Interior Columbia Basin Ecosystem Management Project, the Sierra Nevada Framework, and the Cohesive Fire Strategy calls for a mix of longer rotation periods to increase old-growth characteristics, and thinning treatments that would continue the removal of small diameter trees. Other strategies such as the Lynx Conservation Assessment and Strategy call for preservation of early seral stage habitat that would preclude some future thinning activities.

Reasonably Foreseeable Future Actions – Natural disasters such as wildland fires, windstorms, and insect outbreaks will continue to occur, and the Agency is likely to continue salvaging a portion of the dead and dying trees. These **salvage** sales will continue to be designated as high priority for harvest due to biological and economic factors. The biological factor is the need to control secondary insect outbreaks, like Ips beetle, southern pine beetle and spruce bark beetle, whose populations would increase rapidly by attacking damaged trees and then spreading into the surrounding healthy trees. The economic factor is the rapid deterioration of the dead material due to insect damage, stains, rots, and checking. If dead or dying trees are not salvaged quickly, there will be nothing to salvage.

Timber salvage sales generate vegetation management work completed on the ground and receipts to the Federal treasury from the sale of usable trees. A portion of the money collected from the resulting timber salvage sales is used to help cover the costs of essential rehabilitation work and reforestation. If the Agency elects to reduce the use of timber salvage sales because of continuing public controversy, the use of service contracts funded by appropriations must increase to accomplish fuels reduction or other desired vegetative treatments. Net cost per acre to achieve desired conditions rises substantially over that associated with use of timber salvage. The higher cost may be a disincentive to achieving desired conditions within inventoried roadless areas.

Wildland fires and other natural disasters, especially during a wildland fire season like the one experienced in 2000 in the West, will also eliminate or devalue the timber on some timber sales currently under contract and some that were planned but not offered for sale. However, it is anticipated that the acres of vegetation management that otherwise would have been accomplished through timber harvest will be recovered or slightly increased due to restoration and salvage operations over the next 2 years.

Biodiversity

Biodiversity is the variety and abundance of species, their genetic composition, their communities, and the ecosystems and landscapes of which they are a part (Wilson 1988; Adams and others 2000). The United States has a rich heritage of biodiversity, due in large part to its great topographic and climatic diversity. Extending north to south approximately 50° latitude and east to west more than 120° in longitude, this country contains 21 of 28 globally defined ecoregions and supports at least 4,500 distinct vegetative communities. Nearly 16,000 species of the world's vascular plants are found within the United States, and about 10% of freshwater fish species and 9% of mammal species (Adams and others 2000). Natural disturbance processes have been and continue to be instrumental in the development and maintenance of this biodiversity (Noss 1994).

Protecting areas from human development and activities is an essential part of biodiversity conservation (Wilson 1985, 1989; World Research Institute and others 1992; Noss and Cooperrider 1994). Habitat loss and degradation were identified by Wilcove and others (2000) as the most significant threat to biodiversity in the United States. Habitat loss has been implicated in the decline of approximately 85% of T&E species. Other important contributing factors they identified include competition or predation by nonnative species, pollution, and overexploitation (Wilcove and others 2000).

The current worldwide rate of species extinction is estimated to be approximately 400 times greater than that of recent geologic time, and increasing (Wilson 1985). Based on estimates made by the Nature Conservancy (Stein and Flack 1997), at least 110 species of plants and animals are extinct in the United States, and an additional 416 species are possibly extinct, with no recent documented occurrences. This represents an irretrievable loss of biodiversity.

In this analysis, the direct, indirect, and cumulative effects of alternatives on biodiversity are evaluated using both landscape and species habitat approaches. A landscape approach provides a way of evaluating large-scale biological, physical, and ecosystem processes and patterns that influence biodiversity. These include ecoregion representation, size of habitat area, adjacency to other protected habitats, elevational distribution of habitats, regional distribution and abundance of inventoried roadless areas, relationship to past and present fire regimes, fragmentation, and connectivity.

Potential effects to biodiversity at a species level were determined by considering the kinds and numbers of species potentially affected, identifying the important and sometimes unique characteristics of roadless areas that foster biodiversity, and evaluating the potential adverse and beneficial effects of road construction and timber harvest on those characteristics. These effects are discussed for terrestrial animal species and habitats, aquatic animal species and habitats, terrestrial and aquatic plants, and TEPS species. The cumulative effects of the alternatives were addressed by considering land use and land conversion trends; laws, regulations, and policies that affect biodiversity; and invasion of nonnative species.

To evaluate the adequacy of inventoried roadless areas in representing landscape diversity, a direct 12% threshold of each evaluated category was used. The World Commission on Environment and Development (1987) recommends that at least 12% of a country's land mass is designated as conservation reserves. In this analysis, 12% is used for comparative purposes and may be too low to be a representation target. For example, Noss and Cooperrider (1994) argue that 25% to 75% of a region should be protected to achieve adequate representation of habitat.

The alternatives would not designate conservation reserves or fully protect inventoried roadless areas similar to a Wilderness designation. In this analysis, the effects of the alternatives on landscapes are considered in the context of conserving and protecting certain **landscape characteristics** (i.e., ecoregions, connectivity from reduced fragmentation, and large intact landscapes at all elevational classes). The alternatives prohibit road construction and road reconstruction, and they restrict timber harvest

activities with some exceptions (as identified in Chapter 2). As a result, potential adverse effects from these activities and associated activities would be precluded or reduced, thereby conserving and protecting certain landscape characteristics important to maintaining biodiversity.

