OPPORTUNITIES FOR COORDINATED ROAD MANAGEMENT ON PUBLIC LANDS FOR PURPOSES OF ECOSYSTEM MANAGEMENT: THE CASE OF THE GREATER YELLOWSTONE ECOSYSTEM

by

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A thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of MASTERS in URBAN AND REGIONAL PLANNING

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(ABSTRACT)

Committee Chairman: John Randolph
Urban Affairs and Planning

This study examines opportunities for coordinated road
management for purposes of ecosystem management. The
coordination efforts in Greater Yellowstone provide a case
study illustrating these opportunities.

The study first reviews current literature about
ecosystems, ecosystem management goals, benefits and the
application of the concept to Greater Yellowstone. Issues
of forest road management are also examined.

The study then turns to a critique of current road
management efforts in six National Forests of northwest
Wyoming, southwest Montana and eastern Idaho; which are
considered part of the Greater Yellowstone Ecosystem.
Comparisons of road management planning and policy will be
made primarily through examination of forest plans and
engineering policies, and through personal communication
with forest highway engineers and transportation planners.
Recommendations for improving coordination of forest road
management follow the critique.
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I INTRODUCTION

Current Coordination Efforts in Greater Yellowstone

Conservationists around the world have their eyes on Yellowstone. A new initiative is underway that may change the way large areas of undisturbed public lands are managed. Public land managers are realizing the need to coordinate their efforts and broaden their scope beyond traditional jurisdictional boundaries.

Since the 1960s, Park Service superintendents and Forest Service supervisors in the Yellowstone region have met on an informal basis to coordinate their management activities. The group, called the Greater Yellowstone Coordinating Committee (GYCC) met once or twice a year to identify some of their common problems and try to work out solutions. This dialogue continues today. The GYCC is now a more formal, established group that includes: the Regional Foresters from the Intermountain, Northern and Rocky Mountain regions of the U.S. Forest Service; the Regional Director of the Rocky Mountain region of the National Park Service; plus the original members - the Supervisors of six National Forests and Superintendents of two National Parks.

The Greater Yellowstone Ecosystem stretches beyond the boundaries of the parks and forests into the jurisdictions of the U.S. Fish & Wildlife, Bureau of Land Management,
state, and private landowners. Estimates of the size of the ecosystem range from 9 million acres to 16 million acres, depending on who is doing the estimates. The area defined by the GYCC is about 11.7 million acres, using existing jurisdictional boundaries in northwestern Wyoming, southwestern Montana, and eastern Idaho.

Responding to public concern and threat of congressional intervention in Greater Yellowstone management, the GYCC decided to work out a framework for coordinating management of this vast area. The GYCC-produced draft "Vision for the Future" outlines the coordination process.

The coordination process is exactly that, a process. It is not a plan, but a management framework for coordinating the plans of the various parks and forests in Greater Yellowstone. Goals and objectives are described in the draft Vision; strategies and activities are left for forest and park managers to decide. According to the draft Vision,

"The GYCC does not impose decisions, but helps identify and resolve common management problems and communication gaps. It then sets up mechanisms for resolving those problems."

The complexity of this attempt at ecosystem management begins with the different organizations involved. The U.S. Forest Service, a branch of the Department of Agriculture,
has a legislative mandate of conservation, plus multiple use of public natural resources. The Forest Service lands are used in a variety of ways. They are managed for oil and gas production, timber management and grazing. But the Forest Service land is also managed for values such as recreation, watershed protection, wildlife habitat and wilderness preservation. The Service's dual role in preservation and resource production is a complex task in itself.

The National Park Service, a branch of the Department of Interior, is mandated to preserve magnificent park lands "for the benefit and enjoyment of the people." The Park Service goal is one of resource preservation and not extraction. But this must somehow be done in the midst of enjoyment of the people. So the Park Service, like the Forest Service, has a paradox of their own to deal with: managing facilities for millions of visitors to enjoy, while preserving the precious resources which attract them.

If this sounds difficult, consider the idea of trying to get these two agencies, with completely different management and planning structures, different legislative mandates, and different opinions to come to a consensus on how to manage a vast area, in which both agencies have jurisdiction, as one ecosystem. Such an area is the Greater Yellowstone Ecosystem.
Purpose of the Study

An issue which stirs controversy in both resource management and preservation camps is forest roads. It is a complex issue with no easy solutions. Many valid arguments can be made for both the construction of forest access roads and for the preservation of large tracts of roadless land.

In the forests of the Greater Yellowstone Ecosystem, the construction of forest roads is viewed as a necessary management tool. Roads provide access for timber production, mining, oil and gas production, recreation, fire protection and a host of other uses.

The impacts of inappropriately located or unnecessary roads can reach beyond the borders of the particular forest. Roads open areas to vehicular traffic. This leads to increased hunting and fishing pressure on wildlife. Water quality in streams may be lowered due to erosion, siltation and pollution. Roads also fragment large areas of previously undisturbed wild land. This fragmentation can disrupt wildlife migration routes and divide critical habitat areas. The disruption affects not only the wildlife of the forest in question, but the ecosystem as a whole. The forest roads of Greater Yellowstone need to be managed on an ecosystem level. This requires coordinated road management and common goals. This is not happening yet in the region. The goals are taking shape in the draft Vision
for the Future, but forest plans are not looking beyond their borders. It is the thesis of this study that opportunities exist for improved coordination of forest road management on public lands for purposes of ecosystem management.

Methodology of the Study

The study examines the opportunities for coordinated forest road management for purposes of ecosystem management. The coordination efforts in Greater Yellowstone provide a case study illustrating these opportunities.

The study first reviews current literature about ecosystems, ecosystem management goals, benefits and application to Greater Yellowstone. Issues of forest road management are also examined.

The study then turns to a critique of current road management efforts in six National Forests of northwest Wyoming, southwest Montana and eastern Idaho; which are considered part of the Greater Yellowstone Ecosystem. Comparisons of road management planning and policy are made primarily through examination of forest plans and engineering policies and through personal communication with forest highway engineers and transportation planners. Recommendations for improving coordination of forest road management follow the critique.
II ECOSYSTEMS, ECOSYSTEM MANAGEMENT AND THE
GREATER YELLOWSTONE ECOSYSTEM

Ecosystems

An ecosystem, according to Keiter (1989), is a "unit made up of all the living and non-living components of a particular area that interact and exchange materials with each other." This definition describes a concept which is the basis for understanding the inter-relationships between organisms and their environment.

Ecosystems exist at varying scales, from small systems to large regional areas, with the smaller component systems functioning together to form the larger system. Bailey (1985) offers three scales of ecosystems which are useful in describing the relationships between the component systems. One scale is the "homogenous sites commonly recognized by foresters and range scientists," such as water resources or timber stands. Sites linked together make up a landscape mosaic, on the scale of, for example, a mountain landscape. The component systems of the mountain range are involved in material exchange such as water flow, erosion, animal migration and seed scattering by birds or wind. Landscape mosaics link together to form regions. An example of the linkage between landscape mosaics is the climatic effect of a mountain range on the plain in its rain shadow. These
three scales, while not covering all sizes of ecosystems, offer an illustration of the scaling and relationships between ecosystems (Bailey, 1985).

Ecosystems also vary over time. Perhaps the most constant aspect of natural systems is change. Ecosystems are in a constant state of flux as changes in one component of the system affect other components. Disturbances such as wildfire, floods or avalanches affect ecosystems and are part of the successional process (Johnson and Agee, 1988).

The spatial and temporal variance of ecosystems makes it difficult to define the area’s boundaries. These variables are compounded by the subjectivity of the person delineating the boundaries. According to Clark and Harvey (1988), "Ecosystem boundaries are imaginary and are located at the convenience of the observer. The boundary may be drawn so that it includes all the elements the observer is interested in, or so that it follows a natural boundary such as a shoreline." The Wilderness Society (1986) offers three criteria to consider when delineating ecosystem boundaries:

1) The ecosystem should contain the contiguous area necessary for the long-term survival of all naturally occurring species in the region.

2) It should include the upstream watersheds for important waterbodies within it.

3) It should be large enough to support a natural disturbance regime.
**Ecosystem Management**

The concept of ecosystem management is in its infancy. Current debate over definitions and delineation of ecosystem boundaries leads to questions about applying the concept to public lands management. Even so, some common themes are beginning to emerge. According to Clark and Harvey (1988), "The fundamental idea underlying the concept of 'ecosystem management' seems to be that the ecosystem must be viewed and treated as a unit and that its dynamic interactive processes must be maintained."

**Beyond Traditional Boundaries**

Ecosystem management, as in the case of Greater Yellowstone, often involves an area which exceeds the boundaries of an established national park, national forest or wilderness area. In this situation, management emphasis needs to shift from the efforts of individual jurisdictions to a regional approach; a process which is beginning in Greater Yellowstone. According to Keiter (1989), "the administrative actions of the Greater Yellowstone federal land management agencies have given de facto recognition to the region, or ecosystem, as the relevant management unit."

The regional approach requires substantial interagency coordination and cooperation. But, as Johnson and Agee (1988) point out, coordination "is not an end in itself.
Success in ecosystem management is ultimately measured by the goals achieved, not by the amount of coordination."

Current legislation affecting national forest management supports the regional, trans-boundary approach. The Endangered Species Act (ESA), National Forest Management Act (NFMA), and National Environmental Policy Act (NEPA) each mandate actions which are not limited by jurisdictional boundaries. The ESA, according to Keiter (1989), "reflects an unambiguous federal commitment to preserve dwindling species from extinction, regardless of where those species are found." The NFMA requires coordinated management of adjacent federal public lands. and NEPA "obligates federal agencies to examine the impact that proposed activities would have on neighboring lands" (Keiter, 1989).

**Beyond Multiple Use**

The ecosystem management concept differs from traditional public land and natural resources management by including, but also looking beyond, the multiple uses that benefit man. It is a shift from managing specific resources or species, to managing the interrelationships of the natural processes in which those resources or species exist. Table 1 helps illustrate and clarify these basic differences (Clark and Harvey, 1988).

New ways of thinking about the relationship between
Table 1. Some differences between ecosystem management and traditional natural resources management

<table>
<thead>
<tr>
<th>Basis for comparison</th>
<th>traditional management</th>
<th>ecosystem management</th>
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<tr>
<td>values</td>
<td>primarily extrinsic (resources valued for their usefulness to human purposes, whether economic or aesthetic)</td>
<td>both extrinsic (economic and aesthetic values of ecosystems recognized) and intrinsic (resources valued without reference to their usefulness)</td>
</tr>
<tr>
<td>central goal</td>
<td>manage or extract individual valuable resources or target species (e.g. oil, elk)</td>
<td>maintain long-term viability of natural processes (e.g. nutrient cycling, community interactions)</td>
</tr>
<tr>
<td>taxonomic bias</td>
<td>higher vertebrates; species with commercial value (e.g. elk, timber)</td>
<td>all organisms</td>
</tr>
<tr>
<td>beneficiaries of management</td>
<td>primarily human consumers</td>
<td>all species including humans</td>
</tr>
</tbody>
</table>

Source: Clark and Harvey, 1988.
multiple use and preserved lands are evolving. The fragmented approach of managing individual parks and forests as isolated units needs to be modified to consider a broader scope of impacts and interrelationships.

In addition to a new relationship between preserved and multiple-use lands, according to Keiter (1989), "a new accommodation between man and the natural environment is required." Human settlements within natural ecosystems are a reality which must be accommodated. The land and natural resources which surround these settlements were the driving force which established the logging, mining and tourism-oriented towns. The question is not whether human use will occur, but to what degree human use can occur and "not degrade the ecosystem or irreparably disrupt its essential functions" (Clark and Harvey, 1988). It makes sense that the human settlements which exist primarily on a foundation of the surrounding wildlands and rich resources would not want to disrupt or destroy that very foundation.

Goals of Ecosystem Management

The shift from traditional natural resources management to ecosystem management is an advancement of public land stewardship, rather than a complete change from existing principles. The needs, values and goals of traditional management are not ignored of forgotten, but become part of
the broader goals of ecosystem management. This relationship can be illustrated by the different approaches to accommodating human needs. Local economies, as well as distant markets, depend on the natural resources produced on public lands, and this production needs to continue. Traditional resource management emphasizes maintaining a sustained yield of natural resources. An ecosystem-level approach, as suggested by a recent Keystone Center report (1991), requires that efforts be made "to assure that human activities to meet societal resource needs are consistent with long-term sustainability of both the resource and the ecosystem of which they are a part."

This enhanced relationship between man and environment, and between multiple-use and preserved lands fits into the goals of ecosystem management. Clark and Zaunbrecher (1987) suggest three goals essential to perpetuating ecosystems:

1) Maintenance of all existing plant and animal populations and restoration of species which have been eliminated by man. This would produce a structurally complete ecosystem, protect native habitats and ensure adaptable, viable populations.

