overpopulations far in excess of AML; and
- h. The BLM at the Washington level deprives BLM state and local personnel of authority to timely make wild horse management decisions on when to gather, where to take captured horses, and how to dispose of unadoptable horses.

II. OBJECTIVES

Beaver County's objectives with respect to wild free-roaming horses are as follows:

1. To eliminate the Blawn Wash HA and keep the five HMAs in Beaver County (Bible Spring, Chokecherry, Four Mile, Frisco and Sulphur) as is, with no changes to the existing acreage or boundaries;
2. To keep wild free-roaming horses at or below established AMLs in all HMAs in Beaver County;
3. To achieve a thriving natural ecological balance and multiple-use relationship on all HMAs in Beaver County;
4. To keep wild free-roaming horses off of all public lands outside of the HMAs in Beaver County;
5. To keep all unwanted wild free-roaming horses off private and State lands in Beaver County;
6. To reverse any and all wild horse related reductions of active grazing AUMs that BLM ever required;
7. To demand that the BLM implements management plans that maintain existing vegetation treatment areas and identifies areas for additional vegetation treatments that will increase usable forage for livestock, wildlife and wild horses;
8. To oppose and prevent any wild free-roaming horses and burros from being transferred and introduced into Beaver County from outside the County and from outside any established HMA in the County;
9. To implement a zero tolerance policy for the introduction of wild free-roaming burros into Beaver County; and
10. To work with Utah Congressional delegates to remove language from the Interior Appropriations bills that prohibits the use of funds to deal effectively with excess animals.

III. POLICIES AND GUIDELINES

Beaver County's planned policies and guidelines for accomplishing the foregoing objectives are as follows:

1. Initial Large Gather Outside of HMAs. Following needed NEPA review if any, the BLM during the first field season after implementation of this plan should conduct a countywide gather to remove all wild free-roaming horses found on public lands in Beaver County outside of the HMAs. Animals captured during this gather generally should not be returned to HMAs but rather should be processed for either adoption, sale or destruction according to the requirements of the WFRHBA and applicable BLM rules, stated above. Small exceptions to this general provision could be allowed to introduce new animals into different HMAs for reasons of maintaining genetic diversity, but only if the wild horse population of the HMA is below 85% of AML.
2. Subsequent Biennial Gathers Outside of HMAs. Following needed NEPA if any, the BLM during subsequent alternating field seasons (or more frequently if livestock grazers or other stakeholders determine the need arises) should conduct county wide gathers to remove all wild free-roaming horses found on public lands in Beaver County outside of the HMAs. Animals captured during such gathers generally should not be returned to HMAs but rather should be processed for adoption, sale or destruction according to the requirements of the WFRHBA and applicable BLM rules, stated above. Small exceptions to this general provision could be allowed to introduce new animals into different HMAs for reasons of maintaining genetic diversity of an HMA herd, if wild horse populations are below 85% of AML.
3. Initial Gather In HMAs. Following any needed NEPA, and upon completing an updated inventory count of wild free-roaming horses in each HMA in Beaver County, the BLM during the initial field season following implementation of this plan should conduct gathers in all HMAs where the number of animals is found to equal or exceed the upper AML, removing enough animals to bring the herd number down to lower AML. Animals captured during such gathers should be processed either for adoption, sale or destruction according to the requirements of the WFRHBA and applicable BLM rules, stated above.
4. Subsequent Annual Gathers In HMAs. Following any needed NEPA, and upon completing an updated inventory count of the wild free-roaming horses in each HMA in Beaver County, the BLM annually during each subsequent field season should conduct gathers in all HMAs where the number of animals is found to equal or exceed the upper AML, removing enough animals to bring the herd number down to lower AML. Animals captured during such gathers should be processed either for adoption, sale or destruction according to the requirements of the WFRHBA and applicable BLM rules, stated above.
5. Gathers on Private Lands. BLM should conduct private land gathers of wild free-roaming horses promptly upon proper notice from the landowner. The landowner notice to the BLM should be in writing and should include: location of gather (legal

description), number of animals proposed to be gathered, brief description of animals (color), and a statement indicating desire for the BLM to remove the animals. Animals captured during such gathers should be processed either for adoption, sale or destruction according to the requirements of the WFRHBA and applicable BLM rules, stated above.

6. Interim Small Maintenance Gathers at Water Sites and Other Determined Baiting Areas. Small periodic maintenance gathers of 5 to 30 wild horses may be possible around water sources and other appropriate baiting areas, without the use of helicopters and large round-up crews, and thus better help to maintain horse numbers below upper AML. Animals captured during such gathers should be processed either for adoption, sale or destruction according to the requirements of the WFRHBA and applicable BLM rules, stated above. Additional details for such small gathers are as follows:
 - a. In HMAs and on other public lands outside HMAs: Small periodic maintenance gathers at water sites and other determined baiting areas utilizing catch pens may be appropriate. The use of catch pens may be monitored by livestock operators and BLM officials to determine optimum times to close the pens according to the animals' becoming accustomed to the pens and when they are utilizing water. All capture enclosures would meet BLM Design Features standards and Standard Operating Procedures (SOPs) contained in the current EA.
 - b. On private lands: Same as the preceding paragraph with the following modifications: The BLM and/or the County should supply and erect the pen panels (County could utilize possible assistance of volunteers such as Dedicated Hunters). The landowner should monitor the wild horses' use of the pens and notify the BLM when to catch. The BLM should oversee loading, transport and unloading of the animals. The BLM should supply the feed and the County could, in certain circumstances, supply the personnel to feed the animals.
7. Decisions to conduct any of the wild horse gathers referenced in the preceding paragraphs should not depend on the vacancy rate at pastures and other holding facilities with which the BLM contracts to keep captured and removed animals. Rather, such decisions should depend solely on whether the number of animals in an HMA has reached the upper AML number, and for private land gathers whether the landowner has given the BLM appropriate notice. Because of time constraints involved in doing public scoping, EA's and NEPA studies, the hard trigger for beginning the process to do a gather should begin when the population of a HMA reaches 85% of AML.
8. For all BLM grazing allotments in Beaver County, whether in HMAs or outside of HMAs, the BLM should systematically review for all instances where it has ever ordered

or required reductions of active livestock grazing AUMs due to overpopulations of wild free-roaming horses, perceived or real, present or anticipated. BLM should then reverse all such reductions and restore any such reduced AUMs to active use. Future reductions in AUM's within any HMA should not be mandated if wild horse populations are over the upper AML limit. Wild horse numbers must be reduced to established AML levels prior to any AUM reduction.

9. Following appropriate inventory of HMA range conditions and any NEPA review if needed, BLM should carry out projects in all HMAs in Beaver County and on other public lands impacted by wild horse overpopulations to implement vegetation treatments and to reclaim damaged ranges through restoration projects. Additionally, the BLM should develop and carry out plans for periodic maintenance of vegetation treatment areas.
10. The BLM should reform its policies and guidelines as follows:
 - a. Put aged and unadoptable animals up for sale or euthanasia as legally required, not hold and feed them in contracted pasture or other holding facilities for the rest of their lives at great taxpayer expense;
 - b. Accept and internalize the fact that the demand for adopting wild horses and the adoption rate are low and declining further due to high feed costs, onerous adoption rules and selective demand for young workable horses or horses of the old Spanish barbed lineage;
 - c. Follow sound fiscal practices to avoid the inhumane holding of over 50 thousand wild horses, costing the over \$40 million annually to care for and feed;
 - d. Eliminate the attitude of reducing established grazing levels first, and rather remove excess wild free-roaming horses in order to preserve natural thriving ecological balance and multiple-use relationships;
 - e. Set realistic and reasonable funding priorities to provide for the legally required wild horse gathers outlined in the paragraphs above;
 - f. No longer put off wild horse gather decisions based on vacancy of perennial holding facilities and pastures. Rather, base gather decisions on when actual wild free-roaming horse numbers reach upper AML for each HMA, and when they are found outside of HMAs. Begin the preparation process when the hard trigger point (85% of AML) is reached in advance of rising populations; and

- g. Give back to state and local BLM officials the authority and leeway to make timely wild horse management decisions on when to gather, where to take captured horses, and how to dispose of unadoptable horses, rather than keep that authority bottled up at the Washington level.
 - h. Report to the BLM and demand the immediate gather and removal from Beaver County of any wild free-roaming burro found in the county.
11. An important component to maintaining a healthy and thriving ecological balance is to provide adequate forage for livestock, wildlife and wild horses. Many of the grazing allotments within the HMA's have existing vegetation treatment areas where the encroaching pinyon/juniper was removed and the area seeded to provide forage for grazing. Most of these areas have been neglected and are now overgrown with returning brush and pinyon/juniper stands. Vegetation treatment areas need to be maintained and periodically re-treated.

FERTILITY CONTROL

12. Fertility control is an option in all HMAs in Beaver County as analyzed in the related environmental assessments by the BLM. The primary purpose of using Porcine Zona Pellucidae (PZP) is to reduce the annual population growth. The primary use of fertility control is to maintain the population within AML once achieved. It could be used previous to achieving AML if gather success, holding capacity limitations, population growth rates, other national gather priorities or other circumstances prevent achieving AML during a gather. Use of PZP would be in accordance with BLM Washington IM 2009-090, or the current guidance and best practices directed by the BLM's National Program Office. The use of PZP or other fertility control is not to be used in a manner that would threaten the health of individual animals or the long-term viability of any herd. A trained applicator would be selected to administer the vaccine during scheduled gathers.

WILD HORSE SURVEYS

13. Beaver County shall rely on the Utah Division of Wildlife Resources to conduct wild horse counts to determine if populations are within AML. In circumstances where an excess of wild horses is believed to exist, and the tentative schedule for the UDWR is not timely or sufficient, a disinterested, third party contractor may be used to do aerial surveys of the affected HMA.

10. FOREST MANAGEMENT

I. FINDINGS

Forested lands are an important natural resource to Beaver County and contribute to the quality of life by providing employment, forest products, water resources, open space, wildlife habitat, livestock forage, recreation, and provide numerous other social and economic benefits. According to the United States Department of Agriculture, about 47.5% of the County is forested, comprising approximately 784,900 acres of land in the County. Therefore, it is vital to manage forested lands in a manner that allows Beaver County to continue to enjoy the benefits of forested lands. Approximately 77% of all land in Beaver County is federally managed, with the USFS managing approximately 140,000 acres of land in the Fishlake National Forest that encompasses the Eastern side of the County.

Beaver County's broad range of environmental conditions results in great diversity of natural vegetation. Different types of vegetation are associated with differences in elevation. Increasing elevation is associated with increasing precipitation and decreasing temperatures resulting in varying zones of vegetation types. Typical of the Southern Rocky Mountain region, there are both lower and upper treelines. Below the lower treeline, conditions are generally too dry for trees to survive. Above the upper treeline, conditions are generally too cold. The lower forest vegetation type is comprised of pinyon/juniper, which is the dominant forestland in Beaver County. The upper elevations are comprised of montane forest (i.e. Ponderosa pine, Douglas fir, Engelmann spruce, Aspen, etc.) and woodland forest types (i.e. Gambel oak, Mountain mahogany, intermountain maple).

The National Forest system was originally set aside to provide a continuous supply of timber and for the protection of water sources specifically for local communities and agricultural needs. In 1960, Congress passed the Multiple-Use Sustained-Yield Act that directed that forests should be "administered for outdoor recreation, range, timber, watershed, and fish and wildlife purposes. See 16 U.S.C. § 528. However, Congress also declared that these additional purposes were to be "*supplemental to, but in derogation of the original purposes.*" *Id.* (emphasis added).

Over the past few decades, the principles of multiple-use and sustained-yield have given way to excessive environmental protection and the limitation of many historic uses of forested lands. Many areas were given special wilderness designations after the passage of the Wilderness Act of 1964, which led to closed roads, no prescribed timber harvests, and drastic reductions of grazing AUMs. Since that time, there have been very few wilderness designations added to the National Forest System, however the USFS has managed many lands as de facto wilderness areas by designating Roadless Areas under the Roadless Area Conservation Rule.

This mismanagement of National Forest lands has threatened the health of forested lands in Beaver County. Limitations on timber harvesting have increased the amount of standing dead timber on forestlands. Excessive dead timber increases the risk of large and devastating forest fires. These management practices have been a contributing factor to the increased intensity of wildland fires Utah has experienced in recent years. Failure to remove standing dead timber has many other negative effects. With excessive standing dead timber, forests have no room for new growth. New growth in turn provides more habitats for wildlife and increased forage for grazing. The BLM has adopted and implemented these beneficial management policies for years, but the USFS has been resistant.

There are currently many acres of forests in Beaver County at risk of high severity disturbance, particularly catastrophic wildfire and insect outbreaks. There are many stands that are too dense, leading to high competitive stress and density-related mortality. High relative densities make forest stands susceptible to insect attack. Most of the local Spruce-fir forest types have neither resistance nor resilience to spruce beetle attacks and have been given a high risk rating. In addition, many stands have canopy fuel profiles which make them prone to crown fires. These stands have been given a low “torching index” rating, indicating that crown fires are highly likely. With high relative tree densities, development of fuel ladders, and low torching indexes, the potential for a catastrophic fire is very high.

Timber harvesting has become virtually non-existent in Beaver County according to Headwater Economics’ Economic Profile System. Given the excessive amount of standing dead timber that exists in forested lands in Beaver County, increased prescribed timber harvests would not only improve the health of the forests, but provide an economic stimulus to the County.

Livestock grazing on National Forest lands in Utah has been drastically reduced since the early part of the twentieth century, although over the past 30 years, the livestock numbers have remained fairly constant in most cases. Stocking rates are generally very conservative on Forest Service lands and forage is typically under-utilized by livestock. The USFS monitors vegetation or forage utilization, especially in riparian areas and along streambanks, using various techniques. However, the amount and type of monitoring varies considerably from one forest to another. The use of stubble height measurements has become a popular technique for determining forage utilization in many areas and are written as “standards” in land use plans and annual operating instructions for allotments. These measurements are used to monitor “compliance” with the terms and conditions of grazing permits and as a basis for pasture moves or removal from an allotment. These practices are not supported by range science.

The USFS has failed to adopt a procedure for evaluating range conditions in terms of ecological site potential based on soils, moisture and other factors, as used by the BLM and other agencies. Thus, comparison of conditions and range trends on USFS lands with that of lands managed by other entities is very difficult.

The invasion of noxious weeds is another problem threatening the health of Forest Service lands in Beaver County. Noxious weeds are a significant problem and have been the focus of considerable effort for many years. Scotch thistle is of primary concern, especially in areas burned by fire. Cheatgrass is another invasive plant that has impacted much of the lower elevation areas on the National Forest. Cheatgrass outcompetes other desirable vegetation and is highly susceptible to frequent wildfires.

There are inholdings of state and private lands within the Fishlake National Forest in Beaver County. Management of these lands is primarily entrusted to the Utah Division of Forestry, Fire and State Lands ("Forest Division"). In 2016, the Forest Division developed the Utah Forest Action Plan. The plan provides a comprehensive analysis of the forest-related conditions, trends, threats and opportunities within Utah and will be used to guide the Division's planning efforts and project work. It is vital for the Forest Division to coordinate and consult with Beaver County on forest management initiatives affecting lands within the County.

II. OBJECTIVES

Beaver County's objectives with regard to forest management are as follows:

1. To ensure the forests are managed under the principles of multiple-uses and sustained yield;
2. To take an active role in consulting and coordinating with the County in forest management and planning activities;
3. To prevent forest fires unnecessary to maintaining a healthy ecosystem;
4. To demand that land managers utilize available means of reducing forest fuel such as grazing and timber harvesting.

