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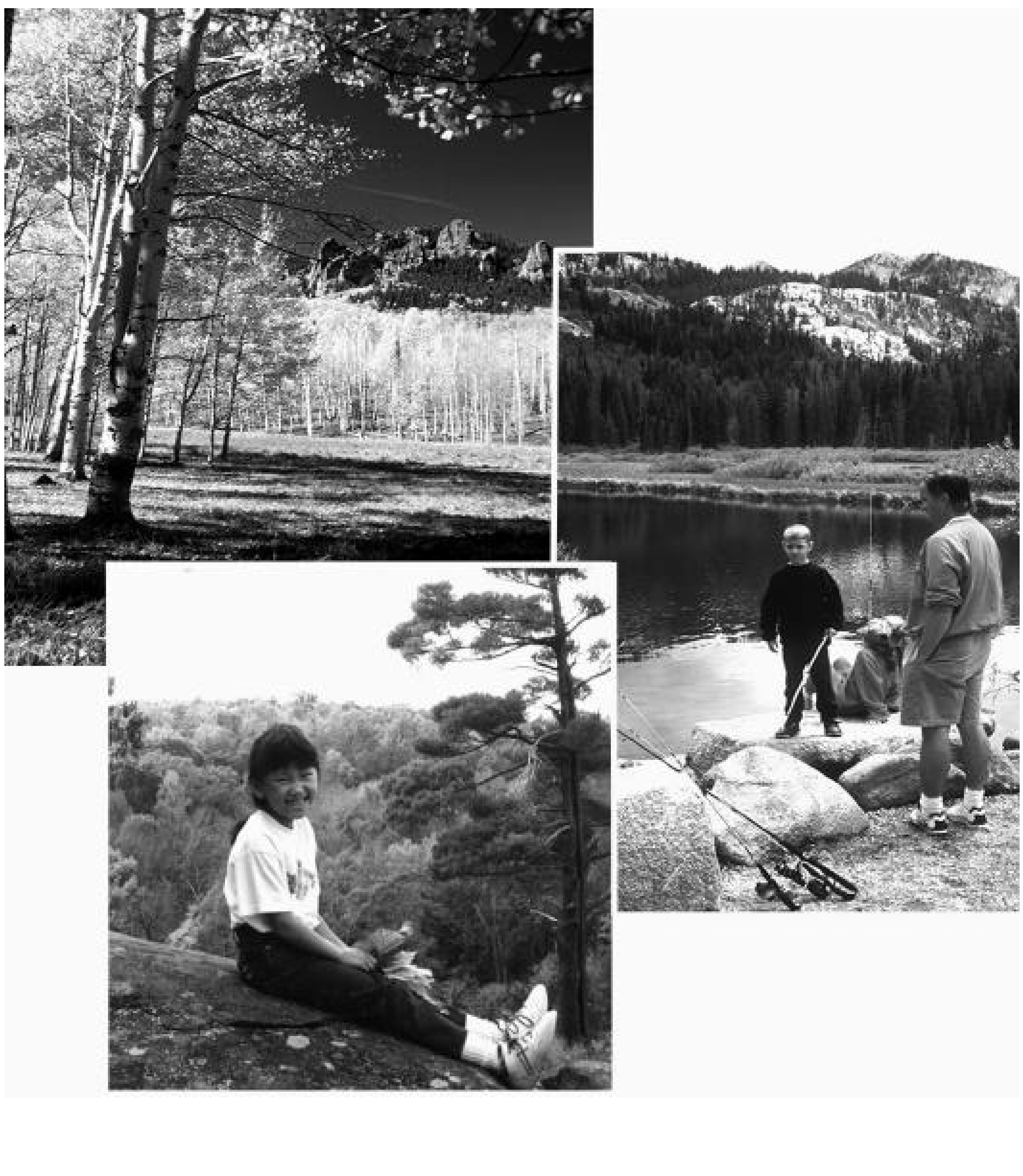
Forest Service
Roadless Area Conservation

Final Environmental Impact Statement

Landscape Analysis and Biodiversity Specialist Report



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Final Environmental Impact Statement

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Abstract:

This specialist report provides the analysis for the affected environment and environmental consequences of the alternatives discussed in the Roadless Area Conservation Final Environmental Impact Statement (FEIS), (November 2000c). The report covers the assumptions, data, methods, and analysis of effects for the landscape ecology portions of the biodiversity section of Chapter 3 of the FEIS.

Inventoried roadless areas on NFS lands were assessed in this analysis to determine the effect of Alternatives 1 through 4 on certain landscape characteristics important to maintaining biodiversity. The percentage of land area in inventoried roadless areas was compared across three geographic divisions (East, West, Alaska), 45 ecoregions, 10 elevation zones, and 11 landcover classes. Variation in the size-class distribution of inventoried roadless areas was also summarized.

The results of our evaluation highlight the value of inventoried roadless areas towards maintaining a representative network of relatively undisturbed areas that function as conservation reserves in the United States, supporting a diversity of plant and animal species. The conservation of inventoried roadless areas under the action alternatives would expand ecoregional representation, increase acreage of low elevation, biologically productive areas, and increase the number of areas large enough to provide refugia for species needing large tracts relatively undisturbed by people.

This analysis demonstrated that below 5,000 feet in elevation, 18.5% of lands are located in inventoried roadless areas, as compared to 10% in Wilderness, thereby providing important additional conservation of lower elevation habitats. These lower elevation habitats may be more biologically productive and diverse than those at higher elevations. Further, a full range of landcover types is represented.

More than 34% of inventoried roadless area acreage is adjacent to designated Wilderness Areas. Maintaining these areas in a roadless condition would help support populations of species needing large, contiguous blocks of roadless area. Additionally, conservation of inventoried roadless areas would increase the proportion of ecoregions functioning as conservation reserves[1] on national forest lands. Although not needed for analysis of this project, a more in-depth analysis may be desirable from which a comprehensive national biological diversity conservation strategy could be built. A promising avenue for such analysis would be a national synthesis of the vegetation and species distribution data contained in the Gap Analysis Project database (Scott and others 1993). A repeatable, computer-based technique for identifying representative reserves (Bedward and others 1992, Davis and others 1996, Kiester and others 1996) could then be used to rigorously quantify the extent to which inventoried roadless areas and conservation reserves contain the range of biodiversity.

[1] In this analysis, areas that are strictly managed or managed to maintain natural values; status classes 1 and 2, respectively (DellaSala and others 2000).

Affected Environment:

More than 700 million acres (about 25%) of the United States land base are federally managed. Most of these lands are managed to help ensure that adverse, irreversible, long-term resource commitments are not made. Of these lands, more than 100 million acres (about 5% of the country) are Wilderness Areas and national parks where roads are prohibited. Most of this land occurs in the West.

Even with this much of the land area under Federal management, more than 200 fish and wildlife species have been listed under the Endangered Species Act as threatened or endangered or are proposed to be listed (TEP), and numerous ecosystems have been lost or significantly degraded (Noss and others 1997). As of 1993, about 50% of all federally listed threatened and endangered species are known to occur on federal lands. The other 50% are found on either State and local public lands, Tribal lands, or private lands. Although not a statistical sample, of the more than 24,500 records of federally listed species collected by the Natural Heritage Network nationwide, 36% are found on federal lands. The Forest Service, with 16% of the total listed species occurrences, has the largest number, followed by the Bureau of Land Management (8%), and the Department of Defense (4%) (Stein and others 1995).

Noss and others (1997), have identified more than 30 critically endangered, 58 endangered, and more than 38 threatened ecosystems in the United States. The major causes for these declines are habitat loss, degradation, and fragmentation (Ehrlich and Ehrlich 1981, Harris 1984, Wilson 1985,1988, Soule 1991, Noss and Cooperrider 1994). Of the serious ecosystem losses throughout the country, the East has had the most.

The World Wildlife Fund (Ricketts and others 1999) recently completed a conservation assessment of terrestrial ecosystems of the United States. This assessment was based on standardized protected-area classifications developed by the US Geological Survey, National Biological Survey, and the GAP Analysis Project. Some general findings from this assessment include:

- The area protected in parks, monuments, Wilderness, and wildlife refuges is 10%.
- Most States east of the Mississippi River have protected <1% of their land area.
- Southern and Midwestern states have the lowest rate of protection (down to .2%)
- Alaska and California have the highest rates of protection.
- Most existing protected areas are at high elevation.
- Protected areas average <25,000 acres. (DellaSala et al, In Press)

Ricketts and others (1999) identified 32 North American ecoregions as globally outstanding, that is, where biodiversity attributes equal or exceed those found in most distinct ecoregions sharing the same major habitat types on other continents. They further reported that, of the 116 ecoregions considered in the United States, 32 are in a critical conservation status, and 22 are endangered. They recommend emphasizing conservation strategies in 13 ecoregions: Hawaiian Moist Forests, Hawaiian Dry Forests, Appalachian Mixed Mesophytic Forests, Southeastern Mixed Forests, Northern California Coastal Forests, Southeastern Conifer Forests, Florida Sand Pine Scrub, British Columbia Mainland Coastal Forest, Central Pacific Coastal Forests, Klamath-Siskiyou Forests, Sierra Nevada Forests, Central Tall Grasslands, and California Coastal Sage and Chaparral.

Ecological Values of Inventoried Roadless Areas

The ecological effects of roads have been well documented (USDA Forest Service *In Press*). The effects can be either direct, such as animal mortality from vehicles, or indirect, such as altering the behavior of animals (Forman and Alexander 1998, Trombulak and Frissell 2000). Some species, such as exotic plants, may benefit from the disturbance and opportunities for introduction and establishment associated with roads (Parendes and Jones 2000).

Inventoried roadless areas provide a wide range of habitat types that support terrestrial wildlife species and communities. These habitats can be described by type, distribution, abundance, size of the area, kinds and intensity of use, disturbances, and the landscape context in which each habitat is found. In addition to supplying habitat for many threatened, endangered, proposed, and sensitive species (TEPS), inventoried roadless areas support numerous other birds, mammals, reptiles, amphibians, and invertebrates.

Inventoried roadless areas are important in maintaining native species and biodiversity. They function as biological strongholds for many species, including wide-ranging carnivores (like grizzly bear) and very localized, relatively less mobile species (like land snails). Native plant and animal communities tend to be more intact in roadless areas than in roaded areas of similar size. Species richness and native biodiversity is more likely to be conserved, particularly in areas large enough to offer a shifting mosaic of habitat patches in various stages of recovery from disturbance (Noss and Cooperider 1994).

Inventoried roadless areas are home to many species of terrestrial and aquatic plants, including rare, sensitive, threatened, and endangered species. Many of these species have narrow geographical ranges determined by soil types, climatic conditions, and other environmental factors. These endemic species, because of their limited distribution, are often at a higher risk of extinction than are widely distributed species. Areas in the United States with many endemic plant species include Hawaii, California, Texas, Alaska, the Pacific Northwest, the Southwest, the Intermountain West, and the South (Gentry 1986).

Inventoried roadless areas support a diversity of aquatic habitats and communities. Without the disturbance caused by roads and associated activities, stream channel characteristics -- such as channel and floodplain configuration, substrate embeddedness, riparian condition, amount and distribution of woody debris, stream flow, and temperature regime -- are less likely to be altered (Furniss and others 1991) compared to stream channel conditions in roaded areas. Illegal introduction and harvest of fish species is also less likely in these areas because access is limited.

Ecosystem Health

The term ecosystem health, as used in this analysis, is the degree to which ecological factors and their interactions are reasonably complete and functioning for continued resilience, productivity, and renewal. This generalized, human concept incorporates many factors that make up the separate but integral parts of a natural ecosystem. These factors were evaluated in this report, and the relative degree to which they contribute to ecosystem health was estimated.

Ecosystem structure, composition, and processes broadly describe these factors. Composition is the biodiversity of an ecosystem – that is, the plants and animals that live there. Structure is the attributes of the environment important to those organisms. For example, a fallen tree is a structural attribute that many species use for their homes. Structure can also mean the size or type of habitat patch an animal uses. Process is the various kinds of activities, interactions, cycles, or disturbances acting in an ecosystem. For example, fire is a natural disturbance process.

Ecosystem health is used to evaluate relative differences in outcomes of planning alternatives. Healthy ecosystems would more likely to contain viable populations of all native plants and animals, have fully functional natural processes (such as hydrologic and fire regimes), and, at a landscape scale, would encompass a range of successional patterns. In this analysis, an ecosystem that lacks plants, animals, structures, or processes that have been a part of that system for many hundreds and sometimes thousands of years is considered to be adversely impacted and would be described as less than healthy.

The estimated historical range of variability is often used as a baseline when evaluating ecosystem health (USDA Forest Service 1996). Scientists can compare historical reference conditions with today's conditions and give a rating of ecosystem health that measures departure from the historical conditions. For example, ponderosa pine forests in the Intermountain West historically experienced frequent, but light, understory burns. Due to effective fire suppression, many of these areas now have dense stands of small diameter trees and shrubbery, which are typically referred to as forest fuels, or being in the state of heavy fuel loading. As a result, these forests may be viewed as having a relatively lower degree of ecosystem health, because they may now be vulnerable to uncharacteristic stand-replacing wildland fires.

In some parts of the country, the historical range of variability is not a useful benchmark because records of pre-settlement ecological conditions are lacking or because of irreversible ecosystem changes. For example, in the East, much of the landscape has changed from the introduction of nonnative invasive species. Large chestnut trees once comprised 25% to 30% of many eastern forests; today, virtually all of these large trees have been eliminated by the chestnut blight, along with seven moth species that feed exclusively on chestnut trees (Opler 1976, Ronderos 2000). In West Virginia, more than 30% of current plant species are nonnative invasives, and much of the forest land has been harvested several times since European settlement (Harmon 2000).