2) Monitoring of major ecological processes via air and water quality, vegetative dynamics and wildlife populations. This will provide a continuous reading on the health of the ecosystem and tell us how to correct problems as they arise.

3) Integration of long-term sustainable human economies within the constraints of (1) above. This will provide significant opportunity for economic development of the ecosystem through scenic, recreational, wildlife and small-scale,
natural-resource-extraction-based economies.

Benefits of Ecosystem Management

Achievement of the goals mentioned above is a reflection of some benefits of an ecosystem approach. Ecosystem management is an effective means of protection of all species in the system, not just the glamorous, high profile wildlife, but plants, insects, etc. which might otherwise be overlooked. In addition, the ecosystem approach shifts the focus of wildlife management from species-specific intervention to "protecting the integrity of the ecosystem in which it dwells" (Norse, et al., 1986). Another benefit of an ecosystem approach is the preservation of the regulatory functions of the natural environment. Runoff and erosion control, groundwater filtration and recharge, climate control and nutrient circulation are examples of the functions which benefit not only the ecosystem, but human populations which depend on its resources (Clark and Harvey, 1988). Conservation of the whole ecosystem ensures sustainable development of local communities by preserving the resources such as recreation, wildlife, timber, water, and magnificent wilderness, on which those communities depend.
The Greater Yellowstone Ecosystem

The Greater Yellowstone Ecosystem is an area of roughly 14 million acres made up of Yellowstone and Grand Teton National Parks and the surrounding mountainous terrain (see Figure 1). This area of northwest Wyoming, southwest Montana and eastern Idaho is a distinct landform of high plateau and even higher elevation mountain ranges, with greater precipitation and vegetation than surrounding lower elevation plains and valleys. The Greater Yellowstone Ecosystem has been described as the "largest essentially intact ecosystem remaining in the earth's temperate zones" (Anderson, 1985). Greater Yellowstone contains the headwaters of three major river systems, which join even larger rivers. The Snake, Missouri and Green rivers all begin in the region and eventually flow to the Columbia, Mississippi and Colorado rivers.

Greater Yellowstone is home of the world's first national park. It was established not for ecological reasons, but to protect the incredible thermal features from private exploitation. It was not until the late 1860s and early 1870s that a series of expeditions confirmed the source of many trappers' tall tales. The Washburn Expedition of 1870 was the first group of white explorers, besides the early trappers, to stumble into the Firehole river basin and observe the geysers and hot springs around
The Greater Yellowstone Ecosystem

Figure 1  The Greater Yellowstone Ecosystem

Source:  Clark and Harvey, 1988
Old Faithful. They are also credited by Langford with conceiving the idea of preserving this area as a public preserve. An excerpt from Langford's diary of the 1870 expedition (1972 printing), recorded upon their return to Helena, Montana, helps capture the feelings of those explorers who helped establish our first National Park:

"My narrations to-day have excited great wonder, and I cannot resist the conviction that many of my auditors believe that I have 'drawn a long bow' in my descriptions. I am perfectly free to acknowledge that this does not surprise me. It seems a most natural thing for them to do so; for, in the midst of my narrations, I find myself almost as ready to doubt the reality of the scenes I have attempted to describe as the most skeptical of my listeners. They pass along my memory like the faintly defined outlines of a dream. And when I dwell upon their strange peculiarities, their vastness, their variety, and the distinctive features of novelty which mark them all, so entirely out of the range of all objects that compose the natural scenery and wonders of this continent, I who have seen them can scarcely realize that in those far-off recesses of the mountains they have existed so long in impenetrable seclusion, and that hereafter they will stand foremost among the natural attractions of the world. Astonishment and wonder become so firmly impressed upon the mind in the presence of these objects, that belief stands appalled, and incredulity is dumb."

The Current Literature on Management of the Greater Yellowstone Ecosystem

The wealth of current literature about the Greater Yellowstone Ecosystem recognizes the importance of the area and lends much credibility to the concept of ecosystem management on large wild lands. References to the area are found in the journals of many different disciplines and many
different sides of the issue.

The term "ecosystem" was first applied to the Yellowstone region by Craighead et.al. in 1974. In his analysis of Grizzly bear populations, F. J. Craighead mentioned that the great bear's range extended beyond the boundaries of Yellowstone Park to a larger ecosystem (Craighead, et.al., 1974). Craighead also mentions the Greater Yellowstone Ecosystem in his famous book Track of the Grizzly (Craighead, 1979).

Yellowstone Ecosystem, the ecosystem on public lands and its legal implications.

An environmental group, the Greater Yellowstone Coalition, founded in 1983, devotes its efforts to the issue and evolution of public land management in the region. According to their brochure, "the Coalition is committed to an alternative - the ecosystem approach to resource management, based on interagency coordination and a common vision of an intact and healthy ecosystem (GYC, no date).

On the federal government level, the Greater Yellowstone Ecosystem has also been recognized. A lengthy oversight hearing on the Greater Yellowstone Ecosystem was held in October, 1985. The Subcommittee on Public Lands and Subcommittee on National Parks and Recreation of the Committee on Interior and Insular Affairs heard opinions from many interest groups. Colorful and insightful debate in the oversight hearings demonstrated the complexity of issues surrounding Yellowstone and of ecosystem management. The main accomplishment of the subcommittee was to realize the lack of comprehensive data for the area. They called for a more detailed study (U.S. Congress, 1985).

A Congressional Research Service (CRS) team gathered data and made some recommendations to the subcommittee. The CRS (1986) produced The Greater Yellowstone Ecosystem: An Analysis of Data Submitted by Federal and State Agencies was
a product of their efforts. One of their findings was that
the coordination efforts were not comprehensive in either
membership or approach, and therefore were inadequate for
providing complete, coordinated ecosystem management. The
CRS also found that boundary conflicts between agencies
still existed and stood in the way of coordinated management
(CRS, 1986).

In response to the Congressional efforts, the Greater
Yellowstone Coordinating Committee (GYCC) (1987) produced An
Aggregation of Park and Forest Management Plans. The
Aggregation "summarizes existing management plans. It
displays the condition and extent of resources and
management activity within the Greater Yellowstone Area and
illustrates the future condition of this vast region as
these management plans are applied over the next 10 to 15
years" (GYCC, 1987).

Following the Aggregation, the GYCC began work on its
draft Vision for the Future. Through review of the
Aggregation and public involvement, the GYCC developed a set
of goals for Greater Yellowstone. The intent of the Vision
is to provide a broad set of goals for individual plans to
work toward. Most existing plans probably include these
goals in one form or another. The key to coordination is to
amend existing plans to meet the criteria of the goals of
The study now turns to the subject of roads on the National Forest. In the next chapter, issues which make forest roads both controversial and a necessary management target are discussed. The discussion defines forest roads, how they are managed, their use, controversies and effects of forest roads.
III THE ROADS ISSUE

Roads On The National Forests

Much of the public controversy and resource impact in the Greater Yellowstone Ecosystem involves human influence and interference as a result of access roads. Roads are necessary for resource management but also cause many disturbances. They are a central controversy and focal point of public lands management. Because roads are so central, they are a good point of intervention, point of leverage at which to focus coordinated management efforts.

This study focuses on the road system of the National Forests in Greater Yellowstone; the Beaverhead, Bridger-Teton, Custer, Gallatin, Shoshone, and Targhee. Maps of Greater Yellowstone show the Caribou National Forest to be a part of the area. A large part of the Caribou which is considered an integral part of the ecosystem is managed by the Targhee. This is why the Caribou is not considered in the comparison of forest plans later in this study. This should not be taken as an exclusion of the Caribou from the ecosystem. The comparison of the six forests illustrates well the problems and opportunities for coordination. These opportunities could apply to the Caribou as well.

Although there is current debate about a winter snowmobile route through National Park Service (NPS) land,
and a new section of public highway in Grand Teton National Park (NPS, 1990), the NPS road system is basically complete. National Park roads should be considered in analysis of open road density, and are a significant impact to the ecosystem. But the access road system of the National Forests is incomplete and holds the greatest opportunity for coordinated efforts.

Forest roads fall into three classes, arterial, collector and local, which describe vehicle traffic patterns. Arterial roads are high standard roads which link state and federal highways to the forest. They provide access to large land areas and can handle traffic at moderate speeds. Collector roads link the arterial system to the interior of the forest and the remaining local roads. Local roads usually are built for resource access and terminate at the site of their resource function (USFS, 1988).

Roads are also referred to by service level and maintenance level. These definitions are technically separate from the above mentioned classes, but are sometimes compared as shown in Table 2. Traffic service level is a road standard that describes conditions a traveler might expect on the road. For instance the road surface may range from stable and smooth for service level "A", to rough and irregular for service level "D". Maintenance levels are a
Table 2 Comparison of Road Functional Class, Traffic Service Level and Maintenance Level

<table>
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<th>Functional Class</th>
<th>Arterial</th>
<th>Collector</th>
<th>Local</th>
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<tr>
<td>Traffic Service Level</td>
<td>A or B</td>
<td>B or C</td>
<td>C or D</td>
</tr>
<tr>
<td>Maintenance Level</td>
<td>5 or 4</td>
<td>4 or 3</td>
<td>2 or 1</td>
</tr>
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road management description. The five levels range from Level 1, an intermittent service road with minimum maintenance, to Level 5, usually a paved, two-lane road in areas where management direction calls for comfort and safety (Bridger-Teton Plan, 1989).

The Planning and Policy Structure of Forest Road Management

There are two hierarchies of policy and planning for the forest road system that range from the broad national level to the specific local level. These two systems are the planning process, and engineering and design. Both systems result from the 1974 Forest Rangeland and Renewable Resources Planning Act (RPA) as amended by the 1976 National Forest Management Act (NFMA) (see Figure 2). The planning process includes the National RPA Program, Regional Guides for each region, and the local-level Land and Resource Management Plans for each forest. The engineering and design system include the forest-wide Forest Service Manual (7700 - Transportation), regional supplements to the manual, and local forest travel maps and large scale "B-maps" which show all inventoried forest roads. This hierarchy provides some consistent overall structure for the road system, but reserves the majority of the management decisions and responsibilities with the individual forest managers.

On the national level, the Rangeland and Renewable
Figure 2  The Planning and Policy Structure of Forest Road Management
Resources Planning Act (RPA) Program provides long-term strategies and goals that forest plans are expected to meet or improve upon. The 1990 RPA Program deals very little with forest roads, but does project the total miles of forest system roads and miles of roads closed for the next fifty years (RPA, 1990). Also on the national level, the service-wide Forest Service Manual specifies policies and goals which all Forest Service roads must follow or work toward. There is also a service-wide engineering handbook for road and bridge design. These two manuals form the basic technical requirements that all forest roads must fulfill (USFS FSM 7700).

On the regional planning level, the Regional Guide link the national RPA planning goals and the forest plans. They provide more specific directions for the region as a supplement to the national policy. In so far as road engineering and design criteria, each region is allowed to supplement the Forest Service Manual to meet regional needs (Draft Rocky Mountain Regional Guide, 1990).

On the local planning level, the Land and Resource Management Plan is the document which the forest uses to show local road management decisions. The forest plan breaks down the forest into management areas and specifies road management decisions to be carried out on each area. Roads are a significant resource in forest land and resource
management. They receive much the same attention as other resources. The basic inventory in forest plans includes soil, water and air, wildlife, recreation, access/roads, visual quality, timber and minerals (Bridger-Teton plan, 1989). The local forest engineering office produces travel maps for the public to use. These maps show open roads, closures and restrictions of travel, but may not list all of the forest roads. The most detailed maps are produced for the Capital Improvement Projects (CIP). These "B-maps" are detailed drawings on large scale (1:24000) maps which list every inventoried road on the forest (Debbitt, 1991).

Roads - What's The Use?

Most forest local roads are initially built to access timber. If new road construction is necessary to reach a timber sale, the site specific road plans are an important part of the sale. But Forest Service officials are quick to point out that roads also serve other purposes.

According to Larry Henson, Associate Deputy Chief of the United States Forest Service (USFS), forest roads serve public uses and administrative uses, along with access to timber resources. Public uses include hunting, fishing, other forms of roaded recreation, firewood gathering and so on. Administrative uses are "fire suppression, grazing administration, cultural activities, insect and disease
suppression and more" (Henson, 1988).