The total land area of the United States (excluding Hawaii) is 2.3 billion acres. Of this, 5% of the United States is strictly managed to maintain natural values (e.g., Wilderness, national parks), 5% is managed to maintain natural values (e.g., National Wildlife Refuges, National Recreation Areas), 21% is multiple-use management (e.g., USDI Bureau of Land Management, national forests), and 69% has no active management to maintain natural values (DellaSala and others 2000). Nationally, the combined percentage managed to maintain natural values varies from a high of 36% in Alaska, to 7% in the Western portion of the United States, and 2% in the East. When Alaska is excluded, about 5% of the United States occurs in areas managed to maintain natural values. This figure is much less than the 12% minimum suggested by the World Commission on Environment and Development (1987) and an order of magnitude less than mid-range minimum suggested by Noss and Cooperrider (1994).

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 area in the United States. When only those inventoried roadless areas where current **management prescriptions** that do not allow roads are considered, approximately 1% of the United States is included.

Nationally, the total area in inventoried roadless areas varies from 14.8 million acres (3.8% of the land area) in Alaska to 42.1 million acres (4.4%) in the Western United States and 1.6 million acres (0.2%) in the Eastern United States. When only inventoried roadless 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%) in the Western United States and 0.9 million acres (0.1%) in the Eastern United States.

Many inventoried roadless areas alone and/or in combination with protected areas (e.g., Wilderness) function as **biological strongholds** supporting a diversity of species such as wide-ranging carnivores, localized species, and rare plants. Biological strongholds are areas that support all major life-history forms of a species that were historically found within them, with stable or increasing population numbers at levels not substantially diminished from their historical size or density. Such areas have typically not been exposed to the same levels of habitat degradation and loss that have characterized a region as a whole. They provide conditions suitable for survival of some species that may be declining elsewhere. Biological strongholds play a key role in maintaining native species and biodiversity.

Native plant and animal communities are generally more intact in inventoried roadless areas than in roaded areas of similar size, with the representation and abundance of species less likely to be altered by human disturbances. **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 Cooperrider 1994).

Inventoried roadless areas support a diversity of aquatic habitats and communities. Without the disturbances 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 flows, and temperature regime, are less likely to be altered (Furniss and others 1991). Illegal introduction and harvest of fish species are also less likely to occur in these areas due to lack of ready access.

Inventoried roadless areas are home to many native species of terrestrial and aquatic plants including rare, TES species. Many have narrow geographical ranges determined by soil types, climatic conditions, or other environmental factors. These **endemic species**, due to their natural, limited distribution, are often at a relatively high risk of extinction from human activities or other causes. Areas in the United States with considerable numbers of endemic plant species include California, Texas, Alaska, the Pacific Northwest, the Southwest, the Intermountain West, and the South (Gentry 1986).

Invasion of nonnative species into North American is one of the most important issues in natural resource management today, with more than 6,000 species originating outside the United States. The ability of these species to alter native populations, communities, and ecosystem structure and function is well documented (Elton 1958; Mooney and Drake 1986; Vitousek and others 1987; Drake and others 1989). The ability of managers to eliminate invasive species, once established, is often limited. Since roads provide an entry way for nonnative species, inventoried roadless areas can act as strongholds against invasion of these species.

The following sections provide a detailed discussion of the potential effects of the prohibition alternatives on biodiversity:

- Ecoregions
- Fragmentation
- Size Considerations
- Elevational Distribution
- Terrestrial Animal Habitat and Species
- Aquatic Animal Habitat and Species
- Terrestrial and Aquatic Plant Species
- Threatened, Endangered, Proposed, and Sensitive Species.

Any other indirect and cumulative effects as well as any effects of the social and economic mitigation for all environments under Biodiversity are discussed at the end of this section.

Ecoregions

Affected Environment

The distribution of plants and animals is strongly influenced by physical environmental gradients (Whittaker 1967). These gradients are generally specified by solar radiation, thermal, moisture, nutrient, and biotic regimes (Nix 1982). These gradients are

overlapping and result in areas where ecological communities, dynamics, and inherent capabilities are distinct from neighboring areas. These areas have been defined as ecologically defined ecoregions. Ecoregions broadly describe key environmental variables across the United States, including: physiography, geology, soils, hydrology, climate, land use, vegetation, and wildlife. Figure 3-26 summarizes the ecoregion classification used in this "coarse" scale analysis (Omernik 1995; Gallant and others 1995). Ricketts and others (1999) provide detailed descriptions of the biodiversity of each ecoregion. Table 3-26 shows inventoried roadless acreage by ecoregion and protected status for ecoregions greater than 100,000 acres. Globally outstanding ecoregions (Ricketts and others 1999) are shaded and in italics.

Alternative 1 – No Action

Forty-five of the 83 ecoregions in the 'lower 48' and Alaska have more than 100,000 acres of NFS land that contain 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 about 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,[8] and rarity.

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 3-26 showing 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

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 3-27). 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).

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

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. In addition, protected acreage would more than double in 13 ecoregions (Table 3-27), which currently protect between 5% and 25% of their area.

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 3-27 shows the increased protection for ecoregions resulting from this alternative. The table only includes ecoregions 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 3-26). 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 3-27).

Alternatives 3 and 4

Under these alternatives, the effects on the area of ecoregions protected from road construction and reconstruction would be the same as under Alternative 2.

Fragmentation

Affected Environment

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 forest landscapes where **clearcutting** was used extensively. (The Tongass National Forest effects analysis includes a discussion of natural and human-caused fragmentation.) As human-caused fragmentation increases, the amount of unaltered central or core habitat decreases, which increases adverse **edge effects** (see Terrestrial Wildlife section), including increase in human activity, 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 Tucer 1993).