In this analysis, the historical range of variability was used as a general environmental baseline. More often, the ecological factors described above were rated qualitatively by alternatives to obtain an estimate of relative differences. Individually, these factors represent various parts of an ecosystem; however, together, they provide a more complete picture of ecosystem health.

Biodiversity

Biodiversity is the variety and abundance of species, their genetic composition, and their communities (Adams and others 2000, Wilson 1988). Protecting areas from damaging human development and activities is an essential part of conserving biodiversity (Wilson 1985, 1988; WRI, IUCN, and UNEP 1992; Noss and Cooperider 1994). The current worldwide rate of species extinction is estimated to be about 400 times greater than that of recent geologic time, and this figure is increasing (Wilson 1985). At least 110 species of plants and animals are known to be extinct in the United States, and an additional 416 species are possibly extinct, with no recent documented sightings.

As described by Noss and Cooperrider (1994), four fundamental principles consistent with biodiversity conservation are to:

- Represent, in a system of protected areas, all native ecosystem types and seral stages across their natural range of variation.
- Maintain viable populations of all native species in natural patterns of abundance and distribution.
- Maintain ecological and evolutionary processes such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions.
- Manage landscapes and communities that are responsive to short-term and long-term environmental change and that maintain the evolutionary potential of the biota.

In addition to the above principles, five basic considerations emerge from conservation biology that resource managers can use to retain habitat at the landscape and regional scale (Shafer 1990, Thomas and others 1993, Wilcove and Murphy 1991, and Noss 1992). These principles are to:

- Minimize the fragmentation of habitats across the landscape;
- Conserve large blocks of habitat;
- Conserve blocks of habitat close together and in contiguous blocks.
- Maintain habitat corridors between blocks of habitat; and
- Maintain favorable habitat conditions for target species across their native range.

Representation of the full range of habitats in conservation reserves is a fundamental goal of nature conservation (Margules and Usher 1981). Because conservation of inventoried roadless areas could expand the area of conservation reserves, determining the potential contribution of these areas towards meeting goals of biodiversity conservation is important.

This analysis evaluates the effects of the alternatives on biodiversity using both landscape and species-habitat approaches (see specialist report on terrestrial and aquatic habitats and species for discussion of species habitat approach). A landscape approach provides a way of evaluating large-scale biological, physical, and ecosystem processes and patterns that influence biodiversity. Additional discussion of the affected environment specific to the factors analyzed is included under the Analysis of Effects of Alternatives section.

Assumptions

Several assumptions were made for this analysis. If Forest Service policy does not change, roading and timber harvest are assumed to continue at a rate no greater than the previous 20 years (5%-10% of area harvested/20 years.) in inventoried roadless areas. Over the next 5 years, about 1 billion board feet (BBF) is expected to be harvested and about 1,160 miles of road built. More than 50% of the expected timber volume from inventoried roadless areas is expected to come from the Tongass National Forest and most (304 miles) of the roads will be built in it's inventoried roadless areas. The Intermountain Region of the Forest Service has the next largest expected timber harvest from inventoried roadless areas (175 million board feet), with road building of 100 miles, followed by the Northern Region (91 million board feet and 30 miles). Although road building is estimated at 20 miles each, timber harvest projections for the Pacific Northwest is 74 million BF and the Rocky Mountain Regions is 35. Less than 10 miles of roads are expected to be built in each of the remaining Regions.

Nationally, clearcutting has decreased from 22% of total harvested acres in FY1992 to only 10% in FY1997 (USDA Forest Service 1998). It is assumed that this downward trend in clearcut acres will continue. However, clearcutting is expected to be the most commonly used practice in Alaska. Many national forests have shifted to stewardship stand treatments to achieve habitat or forest health objectives. From 1993 to 1997, stewardship projects increased from 24% (176,000 acres) to 40% (183,000 acres) of the timber harvest, with the largest increases since 1995. This trend is expected to continue. For this analysis, except for Alaska, about a 5% per year increase in stewardship-type projects is assumed. Over the next 5 years, an estimated 50% to 75% of the acres harvested are expected to meet stewardship goals. Of those acres treated principally for commodity outputs, we expect a variety of treatments, from regeneration with a few green trees remaining to moderate thinnings to improve growth.

Additional assumptions used in analyzing the effects were as follows:

- The number of federally listed threatened and endangered species will continue to increase, and the importance of Federal lands to these species will also continue to increase.
- Non-timber, special forest products demand will continue to increase.
- Subsistence resource demand will continue to increase.
- The Agency will treat fuel hazards on up to 3 million acres annually. Some portion of this will be in inventoried roadless areas.
- Fuel management costs will continue to increase.
- Demand for motorized outdoor recreation use on NFS lands continues to rise, resulting in increased demand for opportunities on inventoried roadless areas (Cordell and others 1999).
- Mechanical pre-treatment may be needed on some forests that now are at moderate to high risk from uncharacteristic wildfire effects before prescribed fire can be applied.
- Because of the ease of access provided by roads, timber and special forest product harvest is higher closer to roads and decreases as the distance from roads increases; therefore, the pressure on those harvest products is greater near roads.
- Management restrictions to protect TEPS species will increase as more species are listed, as will management of habitat where needs conflict between listed species.

- Few forests are at high risk from uncharacteristic wildfire effects in Regions 8, 9, and 10.
- People will continue to place a high value on inventoried roadless areas as a result of increasing demand for open space, clean water, abundant fish and wildlife, and opportunity for personal renewal.
- About 30 million acres of currently unroaded land could become reclassified as roaded because of development, at the same or lower rate of development than in these areas over the past 20 years (5-10% per 20 years).
- Reliance on regeneration harvest will continue to decline, except on NFS lands in Alaska.
- Under Alternative 1, the greatest proportion of roads would be built for timber harvest, including salvage harvesting, which would continue, consistent with land management plans.
- National forest timber volume offer rates will remain relatively constant at about 3.3 BBF/year.
- Reliance on inventoried roadless areas for meeting timber volume projections will decline according to trends in the latest revised land management plans.
- Timber harvest prescriptions will include a full range of intensities from very light thinning to clearcutting, under Alternatives 1 and 2.
- Skidding of logs is not prohibited under alternatives without roads.
- Timber volume reductions from prohibitions in inventoried roadless areas would not be replaced from other NFS lands.
- Protecting public health and safety and private property will continue to be emphasized.

The term “ecosystem health” is a qualitative communication tool to summarize the many ecological factors evaluated in this report.

Methodology and Information Used

The analysis presented here uses methods similar to the Alaska-wide assessment of terrestrial biodiversity as described by Duffy and others (1999). Both studies use coarse-scale surrogates for biodiversity, including ecoregions and landcover types. However, using coarse-scale surrogates may not adequately represent the location and range of biologically important sites (Duffy and others 1999). For example, although a large portion of an ecoregion may be in conservation reserves, the range of biodiversity in that ecoregion may not be represented in those reserves. The distribution of many of the species may reflect ecological conditions operating at finer scales than conditions depicted by broad ecoregions, elevation classes, and landcover types.

For this analysis, the biophysical classification defining ecoregions was used to provide a mapped summary of environmental attributes across the United States. In addition to ecoregions, mapped elevation classes derived from a digital elevation model and landcover classes based on satellite imagery were used as surrogate indicators of biodiversity. In an ecoregion, changes in elevation likely reflect local gradients of temperature and precipitation.

To evaluate the adequacy of inventoried roadless areas in representing landscape diversity, a 12% threshold of each evaluated category was used, based on the recommendation of the World Commission on Environment and Development (WCED 1987) that at least 12% of a country's land mass should be set aside as conservation reserves. In this analysis, 12% was used for comparison, although it may have been too low. For example, Noss and Cooperider (1994) argue that 25% to 75% of a region is required to achieve representation.

The acreages of National Forest Land used in this analysis was obtained from national geographic information system (GIS) maps (USDA Forest Service 2000a). This map contained only gross acreage; that is, private inholdings were included in the acreage estimates. This problem was not large for Alaska or the Western United States, but the gross acreage of NFS lands in the East was nearly double the actual acreage (table 1).

Table 1. Acreage of National Forest System land (rounded to the nearest 1,000 acres), shown with (i.e. gross acreage) and without private inholdings (i.e. net acreage).

Geographic Division	[a]Net area of national forest land (1000 acres)	[b]Gross area of national forest land (1000 acres)	Ratio between net and gross (%)
Alaska	22,083	22,083	100
East	25,252	45,687	55
West	144,966	165,036	88
Total	192,300	232,805	83

[a]USDA Forest Service 1999a; does not include private inholding acreage
[b]USDA Forest Service 2000a; includes private inholding acreage.

The following GIS layers were electronically overlaid and summarized in the analysis of biodiversity representation:

- Ecoregions of North America (Omernik 1995, Gallant and others 1995, as modified by Ricketts and others 1999).
- Elevation classes derived from a national scale digital elevation model (USDI Geological Survey 1996).
- Landcover grid derived from advanced very high-resolution radiometer imagery (AVHRR; Fleming 1997, USDA Forest Service 1999b).
- Land management status (DellaSala and others, *In Press*).
- Inventoried roadless areas (USDA Forest Service 2000a).
- Designated Wilderness Areas (USDA Forest Service 2000b).
- National Forest Lands (USDA Forest Service 2000b).

As with almost any GIS database, any errors associated with these layers transferred into the analytic results. Because the land-management status and inventoried roadless area coverages represent a composite of data from many sources, variations in mapping procedures among the sources potentially caused inconsistencies that were difficult to detect in the combined coverages. The landcover grid undoubtedly contained misclassifications. Variations in acreage estimates summarized from the overlay analyses resulted from variations in the resolution of the input databases and generalization during rasterization. The error rate was estimated to be minimal and it did not affect conclusions drawn from this national-scale analysis.

Based on criteria of species richness, endemism, rare habitat, and rare phenomena, Ricketts and others (1999) assigned globally outstanding status to a subset of ecoregions. These ecoregions are highlighted in the ecoregion summary tables 3 and 4 and are shown in Figure 1.

DellaSalla and others (*In Press*) assigned each polygon in their GIS coverage of land management status to one of four categories (adapted from GAP Analysis Project, Scott and others 1993). Status 1 represents areas with an active management plan in operation to maintain a natural state, in which natural disturbances are allowed to proceed without human intervention or are mimicked through management (such as designated Wilderness Areas and national parks). Status 2 represents areas generally managed for natural values which may receive use that degrades the quality of existing natural communities (such as wildlife refuges). Status 3 represents public lands not specifically designated for maintaining natural values, with mandates that prevent permanent conversion of natural habitat types to human-dominated habitat types and protect federally listed endangered and threatened species (for example NFS lands outside designated Wilderness). Status 4 represents private or public lands without an existing easement or management agreement to maintain native species and natural communities which may be managed for intensive human use. For this analysis, the combination of status classes 1 and 2 is referred to as conservation reserves.

Throughout the text, the term inventoried roadless areas includes all three categories of inventoried roadless areas unless otherwise specified. The three types of inventoried roadless areas distinguished in the FEIS (2000c) include:

1. Inventoried roadless areas where road building is already prohibited under current land management plans.

2. Inventoried roadless areas recommended for Wilderness designation in land management plans and where road building is already prohibited under current plan decisions. In our analysis, these areas were lumped with the first category.

3. Inventoried roadless areas where road building and reconstruction are presently allowed.

For this analysis, each contiguous inventoried roadless area was treated as a separate and unique inventoried roadless area. This distinction was important because many inventoried roadless areas in the Forest Service GIS database contain mapped units (often referred to as GIS polygons) that are not adjacent to each other. Conversely, many map units that adjoin each other create a mosaic of polygons with different classification labels. Consequently, artificial boundaries were created in the database that added no value to understanding the ecological differences. When polygons joined each other, the lines were dissolved and a single map unit was created. The analysis used these separate mapping units.

Increases of reserve areas when inventoried roadless areas were considered along with Wilderness Areas were calculated using the following formulas:

- Overall inventoried roadless area increase = 100 x inventoried roadless acres/Wilderness acres.
- Roads allowed increase = 100 x inventoried roadless acres where roading is now allowed/ (Wilderness acres + inventoried roadless acres where roading is prohibited).

Ecosystem Attributes

The following ecosystem attributes were used to assess ecosystem health in the FEIS:

- Landscape Characteristics
  - Habitat fragmentation
  - Connectivity
  - Inventoried roadless area representativeness
    - Ecoregions
    - Elevation Distribution
    - Landcover class
  - Size of inventoried roadless areas
  - Comparison of size of Wilderness Areas considered with inventoried roadless areas
  - Historical fire regimes
  - Nonnative invasive species

- Species Characteristics
  - Terrestrial animal habitat and species
  - Aquatic animal habitat and species
  - Terrestrial and aquatic plant species
  - Threatened, endangered, proposed and sensitive species

- Watershed Health
  - Water quantity and timing
  - Water quality and drinking water source areas
  - Soil loss, sedimentation and site productivity
  - Landslide potential
  - Channel morphology
  - Fire effects on watersheds
  - Air quality

- Forest Health
  - Insects and disease potential
  - Fuel management
  - Fire suppression

Results

Alternative 1 – No Action

Alternative 2 – Prohibit Road Construction and Reconstruction Within Inventoried Roadless Areas

Alternative 3 – Prohibit Road Construction, Reconstruction, and Timber Harvest Except for Stewardship Purposes Within Inventoried Roadless Areas

Alternative 4 – Prohibit Road Construction, Reconstruction, and All Timber Cutting Within Inventoried Roadless Areas

Ecosystem health would be maintained or enhanced by all of the action alternatives (Table 2). Alternatives 2 and 3 are the most likely to protect[2] ecosystem health in the long-term, while allowing management flexibility for restoring fire-dependent ecosystems. Alternative 4, which prohibits all timber harvest except for that needed for protection or recovery of threatened or endangered species, may negatively affect long-term conservation of biodiversity in some western fire-dependent forests.