If a road proposal creates a controversy, the above arguments are often used to justify the necessity of the road. But the same arguments are often turned around and used by those who oppose the road. The argument of the need for roads for fire suppression is often countered by the reality that more roads bring in more fire-starting visitors. The argument that roads increase recreation potential is countered, especially in large units of the Rockies, by the fact that motorized recreation potential already far exceeds the demands, and the roadless recreation demands are quickly catching up to the roadless recreation capacity. Roads which bring the added benefit of increased hunting and fishing access also allow for increased hunting and fishing pressure, depleting the resource that the road supposedly benefits (O’Toole, 1984). The following excerpt from the Bridger-Teton plan (1989) illustrates this problem as it has occurred in the Mount Leidy Highlands area:

"The sawmill operators in Dubois would like to continue to use the area near Mt. Leidy within the Spread Creek watershed to provide timber for their mills as they have for the last 20 years. In that time, they have removed about 150 million board feet of timber and have developed a road network about 170 miles long. Over the same 20 years, increased hunting pressure from the road system has contributed to changed elk migration patterns and has caused the Wyoming Game and Fish Department to shorten elk seasons and reduce numbers allowed to be harvested."
The Below-Cost Dilemma and Accelerated Road Construction

In the past few years much has been written about below-cost timber sales on the national forests (Sher, 1985, O’Toole, 1984). This situation originates from the way the Forest Service pays for roads, and the increasing costs of road construction. Most of the timber access roads are built by the purchaser with that expense being a credit toward the price of the timber. This process works as long as high quality timber is within easy reach. According to Sher (1985), “When longer roads are needed to reach marginal stands, the Forest Service has had difficulty finding purchasers because road costs often exceed the value of the timber to be harvested. Then the agency more often is forced, particularly in roadless areas, to use its own capital investment funds to build the initial access roads before any timber is sold.” The use of public funds to support money-losing timber sales is the basis for the opposition to below-cost sales.

The below-cost dilemma is common the Yellowstone area forests because of the dominance of lodgepole pine, a lower grade timber, and because of the large roadless areas in the region (O’Toole, 1985). Figure 3 shows the timber receipts for each of the six Yellowstone area forests. This figure includes the 25 percent payment of timber receipts to counties.
Figure 3  Timber Receipts and Costs of the six National Forests of Greater Yellowstone

Accompanying the notion of using public funds to penetrate roadless areas are accusations of a much more serious problem. While these claims may or may not be true, they should not go unnoticed. Several authors claim to have been contacted by unidentified Forest Service employees. According to Sher (1985), "The anonymous callers have alleged a massive conspiracy involving the Forest Service and the timber industry to punch roads into the last roadless areas before Congress has the chance to decide which areas would make suitable additions to the National Wilderness System." These informants tell of accelerated road building programs that are both economic and environmental losers. They claim sales end up bringing only a few cents on the dollar back to the U.S. Treasury. And to add insult to injury, the roads degrade soil and water resources, divide wildlife habitat and essentially de-list a roadless area from consideration as wilderness (Norris, 1985).

O’Toole (1984) distinguishes between "accelerated" and "advancing front" road building strategies (see Figure 4). Accelerated policies are strategies for building roads into the heart of roadless areas. The advancing front is one where roads are "built on the periphery and leaves most of the roadless area intact for many years" (O’Toole, 1984).

All this activity leads to, depending on who you are
Figure 4 Accelerated and Advancing Front Road Building Strategies

Source: O'Toole, 1984.
talking to, either not enough to worry about, or an unbelievable amount of road building. Two different views of the same figure illustrate this. On one hand, Henson (1988) says that there are about 344,000 miles of forest roads and 191 million acres of forest. He says this "averages out to slightly more than one mile of road per square mile of forest." Henson continues with an analogy of the size of a square mile and that only one mile of road per square mile of forest is not very dense. On the other hand, Carey (1988) uses the same figures in a different context. He says that the 344,000 miles of forest roads are "eight times more than the Interstate Highway system." Carey also says "If the roads currently planned are built, the network will contain enough mileage to reach the moon and back - and still circle the globe four times" (Carey, 1988).

However one views the above figures, the bottom line is that roads are a major source of human interaction, intervention and impact with forest lands. Roads are necessary but also can wreak havoc on the environment. Because roads are so central to use and abuse of national forest land, they are a critical point of intervention for managers who wish to somehow balance the need for roads with their impacts. As forest management shifts to an ecosystem approach, and as road proposals become more controversial, road management becomes an even more important management
Effects of Roads

Many of the effects of roads are well documented and monitored by the Forest Service. The National Forest Management Act specifies that "impact on land and resource" be considered equally with road cost and safety (USFS - FSM 7721.1). These effects are evaluated in Environmental Impact Statements (EIS) that accompany forest plans. The Gallatin National Forest Environmental Impact Statement (1987) states that: "Road construction and maintenance have a greater effect on other resources than any other Forest management activity." Also, numerous studies have cited effects or roads on certain species. These studies provide valuable information on which managers may base decisions about roads.

Some of the most dramatic, immediate impacts of road construction are soil erosion, siltation of streams and water pollution. Measures to control sediment runoff are important in any construction situation, and especially in the West where water is a precious resource. Siltation can be reduced by sowing vegetation in exposed road banks and by using siltation barriers or fences. Filter strips of undisturbed forest land should be left as a buffer between roads and streams (Walbridge, 1986). Procedures for monitoring soil loss and water quality are well established
and results are used in EIS's to predict effects from alternative plans. Techniques such as erosion bridges (Blaney and Warington, 1983) and water sampling stations (Ponce, 1980) are effective means of measuring these impacts.

Roads impact fish and wildlife in a number of ways. Population decreases may be attributed to roadkills, increased hunting and fishing pressure and stream sedimentation. Perhaps more importantly, roads disrupt the behavior and movement of wildlife. Roads are a barrier that some animals avoid or will not cross (Diamondback, 1990).

In an extensive study of the effects of timber roads on elk, Jack Lyon developed a system of predicting elk habitat effectiveness in relation to road density. Lyon looked at the type of road and available cover to generate his statistics. He designed a graph which models the decline in elk habitat effectiveness (the elk use of potential habitat) as road density increases. The calculation of road density involves rating different classes of roads and will be discussed later in this study. Lyon's model has been widely accepted and used by Forest Service managers (Lyon, 1979, 1983, 1984).

Studies of road impact on grizzly bears have shown similar patterns of effects. Roadkill, avoidance and displacement are cited by researchers. Of perhaps greater
concern is the increased potential of both bear habituation to humans, and of bear-human contact/conflict. In these situations, the bear is usually the loser (LeFranc, et al., 1987).

Roads impact primitive recreation. Backcountry outfitters and hikers who desire a pristine wilderness experience are affected by roads. The Recreation Opportunity Spectrum (ROS), a Forest Service management tool, describes a range of recreation opportunities which may be found on the forest. The definition of the five classes, Primitive, Semi-Primitive Non-Motorized, Semi-Primitive Motorized, Roaded Natural, and Rural, are based in part on access and proximity to roads (Bridger-Teton Plan, 1989). Forest plans use the ROS to show the location and extent of recreation resources on the forest.

Associated with recreation impacts are the impacts of roads on visual resources. Roads can form an unnatural break in the landscape and disrupt the visual experience. Forest Service planners establish Visual Quality Objectives (VQO's) for different management areas, depending on the management goals for the area. The five VQO's, Maximum Modification, Modification, Partial Retention, Retention and Preservation, describe conditions to which management activities must adhere. In the Retention VQO, for example, roads are allowed, but must be designed to be unnoticed and
to blend in with natural scenery (Wilkinson and Anderson, 1987).

The above-mentioned impacts of roads are examples of what the Forest Service has traditionally, and often very thoroughly, considered when making transportation decisions. It is no means a complete list of criteria by which to judge road effects, but it reflects the type of assessments currently made.

The current forest road impact assessment, according to the emerging theories of landscape ecology and ecosystem management, may be insufficient to sustain the integrity of the natural systems. The traditional analysis of road impacts, according to Harris (1985) is too narrow and does not recognize "the complexity and the importance of dynamic processes at large spatio-temporal scales."

Several problems occur when roads fragment habitat. One consequence is the loss of species that require large, intact forest interior habitats. Other species that are wide ranging, such as large carnivores, may lose the mobility they need. Also, as a result of the human disturbance of the roadway, exotic species have a chance to replace native species. The species in the remaining fragmented habitat islands are genetically isolated which threatens their long-term viability (Noss and Harris, 1986, Noss, 1990).
The solutions to the broader ranging problems of habitat fragmentation involve shifting the conservation focus to a broader spatial and temporal scope. Noss and Harris (1986) state four reasons that current conservation efforts are limited. They say that conservation:

"1) is static (that is, does not effectively deal with continuous biotic change);

2) focuses on individual parks and preserves (content) instead of whole landscapes(context);

3) focuses on populations and species instead of the larger system in which they interact;

4) is oriented toward maintenance of high species diversity instead of characteristic native diversity."

Preserving large roadless areas helps to reduce the effects of fragmentation. But this will not always be the economically or politically feasible solution. The remedy then is to provide some means of linkage between habitats. Movement corridors can be established to physically connect two important areas. This is done in a number of ways from land appropriation, to stream bank protection, to road design which allows safe crossing for wildlife (Harris and Gallagher, 1989).

Where does coordinated road management fit into the ecosystem approach? One answer lies in control of open road density. Consistent road density standards and monitoring among cooperating forest units is one way to make road
management more accountable throughout the ecosystem.

Road density management means sensitive and minimal construction of new roads, and effective closure of unnecessary roads. If these standards were made consistent throughout coordinating jurisdictions, the road density on the ecosystem as a whole could be monitored. Once consistent monitoring is established, studies linking the road density of the ecosystem to road impacts could be initiated.

The next chapter involves a discussion of road management, with some specific references to the need for coordinated road management in Greater Yellowstone. Some concepts and definitions for managing access are discussed, laying the foundation for Chapter V; which is a comparison of how those concepts are applied in the six forests of Greater Yellowstone.
IV ROAD MANAGEMENT

Introduction

Recent literature concerned with ecosystem management and the Greater Yellowstone Ecosystem has generated some interesting new ideas for public lands management. Some of the studies have concluded with worthy suggestions on how to approach the evolving idea of ecosystem based management. Many of the suggestions involve the management of human use and impacts. This makes sense due to the relative ease of communicating management strategies to human beings compared to the other abiotic and biotic elements of the ecosystem. A common thread of the management of human impacts/use is the management of their access to the ecosystem. This study is a response to calls for coordinated, ecosystem oriented management of human access via the road network.

In this chapter, coordination of road management in the National Forests of Greater Yellowstone is examined. The need for these coordination efforts, as called for by congressional reports, interagency documents and agency plans, is shown. The ensuing discussion of road management involves the timing of human access through opening, closing or obliterating roads. How the timing occurs, how open, closed and obliterated is defined and how road mileage is measured is critical to how the open road density (miles per
square mile) is calculated. The density calculations are then discussed in a manner which suggests that herein lies an excellent opportunity for improving road management.

The Need For Coordinated Road Management

Some of the most explicit recommendations about road management are given in the Congressional Research Service (CRS) 1986 publication, Greater Yellowstone Ecosystem: An Analysis of Data Submitted by Federal and State Agencies. In the report, which was a response to the 1985 Oversight Hearings on the Greater Yellowstone Ecosystem, the CRS makes some revealing statements and suggestions. CRS (1986) says, "The most significant effects of development activities on the ecosystem result from access...Despite these effects, road construction and access decisions are determined for each resource specialty, rather than as an integrated issue which is broadly examined for its effects on the ecosystem."

The report also lists three options to consider which emphasize coordination of amount and timing of human access. The three recommendations are:

1) A committee could coordinate current road planning activities, and recommend adjustments when conflict or duplication might occur.

2) A comprehensive road management plan could be developed for the ecosystem, with the plan including:
   a) road construction locations and standards,
   b) required road maintenance levels (including
c) road closure standards (location and timing),
d) road destruction for any roads slated for elimination.

3) A committee could establish zones within the ecosystem which define not only the appropriate levels but the timing of human presence, taking into consideration the requirements of wildlife and other resources in the area.

Some of the findings and recommendations of the Greater Yellowstone Coordinating Committee (GYCC) echo the CRS findings. According to the GYCC’s *An Aggregation of National Park and National Forest Management Plans* (1987), “The network of roads and trails in the Greater Yellowstone affects nearly all resource-related issues.” Map 10 from the Aggregation, shown in Figure 5, shows existing and planned roads in Greater Yellowstone as of 1987. In a briefing guide which accompanied the “Aggregation”, some coordination needs are expressed. The briefing guide lists the need to “acquire, collect or standardize data” and develop “a standard level or intensity of mapping” of local roads.