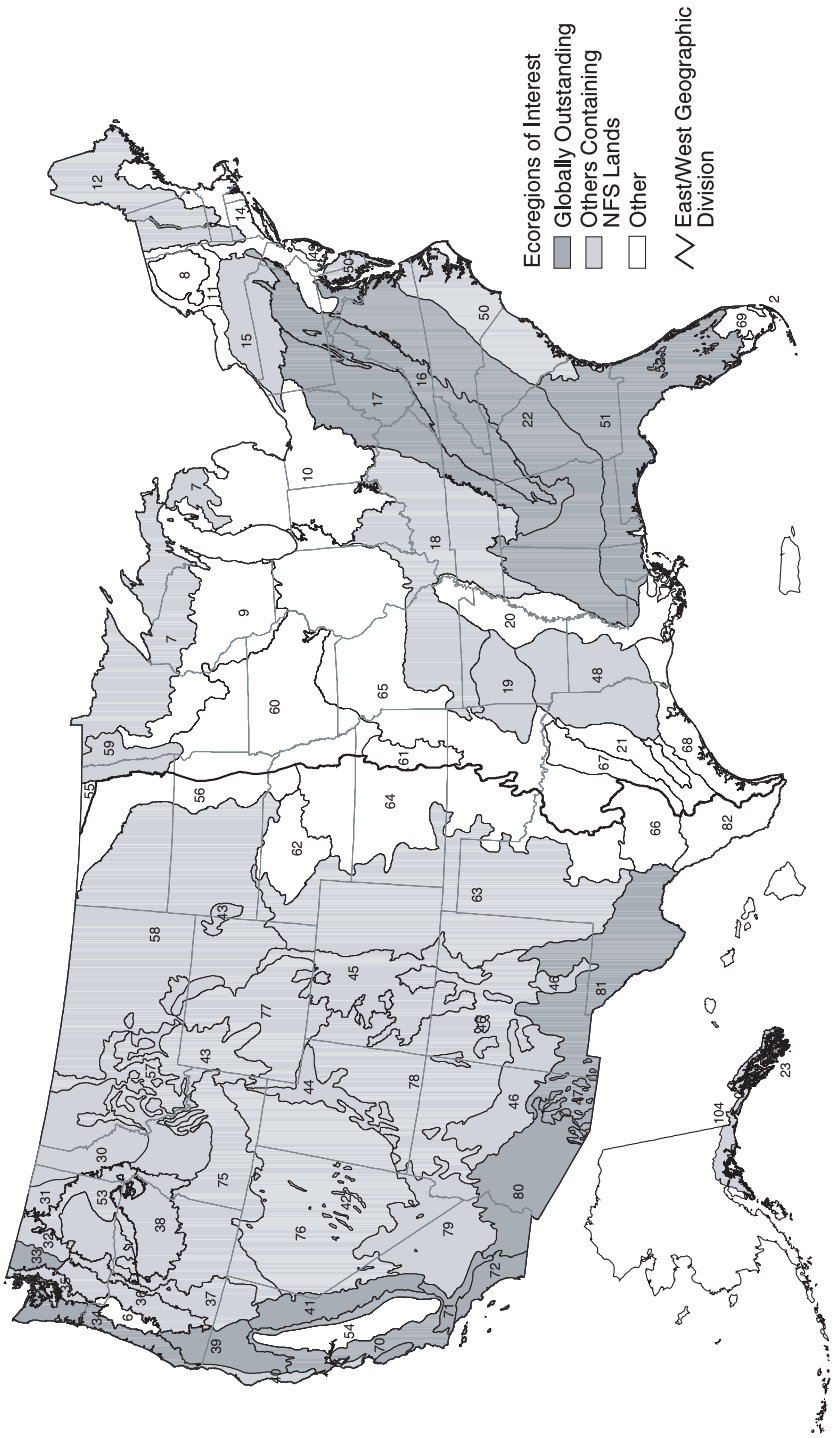

Figure 3-26. Ecoregions of the United States.
(Ricketts 1999)

Table 3-26. Ecoregion area and protected status of inventoried roadless, Wilderness, and other special designated areas. Globally outstanding ecoregions are shaded.

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

Table 3-26 (cont.)

Ecoregion (code number)	Total National Forest System land [a]	Wilderness or other special designated areas [b]	Inventoried roadless areas; road construction prohibited [b]	Inventoried roadless areas; road construction allowed [b]	Wilderness, other special designated areas, or inventoried roadless areas [b]
Arizona Mountains (46)	15,729	16	5	6	27
Madrean Sky Islands (47)	1,517	24	24	0	48
Palouse Grasslands (53)	467	58	1	12	71
Montana Valley/Foothill (57)	1,294	4	4	27	35
Northwest Mixed Grasslands (58)	7,035	0	1	5	6
Western Short Grasslands (63)	3,136	+ [c]	+ [c]	+ [c]	+ [c]
Cen. Cal. Shrub/Savanna (70)	1,180	24	5	19	48
So. Cal. Woods/Shrub (71)	3,040	32	9	18	59
So. Cal. Coastal Scrub (72)	752	16	11	9	36
Snake/Col. Shrub Steppe (75)	1,282	7	9	24	40
Great Basin Shrub Steppe (76)	8,205	12	4	47	63
Wyoming Basin (77)	547	27	1	35	63
Colorado Plateau (78)	3,388	17	3	19	39
Mojave Desert (79)	423	82	2	3	87
Sonoran Desert (80)	179	25	7	3	35
Chihuahuan Deserts (81)	332	5	15	11	31

[a] Thousand acres
[b] Percent
[c] + represents values greater than 0% but less than 0.5%.
(Roadless Database 2000)

Fragmentation results in decreased connectivity, which is a measure of the extent to which habitat patches allow movement of wildlife species across a landscape or region. The degree of connectivity required varies depending on the species of interest. 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 and others 1993).