Potential effects to ecosystem health under Alternatives 2 through 4:

- Protection of large areas for animals sensitive to human noise and disturbance (such as grizzly bears, wolves, pine marten, cougar, and elk).
- Protection of globally outstanding ecoregions and other important habitat.
- Providing a network of landscapes where natural processes can operate without the influence of human activity, and which thus function as reference points for comparison with actively managed landscapes.
- Protection of ecosystems from invasive nonnative species.
- Maintenance of landscape character and health.
- Potential for ecological damage from increased risk of uncharacteristic effects of wildland fires in some areas, under all alternatives including Alternative 1.
- Loss of timber harvest as a management tool under Alternative 4 may limit managers' ability to respond to change which could negatively affect biodiversity and watershed health.

[2] In this analysis, protect, in relation to inventoried roadless areas, refers to the conservation or protection of certain landscape characteristics that would result from the prohibition of certain activities that could degrade those characteristics. It does not infer the same degree of protection conveyed by Wilderness designation.

Table 2. Comparing relative beneficial effects of alternatives: H=high relative benefit; M=moderate; L=low.

Alternatives	1	2	3	4
Effects of alternatives	**No action**	**No road construction or reconstruction**	**No road construction or reconstruction; steward-ship timber harvest only**	**No road construction/ reconstruction; no timber harvest**
Ecosystem health benefits	L	H	H	H
Conservation of biodiversity	L	H	H	H
Protection from fragmentation & improvement in connectivity	L	M	H	H
Representation of ecoregions, elevations, landcover class	L	M	M	M
Size of inventoried roadless areas	L	H	H	H
Size of conservation areas (all Wilderness + inventoried roadless areas)	L	H	H	H
Distribution of conservation areas	L	M	M	M
Restoration of fire regimes	H	M	M	L
Protection from invasive species	L	M	M	M

None of the alternatives would adequately conserve biodiversity in the East, which has few areas managed as conservation reserves, a long history of timber cutting and invasion by nonnative species, and human population densities exceeding other parts of the country. Significant improvements in the conservation of biodiversity in the East could come from management emphasizing ecosystem restoration.

Alaska is rated highest in ecosystem health; more than 65% of the NFS lands are currently managed under strict protection. All prohibition alternatives would increase this to more than 85%, with the largest benefit associated with low elevation stands on the Tongass National Forest. Locally, however, because much of the low elevation land is in old-growth forest and often on highly productive sites, some reductions in ecosystem health would continue.

Many important increases in acreage of poorly protected globally outstanding and nationally important ecosystems would occur under the prohibition. Likewise, increasing the acreage of low-elevation forests protected greatly increases the opportunity to conserve biodiversity. In the West, prohibiting future roading in the inventoried roadless areas that currently allow roading increases the number of inventoried roadless area map units larger than 250,000 acres from 1 to 13 and increases the number of 50,000 to 250,000 map units from 50 to 147. These size increases would greatly enhance the long-term conservation of large wide-ranging TEPS species (such as grizzly bear, wolf, wolverine, and lynx), help ensure continued high-quality water from these areas, and improve the possibility of wildland fire playing a more natural role. In the East, the largest increase in acreage and number of individual inventoried roadless area map units occurs in the 5,000 to 25,000 acre size-class under all action alternatives. Reducing the potential to build roads in largely undisturbed ecosystems would greatly reduce the potential for spread of nonnative species.

Landscape Characteristics

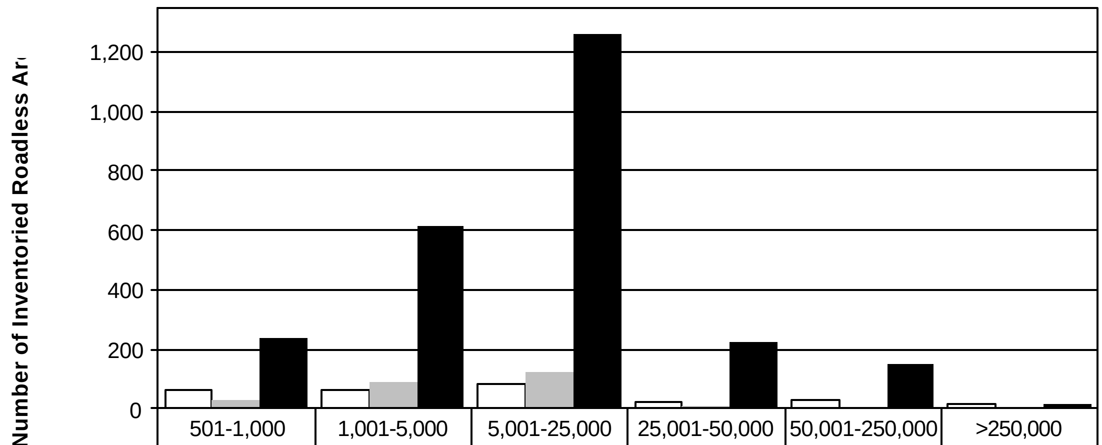
The total land area of the United States (excluding Hawaii) is 2.3 billion acres. Using the database developed by DellaSala and others (2000), 5% of the area is in Status 1, strictly managed to maintain natural values; 5% is in Status 2, managed to maintain natural values; 21% is Status 3, multiple-use management; and 69% is Status 4, no active management to maintain natural values. Nationally, the combined percentage in Status classes 1 and 2 (conservation reserves) ranges from a high of 36% in Alaska to 7% in the West and 2% in the East (DeVelice and Martin, *In Press*). When Alaska is excluded, about 5% of the United States landbase is in conservation reserves. This figure is considerably less than the suggested 12% minimum (WCED 1987) and an order of magnitude less than the midpoint of the range, 25% to 75%, suggested by Noss and Cooperrider (1994).

On a broad geographic basis, the total area in inventoried roadless areas amount varies from 14.8 million acres (3.8% of the land area) in Alaska to 42.1 million acres (4.4%) in the West and 1.6 million acres (0.2%) in the East. When only areas that currently allow roading are considered, the total area included varies from 4.6 million acres (1.2%) in Alaska to 28.7 million acres (3.0%) in the West and 0.9 million acres (0.1%) in the East.

To put the roadless area initiative into context, the total of 58.5 million acres included under all classes of inventoried roadless areas represents about 2.5% of the land in the study area. When only those inventoried roadless areas where current management prescriptions allow roads are considered, only 1% of the U.S. is included.

In general, the number, size, and distribution of inventoried roadless areas across NFS lands is reflective of the level of landscape modification and development. For example, relative to the amount of NFS lands, the amount and size of inventoried roadless areas is progressively smaller from Alaska to the East (figure. 2).

Total acreage alone does not necessarily indicate the relative value of conserving these areas. For example, because of the scarcity of inventoried roadless areas and other protected areas in the East, their value may be quite high.



	501-1,000	1,001-5,000	5,001-25,000	25,001-50,000	50,001-250,000	>250,000
Alaska	64	63	79	24	26	13
Eastern	27	91	121	5	0	0
Western	239	612	1,258	227	147	13

Size Class Categories (acres)

Figure 2. Size-class distribution of protected inventoried roadless area mapping units under Alternatives 2, 3, and 4 *(USDA Forest Service 2000a).*

Analysis of the area protected across the range of vegetation types and ecoregions showed that a higher percentage of the range of types is protected in Alaska and the West than the East (Table 3). Some types in all three regions of the country have a low level of protection, however. Whether this low amount is adequate is unknown; however, it is well below the 25 to 75% suggested by Noss and Cooperrider (1994) for adequate representation of biodiversity.

Ecoregions

The ecoregion classification used in our coarse-scale analysis is summarized in Figure 1 (Table 3 lists ecoregion names) (Gallant and others 1995, Omernik 1995). It summarizes key environmental variables across the United States, including physiography, geology, soils, hydrology, climate, land use, vegetation, and wildlife. These ecoregions were further aggregated into three broad geographic divisions: Alaska, the East, and the West (Table 1).

Ricketts and others (1999) provide descriptions of the biodiversity of each ecoregion and identify globally outstanding ecoregions. Criteria of species richness, degree of endemism (those species with restricted geographical ranges determined by soil types, climate, and other environmental factors), and rarity were used to determine globally outstanding ecoregions.

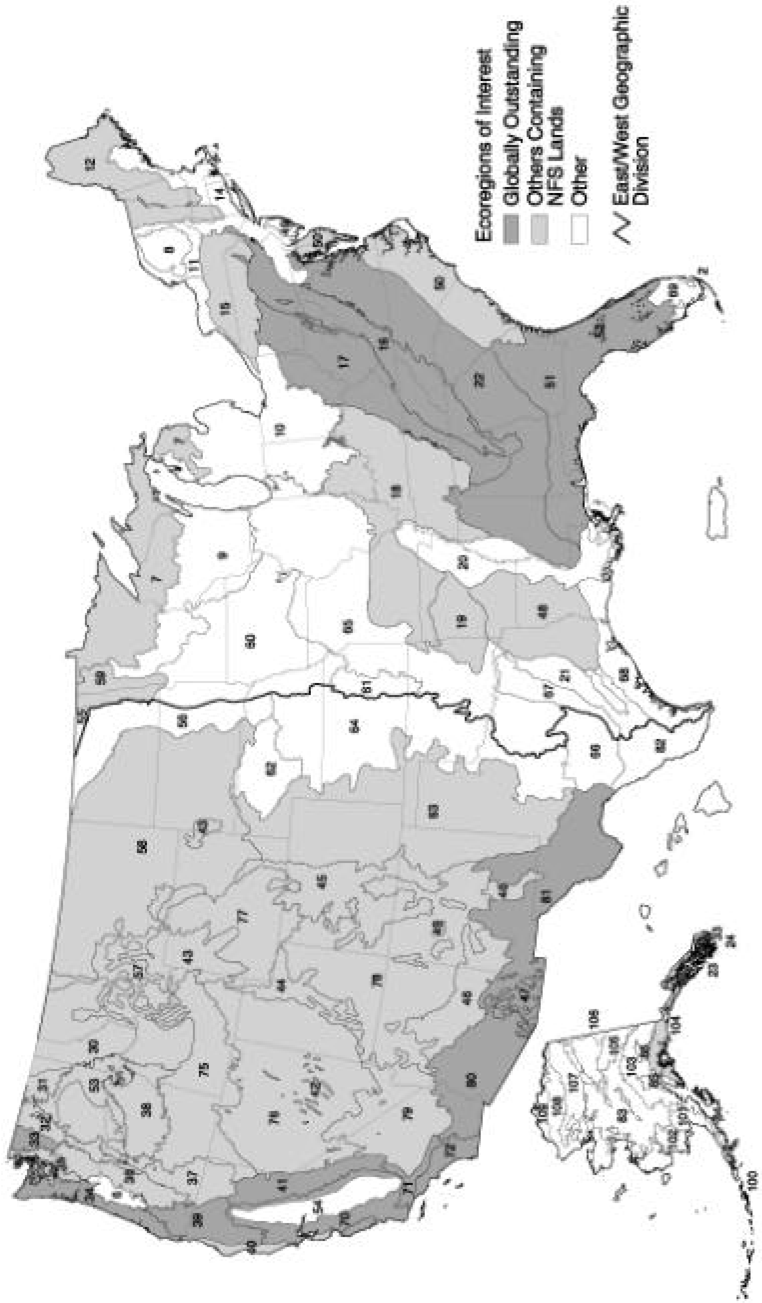


Figure 1. Ecoregions of the United States *(Ricketts and others 1999).*

Table 3. Ecoregion area and protected status of inventoried roadless, Wilderness, and other special designated areas. Globally outstanding ecoregions are shaded.