III. POLICIES AND GUIDELINES

1. It is the policy of Beaver County to continue cooperating with the USFS and the Forest Division to address issues concerning forestland in Beaver County.
2. Beaver County supports the Utah Forest Practices Act and its stated purposes including:
 - a. Preserving water quality and soil stability;
 - b. Preventing fire hazard and insect infestation;
 - c. Minimizing waste of timber resources; and

- d. Protecting forest regeneration and production. *See* Utah Code § 65A-8a-105(1).
3. Providing a continuous supply of timber and protecting water resources shall be the primary goal of all forestland planning and management actions.
4. All forestlands shall be managed for multiple use and sustained yield.
5. Timber resources shall be managed to achieve multiple benefits.
6. Forest management plans shall employ a “shelterwood” system to reduce overstory density and eliminate fuel ladders, particularly in the Ponderosa and Spruce-fir forest types.
7. Forest management plan objectives shall focus on managing in a proactive manner to create forests that are resistant and resilient to both extreme fire and insect outbreak through combinations of mechanical treatments and prescribed fire.
8. Management plans and policies concerning grazing activities on national forest lands should give heavy consideration to historic access and usage; traditional uses and trailing routes shall be maintained.
9. Livestock grazing shall be managed to maintain good ground cover of perennial grasses, forbs and shrubs by stocking at appropriate rates and rotating use during growing seasons when possible; damage to desirable tree reproduction should be avoided.
10. Opportunities for harvesting forest products shall be promoted, including harvest of timber that can be used for energy, lumber, pellets, chips and other products.
11. All Forest Management Plans and NEPA studies shall consider the economic impacts of actions on Beaver County.
12. Prescribed fire, logging and mechanical thinning shall be used to keep forest canopies open to allow for forage production and to reduce high intensity canopy fires.
13. Beaver County shall encourage and support the existing CWMA for collaboration in weed control efforts as they relate to forestlands.
14. National Forest planning and management actions should be consistent with the fire management policies and guidelines found within this plan.
15. Beaver County supports prescribed burns as a fuels reduction management tool where appropriate, when conditions are favorable and where restoration plans are in place.
16. Beaver County encourages the USFS to employ a standardized criteria system for range

condition evaluation based on ecological site potential.

17. Land management agencies shall provide Beaver County with a meaningful opportunity to participate early and often in forest and rangeland planning processes and assist in identifying areas where restoration treatments are needed.
18. Forestlands shall not be managed as de facto wilderness, or given special land status designations unless they explicitly meet the statutory criteria for such and those designations are acceptable to the Board of County Commissioners.
19. The public must have ample and appropriate access to forestlands for multiples uses, including recreational activities.

11. LAW ENFORCEMENT

I. FINDINGS

The Beaver County Sheriff's Office provides law enforcement services to all areas of Beaver County and contract cities, as well as co-operative support services to local, state and federal law enforcement agencies and organizations. Beaver County's powers as a political subdivision of the State of Utah derive from the United States and Utah Constitutions, the Utah Code, the common law, and Beaver County ordinances and resolutions. The State of Utah has general powers of jurisdiction unless expressly assigned to the government of the United States in the United States Constitution. The government of the United States has only those powers expressly delegated to it in the United States Constitution, as expressly exercised by the Congress of the United States.

Law enforcement authority for all lands within its borders is a prerogative of Beaver County as expressed through its duly elected Sheriff and duly hired and appointed and contracted deputy law enforcement agents.

The responsibility of the Sheriff's Office is to protect the lives, property, and rights of all citizens of Beaver County, to maintain order, and to enforce the law. This duty is achieved through the efforts of experienced and well trained officers and staff of the Beaver County Sheriff's Office who strive to improve and maintain the quality of life enjoyed in the County and make it a safe place to live, work, and visit. This includes enforcing the rules, regulations, ordinances and other law set forth by Beaver County's duly appointed planning and zoning commission and elected board of county commissioners. Their mission statement is as follows:

The mission of the Beaver County Sheriff's Office is to protect and serve the citizens of Beaver County with excellence, fidelity, honor, respect, we will always serve with integrity to preserve life, protect property and maintain public order.

In doing so we will perform our duties with the utmost respect to individual rights with no decision ever made based solely on race, religion, color or creed.

We will vigorously pursue those who victimize the innocent, to see that justice is served. We will steady the course in the face of danger and know that our cause is just and needed.

We will show compassion to those who suffer tragedy or fall prey to those who lurk in the shadows of society and know not what compassion means.

We will wear our badge with pride and strive to ensure that the citizens we serve can be confident and proud of those that they have instilled trust in.

Law enforcement agents and other officials of federal land management agencies such as the BLM and the US Forest Service, have no authority, right or permission to enforce state and local criminal and civil laws except as authorized by and consistent with the Federal Assimilative Crimes Act, 18 U.S.C. § 7(3).

The Federal Assimilative Crimes Act permits federal officers to enforce state and local laws by reference (assimilation) only on federal lands that are under either exclusive U.S. jurisdiction or concurrent U.S/State jurisdiction. Federal agents may not rely on the Federal Assimilative Crimes Act as a basis to enforce state or local laws on federal proprietary lands. In Beaver County, all BLM and Forest Service lands are mere proprietary jurisdiction lands, not concurrent or exclusive jurisdiction lands. Therefore, federal agents are NOT permitted by the Federal Assimilative Crimes Act to enforce state and local laws on those lands.

II. OBJECTIVES

Beaver County's objective with regard to law enforcement is as follows:

1. To establish and clarify law enforcement jurisdiction within the county.

III. POLICIES AND GUIDELINES

1. It is the policy of Beaver County, in the interest of the health, safety and welfare of its citizens, to not recognize any attempt by a federal agent to try to enforce state or local criminal or civil laws on any lands in Beaver County, including any BLM and Forest Service lands in Beaver County, and to declare that all criminal and civil state and local laws shall be enforced in Beaver County, only by the Sheriff and Board Of County Commissioners. This applies to all lands within the boundaries of Beaver County.
2. Beaver County serves notice of full reliance upon and conformance with House Bills 67, 147, 149 and 225, 2014 Utah General Legislative Session as codified in Utah Code §§11-51-102 through 104, 63-13-106, 63-13-106.1 through 106.10, and 17-22-31.
3. It is the policy of Beaver County that the right of the Beaver County Sheriff to exclusively exercise all law enforcement powers and to enforce all state and local criminal and civil laws upon any lands within Beaver County, federally owned or otherwise. Any such attempted exercise of law enforcement powers by an agent of a federal land management agency is not recognized by Beaver County, and shall be deemed an imminent threat to the health, safety and welfare of the citizens of Beaver County, unless properly exercised under an exception codified under Utah Code §§ 53-13-101.1 through 106.10.

4. It is the policy of Beaver County that any agent of any federal land management agency who is situated within Beaver County who intends to exercise any law enforcement powers of any kind against any person or entity which may result in the deprivation of property or personal liberty, regardless of whether the action may take place on federal lands or otherwise, and any such agent not already within Beaver County who intends to enter into Beaver County for such purpose, shall first declare his presence and intended action to the Sheriff of Beaver County and seek permission from the Sheriff to pursue such intended action.
5. Beaver County shall continue to support any and all actions to legally relieve the Federal Government of ownership, control and jurisdiction over public lands in Beaver County, and demand the Federal Government dispose and convey all right, title and interest thereto to the State of Utah. This transfer of land to the State will resolve the law enforcement jurisdiction issues stated above.

12. ECONOMIC CONSIDERATIONS

I. FINDINGS

Beaver County faces a number of economic development challenges. Chief among these challenges is a lack of quality housing to accommodate increases in population. Beaver County has found that lack of employment is not the primary reason for the lack of quality housing. Beaver County has identified other contributing factors including: a small and dispersed population; lack of publicly offered amenities; remote location; dry climate; a commuting work force; and a lack of export industries. Beaver County has lower taxable sales per capita in many retail subcategories than comparable counties like Sevier and Iron.

According to the Utah Department of Workforce Services, the average household income in Beaver County in 2015 was \$50,492. This was nearly \$5,300 less than the average household income in the United States and nearly \$12,500 less than the average household income for the State of Utah. The unemployment rate in Beaver County as of January 2017 was 5%, slightly above the state and national average.

Like many other smaller, rural counties, Beaver County lacks a diverse economy, ranking behind only Duchesne, Uintah, and Emery Counties in Utah. Beaver County's largest employment industry is government (primarily local). As of September 16, government employment in Beaver County accounted for 766 jobs.

Unlike many other counties, Beaver County's second largest employment industry is agriculture, due primarily to the many hog producing facilities in the County. As of September 2016, agriculture (including hunting, fishing, and forestry) accounted for 488 jobs in Beaver County. The 2015 output of the agricultural sector was valued at \$115,300,000. In order to maintain this major portion of Beaver County's economy, it is imperative that Beaver County maintains high air, water, and soil quality in a manner consistent with this plan.

Together, government and agricultural employment represent approximately 48% of employment in Beaver County. Most of the remaining employment comes from the leisure, hospitality, and retail industries. These industries typically provide jobs with low median wages.

Beaver County has a variety of natural assets that provide a strong economic foundation. Beaver County projects significant job growth over the next five years stemming from natural resource extraction. However, growth and decline in this industry can be somewhat unpredictable because of fluctuations in global commodity pricing. As a result, growth in the natural resource industry should be leveraged to diversify other industries.

Beaver County has significant competitive advantages that are currently being underutilized that can positively impact other employment sectors. In 2015, the Beaver County

tourism economic output was valued at \$12,700,000, however, given the number of National Parks, State Parks, National Monuments and National Recreation Areas in or near Beaver County, there is an opportunity to expand this sector.

Additionally, Beaver County already has an established renewable energy development corridor, specifically in the Milford Valley. While commercial renewable energy accounted for an estimated \$35,400,000, and contributed significantly to the county tax base, it was not a major job producer. As detailed in the Energy Resources section of this plan, there are opportunities to expand development to take advantage of Beaver County's power producing potential.

II. OBJECTIVES

Beaver County's objectives with regard to economic considerations are as follows:

1. To diversify the local economy, including leveraging job creation opportunities in the natural resource extraction industry; and
2. To prohibit activities that will fundamentally change the rural nature and unique characteristics of the land, which are key to the County's history and culture.

III. POLICIES AND GUIDELINES

1. Beaver County will engage in strategic planning and seek out both public investments to improve workforce infrastructure.
2. It is the policy of Beaver County to support the building, maintenance and expansion of quality housing developments that meet the demands of population growth and will expand Beaver County's workforce.
3. Beaver County will continue to identify recreational activities that extend the tourist season and expand regional tourism.
4. Beaver County's established renewable energy corridor will be utilized to attract industries heavily dependent on clear technology such as data centers and niche manufacturing.
5. Beaver County will establish collaborative partnerships with private industry to identify employer needs in order to find mutually beneficial solutions.
6. Workforce attraction and retention efforts will be coordinated between existing businesses, local governments, and housing developments.
7. Beaver County will explore options to provide work related educational services to allow

Beaver County's workforce to be better prepared and more qualified to meet modern job demands.

8. Beaver County will continue to solicit renewable energy development projects and will continue to support large-scale utility sized development in addition to small-scale residential and agricultural development of renewable energy.
9. Beaver County will explore the possibility of building a major renewable energy research facility.
10. Beaver County will create and promote incentives to draw-in potential employers.
11. Beaver County will coordinate with Tribal, federal and state agencies to identify mutually beneficial economic objectives and partner in projects when applicable and feasible.
12. Beaver County supports protection, maintenance, and expansion of natural resource use and development in furtherance of the mandate to manage public lands for multiple uses and sustained yield and preserves public access to public land.
13. The recreational opportunities in Beaver County will be marketed in order to increase year-round tourism in the County.
14. Given that federal land represents a large portion of Beaver County and Beaver County is economically dependent on use of that land, any federal decision or action affecting Beaver County must include an analysis of the economic impact on the County.
15. Beaver County opposes any federal action or decision that impairs the ability of the County or developers from building, maintaining, or expanding developments that provide quality and high paying jobs to Beaver County's citizens.
16. In order to preserve Beaver County's agricultural sector, which is key to Beaver County's local economy, land managers must ensure that resources such as air, water and soil are managed pursuant to the policies and guidelines set forth in the relevant sections of this plan.

13. AIR QUALITY

I. FINDINGS

Ambient air quality in Beaver County does not currently exceed EPA standards. Visibility is typical of remote areas in the western United States, containing generally clear skies. All atmospheric deposition levels are below federal levels of concern.

The Utah Division of Air Quality (“DAQ”) is responsible for regulating and monitoring air quality in Utah in compliance with the Clean Air Act (“CAA”), except where local regulations mandate more stringent standards. Measurements are typically taken only in urban areas where ambient pollution levels are expected to be the highest and where data is required to assess attainment status. No air quality monitoring stations are located in or near Beaver County. The closest monitoring station is in Hurricane, Utah in nearby Washington County. Even in areas where air quality data is collected, the variability of site-specific conditions creates uncertainty, subjectivity and generalizations regarding air quality over larger areas. Air quality can be impacted by precipitation, wind, temperature, topography along with a host of biogenic and human factors.

The state air quality program is responsible for the implementation of the federal standards under the CAA, as well as state rules for pollution sources not regulated by the CAA. The CAA directs all federal agencies to comply with state and local air quality regulations to the extent they meet or exceed national standards and is administered by the U.S. Environmental Protection Agency (“EPA”).

The CAA establishes two types of air quality standards: primary and secondary. Primary standards are set to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards are set to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The EPA has established health-based National Ambient Air Quality Standards (“NAAQS”) for six pollutants known as criteria pollutants. These are carbon monoxide, nitrogen dioxide, ozone, particulate matter, sulfur dioxide, and lead. Table 4.0.1 provides a brief description of each criteria pollutant and Table 4.0.2 provides a brief description of each criteria pollutant’s primary and secondary NAAQS. The EPA establishes the primary health standards after considering both the concentration level and the duration of exposure that can cause adverse health effects. Pollutant concentrations that exceed the NAAQS are considered unhealthy for some portion of the population.

Areas of the state that are not in compliance with the NAAQS are referred to as nonattainment areas. A maintenance area is an area that was once designated as

nonattainment, and which subsequently demonstrated to the EPA statistically that it would attain and maintain a particular standard for a period of 10 years. Attainment areas meet all NAAQS standards. Beaver County is designated as either attainment or unclassified with respect to National Ambient Air Quality Standards for all criteria pollutants.

Table 4.0.1 EPA Designated Criteria Pollutants

Name	Sources	Health Effects	Welfare effect
Carbon Monoxide (CO)	Burning of gasoline, wood, natural gas, coal, oil, etc.	Reduces the ability of blood to transport oxygen to body cells and tissues. May be particularly hazardous to people who have heart or circulatory problems.	N/A
Nitrogen Dioxide (NO ₂)	Burning of gasoline, natural gas, coal, oil and other fuels.	Can cause lung damage, associated with illness in respiratory system.	Ingredient of acid rain which can damage plants and pollute lakes.
Ozone (O ₃)	Chemical reaction of pollutants and volatile organic compounds	Can cause breathing problems, reduce lung function, asthma, irritated eyes, stuffy nose, and reduced resistance to colds and infections.	Can damage plants and trees; causes reduced visibility.
Particulate Matter (PM ₁₀ , PM _{2.5} , dust, smoke, soot)	Burning of gasoline, oil, coal, natural gas and other fuels; Industrial plants, agriculture, mining, construction and road dust.	Can cause nose and throat irritation, lung damage, bronchitis, and reduced lifespan.	Primary source of visibility reducing haze.
Sulphur Dioxide (SO ₂)	Burning of coal, oil, diesel, and gasoline; industrial processes.	Causes breathing problems and may cause permanent damage to lungs.	Ingredient in acid rain, causes damage to trees and plants. Reduces visibility.
Lead (Pb)	Paint, smelters, batteries, leaded gasoline.	Damages nervous system, including brain damage; causes digestive system damage. Children are at special risk.	Can harm wildlife.

Every three years, the DAQ collects information about the quantity and characteristics of the various air pollutants released by all emission sources in the state. In addition to these triennial inventories, emissions information is also collected annually from the largest industrial sources. Once collected, the inventory information is reviewed, quality assured, analyzed, stored in the DAQ data system, and made available to the public. The DAQ uses this emissions information to review trends over time, as input data for air. In the most recent triennial inventory from 2014, Beaver County averaged 9th lowest across all categories for

Utah's 29 counties.

In 2012, the EPA approved Utah's Smoke Management Program ("SMP"), which is a key element of the State Implementation Plan for regional haze that was required under the CAA. Utah is required, under the approved plan, to manage planned burning in a manner that protects air quality and ascertains air quality impacts locally and regionally. Currently, state and federal land managers attempt to manage air quality prior to controlled burns, but have not developed reliable means or data to accurately assess fire related impacts. For wildfires, many occurring outside Beaver County, no pre-fire or post fire efforts exist to manage air quality. Wildfires continue to be the largest cause of air quality concerns in Beaver County.