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

Roads, the associated corridor along them, and clearcutting are major contributors to forest fragmentation because they divide large landscapes into smaller patches and convert interior forest habitat into edge habitat. As additional road construction and timber harvest activities increase habitat fragmentation across large areas, the populations

Table 3-27. Increased protection for ecoregions under Alternative 2 prohibitions. Globally outstanding ecoregions are shaded.

Ecoregion name (code number)	Increase in acreage protected under Alternative 2 when compared to No Action (%)
Alaska	
Northern Pacific Coast (23)	34
Icefields and Tundra (104)	41
Eastern United States	
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)	+[a]
Western United States	
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
Madrean Sky Islands (47)	0
Palouse Grasslands (53)	156
Montana Valley/Foothill (57)	494
NW Mixed Grasslands (58)	762
Western Short Grasslands (63)	0
Central California. Shrub/Savanna (70)	137
Southern California Woods/Shrub (71)	46

Table 3-27 (cont.)

Ecoregion name (code number)	Increase in acreage protected under Alternative 2 when compared to No Action (%)
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

[a] + represents values greater than 0 but less than 0.5%.
(Roadless Database 2000)

of some species may become isolated, increasing the risk of local extirpations or extinctions (Noss and Cooperrider 1994). Clearcut timber harvest units and associated roads affect 2.5 to 3.5 times more landscape than the surface area occupied by the actual activities themselves (Reed and others 1996). Over the past 50 years, landscapes have been appreciably impacted from fragmentation caused by clearcutting and road construction (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 (personal communication) documented a reduction in habitat for common land snails from fragmentation caused by roads and other land-disturbing activities. Reasons cited included microclimate changes on the road surface; loss of habitat complexity and structure; effective width of roads greater than actual width; and avoidance of exhaust residues, petroleum products, and other chemicals that were exhibited by many species. Timber harvest, particularly where associated with extensive ground disturbance and sizeable canopy removal, also provides a substantial threat to population **viability** of some invertebrates (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 3-28. 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 3-28. 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.

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

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

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, and concern of the 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

No 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.

Size Considerations

Affected Environment

There is a positive relationship between size of an area protected from human disturbance and maintenance of biodiversity (MacArthur and Wilson 1967). Large, relatively undisturbed areas are important for species with large home ranges and species that are sensitive to human activity. Ecosystem processes are generally intact in larger areas; particularly fire disturbance processes. Smaller areas are important for biodiversity conservation as well, especially for species with small home ranges, species with special habitat needs, or for providing linkages between larger areas.

As described in the Landscape Analysis of Inventoried Roadless Areas and Biodiversity specialist report, most of the more than 2,800 inventoried roadless areas in the NFS are larger than 5,000 acres, but some are as small as 2 acres (Figure 3-3).

Alternative 1 – No Action

About 41% of the inventoried roadless areas are currently allocated to prescriptions that do not allow road construction and reconstruction and/or that forest plans recommend as Wilderness (Appendix A). Even though most of these areas are between 1,000 and 5,000 acres in size, most of the acreage occurs in the size class between 5,000 and 25,000 acres. One area is larger than 250,000 acres. In the East, there are about 90% fewer areas protected from road construction and reconstruction in the 5,000 to 25,000 acre size class than in the West. There are no areas larger than 50,000 acres in the East, and three between 25,000 and 50,000 acres in size (Figure 3-27). The East has a higher portion of smaller areas than the West.

In Alaska, more than 10 million acres of inventoried roadless areas are currently protected. On the Tongass National Forest, 76% of the acreage currently protected from road construction and reconstruction occurs in inventoried roadless areas greater than 50,000 acres. Alaska has the largest inventoried roadless areas. In fact, most of the acreage in Alaska occurs in 10 separate areas that are each more than 250,000 acres.

Table 3-29 illustrates that a high percentage of inventoried roadless areas are adjacent to existing Wilderness. This provides 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 9 million acres of inventoried roadless areas adjoin existing Wilderness. These areas are currently protected by land management plans. In the East, this is the case for almost 19% of the 655,000 acres of currently protected inventoried roadless areas.

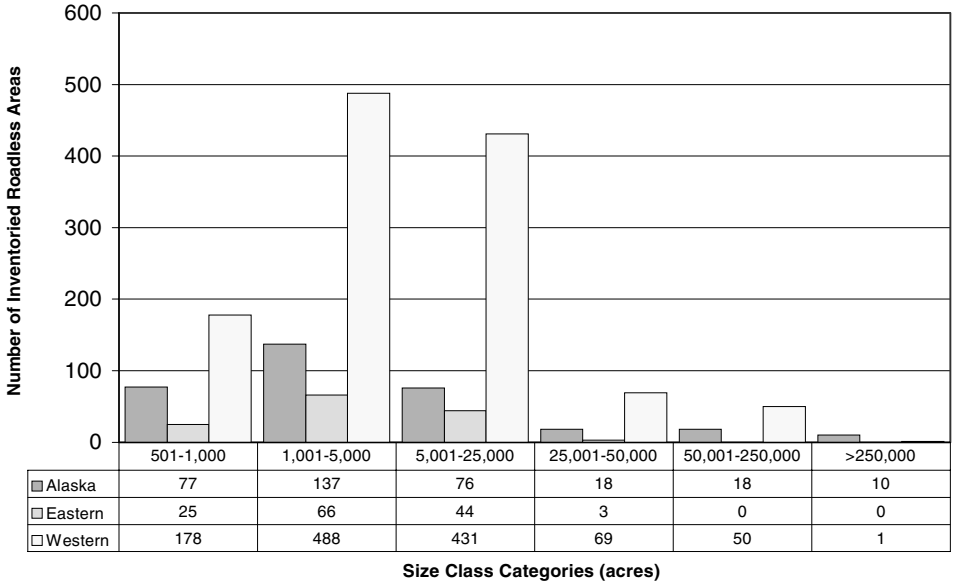

Figure 3-27. Size class distribution of protected inventoried roadless areas under Alternative 1. Inventoried roadless area numbers are for each individual map unit and not groups of units with the same name.

