

Ecological Effects of a Transportation Network on Wildlife:

**A Spatial Analysis of the
Upper Missouri River Breaks
National Monument**

By

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Preface


Land conservation took a remarkable leap when President William J. Clinton, using the authority of the Antiquities Act of 1906, established 14 national monuments on public lands managed by the Bureau of Land Management (BLM). Now part of the National Landscape Conservation System, these monuments constitute an amalgam of extraordinary and ecologically valuable areas. Federally designated Wilderness, Wilderness Study Areas, Wild and Scenic Rivers, National Conservation Areas, and National Historic and Scenic Trails are the system's priceless jewels entrusted to the BLM's care.

The presidential proclamations that created the monuments also mandated that the agency complete management plans for each of them. Every plan must also include a transportation plan to minimize the impact of access routes on monument resources. "*Ecological Effects of a Transportation Network on Wildlife: A Spatial Analysis of the Upper Missouri River Breaks National Monument*" presents the results of a Wilderness Society study to identify how roads, vehicle trails, and other routes are affecting the wild lands within Montana's new national monument.

GIS Analyst/Programmer Dawn Hartley and Landscape Scientist Dr. Janice Thomson, at our Center for Landscape Analysis in Seattle, applied state-of-the-art spatial analysis techniques to examine the impact of various transportation features. Denver-based Resource Economist Dr. Pete Morton analyzed their findings and interpreted the results for this report. Erik Schlenker-Goodrich of the Western Environmental Law Center added his insightful legal expertise.

Our findings tell an important story. Compelling evidence exists that the current transportation network has had a significant impact on wildlife populations and other fragile resources across the landscape. What is clear is that any viable transportation plan must include route closures and the restoration of route corridors to sustain populations of elk and Greater Sage-grouse, among other wildlife species — and to safeguard the monument's singular archaeological and historic attributes.

Beyond the Upper Missouri River Breaks National Monument and looking to the future, we urge the BLM to incorporate new and creative methods such as those employed in this study as standard practices in land management planning. For only well-informed, scientifically sound decision-making will protect the treasures that comprise our vast National Landscape Conservation System in perpetuity.



William H. Meadows
President
The Wilderness Society



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Report Highlights

The spectacular Upper Missouri River Breaks National Monument in north-central Montana, along the Wild and Scenic Upper Missouri River, was established to preserve the area's outstanding ecological, scientific, and cultural values — from its remote and undeveloped character and archaeological and historic sites to its remarkable wildlife, geologic, and paleontological resources.

Presidential Proclamation 7398, which designated the monument, requires the Bureau of Land Management (BLM) to develop a transportation plan as a component of the resource management planning process. The transportation plan is critical to protection of the monument's unique attributes. Although this monument appears to be a wild, relatively untrammelled place, hundreds of years of human travel and recreation, cattle grazing, mining, and hunting have carved innumerable roads, vehicle trails, and other linear transportation features across the landscape. Given their impacts on habitat quantity and quality, the spread of invasive plants, wildlife mortality, soil erosion, air quality, restoration projects, and archaeological and cultural sites, these transportation features must be carefully managed and minimized in accordance with the monument's preservation purpose. The immediate need to resolve transportation issues in this monument cannot be overstated. It reflects a key management challenge facing the BLM in other national monuments and conservation areas that the agency manages across the country.

Spatial analysis techniques can greatly assist the BLM and the public in the design of a transportation plan that minimizes impacts on the ecological and cultural resources of protected areas, while still allowing adequate access. Spatial analysis is predicated on the recognition that roads, vehicle trails, and other linear transportation features must be managed as a cohesive and interwoven system embedded within a landscape and not as a disjointed aggregation of individual access points.

This report presents three landscape fragmentation analysis methods that the BLM can — and should — use to plan ecologically viable transportation networks. The methods include density analysis of existing transportation network features, buffer analysis to examine the effect zone of the transportation network, and core area analysis to identify habitat that remains unaffected by the transportation network. We applied these analyses to Upper Missouri River Breaks and, in this report, discuss the implications of the results for management of the monument, emphasizing potential impacts on wildlife.

We found that wildlife populations are threatened by landscape fragmentation attributable to existing transportation features. Forty percent of occupied elk habitat in the monument is laced with routes at a density of 0.8 miles/mile². Scientific literature indicates that elk habitat is completely lost at this density. Nearly 100 percent of land in the monument is within two miles of a route. It is known that Greater Sage-grouse within two miles of features constructed by people, including routes, have lower nest initiation rates. More than 86 percent of the 791-mile² monument lies within one mile of a transportation feature, leaving just 111 miles² available as potential habitat for wildlife.

The results of our analyses point out the need for route closures to mitigate current and potential impacts of the transportation network on the monument's resources. This report does not make specific route closure recommendations, but it does present a list of actions to ensure that the transportation plan will enhance, not degrade, the values of the monument. Our recommendations include:

▼
Spatial analysis can greatly assist the BLM and the public in designing a transportation plan that minimizes effects on the monument's ecological and cultural resources.
▲

- The BLM must develop a transportation plan as a key element of the monument's Resource Management Plan, emphasizing protection of the objects of interest articulated in the proclamation and key resources that provide an overall measure of the monument's health and integrity. The transportation plan should consist of two components: (1) a baseline transportation network and (2) an adaptive ecosystem management framework to guide all future transportation management decisions.
- In developing the baseline transportation network, the BLM should conduct a habitat fragmentation analysis that overlays spatial data for objects of scientific and historic interest listed in the monument's proclamation and other key resources with transportation analysis layers similar to those generated for this report. "Wildcat" routes and roads or other transportation features that have adverse impacts on the objects and resources or otherwise cause unnecessary or undue degradation of the landscape must be closed.
- Relevant literature concerning the impacts of routes on wildlife should be used to aid interpretation of the results of the habitat fragmentation analysis.
- All routes designated as open should be geographically distributed in a manner that reduces habitat fragmentation and human contact with sensitive resources to an acceptable minimum threshold.
- Once routes are identified for closure, the Resource Management Plan should include a detailed route closure and restoration strategy. Plan implementation should be consistent with the adaptive ecosystem management framework and include enforceable timelines and a stated commitment to devote a portion of staff time and annual budgets to restoration of closed routes.

Spatial analysis, using mapping software and up-to-date ecological data, is a manageable and essential part of crafting transportation plans that protect wildlife and recreation opportunities and other ecological, scientific, and cultural values. The use of spatial planning analysis in Upper Missouri River Breaks National Monument clearly demonstrates the dramatic impacts of the existing transportation network by illustrating how the network causes fragmentation of critical wildlife habitat. This important information can help guide the BLM and the public in making informed choices for transportation management. We believe it is essential for the BLM to incorporate spatial analysis as a standard step in transportation management planning.

1. Introduction

On January 17, 2001, Presidential Proclamation 7398 designated 149 miles of the Wild and Scenic Upper Missouri River as well as adjacent Breaks country and portions of the Judith River and Arrow and Antelope creeks as the Upper Missouri River Breaks National Monument. The proclamation described the area as “remote and nearly undeveloped” and identified “a spectacular array of biological, geological, and historical objects of interest.”

This marvelous backcountry’s riverbanks and uplands are habitat for more than 60 mammal species, 233 bird species, 20 different amphibians and reptiles, and 48 species of fish, including the federally endangered pallid sturgeon (*Scaphirhynchus albus*) and five special status fish species. Mammals of particular interest are the black-tailed prairie dog (*Cynomys ludovicianus*) a special status species, and big game animals — elk (*Cervus elaphus*) bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*) whitetail deer (*Odocoileus virginianus*) and pronghorn antelope (*Antilocapra americana*)

Among the bird species, the Bald Eagle (*Haliaeetus leucocephalus*) is listed as threatened under the federal Endangered Species Act, and the Peregrine Falcon (*Falco peregrinus*) and Mountain Plover (*Charadrius montanus*) are considered special status species. Many raptors such as eagles, Prairie Falcons (*Falco mexicanus*) and hawks perch and nest on the monument’s cliffs, while four species of upland game birds — Gray Partridge (*Perdix perdix*) Sharp-tailed Grouse (*Tympanuchus phasianellus*) Greater Sage-grouse (*Centrocercus urophasianus*) and Ring-necked Pheasant (*Phasianus colchicus*)— inhabit the grasslands.