Ecoregion[a] (name and code number)	**Total NFS land** (acres)	**NFS land in Wilderness or other special designated areas** (%)	**NFS land in inventoried roadless areas where road building is prohibited** (%)	**NFS land in inventoried roadless areas where road construction is allowed** (%)	**Total NFS land in Wilderness, other special designated areas, or inventoried roadless areas** (%)
Alaska					
Northern Pacific Coast (23)[b]	*10,983,000*	*33*	*26*	*17*	*77*
Ice fields and Tundra (104)	10,674,000	36	34	23	94
Eastern United States					
Western Great Lakes (7)	10,883,000[c]	12	0	1	13
New England/Acadia (12)	1,458,000	13	8	9	30
Allegheny Highlands (15)	742,000	7	1	0	8
Appalachian/Blue Ridge (16)	*9,500,000*	*8*	*4*	*4*	*16*
Mixed Mesophytic (17)	*4,534,000*	*2*	*0*	*2*	*4*
Central US Hardwoods (18)	4,764,000	2	0	1	3
Ozark Mountains (19)	3,554,000	6	1	2	9
Southeast Mixed Forests (22)	*3,068,000*	*<0.5*	*0*	*<0.5*	*<0.5*
Piney Woods (48)	2,868,000	2	0	0	2
Middle Atlantic Coast (50)	719,000	7	0	3	10
Southeastern Conifer (51)	*1,969,000*	*5*	*1*	*1*	*7*
Florida Sand Pine Scrub (52)	*246,000*	*4*	*0*	*1*	*5*
Northern Tall Grasslands (59)	138,000	0	0	34	34
Western United States					
North Central Rockies (30)	17,001,000	23	11	16	50
Okanogan Forests (31)	810,000	1	1	16	18
Cascade Mtns. Leeward (32)	3,168,000	52	12	6	70
North Cascades (33)	*1,801,000*	*54*	*18*	*4*	*76*
Central Pacific Coastal (34)	*1,727,000*	*8*	*5*	*2*	*15*
Central/South. Cascades (36)	7,163,000	27	6	4	37
Eastern Cascades (37)	7,923,000	5	2	4	11
Blue Mountains (38)	7,183,000	19	5	8	33
Klamath-Siskiyou (39)	*7,008,000*	*30*	*7*	*8*	*45*
Sierra Nevada Forests (41)	*10,237,000*	*26*	*4*	*7*	*37*
Great Basin Montane (42)	960,000	35	6	46	87
South Central Rockies (43)	30,824,000	29	12	27	68
Wasatch/Uinta Montane (44)	6,980,000	10	6	38	54
Colorado Rockies (45)	19,037,000	21	5	20	46

Source: USDA Forest Service 2000a.
[a]Table includes only ecoregions with inventoried roadless area land and more than 100,000 acres of national forest. Refer to figure 1 to locate the ecoregions.
[b]Globally outstanding ecoregions (Ricketts and others 1999) shaded and in italics.
[c]This number was inadvertently shown as 10,983,000 in the FEIS.

Table 3. ***(cont.)***

Ecoregion (name and code number)	**Total NFS land** (acres)	**NFS Land in Wilderness or other special designated areas** (%)	**NFS land in inventoried roadless areas where road building is prohibited** (%)	**NFS land in inventoried roadless areas where road construction is allowed** (%)	**Total NFS land in Wilderness, other special designated areas, or inventoried roadless areas** (%)
Western U.S. (*cont.)*					
Arizona Mountains (46)	15,729,000	16	5	6	27
Madrean Sky Islands (47)	*1,517,000*	*24*	*24*	*0*	*48*
Palouse Grasslands (53)	467,000	58	1	12	71
Montana Valley/Foothill (57)	1,294,000	4	4	27	35
NW Mixed Grasslands (58)	7,035,000	0	1	5	6
Western Short Grasslands (63)	3,136,000	<0.5	<0.5	<0.5	<0.5
Cen. Cal. Shrub/Savanna (70)	*1,180,000*	*24*	*5*	*19*	*48*
So. Cal. Woods/Shrub (71)	*3,040,000*	*32*	*9*	*18*	*59*
So. Cal. Coastal Scrub (72)	*752,000*	*16*	*11*	*9*	*36*
Snake/Col. Shrub Steppe (75)	1,282,000	7	9	24	40
Great Basin Shrub Steppe (76)	8,205,000	12	4	47	63
Wyoming Basin (77)	547,000	27	1	35	63
Colorado Plateau (78)	3,388,000	17	3	19	39
Mojave Desert (79)	423,000	82	2	3	87
Sonoran Desert (80)	*179,000*	*25*	*7*	*3*	*35*
Chihuahuan Deserts (81)	*332,000*	*5*	*15*	*11*	*31*

Source: USDA Forest Service 2000a.
[a]Table includes only ecoregions with inventoried roadless area land and more than 100,000 acres of national forest. Refer to figure 1 to locate the ecoregions.
[b]Globally outstanding ecoregions (Ricketts and others 1999) shaded and in italics.

Alternative 1 – No Action

Forty-five of the 83 ecoregions in the ‘lower 48’ and Alaska have at least 100,000 acres of NFS land located in inventoried roadless areas. Of these, 35 ecoregions have more than 12% of their area managed to protect natural values, such as Wilderness or inventoried roadless areas. These 35 ecoregions make up over 70% of the NFS land base.

Sixteen ecoregions that contain more than 100,000 acres of NFS lands in the continental United States have been assigned a status of globally outstanding (Ricketts and other 1999). Globally outstanding ecoregions are biologically distinct based on species richness, degree of species endemism,[3] and rarity.

[3] Those species with restricted geographical ranges determined by soil types, climate, and other environmental factors.

Less than 8% of the acreage in the globally outstanding ecoregions is now protected in the East, which is well below the 25% to 75% recommendations of Noss and Cooperrider (1994) and the 12% World Commission on Environment and Development (1987) (Figure 1 shows boundaries of ecoregions in the East). Eighty-three percent of the ecoregions in the West already exceed the 12% protection threshold and 56% exceed the 25% threshold. All of the globally outstanding ecoregions in the West and Alaska already exceed the 12% protection levels, and most (81%) exceed the 25% protection level.

Alternative 2 – Prohibit Road Construction and Reconstruction Within Inventoried Roadless Areas

This alternative would greatly improve the protection of ecoregions from road construction and associated human disturbances within the NFS; more than doubling the ecoregion area protected in inventoried roadless areas in 11 of the 45 ecoregions (Table 4). The largest acreage increases would occur in Alaska, the Sierra Nevada, and the Klamath-Siskiyou regions of California.

Under this alternative, most of the ecoregions on NFS lands would exceed the 12% protection threshold suggested by the World Commission on Environment and Development (1987). Sixty-four percent of the ecoregions would exceed the minimum protection threshold of 25%, and 5 ecoregions would exceed the upper limit of 75% protection suggested by Noss and Cooperrider (1994).

While many of the ecoregions in the United States are not considered globally outstanding, several changes that would result from this alternative are noteworthy. Nationally, 5% or less of Okanogan Forests, Eastern Cascade Forests, Montana Valley and Foothill Grasslands, and Northwest Mixed Grasslands ecoregions are protected in special designated areas. This alternative would more than double the area protected in these ecoregions.

Under this alternative, the Chihuahuan Deserts and Central Pacific Coast (Coastal Washington and Oregon) have the smallest area protected of all the globally outstanding ecoregions in the West. The largest percentage increase in the West occurs in the Northwest Mixed Grasslands, Wyoming Basin, Montana Valley and Foothill Grasslands, and Okanogan forest ecoregions. Table 4 shows the increased protection for ecoregions resulting from this alternative. The table only includes those ecoregions with greater than 100,000 acres of NFS lands. Globally outstanding ecoregions (Ricketts and others 1999) are shaded.

Since relatively few acres are protected in the East, even small increases are important. Under this alternative, four Eastern ecoregions in the national forests would exceed the 12% threshold of protection (Table 3). Two areas, the New England/Acadian Forests and the Northern Tall Grasslands, would exceed the 25% threshold. The largest acreage increase would occur in the Ozark Mountains and Mixed Mesophytic ecoregions (Table 4).

Table 4. Increased protection for ecoregions under Alternative 2 prohibitions. Globally outstanding ecoregions are shaded.

Ecoregion[a] (name and code number)	**Increase in acreage protected in alternative 2 when compared to no-action** (%)
Alaska	
Northern Pacific Coast (23)[b]	*34*
Icefields and Tundra (104)	41
East	
Western Great Lakes (7)	12
New England/Acadia (12)	44
Allegheny Highlands (15)	8
Appalachian/Blue Ridge (16)	*53*
Mixed Mesophytic (17)	*64*
Central US Hardwoods (18)	32
Ozark Mountains (19)	64
Southeast Mixed Forests (22)	*49*
Piney Woods (48)	8
Middle Atlantic Coast (50)	41
Southeastern Conifer (51)	*25*
Florida Sand Pine Scrub (52)	*33*
Northern Tall Grasslands (59)	< 0.5
West	
North Central Rockies (30)	52
Okanogan Forests (31)	1420
Cascade Mtns. Leeward (32)	13
North Cascades (33)	*7*
Central Pacific Coastal (34)	*18*
Central/South. Cascades (36)	16
Eastern Cascades (37)	90
Blue Mountains (38)	42
Klamath-Siskiyou (39)	*28*
Sierra Nevada Forests (41)	*26*
Great Basin Montane (42)	132
South Central Rockies (43)	76
Wasatch/Uinta Montane (44)	249
Colorado Rockies (45)	83
Arizona Mountains (46)	34

Source: USDA Forest Service 2000a.
[a]Table only includes ecoregions with inventoried roadless area land and greater than 100,000 acres of national forest. Refer to figure 1 for the location of the ecoregions.
[b]Globally outstanding ecoregions (Ricketts and others 1999) are shaded and in italics.

Table 4. ***(cont.)***

Ecoregion (name and code number)	**Increase in acreage protected in alternative 2 when compared to no-action** (%)
West (*cont.)*	
Madrean Sky Islands (47)	*<1*
Palouse Grasslands (53)	156
Montana Valley/Foothill (57)	494
NW Mixed Grasslands (58)	762
Western Short Grasslands (63)	<1
Central California. Shrub/Savanna (70)	*137*
Southern California Woods/Shrub (71)	*46*
Southern California Coastal Scrub (72)	*37*
Snake/Col. Shrub Steppe (75)	244
Great Basin Shrub Steppe (76)	380
Wyoming Basin (77)	901
Colorado Plateau (78)	211
Mojave Desert (79)	12
Sonoran Desert (80)	*10*
Chihuahuan Deserts (81)	*56*

Alternative 3 – Prohibit Road Construction, Reconstruction, and Timber Harvest Except for Stewardship Purposes Within Inventoried Roadless Areas

The effects of Alternative 3 on the area of ecoregions protected from roading are the same as in Alternative 2. Alternative 3 prohibits timber harvest except for stewardship purposes. Stewardship timber harvest could only be used where it maintains or improves roadless characteristics and meets one or more of the following objectives: 1) improves TEPS species habitat; 2) reduces the risk of uncharacteristically intense fire; or 3) restores ecological structure, function, processes, or composition. Such stewardship activities can have strong local benefits to biodiversity. For example, reducing fire intensity by reducing accumulated fuels in ponderosa pine forests in the Intermountain West may greatly enhance local biodiversity by increasing the survival of large, old-growth pines after wildland fires; reducing mortality from moisture stress; reducing insect and disease outbreaks in stressed stands; restoring fire-dependent herbs and shrubs; and restoring the historical fire regime.

These benefits would need to be weighed, at the local project scale, against the risks of implementing the treatments. For example, depending on the terrain, equipment type, skill of equipment operators, and administrative oversight, benefits from vegetation treatments may be outweighed by adverse effects to soil and water resources. If all of these factors are carefully managed, the results can be beneficial (see Forest Health section in FEIS (USDA Forest Service 2000c) for a more complete discussion). Although there are many examples of successful fuel reduction efforts in individual forest stands, large-scale treatment of fuels has not been shown to enhance natural fire regimes and conditions effectively.

Alternative 4 – Prohibit Road Construction, Reconstruction, and All Timber Cutting Within Inventoried Roadless Areas

The effects of alternative 4 on the area of ecoregions protected from roading are the same as in alternative 2.

Alternative 4 could have some local negative effects on biodiversity because stewardship vegetation treatments would not be allowed unless needed for protection or recovery of TEP species. As a result, ecosystems that currently are or could be contributing to local biodiversity may be negatively altered by uncharacteristic wildland fire effects, or insect and disease outbreaks. Over time, these areas may experience stand-replacement fires, with landscape vegetation patterns shifting towards larger even-aged stands.

Although many examples of successful fuel reduction efforts in individual forest stands can be cited, large-scale treatment of fuels have not been shown to restore natural fire regimes and conditions effectively.

Ecoregions - Summary of Effects

All of the action alternatives would result in measurable cumulative beneficial effects relative to the amount of protected lands in the 45 ecoregions containing NFS lands. Table 3 displays the cumulative beneficial effects, by ecoregion, of the prohibitions in inventoried roadless areas in concert with other acres currently protected by designations such as Wilderness. The magnitude of cumulative benefits would vary, but all ecoregions show an increase in the acres of protected areas, and approximately 24% of them would more than double. Without a prohibition on road building and reconstruction, there would be a greater likelihood of cumulative incremental loss of lands providing roadless characteristics and values in many ecoregions, particularly where the current percentage of lands in protected status is low. A more complete discussion of cumulative effects to conservation of biodiversity can be found in the Terrestrial and Aquatic Habitats and Species specialist report.

Elevation distribution

Human settlement in North America has primarily affected lower elevation habitats because these were the most accessible and most productive lands. A general misconception is that inventoried roadless areas are mostly at high elevations in poor quality, rocky and cold habitats, which is understandable because most Wilderness Areas are at high elevations, as shown in Figure 3 and Table 5.