The document which follows the “Aggregation”, the GYCC’s draft *Vision for the Future* (1990), outlines several recommendations for road management. One of the transportation goals of the coordination effort, according to the draft “Vision” is “to minimize both the total miles of road and the miles of open road.” This is to be
accomplished through coordinated road closures and obliteration of unnecessary roads. The transportation goals call for forest managers to "balance new construction and road closures in such a way as to cause no net increase in open roads" (GYCC, 1990).

The Forest plans of the Greater Yellowstone Ecosystem acknowledge the conflicts over access and road management, and recognize this as an issue which demands more attention. The Gallatin National Forest Environmental Impact Statement (1987) states that "Road construction and maintenance have a greater effect on other resources than any other Forest management activity." The Bridger-Teton Land and Resource Management Plan (1989), in a section entitled "Need to Establish or Change Management Direction", discusses many of the problems, issues and challenges associated with the complex issue of access.

**Forest Roads – Open, Closed or Obliterated, What Does It Mean?**

**Open Roads**

There is no simple, widely accepted definition of an open forest road. The many different definitions are best described as that which is not closed. The degree and timing of closure or other restriction determines what is considered open. Many closures and restrictions exist from
year-long to seasonal closure, or restriction of motor vehicle type.

Motor vehicle access is one consistency of the definition of "open." This is the target of road closure management. Motor vehicle use is what brings about many of the adverse human impacts.

Included in the open road debate is the right of access to the forest by its users. The two parts of this issue are the rights of the public to access the forest when it is separated from public access by private land. The other concern is access to private inholdings that are surrounded by forest land. This is a common dilemma in the checkerboard fragments of public and private lands that exist in many western forests, including those in Greater Yellowstone. In both cases, the Forest Service is obligated to provide some type of access to the land. This is a source of frustration for all parties concerned.

Closed Roads

The Forest Service has a number of closures and restrictions to employ in road management. The length of time a road is closed may be year-long or temporary. Some closures apply only to certain types of motor vehicles. The degree of closure or restriction depends on resource management goals. For instance, some roads may be closed
for erosion control during wet weather months. The closure might not apply to snowmobiles since they are operated during seasons of snowpack and will not affect the soil. In other areas, all motor vehicles might be excluded from late fall through winter to protect wildlife winter habitat. The road restriction legend from the Gallatin National Forest Visitor map shown in Figure 6 illustrates these various closures and restrictions.

The degree of closure is also dependent on how the road is physically closed. Gates consisting of steel posts and locking cross beams are used for short term closures and when there is little potential for vehicle trespass. These types of closures are not as effective for stopping all traffic, though, as two wheel and other off-road vehicles may be able to make their way around the gate. A barricaded closure is one which is used for more long-term closures. It is designed to prohibit all passage of motor vehicles. These structures may be heavy log posts and beams, earthen berms or rock piles large enough to stop all motor vehicles (Bridger-Teton Plan, 1989).

Sometimes even these efforts may not be enough to stop the most determined trespassers. This is the case in one place or another in many of our national forests. In a study conducted on the Flathead National Forest, Hammer (1986) found that 38% of the closures he examined were
ROAD RESTRICTIONS

The following routes are closed to vehicle travel during the periods shown. These routes are shown on the map in solid red lines.

<table>
<thead>
<tr>
<th>Map Code</th>
<th>Yearlong</th>
<th>Yearlong</th>
<th>Yearlong</th>
<th>Purpose of Restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>🟢</td>
<td>Yearlong</td>
<td>Yearlong</td>
<td>Yearlong</td>
<td>Winter sports, X-country skiing, Erosion control</td>
</tr>
<tr>
<td>🟢</td>
<td>Yearlong</td>
<td>Yearlong</td>
<td>No Restrictions</td>
<td>Wildlife security, Erosion control</td>
</tr>
<tr>
<td>🟢</td>
<td>Yearlong</td>
<td>Jan. 1 - May 31</td>
<td>No Restrictions</td>
<td>Wildlife security, Erosion control</td>
</tr>
<tr>
<td>🟢</td>
<td>Oct. 15 - July 15</td>
<td>Oct. 15 - July 15</td>
<td>No Restrictions</td>
<td>Wildlife security, Endangered species habitat, Erosion control</td>
</tr>
<tr>
<td>🟢</td>
<td>Jan. 1 - May 1</td>
<td>Jan. 1 - May 1</td>
<td>No Restrictions</td>
<td>Winter sports, Erosion control</td>
</tr>
<tr>
<td>🟢</td>
<td>Jan. 1 - June 30</td>
<td>Jan. 1 - June 30</td>
<td>No Restrictions</td>
<td>Erosion control</td>
</tr>
</tbody>
</table>

Figure 6  Examples of Road Restrictions

Source: Gallatin Forest Visitor Map, 1986.
"ineffective in fully restricting passenger vehicles." The study looked at 62 roads in Management Situation 1 (prime) Grizzly Bear habitat. Hammer found that half of the ineffective closures were "due to failure of the agency to diligently insure that gate closures be kept closed and locked." Twenty-five percent of the ineffective closures were unable to stop two and four-wheel drive vehicles from creating a detour around the gate. Of the remaining ineffective closures, 10% were vandalized and 15% were "due to structures reported to restrict road miles, but not yet installed." The 38% of ineffective closures translated to 49 miles of the 111 miles or road in the study area that were not effectively closed. Forty-four percent of "closed" roads were not really closed in an area deemed a priority grizzly bear habitat (Hammer, 1986).

Obliteration

Ultimately, the only permanent closure of a forest road is achieved through obliteration. This means the roadbed is ripped up so that the area may be returned to its original state of vegetation, timber. Road structures such as bridges and drainage pipes are removed and the natural drainage restored. The roadbed may be re-seeded and downfall pulled over the road. In some cases, portions of the road where it connects and is visible to other roads may
be reshaped to disguise the old travel way. In other cases, the entire road cut is returned to original contours and conditions (Bridger-Teton plan, 1989, LeFranc, et al, 1987).

The Forest Service has a legal obligation to remove/obliterate unnecessary or abandoned roads within 10 years of the termination of their use. The Forest Plan is supposed to identify these roads and establish a schedule for elimination. The road is then removed from the forest road inventory. Even though this seems fairly straightforward, some room for error still exists (Hammer, 1990).

Along with the road class, arterial, collector, or local, the forest road inventory indicates whether the road is slated for long-term or short-term use. According to Hammer (1990) "Long-term roads generally are committed to future timber harvest access or other uses, the Forest Service has made a decision not to abandon them in the foreseeable future." In the case of short-term roads, that decision is still pending. These "system" roads are separate from "temporary" roads. Temporary roads associated, for example, with specific timber sales, are obliterated immediately following their project use and are not required to be listed in the inventory.

This inventory system is not without error. Some existing roads, whether built by the Forest Service in the
past, or generated by users, are simply not found in the inventory. In some cases, temporary roads are not properly closed and still allow vehicle access. In a study of the Swan Valley of the Flathead National Forest, Hammer (1988) "found that the Forest Service failed to list 70% of the short-term and temporary roads in the study area." Hammer also discovered "80% of the 'obliterated' and 64% of the 'abandoned and not drivable' roads inventoried by the Forest Service were drivable by conventional passenger vehicle."

It should be noted that since the time the study was conducted, the Flathead National Forest has closed over 400 roads (Hammer, 1990).

**Open Road Density**

The accuracy of the forest road inventory, combined with criteria constituting open v. closed roads are important to calculating the open road density of the forest. As the inventory and criteria vary, so does the density calculation. If the open road density is to be used as an effective management tool, these variations need to be addressed.

Properly calculated open road density is an effective road management tool. It gives the forest planners and engineers a numerical goal to work toward. It also provides the public with an accountable figure which can be
monitored. But not all forests have such a standard.

The idea of open road density as a management tool received much attention in a lengthy and widely accepted study of elk habitat and timber management relationships. Lyon et al. (1985) conducted a 10-year study of elk response to timber roads. The study examined elk displacement distances in relation to the degree and timing of timber operations. Also taken into consideration was available vegetative hiding cover. The observers in the study counted elk scat at various cover density and at various distances from roads. Lyon et al. found that although quality habitat may be available close to a road, elk avoided areas close to roads, thus reducing the amount of available effective habitat. According to Lyon (1979) "In areas with very dense tree canopy, the proportionate elk use within .1 mile of a road is predicted to be 37% of the potential occurring beyond the influence of a road." From the findings of the study, Lyon produced a model, shown in Figure 7, which "predicted levels of effective habitat with different road densities and tree cover." This model suggests a linear relationship which Lyon recognized as having some possible flaws of predicting "negative values for habitat effectiveness where road densities are high and recent timber harvest has been extensive." He mentions that the effective habitat "probably could not be reduced below 10 to
Figure 7  Original Lyon Road Model

Figure 8  Perry-Overly Road Model
Source: Lyon, 1983.

Figure 9  Single Function Road Model
Source: Lyon, 1983.
15% by roads alone" (Lyon, 1979).

Other studies which followed Lyon's produced some adjusted models for predicting habitat effectiveness. In 1983, Lyon compared various models and developed a new non-linear model. Lyon reported that the Perry-Overly model, developed by Thomas, shown in Figure 8, "uses three non-linear functions relating the independent influences of primary, secondary and primitive roads on habitat effectiveness for elk." The Perry-Overly model suggests a scaling of road densities in proportion to their relative impact on elk. The scaling assumes that secondary roads only have 70% of the impact of primary roads, and primitive roads only have 5% of the impact of primary roads. Thus the scaling system produces an open road density (in miles) = primary + .7 secondary + .05 primitive. The new model Lyon produced, Figure 9, "projects road densities as a single, non-linear function of the same shape as the Perry-Overly functions...with scaled road densities in proportions suggested by Perry-Overly."

The Lyon model has been well received by Forest Service managers. Wildlife managers use the habitat effectiveness percentage as a numerical objective. In forest plans one may find references to a certain percent habitat effectiveness as an objective for wildlife management projects. Transportation planners have also embraced the

While the idea of rating road impacts makes intuitive sense, some questions seem to be unanswered. Differences in the definition of open roads will make for differences in road density calculations. In his study, Lyon (1979) defines an open road as simply "one accessible to motor vehicle traffic." If a forest transportation planner applies different criteria to his/her inventory of open roads, the density calculation will vary. Also, if two adjacent forests are trying to compare and coordinate their open road density standards, the criteria must be exactly the same for the comparison to be valid.

Another problem with applying the Lyon model to forests is that Lyon classified roads as primary, secondary and primitive, depending on traffic levels, while forests classify roads as arterial, collector and local. The Bridger-Teton plan (1989) acknowledges that these two classifications are generally the same. But if, for example, some collector roads are listed as primitive, the calculation would be skewed. There is also the possibility that many uninventoried roads are excluded altogether from the calculation, further diluting the actual open road density.

Besides these logistical problems of inconsistent data,
some other, more fundamental questions arise. If open road density is to become an effective tool for ecosystem-level management, is it proper to use a scale which has its basis in elk and timber relationships as a measure for the entire area? What about other resources and management goals? Why not consider the effects of roads on water quality, erosion, recreation, visual quality, habitat fragmentation or species other than elk?

To illustrate this problem, consider the case of using the elk habitat effectiveness goals in managing grizzly bear habitat. The Gallatin National Forest has established an 80% elk habitat effectiveness goal for its Management Situation 1 grizzly habitat. This translates to an open road density of $\leq 0.5$ miles per square mile. While this does set a tangible road density objective, the calculation of the road density is based on elk habitat. Does this mean that grizzly bears react the same to logging roads as do elk? A quick sketch of the actual open road density of this scenario, shown in Figure 10, suggests an alarming amount of roads allowed in prime grizzly habitat (Gallatin plan, 1987).

The Flathead National Forest has attempted to address this question by creating a new open road density model for its grizzly bear habitat. In the Open Road Density Draft Environmental Impact Statement (1990), an open road density
Figure 10  Actual Open Road Mileage at Rated Density of .5 miles/square mile.
function for grizzly habitat is offered. Even if the scale proposed by the Flathead works for grizzly habitat, it still seems to fall short of a holistic, ecosystem-level approach.

One solution, then, is to drop the rating system altogether for a straight-miles, actual road density calculation. This would be the easy way out, but does not take into account the varying degree of impact of different classes of road.

A more creative solution would be to create a new road rating system which, at the very least, considers some of the most important indicators of ecosystem health. The new scale could combine rated effects of roads on water resources, soil erosion, recreation, visual quality, habitat fragmentation and other species besides elk. This does not seem impossible given that forest planning and management currently addresses water quality standards and erosion control. Forest plans also outline the recreation opportunity of different areas of the forest. Visual Quality Objectives are also established. Additional research would be needed for rating degrees of fragmentation and road effects on other indicator species. Scientific research combined with public input could result in a more broad-based open road density standard which could be applied and monitored throughout the entire ecosystem. With the availability of current data and the application of this
idea through a Geographic Information System, this proposal could work.

