



Roadless Area Conservation Along Montana's Rocky Mountain Front: Are We Losing Ground?

Ecological Analysis

SCIENCE FROM



THE WILDERNESS SOCIETY

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Since 1935, **The Wilderness Society** has worked to preserve America's unparalleled wildland heritage and the vast storehouse of resources these lands provide. From the threatened tupelo and cypress forests of the Southeast to critical grizzly bear and wolf habitat in the Yellowstone-to-Yukon corridor to the incomparable, biologically rich Arctic, The Wilderness Society has forged powerful partnerships with members and friends across the country to conserve interconnected landscapes for our nation. We want to leave a legacy rich in the biological diversity and natural systems that nurture both wildlife and humans alike.

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Legislators, on-the-ground resource managers, news reporters, our conservation partners, and — most importantly — the American people must have the facts if they are going to make informed decisions about the future of this nation's vanishing wildlands. The answers to the pressing legal, economic, social, and ecological questions now at issue are the stepping stones to that understanding and, ultimately, to achieving lasting protection for the irreplaceable lands and waters that sustain our lives and spirits.



Roadless Area Conservation Along Montana's Rocky Mountain Front: Are We Losing Ground?

EFFECTS OF MOTORIZED TRANSPORTATION IN
THE ROCKY MOUNTAIN RANGER DISTRICT

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This science report is one of a series that stems from conservation research studies conducted by The Wilderness Society's Ecology and Economics Research Department. Other reports in the series that focus on issues relevant to this report include:

- **Roadless Areas — The Missing Link in Conservation:** An Analysis of Biodiversity and Landscape Connectivity in the Northern Rockies
- **Ecological Effects of a Transportation Network on Wildlife:** A Spatial Analysis of the Upper Missouri River Breaks National Monument
- **Protecting Northern Arizona's National Monuments:** The Challenge of Transportation Management

The entire series is available on The Wilderness Society's website <www.wilderness.org> and from The Wilderness Society, Communications Department, 1615 M Street, NW, Washington, DC 20036 (202-833-2300 or 1-800-THE-WILD).

Preface

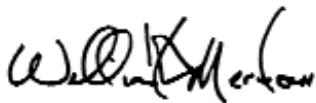
The Rocky Mountain Ranger District of the Lewis and Clark National Forest harbors far-ranging wildlife species that roam at will today, much as they did centuries ago. In 2004, as our nation celebrates the 200th anniversary of the Lewis and Clark expedition, it is only fitting that we pay tribute to the “wildness” those explorers encountered in this extraordinary natural area — by conserving its rich biodiversity for the generations that follow us.

Some portions of the district are now protected as designated Wilderness. Other tracts, known as inventoried roadless areas, are not yet fully protected but are widely recognized for their outstanding ecological characteristics. Roadless areas are wild enclaves that provide critical wildlife habitat, outstanding backcountry recreation opportunities, and breathtaking scenery — values that are currently under serious threat. The Forest Service has proposed to expand the number of motorized roads and trails in the forest, a move that would encroach upon essential lowland habitat and slice through higher elevation backcountry.

In The Wilderness Society’s report *Roadless Area Conservation Along Montana’s Rocky Mountain Front: Are We Losing Ground?*, Forest Ecologist Michele Crist, GIS Analyst/Programmer Dawn Hartley, Landscape Scientist Janice Thomson, and Regional Associate Peter Aengst document the results of their state-of-the-art landscape analysis within the Rocky Mountain Ranger District. Examining the effects of the proposed travel plan on habitat and wildlife species, they illustrate its long-term impact on the integrity of this important landscape. Our findings clearly show that the agency’s initial proposal runs counter to its own conservation objectives for the forest.

It is the non-wilderness lands, especially the roadless areas, which contain the most ecologically important lower elevation habitats. A number of different species, including several that migrate seasonally from higher elevations, rely on lowlands to survive. The report demonstrates the deleterious effects the proposed road and motorized trail system might have: fragmenting key areas and disrupting natural behavior and movement patterns. Our strong recommendation is that the Forest Service reconsider its current proposal and carefully analyze the potential impacts of any subsequent proposals.

If we are to sustain the viable wildlife populations that comprise one priceless legacy of America’s national forests, then we must ensure that every decision about the forest is made with those species in mind.



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ROADLESS AREA CONSERVATION ALONG MONTANA'S ROCKY MOUNTAIN FRONT

Report Highlights

The Rocky Mountain Ranger District on the Lewis and Clark National Forest is a biologically rich landscape that harbors a vast array of important vegetative types and wildlife species — from raptors and songbirds to carnivores such as the grizzly bear, gray wolf, wolverine, and lynx. Free of roads and motorized trails in designated Wilderness and other large core areas, the District exhibits an extraordinary wild nature that nurtures viable populations of wide-ranging wildlife species. It represents an increasingly rare contribution to biodiversity throughout the region and across the country.

The District's high-quality habitat is at risk from a pending revision of the current travel plan. A preliminary proposal, released by the Forest Service, would increase the number of motorized trails and open pristine backcountry to use by off-road vehicles and other motorized transport.

This study employed state-of-the-art landscape analysis to determine the effects that the proposed changes to the transportation system would have on a number of wildlife species. Key findings include:

- The Forest Service's proposal would fragment lower-elevation land cover types in inventoried roadless areas — essential for species that require lower-elevation habitats.
- Ponderosa pine, sagebrush, and grasslands communities, all endangered ecosystems in the Northern Rockies and found only in the non-wilderness and roadless portions of the District, would be negatively affected by the transportation proposal.
- The proposed transportation system would fragment wildlife habitat, thus disrupting natural behaviors and movement patterns for many wildlife species.
- In the District nearly 40 percent of the Badger-Two Medicine, Birch-Teton, and South Fork Sun River zones and 9 percent of the Dearborn Elk zone would have road and motorized trail densities in excess of 1 mi/mi². Densities in excess of 2 mi/mi² would occur in 15 percent of the Badger-Two Medicine and South Fork Sun River zones and 7 percent of the Birch-Teton zone.
- Scientific studies demonstrate that these densities are detrimental to many wildlife species, including the grizzly bear, gray wolf, elk, and bighorn sheep.

Recommendations

In its transportation planning process, the Forest Service should recognize the impacts of roads and motorized trails on ecological integrity and overall biodiversity. Loss and fragmentation of natural habitat are primary causes in declines and extinctions of native species. To help ensure maximum vegetative and wildlife biodiversity in the District and to contribute to these values across the broader region, The Wilderness Society urges the Forest Service to adopt the following recommendations.

- The agency must develop the District's travel plan in the context of the entire Lewis and Clark National Forest. The forest already contains abundant opportunities for motorized use across an extensive road and trail system in the Crazy Mountains, Little Belt Mountains, Castle Mountains, Highwood Mountains, Big Snowy, and Little Snowy Mountains areas. In fact, the forest-wide transportation system exceeds 1,500 miles of roads and 1,070 miles of trails open to motor vehicles.
- The agency should adopt the principles of a sound transportation network that are outlined on pages 22 to 24 of this report.

▼
Viable populations of wildlife species such as the grizzly bear, gray wolf, elk, and bighorn sheep are at risk if the Forest Service doesn't perform the necessary analyses to control road densities in the Rocky Mountain Ranger District.
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The Lewis and Clark National Forest already contains abundant opportunities for motorized use across an extensive road and trail system — more than 1,500 miles of roads and 1,070 miles of trails open to motor vehicles.
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- The agency should:
 1. Develop a conservation strategy that protects rare and under-represented ecological communities in the Northern Rockies, including whitebark pine, aspen, ponderosa pine, shrub-dominated riparian, sagebrush, xeric and mesic upland shrub, vegetated sand dunes, grasslands, and grass-dominated riparian areas.
 2. Protect relatively undisturbed lower-elevation land cover classes that serve as critical wildlife habitat and as connections for the movement of wildlife species.
 3. Designate roadless areas off limits to motorized use. These areas function as high-quality mid- to lower-elevation habitat for many wildlife species.
 4. Determine the specific road and motorized trail network and close and restore all other routes that have been used for motorized use.
 5. Calculate a comprehensive set of habitat fragmentation metrics for each species of interest.
 6. Ensure that motorized route densities for the road and trail network are lower than those that are known to adversely affect all species of concern and threatened and endangered species.
 7. Maintain non-motorized core areas of sufficient size to allow life history functions for ungulates and large carnivores.
 8. Ensure habitat connectivity with adjacent areas that contain important, high-quality habitat.
 9. Determine the cumulative effects of the route network on wildlife species and habitats for lands within the planning area and for adjacent lands.
 10. Retain traditional non-motorized uses (hunting, fishing, camping, outfitting, hiking, and more) to assure historically high numbers of big game animals and forest carnivores.



PHOTO BY BILL CUNNINGHAM

The Rocky Mountain Front comprises a relatively undisturbed area that supports mountain, foothill, and grassland ecotypes and viable populations of many wildlife species, including several listed under the federal Endangered Species Act.

1. Introduction

The 783,000-acre Rocky Mountain Ranger District of the Lewis and Clark National Forest is arguably one of the nation's most wild, diverse, and biologically rich landscapes. Located just east of the Continental Divide along Montana's mountain Front, the District comprises a relatively undisturbed area that supports mountain, foothill, and grassland ecotypes and viable populations of many mammal species — from white tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), moose (*Alces alces*), bighorn sheep (*Ovis canadensis*), mountain goats (*Oreamnos americanus*), and pronghorns (*Antilocapra americana*) to mountain lions (*Felis concolor*), black bears (*Ursus americanus*), and grizzly bears (*Ursus arctos*). The largest populations of wolverines (*Gulo gulo*), Canada lynx (*Felis lynx*), and grizzly bears in the lower 48 states are found in the District, and it is the only place in the hemisphere where grizzlies still roam from the mountains to the prairies as they did historically (Aderhold 2002).

At least 21 species of raptors breed in the District, including nine species of owls, and biologists have documented more than 700 species of vascular plants in the area, representing more than a third of all plants known throughout Montana (Aderhold 2002). The area harbors populations of the Canada lynx, Piping Plover (*Charadrius melodus*), gray wolf (*Canis lupis*) and grizzly bear — four of the 14 species of wildlife in Montana that are listed under the federal Endangered Species Act — and is home to numerous species of concern.