II. OBJECTIVES

Beaver County's objectives with regard to air quality are as follows:

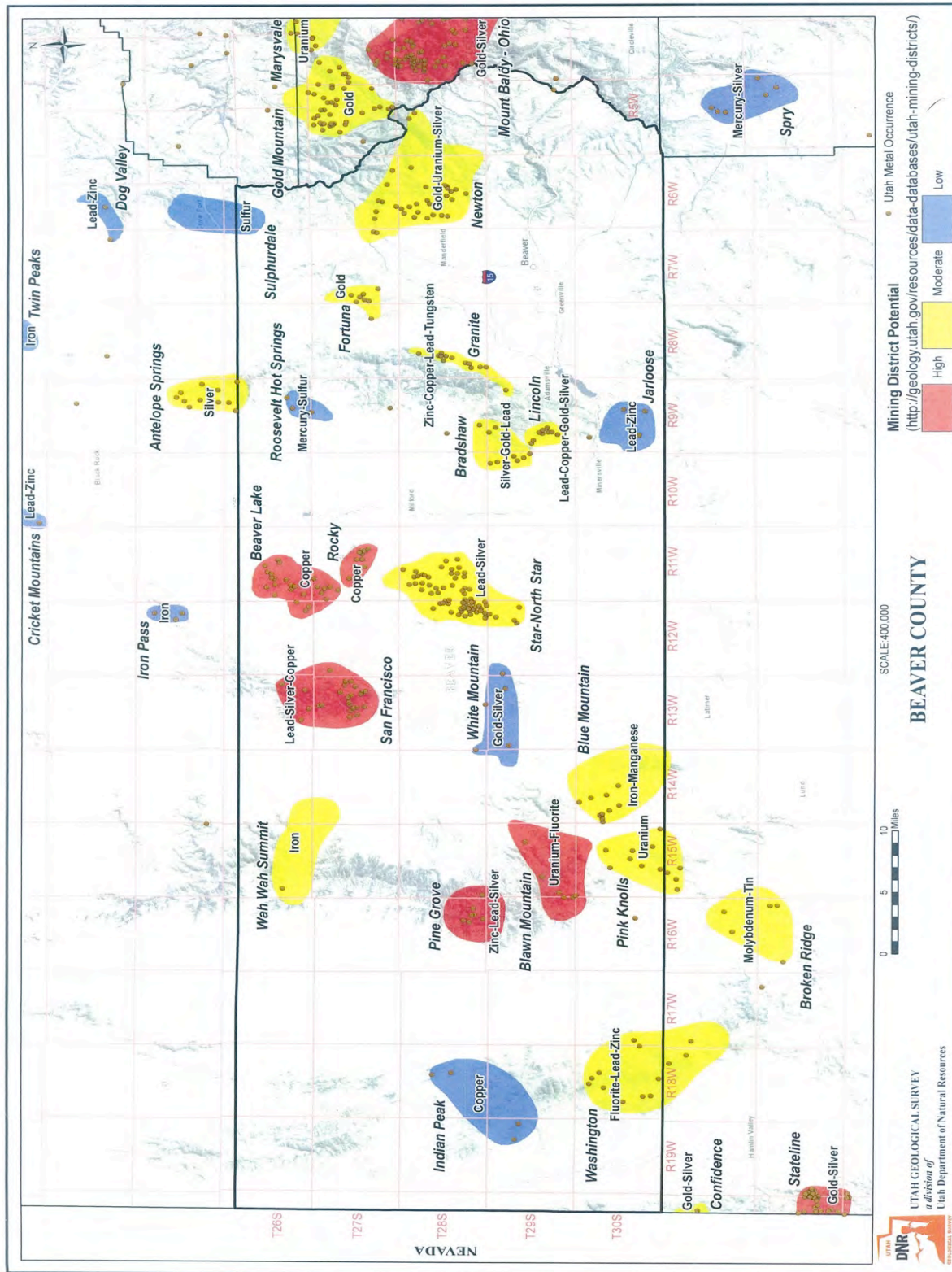
1. To fulfill its responsibility to protect the health, safety and welfare of its citizens and visitors. Maintaining or improving air quality is part of that responsibility;
2. To coordinate with federal land managers to limit and mitigate air quality problems associated with wildland fires and prescribed burns; and
3. To maintain compliance with the CAA.

III. POLICIES AND GUIDELINES

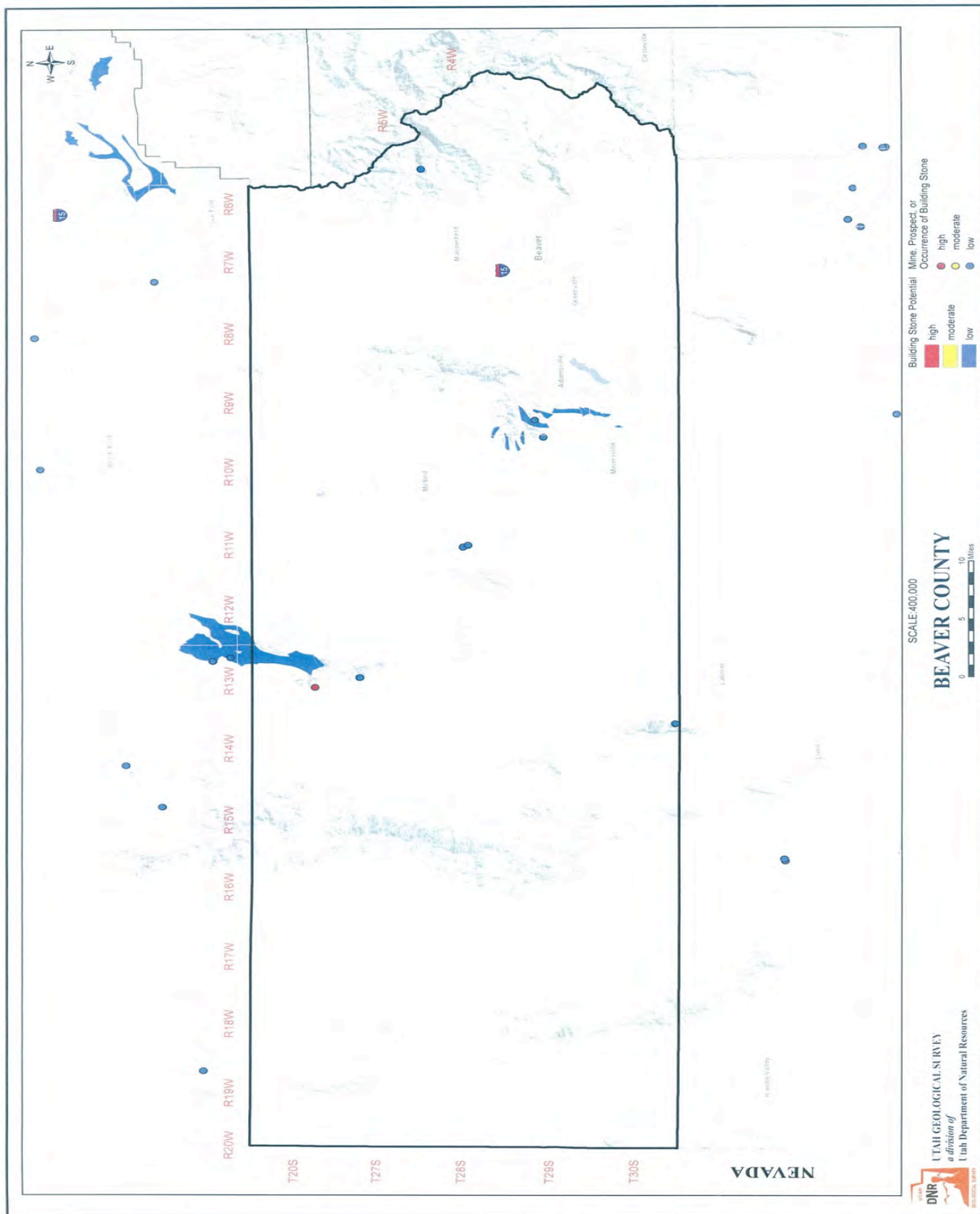
1. Beaver County's air quality shall be protected by standards described in the Utah State Implementation Plan approved by the EPA, under authority of the CAA. Good air quality is necessary for the health of citizens, for quality of life and to prevent a non-attainment designation with potential restrictions on future economic development.
2. Prescribed fires or burning projects shall be conducted and managed in compliance with guidelines found in the Utah Smoke Management Plan.
3. Agencies shall prioritize mechanical treatments, such as thinning, brush hogging, etc., and timber harvesting over prescribed burning whenever possible.
4. Natural fugitive dust shall be reduced through improved vegetative cover, vigor and utilization.
5. Federal agencies shall resolve inconsistencies with biogenic pollutants, natural fugitive dust, wildland fire, and prescribed fire prior to restricting projects needed for socio-economic stability.

6. Land managers shall include Beaver County as cooperating agency in all NEPA processes and coordinate activities that impact air quality, in accordance with federal law.
7. Land owners/managers that generate, or allow to be generated, excessive levels of fugitive dust, such that health concerns are created, shall be responsible for mitigating, or the cost of mitigating dust control.
8. All mining and agricultural operations shall be responsible for monitoring and controlling dust and particulate matter within CAA standards.
9. It is the policy of Beaver County that solid waste shall not be burned.

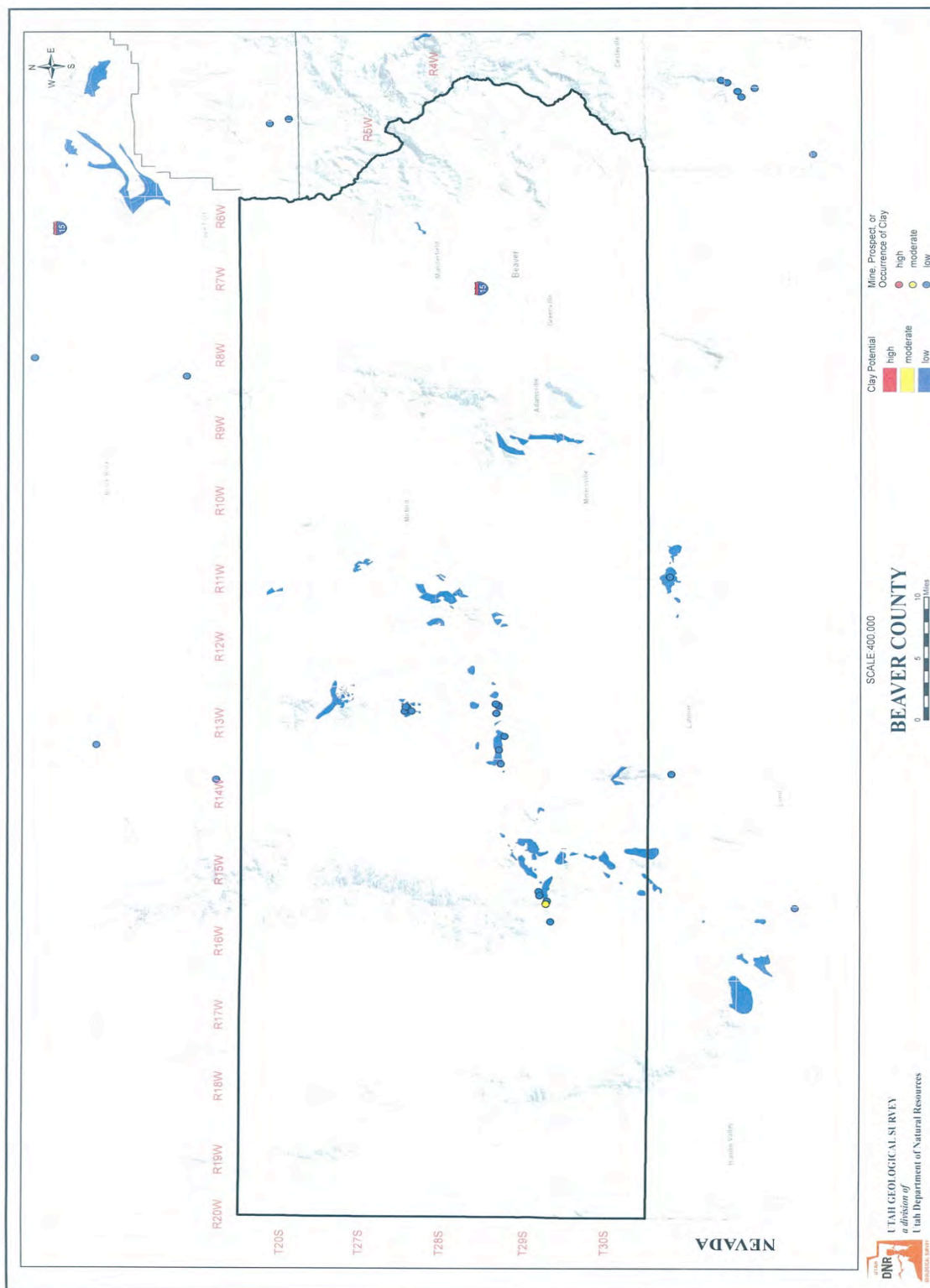
MAP 1 – Locatable Minerals



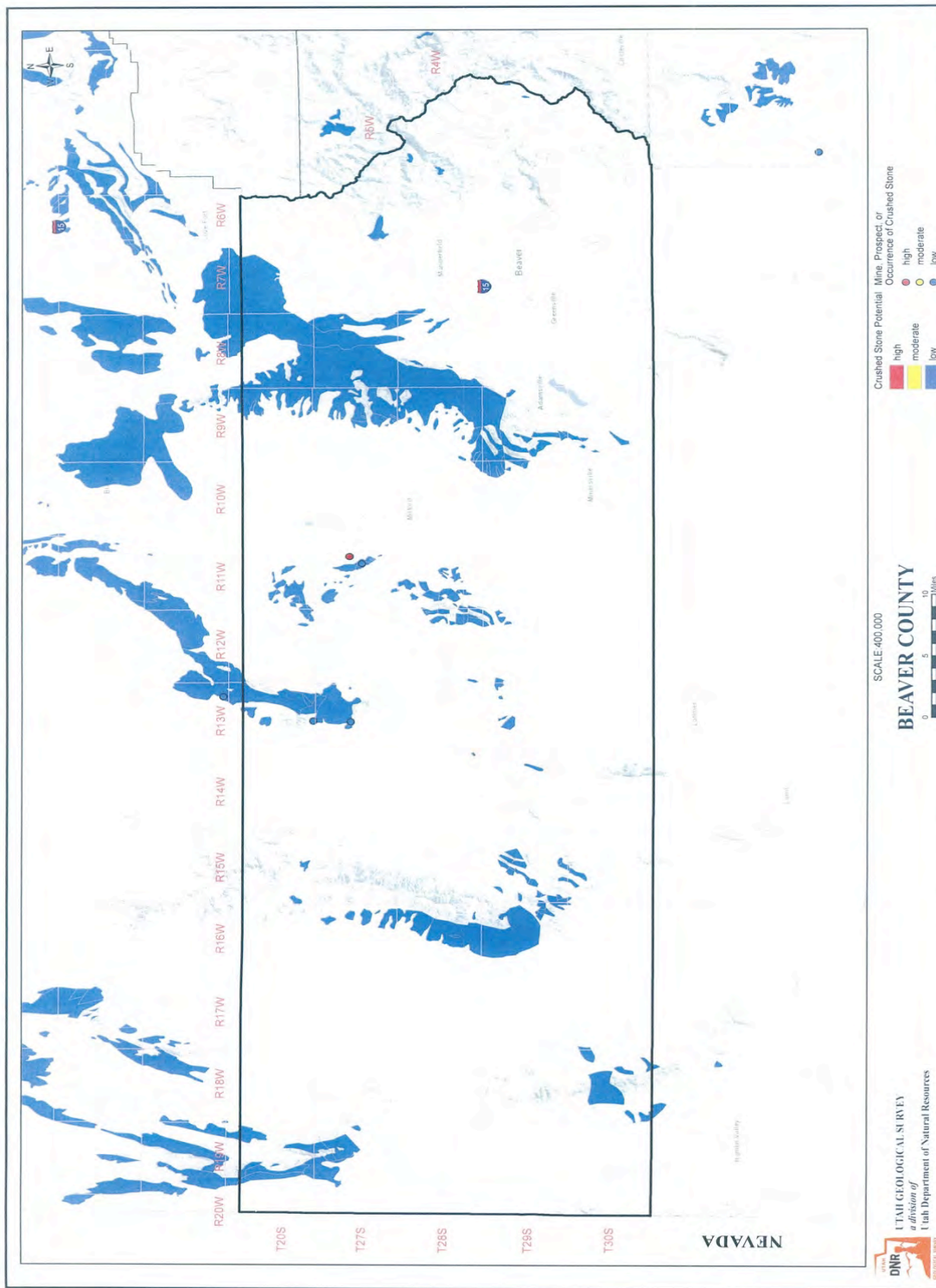
MAP 2 – Salable Minerals (Building Stone)