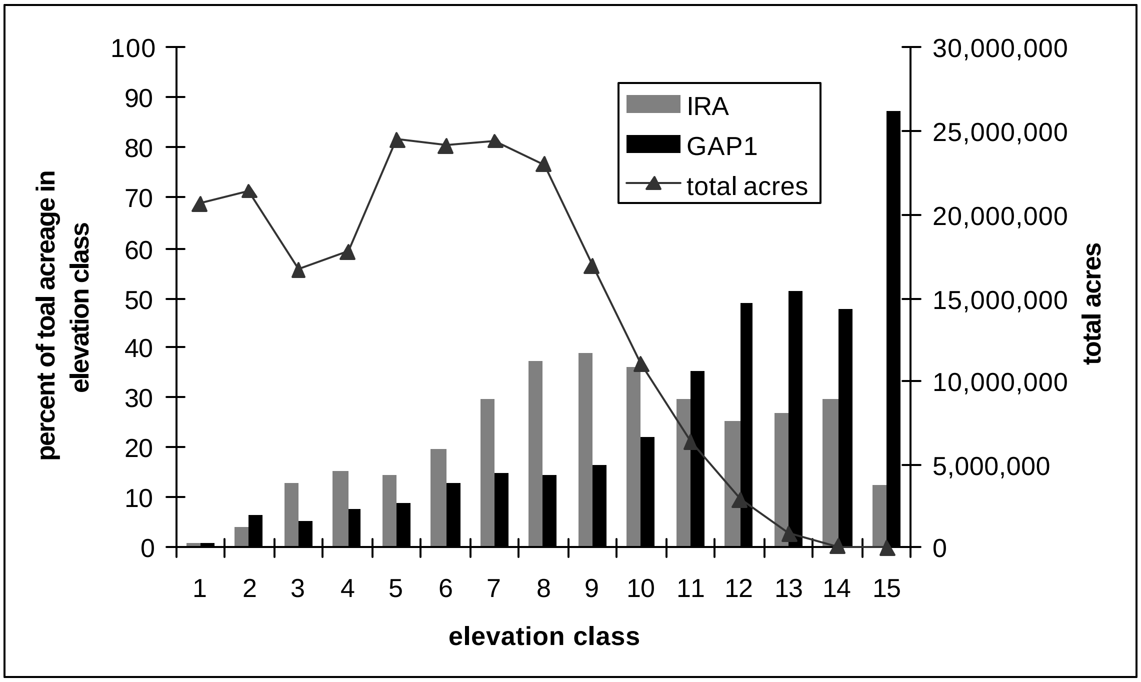


Figure 3. Percentage and acreage of National Forest lands in the conterminous United States in inventoried roadless areas versus GAP1, by elevation. Class 1 = 0-1000 feet; 2 = 1001-2000; 3 = 2001-3000; and so on. GAP1 = All agency Wilderness.

Figure 3 displays three sets of information. The bars display two sets of information for each elevation class: the percentage of total NFS land in that elevation class that is located in inventoried roadless area; and the percentage of total NFS land in that elevation class that is located in GAP1 status (i.e. all agency Wilderness). The triangles connected by a line display the total NFS acreage for each elevation class. For instance, this figure shows that for almost 25 million acres of NFS land that lies between elevations of 6,000 and 7,000 feet (elevation class 7), approximately 30% of that acreage is located in inventoried roadless area, and approximately 15% is located in GAP1 (Tongass data are not included in Figure 3).

The distribution of habitats across a range of elevations can indirectly describe the diversity of habitats. Habitats at high elevations are dominated by plants that thrive in cold environments with short growing seasons. These habitats often have shallow, poor soils and greatly reduced tree growth. Habitats at low elevations are generally more productive. Forests at low elevations grow some of the largest trees in North America such as the redwood and Douglas fir that grow along the coast of northern California and in western Oregon. Species richness is generally greater at low and mid-elevations (Noss and Cooperrider 1994).

Table 5. Distribution of inventoried roadless areas and designated Wilderness by elevation class and geographic division.

Elevation classes (feet)	[a]Total area of NFS land in each elevation class (acres)	Inventoried roadless areas where road building is allowed in each elevation class (%)	Inventoried roadless areas where road building is prohibited in each elevation class (%)	Wilderness area within each elevation class (%)	Inventoried roadless area plus Wilderness area total within each elevation class (%)
Alaska					
0000-1000	8,109,000	17	36	20	73
1001-2000	5,278,000	22	39	25	87
2001-3000	3,376,000	24	45	26	95
3001-4000	2,499,000	24	48	25	97
4001-5000	1,518,000	20	54	24	97
5001-6000	587,000	15	56	27	98
6001-7000	170,000	11	69	18	98
7001-8000	63,000	10	78	11	99
8001-9000	35,000	4	95	1	99
>9000	30,000	3	95	0	98
East					
0000-1000	19,443,000	1	+	2	3
1001-2000	18,068,000	2	1	8	10
2001-3000	5,209,000	6	5	5	16
3001-4000	2,464,000	8	6	8	22
4001-5000	445,000	11	4	11	26
5001-6000	55,000	16	4	23	42
>6000	3,000	26	10	7	44
West					
0000-1000	1,181,000	2	5	4	11
1001-2000	3,317,000	7	7	8	22
2001-3000	11,473,000	9	5	8	22
3001-4000	15,332,000	9	7	10	25
4001-5000	24,054,000	9	6	10	25
5001-6000	24,051,000	12	8	15	34
6001-7000	24,394,000	20	10	17	46
7001-8000	22,992,000	28	10	16	53
8001-9000	16,967,000	30	9	18	57
>9000	21,275,000	23	9	36	68

Source: USDA Forest Service 2000a.
+ represents values greater than 0, but less than 0.5
[a] Gross National Forest Land, Includes private Inholdings.

Alternative 1 – No Action

In the West, only about 1 million acres of land is below 1,000 feet in elevation. Most land is above 4,000 feet. Likewise, most of the land that is currently unroaded due to Wilderness designation or decisions in land management plans is at higher elevations. Less than 10% of the land below 1,000 feet in the West is protected (Table 5).

In the East, about 2.8 million acres are currently protected in Wilderness, areas recommended for Wilderness, and inventoried roadless areas where land management plans currently prohibit road construction. More than 70% of this land lies between 1,000 and 3,000 feet in elevation. Very little acreage is protected above 4,000 feet or below 1,000 feet. This situation is most pronounced on forests in the Southeastern United States, since there are very few designated Wilderness Areas, or other areas that limit road construction.

In Alaska, more than 55% of all elevation classes are currently protected from road construction. Above 5,000 feet, more than 75% of the land is in categories that prevent road construction. On the Tongass National Forest, more than 55% of elevation classes between 3,000 and 7,000 feet are protected, and more than 30% of the classes between 0 and 3,000 feet are protected from roading.

Alternatives 2 through 4

Habitat protected from roading would increase across all elevation classes in the NFS under this alternative. More than 74% of all elevation classes in Alaska would be protected from roading with the largest increases occurring in the lower elevation classes. In the West, more than 42% of elevation classes above 1,000 feet on NFS lands would be protected from roading. Elevations below 1000 feet would be the least protected in both the East and West.

Elevation Distribution – Summary of Effects

All action alternatives would have cumulative beneficial effects to biodiversity by improving the elevational distribution of protected areas, and by increasing the number of protected acres in each elevation class. Without a prohibition on road building and reconstruction, it is likely that cumulative incremental loss of roadless characteristics would increase and the ecological value of these lands would decline.

Size Considerations

The size of a protected area is positively related to biodiversity (MacArthur and Wilson 1967). Large areas generally contain more species, more species with large home ranges, and more species sensitive to human activity. Ecosystem processes, particularly fire disturbance processes, are generally more intact in larger areas. Small areas are important for conserving biodiversity of species with small home ranges, species with special habitat needs, or for providing linkages between larger areas.

Of the more than 2,800 named inventoried roadless areas, about 70% of these areas are larger than 5,000 acres (USDA Forest Service 2000a). Some areas, though, are as small as 2 acres, such as small islands which were given individual roadless area names, even though they may function collectively as a single unroaded area.

Describing the inventoried roadless areas by the size of each map unit is more ecologically informative than arbitrarily grouping map units. For example, roads or other developments may isolate map units within the same named inventoried roadless area. Consequently, this area would have very different value to wildlife than would one large contiguous area. Species, such as grizzlies or wolverine, which thrive in undeveloped areas, would likely do well in a large, contiguous area, but they may not inhabit an area of similar size dissected by roads and clearcuts. In this example, the large, contiguous block of habitat provides the animals with needed security habitat.

Of the 58.5 million inventoried roadless acres, more than 96% of the acreage is in contiguous map units larger than 5,000 acres each. About 22% of the 2,827 individually named units are between 500 and 5,000 acres. The inventoried roadless areas less than 500 acres are not included in this analysis because most of the acreage is in the larger size-classes.

The number of inventoried roadless areas and size class distribution in Alaska, the East, and the West are shown in Figure 2. Most of the areas larger than 500 acres are less than 25,000 acres (2,554 areas totaling 18.5 million acres), and 26 areas totaling 15.7 million acres exceed 250,000 acres. The West has the greatest number of inventoried roadless areas larger than 500 acres (2,496 areas); the East has 244 and Alaska has 269.

About 20 million acres of inventoried roadless area in the conterminous United States and Alaska area are adjacent to designated Wilderness (Table 6). This acreage represents about 34% of the total roadless acreage. Most polygons of designated Wilderness larger than 500 acres on NFS lands are less than 50,000 acres (353 polygons out of 462, totaling 5.3 million acres), and only 25 polygons totaling 19.3 million acres exceed 250,000 acres (Figure 4). If all of the adjacent inventoried roadless areas are considered along with designated Wilderness, the number of polygons larger than 500 acres but smaller than 50,000 acres decreases to 295 (4.5 million acres), and the number of polygons larger than 250,000 acres increases to 45 (39.3 million acres).

Without the limitation of adjacency, 2,435 areas (totaling 24.9 million acres) smaller than 50,000 acres but larger than 500 acres are in the merged inventoried roadless area and Wilderness analysis class (Figure 5), and 57 areas are larger than 250,000 acres (totaling 47.0 million acres).

Table 6. Acreage of inventoried roadless areas adjacent to existing Wilderness.

Geographic Division	Wilderness within NFS lands (acres)	Inventoried roadless areas recommended for Wilderness where road building is already prohibited			All inventoried roadless areas		
		Lands adjacent to Wilderness (acres)	Total lands in this Category (acres)[a]	Percent adjacent to Wilderness (%)	Lands adjacent to Wilderness (acres)	Total lands in this category (acres)[a]	Percent adjacent to Wilderness (%)
Alaska	5,747,000	4,140,000	10,117,000	41	5,649,000	14,779,000	38
Eastern U.S.	2,025,000	122,000	655,000	19	460,000	1,618,000	28
Western U.S.	26,917,000	4,625,000	13,409,000	34	13,972,000	42,121,000	33
Totals	34,690,000	8,886,000	24,182,000	37	20,080,000	58,518,000	34

Source: USDA Forest Service 2000a.
Note: data rounded to nearest 1000 acres.

Alternative 1 – No action

If only those inventoried roadless areas larger than 500 acres but smaller than 25,000 acres where road building is already prohibited are considered (fig. 6) they total 1,522 areas across 7.9 million acres. Eleven areas totaling 7.0 million acres exceed 250,000 acres.

About 33% of the inventoried roadless area map units currently protected under the no-action alternative are between 5,000 and 25,000 acres[1] (fig. 6). Eleven units are greater than 250,000 acres (with 10 of these in Alaska). The East has about 10% the number of map units protected in the 5,000 to 25,000 acre size-class than does the West. No map units are larger than 50,000 acres in the East, and only three are between 25,000 and 50,000 acres. The East has a higher percentage of smaller areas than the West does. In Alaska, more than 10 million acres of inventoried roadless areas are currently protected. Of this acreage, 81% is in inventoried roadless area map units larger than 50,000 acres. Alaska also has the largest inventoried roadless areas. Most of the acreage in Alaska occurs in 10 separate areas that are each more than 250,000 acres.

[1]Map units refer to the individual parcels defined in the geographic information system (GIS) database. For reporting purposes, forests often grouped several map units into a single named inventoried roadless area.

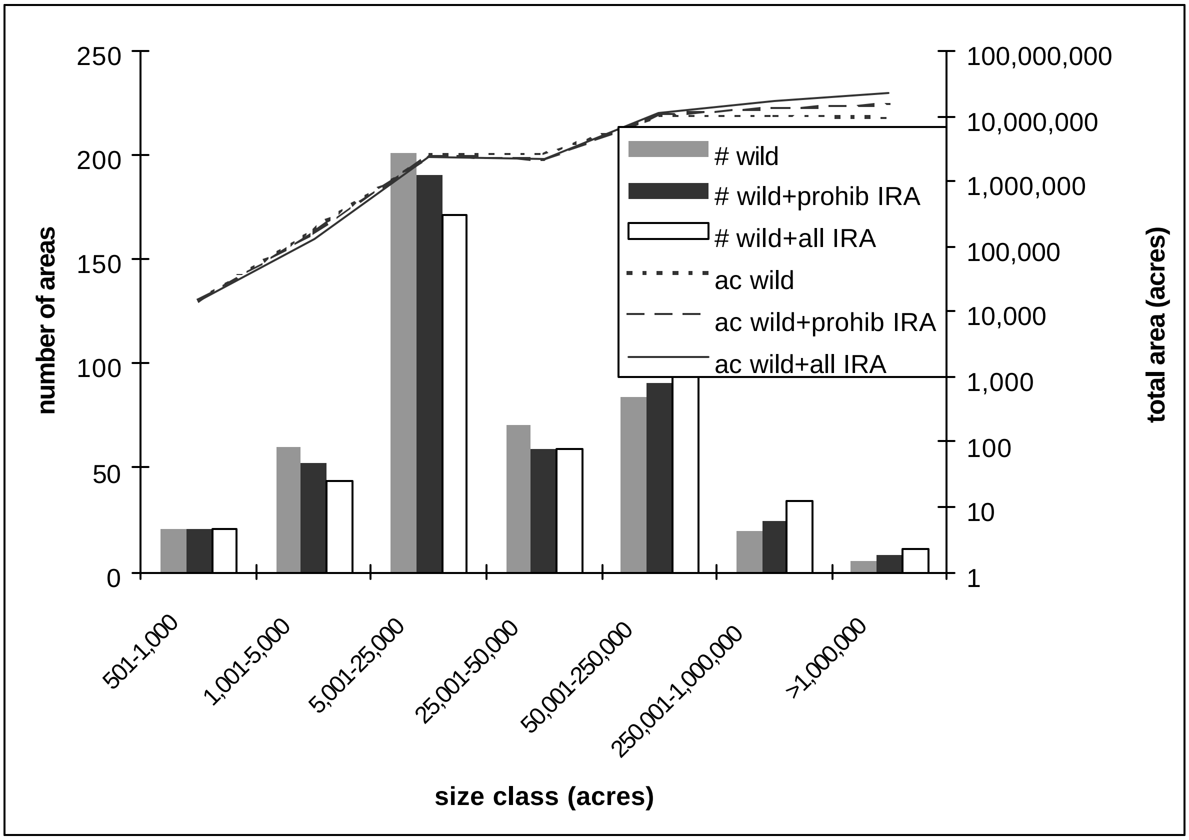


Figure 4. Increased number of protected areas when inventoried roadless area acreage is considered with adjacent Wilderness acreage *(USDA Forest Service 2000a).*

A substantial percentage of inventoried roadless areas are adjacent to existing Wilderness (Table 6), providing a major cumulative benefit for large animals such as the grizzly bear, by increasing the size of security areas and improving travel ways to other habitat. In Alternative 1, nearly nine million acres of inventoried roadless areas adjoin existing Wilderness and are currently protected by land management plans. In the East, one-fifth of the 655,000 acres of the currently protected inventoried roadless areas are next to Wilderness and protected by land management plans.