(Roadless Database 2000)

Table 3-29. Inventoried roadless areas, in thousands of acres, adjacent to existing Wilderness.

Geographic division	Wilderness within National Forest System lands	Inventoried roadless areas recommended for Wilderness or where road construction and reconstruction is already prohibited			All inventoried roadless areas		
		Lands adjacent to Wilderness	Total land in this category	Percent adjacent to Wilderness	Lands adjacent to Wilderness	Total land in this category	Percent adjacent to Wilderness
Alaska	5,747	4,140	10,117	41%	5,649	14,779	38%
Eastern U.S.	2,025	122	655	19%	460	1,618	28%
Western U.S.	26,917	4,625	13,409	34%	13,972	42,121	33%
Total	**34,690**	**8,886**	**24,182**	**37%**	**20,080**	**58,518**	**34%**

(Roadless Database 2000)

In Alaska, 41% of the currently protected inventoried roadless areas are adjacent to Wilderness. In the West, 34% of the inventoried roadless areas that currently prohibit road construction are adjacent to Wilderness. These areas together encompass large areas where road construction and reconstruction are prohibited (Figure 3-28).

The six Grizzly Bear Recovery Areas identified in the Grizzly Bear Recovery Plan (USDI Fish and Wildlife Service 1993) include more than 23 million acres, of which 7.5 million is Wilderness (Table 3-29). These areas are located in Montana, Idaho,

Washington, and Wyoming. Figure 3-29 illustrates how effectively inventoried roadless areas contribute to overall integrity of these management units. More than 44% of the Grizzly Bear Recovery Areas are currently protected from road construction by inventoried roadless areas that currently prohibit roading and adjacent Wilderness

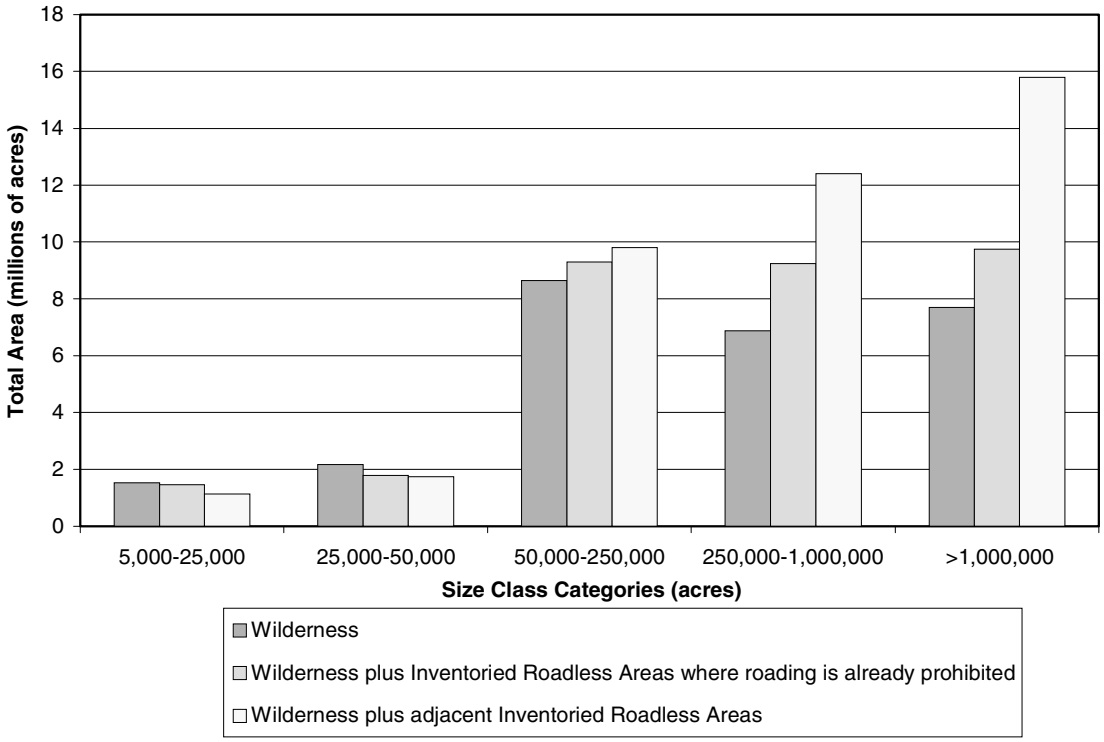

Figure 3-28. Acreage of large protected areas in the Western United States from combining inventoried roadless areas and adjacent Wilderness.
(Roadless Database 2000)

Alternative 2

Alternative 2 would greatly increase the protection of large (>5,000 acres) contiguous inventoried roadless areas from road construction and reconstruction (Table 3-30). This would have a large positive effect on conserving biodiversity in the contiguous United States. Since so much of Alaska is already protected from road construction, the proportional benefits to biodiversity could be less than in some other States.

In the West, 12 inventoried roadless **map units** more than 250,000 acres, 97 areas between 50,000 and 250,000 acres, and 827 areas between 5,000 and 25,000 acres would be added to the already protected units under Alternative 1 (Figures 3-27 and 3-30). The number of areas protected below 5,000 acres would increase by 185. In the East, the largest change would occur in the 5,000 to 25,000 acre size class where 77 inventoried roadless map units are added to what is already protected under Alternative 1. Two map units between 25,000 and 50,000 acres would be added in the East because of this alternative.