MAP 3 – Salable Minerals (Clay)

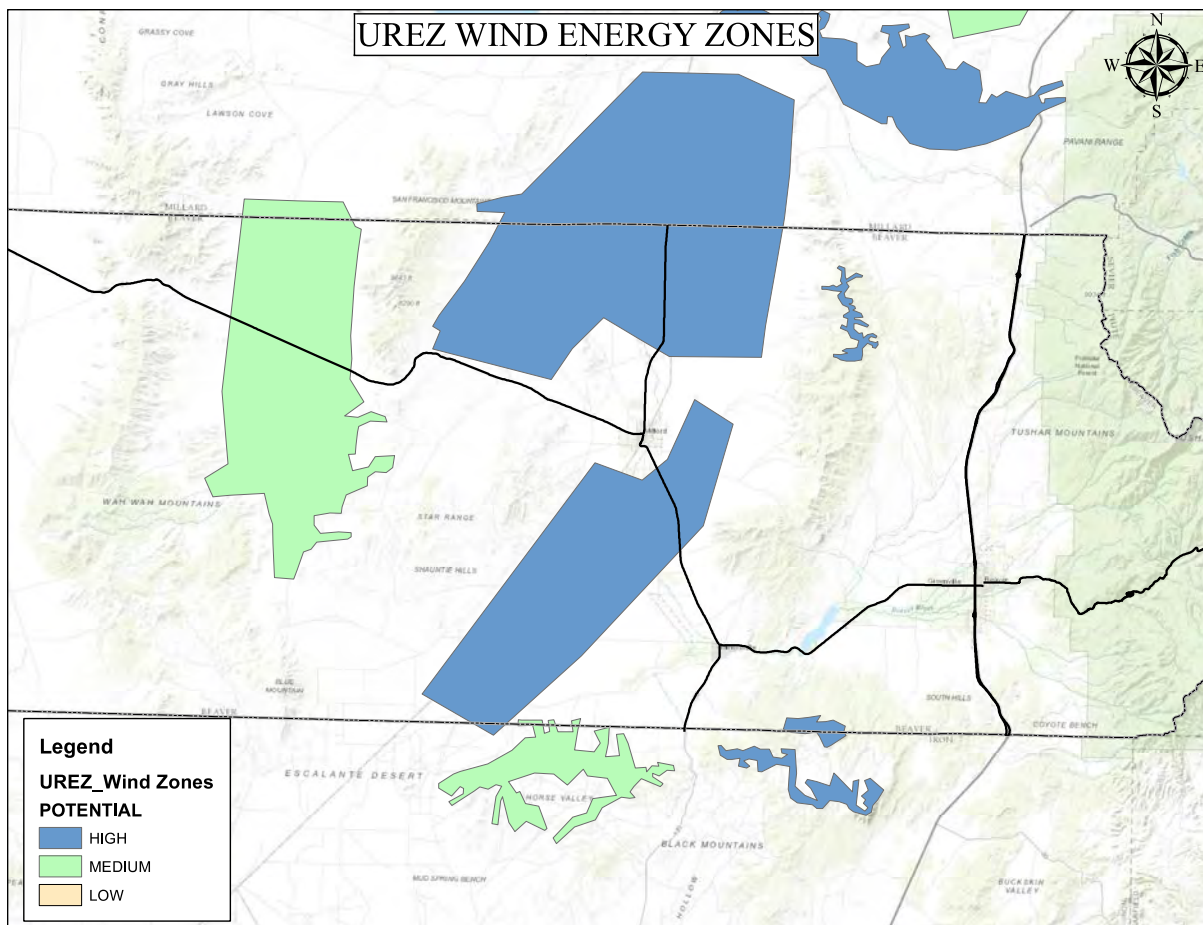


MAP 4 – Salable Minerals (Crushed Stone)

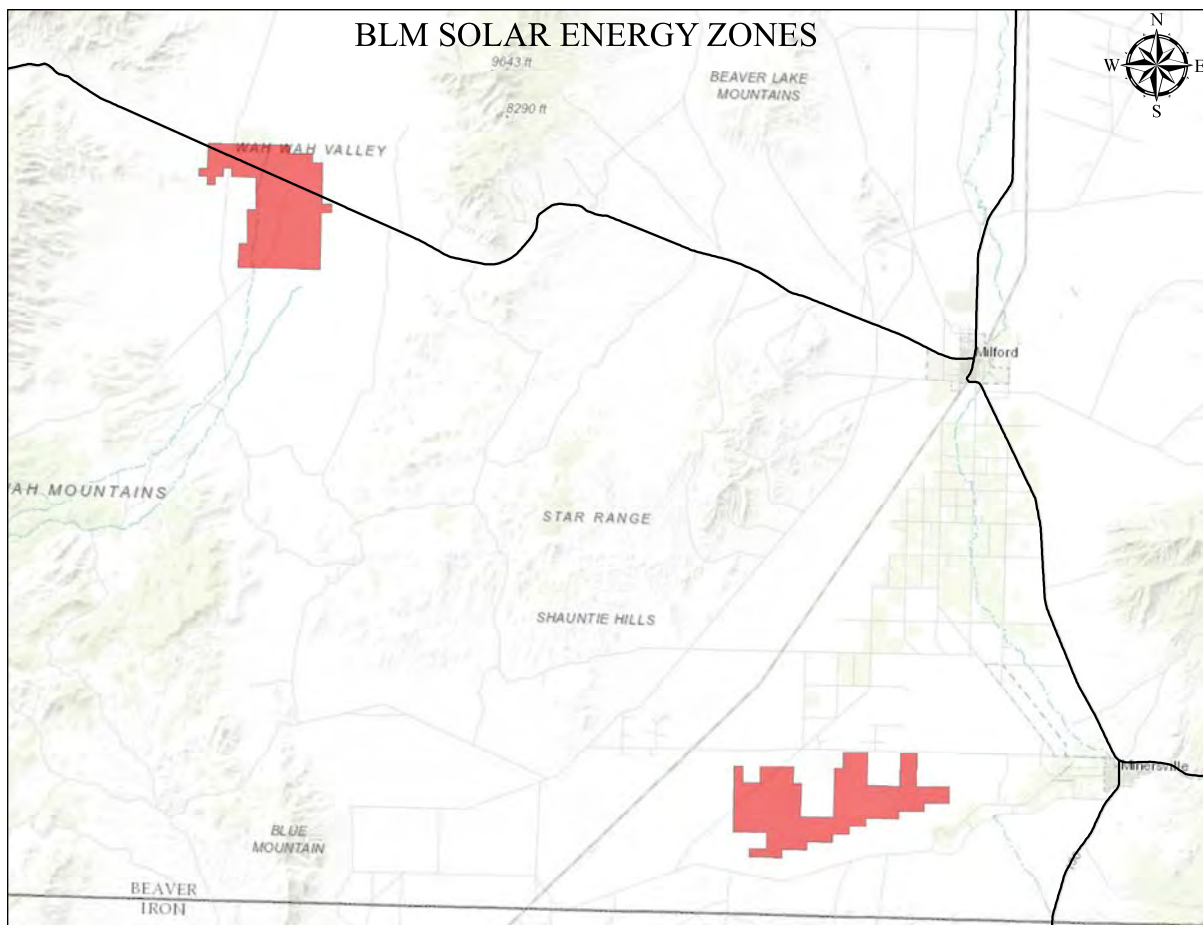


Map of Beaver County, Utah, showing Alunite Potential. The map is divided into a grid of 12 columns (R20W to R31W) and 5 rows (T25S to T30S). Alunite potential is indicated by color: red for high, yellow for moderate, and blue for low. The map shows various geographical features, including the Colorado River, Lake Powell, and several towns. A legend in the bottom right corner explains the color coding and symbols. The map is titled "BEAVER COUNTY" and "SCALE 400,000". The Utah Geological Survey logo is in the bottom left corner.

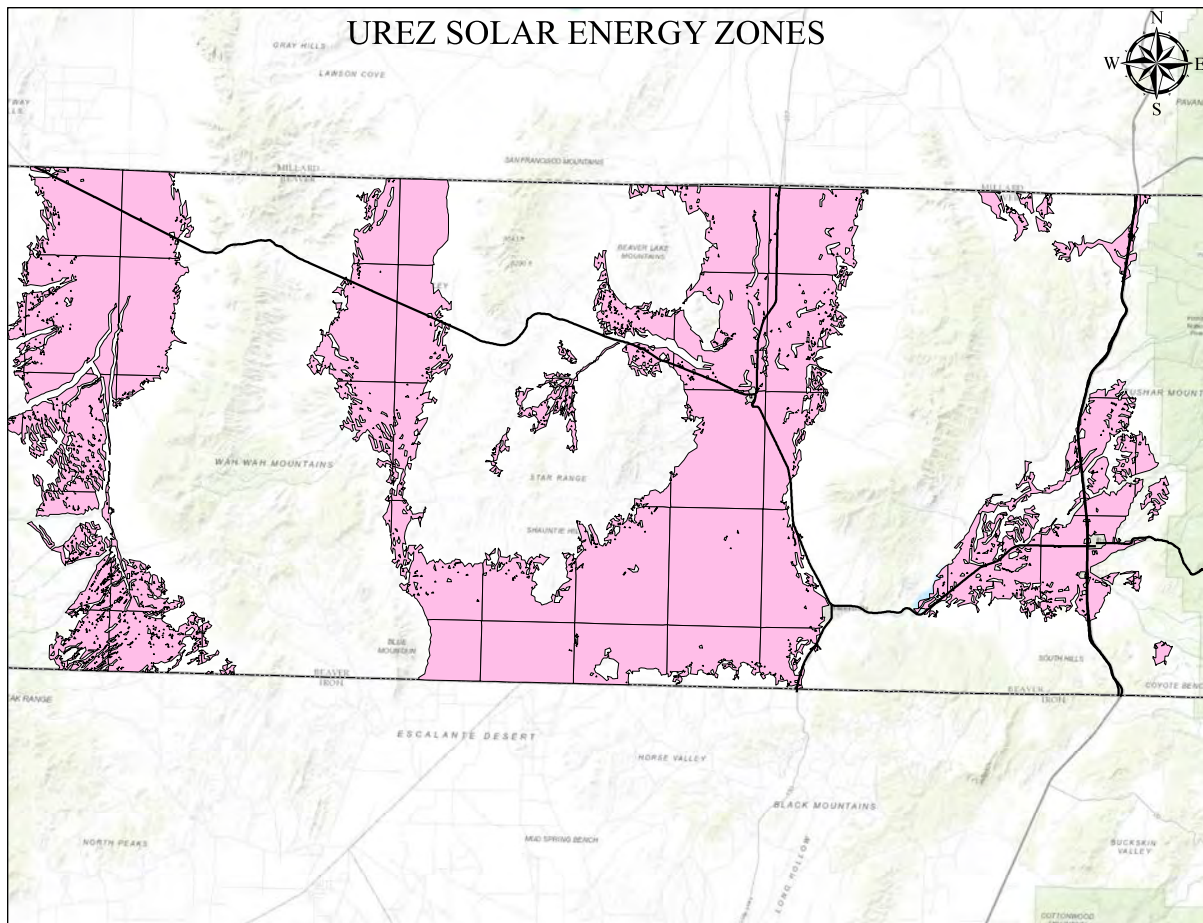
MAP 6 – Wind Energy



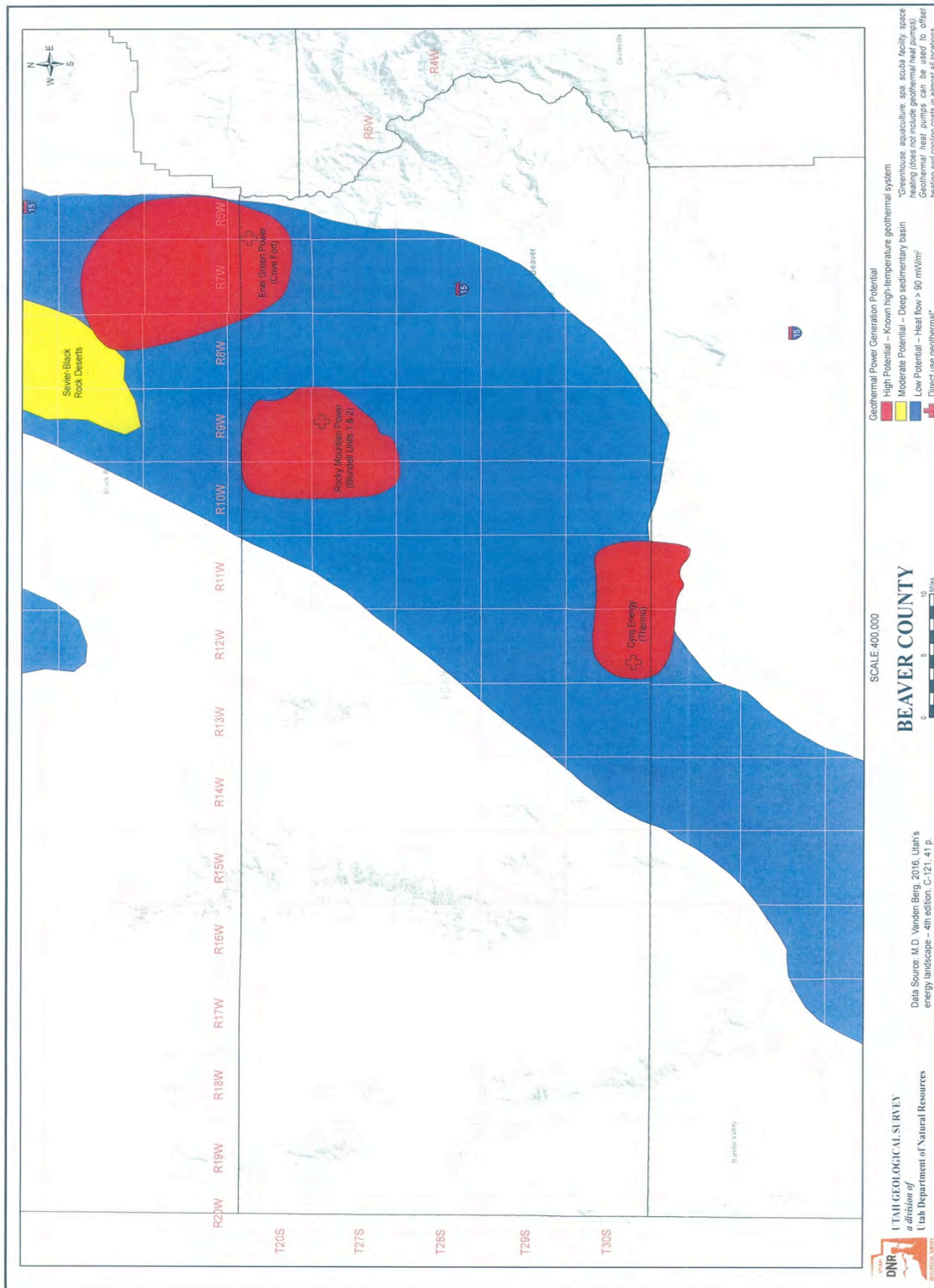
MAP 7 – Solar Energy (BLM Study)