In Alaska, 41% of the currently protected inventoried roadless areas are adjacent to Wilderness; in the West, 34% are adjacent to Wilderness. When Wilderness and inventoried roadless areas where road building is currently prohibited are considered together, the size of these areas increases considerably (Figure 4). The six grizzly bear recovery areas identified in the recovery plan (USDI Fish and Wildlife Service 1993) include more than 23 million acres, of which 7.5 million is Wilderness (Table 7). When the inventoried roadless areas that currently prohibit roading are considered along with Wilderness, about 44% of the recovery areas are protected from road building and other development.

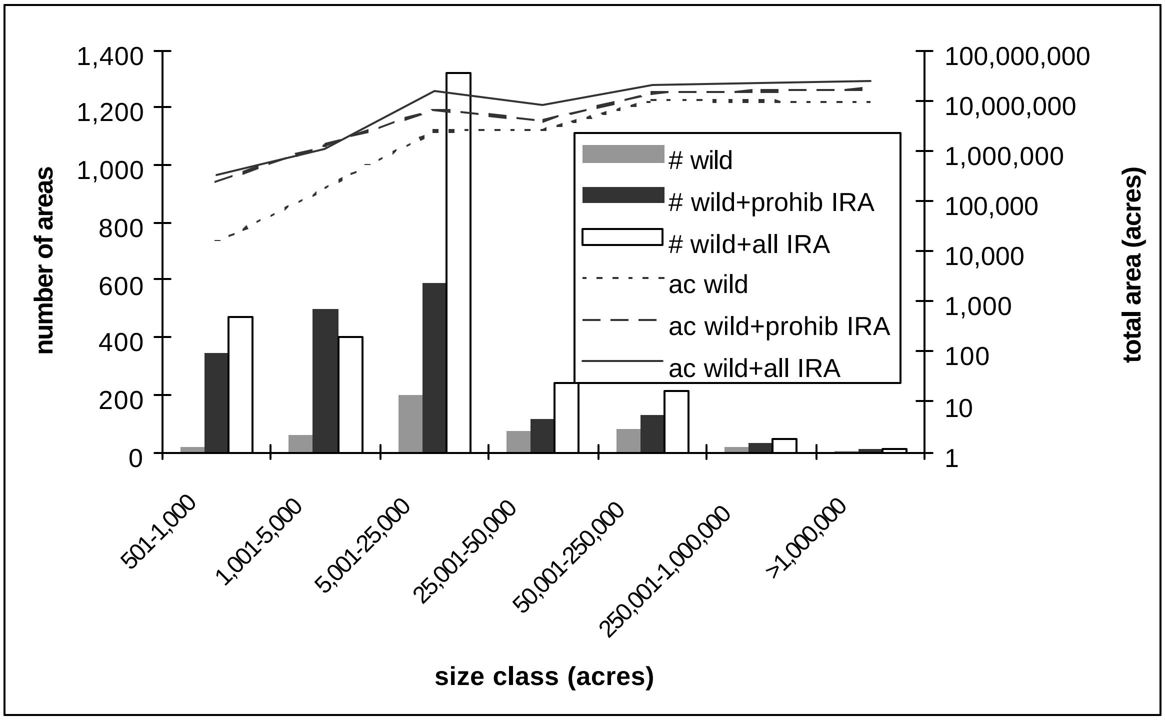
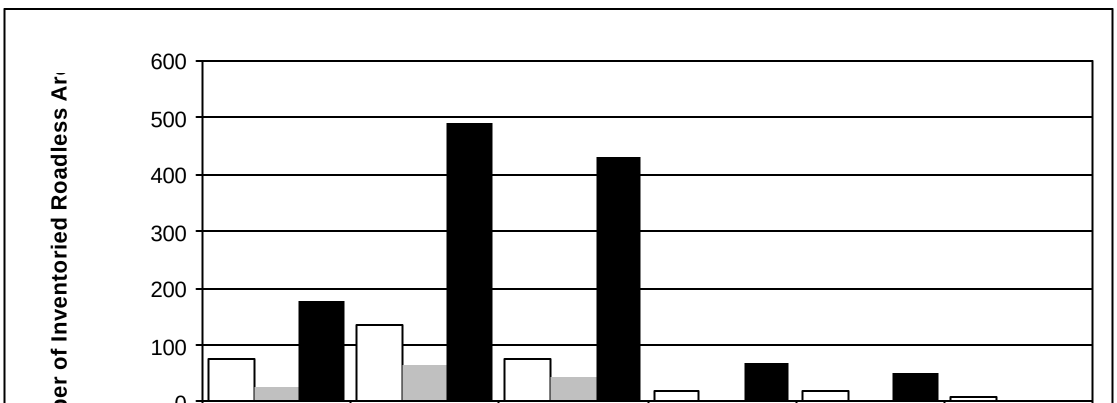


Figure 5. Increased number of protected areas when inventoried roadless area acreage is combined with Wilderness acreage, without the adjacency restriction *(USDA Forest Service 2000a).*



	501-1,000	1,001-5,000	5,001-25,000	25,001-50,000	50,001-250,000	>250,000
Alaska	77	137	76	18	18	10
Eastern	25	66	44	3	0	0
Western	178	488	431	69	50	1

Size Class Categories (acres)

Figure 6. Current size-class distribution of protected inventoried roadless area mapping units (USDA Forest Service 2000a).

Alternative 2 –Prohibit Road Construction and Reconstruction Within Inventoried Roadless Areas

Alternative 2 greatly increases the protection of the large (>5,000 acres) contiguous roadless areas. This increase would have a large positive effect on conserving biodiversity in the "lower 48". Since much of Alaska is already protected from road construction, the proportional benefits to biodiversity could be less than in some other states.

Table 7. Acreage of inventoried roadless areas in grizzly bear recovery areas in Montana, Idaho, Washington, and Wyoming.

Recovery areas	**Total recovery area** (acres)	**NF land in Wilderness** (acres)	**NF land in roadless areas where road building is prohibited** (acres)	**NFS Land in Roadless areas where road construction is allowed** (acres)	**Total NF in Wilderness or inventoried roadless area** (acres)
Bitterroot	3,468,000	1,713,000	752,000	682,000	3,147,000
Cabinet/Yaak	1,488,000	94,000	332,000	224,000	649,000
North Cascades	6,245,000	1,928,000	954,000	312,000	3,194,000
Northern Continental Divide	5,717,000	1,640,000	428,000	688,000	2,757,000
Selkirk Mountains	690,000	42,000	86,000	137,000	265,000
Yellowstone	5,899,000	2,126,000	342,000	328,000	2,797,000

Source: USDA Forest Service 2000a.

In the West, 12 inventoried roadless map units of more than 250,000 acres, 97 areas between 50,000 and 250,000 acres, and 985 areas between 5,000 and 50,000 acres would be added to the already protected units in the no-action alternative (Figures 2 and 6). The number of areas below 5,000 acres increases by 185. In the East, the largest change is in the 5,000 to 25,000 acre size-class where 77 inventoried roadless map units are added to what is already protected in the no-action alternative. Two map units between 25,000 and 50,000 acres are added in the East as a result of Alternative 2.

In Alaska, the number of inventoried roadless areas of more than 5,000 acres increases slightly from 122 in the no-action alternative to 142 with a prohibition of road construction and reconstruction (Figures 2 and 6). The total acreage in these size-classes increases by about 50%. In the less than 5,000-acre size-classes, the number of inventoried roadless map units shrinks by about 60%.

Most polygons of designated Wilderness on the national forests are less than 50,000 acres (353 polygons out of 462, totaling 5.3 million acres), and only 25 polygons totaling 19.3 million acres exceed 250,000 acres (Figure 4). Alternative 2 increases the amount of protected inventoried roadless area adjacent to Wilderness from about 9 million to more than 20 million acres (Table 6). When adjacent inventoried roadless areas are considered along with national forest Wilderness Areas, the number of these combined areas smaller than 50,000 acres decreases to 295 (4.5 million acres), and the number or polygons larger than 250,000 acres increases from 25 to 45 (39.3 million acres). The cumulative beneficial effect of the prohibitions in inventoried roadless areas is shown in concert with other areas currently protected by Wilderness designation (Figure 4 and Table 6).

The largest acreage adjoining Wilderness is in the West, with nearly 14 million acres (33%) adjacent to Wilderness Areas (Table 6). Relative to the no-action alternative, the largest increases in the West are in the upper size-classes. In the 250,000 to 1 million-acre size-class, the number of roadless areas increases from 18 to 26; in the 1-million-acre-or greater size-class, the number increases from 5 to 8 (Figure 7).

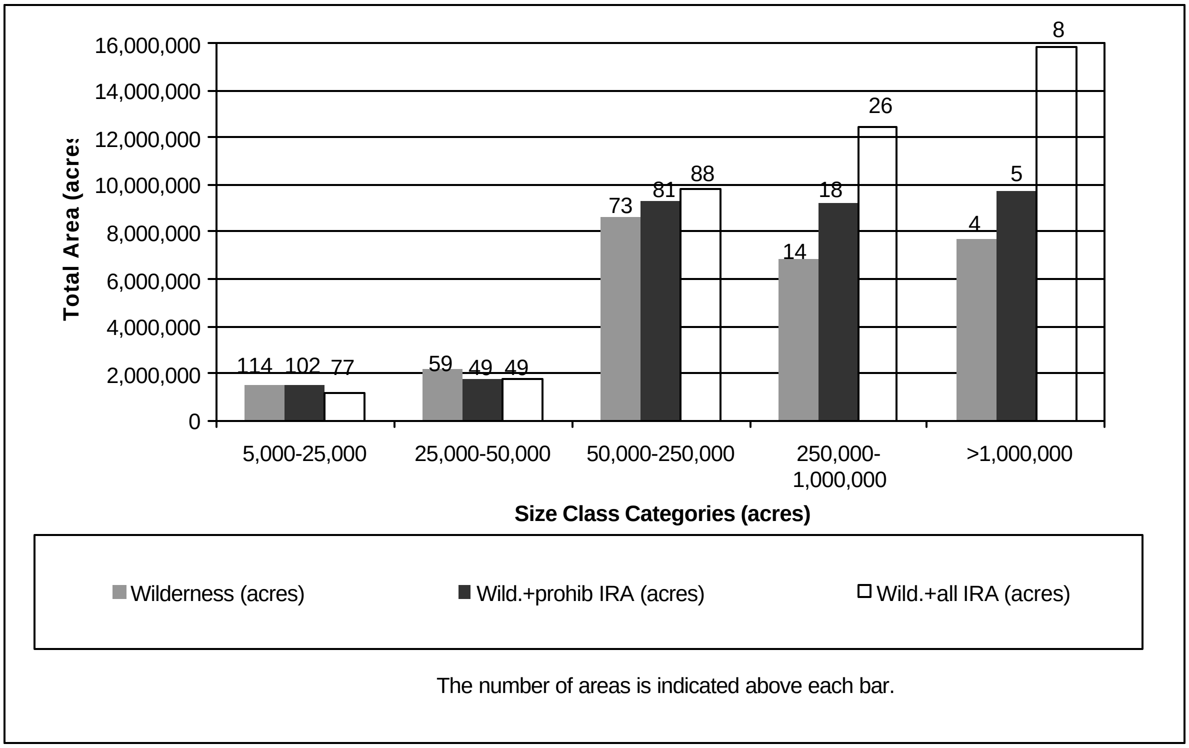


Figure 7. Increased number of large protected areas when inventoried roadless area acreage is combined with adjacent Wilderness acreage in the Western U.S. ***(USDA Forest Service 2000a).***

This alternative would support the recovery of grizzly bears in the West by increasing the acreage of Wilderness and inventoried roadless areas in grizzly bear recovery areas from 44% in the no-action alternative, to 54% in Alternative 2 (Table 7). Likewise, it greatly increases the number and size of protected areas along important wildlife corridors between them. The largest increases in connectivity are shown in Figure 8.