Upper Missouri River Breaks is a unique blend of forested coulees and drainages leading down to the Missouri

River and its tributaries. The monument’s ridge tops and benches support the sagebrush/prairie grassland communities typical of Northern Great Plains/Northern Rockies landscapes. The forested draws harbor ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) with a smaller component of Rocky Mountain juniper (*Juniperus scopulorum*). River communities exhibit a wide variety of vegetative types, including cottonwoods (*Populus deltoides*, *P. augustifolia*, *P. trichocarpa*)

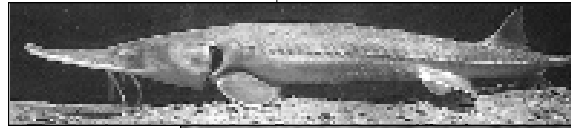


PHOTO COURTESY NEBRASKA GAME AND PARKS COMMISSION



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PHOTO COURTESY DEAN BIGGINS, U.S. FISH AND WILDLIFE SERVICE

The monument’s backcountry riverbanks and uplands are habitat for more than 60 mammal species, 233 bird species, 20 different amphibians and reptiles, and 48 species of fish, including (top to bottom) the federally endangered pallid sturgeon and the black-tailed prairie dog, Peregrine Falcon, and bighorn sheep.



PHOTO COURTESY RICK AND SUSIE GRAETZ

Three species of cottonwood comprise a portion of the riparian vegetation along the Missouri River. One of the few remaining, fully functioning cottonwood gallery forest ecosystems on the Northern Plains is found in the monument. Arrow Creek, a tributary to the Missouri River and included in the monument, is a critical seed source for cottonwood trees along the Missouri's flood plain.

green ash (*Fraxinus pennsylvanica*) silver sagebrush (*Artemisia tridentata*), and black greasewood (*Sarcobatus vermiculatus*) (Hansen et al. 1990).

In addition to its richly diverse wildlife habitat and wild nature, the monument is a source of varied recreational opportunities — not the least of which is the chance to experience a western landscape much as it was years ago when Plains Indians held sway, the Lewis and Clark expedition crossed the land, and fur trappers and steamboat captains negotiated the rivers. The monument protects segments of the Lewis and Clark National Historic Trail, which follows the Missouri River, and the Chief Joseph National Historic Trail, which traverses the area from south to north.

The monument's upstream, western boundaries generally conform to those of the Missouri River, while downstream the monument expands both north and south of the river to include six BLM Wilderness Study Areas, the rugged and remote Bullwhacker coulee area, and other wild places. The BLM manages 590 of the 791 miles² in the monument, while the remaining 201 miles² consist of state lands and private property.¹

The BLM's primary responsibility, as mandated by the monument's proclamation, is to protect the "objects of interest" identified in the proclamation. As part of this responsibility, the agency must prepare "a transportation plan that addresses the actions, including road closures or travel restrictions, necessary to

¹ All analyses for this report were completed using the monument's administrative boundary and did not address ownership patterns within the monument. Square miles are used for all area measurements in this report for unit consistency (1 mile² = 640 acres).

protect the objects identified in this proclamation.” Roads and other transportation features are of major concern because they fragment wildlife habitat, pose a threat to historic and archaeological objects, and destroy opportunities for remote wildland recreation. Given the fundamental significance of the transportation network to management and to public use of the monument, in addition to the network’s profound environmental impacts, the transportation plan must be developed simultaneously with — and as an integral element of — the Resource Management Plan for the monument.

Historically, the BLM has failed to employ spatial analysis effectively in evaluating the direct, indirect, and cumulative impacts of transportation networks on cultural and natural resources. BLM policies pertaining to transportation management are generally limited to maintenance and design stan-

dards for individual routes and provide little or no guidance as to the development and analysis of transportation systems (see, for example, BLM Manual, Section 9113). However, the technology is available and the need is apparent to complete spatial analyses. This report demonstrates the feasibility of using three landscape fragmentation metrics to evaluate the monument’s transportation network at two different scales. Use of spatial analysis technology in Upper Missouri River Breaks is particularly important because of the BLM’s obligation to protect objects of interest in the monument. Based on the results of our spatial analysis, we prepared this report to discuss the implications of transportation networks on the monument’s cultural and natural resources and recommend proactive and necessary management actions to assist the BLM in ensuring that its decisions are reasoned and informed.

Note: Use of the terms “transportation features” and “routes” in this report is intended to encompass all linear features used to access the monument, including “roads.” However, it is important to note that the term “roads” holds a precise legal definition with important management implications: within the monument, all motorized and mechanized vehicle use is to be confined to “roads” formally designated in the Resource Management Plan. We briefly discuss the definition of “road” in our conclusions.

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The BLM’s primary responsibility is to protect the objects of interest identified in the monument’s proclamation.
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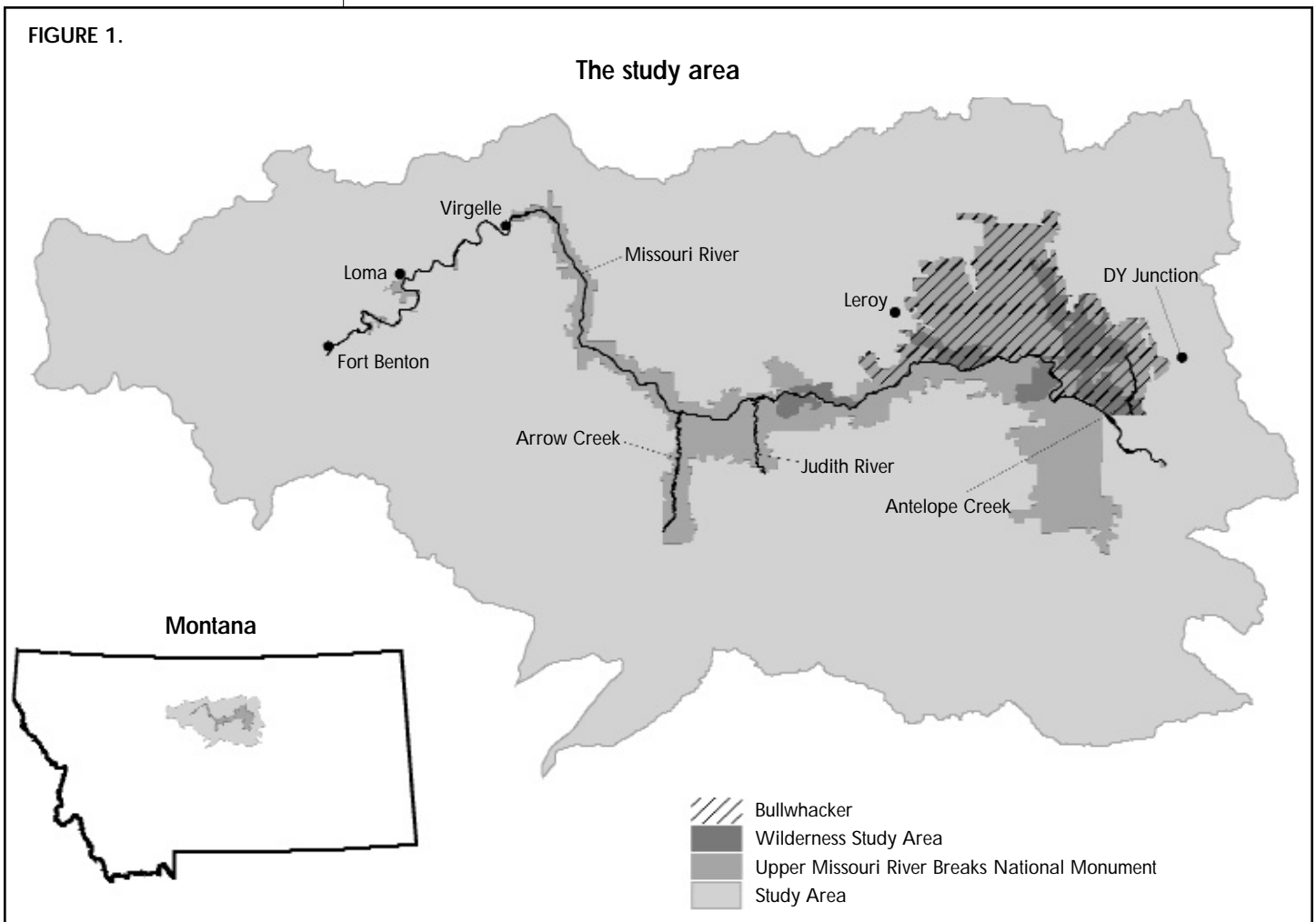
2. Analytical Methods

Data Input

To provide a broader context for our analyses, we defined a study area that encompasses the monument and surrounding landscape. Examination of the monument in a broader context is consistent with the National Environmental Policy Act of 1969, which requires the BLM to analyze the direct, indirect, and cumulative impacts of management actions on the broader landscape, not just

the lands within the administrative boundaries of the monument. Figure 1 displays the study area, which, based on watershed-level hydrologic unit boundaries, is 6,739 miles² in size.