The existing transportation system in the District maintains large core areas free of roads and motorized trails. Those “unroaded” areas contribute to the continued viability of numerous wildlife and plant species and may help prevent the

need to list some as threatened or endangered (Gilbert 2003).

However, the District's wildlife values are threatened by the potential expansion of off-road vehicle (ORV) use, and particularly increased use of newer and more powerful all-terrain vehicles (ATVs) that can penetrate further into the backcountry and compromise the large core areas that offer security to wildlife. Scientific studies show that use of ORVs greatly magnifies the effects of human disturbance on wildlife species, primarily because the vehicles can travel across a wide range of landscapes and because of their noise levels. Gilbert (2003) focused on motorized disturbance and found that ORVs pose a more serious threat to wildlife than paved roads and highways because the motorized trails reached into lands that were previously considered secure in the Northern Rockies. Wisdom et al. (2004) found that ORV use on public lands caused substantially higher movement rates and probabilities of flight response for certain wildlife species when compared to control periods of no motorized activity.

The 1976 National Forest Management Act (NFMA) recognized the importance of national forests in the context of biological conservation, and NFMA regulations require the U.S. Forest Service to manage the national forests in a sustainable manner that preserves their biological diversity and maintains viable species and their habitat (36 C.F.R. 219).

In 2002, the Forest Service proposed revisions to the existing 1988 Access and Travel Management Plan for the Rocky Mountain Ranger District. As part of the scoping process for the associated Environmental Impact Statement (EIS), the agency released a Proposed Action that outlined changes to the existing road and trail network.

“It [the Rocky Mountain Ranger District] would be a landscape as close to primitive America as can be found, a place of appreciation and contemplation of biodiversity on a scale found only in Alaska or the plains of East Africa.”

— Biologist Barry Gilbert, 2003



PHOTO BY HOWARD G. BUFFETT

The changes included an increase in the number of miles of motorized trails.

The Proposed Action met with considerable opposition. Of the 7,600 public comments received, 98 percent requested that the Forest Service limit trail access to traditional non-motorized means. Over 90 percent of Montanans who commented favored



PHOTO BY JOHN FANDEK

entire Lewis and Clark National Forest, which contains abundant opportunities for motorized use within an extensive road and trail system across six other districts — Crazy Mountains, Little Belt Mountains, Castle Mountains, Highwood Mountains, Big Snowy and Little Snowy Mountains. The forest-wide transportation system exceeds 1,500 miles of roads open to motorized vehicles and 1,800 miles of trails, 1,070 miles of which are open to motorized use.

In the process of transportation planning, the Rocky Mountain Ranger District needs to recognize the impacts of roads and motorized trails on ecological integrity. Loss and fragmentation of natural habitat are the leading causes of the decline and loss of native species.

The Wilderness Society undertook this study to determine the important elements of biodiversity that the Rocky Mountain Ranger District protects and demonstrate how the Forest Service's Proposed Action would likely affect those elements. Roads and motorized trails in the Proposed Action are preliminary, not necessarily the agency's preferred alternative. Nevertheless the routes in the Proposed Action constitute a starting point to demonstrate potential impacts on wildlife and the kind of assessment that must be conducted to determine an ecologically sound route network. We used the results of our analyses to draw conclusions about the potential effects of increased motorized use throughout the District and present recommendations to the Forest Service that will hopefully be incorporated as the agency revises its travel plan.



U.S. FISH AND WILDLIFE SERVICE/PHOTO BY DEAN BIGGINS

this position. The comments centered on the effects that increased motorized use would have on wildlife and the area in general.

Frequently cited effects were direct disturbances to wildlife and fragmentation of the landscape that would lead to loss and degradation of wildlife habitat.

Subsequently, the Forest Service decided to develop a different preferred alternative as part of its Draft EIS,

expected to be released in the

fall of 2004. The Draft EIS will likely contain five alternatives, including the original Proposed Action and a No Action alternative.

The travel plan for the District should be considered in the context of the

The Rocky Mountain Ranger District, one of the nation's most wild, diverse, and biologically rich landscapes, supports populations of many wildlife species such as Canada lynx, moose, and bighorn sheep.

2. Methods

Study Area

The Rocky Mountain Ranger District of the Lewis and Clark National Forest is bounded to the west by the Continental Divide and Flathead and Lolo national forests, to the north by U.S. Highway 2 and Glacier National Park, to the south by Helena National Forest, and to the east by the Blackfeet Indian Reservation and state, Bureau of Land Management, and private lands (Figure 1). The District's 783,000 acres include 386,000 acres in the Bob Marshall and Scapegoat wilderness areas and 397,000 acres of non-wilderness lands, 80 percent of which are in inventoried roadless areas. To facilitate display and discussion of the District's non-wilderness lands, the Forest Service divided those acres into four zones. From north to south, they are named Badger - Two Medicine, Birch -

Teton, Dearborn Elk, and South Fork Sun River (Figure 2).

Throughout this study, we often refer to the Rocky Mountain Ranger District as the "District," the Bob Marshall and Scapegoat wilderness areas as "Wilderness," all remaining lands "non-wilderness," and inventoried roadless areas as "roadless areas."

Data

The assessment of important biodiversity elements and habitat fragmentation required spatial data for the District in geographic information system (GIS) format. GIS data for the land management boundaries of the district, roadless areas, and transportation routes for the Proposed Action were acquired from the Forest Service. Land cover data providing vegetation and non-vegetation communities were acquired from the Montana GAP Analysis Program (Scott et al. 1996). Elevation data are from the

FIGURE 1.

Rocky Mountain Ranger District (cross-hatched area), Lewis and Clark National Forest

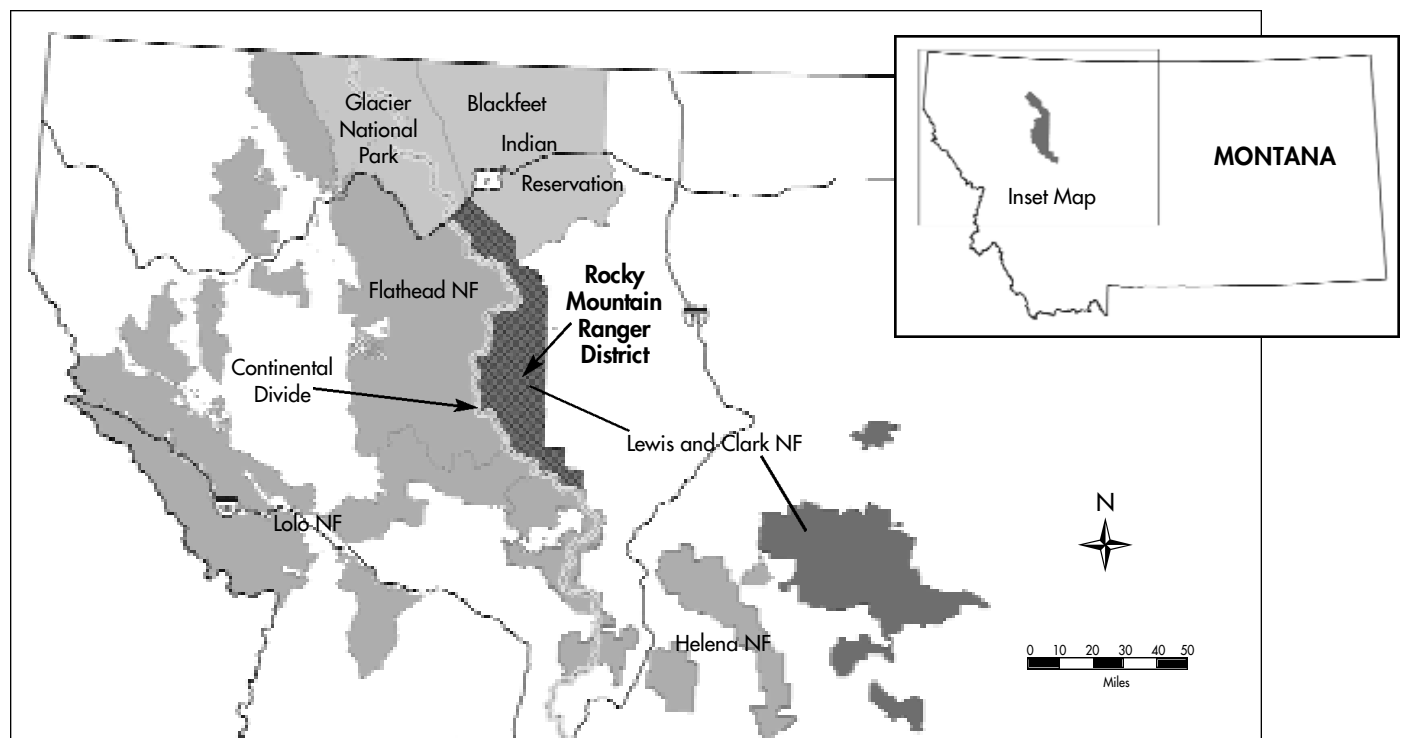
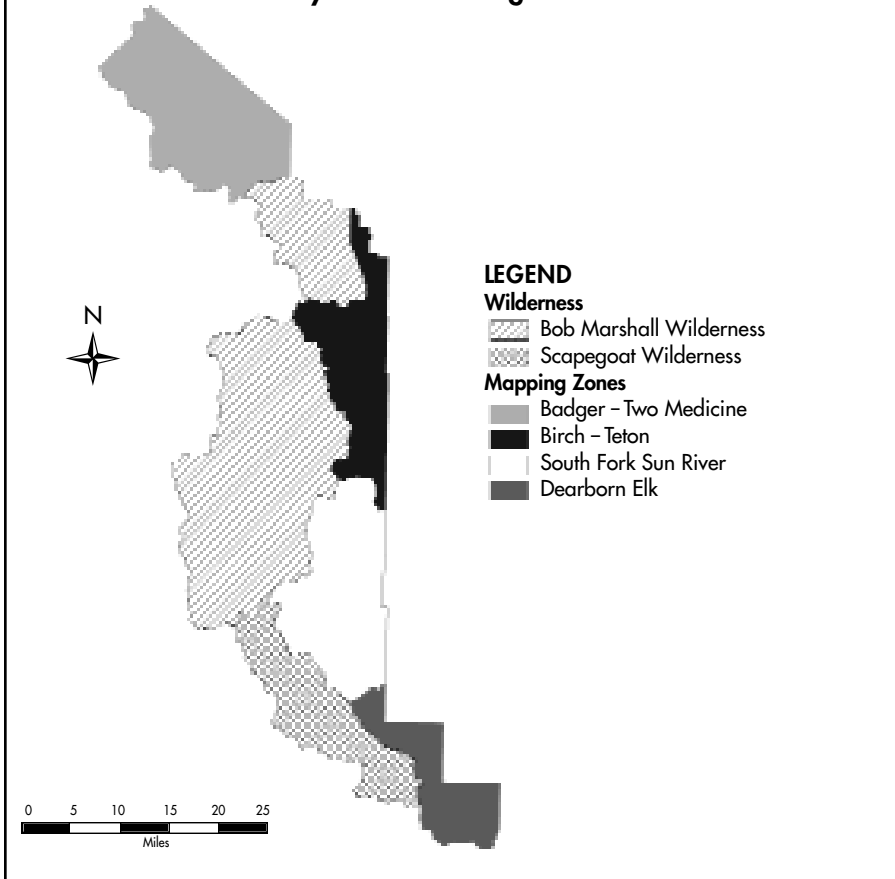