In the East, the area adjoining Wilderness Areas increases from about 122,000 acres to about 460,000 acres (Table 6). The size-class distribution of the contiguous Wilderness and inventoried roadless areas is about the same as the no-action alternative, but the 50,000 to 250,000 acre size-class increases from 3 to 5 areas in the East (totaling about 310,000 and 458,000 acres, respectively).

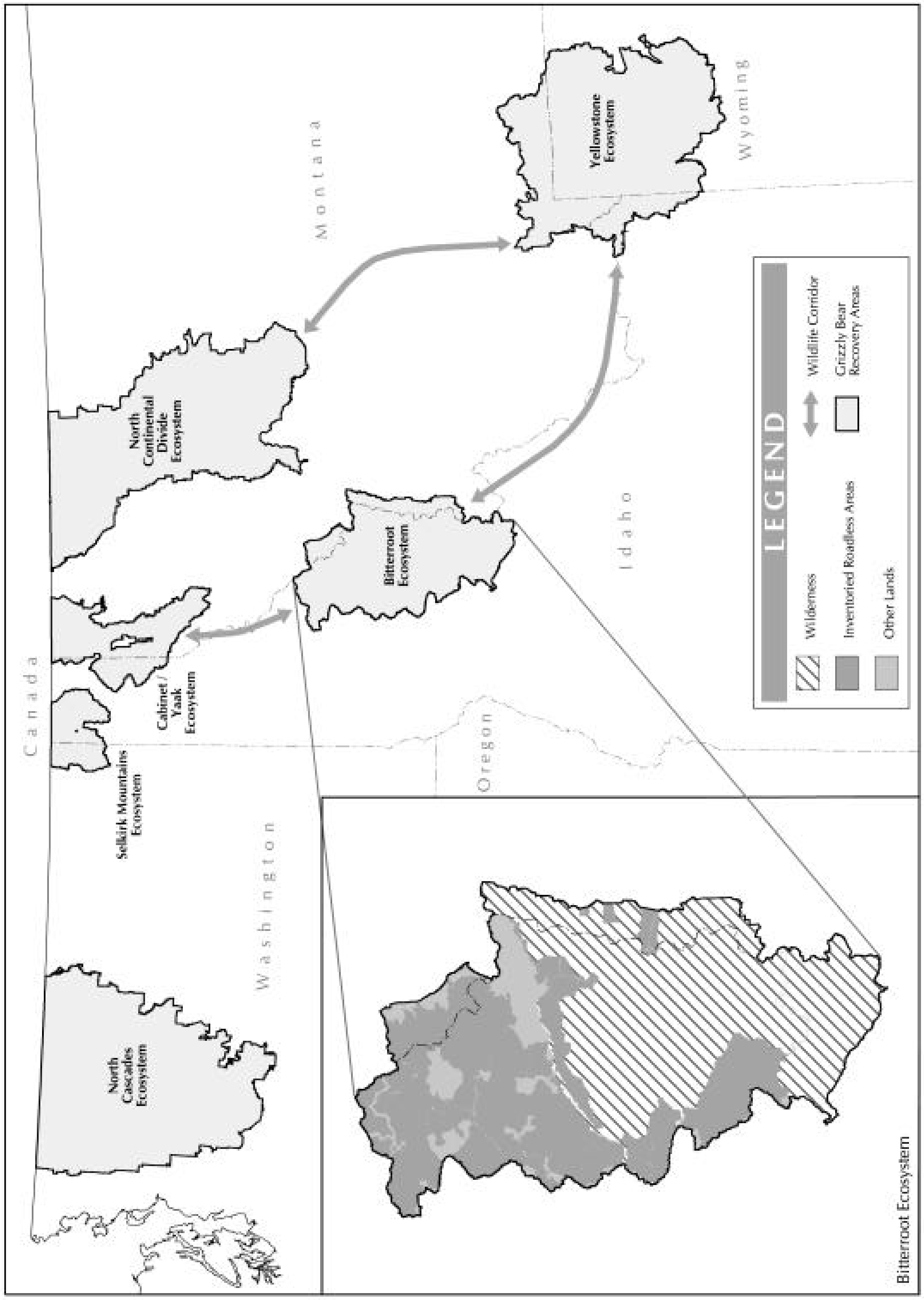


Figure 8. Example of inventoried roadless area contributions to grizzly bear recovery areas *(Weaver and other 1986, USDI Fish and Wildlife Service 1993, USDA Forest Service 2000a).*

Alternative 3 – Prohibit Road Construction, Reconstruction, and Timber Harvest Except for Stewardship Purposes Within Inventoried Roadless Areas;
and
Alternative 4 – Prohibit Road Construction, Reconstruction, and All Timber Cutting Within Inventoried Roadless Areas

The effects on biodiversity related to the size of inventoried roadless areas would be the same as in Alternative 2.

Size Considerations - Summary of Effects

All of the action alternatives would have cumulative beneficial effects to biodiversity by increasing the number and acreage of protected, large contiguous blocks of habitat. The magnitude of cumulative benefits would vary, with the greatest gains in number of large protected areas in the West and the greatest number of acres in large protected areas in Alaska. Nationally, about 34% of inventoried roadless acreage is adjacent to Wilderness. Without a prohibition on road building and reconstruction under Alternative 1- No Action, cumulative incremental loss of large contiguous blocks of these lands providing roadless characteristics and values would be more likely. A more complete discussion of cumulative effects to conservation of biodiversity can be found in the Terrestrial and Aquatic Habitats and Species Specialist Report.

Landcover Class

The distribution of inventoried roadless area and designated Wilderness acreage by landcover class on national forest lands is summarized in Table 8.

In Alaska, designated Wilderness exceeds 12% of the area in five of eight landcover classes. Inventoried roadless areas represent about 74% of the combined acreage of deciduous forests, mixed forests, and shrublands, and less than 10% of the combined acreage in these landcover classes is contained in designated Wilderness.

In the East, if all inventoried roadless area acreage is considered along with designated Wilderness acreage, representation of the evergreen class would exceed the 12% threshold. None of the other eight landcover classes would be represented at or above the 12% threshold.

In the West, designated Wilderness exceeds 12% of the area in three of eight landcover classes. If inventoried roadless area acreage were considered along with designated Wilderness acreage, seven of the eight landcover classes would exceed the 12% threshold. Only the water class would remain below the threshold.

Table 8. Percentage of National Forest lands in inventoried roadless areas (USDA Forest Service 2000a) and designated Wilderness (USDA Forest Service 2000b) by landcover class (derived from Fleming 1997 and USDA Forest Service 1999b) and geographic division. The Wilderness acreage includes inventoried roadless areas with special designations. Total area values are gross National Forest System acres.

	Landcover type	Total Area (acres)	All inventoried roadless areas (%)	Inventoried roadless areas - roads allowed (%)	Wilderness area (%)
	Alaska				
1	Deciduous Forest	1,000	90	70	0
2	Evergreen Forest	11,496,000	54	18	23
3	Mixed Forest	3,000	46	13	0
4	Shrub-Brush	1,107,000	74	53	9
7	Tundra	87,000	66	23	15
9	Barren Land	3,948,000	59	18	37
10	Water	155,000	51	19	23
11	Glaciers-Snow	4,867,000	82	19	15
	East				
1	Deciduous Forest	24,226,000	4	2	3
2	Evergreen Forest	11,806,000	3	2	10
3	Mixed Forest	6,124,000	4	2	3
4	Shrub/Brush	1,000	0	0	0
5	Rangeland	3,000	0	0	0
6	Wetland	7,000	0	0	0
8	Undifferentiated Shrub/Grass	2,713,000	4	3	1
10	Water	807,000	1	1	8
	West				
1	Deciduous Forest	7,861,000	31	26	10
2	Evergreen Forest	120,148,000	26	17	18
4	Shrub/Brush	15,820,000	25	18	12
5	Rangeland	9,350,000	11	10	3
7	Tundra	2,798,000	22	11	61
8	Undifferentiated Shrub/Grass	8,406,000	26	20	9
9	Barren	89,000	40	40	10
10	Water	565,000	6	3	2

Fragmentation

Fragmentation, in this analysis, refers to human activities dividing large areas of forest into smaller tracts separated by different landscape elements. Examples are common in urban areas and in forest landscapes where clearcutting was used extensively. (The Tongass Biological Resources Specialist Report includes a discussion of natural and human-caused fragmentation regarding the Tongass National Forest). As fragmentation increases, the amount of unaltered central or core habitat decreases, and ecosystems are increasingly subject to adverse edge effects (see Terrestrial Wildlife specialist report) from surrounding human activity or changes in microclimate (Chen and others 1995, Concannon 1995), increase in human-caused fires, and invasion of nonnative species (Saunders and others 1991, Skole and Tucker 1993).

Connectivity is a measure of the extent to which habitat patches allow wildlife species to move across a landscape or region. The degree of connectivity required varies by species. For example, a landscape for spotted owls is considered well connected if habitat patches are less than 6 miles apart, and weakly connected if the patches are more than 24 miles apart (USDA Forest Service 1993).

Habitat in roadless areas tends to be less fragmented and better connected than in roaded areas of similar size. This connectivity is important to fisher, marten, and lynx populations that have been negatively affected by fragmentation and loss of connectivity resulting from timber harvest (Ruggiero and others 1994) and forest roads (USDI Fish and Wildlife Service 1998). Smaller patch size and loss of interior forest habitat has adverse effects on numerous species dependent on such habitat.

Roads are a major contributor to forest fragmentation because they divide large landscapes into smaller patches, and convert interior forest habitat into edge habitat. As additional road building and timber harvest activities increase habitat fragmentation across large areas, populations of some species may become isolated in smaller groups, increasing the risk of local extinctions (Noss and Cooperider 1994). Clearcut timber harvest units and associated roads affect 2.5 to 3.5 times more of the landscape than the surface area occupied by the actual activities themselves (Reed and others 1996). Over the past 50 years, landscapes have been appreciably affected by fragmentation caused by clearcutting and road building (Harris 1984, Saunders and others 1991, Noss and Csuti 1994, Forman and Alexander 1998).

Roads also fragment some invertebrate habitat. In the Klamath-Siskiyou province, Frest (pers. comm.) documented a reduction in habitat for common land snails from fragmentation caused by roads and other land-disturbing activities. Reasons cited include microclimate changes on the road surface; loss of habitat complexity and structure causing increased exposure to predators; increased effective width of roads; and chemical avoidance of exhaust residues, petroleum products, and other chemicals by many species. Timber harvest, particularly where associated with extensive ground disturbance and canopy removal, provides a substantial threat to population viability of invertebrates as well (Frest 1993, Frest and Johannes 1995).

Alternative 1 – No Action

The relative effects of the most common ground-disturbing activities on landscape fragmentation and connectivity are summarized in Table 9. Alternative 1 would result in the greatest degree of fragmentation and the largest negative impact on biodiversity when compared to the other alternatives. Over the next 5 years, the projected road construction miles and timber harvest levels are the largest in this alternative.

More than half of the timber harvest volume would be from clearcutting, primarily on the Tongass National Forest (if the roading prohibitions apply to the Tongass, very little clearcutting would occur). Clearcutting is an important cause of biodiversity loss due to the loss of biological legacies, such as snags and logs, which usually remain after a natural disturbance (Franklin and others 2000). In the long term, since inventoried roadless areas would likely continue to be available for development, fragmentation and effects from loss of connectivity are expected to continue to occur over time. The actual effect will vary depending on the location, final harvest and roading prescriptions, mitigation measures, and the condition of the surrounding landscapes. Actual estimates of biodiversity losses would be determined at the local project level.

While the Intermountain Region would have the highest harvest levels and road construction in the 'lower 48', less than 10% of the acres harvested are expected to be from clearcutting. The remaining acres harvested are likely to be through tree thinning, which can be less fragmenting if post-harvest canopy cover remains relatively high. For example, thinnings that substantially lower canopy covers can have adverse affects on the movements of northern goshawk (Reynolds and others 1991) and American marten (Ruggiero and others 1994) prey species, at least in the short term. Harris (1984) suggests that impacts from fragmentation generally are relatively low from thinning compared to clearcutting.

Table 9. Relative impact of management activities on fragmentation and connectivity.

Management activity	Most impact	Moderate impact	Least impact
Clearcutting and associated roads	X		
Thinning from below to reduce fire risk or to enhance old growth [a]			X
Classified road construction		X	
Temporary road construction [b]			X

[a] Thinning of small diameter trees in the understory.
[b] Designed with minimal clearing widths and decommissioned after use.
(Roadless Database 2000)

There may be local impacts on some national forests, such as the Payette, Dixie, Manti-Lasal, Clearwater, and the Idaho Panhandle, since a higher percentage of timber harvest is expected on these forests than others in the West. Seven national forests in the East are planning to harvest more than 5MMBF over the next 5 years. Of these, the Monogahela, Superior, and Ozark/St. Francis are projecting the highest levels of harvest volume and road construction, and may experience some increase in fragmentation depending on harvest prescriptions and levels of associated road construction.

This alternative would provide the opportunity for thinning, brush piling, under burning, and other vegetation treatments to conserve or enhance ecosystem structure, function, and composition. Such stewardship activities can have important local beneficial effects on biodiversity. For example, reducing wildland fire intensity by reducing accumulated fuels in ponderosa pine forests in the West may conserve local biodiversity by increasing the survivability of large, old-growth pines following wildland fires; reducing mortality from moisture stress; reducing insect and disease outbreaks in stressed stands; restoring fire dependent herbs and shrubs; and restoring the historical fire regime.