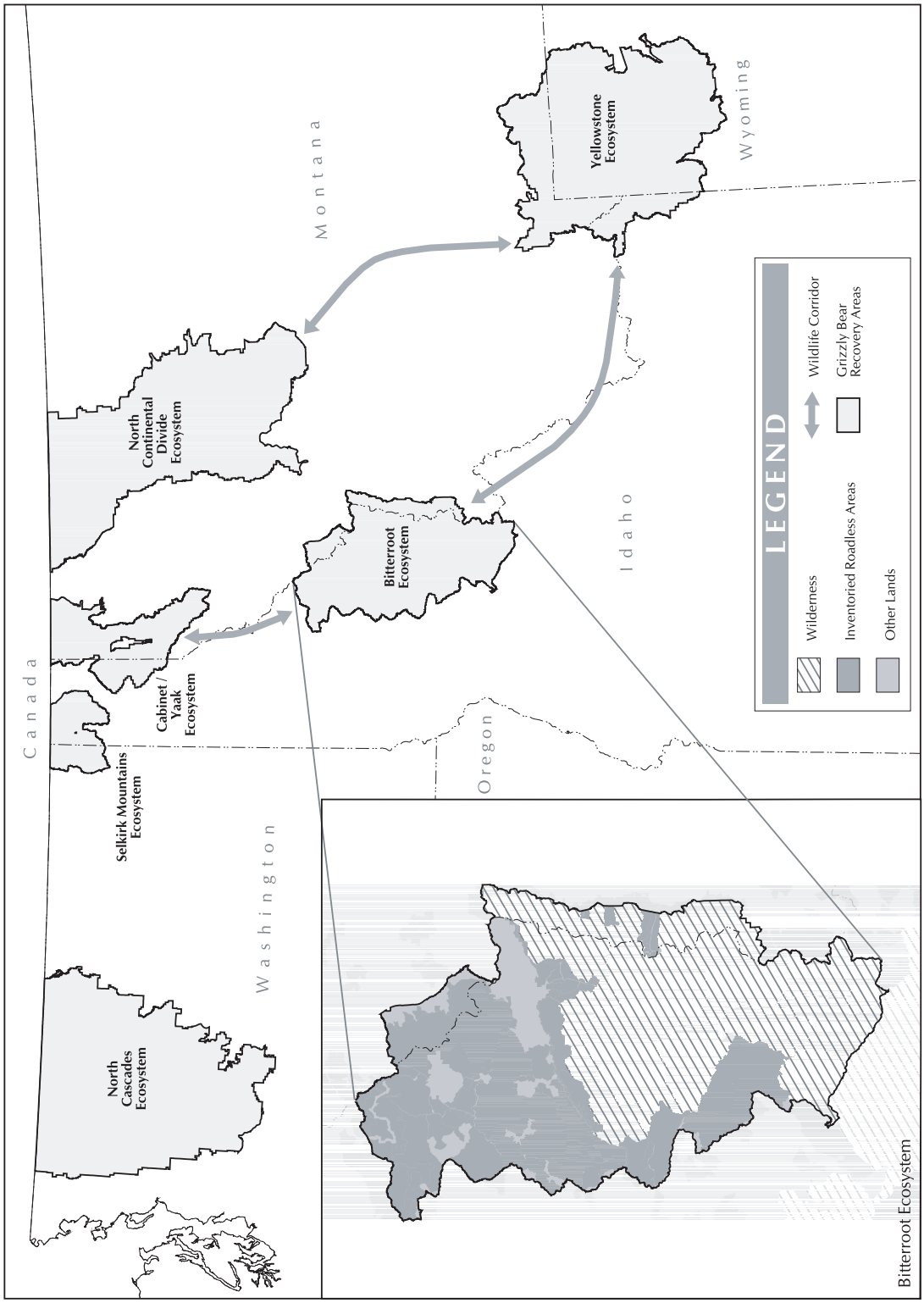

Figure 3-29. Example of inventoried roadless area contributions to the integrity of Grizzly Bear Recovery Areas.

(Roadless Database 2000; USDI Fish and Wildlife Service 1993; Weaver and others 1986)

Table 3-30. Acres, in thousands, of inventoried roadless areas within Grizzly Bear Recovery Areas.

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

(Roadless Database 2000)

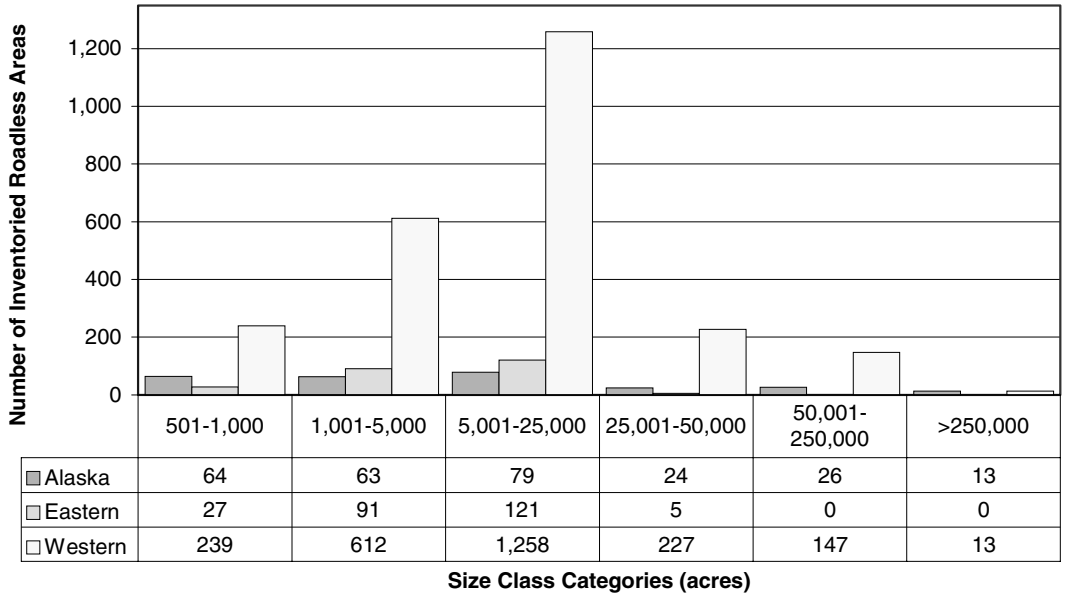

Figure 3-30. Size class distribution of protected inventoried roadless areas under Alternative 2.
(Roadless Database 2000)