FIGURE 2.

Wilderness Areas and Mapping Zones, Rocky Mountain Ranger District



National Elevation Dataset distributed by the U.S. Geological Survey's EROS Data Center (<http://edc.usgs.gov/geodata>).

The Forest Service's transportation dataset contained roads, motorized trails, and non-motorized trails divided into 22 categories according to use and management restrictions. Based on these attributes in the GIS data layer, we selected a subset of roads and motorized trails for our analyses. Our selection included public roads, roads with no restrictions, roads with both seasonal and yearlong restrictions, special use or permittee roads, other roads where access requires permis-

sion, roads and trails with rights-of-way to be negotiated, trails open to any motorized vehicle, private roads, and system roads or trails to be decommissioned. We chose these roads and trails because all receive or could receive some level of motorized use (Figure 3)¹. And because enforcement and restrictions may or may not control use, we assumed that some categories may receive more motorized use than the name of the category implies.

This dataset of transportation routes was developed during the early stages of the transportation planning process and may differ from the alternatives to be released in the Draft EIS. Our study represents a conservative assessment because it does not account for off-trail travel on routes that users have created and that are not shown in the official Forest Service dataset.

Additional data layers such as state highways and hydrographic features were obtained from Montana State Library Natural Resource Information System for use in the preparation of cartographic products.

Data Analysis Ecological Community Representation

An important objective in managing public lands is to represent a full range of native biodiversity (Shelford 1926, Margules et al. 1988, Church et al. 1996, Possingham et al. 2000). To meet this objective, land managers often consider wilderness areas and national parks as reservoirs of biodiversity. However, current wilderness areas and national parks in the Northern Rockies are, for the most part, concentrated at high elevations and on sites with low soil productivity where important elements of biodiversity are most likely poorly represented

¹ The roads and trails scheduled for decommissioning are assumed to receive motorized use since it is rare to decommission non-motorized routes. Verification that routes for decommissioning are indeed motorized would require a feature-by-feature visual comparison with the 1988 travel plan and was beyond the scope of this analysis.

(Davis et al. 1994, Scott et al. 2001). Thus, protecting relatively undisturbed areas at middle and lower elevations on sites with relatively high soil productivity may make valuable contributions in protecting those elements of biodiversity that are currently not well represented in wilderness areas and national parks (DeVelice and Martin 2001).

Land Cover Representation. For this study, land cover representation analyses were conducted across four study regions: (1) the entire District, (2) Wilderness lands in the District, (3) non-wilderness lands in the District, and (4) all roadless areas within the non-wilderness lands.

For all four study regions, we calculated the total acreage of each land cover class. For the three sub-district regions, we calculated the percent representation (or proportion) of each land cover class by dividing the acreage of each land cover class by the total acreage of the corresponding land cover class from the entire District. We then compared acreages and percentages for the regions.

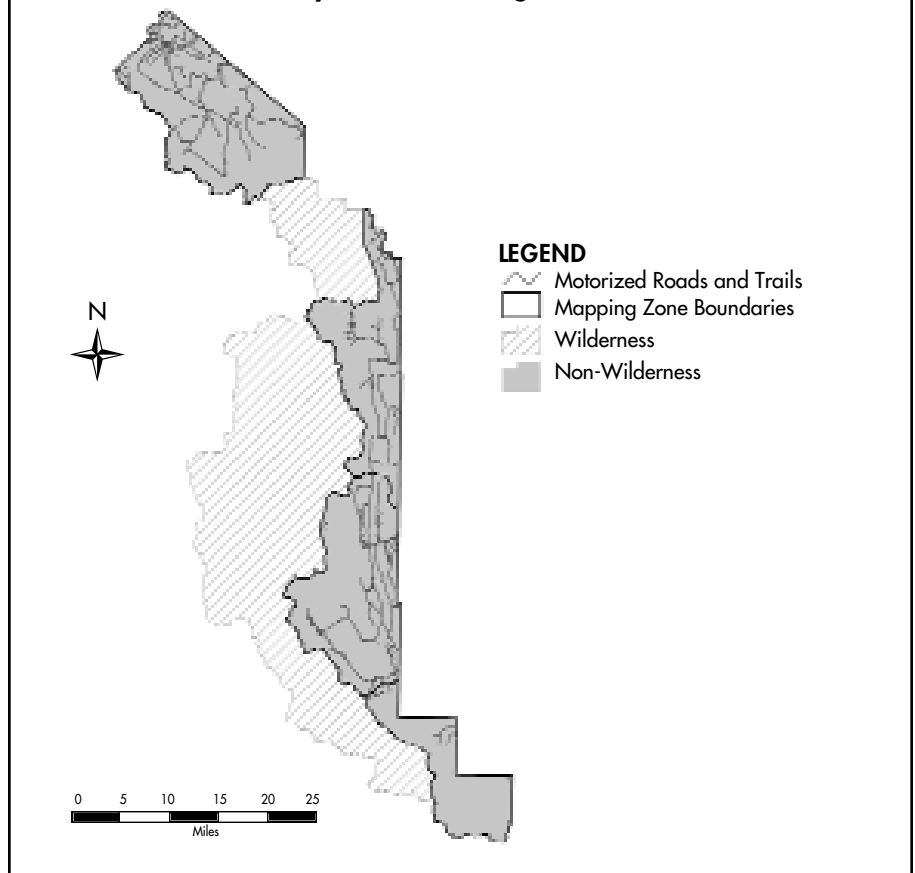
Elevation Representation. Elevation data for the four study regions were divided into approximately 1,256-foot intervals (converted from 200 meter intervals). The total acreage was calculated for each interval. For the three sub-district regions, we calculated the percent representation for each elevation interval by dividing the region's acreage by the total acreage of the corresponding elevation interval for the entire District. We then compared total acreage and percentages across the four data layers.

Habitat Fragmentation Patterns

Fragmentation has been defined as the "creation of a complex mosaic of spatial and successional habitats from formerly contiguous habitat" (Lehmkuhl and Ruggiero 1991). The degree of fragmentation caused by the transportation network, as well as the effects of such frag-

FIGURE 3.

Motorized Roads and Trails, Rocky Mountain Ranger District



mentation on the ecological composition, structure, and functions of a landscape, is difficult to measure and not fully understood. However, a variety of landscape metrics have been documented to help measure the condition of a landscape and its level of fragmentation (McGarigal and Marks 1994).

For our calculations of habitat fragmentation caused by the road and motorized trail system in the Proposed Action, we selected three landscape metrics widely used in scientific literature to determine the effects of fragmentation. These metrics were the density of roads and motorized trails, the acreage of habitat within the transportation effect zone, and the acreage of core areas. These metrics were calculated across all non-wilderness lands in the District.

Wilderness lands were excluded because motorized routes are not permitted there.

Habitat Fragmentation Metric #1: Density analysis of transportation features. Density is a measure of linear transportation features per unit area and is a common metric in quantitative assessments of ecological impacts within a landscape perspective.

The density of transportation features was calculated as an average across the analysis area and for each portion of the four mapping zones in the analysis area. In addition, the landscape was subsampled using a series of sampling windows across the analysis area. A window size of roughly 1-mile² was selected based on numerous wildlife assessment models developed by Gaines et al. (2003). Measuring density in sampling windows provides an understanding of the variability of density across a landscape and at different scales. This principle is important to gauge the effects of fragmentation on different species (Urban et al. 1987, Wiens and Milne 1989, Turner et al. 1994). For example, differences in dispersal distances among species cause them to respond to habitat features at different scales.

Habitat Fragmentation Metric #2: Analysis of the transportation effect zone. Forman (1999) uses the term "road effect zone" to describe the influence of roads beyond the actual physical structure. Extending this concept to include motorized trails, we defined a "transportation effect zone" or TEZ. The width of the zone depends on the effects measured (e.g., noise, dust, erosion, human presence, etc.) and the activity being affected (e.g., elk calving, grizzly bear denning, wilderness experience for hikers, etc.).

We examined fragmentation patterns associated with the physical footprint alone and transportation effect zones of three different widths. The physical footprint was estimated by applying a width of approximately 12 feet to the

transportation features, which represents the average width of a single lane road (Trombulak and Frissell 2000). While this width will over-estimate the physical width of some motorized trails, the width is not significant compared to the widths of the effect zones measured; narrowing the width would not alter the conclusions of this report.

Transportation effect zone data layers were generated by applying buffer widths of approximately 1,000 feet, 1,600 feet, and 3,200 feet to each side of the roads and motorized trails (Ward 1976, Kasworm and Manley 1998, Papouchis et al. 2001, Graves 2002). The effect zone widths were selected to represent a range of potential impacts, including hunting and avoidance, as noted in scientific literature.