The next chapter shifts to an examination of the extent of and need for coordinated road management in Greater Yellowstone. Current consistencies in road management are discussed. This discussion is followed by a critique of the inconsistencies in road management which fragment the efforts to manage access in the ecosystem.
V THE EXTENT TO WHICH ROAD MANAGEMENT IS COORDINATED IN THE
GREATER YELLOWSTONE ECOSYSTEM: A CASE STUDY

Introduction

Regardless of the method for calculating open road
density, straight mileage, elk habitat effectiveness, or a
broader ecosystem scale, the inventory and monitoring of
road mileage in each forest must be consistent. Thus the
first step in the process of coordinating road management
throughout an ecosystem such as Greater Yellowstone is to
examine the current status of road management. What follows
is an look at the degree of consistency of transportation
planning and management in Greater Yellowstone.

Current Coordination Efforts

The efforts of the Greater Yellowstone Coordinating
Committee (GYCC) to provide some consistent goals for
management of Greater Yellowstone are outlined in the draft
"Vision for the Future." As mentioned at the beginning of
Chapter IV, the draft Vision (1990) outlines several
transportation-oriented criteria for coordination. A
central road management goal in the coordination effort,
according to the Vision is "to minimize both the total miles
of roads and the miles of open roads." This is to be
accomplished through coordinated road closures and
obliteration of unnecessary roads. The transportation goals
call for forest managers to "balance new construction and road closures in such a way as to cause no net increase in open roads," and "evaluate all existing roads and reclaim any roads not necessary to meet management objectives. The Vision also states that "Every five years, the GYCC will review the need, occurrence and effectiveness of reclamation and access closures, and the status of open roads in Greater Yellowstone" (GYCC, 1990). Although still in draft form, the document clearly states an objective of "no net increase" and a desire to monitor open road density. These goals and objectives are a critical first step. The next step is to look at how they might be achieved.

Present Consistencies in Road Management

National Direction

Fortunately, most of the broader goals of forest road management are consistent. The Forest Service Manual, and accompanying Forest Service Handbook offer service-wide direction for road planning, design and construction. These guidelines are a product of the statute and resulting regulations of the National Forest Management Act (NFMA) of 1976 (Hammer, 1990). These manuals are available for examination at any Forest Service office. Some examples of the requirements of the FSM are: .
FSM 7721.1 Design (roads)

NFMA implies that each of the following factors is to be considered equally when determining standards appropriate for the intended uses.

1) Cost of transportation
2) Safety
3) Impacts on the land and resources

Balance these factors for each road, or section of road when selecting the individual standards. The entire road may be designed with the same set of standards, or different standards may be applied to different sections. There must be a harmonious blending of design considerations for all sections.

FSM 7721.2 Environmental Considerations

Identify the environmental protection requirements on both National Forest and private lands. Consider the control of soil erosion, and protection of watersheds, fish-producing streams, wildlife habitat, and scenic resources at all stages of location and design.

Develop alternatives, including their costs and effects, for management selection and approval when the selection of road elements and standards to meet the slated design criteria requires compromise between the environmental protection needs and variables, such as safety and costs.

Plan Structure

Another consistency in road management of the Greater Yellowstone Ecosystem is the structure of forest Land and Resource Management Plans. Although each plan is as unique as the forest it describes, the plans follow the same basic format. Each plan takes into consideration the same basic range of resources in the analysis of existing conditions, forest-wide management direction, and monitoring and
implementation guidelines. This structure allows for comparison of resource goals and objectives between different forests. Roads are discussed under the heading of Access or Facilities. Access/Facilities are considered along with the resources such as Recreation, Wilderness, Fish and Wildlife, Vegetation, Soil and Water, and Minerals.

Usually near the beginning of the document, the LRMP contains an analysis of existing conditions. Here the reader will find discussions of the forest setting; which describes the physical and biological features of the forest. Also included in the analysis are socio-economic conditions, resource supply and demand trends, future research and management needs. The existing conditions for each of the range of resources are discussed. In the Access/Facilities section, the reader can usually find current and planned road management activities. It is also a good place to look for road mileage statistics (Targhee plan, 1985).

This type of resource specific emphasis continues throughout the plan. Forest-wide management direction for each resource is given along with standards and guidelines for achieving the direction. In the breakdown of the forest into Management Areas, more specific goals and objectives are given for each resource. Monitoring and evaluation criteria are offered for each resource as well. This
consistency of structure allows the reader to examine and compare, for example, wildlife management, recreation management, or road management between forests (Bridger-Teton plan, 1989).

Road Classification, Maintenance Level, Traffic Service Level

Roads are described either by functional class, maintenance level or service level. These descriptions are consistent throughout the forest road system. As mentioned above, the functional class describes vehicle traffic patterns, the road network. Maintenance level describes how the road is to be managed and what levels of maintenance correspond with the management emphasis. Traffic service level is a road standard which describes conditions a traveler may encounter on the road. Although these descriptions are technically separate, they are consistent. For example, maintenance levels on one forest are basically equivalent to maintenance levels on other forests (Bridger-Teton plan, 1989).

Forest Travel Maps

The forest highway engineers and transportation planners produce travel plans/maps which are available to the public. Each travel plan displays which roads are open
or closed to public use. Descriptions and justifications of seasonal closures or other restrictions are usually given in the map legend. These maps show roads which exist on the forest road inventory at the time of publication. More complete, updated road information is available on the inventory and large scale maps in the engineer's office (Gallatin visitor map, 1986).

Present Inconsistencies in Road Management

Three Converging Forest Regions

The fragmentation of Greater Yellowstone into different forest regions exemplifies the divided land jurisdictions of the area. The Northern, Rocky Mountain and Intermountain Regions, Region 1, 2 and 4 respectively, join at the heart of the Greater Yellowstone Ecosystem (see Figure 11). Yellowstone National Park is bordered by six national forests in the three different Regions. The Beaverhead, Custer and Gallatin National Forests are in the Northern Region. The Shoshone is in the Rocky Mountain Region. And the Bridger-Teton and Targhee are in the Intermountain Region.

Three different Forest Service Regions mean three different Regional Guides affecting local forest plans. The Regional Guides link national direction of the RPA Program to local forest plans. Although the Regional Guides offer
Figure 11  Forest Service Regions and Assessment Regions

Source: USFS, 1990 RPA Assessment
only broad goals with respect to forest roads, they could be a point of influence for future coordination of road management in Greater Yellowstone.

Each region is allowed to supplement the Forest Service Manual and Forest Service Handbook to enhance management of the region. The "blue pages" of the manual and handbook give management direction which is offered in addition to the national guidelines. Differences in the supplements at the regional level translate to different direction for local forest engineering and transportation planning.

An example of this different direction is illustrated by looking at the road management documentation supplements for the Rocky Mountain Region. The Rocky Mountain Region requires documentation of management objectives for new road construction and reconstruction. The three-page worksheet shown in Appendix 1 "provides for documentation of related management area direction, access management objectives, and road design, operation and maintenance criteria" (FSH 7709.55, Region 2, Supplement 1, 1989). Existing roads are to be listed according to the one-page worksheet also shown in Appendix 1. The Northern and Intermountain regions do not have a supplement which mandates such documentation. The forests in these regions follow a basic format in the Forest Service Handbook, or are allowed to develop
individual forms and procedures for documentation (Neeley, 1991, Greer, 1991). Herein lies another point of intervention which could be used to coordinate road management. Consistent road documentation of this sort could go a long way toward consistent reporting of road management objectives.

Another opportunity for coordination lies in regional definitions of a closed road. According to Hammer (1990) the working definition of a closed road on the Northern Region is "five vehicles per week maximum, which allows for administrative access for each day of the week, each presumable a round trip." Although it is not an official figure and only a "working definition", the Northern Region transportation planners believe that a limit of this number of vehicles satisfies their objectives for closure and would not disturb wildlife (Greer, 1991). The Intermountain and Rocky Mountain Regions have no such definition (Neeley, 1991, Bachensky, 1991).

**Inconsistencies at the Local Forest Level**

A comparison of road management definitions and criteria of the six national forests in Greater Yellowstone reveals some inconsistencies. The most striking differences are in the following four categories: definitions of closed roads, display of road mileage in forest plans, open road
density calculations/standards, and access/facilities monitoring. In the following section, these four categories are discussed. A forest by forest breakdown of each category, from which this discussion is based, is given in Appendix 2 for the reader to examine. Unless otherwise cited, all references in both the discussion and Appendix 2 are from the forest Land and Resource Management Plans, Environmental Impact Statements and Travel Maps.

Definition of Closed Road

The definition of a closed road varies greatly from one forest to the next, or in some cases, does not exist. On the Bridger-Teton National Forest, closed roads are defined with respect to elk management. Timing of road closure with respect to elk hunting season or periods of elk use is the basis for the definition. On the Gallatin, the miles of road behind a closure are counted as "miles of closed road." This includes seasonal and year-long closures, and all types of closures (Debbitt, 1991). The Shoshone has a different definition, which considers only year-long closures to be counted as closed roads. Seasonal closures are not counted as closed (Fisher, 1991). The definition of closed road on the Targhee is vague at best. According to Bunnell (1991), a road is considered closed by assigned Maintenance Level. Maintenance Level 1 and some Maintenance Level 2 and 3 roads
are closed. Both seasonal and long-term closures qualify a road to be counted as closed. No distinct definitions of a closed road exist on the Beaverhead or Custer.

The forests of Greater Yellowstone need to establish a workable, consistent definition of closed road. This definition is important to many aspects of road management. It affects the accuracy of monitoring and open road density management efforts. Consistent guidelines for seasonal restrictions and types of closures could be incorporated into this definition.

Display of Road Mileage in Forest Plans

Reporting of road mileage in forest plans is not consistent. Table 3 illustrates the different breakdowns of road mileage displayed in each forest plan. It is difficult if not impossible to accurately compare road mileage between two plans when one lists roads by Traffic Service Level and another lists roads by Maintenance Level. As mentioned earlier in the study, Functional Class, Maintenance Level and Traffic Service Level are consistent descriptions of forest roads. But these descriptions, according to the Bridger-Teton plan, "are not technically interchangable." Miles of road at Traffic Service Level C could be either collector or local class. Maintenance Level 4 roads could be either arterial or collector class, or Traffic Service
Table 3  Display of Road Mileage in Forest Plans

**BRASHERHEAD**

<table>
<thead>
<tr>
<th>Functional Class</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial and Collector</td>
<td>585</td>
</tr>
<tr>
<td>Local</td>
<td>1100</td>
</tr>
</tbody>
</table>

Total 1685 *estimated 2500 miles of two-track road

**BRIDGE-TETON**

<table>
<thead>
<tr>
<th>Traffic Service Level</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>116</td>
</tr>
<tr>
<td>B</td>
<td>246</td>
</tr>
<tr>
<td>C</td>
<td>831</td>
</tr>
<tr>
<td>D (constructed)</td>
<td>346</td>
</tr>
<tr>
<td>Two-track (non-constructed)</td>
<td>1400</td>
</tr>
<tr>
<td>Total</td>
<td>2939</td>
</tr>
</tbody>
</table>

**CUSTER**

1980 Total Miles = 3803
Table 3 continued

GALLATIN

Maintained Annually by Forest Service 250
Maintained under cost-share by 10-15
Burlington-Northern
Intermittent-use and generally closed 250
Generally maintained at a primitive standard
and experiences very low traffic volume @190

Total 807

SHOSHONE

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Arterial</th>
<th>Collector</th>
<th>Local</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>35.0</td>
<td>14.0</td>
<td>5.4</td>
<td>54.9</td>
</tr>
<tr>
<td>Aggregate</td>
<td>78.0</td>
<td>30.7</td>
<td>24.9</td>
<td>133.6</td>
</tr>
<tr>
<td>Graded and Drained</td>
<td>13.8</td>
<td>214.7</td>
<td>190.4</td>
<td>418.6</td>
</tr>
<tr>
<td>Primitive</td>
<td>0</td>
<td>70.0</td>
<td>905.5</td>
<td>975.5</td>
</tr>
<tr>
<td>Total</td>
<td>127.3</td>
<td>329.4</td>
<td>1126.2</td>
<td>1582.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maintenance Level</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 - Custodial Care</td>
<td>326</td>
</tr>
<tr>
<td>Level 2 - Limited Passage</td>
<td>944</td>
</tr>
<tr>
<td>Level 3 - Safe for car</td>
<td>246</td>
</tr>
<tr>
<td>Level 4 - User Comfort</td>
<td>29</td>
</tr>
<tr>
<td>Level 5 - High Volume Traffic</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>1583</td>
</tr>
</tbody>
</table>

TARGHEE

<table>
<thead>
<tr>
<th>Maintenance Level</th>
<th>Miles</th>
<th>Percent of Total Road System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>Level 2</td>
<td>883</td>
<td>47</td>
</tr>
<tr>
<td>Level 3</td>
<td>604</td>
<td>32</td>
</tr>
<tr>
<td>Level 4</td>
<td>274</td>
<td>14</td>
</tr>
<tr>
<td>Level 5</td>
<td>96</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>1888</td>
<td></td>
</tr>
</tbody>
</table>
A, B, or C. The six national forests of the Greater Yellowstone Ecosystem need to adopt a consistent road classification. By doing so, an ecosystem-wide breakdown of each category of road would be available for analysis.