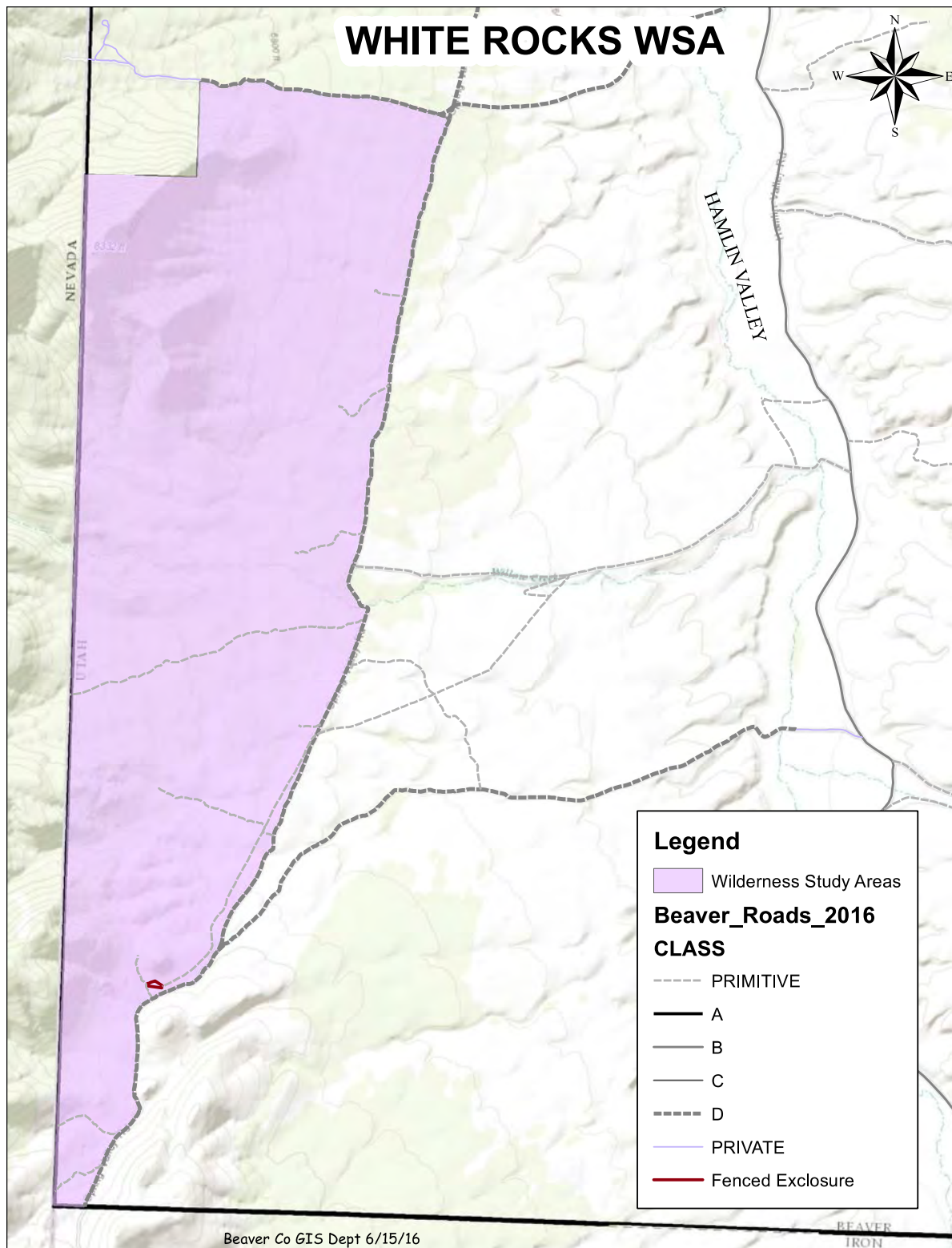
MAP 8 – Solar Energy (UREZ Study)