Habitat Fragmentation Metric #3: Analysis of core area. Core areas, sometimes referred to as interior habitat or habitat security areas, exist in natural landscapes as contiguous blocks of uniform habitat types away from habitat edges. Free from fragmentation, communities of native species and ecological functions persist uninterrupted in these areas. For our analysis, core areas are defined as portions of the landscape that are sufficiently far from transportation corridors to be relatively unaffected by them.

For each of the transportation effect zone data layers described above, we created a corresponding core area data layer by identifying all lands outside of the transportation effect zone. We also calculated the mean core area size by dividing the total core area by the number of core areas. Scientists generally agree that as core area increases, the quality of wildlife habitat increases.

The analytical work for this study was conducted using commercial GIS software from ESRI and custom software developed by The Wilderness Society.

3. Results

Ecological Community Representation

Land Cover Representation. Results demonstrate that the District contains a diverse range of 21 land cover classes (Table 1). Wilderness, non-wilderness, and the roadless study regions, separately, are also diverse, but each region differs considerably in the amount of acreage and the percent representation for certain land cover classes.

Results for the entire District also show that 8 land cover classes (water, alpine meadow, mesic upland shrub, lodgepole pine, mixed conifer, mixed subalpine forest, whitebark pine, and

subalpine meadow) exhibit significantly high acreages, ranging from 44,000 acres to 167,000 acres.

Comparing the representation between the Wilderness, non-wilderness, and roadless study regions, the Wilderness study region exhibits a higher percentage representation for mixed barren lands, alpine meadow, lodgepole pine, mixed subalpine forest, and whitebark pine typical of higher elevation wilderness areas in the Northern Rockies. The non-wilderness and roadless study regions exhibit higher percentages of vegetated sand dunes, exposed rock/soil, clear-cut conifer, burned forest, shrub-dominated riparian, grass-dominated riparian, grasslands, sagebrush, mesic and xeric upland

TABLE 1.

Acreage by Land Cover Class*

Land Cover Class	Ranger District		Wilderness		Non-Wilderness		Roadless Areas	
	Acreage	Percent	Acreage	Percent	Acreage	Percent	Acreage	Percent
Agriculture	40	0	0	0	40	100	0	0
Vegetated Sand Dunes	1,263	10	122	10	1,141	90	98	8
Water	87,828	52	45,918	48	42,093	48	41,058	47
Exposed Rock/Soil	5,010	40	2,018	60	2,990	60	2,904	58
Mixed Barren Lands	1,223	89	1,087	8	92	8	92	8
Clearcut Conifer	15,320	40	6,189	59	9,075	59	8,913	58
Alpine Meadow	69,876	62	43,129	38	26,763	38	26,344	38
Burned Forest	9,954	37	3,715	63	6,241	63	5,134	52
Shrub-dominated Riparian	3,649	29	1,051	71	2,608	71	1,915	52
Grass-dominated Riparian	168	24	40	76	128	76	62	37
Grasslands	10,536	13	1,355	88	9,223	88	6,793	64
Sagebrush	1,221	30	366	70	857	70	849	70
Mesic Upland Shrub	60,113	28	17,021	72	43,290	72	41,132	68
Xeric Upland Shrub	1,037	42	436	60	622	60	606	58
Aspen	15,938	11	1,789	89	14,163	89	9,832	62
Ponderosa Pine	490	0	0	100	490	100	482	98
Lodgepole Pine	98,963	55	54,921	45	44,066	45	37,329	38
Mixed Conifer	127,491	48	61,664	52	65,979	52	58,337	46
Mixed Subalpine Forest	167,712	55	93,048	45	74,714	45	66,133	39
Mixed Whitebark Pine	44,526	56	24,851	44	19,595	44	18,464	41
Subalpine Meadow	57,791	47	27,259	53	30,584	53	29,553	51
Total	780,148		385,979		394,754		356,032	

*Total acreage for each land cover class in the entire Rocky Mountain Ranger District and in designated Wilderness, non-wilderness, and roadless areas. For Wilderness, non-wilderness and roadless areas, percent representations are shown. Totals may vary slightly from other sources because of GIS raster (grid) calculations.

Source: Montana land cover GAP analysis (Scott et al. 1996)

TABLE 2.

Elevation Range by Total Acreage*

Elevation Range (feet)	Ranger District	Wilderness		Non-Wilderness		Roadless Areas	
	Acres	Acres	Percent	Acres	Percent	Acres	Percent
4,265-4,919	10,987	1,972	18	9,017	82	4,618	42
4,920-5,574	107,723	40,471	38	67,252	62	47,297	44
5,575-6,233	216,195	93,056	43	123,139	57	114,519	53
6,234-6,889	222,078	110,007	50	112,071	50	108,590	49
6,890-7,545	157,272	93,584	60	63,687	40	62,863	40
7,546-8,201	57,661	39,116	68	18,544	32	18,376	32
8,202-8,857	6,097	4,758	78	1,339	22	1,289	21
8,858-9,512	168	94	56	74	44	66	39
Total	778,181	383,059		395,124		357,617	

*Total acreage for each elevation range in the entire Rocky Mountain Ranger District and in designated Wilderness, non-wilderness and roadless areas. Totals were first calculated in meters for each elevation range and then converted into feet. For Wilderness, non-wilderness, and roadless areas, percent representations are shown. Totals may vary slightly from other sources because of GIS raster (grid) calculations.

Source: USGS — EROS Data Center, National Elevation Dataset

shrub, aspen, ponderosa pine, and sub-alpine meadows. All of these cover classes generally occur at mid- to lower elevations within the Northern Rockies. When roadless percentages are compared with the analysis area percentages, roadless areas contain a majority of the acreage for almost all cover classes except agriculture and vegetated sand dunes, which occur on private inholdings or on forest service lands outside of wilderness and roadless, respectively.

Elevation Representation. Elevations vary widely across the District, from approximately 4,300 feet to 9,500 feet (Table 2). Comparing the study units, we found that Wilderness lands range from about 4,700 feet to 9,250 feet, non-wilderness from 3,700 feet to 9,400 feet, and roadless areas from 4,500 feet to 9,300 feet.

When acreage and percent representation for elevation ranges are compared among the three study regions, all show a 50-percent representation for elevations ranging from 6,200 feet to 6,900 feet. For elevation ranges lower than 6,200 feet, the non-wilderness and roadless regions show a higher percent repre-

TABLE 3.

Road and Motorized Trail Densities in Non-Wilderness Areas by Mapping Zones

Mapping Zone	Density (mi/mi ²)
Badger – Two Medicine	0.9
Birch – Teton	0.8
South Fork Sun River	0.9
Dearborn Elk	0.2

sentation. Wilderness areas exhibited a higher percent representation for elevations above 6,900 feet.

Fragmentation Effects

Density of transportation features.

The fragmentation analyses were calculated over the non-wilderness areas only (approximately 397,000 acres) and captured 480 miles of roads and motorized trails. This represents an average transportation feature density of 0.8 mi/mi². Table 3 summarizes the density results within each of the four non-wilderness Forest Service zones in the District.

Transportation feature density estimates are, however, scale dependent and

TABLE 4.

Transportation Densities by Mapping Zones — Sub-sampled Analysis

Feature Density (mi/mi ²)	Badger – Two Medicine	Birch – Teton	South Fork Sun River	Dearborn Elk	Total Non-Wilderness Area
0	39%	42%	48%	78%	48%
>0 – 0.5	9%	13%	4%	9%	8%
0.5 – 1.0	13%	7%	8%	4%	9%
1.0 – 2.0	24%	31%	25%	7%	24%
2.0 – 4.0	14%	6%	14%	2%	10%
> 4.0	1%	1%	1%	0%	1%

vary across any landscape. Densities measured within the sample window illustrate the spatial variation in feature density across the analysis area (Table 4 and Figure 4).

The maximum values calculated for the sub-sampled density analysis are 5.6 mi/mi² for the analysis area and the Badger-Two Medicine zone, 5.3 mi/mi² for the Birch-Teton zone, 4.3 mi/mi² for the South Fork Sun River zone, and 2.3 mi/mi² for the Dearborn Elk zone.

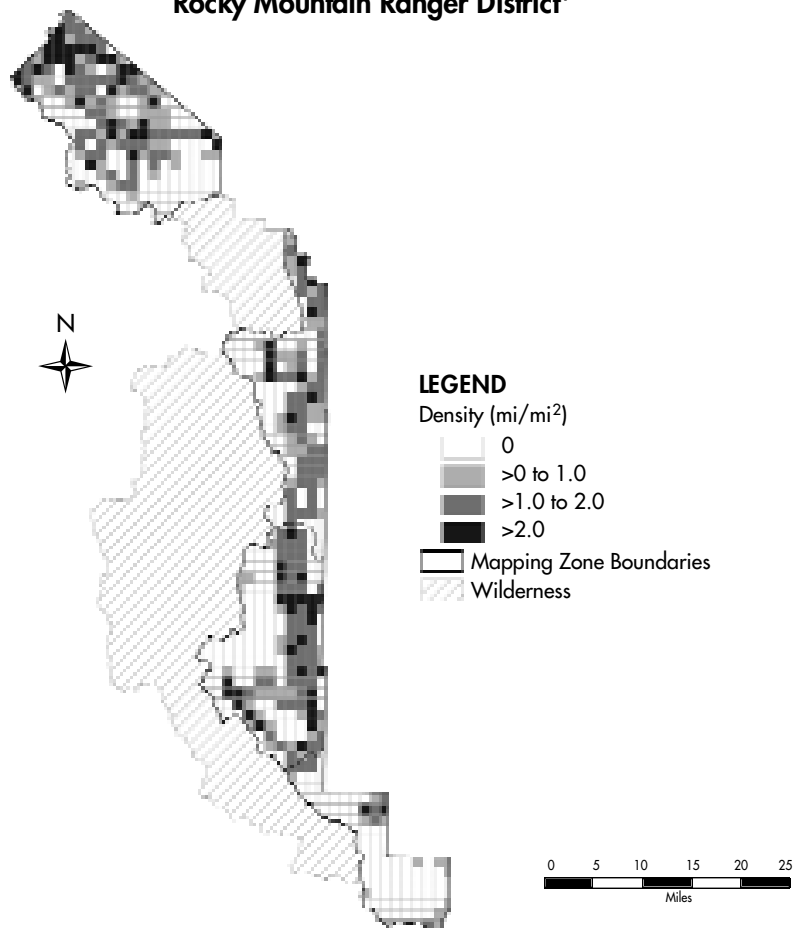
Analysis of the transportation effect zone. The physical footprint of the transportation network in the analysis area covers approximately 667 acres, or less than 1 percent of the total area of the analysis. Within the four Forest Service mapping zones, the physical footprint ranges from 25 to 272 acres, which also represents less than one percent of the total area of each zone. Beyond this area of direct impact are the different transportation effect zones that affect 22 to 54 percent of the analysis area (Table 5, Figure 5). Results for the four mapping zones show that widely varying portions, 7 to 63 percent, of the mapping zones are affected, depending on the size of the transportation effect zone and the mapping zone being analyzed.