These benefits should be weighed at the local project level against the risks of implementing these treatments. For example, depending on the terrain, tree removal prescription, equipment type, skill, and concern of the equipment operators, and administrative oversight, benefits from stewardship timber harvest may be outweighed by adverse impacts to terrestrial and aquatic resources. Since this alternative would allow the full range of timber harvest to occur, some local negative impacts to these resources and to biodiversity from reduction in snags, coarse down wood, canopy cover, and large old-growth trees would likely occur.

Alternative 2 – Prohibit Road Construction and Reconstruction Within Inventoried Roadless Areas

This alternative would greatly reduce the potential for further fragmentation and loss of connectivity from road construction or timber harvest. The level of fragmentation depends on the land management objectives and type of timber harvest. On the Tongass National Forest, the roads prohibition would greatly reduce clearcutting and the effects from human-caused fragmentation.

This alternative would be beneficial to animals with large home ranges such as the grizzly bear. In the West, important connectivity would be conserved between Yellowstone, Bitterroot, North Continental Divide, and Cabinet/Yaak ecosystems because of increased inventoried roadless area protection.

Alternative 3 – Prohibit Road Construction, Reconstruction, and Timber Harvest Except for Stewardship Purposes Within Inventoried Roadless Areas

The impacts on biodiversity from increased fragmentation and reduced connectivity would be less than under Alternative 2. Clearcutting is not expected to occur under this alternative. Only timber harvest that maintains or restores biodiversity is expected under this alternative.

This alternative would provide the opportunity for thinning, brushing, under burning, and other vegetation treatments to conserve or enhance ecosystem structure, function, and composition. Such stewardship activities can have important local benefits on biodiversity and overall ecosystem health. For example, reducing fire intensity by reducing accumulated fuels in ponderosa pine forests in the West may conserve local biodiversity by: increasing the survivability of large, old-growth pines following wildland fires; reducing mortality from moisture stress; reducing insect and disease outbreaks in stressed stands; restoring fire dependent herbs and shrubs; and restoring the historical fire regime.

Depending on the terrain, equipment type, skill of equipment operators, and administrative oversight, benefits from vegetation treatments may be outweighed by adverse impacts to terrestrial and aquatic resources. If all of these factors are carefully managed, the results can be positive. While there are many examples of successful fuel reduction efforts in individual forest stands, it has not been shown that large-scale treatment of fuels can effectively restore natural fire regimes and ecological conditions.

Alternative 4 – Prohibit Road Construction, Reconstruction, and All Timber Cutting Within Inventoried Roadless Areas

No adverse effects on biodiversity from fragmentation and loss of connectivity are expected since no timber would be harvested.

This alternative would have some local negative effects on biodiversity since stewardship-type timber harvest treatments would not be allowed with the exception of those timber harvest activities needed for protection or recovery of a T&E species, or species that have been proposed for listing under the ESA. As a result, ecosystems that currently are or could be contributing to local biodiversity may be negatively altered by uncharacteristic wildland fire or insect and disease outbreaks. It is likely that some of these areas, over time, would experience stand replacement fires, and landscape vegetation patterns would shift more towards larger, even-aged stands initiated by large fire.

Fragmentation - Summary of Effects

Cumulatively, all of the action alternatives would result in a lower risk of future increases in landscape fragmentation, relative to the no-action alternative. Because no substantial differences exist in the rate of timber harvest activities between action alternatives, a marked difference in the level of cumulative beneficial effects is unlikely. Both federal and non-federal lands will likely show some increases in habitat fragmentation and loss of connectivity from unrelated actions, and some beneficial site-specific decisions. Assessing the magnitude of beneficial cumulative effects will be difficult. The effects of the no-action alternative, considered in light of reasonably likely increases in habitat fragmentation and loss of connectivity in adjacent landscapes, would likely result in some adverse cumulative effects to biodiversity. A more complete discussion of cumulative effects to conservation of biodiversity can be found in the Terrestrial and Aquatic Habitats and Species Specialist Report.

Historical Fire Regimes

Fire regimes are typically characterized by fire frequency, size, and intensity (Agee 1993). For example, coastal spruce-fir forests of western Oregon historically burned every 200 to 400 years in large, intense, stand-replacing fires. This fire regime can be contrasted with ponderosa pine forests where fires often burn every 5 to 10 years. These fires are usually light, understory burns that do little damage to overstory trees. Fire regimes have been mapped for the Forest Service's fuels management strategy (Hardy and others 2000).

About 39 million acres of national forest lands in the interior west have been affected by fire suppression (USDA Forest Service 2000d). The largest effects have been in ecosystems with low-intensity, frequent (0-35 years) fire return intervals. These ecosystems are typified by plant associations on dry sites in the West such as the Ponderosa Pine and Douglas-fir types. Effects from fire suppression have resulted from excluding several fire cycles. Excluding fire has increased tree density of shade-tolerant trees in the understories and increased fuel build-up on the forest floor. During periods of drought, the increased competition for water and nutrients often causes significant stand mortality from insects and diseases attacking stressed trees that in turn amplify the fuel-loading problem. Consequently, when a wildfire starts under these conditions, it often burns the entire stand.

Many stands have developed such a large fuel load that using only prescribed fire to reduce the fuels has a high risk of killing the larger and older trees. Thus, pretreatment using either hand piling of fuels or commercial treatments, is needed to reduce prescribed fire intensity. About 7.5 million acres meet criteria for stand condition, type, and fuel loads that indicate some type of mechanized pretreatment would be needed before fire is reintroduced.

Alternative 4, which precludes the use of commercial harvest, is assumed to have the least likelihood of fuel treatments to restore historical fire regimes because hand piling and burning are very costly. Based on historical funding levels, sufficient funds to treat fuels in alternatives 2-4 are unlikely. In some local areas, lack of fuel treatments could degrade stand and landscape structure and biodiversity. Alternatives 1, 2, and 3 provide the most management flexibility to use the full range of tools available to restore historical fire regimes.

Nonnative Invasive Species

Invasion by nonnative species is one of the most important issues in natural resource management. The ability of these species to alter native population, community, and ecosystem structure and function is well documented (Mooney and Drake 1986, Vitousek and others 1987, Drake and others 1989). More than 6,000 species now growing in this country are known to have originated outside the United States (Table 10). Unfortunately, the ability of natural resource managers to eliminate invasive species, once they have become established, is very limited.

Table 10. Estimated number of established nonnative species in the United States.

Species	Number
Plants	3,723
Terrestrial vertebrates	142
Insects and arachnids	>2,000
Fishes	76
Mollusks	91
Plant pathogens	239
Total	>6,200

Source: Williams and Meffe 1998.

One of the major effects of nonnative species on biodiversity is loss of native species (Nott and others 1995). Invasive species are known to have caused the extinction of at least 109 vertebrate species around the world (Cox 1993). In the United States for example, seven moth species that fed exclusively on the American chestnut are now extinct because of the loss of the American chestnut (Opler 1976). Chestnut blight, a nonnative fungal disease from Asia, was introduced to this country early in the 20th Century; it was responsible for the nearly complete loss of large American chestnut trees in forests in the East.

Roads influence the spread of invasive organisms through transport by vehicles or by altering the adjacent habitat to encourage these species and other early successional ones. In the Pacific Northwest, transport of Port-Orford-cedar root disease on vehicles is primarily responsible for the extensive loss of Port-Orford-cedar (Zobel and others 1985).

Road building creates habitat along roads typically unique to the surrounding native ecosystem and often favored by many nonnative invasive plants. These roadside habitats typically persist for as long as the road is maintained. Hundreds of these plant species occupy roadside and adjacent habitats all over the country (Westbrooks 1998). Nonnative blackberries, St. John's wort, kudzu, and Scotch broom are examples of invaders that thrive in the conditions along roadsides; roadside habitat allows these light-loving species to persist and flourish. In turn, their presence along the roads, allows them to spread readily into surrounding landscapes after timber harvest or wildfire. Spread into surrounding landscapes is more likely in ecosystems with high natural disturbance rates, or where native ecosystems have already been significantly affected by these species. Once these species invade, eradication efforts are rarely successful; hence, the effects are usually irreversible.

The no-action alternative, Alternative 1, which would not prohibit building roads into inventoried roadless areas, would have the highest likelihood of introducing and spreading road-transported invasive species. In the West, 29 national forests have more than 5 MMBF of timber harvest (requiring road construction) scheduled from inventoried roadless areas. Although invasive plant introductions could increase in all of these forests, the most effects would be expected on the Dixie, Payette, Manti-Lasal, Fishlake and Idaho Panhandle National Forests. Increased effects on these forests are expected to result from projected higher timber volume and road-building miles, and moderate to high incidence of natural disturbance.

Although the Tongass National Forest has the largest road mileage and volume proposed in unroaded areas, the climate and low rates of natural disturbance limit the risk of road-transported species introductions and spread. Of the seven forests in the East harvesting more than 5 million BF from unroaded areas, the Monogahela, Superior, and the White Mountain national forests are projecting the highest harvest volume and road building miles; they may experience the greatest risk of introductions. It is estimated that more than 60% of the plant species on the Monogahela National Forest are exotics that have become naturalized and 28% of the landscape has been affected by these species. Consequently, the activities on the Monogahela in inventoried roadless areas are expected to further reduce the limited native ecosystems in the East.

Reference Landscapes

Because knowledge about the effects of management activities is incomplete, the demand for information addressing ecological issues over long periods and large landscapes is great. Never before has such widespread consensus been reached on the importance of acquiring more knowledge about large-scale ecological patterns, processes, and management activities (Bormann and others 1999). Issues, such as continued viability of wide-ranging animals, watershed cumulative effects, and restoration of fire-dependent ecosystems, appear to require working at these larger scales.

In the West, for example, though broad consensus on allowing fire to play a more natural role is apparent, no consensus has been reached on the best way to do this, let alone whether planned treatments can even make a significant difference. Substantial evidence suggests that small-scale fuel reduction and prescribed fire efforts can change the response of these stands to wildfire. Little direct evidence has been found that landscape-scale management activities can significantly alter the behavior of wildfire. Several strategies could be used to address this question.

Historically, managers have relied on the learning-from-experience model supported by small-scale research projects. This type of management is similar to what Walters (1986) calls passive adaptive management. Passive adaptive management was most commonly used over the past several decades to evaluate landscape effects from clearcutting. In this example, managers, influenced by the public and scientists were eventually convinced to change. This method of learning tends to be slow, disruptive, and qualitative.

Comparative management approaches are a more active form of adaptive management. These approaches may incorporate principles of the scientific method in managing -- such as establishing controls, using multiple treatments, repeating those treatments (replication), and randomly assigning treatments. These learning approaches greatly enhance the ability of people to compare and contrast long-term differences on the ground. These comparisons are particularly important in forest ecosystems where differences may not play out within the career lives of managers, scientists, or local citizens. In the long-term, use of comparative management approaches can greatly improve the choices for future generations.

These approaches have been widely used to test stand-scale treatments, particularly when researchers have become involved. Very few examples of application at the landscape or watershed scale exist. In the fire example, such a large-scale management experiment may compare different treatments in inventoried roadless areas such as continued fire suppression, wildfire only, prescribed fire only, and combinations of mechanical or hand treatments with fire. This approach to answer the question about whether management can influence wildfire behavior at the landscape scale could be applied at a variety of scales. Such an approach would require a long-term commitment to management direction for landscape or watershed treatment units.

Inventoried roadless areas may be valuable as reference landscapes (or watersheds) for helping to ensure a long-term commitment to large-scale monitoring and experiments. As such, they provide an opportunity for retrospective study, evaluating long-term trends and conditions in natural settings, or for long-term comparison of treatments in surrounding landscapes.

Reference areas do not mean "hands off" management. These areas may be useful as part of more structured management experiments where treatments are assigned, implemented, and monitored over a long period. For example, reference areas may provide useful long-term information about approaches to restoring historical fire regimes and fuel loads in the Intermountain West. Some areas could be allowed to burn only by wildfire, some using prescribed fire, and others with a combination of mechanical treatments and prescribed fire. Some areas could be selected where fires will continue to be suppressed. The type of treatments or management approach used should be dictated by local conditions and the questions that scientists, managers, and the public, working together, determine to be most valuable.

Long-term commitment to learning is essential. Typically, the next generation of scientists, citizens, and managers will be the ones to gain the knowledge from the large management experiments established today. Selection of reference areas should thus be collaborative among scientists, managers, and the public. This collaboration will help ensure that the right questions and values are being considered and long-term commitments to learning are made. Consideration may also be given to other means to ensure this long-term view, such as designating of certain inventoried roadless areas as research natural areas or experimental forests.

Reference landscapes not only provide a crucial resource for research pertaining to adaptive management; they also provide places that scientists can engage in species-specific research to gain a better understanding of the biology and ecology of individual species or assemblages. These areas also provide important teaching opportunities.

No alternative would preclude the use of inventoried roadless areas as reference landscapes or watersheds for long-term study. The no-action alternative would provide less opportunity for building commitment to long-term study in natural settings because many inventoried roadless areas would be subject to commodity production. Alternatives 2 and 3 would place progressively greater limits on human activities, which would narrow the range of possible management experiments. Alternative 4, which does not allow timber harvest with the exception of that needed for recovery or protection of TEP species, places the most limits on the range of possible management experiments. Alternatives 2, 3, and 4, however provide the best opportunity for long-term commitment to gaining important knowledge about landscape-scale challenges facing resource managers today.

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