Geographic data for the transportation network were obtained from the U.S. Geological Survey (USGS) in digital line graph (DLG) format.² This dataset contains roads, vehicle trails, and railroads — all features that contribute to landscape fragmentation³ (Figure 2). Because the BLM has not, to date, com-



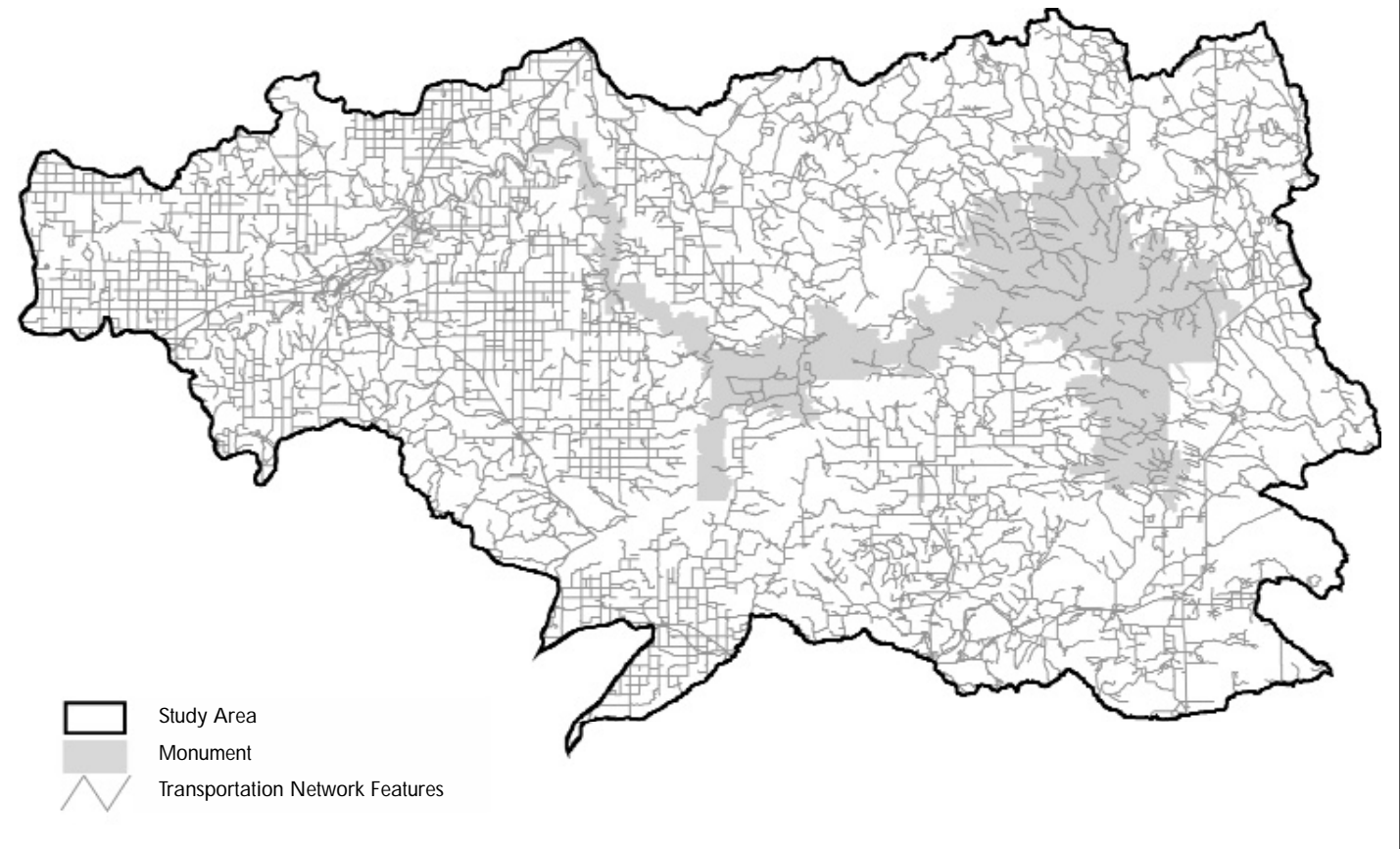
² Transportation feature files for the full extent of the study area boundary were downloaded in spatial data transfer standard (SDTS) format from www.mapmart.com. The individual files were then combined into a single ESRI shapefile using the GlobalMapper software application, available from www.globalmapper.com.

³ Railroads and other minor transportation features are essentially absent in the monument, where they account for less than one percent of the transportation network. In the larger study area, they comprise a little more than two percent of the transportation network.

FIGURE 2.

The physical footprint of the transportation network in the study area

This figure depicts the 7,692 miles of linear transportation features (roads, vehicle trails, and railroads) in the 6,739-mile² study area.



pleted an inventory of roads and trails in the monument, the USGS dataset is the best available.⁴ This dataset is likely to underestimate the mileage of “wildcat” routes created by off-road travel allowed before the monument was designated.

Geographic data for the monument’s boundary and streams were acquired from the BLM.⁵ Species-distribution data layers were obtained from the

Montana State Department of Fish, Wildlife and Parks,⁶ and watershed boundaries were obtained from the Montana State Library’s website.⁷

Methods of Measuring Fragmentation Patterns

Fragmentation has been defined as the “creation of a complex mosaic of spatial and successional habitats from formerly

⁴ While the road and trail inventories are important, it is equally critical to inventory the monument’s objects of interest and key resources that provide an overall measure of the monument’s health and integrity.

⁵ BLM Lewiston Field Office.

⁶ Species distribution data was downloaded in ESRI export format from the Montana State Department of Fish, Wildlife and Parks website at <http://fwp.state.mt.us/insidefwp/fwplibrary/gis/gisdownloads.asp#Wildlife>.

⁷ Montana 5th-Code 11-Digit Watersheds were downloaded in ESRI export format from the Montana State Library’s Natural Resource Information System at <http://nris.state.mt.us/gis/datatop.html>.

▼ We conducted a spatial analysis of the monument and the surrounding landscape to illustrate impacts of the transportation network on the monument's objects of interest and other key resources.



contiguous habitat" (Lehmkuhl and Ruggiero 1991). The degree of fragmentation caused by the transportation network and the effects of such fragmentation on the ecological composition, structure, and functions of a landscape are difficult to measure and far from fully understood. But a variety of landscape metrics have been documented in the scientific literature to help measure the condition of a landscape and its level of fragmentation (McGarigal and Marks 1994).

For our study, we selected three landscape metrics: (1) density of roads and other linear features in the transportation network, (2) amount of habitat within the transportation effect zone, and (3) size of core areas. Each of these landscape metrics is important and relevant to any credible environmental analysis and any decision reached pursuant to such analysis. The analytical work was conducted using commercial geographic information systems (GIS) software from ESRI and custom software developed by The Wilderness Society.

Method #1: Density analysis of transportation features. Density is a measure of the number of miles of linear transportation features per unit area and is a common metric in quantitative assessments of ecological impacts from a landscape perspective. Density analysis provides easily obtainable base-level information to help ensure reasoned and informed decisions.

The density of transportation features was calculated as an average across the monument and overall study area. In addition, the landscape was sub-sampled, using a series of 1-mile² and 4-mile² sampling windows, for both the monument and study area. Measuring density in sampling windows of different sizes provides an understanding of the variability of density across scales. This principle is important to gauge the effects of frag-

mentation 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.

Method #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 feature. Extending this concept to include not just roads, but all features of a transportation network, we defined a "transportation effect zone." The width of the zone depends on the effects measured (for example, noise, dust, erosion, human presence, etc.) and the activity that is affected (for example, Greater Sage-grouse breeding, elk calving, or wilderness experience for hikers).

Analysis of transportation effect zones enhances the credibility and viability of environmental analyses and decisions reached in accordance with such analyses by more accurately disclosing the direct, indirect, and cumulative impacts of fragmentation across the landscape. Ignoring or discounting transportation effect zones reduces and, in some cases, fatally compromises the credibility and viability of environmental analyses and associated decisions.

We examined fragmentation patterns associated with the physical footprint alone and the transportation effect zones of four different widths for the monument and overall study area. The physical footprint of the road was estimated by applying a width of 3.5 meters to the road data, which represents the average width of a single lane road (Trombulak and Frissell 2000). Transportation effect zone data layers were generated by applying widths of 1/4 mile, 1/2 mile, 1 mile, and 2 miles to the transportation features. The zone widths were selected to represent a range of other potential impacts, including noise and hunting.

Method #3: Analysis of core area.

Core areas, sometimes called interior habitat or habitat security, exist in natural landscapes as contiguous blocks of uniform habitat away from habitat edges. Free from fragmentation, communities of native species and ecological functions persist uninterrupted in the core 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. Generally, the larger the core area, the more viable the wildlife habitat. Analysis of core areas is essential to credible and viable environmental analyses, providing valuable information that increases the prospects for reasoned and informed decisions.