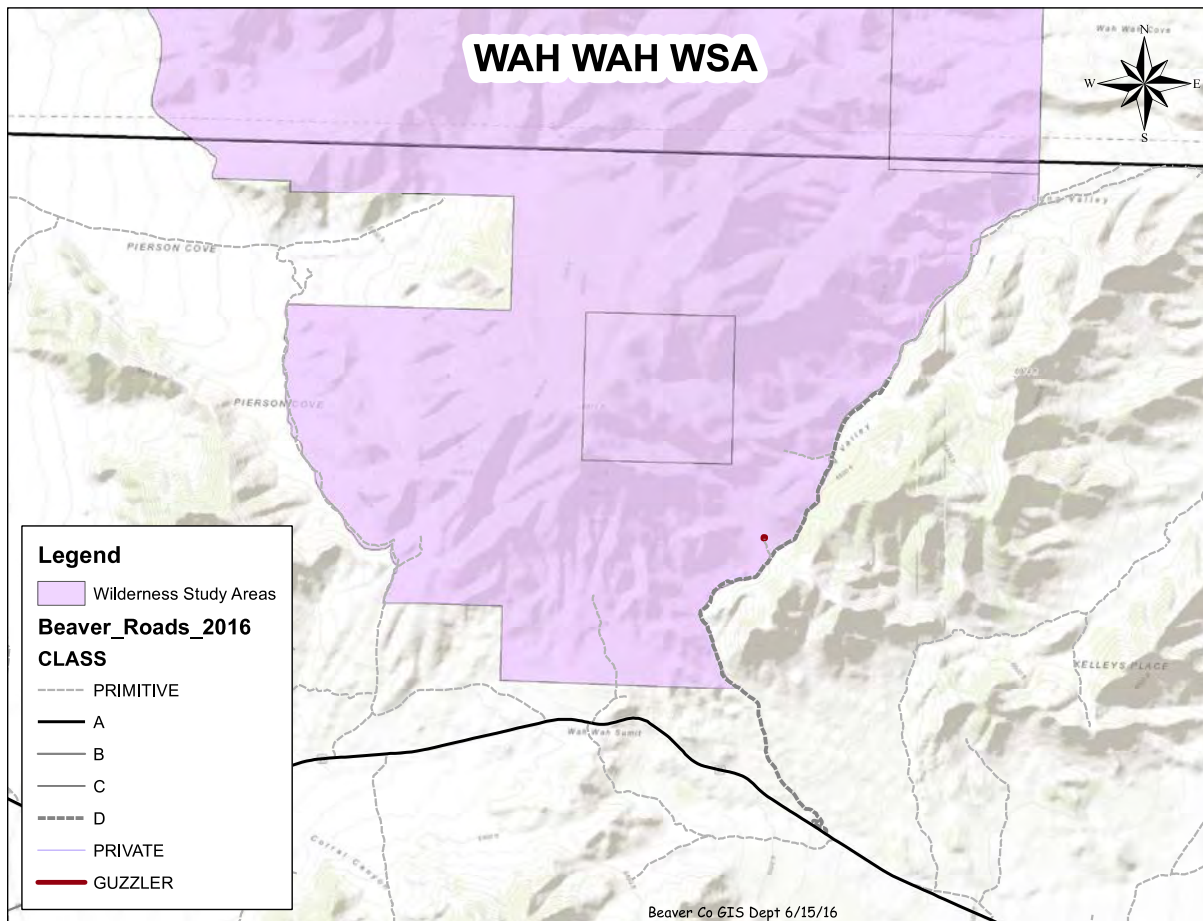
MAP 9 – Geothermal Energy



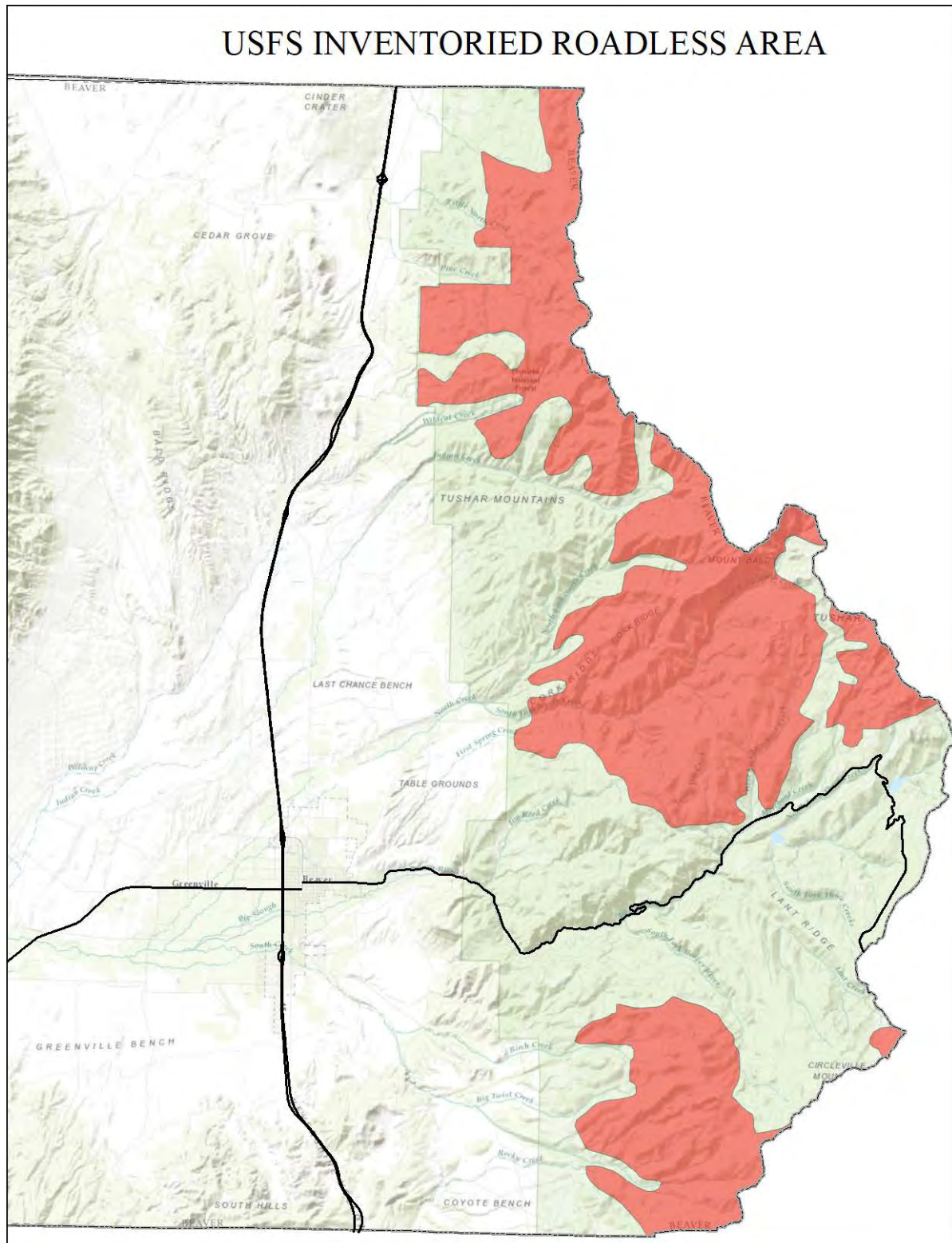
MAP 10 – White Rocks Range WSA



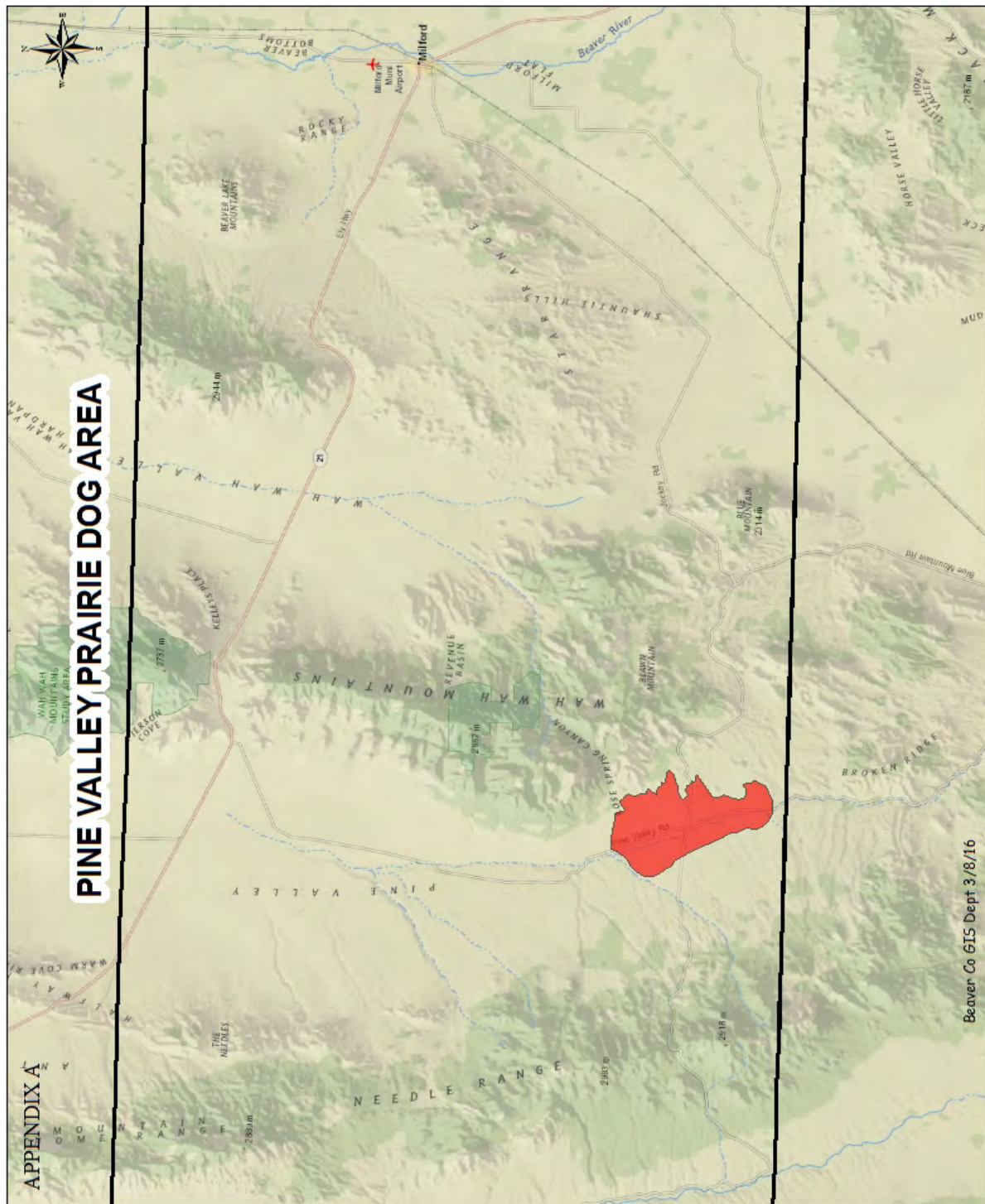
MAP 11 – Wah Wah Mountains WSA



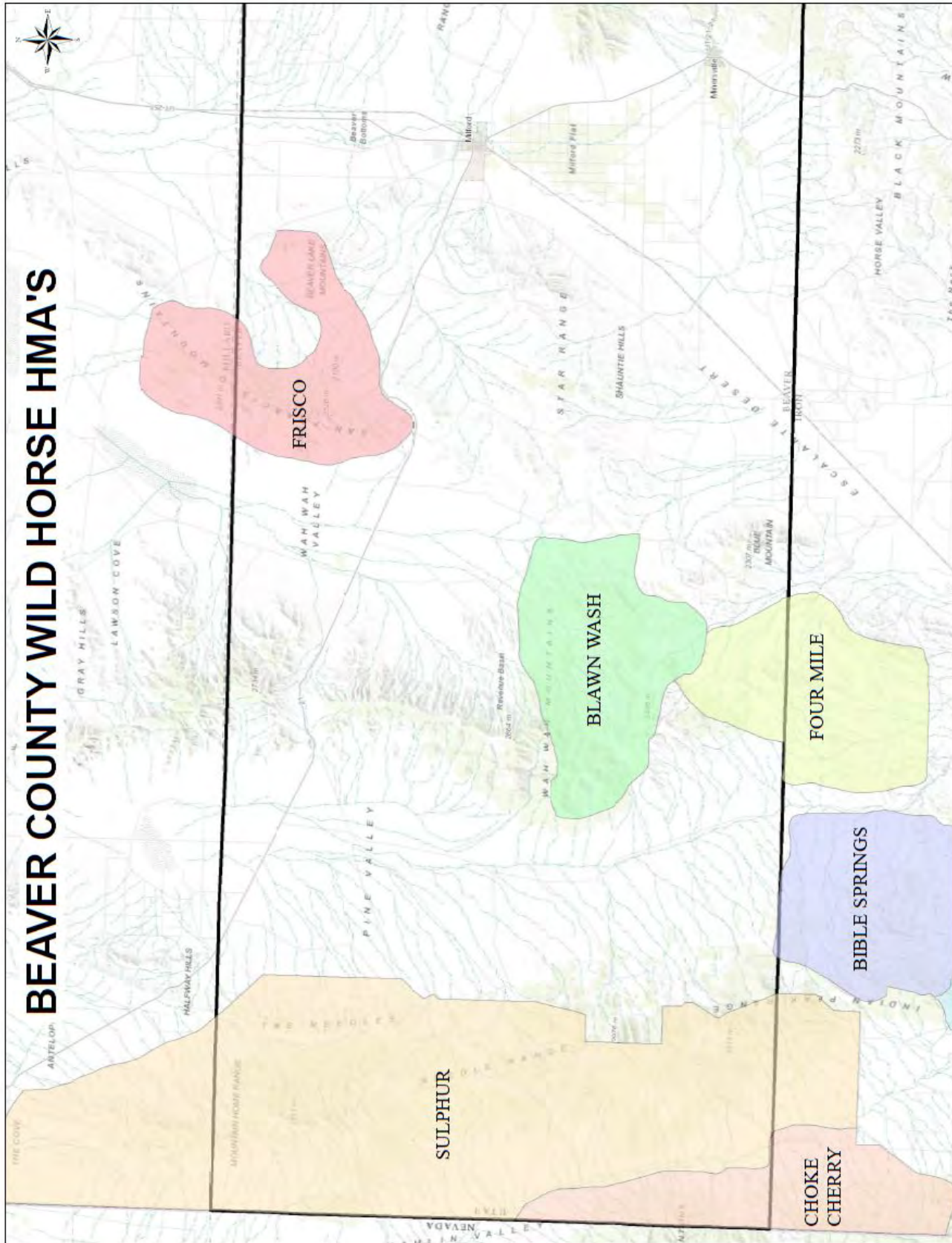
MAP 12 – Inventoried Roadless Areas

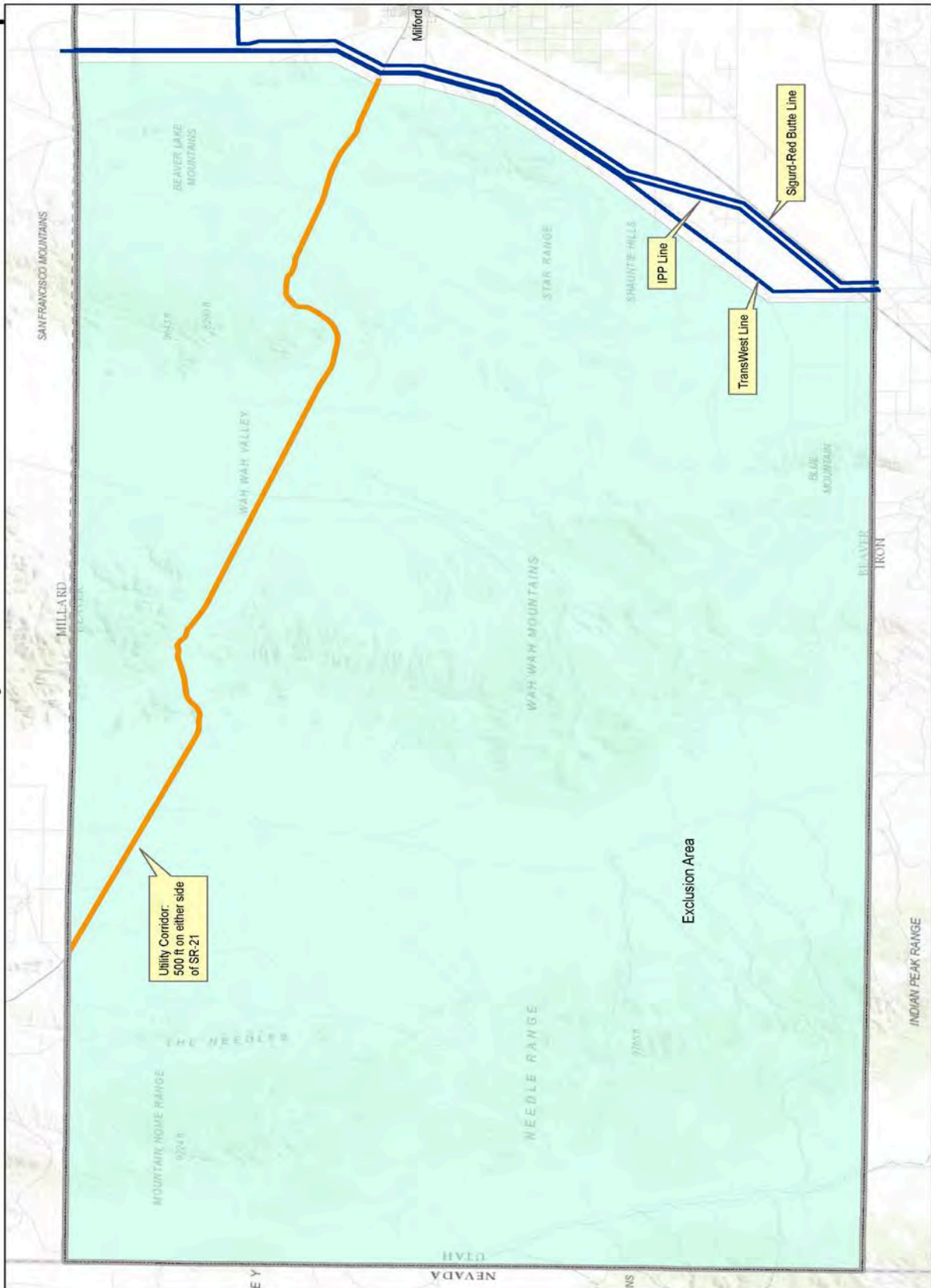


MAP 13 – Pine Valley Prairie Dog Area



MAP 14 – Beaver County BLM HMAs





APPENDIX 1 – Scenic Quality Inventory and Evaluation Chart

Form 8400-5

INSTRUCTIONS

Form is used in conjunction with the Scenic Quality, Inventory and Evaluation Chart.

SCENIC QUALITY INVENTORY AND EVALUATION CHART			
Key Factors	Rating Criteria and Score		
Landform	High vertical relief as expressed in prominent cliffs, spires, or massive rock outcrops; or severe surface variation or highly eroded formations including major badlands or dune systems; or detail features dominant and exceptionally striking and intriguing such as glaciers. 5	Steep canyons, mesas, buttes, cinder cones, and drumlins; or interesting erosional patterns or variety in size and shape of landforms; or detail features which are interesting though not dominant or exceptional. 3	Low rolling hills, foothills, or flat valley bottoms; or few or no interesting features. 1
Vegetation	A variety of vegetative types as expressed in interesting forms, textures, and patterns. 5	Some variety of vegetation, but only one or two major types. 3	Little or no variety or contrast in vegetation. 1
Water	Clear and clean appearing, still, or cascading white water, any of which are a dominant factor in the landscape. 5	Flowing, or still, but not dominant in the landscape. 3	Absent, or present, but not noticeable. 0
Color	Rich color combinations, variety or vivid color; or pleasing contrasts in the soil, rock, vegetation, water or snow fields. 5	Some intensity or variety in colors and contrast of the soil, rock, and vegetation, but not a dominant scenic element. 3	Subtle color variations, contrast, or interest; generally mute tones. 1
Influence of Adjacent Scenery	Adjacent scenery greatly enhances visual quality. 5	Adjacent scenery moderately enhances overall visual quality. 3	Adjacent scenery has little or no influence on overall visual quality. 0
Scarcity	One of a kind; or unusually memorable, or very rare within region. Consistent chance for exceptional or wildflower viewing, etc. 5+	Distinctive, though somewhat similar to others within the region. 3	Interesting within its setting, but fairly common within the region. 1
Cultural Modifications	Modifications add favorably to visual variety while promoting visual harmony. 2	Modifications add little or no visual variety to the area, and introduce no discordant elements. 0	Modifications add variety but are very discordant and promote strong disharmony. -4

INSTRUCTIONS

Purpose: To rate the visual quality of the scenic resource on all BLM managed lands.

How to Identify Scenic Value: All Bureau lands have scenic value.

How to Determine Minimum Suitability: All BLM lands are rated for scenic values. Also rate adjacent or intermingling non-BLM lands within the planning unit.

When to Evaluate Scenic Quality: Rate for scenery under the most critical conditions (i.e., the highest user period or season of use, sidelight, proper atmospheric conditions, etc.).

How to Delineate Rating Areas: Consider the following factors when delineating rating areas.

1. Like physiographic characteristics (i.e., landform, vegetation, etc.).
2. Similar visual patterns, texture, color, variety, etc.
3. Areas which have a similar impact from cultural modifications (i.e., roads, historical and other structures, mining operations, or other surface disturbances).

Explanation of Criteria:
(See Illustration I.)

NOTE: Values for each rating criteria are maximum and minimum scores only. It is also possible to assign scores within these ranges.

SCENIC QUALITY

A = 19 or more
B = 12-18
C = 11 or less

** A rating of greater than 5 can be given but must be supported by written justification.

APPENDIX 2 – Visual Resource Management Classification Process

Five steps are involved in the visual resource management (VRM) classification process. These are: 1) outlining and numerical evaluation of scenic quality; 2) outlining of visual sensitivity levels; 3) delineating distance zones; 4) overlaying the scenic quality, sensitivity levels and distance zones using a matrix to develop visual resource inventory classes (VRI) I-IV; and 5) adjusting the inventory to meet the multiple use goals of the RMP and designating VRM management classes I-IV with objectives for each class through the planning process.

SCENIC QUALITY

The first step is accomplished by outlining scenery of similar nature on a topographic map. Once the area has been outlined, numerical values are given to its key factors (landform, color, water, vegetation, adjacent scenery, scarcity, and cultural modifications). When these values are established the total determines whether the area is A, B, or C, class scenery.

Class A scenery combines the most outstanding characteristics of each rating factor. Class B scenery combines some outstanding features and some that are fairly common to the physiographic region. Class C scenery combines features that are fairly common to the physiographic region.

VISUAL SENSITIVITY LEVELS

Sensitivity levels indicate the relative degree of user interest in visual resources and concern for changes in the existing landscape character. Public lands are assigned high, medium, or low sensitivity levels by analyzing the various indicators of public concern. Factors considered are the type of use, amount of use, public interest, adjacent land use, special areas, and other factors.

DISTANCE ZONES

The distance zones are outlined on topographic maps in three areas: (1) foreground/middle ground, (2) background, and (3) seldom seen. The foreground/middle ground zone is a distance of from 0 to 5 miles away. The background is the remaining area up to 15 miles distant, and seldom seen is the area beyond 15 miles. All distances are taken from any substantial travel corridor.

VISUAL RESOURCE INVENTORY CLASSES

Inventory classes are informational in nature only and are assigned through the inventory process. Class I is assigned to those areas where a management decision has been made previously to maintain a natural landscape. This includes areas such as national wilderness areas, the wild section of national wild and scenic rivers, and other congressionally and administratively designated areas where decisions have been made to preserve a natural landscape. Class II, III, and IV are assigned based on a combination of scenic quality, sensitivity level, and distance zones. This is accomplished by combining the scenic quality, sensitivity levels, and distance zones maps, using a matrix (see BLM H-8410-1) to assign the proper inventory class.

VISUAL RESOURCE MANAGEMENT CLASSES

Management classes are assigned through Resource Management Plans (RMPs). The assignment of visual management classes is ultimately based on the management decisions made in the RMPs. However, visual values must be considered throughout the RMP process. All actions proposed during the RMP process that would result in surface disturbance must consider the importance of the visual values and the impacts the project may have on these values. Management decisions in the RMP must reflect the value of visual resources. In fact, the value of the visual resource may be the driving force for some management decisions. For example, highly scenic areas, which need special management attention may be designated as scenic Areas of Critical Environmental Concern and classified as VRM class I based on the importance of the visual values (see Figure 2 for current VRM inventory classes).

OBJECTIVES FOR VISUAL RESOURCE MANAGEMENT CLASSES

Class I Objective. The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and should not attract attention.

Class II Objective. The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III Objective. The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Class IV Objective. The objective of this class is to provide for management activities, which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements of the landscape.

(BLM 1992)

APPENDIX 3 – List of Acronyms

ACEC	Area of Critical Environmental Concern
ADC	Animal Damage Control
AML	Appropriate Management Level
AOI	Annual Operating Instructions
APHIS	Animal and Plant Health Inspection Service
ATV	All-Terrain Vehicle
AUM	Animal Unit Month
BLM	Bureau of Land Management
BMP	Best Management Practices
CAA	Clean Air Act
CAS	Conservation Agreement Species
CFR	Code of Federal Regulations
CRMP	County Resource Management Plan
CWA	Clean Water Act
CWMA	Cooperative Weed Management Area
DAQ	Utah Division of Air Quality
DNR	Utah Department of Natural Resources
DOE	Department of Energy
DOGM	Utah Division of Oil, Gas and Mining
DOI	Department of Interior
EA	Environmental Assessment
EIS	Environmental Impact Statement

EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESR	Emergency Stabilization and Rehabilitation
FDQA	Federal Data Quality Act
FEMA	Federal Emergency Management Agency
FLPMA	Federal Land Policy and Management Act
GIP	Utah Grazing Improvement Program
GIS	Geographical Information Systems
HA	Herd Area
HFRA	Healthy Forests Restoration Act
HMA	Herd Management Area
IRA	Inventoried Roadless Area
kW	Kilowatt
LWC	Lands with Wilderness Characteristics
MW	Megawatt
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFMA	National Forest Management Act
NFP	National Fire Plan
NGO	Non-Governmental Organization
NHPA	National Historic Preservation Act
NPS	National Park Service
NRHP	National Register of Historic Places

NWPCP	National Wetlands Priority Conservation Plan
NWSRS	National Wild and Scenic River System
OHV	Off-Highway Vehicle
OMB	Office of Management and Budget
PEIS	Programmatic Environmental Impact Statement
PHMA	Priority Habitat Management Area
PJ	Pinyon-Juniper
PLPCO	Governor's Public Lands Policy Coordinating Office
PZP	Porcine Zona Pellucidae
RAC	Regional Advisory Council
RMP	Resource Management Plan
ROW	Right-of-Way
SEZ	Solar Energy Zone
SGMA	Sage-Grouse Management Area
SHPO	State Historic Preservation Office
SITLA	Utah School and Institutional Trust Lands Administration
SOP	Standard Operating Procedures
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TPA	Tons Per Acre
UCA	Utah Code Annotated
UDAF	Utah Department of Agriculture and Food
UDOT	Utah Department of Transportation

UDWR	Utah Division of Wildlife Resources
UFAA	Utah Farmland Assessment Act
UGS	Utah Geological Survey
UREZ	Utah Renewable Energy Zone
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VRM	Visual Resource Management
WFRHBA	Wild Free-Roaming Horses and Burros Act
WRI	Watershed Restoration Initiative
WS	Wildlife Services
WSA	Wilderness Study Area
WSC	Wildlife Species of Concern
WSR	Wild and Scenic River
WSRA	Wild and Scenic Rivers Act
WUI	Wildland-Urban Interface

THE EFFECTS OF OFF-ROAD VEHICLES ON ECOSYSTEMS

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For many years, the impacts and effects of off-road vehicles (ORV) on ecosystems have been a controversial subject across the United States and throughout the world (Webb and Wilshire, 1983). In the United States, it became an issue during the 1970s when environmentalists became concerned with ORV use on federal properties. During this time, scientific investigations were conducted to evaluate the environmental effects of human uses on resources in the California Desert Conservation Area. The findings from this research were published in a book entitled "Environmental Effects of Off-Road Vehicles". More recently, a book entitled "No Place Distant" investigated and revealed a more complete story of the effects of all roads on America's public lands (Havlick, 2002). This paper is intended to review research documenting the effects of ORV traffic on the ecosystems.

According to Kockelman (1983), the problems associated with ORV traffic were recognized by user and conservation groups, state and federal agencies, professional societies, individual scientists, the United States Council of Environmental Quality, state courts, Congress, and two former presidents. This prompted the 1972 Executive Order 11644 to control ORV use on federal public lands. This was followed by Executive Order 11989, in 1977, to provide immediate closure of trails to ORVs, which are causing or "will cause" considerable adverse effects to the ecosystem (Kockelman, 1983).

According to Sheridan (1980), the use of ORVs was a recognized management problem in the deserts of the southwestern United States and elsewhere (Webb, 1983). Not satisfied with traditional access areas, many people utilize ORVs to go past the traditional areas and into more remote locations. These vehicles are made to transverse mud, sand, gravel and water where standard vehicles cannot go. Off-Road Vehicles sales have substantially increased over the last decade. Not surprisingly, ORV activities along the waterways also increased. In Texas, recent attention has focused on the Nueces River Basin where it is not uncommon to see 50-100 ORVs in and around the river. Organized

rallies can result in even greater numbers. A common concern between ecologists and environmental groups is the degree of effect these vehicles have on sensitive ecosystems.