Analysis of the core area. The total core area ranged from a high of 396,110 acres with no effect zone around the transportation network, to a low of 181,375 acres based on the 3,281-foot

transportation effect zone width. Complete results for the core area analysis are shown in Table 6 and Figure 6.

The results show that as the transportation effect zone width increases the

FIGURE 4. Subsampled Density of Motorized Roads and Trails, Rocky Mountain Ranger District*



*Road and motorized trail density based on one square mile sample window.





TABLE 5.
Transportation Effect Zones in Non-Wilderness by Mapping Zones

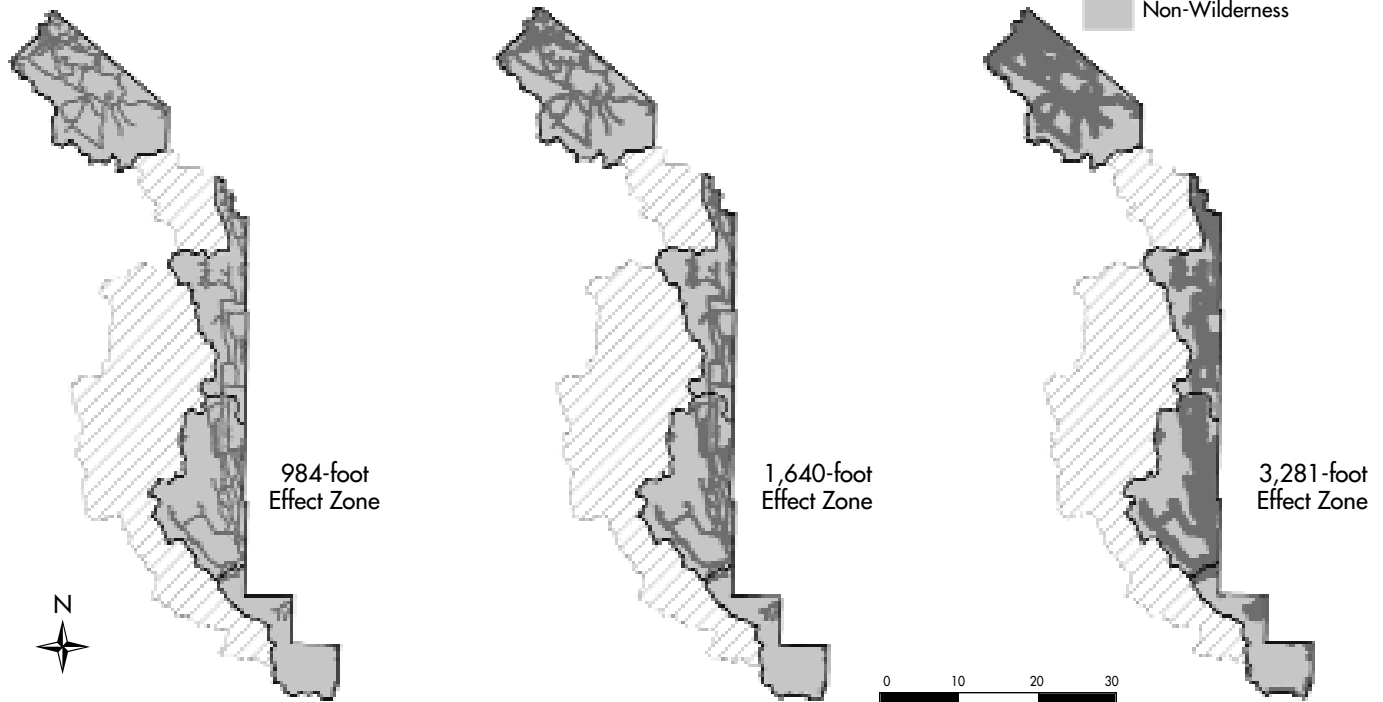
	Physical Footprint	Transportation Effect Zone Width		
		984 feet	1,640 feet	3,281 feet
Badger – Two Medicine				
Zone Area (acres)	272	35,731	53,078	84,139
% in Zone	<1	27	40	63
Birch – Teton				
Zone Area (acres)	148	20,411	31,432	51,497
% in Zone	<1	23	36	59
South Fork Sun River				
Zone Area (acres)	222	28,219	42,502	66,125
% in Zone	<1	24	36	56
Dearborn Elk				
Zone Area (acres)	25	4,250	6,968	13,739
% in Zone	<1	7	12	24
Total Non-Wilderness Area				
Zone Area (acres)	667	88,587	133,981	215,501
% in Zone	<1	22	34	54

FIGURE 5.

**Transportation Effect Zones,
Rocky Mountain Ranger District***

LEGEND

-  Transportation Effect Zone
-  Mapping Zone Boundaries
-  Wilderness
-  Non-Wilderness



*Transportation Effect Zones converted from 300, 500, and 1,000 meters.

TABLE 6.
Summary of Core Area Analysis in Non-Wilderness by Mapping Zones

	Physical Footprint	Transportation Effect Zone Width		
		984 feet	1,640 feet	3,281 feet
Badger – Two Medicine				
# of Core areas	78	38	27	18
Maximum Core Size (acres)	64,247	54,363	47,938	29,653
Mean Core Size (acres)	1,705	2,545	2,965	2,718
Total Core Area (acres)	132,696	97,112	79,815	48,680
% of Zone	99.8	73	60	37
Birch – Teton				
# of Core areas	32	19	15	14
Maximum Core Size (acres)	56,587	46,950	41,514	22,981
Mean Core Size (acres)	2,718	3,509	3,731	2,545
Total Core Area (acres)	86,981	66,718	55,846	35,830
% of Zone	99.8	77	64	41
South Fork Sun River				
# of Core areas	90	20	24	14
Maximum Core Size (acres)	64,247	56,587	51,892	38,548
Mean Core Size (acres)	1,310	4,522	3,163	3,756
Total Core Area (acres)	118,363	90,441	76,108	52,386
% of Zone	99.8	76	64	44
Dearborn Elk				
# of Core areas	53	5	5	2
Maximum Core Size (acres)	57,081	53,375	50,904	44,479
Mean Core Size (acres)	1,112	10,799	10,255	22,264
Total Core Area (acres)	58,317	54,116	51,398	44,479
% of Zone	100	93	88	76
Total Non-Wilderness Area				
# of Core areas	253	82	71	48
Maximum Core Size (acres)	64,247	56,587	51,892	44,479
Mean Core Size (acres)	1,557	3,756	3,707	3,781
Total Core Area (acres)	396,110	308,388	262,920	181,375
% of Non-Wilderness Area	99.8	78	66	46





total core area decreases. Also decreasing is the number and maximum size of the core areas. For each of the zones, the mean core size increases between the physical footprint and 984-foot effect zone as many small core areas associated with short route segments are eliminated by the larger buffer size. Mean core area varies between each of the three effect zone widths based on the distribution of roads and trails.

When roads and trails are in close proximity, increasing the effect zone will

often cause smaller core areas to be incorporated into the effect zone and disappear, thereby increasing the mean core area by eliminating small patches. However, once these smaller patches have been eliminated, further increase of the effect zone will result in a decrease in the overall mean core area. This general trend is demonstrated in the Badger – Two Medicine and Birch – Teton core areas.

FIGURE 6.

**Core Areas Beyond Transportation Effect Zone,
Rocky Mountain Ranger District***

- LEGEND**
-  Core Area
 -  Mapping Zone Boundaries
 -  Wilderness
 -  Non-Wilderness



*Transportation Effect Zones converted from 300, 500, and 1,000 meters.

4. Implications for Management and Conservation

Ecological Community Representation

The scientific literature describes the importance of intact, functioning natural ecosystems to the maintenance of native biodiversity and ecological processes (McArthur and Wilson 1967; White 1987; Usher 1987; Shafer 1995; Noss et al. 1997). While land managers often consider wilderness areas and national parks as reservoirs of native biodiversity and ecological processes, current wilderness areas and national parks in the Northern Rockies are, for the most part, concentrated at higher elevations where important elements of biodiversity may not be well-represented (Davis et al. 1994, Scott et al. 2001).

Unprotected middle and lower elevation lands may make valuable contributions in maintaining certain elements of biodiversity and ecological processes that are not well represented in wilderness areas and national parks (DeVelice and Martin 2001) and may be in danger of fragmentation, degradation and loss of habitat due to increased human activities.