Another point to note with respect to road mileage is the estimates of non-inventoried "two-track" roads. Every forest has problems with non-system roads which result from off road travel. Even though they are not part of the official road inventory, these roads continue to be used and continue to hamper efforts to manage access. Simply estimating the mileage of two-track roads helps identify the problem, but an aggressive campaign to permanently close them needs to occur.

Open Road Density Calculations/Standards

Only two forests in Greater Yellowstone, the Bridger-Teton and the Gallatin, currently have standards for open road density; the other forests do not calculate open road density. These standards are based on the Lyon model for elk habitat effectiveness, but their similarity ends there.

The Bridger-Teton has the most elaborate system of calculating open road density. It is an adaptation of the Lyon model, but takes into consideration timing of closure around elk hunting season, and effectiveness of closures in order to adjust the rating of road mileage. The open road
density standard varies throughout the forest depending on management goals and objectives. Details of these calculations are discussed in Appendix 2. The Gallatin National Forest uses the same methods of rating road mileage as the Lyon model. But the open road density standards are only applied forest-wide during elk hunting season (Debbitt, 1991). Stricter standards are applied year-round for grizzly bear habitat.

Controlling open road density can be an effective means of managing human access. But the calculations of the figure and setting of density standards as measurable objectives is a complicated process with room for error. Problems exist with basing the calculation solely on elk-timber relationships, with interpretation and rating the miles of different road classification, and with accountable tabulations of open road mileage.

The national forests of Greater Yellowstone need to figure out a suitable method of calculating open road density and establish appropriate standards as a measurable objective. This requires considering effects of roads on species other than elk and on other forest resources. It also requires agreeing upon a method for classifying roads, with strict and measurable definitions of closed roads.

**Access/Facilities Monitoring**

Table 4 shows the access monitoring requirements from
each forest plan. In the table, excerpts from each plan are placed together to allow for comparison of the similarities and differences in monitoring criteria.

Collectively, the access monitoring requirements of the six national forests of Greater Yellowstone comprise a fairly thorough assessment. If all of the monitoring requirements were used by all of the forests, this in itself would be a step forward. But the problem, as Table 4 illustrates, is that the collective list is divided among six forests, with very little overlap or similarity between forests. For example, the Bridger-Teton plan requires monitoring of traffic levels; the Gallatin plan requires monitoring of off-road vehicle use; and the Custer plan requires monitoring of public access. The monitoring requirements which are similar, such as closure monitoring on the Beaverhead and Custer, are consistent except for the "variability which would initiate further evaluation." Efforts to coordinate access monitoring into a thorough and consistent assessment are essential for evaluating the effectiveness of road management.
Table 4 Access/Facilities Monitoring in Forest Plans
Beaverhead National Forest

<table>
<thead>
<tr>
<th>Monitoring Item</th>
<th>Activity, Practice, or Effect to be Measured</th>
<th>Unit of Measure</th>
<th>Data Source</th>
<th>Expected Precision</th>
<th>Variability</th>
<th>Frequency of Measurement</th>
<th>Reporting Period</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 Facilities</td>
<td>Are the assumptions about local/collector density, miles, and standards correct?</td>
<td>TIS Inventory, MAR's, Field review</td>
<td>N N 100%</td>
<td>Annual</td>
<td>5 years plus 10% in any one year; noncompliance for Forest Plan standards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-2 Facilities</td>
<td>Are the assumptions about road management valid, especially regarding closures and restrictions?</td>
<td>TIS Inventory, Maintenance Plan, Visitor Map, Program Reviews</td>
<td>N N Program Review on one District each year</td>
<td>Annual</td>
<td>5 years Noncompliance with Forest Plan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-6 Facilities</td>
<td>Road Management - Miles is the scheduled maintenance and planned management occurring?</td>
<td>TIS Inventory, NRS</td>
<td>N N 100%</td>
<td>Annual</td>
<td>5 year Less than 80% of schedule accomplished over five years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element and Priority</td>
<td>Monitoring Technique</td>
<td>Precision/Reliability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness monitoring of road closures - Priority 1</td>
<td>Check such things as road closure effectiveness and maintenance needs</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness monitoring of road maintenance - Priority 2</td>
<td>Condition surveys</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Validation monitoring of traffic - Priority 2</td>
<td>Measure road traffic use and type of use through traffic count device and traffic component sampling</td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Frequency of Measurement**
- At least once annually or more frequently if needed

**Deviation Requiring Further Evaluation or Change in Management**
- Maintenance needs are not met, or closures are violated
- A change be one condition class of the desired traffic service level
- An increase of use exceeding traffic service level standards for roads
Table 4 continued - Custer National Forest

<table>
<thead>
<tr>
<th>Monitoring Item</th>
<th>Subject</th>
<th>Activity, Practice, or Effect to be Measured</th>
<th>Data Source</th>
<th>Expected Precision</th>
<th>Expected Reliability</th>
<th>Frequency of Measurements</th>
<th>Reporting Period</th>
<th>Variability (?) Which Would Initiate Further Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Facilities</td>
<td>Road and Trail Construction/Reconstruction</td>
<td>Travel Inventory System</td>
<td>High</td>
<td>High</td>
<td>100% Sample</td>
<td>Annually</td>
<td>Less than 80% accomplishment of 5 year program</td>
</tr>
<tr>
<td>L2</td>
<td>Public Access</td>
<td>Miles of Roads Open, Travel Inventory Systems, Access gained</td>
<td>High</td>
<td>High</td>
<td>On-going</td>
<td>Annual</td>
<td>Less than 20% of target miles and public access open to public</td>
<td></td>
</tr>
<tr>
<td>L3</td>
<td>Road closure and rehab.</td>
<td>Miles of road closed/rehab</td>
<td>High</td>
<td>High</td>
<td>100% Sample</td>
<td>Annually</td>
<td>Less than 95% of roads identified as no longer needed closed within 2 yrs</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>NFMA Monitoring Requirements</td>
<td>Actions, effects, or Resources to Be Measured</td>
<td>Expected Precision</td>
<td>Expected Reliability</td>
<td>Reporting Time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>---------------------------------------------</td>
<td>--------------------</td>
<td>---------------------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>.12(k)(2)</td>
<td>Monitor effects of O.R.V. Use</td>
<td>.12(k)(4a)</td>
<td>.12(k)(4b)</td>
<td>.12(k)(4c)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4 continued - Shoshone National Forest

<table>
<thead>
<tr>
<th>Item Monitored</th>
<th>Data Source Techniques Used</th>
<th>Measurement Frequency</th>
<th>Allowable Variability from Plan Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road construction/reconstruction (arterial and collector)</td>
<td>Annual Report of FR&amp;T Accomplishment</td>
<td>Annual</td>
<td>± 25% of planned accomplishment</td>
</tr>
<tr>
<td>Trail construction/reconstruction</td>
<td>Annual Report of FR&amp;T Accomplishment</td>
<td>Annual</td>
<td>± 25% of planned accomplishment</td>
</tr>
<tr>
<td>Item No.</td>
<td>Activity, Practice Effect</td>
<td>Purpose</td>
<td>Method/Data Source</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------</td>
<td>---------</td>
<td>--------------------</td>
</tr>
<tr>
<td>6.</td>
<td>Travel plan</td>
<td>To ensure road management that is compatible with wildlife, recreation, soil, and water objectives.</td>
<td>Ground and aerial observation</td>
</tr>
</tbody>
</table>
Summary

In summary, the above critique reveals some consistencies and inconsistencies in the road management of the six national forests of Greater Yellowstone.

Consistencies

* National Direction
* Road Classification
* Plan Structure
* Forest Travel Maps

Consistency is due in large part to the influence of Forest Service-wide direction. The Forest Service Manual (FSM) and Forest Service Handbook (FSH) provide a consistent framework for road management on all of the nation’s national forests. Other service-wide aspects of road management, such as road classification, have the same meaning throughout the forest system. The structure of forest plans and travel maps are also consistent enough to allow easy comparison of resources and policies from one forest to another.

Inconsistencies

* Regional Level
  - Three Converging Forest Service Regions

* Local Level
  - Definition of Closed Road
  - Display of Road Mileage in Forest Plans
  - Open Road Density Calculations/Standards
  - Access/Access/Standards Monitoring
Inconsistencies of road management in the national forests of Greater Yellowstone are found at the regional and local level. Three Forest Service regions converge at Greater Yellowstone. This means three different supplements to the FSM and FSH, and three different regional guides; both affecting local forest road management. Definitions of "closed road" vary from one region to the next. At the local level, basic data essential to road management varies from one forest to the next. Road management definitions, road density calculations and standards, and monitoring criteria are different, making comparison or coordination of road management difficult. The opportunities for coordination, which is the subject of the next chapter, are greatest in these areas of inconsistency at the regional and local level.
VI CONCLUSIONS AND RECOMMENDATIONS

In this final chapter, conclusions are drawn from the study with respect to opportunities for coordinated road management in Greater Yellowstone. Following this discussion, some recommendations are proposed and discussed in relation to their benefits to ecosystem management. Although they result from a critique of the forests of Greater Yellowstone, these recommendations could apply to other ecosystem management efforts.

It is the thesis of this study that opportunities exist for coordinated road management on public lands for purposes of ecosystem management. In order to demonstrate how these opportunities benefit ecosystem management, they should be discussed in relation to the meaning of ecosystem management. According to Clark and Harvey (1988), "The fundamental idea underlying the concept of 'ecosystem management' seems to be that the ecosystem must be viewed and treated as a unit and that its dynamic interactive processed must be maintained."

The two parts of this idea, treating the area as a unit and maintaining ecosystem dynamics, are interdependent. Some knowledge of ecosystem dynamics is needed to define the unit. And maintaining those dynamic processes cannot be achieved without managing the area as a cohesive unit.
The interdependence of the concepts of ecosystem management does not mean that complete knowledge of ecosystem dynamics is necessary in order to begin managing an area as a cohesive unit. Although ecologists maintain that much remains to be learned about ecosystem processes, this study demonstrates that enough is currently known to say that areas such as Greater Yellowstone constitute an ecosystem, and should be managed as a unit. With this in mind, the process of ecosystem management can begin with efforts to coordinate the planning and management of the agencies which have jurisdiction within the area. Hopefully, the implementation of these coordinated efforts will be effective in maintaining ecosystem processes until more is learned about them.

Opportunities for Coordination

*Definition of Closed Road  
*Reporting of Road Mileage in Forest Plans  
*Open Road Density Calculations/Standards  
*Access/Facilities Monitoring

Most of the opportunities for coordinating road management in Greater Yellowstone lie within the realm of "treating the area as a unit." These opportunities, once realized, could become part of a broad road management effort which would become one of the tools in working toward
maintenance of the ecosystem. What follows is a look at these opportunities, recommendations for improvement, and how the recommendations would benefit ecosystem management.

Definition of Closed Road

No concise, consistent definition of a closed road currently exists in Greater Yellowstone. Consequently, a closed road on one forest may be considered open on another. This is a problem which could be remedied at either the regional or local level.

Inconsistencies at the regional level exist due to the "working definition" of a closed road adopted by the Northern Region. The Rocky Mountain and Intermountain Regions have no such definition. An agreed upon definition of closed road, with specific criteria, could be incorporated into regional supplements of the Forest Service Manual.

The alternative to a regional definition of "closed" would be one proposed and agreed to at the local level. The current problems are illustrated by the different criteria applied at different forests in Greater Yellowstone. For example, on the Gallatin, any road behind a gate is considered closed; while on the Shoshone, only roads closed year-long are considered closed.

Consistent guidelines for seasonal restrictions and
types of closures should accompany this definition. The timing and effectiveness of closures is a crucial aspect of managing access. By establishing such a definition and guidelines, a closed road on the ecosystem would have a measurable and accountable meaning.