The natural resources of Texas include 15 major river basins and to date, ORV activity has been documented in eight of them (Gordon Linam, pers. com.). Accordingly, Texas probably has the greatest diversity of waterways than any other state (Belisle and Josselet, 1974). Most of the other states have vast amounts of federal lands, whereas, Texas being approximately 97% privately owned, has very little public lands. Since Texas has such a very small amount of public land set aside as parks and forests, etc., navigable rivers and streams provide a significant source of public property. Public lands in Texas and other states typically have regulations and enforcement governing recreational activities and access. In Texas, minimal such consideration and planning has been given to ORV use in waterways. While the concerns of ORV traffic on the ecosystem has been studied for the past 25 years throughout the United States, the information has been slow to reach Texas. To understand the effects of ORV traffic on the ecosystem, one must review literature that has been documented. While only limited research has been conducted in Texas, numerous other studies have been conducted in other states that we can draw from for better education.

According to Havlick (2002), ORV use near streams, rivers, and lakes, creates a serious water pollution threat. With ORV use exceeding 80 million visitor days in national forests alone including all terrain vehicles (ATVs), tens of millions of gallons of gasoline and motor oil likely enter the soils and waters of our public lands each year, as a result of inefficient combustion and emissions (Havlick, 2002). Oil has been observed on the gravel beds of the Nueces River and many vehicles frequently ford areas deep enough to dislodge or wash off engine fluids into the river. In Texas, response to concerns regarding negative ORV environmental impacts on riparian communities and endangered and threatened species, the United States Forest Service closed numerous off-road vehicle trails in the Angelina National Forest. These included red cockaded woodpecker areas, streamside and lakeshore zones to 100 feet, research natural areas, protected river and stream corridors, cultural areas and sensitive bog sites (Evans, 2001).

Soils in arid regions can be severely affected and damaged by ORV through disruption and compaction. Soil stabilizers include macrofloral elements (plants),

microfloral elements (lichen, fungal, and algal crusts) and inorganic elements (soil crusts)(Wilshire, 1983). These natural soil protective elements in the desert are highly vulnerable to vehicle use. The force of rolling wheels on soil can cause compaction and have a serious long lasting negative effect (Webb, 1983). Soil compaction can decrease water infiltration, increase runoff, and cause severe erosion problems. Webb (1983), reported that soils most susceptible to compaction are loamy sands and gravelly soils with a wide range of particle sizes. These soil types are very similar to many areas along Texas rivers. Where riverbeds are predominantly gravel, ORV traffic frequently travels outside the gravel bed and onto upland habitat.

The majority of the earth's surface has been shaped through various forms of natural erosion including water, wind, and mechanical. Water is the most important erosive agent, either flowing across land or in rivers and streams (Hinckley et al, 1983). Mechanical or man induced erosion can accelerate the natural processes of water and wind erosion. In the Nueces River Basin, greater erosion was documented in areas with off-road vehicle use, where floodwaters removed and redistributed gravel, than in areas where off-road vehicle traffic was absent (Taylor, 2001; Garrett, 2001).

According to Hinckly et al. (1983), ORV increases overland flow sediment transport capacity by causing surface changes that alter runoff hydraulics and that channelization in vehicle tracks has especially important implications for accelerated erosion. Obstructions to overland flow are smoothed, resulting in greater flow rates over riparian areas, often leading to erosion and the creation of channels and gullies. Hinckly et al., (1983) and Kirkby and Kirkby (1974) noted that measurable erosion on natural desert hill slopes was often confined to areas of channelized flow. These studies corroborate Texas Parks and Wildlife (TPW) biologists' observations within the Nueces River Basin where water is channeled through vehicle tracks. As the degree of slope length increases, the magnitude of net erosion caused by ORV traffic reduces infiltration rates and surface roughness markedly increase (Hinckley et al, 1983). Off-Road Vehicle traffic can change the speed, timing, quantity, and quality of water moving through the landscape.

Off-road vehicle induced rilling and gullying proceeds much more rapidly than other land use practices such as grazing. According to Heede (1970), rills and gullies

were often discontinuous in natural undisturbed areas, consequently; water flow velocities and energies do not reach the large magnitudes attained by continuous flows. The tracks of ORVs, especially on erosion sensitive soil surfaces, form continuous rills and channels, which can grow into continuous gullies (Heede, 1983).

As with the physical effects of ORV on the ecosystem, the biological effects of ORV traffic on the ecosystem is just as alarming. Hall (1980) concluded that ORVs reduce perennial and annual plant cover and density, and the overall above ground biomass. The degree of loss is dependent on the intensity of use, although the terms moderate and heavy use are relative and may vary from site to site. Smaller shrubs are often the first to be damaged or eliminated.

Payne et al. (1983), found that losses of plant species increased as the summer progressed due to the phenology of the plant. In the spring, grasses and forbs are growing and more pliable; however, as the plant matures it becomes drier and brittle making it more susceptible to loss. A single vehicle pass can destroy or disrupt many types of plants, microfloral crusts, and soil. Plants with shallow root systems typical of many of the desert and arid region species are especially vulnerable. Certain tough, deep-rooted plants may require many passes to destroy (Wilshire, 1983; Lacey et al. 1997). The loss of vegetative cover increases susceptibility to wind and water erosion, which accelerates decomposition of remaining organic matter, weakens soil aggregate stability, and results in the formation of inorganic surface crusts. These surface crusts increase runoff, inhibit the germination and emergence of seedlings, and reduce water penetration, resulting in a harsher environment for plants and animals to survive (Dregne, 1983). In southwest Texas, where droughts are frequent and the summers are very hot and dry, the chances of vegetation damage is great, as the plants are less likely to reestablish at this time of year. Unfortunately, this stress period for plants coincides with the peak use of ORV activities, thus magnifying the problem.

Additionally, ORVs are frequently cited as the key link in the spread of invasive or noxious plants that are becoming a threat to numerous grassland and forest ecosystems in the United States. A study in Montana found that the undesirable spotted knapweed could hitchhike thousands of seeds on the undercarriage of ORVs for distances of up to 10 miles (Lacey et al., 1997). Restoration of disturbed lands occurs only through the

process of natural revegetation and recovery may take many years (Lathrop and Rowlands, 1983). Although frequent floods occur within the confines of river systems, ORV interrupts the natural process of revegetation, even on a temporary scale.

In addition to stirring up sediment and increased stream bank erosion when ORVs ford streams, the loss of vegetation in riparian areas may result in increased water temperatures and turbidity (from suspended solids). Elevated water temperatures reduce the solubility of dissolved oxygen and decrease the oxygen carrying capacity of the water. These high temperatures increase metabolism, respiration, and oxygen demand of fish and other aquatic organisms (Kolbe and Luedke, 1993). Turbidity reduces the penetration of sunlight into the water that may affect the primary producers such as algae, phytoplankton, and other aquatic plants; thus potentially limiting photosynthetic activity, which many organisms depend on for survival (Kolbe and Luedke, 1993). Suspended solids can settle over eggs and fish nests resulting in lower reproductive rates, as well as disrupts the food base filling the interstitial spaces between larger substrates such as gravel and cobble rendering this habitat as marginal at best for those macro invertebrates which typically reside in these spaces. The changes in the physical characteristics of streams and rivers can critically affect aquatic insects, fish, and other animals who depend upon clear cold waters for habitat, spawning, or food (Hynes, 1987, in Havlick, 2002).

Lathrop and Rowlands (1983) stated “the desert is not as “tough” as some off-road enthusiasts have so glibly put it, and restoration as a management objective is for all practical purposes unattainable as long as ORV activity occurs, even on a regular basis”. Similar statements have been made regarding Texas rivers and that ORV traffic traveling within the riverbed are no more damaging to the physical and biological features of the river than naturally occurring floods. In the Angelina National Forest, Evans (2001) observed that the banks were cut and collapsing where ORV trails traversed the sites along the Angelina River, resulting in a loss of habitat for benthic macro invertebrates and the reduction of vegetation.

Benthic communities are macro-invertebrates living in, or on the bottom, or attached to substrate on the bottom of aquatic systems and are frequently used to assess water quality (Evans, 2001). Example of benthic communities include may flies, dobson

flies and damsel flies which exhibit a range of responses to environmental stress. Evans (2001), found statistically significant effects from ORV on benthic macroinvertebrates and water quality in pools. Repeated benthic community sampling conducted by the Nueces River Authority staff indicated significant differences exists between disturbed versus non disturbed riffle areas at various locations along the Nueces River (Sky Lewey, pers.comm.). In the Angelina National Forest, Evans (2001), observed habitat deterioration and erosion at each ORV crossing site that was not reported in the ecological analysis. This analysis agrees with the unpublished reports submitted by Texas Parks and Wildlife biologists in their assessments of ORV disturbance in the Nueces River Basin (Garrett, 2001; Taylor, 2001).

A preliminary assessment by TPW indicated that ORV does have an effect on the aquatic communities of the Nueces River (Taylor, 2001; Garrett, 2001). Garrett (2001), compared an impacted site to an unimpacted site and documented that 79% of the fish at the impacted site were comprised of environmentally tolerant species and that environmentally sensitive species were absent. At the unimpacted site numerous indicator species were found that require clean, flowing water, aquatic macrophytes and sand and gravel for spawning. These characteristics were absent at the impacted site. Taylor (2001), observed numerous areas where vegetation was impacted including loss of first stage growth, roots above ground and uprooted grasses, bank destabilization, cut banks, diverted stream flows, and extensive pollution. This author conducted site and photo comparisons of pre-flood and post flood area. It was clearly documented that gravel was lost and moved from locations where ORV traffic had previously followed the side of the river bed, whereas an unimpacted island within the Nueces river with adequate grass, shrubs, and trees showed very little disruption by the major flood (Fig. 1).

Havlick (2002), cites numerous investigations that indicate wildlife including birds, reptiles, and large ungulates respond to disturbance with accelerated heart rate and metabolic function, and suffer from increased levels of stress. These factors can lead to displacement, mortality, and reproductive failure. He also noted wildlife will tend to avoid areas with high disturbance levels. The direct effects of ORV on wildlife have been documented in various areas throughout the desert southwest. Noise may negatively affect certain small mammals and reptiles by interfering with their specialized senses

used for protection from predators and to find prey themselves. Studies on desert kangaroo rats have shown that noise from ORV can directly impact these senses causing frantic behavior, ear bleeding and temporary loss of hearing. The magnitudes and frequencies of sounds generated by ORV in the California desert had direct impacts on populations of desert kangaroo rats and presented a clear and present danger to the well being of the natural wildlife of the arid regions. Brattstrom and Bondello (1983), found that the acoustical sound of dune buggies induced hearing loss in the Mojave fringe-toed lizard even under moderate intensity of short duration. In another study, motorcycle sounds of intermediate intensity caused a captive burrowed Couch's spadefoot toad to emerge from underground. These toads generally burrow underground and emerge following thunderstorms primarily to breed. Premature immergence prior to the natural season of the toad may have devastating effects due to stress, dehydration, and lack of available food. Ultimately ORVs could have a disruptive influence on these populations (Battstrom and Bondello, 1983). Similar effects on small mammals and reptiles in the arid regions of Texas may also take place.

Wildlife depends upon soils, plants, air, and water to survive for their sustenance and shelter. When any of these natural requirements are altered, dependent wildlife will be affected (Havlick, 2002). Whereas the indirect effects of ORV have been documented, direct effects include increased mortality by accidental collisions with wildlife species, which may resting or loafing under rocks or brush in the heat of the day (Havlick, 2002). Additionally, access to more remote areas may increase the likelihood of poaching, thus impacting the economics of wildlife enterprises.

During the last 25 years, use of public areas has greatly increased throughout the United States including Texas. While the concerns of ORV traffic on the ecosystem has been studied for the past 25 years throughout the U.S., the information has been slow to reach Texas. Research and literature regarding the issues of ORV overwhelmingly document the negative impact the environment sustains from them. Throughout the United States, these impacts adversely affect natural ecosystems including erosion, soil compaction, bank stability, water quality, destruction and loss of vegetation, aquatic losses, and wildlife impacts. This is especially true in sensitive and arid areas. Recovery times are dependent on many factors including soil types, magnitude of soil compaction,

rainfall rates, propagation rates of vegetation, and the degree of human disturbance (Webb et al., 1983). Webb et al. (1983) state, “It is clear that the full recovery time required to ameliorate severe ORV impacts probably should be estimated in terms of human life spans”. As the human population in Texas grows, there will be an ever-increasing demand outdoor recreation. The effect this demand has on our natural resources needs to be carefully considered and strategic plans developed to cope with conflicts, which will certainly arise in the future.

Literature Cited

- Belisle, H.J. and R. Josselet. 1974. An Analysis of Texas Waterways. Texas Parks and Wildlife Department. Austin, TX.
- Brattstrom, B.H. and M.C. Bondello. 1983. Effects of off-road vehicle noise on desert vertebrates. Pages 167-206 *in*: R. H. Webb and H. G. Wilshire (eds.). Environmental effects of off-road vehicles: Impacts and management in arid regions. Springer-Verlag. New York.
- Dregne, H.E. 1983. Soil and soil formation in arid regions. Pages 15-30 *in*: R. H. Webb and H. G. Wilshire (eds.). Environmental effects of off-road vehicles: Impacts and management in arid regions. Springer-Verlag. New York.
- Evans, Deborah A. M. 2001. A benthic macroinvertebrate and physicochemical analysis of the effects that off-road vehicles (ORV's) have on water quality at three stream crossing sites in the Angelina National Forest in east Texas. M.S. Thesis. Stephen F. Austin State University. Huntsville, TX. 203 pp.
- Garrett, G. 2001. Nueces River collection report. Unpublished report. Texas Parks and Wildlife. Austin, TX.
- Hall, J. A. 1980. Direct impacts of off-road vehicles on vegetation. Pages 63-74 *in*: P.G. Rowlands (ed.). The effects of disturbance on desert soils, vegetation and community processes with emphasis on off-road vehicles: a critical review. U.S. Dept. Interior, Bureau of Land Management, Desert Plan Staff Special Publication. Riverside, CA.
- Havlick, David G. 2002. No Place Distance: Roads and Motorized Recreation on America's Public Lands. Island Press. Washington D.C. 297 pp.

- Heede, B. H. 1970. Morphology of gullies in the Colorado Rocky Mountains. *Bull. Intl. Assoc. Sci. Hydrol.* 15:79-89.
- Heede, B. H. 1983. Control of rills and gullies in off-road vehicle traffic areas. Pages 245-264 *in*: R. H. Webb and H. G. Wilshire (eds.). *Environmental effects of off-road vehicles: Impacts and management in arid regions*. Springer-Verlag. New York.
- Hinckley, B.S., R.M. Iverson, and B. Hallet. 1983. Accelerated water erosion in ORV-use areas. *In*: Webb, Robert H. and Howard G. Wilshire (eds.), *Environmental effects of off-road vehicles: Impacts and management in arid regions*. Springer-Verlag. New York.
- Hynes, H.B.N. 1970. *The ecology of running waters*. University of Toronto Press. Toronto, Ontario
- Kirkby, A.V.T. and M.J. Kirkby. 1974. Surface wash at the semi-arid break in slope. *Z. Geomorphol. Suppl.* 21:1521-2176
- Kockelman, W.J. 1983. Introduction. Pages 1-11 *in*: Webb, R. H. Webb and H. G. Wilshire (eds.). *Environmental effects of off-road vehicles: Impacts and management in arid regions*. Springer-Verlag. New York.
- Kolbe, C. M. and M.W. Luedke. 1993. *A guide to freshwater ecology*. Texas Natural Resource Conservation Commission. Austin, TX. 138 pp.
- Lacey, C.A., J.R. Lacey, P.K. Fay, J.M. Storey, and D.L. Zamora. 1997. Controlling knapweed on Montana Rangeland. Montana State University Extension Service Circular 311.

- Lathrop, E.W. and P.G. Rowlands. 1983. Plant ecology in deserts: an overview. Pages 114-152 *In*: R. H. Webb and H.G. Wilshire (eds.), Environmental effects of off-road vehicles: Impacts and management in arid regions. Springer-Verlag. New York.
- Payne, G.F., J.W. Foster, and W.C. Leininger. 1983. Vehicle impacts on Northern Great Plains range vegetation. *J. of Range Manage.* 36(3): 327-331.
- Sheridan, D. 1980. Off-Road vehicles on public lands. Council on Environmental Quality. Washington D.C., 84 pp.
- Taylor, R.B. 2001. Letter to Nueces River Authority on observations on Nueces River. Unpublished. Texas Parks and Wildlife. Austin, TX.
- Webb, R.H. 1983. Compaction of desert soils by off-road vehicles. Pages 51-79. *in*: R. H. Webb and H. G. Wilshire (eds.). Environmental effects of off-road vehicles: Impacts and management in arid regions. Springer-Verlag. New York.
- Webb, R.H., H.G. Wilshire, and M.A. Henry. 1983. Natural recovery of soils and vegetation following human disturbance. Pages 279-302 *in*: R. H. Webb and H. G. Wilshire (eds.). Environmental effects of off-road vehicles: Impacts and management in arid regions. Springer-Verlag. New York.
- Wilshire, H.G. 1983. The impact of vehicles on desert soil stabilizers. Pages 31-50 *in*: R.H. Webb and H. G. Wilshire (eds.). Environmental effects of off-road vehicles: Impacts and management in arid regions. Springer-Verlag. New York.