MONTANA WILDLIFE FEDERATION

Vehicle trail across uplands habitat in the monument. Many such trails across the monument's landscape create barriers to wildlife movement and break up important wildlife habitat.

▼ Depending on the width of the transportation effect zone, the transportation network affects between 32 and 99 percent of the monument and between 46 and 99 percent of the overall study area. ▲

3. Results

Density of transportation features

The monument's administrative boundary covers approximately 791 miles² and captures 523 miles of linear transportation features. This represents an average transportation feature density of 0.7 miles/mile². Within the 6,739-mile² study area, there are 7,692 miles of linear transportation features, for a transportation feature density of 1.1 miles/mile².

Transportation feature density estimates are scale dependent, however, and vary across any landscape. Densities measured within 1- and 4-mile² sampling windows illustrate the spatial variation in feature density across the monument and overall study area (Table 1 and Figure 3).

Results show that in the 1-mile² sampling windows, densities range from a high of 9.3 miles/mile² to a low of 0.0 miles/mile² for the monument and from a high of 9.2 miles/mile² to a low of 0.0 miles/mile² for the study area. In the 4-mile² sampling windows, densities range from a high of 6.8 miles/mile² to a low of less than 0.1 miles/mile² for the monument and from a high of 6.1 miles/mile² to a low of 0.0 miles/mile² for the study area.

The transportation feature densities calculated for the 1-mile² sampling win-

dows were compared to maps of occupied elk habitat within the monument. Based on this overlay analysis, we found that just over 50 percent of the habitat has transportation feature densities greater than 0.5 miles/mile², and 40 percent has feature densities greater than 0.8 miles/mile². Furthermore, 35 percent of the monument's occupied elk habitat has transportation feature densities greater than one mile/mile², and 6 percent of the habitat contains transportation features at greater than two miles/mile². The maximum route density within occupied elk habitat was 4.3 miles/mile², based on the 1-mile² sampling window.

Analysis of the transportation effect zone

The physical footprint of the transportation network in the monument covers approximately 1 mile², or less than one percent of the monument. Within the study area, the physical footprint is 16 miles², representing less than one percent of the study area. Beyond this area of direct impact are the different transportation effect zones that affect 32 to 99 percent of the monument (Table 2 and Figure 4). Results for the overall study area, also included in Table 2, show that 46 to 99 percent is affected, depending on the size of the transportation effect zone.

TABLE 1.

Summary of density analysis

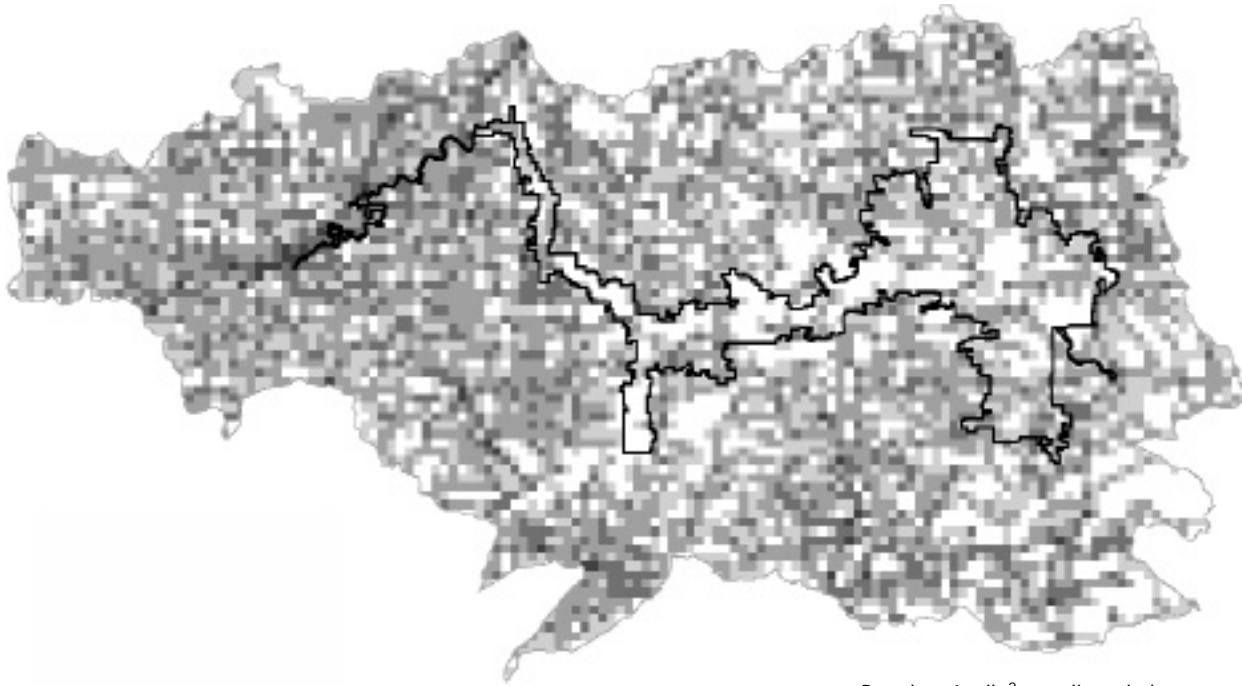
Percent of monument and study area containing different densities of transportation features for two sampling window sizes.

Feature Density mile/mile ²	MONUMENT		STUDY AREA	
	1-mile ² window (%)	4-mile ² window (%)	1-mile ² window (%)	4-mile ² window (%)
0	34	9	21	5
0-1	30	63	28	48
1-2	28	26	36	39
2-4	7	1	14	7
>4	<1	<1	<1	<1

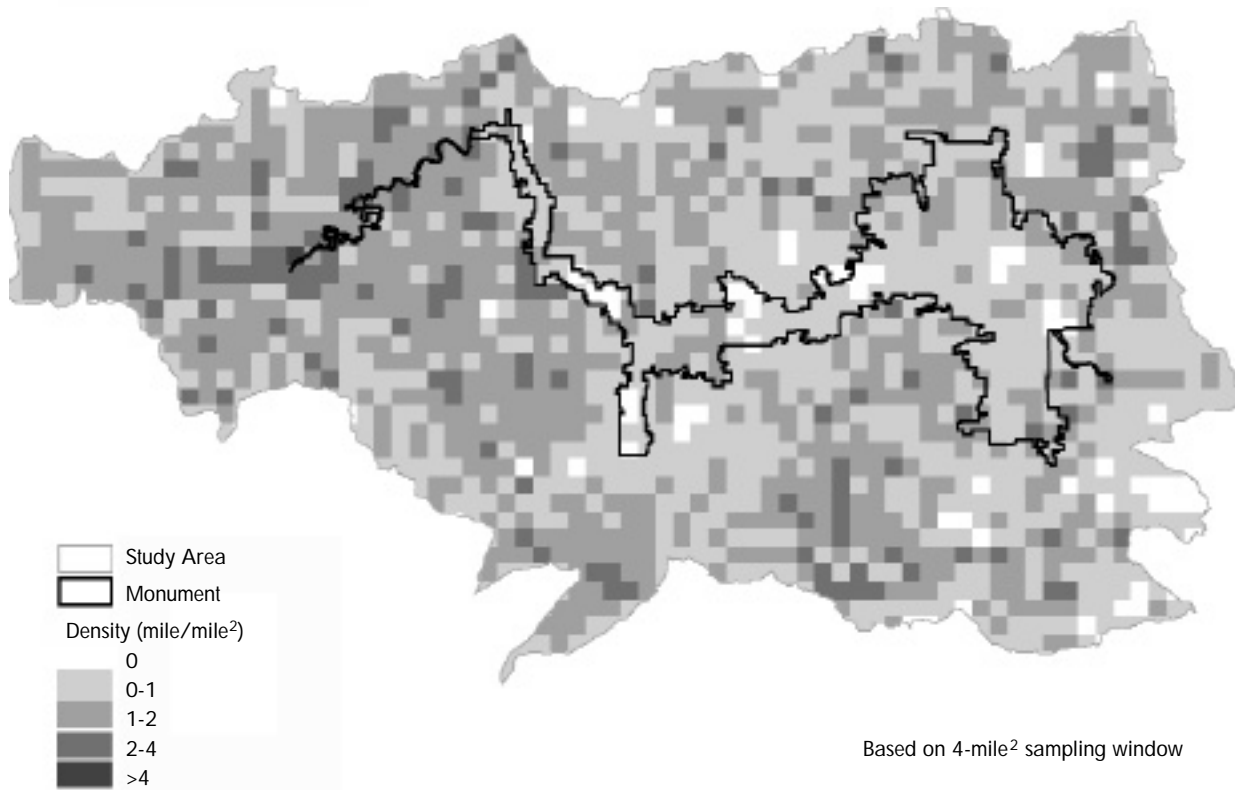
FIGURE 3.