Reporting of Road Mileage in Forest Plans

There is no way to accurately compare road mileage between forests when they are displayed in different categories. The forest plans should display road mileage and breakdowns of road type consistently. This would facilitate easy and accurate comparison of roads between forests. It would also allow for an accurate assessment of the total amount of inventoried roads, by type or class, for the entire Greater Yellowstone Ecosystem. This type of coordination is essential for establishing baseline data for use in an ecosystem-wide road management effort.

The reporting of road mileage should include the estimate of non-inventoried "two-track" roads. Although not officially counted in road inventories, these roads exist none the less and continue to hamper road management efforts. The Forest Service is required to permanently close roads which are no longer needed. The most effective means of permanent closure is by obliteration; physically ripping out the roadbed, re-seeding and re-vegetating the
road. Currently, attempts are made to account for non-inventoried roads. But an aggressive campaign to inventory and/or obliterate two track, non-system roads needs to occur.

Open Road Density Calculations/Standards

Coordinated road management definitions and monitoring would facilitate a coordinated effort to manage open road density. Currently, road density standards of the forest are either inconsistent or not applied. Comparing the open road density of the Gallatin and Bridger-Teton is not useful because each forest has different calculation methods. Comparing the open road density of the Shoshone with the Bridger-Teton is impossible because the road density of the Bridger-Teton is calculated by rating road mileage. The Shoshone reports only actual miles of road.

The calculation of open road density raises other questions. The Lyon model of habitat effectiveness is based on relationships between timber management and elk. But it may not be an effective model of road impacts for the entire forest. Forest plans describe the effects of roads on other resources. These effects should be considered in managing open road density.

Two alternatives should be considered with respect to calculating open road density: Either drop the rating
system for a straight-miles, actual road density
calculation, or develop a new road rating system which
considers some of the most important indicators of ecosystem
health. Both alternatives would allow consistent standards
of open road density to be applied throughout Greater
Yellowstone.

The first alternative would be the most
straightforward. Following the establishment of coordinated
road management definitions, criteria and monitoring
requirements, a system or road density standards could be
set. Consistent reporting of road mileage, with concrete
definitions of closed v. open roads, would allow forest
managers to measure miles of open road. This figure would
be divided by square miles of the area under consideration,
to give an open road density.

The second alternative would be an expansion of the
ideas from the Lyon model. While it would be more complex,
developing a broader system of rating road effects would
generate new research into cumulative effects of roads on
large scale ecosystems. Following the establishment of
coordinated road management definitions, criteria and
monitoring requirements, work to develop a new model of
calculating open road density could begin. The new scale
could combine rated effects of roads on water resources,
soil erosion, recreation, visual quality, habitat
fragmentation and species other than elk. This does not seem impossible given that forest planning and management currently addresses water quality standards and erosion control. Forest plans also outline the recreation opportunity of different areas of the forest. Visual Quality Objectives are also established. Additional research would be needed for rating degrees of fragmentation and road effects on other indicator species. Scientific research combined with public input could result in a more broad-based open road density standard which could be applied and monitored throughout the entire ecosystem. With the availability of current data and the application of this idea through a Geographic Information System, this proposal could work.

**Access/Facilities Monitoring**

Opportunities exist for coordinating monitoring of forest roads. Collectively, the access monitoring requirements of the six national forests of Greater Yellowstone comprise a fairly thorough assessment. If all of the monitoring requirements were used by all of the forests, this in itself would be a step forward. But the problem is that the collective list is divided among six forests, with very little overlap or similarity between forests. Consistent monitoring could be tied into
consistent definitions of closed road, consistent accounting of road mileage and consistent measurement of open road density. These efforts would create a data base which would allow managers to not only effectively assess road management of individual forests, but also Greater Yellowstone as a whole. Once this is accomplished, research into the cumulative effects of roads on the ecosystem would have reliable baseline data.

**Recommendations**

In review, the following recommendations are suggested for the forests of Greater Yellowstone. Although these recommendations result from a critique of Greater Yellowstone, they could be applied to other ecosystem management situations.

- Establish consistent definitions of open and closed roads.
- Establish consistent guidelines for seasonal road restrictions, types and effectiveness of closure.
- Coordinate reporting of road mileage and road classification in forest plans.
- Inventory and/or obliterate non-system roads.
- Establish consistent access monitoring requirements
- Establish consistent methods of calculating open road density and consistent open road density standards.
Benefits to Ecosystem Management

These recommendations will enhance ecosystem management by helping to establish a unified road management information, planning and policy. As demonstrated by the study, much of the information on which road management decisions are based varies from one forest to the next.

Inconsistent road management data and standards exist due to different or vague definitions of a closed road, inconsistent reports of road mileage in plans, inconsistent road monitoring criteria, and varying open road density standards. These differences demonstrate the current fragmentation of road management efforts and the need and opportunity for coordination. The establishment of consistent road management information would help establish cohesive, usable and accountable source of baseline data for road management decisions which could be used for further study into the effects of roads on the ecosystem.

The establishment of coordinated road management criteria and standards helps work toward the first part of the concept of ecosystem management - "treating the area as a unit." But the implementation of the coordination effort is what must work toward "maintaining dynamic interactive processes" of the ecosystem. To illustrate this point, consider the relationship between coordinated road management and the road management objective of "no net
increase" in open roads from the draft *Vision for the Future*. No net increase is a tangible objective which describes a desired level of human access. It is tangible only if the area is "treated as a unit" through coordinated road management information and standards.

The objective suggests that human access needs to be controlled. This study has demonstrated that human access and the roads which supply the access have significant impact on forest resources. It is fair to say that, even though knowledge of the dynamic interactive processes of an ecosystem is still lacking, these processes are probably affected as well. Because of the widespread and complex effects of roads, "no net increase" is an objective which, if reached, should help maintain natural processes. It is an objective which could be attained through implementation of coordinated road management.

**Concluding Remarks**

Managing human access through coordinated road management is one of the tools that public land managers can use to work toward the goals of ecosystem management. Clark and Zaunbrecher (1987) suggest three goals essential to perpetuating ecosystems:

1) Maintenance of all existing plant and animal populations and restoration of species which have been eliminated by man.
2) Monitoring of major ecological processes.

3) Integration of long-term sustainable human economies within the constraints of (1) above.

Coordinated road management is a point of intervention, a lever which the manager can pull to mitigate the effects of roads and their associated human activities on the components and dynamic processes of the ecosystem. But it is not the only intervention available and ecosystem-based road management by itself cannot preserve ecosystems. Road management is related to and dependent on other tools for ecosystem management.

Managing human access should work hand in hand with other tools for ecosystem management. The tools of ecosystem management cannot be applied separately, but rather as a unified, holistic approach. Species re-introduction efforts need to be considered when determining the timing, location and effectiveness of road closures. Management policies which allow natural disturbances such as wildfire to assume a role in the ecosystem can benefit from coordinated road management. The question of availability or denial of access is important to the "integration of long-term sustainable human economies" within the ecosystem. Human recreation and natural resource needs are tied to managing access. Water and air quality monitoring programs and other indicators of ecosystem health should be essential
components of road management efforts.

Greater Yellowstone is an excellent candidate for ecosystem management. Not only is it the foundation of American public land preservation, and a special attraction to visitors from all over the world, it is still an essentially intact ecosystem. But it cannot exist as a functioning ecosystem without enlightened efforts which constitute a revolution in public land management. Conservationists around the world are anticipating what is sure to be a precedent-setting effort in Greater Yellowstone. The task is as challenging as it is enormous. But it needs to be done right; and it needs to be done soon. There will not be a second chance.
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The Forest Service Program for Forest and Rangeland Resources: A Long-Term Strategic Plan, May, 1990.

APPENDIX 1
Rocky Mountain Region Road Management Supplement to the Forest Service Handbook

ROAD MANAGEMENT OBJECTIVES WORKSHEET
(New Construction or Reconstruction Projects) New: __________ Update: __________

Approved: __________ Review: __________
District Ranger Date Forest Engineer Date

Forest: __________ District: __________

<table>
<thead>
<tr>
<th>Road Number</th>
<th>Road Name</th>
<th>Termini</th>
<th>Length</th>
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</tbody>
</table>

Functional Class: Arterial [ ] Collector [ ] Local(s) [ ]
Service Life: Constant [ ] Intermittent [ ]

MANAGEMENT AREA DIRECTION
(PSH 7709.55, 33.1.a.)
The Forest Plan Management Area Map shows the following area prescription for this road(s): [ ] Emphasis is on: [ ]
Visual Quality Objective (VQO) is: [ ]

ACCESS MANAGEMENT OBJECTIVES
(PSH 7709.55, 33.1.b.)
ROS classification is: [ ]

DESIGN CRITERIA
(PSH 7709.56, W.1)

ENVIRONMENTAL & RESOURCE CONSIDERATIONS: (Requirements for protection of adjacent resources & improvements)

FSH 10/89 R-2 SUPP 1
SAFETY: (Unique or Special Considerations; Intersections; Hazards, etc.)

TRAFFIC REQUIREMENTS:
Volume: SADT-Jul & Aug [ ]
Composition: Trucks [ ]% Motor Homes & Vehicles Towing Trailers [ ]%
Distribution: Average Weekday [ ]% Average Weekend [ ]%

TRAFFIC SERVICE LEVEL: [ ] B[ ] C[ ] D[ ]

VEHICLE CHARACTERISTICS:
Design Vehicle:
Critical Vehicle:
Number of Entries:

ROAD USER (TRAFFIC TYPE): Approx. Volumes & Types of Traffic.
Recreation: [ ]% Administrative [ ]% Commercial: [ ]%
Commercial Use: Planned Volume [ ] Sold Volume [ ]
Future Volume 20 Yr. [ ] Will Road be extended? [ ]

ECONOMICS:
Design Stds. used in Econ Anal: No Lanes [ ] Design Speed [ ] Surfacing [ ]
Preliminary Road Cost Estimate [ ] Annual Maintenance Cost [ ]
Detailed Economic Analysis is located in [ ] Project File.
EA Benefit Cost Ratio: [ ] Revenue Cost Ratio: [ ]
NEPA Decision Document Name [ ] Signed/Date [ ]

OPERATION CRITERIA
(FSH 7709.59, Chapter 10)

SUBJECT TO THE HIGHWAY SAFETY ACT: [ ] No [ ] (FSM 7713.11 & FSH 7709.21)

JURISDICTION: Forest Service [ ] County [ ] (FSM 7703.2 & 7705)
TRAFFIC MANAGEMENT STRATEGY: (FSM 7731.11 & R-2 FSH 7709.21)
Public Use: During Commercial Use:
Encourage [ ] Accept [ ] Discourage [ ] Eliminate [ ] Prohibit [ ]
Public Use: After Commercial Use:
Encourage [ ] Accept [ ] Discourage [ ] Eliminate [ ] Prohibit [ ]
Season of Use: Season of Closure:

TRAFFIC RULES AND ORDERS: (FSM 7731.12 & 7731.14 & R-2 FSH 7709.21)

PERMITS: (FSM 7731.16)

TRAFFIC CONTROL DEVICES: (FSM 7731.15 & R-2 FSH 7709.21)

MAINTENANCE CRITERIA
(FSH 7709.58)

MAINTENANCE RESPONSIBILITY: FSI [ ] County[ ] Permittee[ ] Purchaser[ ] Other[ ]

ENVIRONMENTAL & RESOURCE CONSIDERATIONS: (Requirements for protection of adjacent resources & improvements - refer to Design Criteria).
Additional Maintenance Criteria:

MAINTENANCE LEVEL
(FSH 7709.58)

Operational Level [ ] 1[ ] 2[ ] 3[ ] 4[ ] 5[ ]
Objective Level [ ] 1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

Worksheet Preparation:
Prepared By: Title: Date:
Recommenda By: Title: Date:

FSH 10/89 R-2 SUPP 1
Exhibit 2

ROAD MANAGEMENT OBJECTIVES WORKSHEET (EXISTING ROADS)

Approved: _____________________________ Review: _____________________________ New Update:

Forest: _____________________________ District Ranger: _____________________________ Date: _____________________________ Forest Engineer: _____________________________ Date: _____________________________

Road No/Sec: _____________________________ Road Name: _____________________________ District: _____________________________ Termini: _____________________________ Length: _____________________________

Functional Class: Arterial [ ] Collector [ ] Local(s) [ ] Service Life: Constant [ ] Intermittent [ ]

OPERATION CRITERIA: (FSH 7709.59, Chapter 10)

Subject to the Highway Safety Act: Yes[ ] No[ ] (FSH 7713.11 & FSH 7709.21) Jurisdiction: Forest Service [ ] County [ ] (FSH 7703.2 & 7705)

Traffic Management Strategy: (FSH 7731.11 & R-2 FSH 7709.21) During Comm Use: Encourage[ ] Accept[ ] Discourage[ ] Eliminate[ ] Prohibit[ ]

After Comm Use: Encourage[ ] Accept[ ] Discourage[ ] Eliminate[ ] Prohibit[ ]

Traffic Rules and Orders: (FSH 7731.12 & 7731.14 & R-2 FSH 7709.21)

Permits: (FSH 7731.16)

Traffic Control Devices: (FSH 7731.15 & R-2 FSH 7709.21)

MAINTENANCE CRITERIA: (FSH 7709.58)

Maintenance Responsibility: FS[ ] County[ ] Permittee[ ] Purchaser[ ] Other[ ]

Environmental & Resource Considerations: (Requirements for protection of adjacent resources & improvements)

Other Maintenance Criteria:

Season of Use and Approximate Volumes and Types of Traffic:

Recreation: [ ] Administrative: [ ] Commercial: [ ]

Season of Use: 0-25 [ ] 25-50 [ ] 50-100 [ ] 100-400 [ ] 400+ [ ]

Current and Future Operation and Maintenance Strategies:

Traffic Service Level: A [ ] B [ ] C [ ] D [ ]

Maintenance Level: Operational 1[ ] 2[ ] 3[ ] 4[ ] 5[ ] Objective 1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

Prepared By: _____________________________ Title: _____________________________ Date: _____________________________

Recommend By: _____________________________ FSH 10/98 R-2 SUPP 1
APPENDIX 2
Forest by forest comparison of road management inconsistencies

Beaverhead National Forest

Closed Roads

No specific definition of "closed" is offered in the plan. Varying degrees of closure and access are listed in the "Area Access Guidelines" of the plan. Each "Geographic Display Area" is assigned one or more of the guidelines which "guide the level, density and standards of facility development." Examples of the guidelines range from: "No developed facilities maintained for public access," to "Access via closed use roads that are closed to motorized access during sensitive times of the year," to "Access via fully developed roads and trails in a highly developed system." The guidelines help direct transportation planning, but do not offer a distinct definition of closed.