Representation of a full range of biodiversity requires an understanding of all species and ecosystem processes operating in a given landscape. In the Northern Rockies, ecological communities are often associated with elevation gradients (Hansen and Rotella 1999). Since researchers do not yet have a complete understanding of species and ecosystem functions, they often use ecological communities and elevation ranges as coarse-scale surrogates for native biodiversity in land management (Scott et al 1993, Host et al. 1996). This concept is based on the idea that if a full range of ecological communities and elevation ranges are protected, it is more

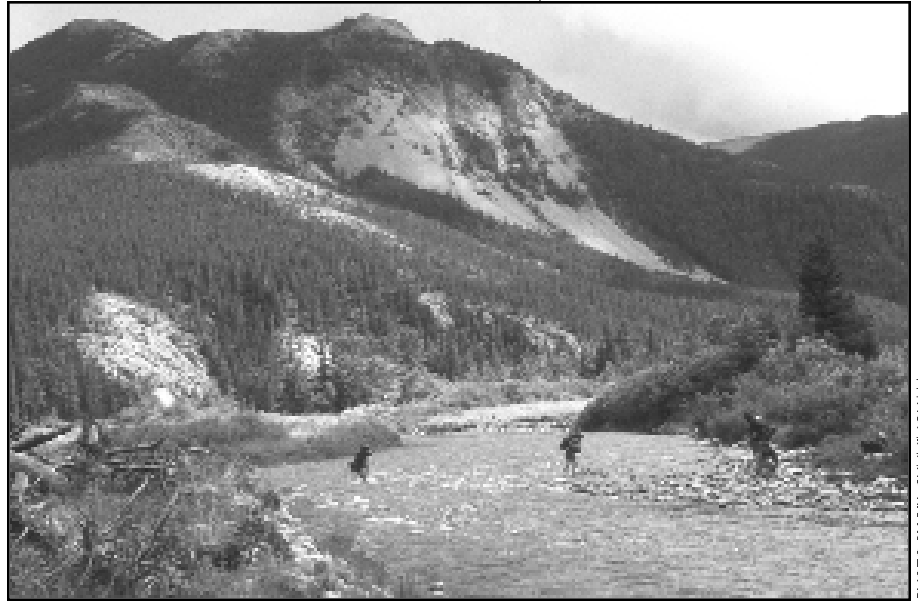


PHOTO BY BILL CUNNINGHAM

likely that many ecological communities, wide-ranging species, and ecosystem processes will be maintained.

Land Cover Representation. Our analysis indicates 21 different land cover classes in the Rocky Mountain Ranger District, demonstrating that this area is likely important for protecting many elements of biodiversity that sustain viable and abundant populations of the diverse wildlife species and the overall ecological integrity of the broader landscape. The Wilderness, non-wilderness, and roadless study regions, separately, contained a similar diverse range of land cover classes. However, each study region differed considerably in percentage and acreage representation for each land cover class. The results show that lower elevation land cover classes, rarely protected on national forests (Strittholt and DellaSala 2001, Crist and Wilmer 2002), occur mainly in the non-wilderness and roadless study regions.

A biodiversity representation study by Crist and Wilmer (2002) across the entire Northern Rocky region (Montana, Wyoming, and Idaho) found that a large number of certain land cover classes were underrepresented (less than 12 percent representation) in current protected areas (wilderness, national

River crossing in Badger – Two Medicine. Grandeur and solitude characterize the pristine lands of the Rocky Mountain Ranger District.

▼
 Many
 endangered
 ecosystems in the
 Northern Rockies
 are not protected
 in the Rocky
 Mountain Ranger
 District.
 ▲

parks, special management areas, wildlife refuges). The study also found that inventoried roadless areas increased the percent representation of the underrepresented land cover classes considerably — relative percent increases ranged from 43 to 480 percent (aspen exhibited the highest percent increase).

Among our four study regions, non-wilderness and roadless areas contain a majority of the underrepresented land cover classes, including shrub-dominated riparian, sagebrush, xeric and mesic upland shrub, vegetated sand dunes, ponderosa pine, aspen, grasslands, and grass-dominated riparian. These two study regions also contain mixed conifer, which was found to be minimally represented (12 percent to 25 percent) in protected areas by the Crist and Wilmer study.

For the entire District, 9 out of 21 land cover classes, or almost half of the land cover classes that occur across the larger landscape, are underrepresented in protected areas. One land cover class, mixed conifer, is minimally represented, and another, whitebark pine, is a species of concern throughout the Northern Rockies. Therefore, 11 of the 21 classes present in the District are either underrepresented or in need of more protection. The 11 land cover classes total 221,000 acres, or about 30 percent of the 783,000-acre District, and for the 397,000 acres of non-wilderness lands, the 11 land cover classes total 158,000 acres, or about 40 percent.

Throughout the Northern Rockies, increased representation of certain land cover classes in protected areas is particularly important to sustain populations of many wildlife species and their habitats. In the District, approximately 89 percent of the 16,000 acres of aspen occurs on non-wilderness lands, and 62 percent is found in roadless areas. Aspen is declining in the Northern Rockies (Gallent et al. 1998), and many songbirds are dependent on this important habitat type (Hansen and Rotella 2000).

Whitebark pine is also rapidly declining in the Northern Rockies, mostly because of white pine blister rust (*Cronartium ribicola*), an introduced disease. Whitebark pine is considered a “keystone” species, important to many higher elevation species (Keane et al. 1994). As examples, Clark’s Nutcrackers (*Nucifraga columbiana*) and grizzly bears rely on whitebark pine as a food source. The entire district contains only about 44,000 acres of whitebark pine in the higher elevations, 44 percent of which occurs on lands outside of wilderness and 39 percent occurs in roadless areas (Table 1).

Our results indicate that ponderosa pine, sagebrush, and grasslands communities, considered to be endangered ecosystems in the Northern Rockies (Hauffler and Mehl 2003), are found only in the non-wilderness and roadless portions of the District; none are in Wilderness (Table 1). The loss and degradation of ponderosa pine ecosystems has led to a corresponding functional loss of habitat for many associated species. Hauffler and Mehl (2003) found that 19 wildlife species of concern — among them the White-headed Woodpecker (*Picoides albolarvatus*), Flammulated Owl (*Otus flammeolus*), Pygmy Nuthatch (*Sitta pygmaea*), Northern Goshawk (*Accipiter gentilis*), Great Gray Owl (*Strix nebulosa*), and long-legged myotis (*Myotis volans*) — are “closely” and “generally” associated with late-successional ponderosa pine. Despite the well-known importance of sagebrush steppe habitat to Greater Sage-Grouse (*Centrocercus urophasianus*) and other sagebrush obligates (Braun et al. 1976, Gilbert 2003), sage-grouse populations and the quality and quantity of sagebrush habitats continue to decline (Braun 1987, Swenson et al. 1987, Connelly and Braun 1997, Gilbert 2003).

Approximately 88,000 acres of water lie in the District, more than half (52 percent) of it in Wilderness and 47 percent in roadless areas. The District’s two riparian-dominated land cover classes (grass and

shrub-dominated riparian areas) are primarily in roadless areas. The integrity of watersheds, riparian zones, and water in general is a growing concern across the United States, in part because of rapid losses of aquatic biodiversity as aquatic ecosystems are severely altered by human activity (Moyle and Randall 1998). Protection of aquatic ecosystems often lags behind protection of terrestrial ecosystems; wilderness areas and national parks are usually demarcated around terrestrial features, and this can result in the protection of just fragments of watersheds. It should also be noted that lower-elevation riparian areas serve as important food and water sources, as well as movement corridors, for wide-ranging species such as ungulates, carnivores, and migrating birds (Gilbert 2003).

Elevation Representation. Our study shows a wide range in elevation — from approximately 4,400 feet to 9,400 feet — across the District, and a possible threshold between approximately 6,200 and 6,900 feet below which roadless areas exhibit a higher percentage of land and above which Wilderness areas exhibit a higher percentage of land. This result is important for transportation planning. The majority of lower-elevation acreage and lower-elevation land cover classes occur in the non-wilderness and roadless areas. Crist and Wilmer (2002) found that inventoried roadless areas increase the representation of lands at elevations ranging from approximately 5,600 feet to 7,900 feet in the Northern Rockies when compared to wilderness areas alone. Also, the non-wilderness and roadless study regions exhibit a wider range of elevation than the Wilderness study region. This indicates that terrain in the roadless and analysis area regions is steeper — composed of high ridgetops and low-elevation valley bottoms. The lower-elevation valley bottoms are important for maintaining species movement throughout the entire Rocky Mountain Front area (Gilbert 2003).

Recent studies show that roadless areas represent a wider range of elevations — especially low to mid-elevations — than do wilderness areas (DeVelice and Martin 2001, Strittholt and DellaSala 2001, Crist and Wilmer 2002). Since many lower-elevation lands in the Northern Rockies have been converted for agriculture, urban and suburban commercial and residential purposes, and other uses, it is crucial to increase representation of lower-elevation sites in protected areas (Strittholt and DellaSala 2001, Crist and Wilmer 2002) to help conserve lower-elevation species and ecological communities.

Landscape Connectivity. The District's non-wilderness and roadless areas are positioned in such a way along the Rocky Mountain Front that they serve as a buffer between human settlements to their east and Wilderness areas to their west. This enables them to function as crucial landscape connectors for many wildlife species that move between lower and higher lands. Gilbert (2003) found that increased motorized use in the District threatens to break up this portion of the transboundary ecosystem that links the Banff-Jasper area in Canada with the Salmon-Selway and Yellowstone systems in Idaho, Montana, and Wyoming.

Crist and Wilmer (2002) found that roadless areas increased landscape connectivity across the entire Northern Rocky region, reducing the distance



USFWS/PHOTO BY GARY KRAMER



USFWS/PHOTO BY CHRISTOPHER SERVHEEN

Wildlife species such as the Greater Sage-Grouse and grizzly bear use lower-elevation sites at specific times of the year. While these lower-elevation valley bottoms are important for maintaining species movement throughout the entire Rocky Mountain Front, our study shows that the majority of lower-elevation land cover classes and acreage occur in unprotected areas.

▼ Scientific studies have shown that roads are the leading cause of landscape fragmentation. ▲

among protected areas that are critical to the movement of many species (MacArthur and Wilson 1967, Murphy and Noon 1992, Reed et al. 1996, Beauvais 2000, Hansen and Rotella 2000, Shinneman and Baker 2000). In the District, roadless areas are adjacent to Wilderness areas, thus increasing the functional size of Wilderness areas. Compared to small protected areas, larger areas generally contain more species and individuals, species with wide home ranges, species sensitive to human activity, and more intact ecosystem processes (Turner et al. 1993, Newmark 1995, Shafer 1995).