Density of transportation network features in the study area

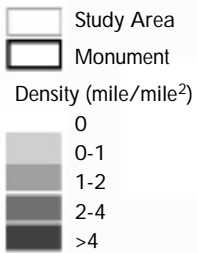
Calculated for 1-mile² and 4-mile² sampling windows. The darker the shading, the higher the transportation feature density.



Based on 1-mile² sampling window



Based on 4-mile² sampling window



Analysis of the core area

The total core area within the monument ranged from a high of 790 miles² with no effect zone around the transportation network to a low of 7 miles² based on the 2-mile transportation effect zone width. Similarly, core area ranged from 6,722 miles² to 28 miles² within the overall study area.

The results, summarized in Table 3 and illustrated in Figure 5, show that as the transportation effect zone width increases, the total core area *and* the number and

maximum size of core areas decrease. In the monument, the mean size of core areas also decreases. In the study area, this is also generally true except for an apparently anomalous increase for the 2-mile transportation effect zone, likely due to the elimination of smaller core areas as one moves from the 1-mile to the 2-mile zone.

Using the 1-mile effect zone within the monument, the remaining core area lies mostly along the Wild and Scenic Missouri River corridor and the area in the vicinity of Arrow Creek.

TABLE 2.

Summary of transportation effect zone analysis

Transportation effect zones have impacts on widely varying areas of the monument and study area depending on the type of impact and, consequently, the width of the zone being measured.

	Physical footprint	TRANSPORTATION EFFECT ZONE WIDTH			
		1/4 mile	1/2 mile	1 mile	2 miles
Monument					
Zone area (miles ²)	1	251	458	680	784
% in zone	<1	32	58	86	>99
Study Area					
Zone area (miles ²)	16	3,079	4,956	6,314	6,711
% in zone	<1	46	74	94	>99

TABLE 3.

Summary of core area analyses

As the width of the transportation effect zone increases, the number of core areas, maximum core area size, and total core area decreases. The mean size of core areas decreases throughout the monument and generally in the overall study area.

	Physical footprint	TRANSPORTATION EFFECT ZONE WIDTH			
		1/4 mile	1/2 mile	1 mile	2 miles
Monument					
# of core areas	151	114	110	44	7
Maximum core size (miles ²)	254	174	49	18	2
Mean core area size (miles ²)	5.2	4.7	3.0	2.5	1.0
Total core area (miles ²)	790	541	334	111	7
% of monument	> 99	68	42	14	< 1
Study Area					
# of core areas	2,191	1,480	1,057	256	15
Maximum core size (miles ²)	353	232	101	40	14
Mean core area size (miles ²)	3.1	2.5	1.7	1.7	1.9
Total core area (miles ²)	6,722	3,659	1,782	424	28
% of study area	> 99	54	26	6	< 1

FIGURE 4.

Transportation network effect zones

Two examples of transportation network effect zones based on zone widths of $\frac{1}{4}$ mile and 2 miles. Shading indicates the extent of the study area that is affected by the transportation network.

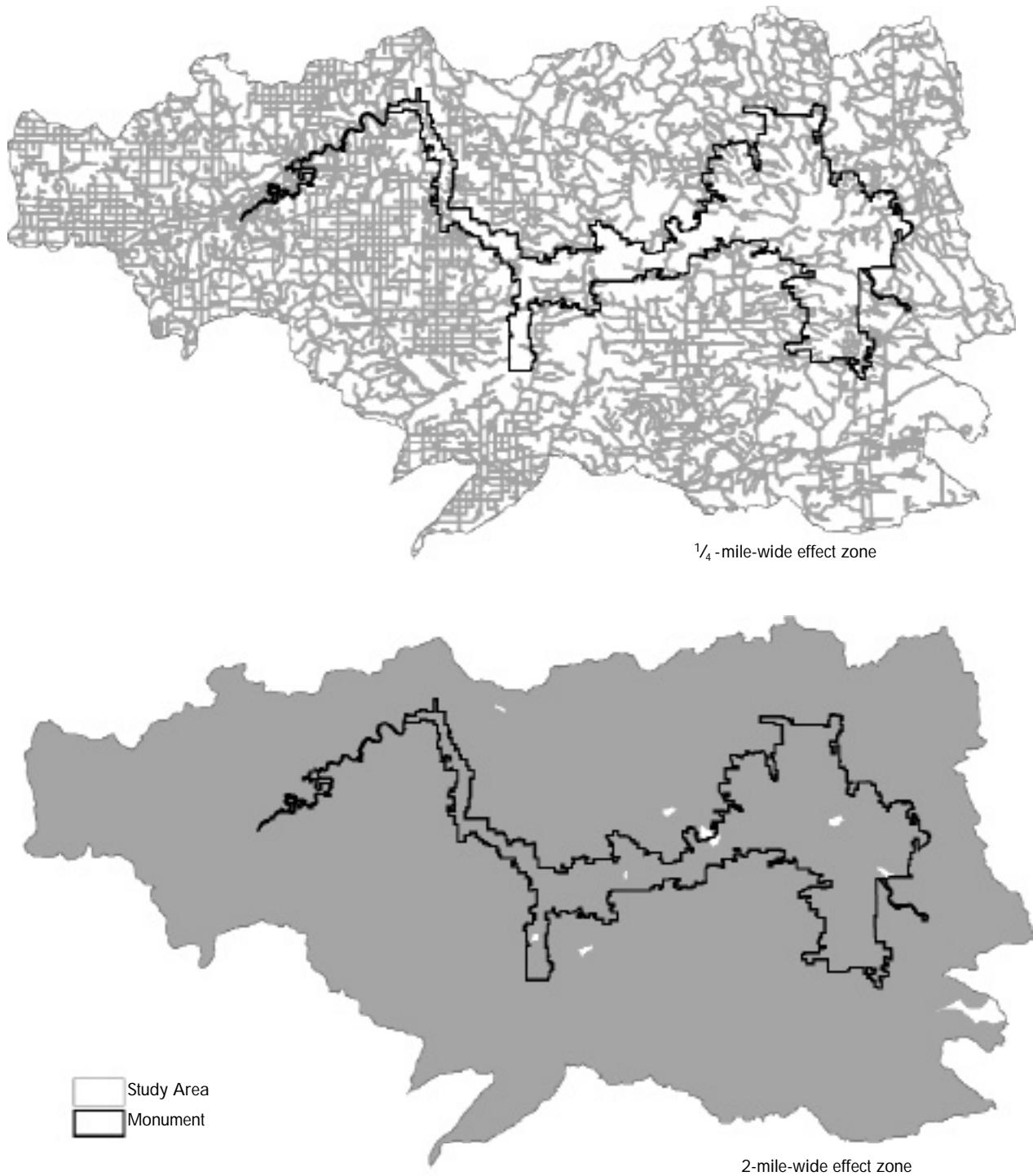


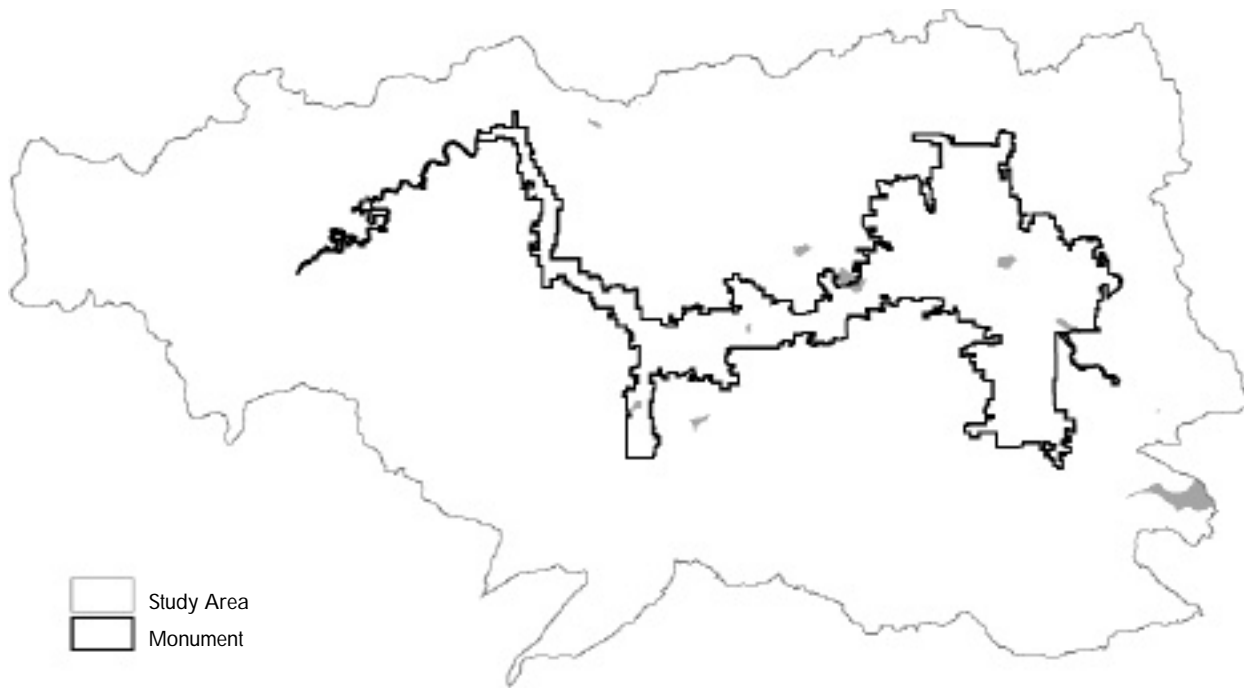
FIGURE 5.