Figure 1. Using the encircled rock as a point of reference, one can evaluate the loss of gravel accelerated by ORV traffic (mechanical erosion) between the pre-flood (A) and post-flood (B) photographs.

Introduction



Moab has numerous trails suitable for ATVs and UTVs. Much of the public land surrounding the national parks is open to ATV & UTV travel on existing trails. **However, please note that ATV & UTV riding is not allowed within either Arches or Canyonlands National Parks.** ATV and UTV enthusiasts can use all of the popular [Moab 4WD Trails](#) or explore many of the other backcountry trails that surround Moab.

Always remember that travel is limited to designated motorized routes only. Off-road travel is illegal.

ATVs and UTVs are an amazing way to explore the public lands surrounding Moab. With their booming popularity comes a responsibility to be prepared when you hit the trail, to know trail etiquette, and to leave the land beautiful for the next generation to enjoy. This video is a quick guide of what you

need to know!

Recreate Responsibly

Help us to protect your right to enjoy UTV riding in the Moab area by doing the following:

- **We encourage UTV riders to limit in-town driving by trailering their vehicles to the trailheads whenever possible.**
- If you must ride in town, please try to avoid driving through neighborhoods and avoid driving at night to provide solitude for residents in the evening.
- Please note that the OHV speed limit in Moab is now 15 mph.
- When on the trails, don't bust the crust – protect fragile desert soils.
- Pack out what you pack in.
- Dispose of human and pet waste properly.



Speed Limits for Street Legal OHVs



To help reduce noise, Moab's in-town speed limit for OHVs is 15 mph. Grand County also has a speed limit on County B Roads which is 10 mph less than the posted speed limit. Please observe all speed limits and avoid driving through neighborhoods at night to provide solitude for residents and preserve your right to ride.

Age Requirements

No one under eight years of age is allowed to operate any OHV on public lands, roads or trails in Utah. Operators eight through 15 years of age may operate an OHV provided they possess an Education Certificate issued by Utah State Parks and Recreation or equivalent from their home state. Resident operators 16 years of age or older may operate an OHV if they possess either a valid driver's license or an OHV Education Certificate. Education Certificates are issued to anyone eight years of age or older who completes Utah State Parks and Recreation's Know Before You GO! OHV education course. Education Certificates are issued for snowmobiles, ATVs, and motorcycles. For information on this training opportunity, contact the OHV Education Office at [801-538-7433](tel:801-538-7433).

Helmet Requirements

Properly fastened helmet, having at least a "DOT Approved" safety rating for motorized use are required for all OHV operators and passengers under the age of 18 years. A properly fitting, safety rated helmet is the most important piece of safety gear available to an OHV rider.

Equipment Requirements

All OHVs are required to have certain equipment in working order while being operated in Utah, including:

- Brakes sufficient to stop and hold the machine
- A headlight and taillight while being operated between sunset and sunrise
- A brightly colored whip flag attached to the OHV and at least eight feet off the ground while being operated on designated sand dune areas
- A muffler and spark arrestor (snowmobiles are exempt from the spark arrestor requirement).

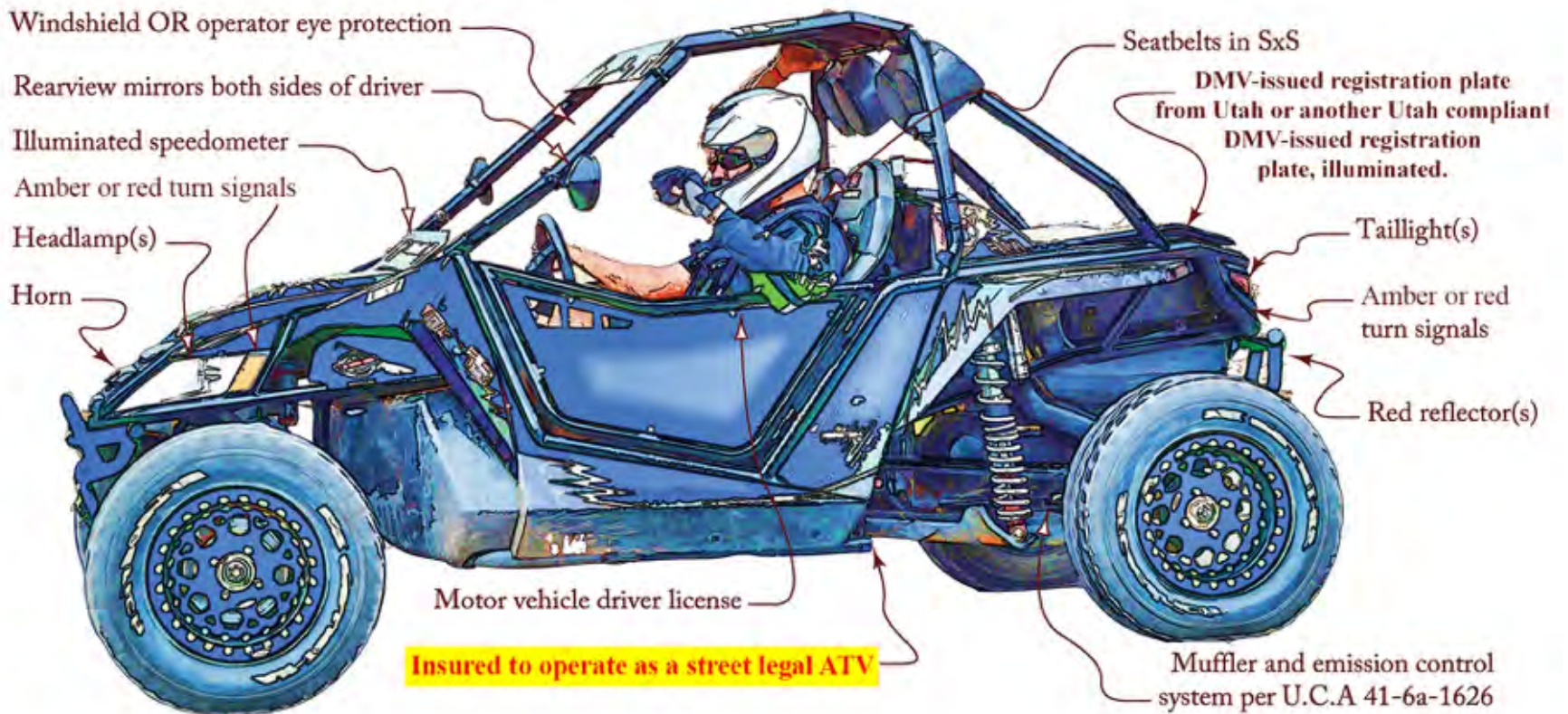
Street-Legal ATV Requirements

Your vehicle must have (1) a license plate from your home state and (2) meet all of the requirements shown below. If your home state does not issue license plates to ATV/UTVs, your vehicle cannot be street legal in Utah. If your vehicle is not street legal it must be trailered or towed to the trailheads.

What is Street-Legal in Utah?

All elements are required for on-road operation, regardless of state of registration.

See Utah code 41-6a-1509 for some distinctions between different vehicle types.



OHV Registration

Residents

Any OHV being operated or transported on public lands, roads, or trails, of the State of Utah must display a current OHV registration sticker. All OHV registrations are handled by the Utah Division of Motor Vehicles.

Non-Residents

If a street-legal OHV is registered and has a license plate from your home state, and it meets all of Utah's street-legal requirements (shown above), you do not need to purchase a Utah Non-Resident OHV Permit. If your vehicle is not street legal you need to purchase a permit either [online](#) or in town. Permits are available at the vendors shown below. The permits are \$30 and are good for a full year. Please note that this permit is only for riding on Moab's OHV trails, not on roads, streets and highways.

Moab Information Center

Center and Main

[435-259-8825](tel:435-259-8825)

Mad Bro

1805 S Hwy 191

[435-259-6232](tel:435-259-6232)

Maverik

435 N Main

[435-259-8718](tel:435-259-8718)

Maverik

985 S Hwy 191

[435-259-0775](tel:435-259-0775)

Spanish Trail Shell

2420 Spanish Trail Rd

[435-259-3939](tel:435-259-3939)

When applying in person, you will need the following:

1. Proof of residency: driver's license or other state issued identification.
2. Proof of ownership: title or current registration or bill of sale

Revenues generated from OHV user fees are dedicated to construction, improvement, operation and maintenance of OHV trails. For assistance with questions concerning OHV's, along with online registration forms, visit:

Utah State Parks and Recreation

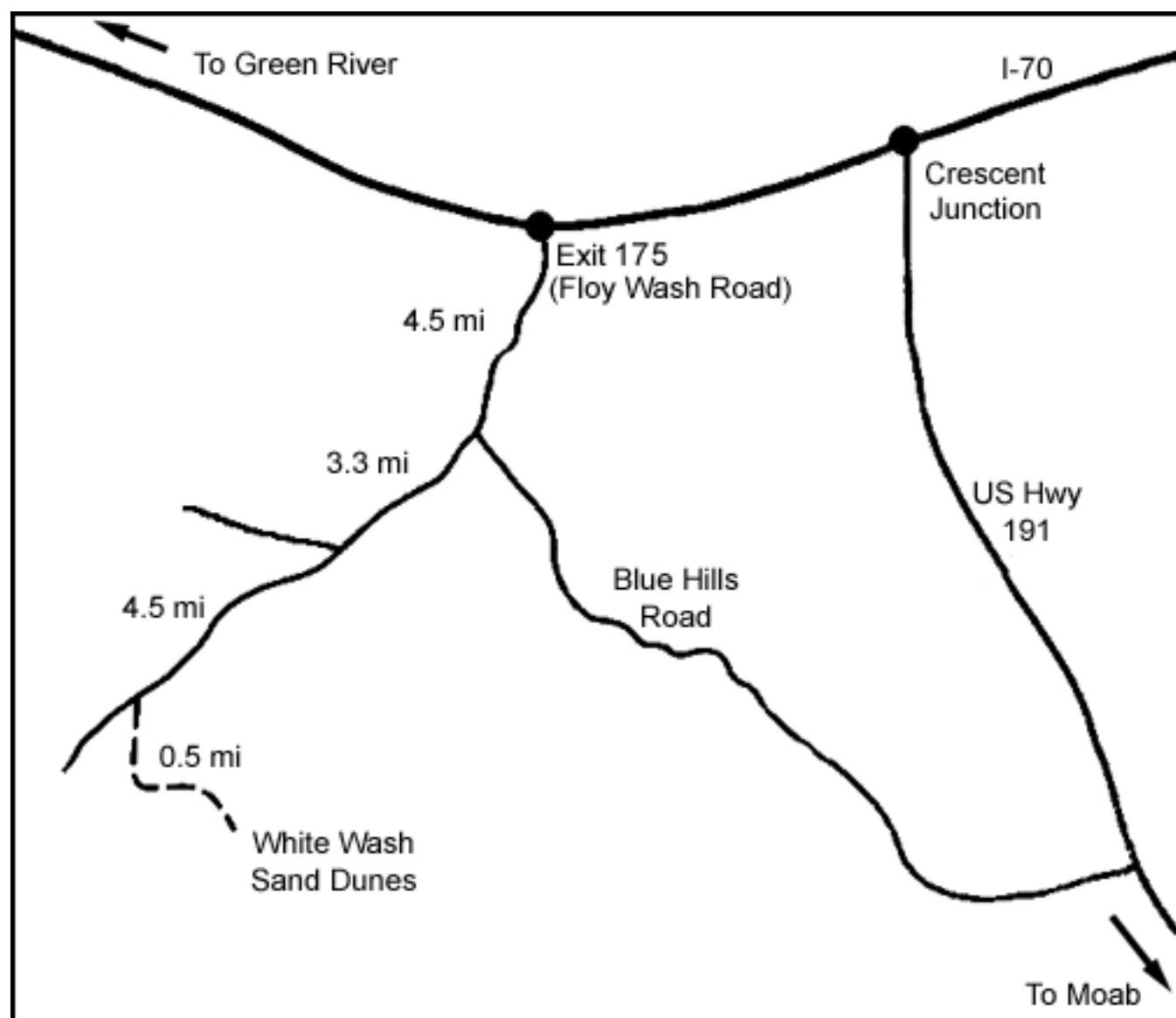
[Website](#)

1594 West North Temple, Ste 116

[801-538-7433](tel:801-538-7433)

White Wash Sand Dunes

One area that is particularly popular for riding ATVs is the White Wash Sand Dunes. The White Wash Sand Dunes are located 48 miles northwest of Moab, and 25 miles southeast of Green River. The Sand Dunes themselves are delineated and fenced for open OHV play; cross country travel is allowed only in the open area. Outside this area, there are hundreds of miles of designated roads and trails to be enjoyed. All motorized travel outside the open area must stay on the designated routes. Staying on the designated routes helps keep these routes open for your enjoyment. Damage to adjoining private property has occurred, and is a threat to your continued enjoyment of this area. Staying on designated routes assures that you will not trespass on private property. Please avoid the oil production facilities and the adjoining ranch, and never chase or harass livestock. When going through gates, leave them open or closed as you found them.



You must stay on designated roads and trails when riding outside the dune

area. These routes are marked with white arrows and/or white paint. Bighorn sheep inhabit this area; riders should avoid stressing these animals by giving them the space they need. The cottonwood trees growing in the White Wash area are quite unique. Please avoid damaging these trees and give them a wide berth to reduce potential for soil compaction.

To reach the White Wash Sand Dunes from Moab drive 7 miles west of Highway 191 on I-70. Take Exit 175 (Floy) to the south. Continue southwest on the Floy Wash Road for 12 miles. Be sure to bear right 4.5 miles from I-70, and then continue straight at 7.8 miles from I-70. Go east (left) at 12.3 miles southwest of I-70. The trailhead latitude/longitude is 38.80348623, -110.0444765.

There are no facilities of any type at White Wash Sand Dunes. Visitors must pack out all trash. There is no drinking water in the area. If you camp, please use a previously used camping spot. Be advised that the closest dump stations are in the town of Green River. Specific campsites are not marked and portable toilets are required.

Trailer Parking

Need somewhere to to park your trailer? Although the City of Moab does not have any public long-term parking areas, we have a list of Moab companies that provide safe, secure trailer storage [here](#).

Safety Tips

By following a few simple rules, OHV riders can make certain that every trip is a safe and enjoyable experience.

- Always ride in control. Ride within your abilities and your machine's capabilities. Never attempt anything that is beyond your skill level.
- Always wear the appropriate safety gear. At a minimum, this should include a helmet, shatter resistant eye protection, long sleeves, long

pants, gloves, and boots that cover the ankle.

- Only carry passengers if your OHV is specifically designed to do so. ATVs and off-road motorcycles are designed to be ridden by only one rider. Carrying passengers can alter the balance of the machine, causing a loss of control.
- Riders under the age of 16 should be supervised by a responsible adult at all times.
- Riders should be able to straddle the machine with a slight bend to the knees while both feet are on the footrests. Riding a machine that is too big is a major cause of injuries to young riders.
- Always tell someone where you are going and when you will return. Provide them with a map of your intended riding area.
- Be prepared for any emergency. Always carry a tool kit and spare parts, a first aid kit, and survival equipment when you ride. Carry plenty of extra food, water and fuel.
- Check the weather forecast before leaving home. For winter riders, always check the avalanche forecast before venturing into the back country. Avalanche information is available from the Avalanche Forecast Center at [801-364-1581](tel:801-364-1581)
- Never, ever drink and ride. Alcohol and OHVs don't mix, but create a deadly and illegal combination.

Moab Outdoor Adventure Guide

The Moab Outdoor Adventure Guide is a new comprehensive guide to adventures and activities that are available on the public lands surrounding Moab. If you are interested in hiking, off-road driving, river activities, scenic byways, dark sky observing, mountain biking, e-biking, rock art tours, camping, dinosaur trails, or traveling with pets, this guide will set you on the right path. It will be going to press in a few months however the FREE eBook version is available right now! [Click here](#) to view the Moab Outdoor Adventure Guide online.

USEFUL LINKS

Bureau of Land Management (BLM) Motorized Travel Routes