Habitat Fragmentation Effects

The effects of landscape fragmentation occur when an area of relatively continuous habitat is lost altogether or is divided into smaller parcels. As habitat is lost or fragmented by human disturbances, residual habitat patches become smaller and more isolated from each other. This decreases the availability of habitat and limits the movement of species. Through increased isolation, species face greater risk of disappearing from a region. Destruction and fragmentation of natural habitat are the leading causes of the decline and loss of native species (Harris 1984, Wilcox and Murphy 1985, Pickett and White 1985, Wiens et al. 1985, Wilcove 1989, Turner et al. 1993, Noss and Cooperrider 1994, Reice 1994, Newmark 1995, Sinclair et al. 1995, Soule and Terborgh 1999).

Construction and maintenance of roads are highlighted in the scientific literature as major causes of landscape fragmentation on public lands. The effects of roads on many terrestrial and aquatic wildlife species are broad and include mortality from collisions, modification of animal behavior, disruption of the physical environment, alteration of chemical environments, spread of exotic species, and change in human use of the lands and water (Trombulak and Frissell 1999).

Other examples of negative effects include habitat loss and fragmentation; reduction in core habitat; increase in edge effects; diminished animal use of habitats because of noise, dust emissions, and increased presence of humans; loss of forage for herbivores; interference with wildlife life-history functions (e.g., courtship, nesting, and migration); increased poaching or unethical hunting practices; increased recreation; and degradation of aquatic habitats through alteration of stream banks and increased sediment loads (Franklin and Forman 1987, Lehmkuhl and Ruggiero 1991, Reed et al. 1996, Trombulak and Frissell 1999, Gilbert 2003). While motorized trails have not been studied as extensively as roads, a recent literature survey by Gaines et al. (2003) has shown that motorized trails cause some of these same negative effects.

Variability of Habitat Fragmentation Across Mapping Zones. The effects of roads and motorized trails differ substantially among the four Forest Service zones in the non-wilderness area. The largest effect is in Badger - Two Medicine, and the least effect is in Dearborn Elk.

Figures 4 through 6 illustrate the variability of potential road and motorized trail effects across the four zones of the non-wilderness area and the existence of a south to north gradient of increasing road and motorized density. Specifically, Figure 4 and Table 4 show that 78 percent of the southernmost Dearborn Elk zone coincides with sampling windows where there are no transportation features, while that can be said of just 48 percent of South Fork Sun River, 42 percent of Birch - Teton, and 39 percent of the northernmost Badger - Two Medicine zone.

Windows that captured transportation features indicate that approximately 40 percent of the Badger - Two Medicine, Birch - Teton, and South Fork Sun River zones have road and motorized trail densities in excess of 1 mi/mi², while only

9 percent of Dearborn Elk exhibited such density. Densities in excess of 2.0 mi/mi² account for 15 percent of the Badger – Two Medicine and South Fork Sun River zones, 7 percent of Birch – Teton, and 2 percent of Dearborn Elk.

Transportation effect zones in Figure 5 and core areas in Figure 6 depict the relative differences among the four mapping zones and the analysis area as a whole. As one example, given a 1,640-foot transportation effect zone, 40 percent of Badger – Two Medicine has been impacted by the transportation network compared to just 12 percent of Dearborn Elk and 34 percent for the total non-wilderness area. This means Badger – Two Medicine contains a 60-percent core area compared to an 88-percent core area in Dearborn Elk and a 66-percent core area for the total non-wilderness area. Note that the mean core size associated with the 1,640-foot transportation effect zone is substantially larger at 10,255 acres in Dearborn Elk than in Badger – Two Medicine (2,965 acres).

Fragmentation Effects on Native Wildlife Species. To illustrate the value of spatial analysis in quantifying potential negative effects of roads and motorized trails on the movement of wildlife species and on wildlife habitat connections, we briefly examine the impacts of the analysis area's transportation network on ungulates — elk and bighorn sheep — and carnivores (grizzly bears and gray wolves). These brief analyses provide guidance for some management recommendations, but substantially more information is needed for a complete assessment of wildlife in the non-wilderness area and to make specific recommendations for motorized route closures.

Ungulates. Numerous studies document reduction in habitat effectiveness from roads and road avoidance by elk. Lyon (1983) showed that elk do not use habitat adjacent to roads to its full potential. Lyon found that when road

densities are as low as 1 mi/mi², 35 percent of the non-wilderness area, effective use of habitat by elk is reduced by 25 percent. Lyon's work suggests that three district zones (Badger – Two Medicine, Birch – Teton, and South Fork Sun River) already have their elk habitat effectiveness reduced by 25 percent over 38 to 40 percent of their areas. With road densities 2 mi/mi², 11 percent of the non-wilderness area and 15 percent of the Badger – Two Medicine and South Fork Sun River zones, elk are displaced from up to 50 percent of their habitat. Research is needed to better document the effects of motorized recreation on elk.

Ward (1976) found that elk were displaced within 400 meters (1,312 feet) of roads, a distance that falls between our 984-foot and 1,640-foot transportation effect zones. Our results related to these effect zones suggest that potential habitat is reduced between 22 and 34 percent across the analysis area and between 27 and 40 percent for Badger – Two Medicine. The Dearborn Elk zone would see the least displacement, between 7 and 12 percent, while Birch – Teton and South Fork Sun River would experience displacement in approximately 24 to 36 percent of their areas.

Wisdom et al. (2004) found that ORV use on public lands caused substantially higher movement rates and probabilities of flight response in elk and mule deer when compared to control periods of no motorized activity. And animal energy budgets may be adversely affected by loss of foraging opportunities while responding to off-road activities. Deer, for example, may respond to ORV use by seeking dense cover; this can lead to reduced foraging and, consequently, to insufficient fat reserves for winter survival (Wisdom et al. 2004).

Bighorn sheep are known to be sensitive to the presence of humans and have been described as the big game species most susceptible to the detrimental

effects of human disturbance (Canfield et al. 1999). Papouchis et al. (2001) found that bighorn sheep respond to hikers at an average distance of 200 meters (656 feet). Our 984-foot transportation effect zone (Table 3) shows that approximately one-fifth of the analysis area and one-fifth to one-quarter of the Badger – Two Medicine, South Fork Sun River, and Birch – Teton zones could potentially occur in the bighorn sheep's disturbance response range. Again, research is needed to better document the effects of motorized recreation on bighorn sheep.

Carnivores. The results of our transportation effect zone analysis indicate that for the 1,640-foot and 3,281-foot effect zones, grizzly bears may avoid up to 34 percent of the non-wilderness area. Results for the 1,640-foot effect zone indicate that the bears would avoid 40 percent of land in Badger – Two Medicine because of the presence of roads and motorized trails. A large body of literature suggests that most grizzly bears under-utilize habitats in proximity to roads and motorized trails. Recent examples include Kasworm and Manley (1998), who found that areas within 500 meters (1,640 feet) of a road received significantly less use than expected, while areas more than 1,000 meters (3,281 feet) from a road received significantly greater use than expected. Graves (2002) monitored four female grizzly bears, fitted with GPS collars, in Badger – Two Medicine to determine the effect on the bears of motorized vehicles traveling along trails. That study found that bears “selected against areas within 250-500 meters [820-1,640 feet] from ATV trails and within 450-600 meters [1,476-1,969 feet] from single track trails, which had some motorbike use.”

Mace and Manley (1993) found that bears avoided areas where total road density exceeded 2 mi/mi² and open road density exceeded 1 mi/mi². As noted earlier, our route density analysis indicates that 35 percent of the non-wilderness area has a motorized route density greater than 1 mi/mi² and 11 percent exceeds a density of 2 mi/mi².

Gray wolf habitat viability has been linked to road density (Mladenoff et al. 1995), and other studies have found that road densities in excess of approximately 1 mi/mi² act as barriers to wolf dispersal and have direct bearing on wolf survival (Thiel 1985, Jensen et al. 1986, Mech et al. 1988). Again, we show that this threshold is exceeded in 35 percent of the non-wilderness area, 39 percent of Badger – Two Medicine, 38 percent of Birch – Teton, 40 percent of South Fork Sun River, and 9 percent of Dearborn Elk.

Other species, like the wolverine and pine marten (*Martes americana*) as well as various songbirds, are also affected by roads and motorized trails along the Rocky Mountain Front, perhaps to an even greater extent than the animals discussed above. There is little literature available to demonstrate the specific effects of travel routes on these species and their habitats. However, studies have shown that roads act as an agent of landscape fragmentation and that they function as barriers to wildlife movement and reduce overall landscape connectivity for many native species.² Research has also shown that reductions in core habitat and increased edge effects may lead to a series of negative effects on species that depend on interior forest. Such effects include greater competition with species that prefer edge or open habitats, nest predation and parasitism, secondary extinctions

² See, for example: Harris 1984, Pickett and White 1985, Wiens et al. 1985, Wilcox and Murphy 1985, Wilcove 1989, Andrews 1990, Foreman and Wolke 1992, Turner et al. 1993, Noss and Cooperrider 1994, Reice 1994, Newmark 1995, Sinclair et al. 1995, Reed et al. 1996, Soule and Spellerburg 1998, Terborgh 1999, Trombulak and Frissell 2000, and McGarigal et al. 2001.

from the loss of keystone species, progressive loss of patches because of edge creep, and changing microclimates (increased evaporation, increased temperature, increased solar radiation, and decreased soil moisture) (Franklin and Forman 1987, Lehmkuhl and Ruggiero 1991, Reed et. al 1996).

Limitations and Potential Future Work

This report showcases techniques for assessing all proposed and potential motorized travel networks in the planning area. The data layer we incorporated does not contain the revised route network now under development by the Forest Service for the District, but it is a reasonable data set to use in illustrating the important assessment methods that should be applied to any future alternatives developed by the agency.

The study did not analyze how the current road and motorized trail system fragments the specific land cover classes. Such an analysis would be useful, especially for the underrepresented and lower-elevation classes, to identify the exact locations on the ground that need to be protected, where ORV use needs to be minimized, and where motorized route removal and decommissioning needs to occur to restore rare land cover classes.