Core areas beyond transportation network effect zone



Two examples of core areas (shading) that lie beyond relatively narrow ($1/4$ -mile) and wider (2-mile) transportation network effect zones.



Core areas beyond $1/4$ -mile-wide effect zone



Core areas beyond 2-mile-wide effect zone

 Study Area
 Monument

4. Implications for Management and Conservation

Transportation planning is one of the most significant challenges facing the BLM in the development of Resource Management Plans for national monuments. Transportation features facilitate legitimate access needs such as recreation and public safety, but these needs must be balanced against the requirement to protect the objects identified in a monument's proclamation and other key resources.

Objects and values identified in the proclamation for Upper Missouri River Breaks National Monument are:

- abundant wildlife (including 233 bird species, more than 60 species of mammals, 20 amphibians and reptiles, and 48 species of fish);
- unique plant life (healthy and diverse riparian zones and one of the few remaining, fully functioning cottonwood gallery forest ecosystems on the Northern Plains);
- remote and undeveloped character (especially the wild Bullwhacker area and six Wilderness Study Areas);
- cultural and historic sites (including the Lewis and Clark National Historic Trail, Nez Perce National Historic Trail, and prehistoric sites of archaeological interest); and
- unique geologic features (cliffs, arches, hoodoos, and breaks).

The effects of transportation features on terrestrial and aquatic wildlife are documented by Trombulak and Frissell (2000) and include mortality from collisions, modification of animal behavior, disruption of the physical environment, alteration of the chemical environment, spread of exotic species, and changes in human use of the lands and water. Specific examples include habitat loss and fragmentation; diminished animal use of habitats because of noise, dust

emissions, and the presence of humans; loss of forage for herbivores; interference with wildlife life-history functions (for example, courtship, nesting, and migration); spread of non-native species carried by vehicles; increased poaching or unethical hunting practices; increased recreation, particularly by off-road vehicles; and degradation of aquatic habitats through alteration of stream banks and increased sediment loads. Transportation access also increases vandalism, theft, and damage to archaeological and cultural sites.

Reductions in the number and size of core areas and increased edge habitat created by transportation features lead to a series of potentially intersecting and cumulative adverse effects on species that depend on natural interior landscapes. Included among such effects are greater competition with species that prefer edge habitat or openings in the landscape, nest predation and parasitism, secondary extinctions from the loss of keystone species, progressive loss of patches through edge creep, and changing microclimates such as increased evaporation, temperature, and solar radiation and decreased soil moisture (Franklin and Forman 1987, Lehmkühl and Ruggiero 1991, Reed et al. 1996).

To protect the objects and values listed in the proclamation and comply with its obligations under the National Environmental Policy Act of 1969, the BLM should conduct spatial analyses of the potential negative effects of transportation features on the objects of interest and other key resources and values that serve as an overall measure of the monument's health and integrity. Spatial analyses provide critical information essential to all reasoned and informed management decisions for the monument.

To illustrate the value of spatial analysis, we first compare the impact of transportation features within the monument to impacts on the larger, surrounding study

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There is much that should be done to reduce fragmentation of the monument's habitat caused by the transportation network and thus increase the monument's value to wildlife.
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PHOTO COURTESY RICK AND SUSIE GRAETZ

Cow Island, an historically important site in the monument. Lewis and Clark passed through this area in 1805; 72 years later, Chief Joseph and the Nez Perce crossed the Missouri River at Cow Island during their epic journey to Canada.

area. Next, we look within the monument to briefly examine the potential impacts of the monument's transportation network on big game species (elk, bighorn sheep, mule deer, whitetail deer, and pronghorn antelope) and the Greater Sage-grouse and black-tailed prairie dog. While these brief analyses provide adequate guidance for some management recommendations, substantially more information is needed for a complete assessment of wildlife in

the monument and to make specific recommendations for road closures. We also summarize the potential impacts of transportation features on water resources and wilderness recreation opportunities.

We emphasize that information is sorely lacking in regard to the monument's objects of interest and other key resources. Because such information is essential to reasoned and informed management choices, it is incumbent upon the BLM to collect the information or justify why such data and information were not obtained as part of the resource management planning process.⁸ In either case, the burden of proof is on the agency to justify management decisions and, where such information is lacking, to establish a process to collect the information, act cautiously, and defer to the side of conservation.

Context of the Monument

Examination of Figures 3 through 5 reveals the value of the monument in the context of the study area. It is apparent in Figure 3 that transportation feature densities are generally lower in the eastern portion of the study area, where the majority of the monument is located and that the monument contains relatively few higher-density sampling windows compared to the rest of the study area. This is statistically substantiated for both the 1- and 4-mile² sampling windows.

The transportation effect zones in Figure 4 and core areas in Figure 5 also show that the transportation network affects the monument less than the surrounding study area. For example, in the 1/4-mile transportation effect zone, 74 percent of the study area is impacted by the transportation network compared to 58 percent in the monument. This corresponds to 26 percent core area in the study area and 42 percent core area in

⁸ 40 C.F.R. § 1502.22(b)

the monument. It is also important to note that the mean core size of 3.0 miles² is larger in the monument than the 1.7-mile² mean core area size in the study area for the 1/2-mile transportation effect zone.

The greater proportion of core area in the monument clearly indicates the monument's high value to wildlife relative to habitat available in the surrounding study area. Still, there is much that should be done to reduce fragmentation of the monument's habitat caused by the transportation network and thus increase its value to wildlife.

Big Game Wildlife Species. As the density of transportation features increases, big game species suffer from greater hunting pressure and reduced habitat security caused by fragmentation and associated disturbance (Lyon 1983, Hurley 1994, Canfield et al. 1999).

According to Lyon (1983), elk avoid routes and do not fully use habitat adjacent to routes. Lyon found that when route densities are as low as 1 mile/mile², which represents approximately 35 percent of the monument's occupied elk habitat, elk habitat effectiveness is reduced by 25 percent. At 2 miles/mile², which accounts for approximately 6 percent of the monument's occupied elk habitat, elk are displaced from up to 50 percent of their habitat.

Route avoidance by wildlife is particularly evident in open landscapes with little surrounding vegetation (Perry and Overly 1976, Morgantini and Hudson 1979, Rost and Bailey 1979) such as that found in the monument. In areas with little cover, habitat is completely lost at a route density of just 0.8 miles/mile² (Lyon 1979), which accounts for 40 percent of the monument's occupied elk habitat.

The effect on elk from transportation features in the broad, open sagebrush and grassland areas of the monument warrants particular attention. A study on



elk habitat effectiveness in north-central Wyoming found that few elk used areas with route densities higher than 0.5 miles/mile² (Sawyer et al. 1997). Just over 50 percent of the monument's occupied elk habitat has transportation feature densities greater than 0.5 miles/mile².

As the volume of traffic on routes increases, elk tend to occupy habitat further from routes (Johnson et al. 2000). This may be an issue at the monument as visitation rises. Further, human disturbance during the calving season reduces elk calving success rates (Phillips and Alldredge 2000). Ward (1976) discusses the importance of retaining a buffer of trees around a route to minimize the displacement of elk and suggests buffers of 100 meters between a route and elk feeding site.

Antelope, bighorn sheep, and deer are also affected by human disturbances across a landscape. The BLM found that antelope exhibited signs of the impacts of oil and gas projects with "nearly one mile of road per every square mile of occupied habitat" (Bureau of Land Management 1999). Similarly, a study conducted in North Dakota found that mule deer avoided feeding and bedding in areas within 300 feet of well sites, resulting in a 28-percent reduction of

In their occupied habitat, pronghorn antelope are known to be affected by a route density of 1 mile/mile².