In Alaska, the number of inventoried roadless areas more than 5,000 acres would increase slightly from 122 under Alternative 1 to 142 (Figure 3-27 and 3-30). However, the acreage in the upper size classes would nearly double. In the less than 5,000-acre size classes, the number of inventoried roadless map units would shrink by about half.

Most designated Wilderness areas on the national forests are less than 50,000 acres in size (277 areas totaling 5 million acres), and 30 areas exceed 250,000 acres (totaling 20 million acres). This alternative would increase the amount of inventoried roadless area adjacent to Wilderness from about 9 million to more than 20 million acres. When

adjacent inventoried roadless areas are viewed together with Wilderness areas, the acreage of combined areas smaller than 50,000 acres decreases, while areas larger than 250,000 acres would increase.

The largest inventoried roadless area acreage-adjoining Wilderness occurs in the West where nearly 14 million acres (33%) adjoins Wilderness areas (Table 3-29). The largest increases in the West would occur in the upper size classes. In the 250,000 to 1 million-acre size class, the acres of inventoried roadless areas would increase from 9 to more than 12 million and in the 1 million acre or greater size class; the number of acres would increase from about 10 to nearly 16 million acres (Figure 3-28).

This alternative should support the recovery of grizzly bears in the Western United States by increasing inventoried roadless areas protected from roading by more than 2 million acres within Grizzly Bear Recovery Areas. Likewise, it greatly increases the number and size of wildlife corridors between protected areas. In the East, the area adjoining Wilderness areas would increase from about 122,000 acres to more than 460,000 (Table 3-29). The size class distribution of the contiguous Wilderness and inventoried roadless areas is about the same as under Alternative 1.

Alternatives 3 and 4

The effects on biodiversity related to the size of inventoried roadless areas would be the same as Alternative 2. Overall, this alternative would have the most beneficial effects to biodiversity of all the alternatives.

Elevation Distribution

Affected Environment

Ecologically, the distribution of habitats across a range of elevations can indirectly describe the habitat diversity. Plants that thrive in cold environments with short growing seasons generally dominate habitats at high elevations. Often these habitats have shallow, poor soils, and tree growth is greatly reduced. On the other hand, habitats at low elevations are generally the most productive. Forests at low elevations grow some of the largest trees in North America, such as redwood and Douglas fir, which grow along the coast of northern California. Furthermore, species richness is generally greater at low and mid-elevations (see summary by Noss and Cooperrider 1994). Human settlement in North America has had the greatest impact on lower elevation habitats. These areas were the most accessible and the most productive, consequently the amount of low elevation habitat types is much less than high elevation types.

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 3-31).

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 2,000 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 20% of elevation classes at about 1,000 feet would be protected from roading. Elevations below 1000 feet would be the least protected in both the East and West.

Terrestrial Animal Habitat and Species

Affected Environment

Inventoried roadless areas encompass a range of habitat types including grass and shrublands, young forested stands, and **old-growth forests**. The character, distribution, and extent of habitats are affected by the size of an area, the kinds, intensity and timing of management-induced and natural disturbances that have occurred, and the landscape context in which they are found. Inventoried roadless areas provide large, relatively undisturbed blocks of important habitat for terrestrial animal species and communities. In addition to supplying or influencing habitat for more than 300 TEPS terrestrial animal species, these areas support numerous other game and non-game vertebrate and invertebrate species.

Many of these inventoried roadless areas function as biological strongholds and places of refuge for many species, covering the spectrum from wide-ranging carnivores to narrowly distributed endemic snails (that is, restricted to a specific location). Some of these areas may play an increasing role in supporting species viability and overall native biodiversity than in the past, due to the cumulative degradation and loss of other habitat in adjacent landscapes.

In general, the composition of, and relationships between native plant and animal communities in inventoried roadless areas may be less disrupted than in roaded areas of similar size. Species richness and native biodiversity are more likely to be effectively

Table 3-31. Distribution of inventoried roadless areas and Wilderness Areas by elevation class and geographic division.

Elevation classes (feet)	Total area within National Forest System[a] (thousand acres)	Inventoried roadless areas where road construction is allowed within each elevation class (%)	Inventoried roadless areas where road construction is prohibited within each elevation class (%)	Wilderness Areas within each elevation class (%)	Wilderness areas or inventoried roadless area within each elevation class (%)
Alaska					
0000-1000	8,109	17	36	20	73
1001-2000	5,278	22	39	25	87
2001-3000	3,376	24	45	26	95
3001-4000	2,499	24	48	25	97
4001-5000	1,518	20	54	24	97
5001-6000	587	15	56	27	98
6001-7000	170	11	69	18	98
7001-8000	63	10	78	11	99
8001-9000	35	4	95	1	99
>9000	30	3	95	0	98
Eastern U.S.					
0000-1000	19,431	1	+[b]	2	3
1001-2000	18,219	2	1	8	10
2001-3000	5,251	6	5	5	16
3001-4000	2,466	8	6	8	22
4001-5000	441	11	4	11	26
5001-6000	53	16	4	23	42
>6000	3	26	10	7	44
Western U.S.					
0000-1000	1,214	2	5	4	11
1001-2000	3,440	7	7	8	22
2001-3000	11,497	9	5	8	22
3001-4000	15,503	9	7	10	25
4001-5000	24,804	9	6	10	25
5001-6000	24,577	12	8	15	34
6001-7000	25,484	20	10	17	46
7001-8000	24,197	28	10	16	53
8001-9000	18,079	30	9	18	57
>9000	21,923	23	9	36	68