This analysis of landscape fragmentation does not account for features unrelated to the transportation network that fragment the landscape; nor, does the analysis address habitat suitability and connectivity, variations in scale, differences in types of motorized transportation features, or seasonal variations in the populations of species. Other human constructions and even natural features such as topography contribute to land-

scape fragmentation and should be assessed along with the transportation network. It is important to consider connectivity of landscape patches when assessing fragmentation because the size and number of core areas may matter little to a species if it cannot migrate among them.

A multi-scale assessment of spatial pattern changes is essential to understand ecosystem functions (Hessburg et al. 1999) because different impacts of road and motorized trails can be measured at varying scales.

This study did not account for the different degrees of physical impacts on the ecosystem that a jeep trail may have compared to, say, a motorcycle trail or for varying levels of use. The analysis also did not address the effect of seasonal use on transportation features, wildlife, or recreation (for example, whether a species' tolerance for and use of a landscape changes during different seasonal activities or whether human use of some transportation features varies by season). A more exhaustive analysis should compare the seasonal habitat use of each species of concern with seasonal motorized use.



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PHOTO BY J.L. DAVIS



PHOTO BY HOWARD G. BUFFETT

Loss and fragmentation of natural habitat are the leading causes of the decline of native species. Studies have shown that roads act as an agent of landscape fragmentation and function as barriers to wildlife movement, reducing overall landscape connectivity for many native species such as pine martens, Olive-sided Flycatchers, and elk.

▼
 The Forest Service's preliminary proposed road and motorized trail network threatens the ecological integrity of the Rocky Mountain Ranger District.
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5. Conclusion and Recommendations

This study found that the Forest Service's preliminary proposed road and motorized trail network would be a threat to the ecological integrity of the Rocky Mountain Ranger District. Our results demonstrate that many under-represented and ecologically important lower-elevation land cover classes occur in the District's unprotected non-wilderness lands, and particularly in inventoried roadless areas.

We also found that the non-wilderness lands have the potential to protect lower-elevation habitats — areas of importance to species that occur at lower elevations, species that require lower-elevation winter range — and maintain landscape connections for species that migrate between the higher elevations of the Rocky Mountains and lower-elevation grassland plains.

As this report shows, the proposed road and motorized trail system would directly cause fragmentation of wildlife habitat and would likely disrupt natural behaviors and movement patterns for many different wildlife species over portions of the District. The level of this fragmentation occurs on a north-south gradient with the highest levels of fragmentation impacts occurring in the northern Badger – Two Medicine unit. Also important, the results of our representation analysis apply independent of the route network, and the techniques for the fragmentation study should be used to evaluate all proposed route networks.

Recommended Guidelines for Developing a Baseline Transportation Network for the Rocky Mountain District

Forest Service transportation plans contain a baseline transportation network that is designed during the agency's land management planning process. In design-

ing the transportation network, the Forest Service has a legal duty to protect current roadless areas and to examine existing road and trail systems to identify areas that are most susceptible to resource damage resulting from roads and motorized trails and identify priority areas for motorized route closure and decommissioning.

We recommend that the staff of the Lewis and Clark National Forest take the following sequential steps to create a transportation network:

1. Establish criteria that reflect the national forest's conservation purpose. These criteria will guide and inform each stage of the planning process. In general, they should ensure that the Forest Service protects key resources and overall landscape integrity by minimizing motorized routes to those that cause no unnecessary or undue degradation of key resources and landscape integrity.
2. Identify existing individual routes that are necessary and disclose the reasoning behind that necessity.
3. Use habitat fragmentation analysis to evaluate all routes deemed necessary to ascertain their direct, indirect, and cumulative impacts on key biological, physical, recreational, and cultural resources. The evaluation should specifically include calculations of, at a minimum, transportation feature density, transportation effect zones, and the size of core areas around each transportation route.
4. Assess all five alternative networks in the Draft EIS through habitat fragmentation analysis and determine their impacts on under-protected low-elevation vegetative habitat types. Roads or motorized trails that adversely impact key resources or otherwise degrade the landscape must automatically be excluded from alternatives.

- Interpret the results of the habitat fragmentation analysis for each alternative in light of relevant literature concerning the impacts of roads or motorized trails on wildlife. The Forest Service should make the results publicly available, subject them to peer review, and summarize them in the Final EIS.

Specific Recommendations

Transportation management planning for the Rocky Mountain Ranger District must address the full range of effects on terrestrial and aquatic resources across the landscape (Trombulak and Frissell 2000) and the effects on the quality of the recreational experience. Direct, indirect, and cumulative impacts must be disclosed for individual routes and for the collective system of routes within the forest's boundaries *and* across the surrounding broader regional landscape. In too many cases, transportation decisions are made without full understanding of their impacts on the broader landscape within and beyond Forest Service boundaries.

Decisions are frequently made without using readily available spatial technologies such as GIS to assess the impact of motorized transportation routes on forest resources. The result is an inefficient aggregation of routes that requires continued expenditures of taxpayer dollars to maintain and has destroyed valuable public resources. To mitigate current and foreseeable impacts to the District and its ecological, scientific, and cultural resources, our results point to the need for significant route decommissioning and restoration of the landscape's ecological health and integrity.

We strongly recommend that the Lewis and Clark National Forest make aggressive use of the various management tools at its disposal — in conjunction with sound science and the spatial analysis techniques described in this report — to design a protective trans-

portation plan. Below are recommendations that should be incorporated into the environmental impact statement for the proposed revision to the Lewis and Clark National Forest travel plan:

- Develop a conservation strategy that protects rare and underrepresented ecological communities in the Northern Rockies from further loss and/or degradation resulting from motorized use within the Lewis and Clark National Forest and surrounding regions. Underrepresented cover classes include white-bark pine, aspen, ponderosa pine, shrub-dominated riparian, sagebrush, xeric and mesic upland shrub, vegetated sand dunes, grasslands, and grass-dominated riparian.
- Protect relatively undisturbed lower-elevation land cover classes that serve as critical habitat and connections for movement of wildlife between higher- and lower-elevation lands during winter and summer migrations. This can be accomplished in part by banning motorized use in these critical areas (e.g., riparian areas, lower-elevation valley bottoms, and other important wildlife habitats in the Rocky Mountain District that function as important landscape connections for movement by wildlife).
- Designate roadless areas off-limits to motorized use. Roadless areas in the Rocky Mountain Ranger District are relatively undisturbed and function as high-quality mid-to lower-elevation habitat for many wildlife species. These

Key Recommendations

The Forest Service should:

- Develop a conservation strategy that protects rare and underrepresented ecological communities in the Northern Rockies.
- Protect relatively undisturbed lower-elevation land cover.
- Designate roadless areas off limits to motorized use.
- Determine the specific road and motorized trail network and close and restore all other routes that have been used for motorized use.
- Calculate a comprehensive set of habitat fragmentation metrics for each species of interest.
- Ensure that motorized route densities for the road and trail network are lower than those that are known to adversely affect all species of concern and threatened and endangered species.
- Maintain non-motorized core areas of sufficient size to allow life history functions for ungulates and large carnivores.
- Ensure habitat connectivity with adjacent areas that contain important, high-quality habitat.
- Determine the cumulative effects of the route network on wildlife species and habitats for lands within the planning area and for adjacent lands.
- Retain traditional non-motorized uses (hunting, fishing, camping, outfitting, hiking, and more) to assure historically high numbers of big game animals and forest carnivores.

PHOTO BY PETER AENGST



Dearborn drainage, in the central part of Montana's Rocky Mountain Front, typifies the scenic and wildlife-rich landscape where mountain and prairie ecosystems meet. The Forest Service's initial proposed travel plan would open more trails in the drainage to motorized use — to the likely detriment of elk, mule deer, pronghorns, grizzly bears, and other wildlife still found in this area.

areas have important regional ecological importance and motorized recreation needs are already significantly accommodated on other districts of the Lewis and Clark Forest.

- Designate the specific route network for roads and motorized trails. Design and implement a strategy to close and restore all other routes that have been used for motorized use within the planning area.
- Calculate a comprehensive set of habitat fragmentation metrics for each species of interest depending on how close to a transportation feature the species will use habitat (transportation effect zone width) and how large an area of contiguous habitat is required for different life functions (core area size). Then compare the effect zone and core areas spatially to actual habitat data for each species. The measurements can determine the amount of remaining habitat and indicate priority areas to protect and restore. When interpreting these measurements, take into account high levels of natural fragmentation (heterogeneity) and natural barriers to movement within the steep topography of the District.
- Motorized route densities for the road and trail network should be lower than those that are known to adversely affect all species of concern, including those listed as threatened and endangered. When wildlife data are insufficient, management decisions should be made carefully, and monitoring should be implemented until the effects of motorized travel on species are better understood.
- Maintain non-motorized core areas of sufficient size to allow life history functions (breeding, migration, seasonal habitat) for ungulates and large carnivores in the planning area.
- Ensure habitat connectivity with adjacent areas that contain important, high-quality habitat. Those areas include the Bob Marshall Wilderness, state Wildlife Management Areas, Glacier National Park, and other undisturbed lands immediately to the east.
- Determine the cumulative effects of the route network on wildlife species and habitats for lands within the planning area and for adjacent lands, including the Bob Marshall Wilderness, lands administered by the Bureau of Land Management, Glacier National Park, state Wildlife Management Areas, and both state and private lands to the east of the planning area.
- Develop a policy to retain traditional non-motorized uses (hunting, fishing, camping, outfitting, hiking, and more) in the Rocky Mountain Ranger District. The goal should be to maintain historically high numbers of big game animals and forest carnivores as a living example of our western heritage and as a popular place for people to experience unusual wildlife and nature. Such a policy would reduce motorized travel routes leading to elimination of the majority of conflict between non-motorized and motorized uses.

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COVER PHOTOS:
South Fork Two Medicine.
This stream originates high in Montana's
Badger-Two Medicine area.
Photo courtesy of George Wuerthner.

Blackleaf region of Montana's
Rocky Mountain Front.
Photo courtesy of Peter Aengst.



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