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One study showed that few elk use areas with road densities higher than 0.5 miles/mile². We found that more than 50 percent of the monument's occupied elk habitat has transportation feature densities greater than 0.5 miles/mile².
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PHOTO COURTESY GARY KRAMER, U.S. FISH AND WILDLIFE SERVICE



The monument provides essential winter habitat for the Greater Sage-grouse. This special status species is affected by routes and other structures for miles beyond the actual physical features.

secure bedding areas (Jensen 1991). The deer avoided routes and other human structures for more than seven years, indicating long-term and chronic loss of habitat. Of the five big game species, Canfield et al. (1999) found that bighorn sheep appear to be the most susceptible to the detrimental effects of human disturbance.

Greater Sage-grouse. The Proclamation states that the monument “contains essential winter range for sage grouse,” a special status species whose breeding populations have declined by as much as 47 percent in some areas (Connelly and Braun 1997). Greater Sage-grouse depend on sagebrush habitat (Patterson 1952, Braun et al. 1977, Braun 1987, Connelly et al. 2000), particularly during winter when they feed almost exclusively on sagebrush leaves (Patterson 1952, Wallested 1975).

This bird is affected by human disturbance for miles beyond the actual physical features. A recent study in Wyoming (Lyon 2000) compared the behavior of females captured on leks (strutting or mating grounds) within two miles of human developments to those captured on undisturbed leks more than two miles from any development and found that the hens captured on disturbed leks had lower nest-initiation rates and moved longer distances to nest sites than hens captured on undisturbed leks. Our analysis of the transportation effect zone indicates that 99 percent of the monument is within two miles of a linear transportation feature, suggesting that lek disturbance is potentially significant.

Black-tailed Prairie Dog. The black-tailed prairie dog is recognized as a keystone species in the grassland environment because of its unique and significant influences on the ecosystem (Van

Pelt 1999) and is a candidate for listing as threatened under the federal Endangered Species Act of 1974. Monument prairie dog towns serve as important actual and potential habitat for numerous other special status species, including Ferruginous Hawks (*Buteo regalis*), Mountain Plovers, Burrowing Owls (*Athene cunicularia*) and black-footed ferrets (*Mustela nigripes*).

This important animal has long been treated as a varmint and subjected to recreational shooting. High-powered rifles enable consistent accuracy at distances of 400 yards or more, and just one hunter may kill a considerable number of prairie dogs on any given day (Knowles 1995, Van Pelt 1999). Although prairie dog habitat data were not available for this study, the 1/4-mile (approximately 440 yards) transportation effect zone should be compared in future analyses of Upper Missouri River Breaks to the locations of known prairie dog colonies and potential habitat.

Water Resources and Riparian Habitat. Routes running near or through riparian strips can lead to fragmentation of riparian habitat and cause species to avoid riparian areas (Gaines et al. in press). Routes and bridges near streams can change the patterns of surface or subsurface flow, which, in turn, can harm plants or wildlife that depend on natural flow patterns, increase stream sedimenta-



U.S. FISH AND WILDLIFE SERVICE

The black-tailed prairie dog is a candidate for listing as threatened under the federal Endangered Species Act.

tion and turbidity, and reduce fish productivity. Additional effects include alteration of hydrodynamics and sedimentation with resulting negative impacts on shorelines for miles upstream and downstream, changes in wildlife migration patterns that reduce distribution and productivity, and changes in aquatic plant assemblages because of altered nutrient levels or chemicals introduced by routes (Trombulak and Frissell 2000). Water and riparian habitat are prominent features of the monument, and managers must take care to avoid negative impacts from routes.

Wilderness Recreation

Opportunities. Outdoor recreation increased substantially in the United States during the past 50 years (Tempel et al. 2003), and Upper Missouri River Breaks has the potential to provide world-class non-motorized and wilderness recreation experiences. Remote wildlands provide a range of benefits to recreation and outdoor enthusiasts, including “personal development (spiritual growth, improved physical fitness, self-esteem, self-confidence and leadership abilities); social bonding (greater family cohesiveness and higher quality of family life); therapeutic and healing benefits (stress reduction helping to increase worker productivity and reduce illness and absenteeism at work); and social benefits (increased national pride)” (Morton 2000).

Many forms of high-quality non-motorized recreational opportunities, including hiking, camping, rafting, canoeing, horseback riding, wildlife viewing, hunting, and fishing, require core areas well away from motorized access. Currently, just 14 percent of land in the monument is more than a mile from a transportation feature, suggesting a need to consider route closures to improve wilderness recreation opportunities.

Future Analytical Priorities. This analysis of habitat fragmentation does not account for features unrelated to the transportation network that fragment the landscape, nor did it address habitat connectivity, variations in scale, differences in types of transportation features, or seasonal variations in species’ popula-



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tions. Other human constructions and even natural features such as topography contribute to habitat fragmentation and should be assessed along with the transportation network. It is important to consider the connectivity of patches when assessing fragmentation because the size and number of core areas may matter little to a species if it cannot migrate among them.

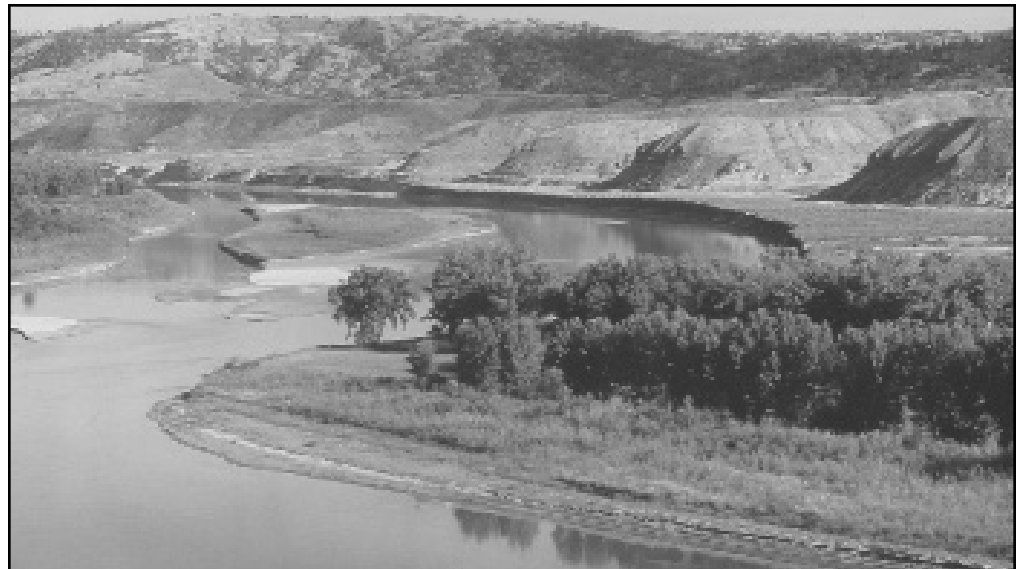
A multi-scale assessment of spatial pattern change is essential to understand changes in ecosystem functions (Hessburg et al. 1999) and could be accomplished by further varying the sampling window sizes across the landscape to relate to specific wildlife

Many forms of high-quality recreation require core areas away from motorized access. Just 14 percent of land in the monument is more than a mile from a transportation feature, suggesting a need to consider route closures to improve wilderness recreation opportunities.

activities or ecosystem processes. In this context, we encourage the BLM to make use of its own policies that emphasize the importance of assessing issues at multiple scales to ensure that decisions are properly informed and tailored to specific needs and circumstances (see BLM Land Use Planning Handbook, H-1601-1 (II) (D)).

This study did not account for the different degrees of physical impact on the ecosystem that a road may have compared to, say, a vehicle trail or for variations in use of roads and trails. And this analysis did not address the effect of seasonal use on transportation features, wildlife, or recreation — for example, whether a species’ tolerance for and use of habitat changes during different seasonal activities or whether human use of some transportation corridors varies by season.

A more comprehensive assessment of fragmentation metrics should be recalculated for each species (or suite of 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). Such an assessment ensures that the underlying environmental analysis constitutes the “hard look” required by the National Environmental Policy Act of 1969. As one example, if a species prefers to stay 300 feet from routes and/or clear-cuts, a 300-foot transportation effect zone should be used to evaluate the potential core areas. With such species-specific metrics, the measurements can determine the amount of remaining habitat and indicate priority areas to protect and restore wildlife habitat affected by fragmentation.



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There is much to learn about the monument’s resources, and it is incumbent upon the BLM to gather needed information for use in resource management and transportation planning.