Display of Road Mileage in Plan

The plan lists road mileage as shown in Table 3. According to the plan, of the total 1685 miles of road, "950 are maintained and 735 remain in primitive condition." The plan also acknowledges problems with off-road vehicle use and large numbers of non-system roads. The plan states that "at least 2500 miles of unmapped non-system roads 'wheel tracks' and 'jeep tracks' exist."
Open Road Density Calculations/Standards

Open road density is not calculated for the forest, and thus no standards are established. Wildlife managers have used the Lyon model during project level analysis. Elk effective cover is calculated for timber sales, and the plan states that as "effective cover rating of at least 70% will be maintained during hunting season." Road mileage is rated as per the Lyon model to get a "habitat effectiveness" figure. The elk use potential, a percentage of available security cover, is multiplied by habitat effectiveness (influence of road density) to calculate elk effective cover.

Access/Facilities Monitoring

Facilities monitoring is shown in Table 4.

Bridger-Teton National Forest

Closed Roads

Closed roads are defined with respect to elk management and the Lyon model for calculating open road density. The Bridger-Teton plan lists the following definitions:

*Open road status* means open to motorized use during the period elk normally use the area. *Closed hunting season* means closed for about a 1-month period when area is open for elk and deer hunting. *Closed with gates* means closed to motorized
vehicles for entire period of elk use. 
*Closed with barriers* means to close roads with effective means for stopping all 4-wheeled traffic. 
*Closed completely means* that roads have been revegetated with brush or for one reason or another, all types of motorized travel are prevented.

The plan acknowledges the difference in effectiveness between gated and barricaded closures. Gated closures, according to the plan, "will allow for a minimal amount of administrative activity." Also these closures sometimes do not prevent trespass and thus are not considered as effective as barricaded closures.

Display of Road Mileage in Plan

The Environmental Impact Statement lists road mileage for the entire forest by traffic service level as shown in Table 3. This same breakdown of roads is given for each Management Area. Mileage is displayed as actual miles, then rated for the open road density calculations. Approximately half of the 2900 miles of roads on the Bridge-Teton are "two-track." These roads were "never planned or built by the Forest Service." but are considered in road closure management. These roads, when inventoried, are counted as Traffic Service Level D in the calculation of open road density.
Road Density Calculations/Standards

Of the six national forests in Greater Yellowstone, the Bridger-Teton has the most elaborate system of calculating open road density. As mentioned above, the degree of closure is measured in relation to elk management. This is incorporated into the calculation of open road density as shown in Table 5. Each classification of closure is assigned a different weight by which to multiply actual miles. "Standard miles" is the rated mileage, actual miles times the multiplier.

The density calculation is an adaptation of Lyon's model. It uses the same function curve and also considers "hiding cover" dense enough to hide 90% of an elk at a given distance. According to the criteria of the plan, "Vegetation must be dense enough to qualify as hiding cover within 300 feet on both sides of a road, or it is considered open." For example, as shown in Table 5, if a secondary, open status road has sufficient hiding cover, its mileage is rated at .5 of the actual distance. If it does not have sufficient cover, it is rated at .9 of the actual mileage.

The open road density standard varies throughout the forest depending on management goals and objectives. Average open road density standards vary from .25 miles / square mile in areas with emphasis on "grizzly bear habitat recovery," to an average of 1.5 miles / square mile in areas
Table 5 Equivalent Mileage of Standard Road for 1 mile of various types of roads, road closures and vegetation adjacent to road

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Road Status</th>
<th>Hiding Cover</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>Open</td>
<td>.80</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>Closed-hunting season</td>
<td>.71</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>Closed-entire elk use period (with gates)</td>
<td>.24</td>
<td>.36</td>
</tr>
<tr>
<td></td>
<td>Closed-entire elk use period (with barrier)</td>
<td>.08</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td>Closed completely</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Secondary</td>
<td>Open</td>
<td>.50</td>
<td>.90</td>
</tr>
<tr>
<td></td>
<td>Closed-hunting season</td>
<td>.44</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>Closed-entire elk use period (with gates)</td>
<td>.15</td>
<td>.27</td>
</tr>
<tr>
<td></td>
<td>Closed-entire elk use period (with barrier)</td>
<td>.05</td>
<td>.09</td>
</tr>
<tr>
<td></td>
<td>Closed completely</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Primitive</td>
<td>Open</td>
<td>.03</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>Closed-hunting season</td>
<td>.03</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>Closed-entire elk use period (with gates)</td>
<td>.01</td>
<td>.02</td>
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<tr>
<td></td>
<td>Closed-entire elk use period (with barrier)</td>
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</tr>
<tr>
<td></td>
<td>Closed completely</td>
<td>.00</td>
<td>.00</td>
</tr>
</tbody>
</table>
which emphasize "substantial commodity resource development with moderate accommodation for other resources." Of the approximately 3,437,700 acres of forest, approximately 1,391,000 are wilderness or wilderness study area. Of the remaining 2,046,400 acres, 51% (1,046,610 acres) have an average open road density standard of 1 mile or more of open roads per square mile.

Access/Facilities Monitoring

Monitoring of access in the Bridger-Teton is shown in Table 4.

Custer National Forest

Only the Beartooth District of the Custer National Forest is considered a integral part of the Greater Yellowstone Ecosystem. The other parts of the forest land are separate units which include grasslands in eastern Montana and in North and South Dakota. The majority of the Beartooth District is composed of the 339,841 acre Absaroka-Beartooth Wilderness, other recommended Wilderness, Research Natural Areas, wildlife habitat and protected viewsheds, all of which have either no roads or no planned road construction. This makes the job of road management considerably easier for the Custer National Forest.
Closed Roads

No definition of "closed" is given in the forest plan. According to Shaller (1991) roads slated for closure are identified in the process of updating the forest travel map. Some problems exist with un-inventoried two-track roads. An attempt is made to inventory these roads during update of the travel map. Possibilities for new road construction are very limited due to the Wilderness classification of the majority of the Beartooth District, and because the district has no present timber program. The occurrence of two-track roads created by forest users is limited due to terrain constraints along existing roads and inclusion of high, open plateau, which could be negotiated by off-road vehicles, in protected Wilderness Areas.

Display of Road Mileage in Plan

Miles of road are given only as a 1980 total of 3803 miles. No breakdown of miles per road classification is given. The Greater Yellowstone Coordinating Committee's 1987 Aggregation of Park and Forest Plans lists the Custer having 131 miles of existing open roads, presumably this is the Beartooth District, with no closed or restricted roads. All reported mileage is actual miles of road.
Open Road Density Calculations/Standards

The Custer National Forest does not use the Lyon model for calculating open road density, thus no general density standards are established. Open road density is mentioned for Management Area E, "areas of high mineral potential and existing mineral development activities." According to the plan, in Management Area E, "Road densities will average about two miles per square mile during initial development. Secondary and tertiary recovery could increase this mileage to a total of five to six miles per square mile." This is an "actual miles" density.

Access/Facilities Monitoring

Facilities monitoring is shown in Table 4.

Gallatin National Forest

Closed Roads

The Gallatin National Forest Travel Map offers the following definition: "closed area, road or trail - an area, road or trail where the use of off-road vehicles is permanently or temporarily prohibited." The miles of road behind a closure are counted as "miles of closed road." This includes seasonal and year-long closures, and all types of closures (Debbitt, 1991).
Display of Road Mileage in Plan

Road mileage is shown as the total miles of inventoried roads. No breakdown of road class, maintenance level or traffic service level is given. Mileage which is "maintained annually", or "intermittent use and generally closed" is given in the plan, as shown in Table 3. The plan states that at least 1000 miles of uninventoried, two-track roads exist on the forest.

Road Density Calculations/Standards

The Gallatin uses the Lyon model to calculate open road density. The same rating system, primary x 1, secondary x .7, primitive x .05 is used to convert actual miles to rated miles. The Gallatin has a forest-wide open road density standard of .75 miles / square mile; to be achieved during elk hunting season (Debbitt, 1991). Density standards of .5 miles / square mile, and 1 mile / square mile are applied to Management Situation 1 and Management Situation 2 Grizzly Bear Habitat, respectively. As mentioned above, miles of road behind a closure, regardless of type, or effectiveness, are used in the tabulation of closed road miles.

Monitoring

The only access/facilities monitoring the plan requires is that of the effects of off-road vehicle use (see Table
4).

**Shoshone National Forest**

**Closed Roads**

The only roads the Shoshone lists as closed are those closed yearlong to all vehicle traffic. Seasonal closures and restrictions are counted separately and not counted as closed. Two-track roads, when inventoried, are counted as local roads (Fisher, 1991).

**Display of Road Mileage in Plans**

Road mileage is broken down by road classification and by maintenance level, as shown in Table 3. All reported road mileage is actual miles, not rated.

**Open Road Density Calculations/Standards**

The Shoshone National Forest does not use Lyon's model for calculation of open road density. No rating of road miles is performed. No open road density is calculated and thus no open road density standards are established (Fisher, 1991).

**Access/Facilities Monitoring**

Facilities Monitoring is shown in Table 4.
Targhee National Forest

Closed Roads

The Targhee plan offers no specific definition of a closed road. According to Bunnell (1991) a road is considered closed by assigned maintenance level. Maintenance Level 1 and some Maintenance Level 2 and 3 roads are closed. Both seasonal and long-term closures qualify a road to be counted as closed. The plan does not specify how or if two-track roads are considered.

Display of Road Mileage in Plan

Road mileage is displayed by Maintenance Level as shown in Table 3. No breakdown of open v. closed roads is given. Mileage is given in actual miles.

Open Road Density Calculations/Standards

The Targhee does not use Lyon's model for calculating open road density. No rating of road mileage is performed. No open road density is calculated and thus no open road density standard is established (Bunnell, 1991).

Access/Facilities Monitoring

The plan does not call for specific monitoring of facilities or access. There is one reference to monitoring of the travel plan, as shown in Table 4, but with no
specific objectives to be measured.

The five year monitoring report (1986) does identify the need for monitoring of roads. The report states that "Actual road construction has exceeded the planned levels by 73 miles, or 17 percent." The report calls for the addition of road monitoring to the plan.
Vita

The author, David R. Holladay, was born June 9, 1961 in Front Royal, Virginia. He graduated from Parry McCluer High School in Buena Vista, Virginia in 1979. He entered Virginia Polytechnic Institute and State University where he earned a B.A. degree in Communication Studies in March, 1984. For the next four years he was employed by T W Services, a concessionaire in Yellowstone National Park, where he held various seasonal positions such as Bar Manager, Old Faithful Lodge, Bellman, Old Faithful Inn, and Snow Coach Driver, Old Faithful Snow Lodge. Following his return to Virginia, and some temporary employment, he enrolled in the graduate school at Virginia Tech in the Fall of 1989, in the Urban and Regional Planning Program, which he completed in May, 1991.

[Signature]