5. Conclusions

The viability of the Upper Missouri River Breaks National Monument and its ecological, cultural, and scientific resources depends on the management strategy — and in particular, the transportation plan — adopted by the BLM as part of the Resource Management Plan for the monument. Transportation management must address the full range of terrestrial and aquatic impacts across the landscape (Trombulak and Frissell 2000) and impacts 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 — in both the monument and its broader regional landscape.

This report demonstrates the importance of using sound science and spatial analysis to guide the transportation plan. In too many cases, transportation decisions are guided by an ill-informed and inadequate understanding of the impacts to the broader landscape. The result is an inefficient and highly damaging aggregation of routes that requires continued expenditures of taxpayer dollars and destroys valuable public resources. To mitigate current and foreseeable impacts to the monument 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 BLM 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 transportation plan. Distilled to their essence,

we recommend that the agency incorporate the following basic principles into the transportation plan (for more information concerning legal provisions governing the BLM that are cited in this report, see Schlenker-Goodrich 2003).

- The transportation plan must advance the protective purposes of the national monument and thus minimize routes to only those necessary for use of and access to the monument and that cause no unnecessary or undue degradation of the monument.
- Any feature identified as a “road” in the transportation plan must meet the legal definition of a road as set forth in the legislative history of the Federal Land Planning and Management Act of 1976.⁹ This automatically precludes the inclusion of “wildcat” routes.
- Each road must be justified and managed through the proper level of analysis (centered on the objects of scientific and historic interest and other key resources) required by the National Environmental Policy Act, taking into account the spatial pattern of roads and not just mileage.
- Each road must be deemed in fact necessary for specified and defined uses of the monument.
- Procedures and standards must be incorporated to close and reclaim roads and routes that are not justified, do not meet the definition of a road, or for which specified uses have been completed.

To best realize these principles, we recommend a transportation plan that consists of two interdependent components: (1) an initial, baseline transportation system and (2) an adaptive ecosystem

⁹ The legal definition of road for public lands managed by the BLM is derived from the definition of ‘roadless’ in the legislative history of FLPMA: “The word ‘roadless’ refers to the absence of roads which have been improved and maintained by mechanical means to insure relatively regular and continuous use. A way maintained solely by the passage of vehicles does not constitute a road.” (H.R. Rep. No. 94-1163 at 17 (1976)).

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Incorporating spatial
analysis in
transportation
management
planning will help
the BLM meet its
obligations to protect
resources in Upper
Missouri River
Breaks National
Monument and other
lands that the
agency manages.
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 A protective transportation plan is the best hope of ensuring the monument's long-term health while providing public access to this splendid, irreplaceable landscape.
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management framework designed to guide and inform the public and the BLM in all future transportation management decisions. Consistent with the monument's protective purpose, a protective transportation plan provides the best hope of ensuring the monument's long-term health and integrity while providing the public with access to use and experience this splendid, irreplaceable landscape.

Establish and Assess a Baseline Transportation System

The first component of the transportation plan consists of a baseline transportation network designed during the resource management planning process. The BLM should take the following sequential steps to create this network:

1. Establish criteria¹⁰ to reflect the monument's protective purpose to identify routes necessary for access and use of the monument. These criteria will guide and inform each stage of the planning process. In general, they should ensure that the BLM protects and restores the objects of interest, key resources, and overall landscape health and integrity by minimizing routes to only those necessary for use of and access to the monument and which cause no unnecessary or undue degradation of the monument.¹¹ Specifically:
 - Routes should be evaluated in light of ground-truthed digital spatial data obtained for the objects of interest and other key resources that indicate overall land health and integrity or otherwise require heightened legal protection.
 - Designated routes should be geographically distributed in a manner that reduces habitat fragmentation and contact with key resources, in particular the objects of interest identified in the proclamation.

- Individual routes must in fact be designated, and the Resource Management Plan must identify the allowable uses of the route (as examples, general public, recreation, administrative) and the allowable intensity of that use. As per the proclamation, motorized and mechanized travel must be confined to designated roads; that is, routes meeting the definition of "road" as per the legislative history of the Federal Land Policy and Management Act of 1976. For administrative routes (including rights of way for lessees and private inholdings), use should be limited to the stated administrative purpose, and the route should be automatically closed and scheduled for reclamation once the administrative purpose ends.
 - All unnecessary routes such as redundant routes and routes with little or no use, all "wildcat" routes, and all routes that adversely impact the objects of interest articulated in the proclamation or cause undue degradation to the landscape, even if the route is otherwise necessary, must automatically be closed and scheduled for reclamation.
 - All routes not incorporated into the final transportation system must be closed and scheduled for decommissioning. This requires a detailed route closure and restoration strategy, complete with timelines and a stated commitment to devote staff and a portion of annual budgets to restoration of closed routes. To discourage resource degradation and provide clear information to the public, routes scheduled for decommissioning should not be placed on official monument maps.
2. Aggregate in digital format and ground-truth existing data concerning the objects of interest and key

¹⁰ 43 C.F.R. § 1610.4-2

¹¹ 43 U.S.C. § 1732(b)

- resources.¹² Where existing data for the objects and resources are incomplete or unavailable, the agency should aggressively inventory the monument to obtain such data, in particular where the data are essential to a reasoned choice among alternatives and the overall costs are not exorbitant.¹³
3. In accordance with the established criteria (see 1. above), identify existing individual routes necessary for use and enjoyment of the monument. The BLM should disclose why each route deemed “necessary” is, in fact, necessary.
 4. Use habitat fragmentation analysis to evaluate¹⁴ 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.
 5. Devise several alternative transportation networks¹⁵ based on the evaluation of existing routes and subsequently assess each alternative network through habitat fragmentation analysis. Roads or other transportation features that adversely impact the objects of interest or key resources or otherwise unnecessarily or unduly degrade the landscape must automatically be excluded from each of the alternatives.
 6. Interpret the results of the habitat fragmentation analysis for each alternative in light of relevant literature concerning the impacts of roads on wildlife.¹⁶ The BLM should make the results publicly available, subject them to peer review, and summarize them in the Environmental Impact Statement accompanying the Resource Management Plan.
 7. Identify and propose a preferred transportation system from the range of alternatives.¹⁷ The BLM’s choice should be driven by the agency’s paramount duty to advance the protective purposes of the monument.
 8. Establish an adaptive ecosystem management framework to implement the transportation system and to guide and inform the public and the BLM with regard to all future transportation-related decisions.

Establish and Implement an Adaptive Ecosystem Management Framework

The second component of the transportation plan consists of an adaptive ecosystem management framework that provides the means to deal with the inherent uncertainty in management of public lands. Adaptive ecosystem management directs the BLM to continuously collect and update information and apply that information to existing and future decisions. The goal is to ensure that environmental considerations are taken into account, along with economic and technical considerations, even when information is incomplete or unavailable.¹⁸ In Upper Missouri River Breaks National

¹² 43 C.F.R. § 1610.4-3

¹³ 43 U.S.C. § 1711(a); 40 C.F.R. § 1502.22(a)

¹⁴ 43 C.F.R. § 1610.4-4

¹⁵ 43 C.F.R. § 1610.4-5

¹⁶ 43 C.F.R. § 1610.4-6

¹⁷ 43 C.F.R. §§ 1610.4-7, 1610.4-8

¹⁸ 42 U.S.C. § 4332(2)(B); 43 U.S.C. § 1711(a); 40 C.F.R. § 1502.22; 43 C.F.R. § 1610.4-9

Monument, we recommend the following elements for an adaptive ecosystem management framework:

- Aggressive inventories of the various natural and cultural resources of the monument and enforceable monitoring and evaluation requirements to track use and management of the baseline transportation system. All data collection should be standardized and scaleable to facilitate decision-making at multiple geographic and time scales.
- Use of Resource Management Plan-level habitat fragmentation analysis as a living, baseline analysis. Information collected through inventories, monitoring, and evaluation should be routinely incorporated into the analysis to ensure that it is up to date. Implementation-level decision-making should incorporate the Resource Management Plan-level analysis into decisions, refining the analysis within an ecologically defined project area identified for each decision.
- Criteria (within the Resource Management Plan) for all implemen-

tation-level decisions, including criteria and timelines for route closures and decommissioning and all route maintenance and construction work. These criteria should be consistent with the initial planning criteria used to identify the baseline transportation system. Quantifiable thresholds should be identified for each landscape metric that, when crossed, trigger or prohibit specific action on the part of the BLM, both at the Resource Management Plan and implementation levels. The thresholds can be used as a floor to allow development of more refined and, if appropriate, more stringent thresholds at an ecologically defined implementation-level scale.

- A prioritized route decommissioning schedule that is implemented through a committed portion of the monument's staff and annual budget. Prioritization of the schedule should be based principally on the direct, indirect, and cumulative harm caused by the identified route. While factors such as budget and staff should be factored into the equation, they must not be used as excuses to evade the decommissioning process.

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