[a] Private inholdings not subtracted from acreage.
[b] Represents values greater than 0% but less than 0.5%.
(Roadless Database 2000)

conserved in inventoried roadless areas, particularly in areas large enough to offer a shifting mosaic of habitat patches in various stages of recovery from disturbance (Noss and Cooperrider 1994). For example, in comparing the distribution of inventoried

roadless areas with centers of biodiversity identified in the Interior Columbia Basin Ecosystem Management Project (ICBEMP) (Quigley and Arbelbide 1997a), these areas cover approximately 21% (1,650,000 acres) of the identified acreage in centers of biodiversity for animals. In addition, almost 10% (2,780,000 acres) of the acreage identified in the ICBEMP as centers of endemism for animals is contained in inventoried roadless areas.

Habitat in these areas is likely to be less fragmented from human activities and more likely to be better connected than in roaded areas of similar size. This is important to a number of species, as the following examples illustrate:

- Fisher, marten, and lynx populations have been negatively affected by habitat fragmentation and loss of connectivity due to timber harvest (Ruggiero and others 1994) and **roads** in forested areas (USDI Fish and Wildlife Service 1998b).
- Hargis and others (1999) documented an adverse response by American martens even to low levels of habitat fragmentation in the Uinta Mountains and determined that martens also respond negatively to increased size and proximity of open areas such as clearcuts.
- Analyses done in the northern Rocky Mountains illustrate the value of inventoried roadless areas in supporting connectivity between large core areas of quality habitat for grizzly bear, mountain lion, and elk, and in providing important contributions of core habitat (American Wildlands, 2000). Figure 3-29 illustrates the contribution made by inventoried roadless areas in providing important grizzly bear habitat.
- Smaller habitat patch size and loss of interior forest habitat has adverse effects on numerous species dependent on such habitat including some neotropical migratory bird species such as the cerulean warbler, hooded warbler, and wood thrush (Southern Appalachian Man and the Biosphere 1996a).

Inventoried roadless areas may provide important habitat to species that are sensitive to human disturbance. Such disturbance can disrupt species migration, reproduction, and rearing of young, and can increase physiological stress. The importance of this type of habitat has been identified in a number of studies:

- Isolated forest habitat has been shown to be essential for wolverine presence (Ruggiero and others 1994).
- In some areas, large mammals, such as elk, bighorn sheep, grizzly bear and wolf, exhibit strong road avoidance (Trombulak and Frissell 2000).
- The recovery plan for the grizzly bear acknowledges that increases in bear-human conflicts or adverse changes in the quality and security of habitat can affect population viability (USDI Fish and Wildlife Service 1993).
- Remoteness from human activity is a key characteristic of black bear habitat (Southern Appalachian Man and the Biosphere 1996c).
- In selection of nest sites, some bird species, including bald eagles, golden eagles, and sandhill cranes, may avoid areas close to roads (Anthony and Isaacs 1989; Fernandez 1993; Norling and others 1992).

It has become increasingly apparent that in certain parts of the country some types of past timber harvest, combined with the effectiveness of wildland fire suppression over the past century, have caused significant ecological shifts in vegetation composition and structure.

Fire regimes have become altered in some vegetation types because of increasing fuel loads and flammability. These changes in vegetation have resulted in habitat losses for species using open old growth and early seral stages such as the flammulated owl and northern goshawk (Smith 2000). Conversely, multi-storied, late-successional forested habitats preferred by species such as the northern spotted owl, pileated woodpecker, and American marten, have been enhanced in some areas.

Response activities for fire suppression in inventoried roadless areas have likely been more limited in the past, due in part to a lower priority being placed on rapid suppression of fires in these areas, relative to fires in roaded and more developed areas. Many of these areas have also had lower levels of commodity timber harvest, which can remove larger and more fire resistant trees, leaving smaller diameter, less fire resistant stems. Stand conditions within these areas may lie within or closer to the historic range of variability, and they may have more normal levels of fuel loading and stand composition and structure. The precise condition of these areas relative to risk of uncharacteristic wildland fire effects has not been determined, but estimates made indicated that approximately 8 million acres, or 14%, of inventoried roadless areas in all fire regimes may be at high risk of uncharacteristic wildfire effects. This compares to an estimate of 38 million acres or 20% of all NFS lands estimated to be at high risk. Further discussion relative to regional levels of risk can be found in the Fuel Management section in this chapter.

Many inventoried roadless areas include plant associations (for example Rocky Mountain lodgepole pine, spruce/fir/whitebark pine and true fir/hemlock) where long fire intervals (70 to 400 years) and stand-replacement fires are consistent with the historic range of variability. In many cases, these are associated with upper elevation fire regimes that encompass a significant amount of inventoried roadless areas. For example, in the western United States 32% and 39% of inventoried roadless areas are > 9,000 feet and 8000-9000 feet in elevation respectively. As exemplified by the 1988 Yellowstone fires, both uniform stand-replacing fire events and mosaic mixed severity fire events are possible in these areas.

For many terrestrial ecosystems, fire has played an important role in creating and maintaining suitable habitat at varying temporal and spatial scales. Many species evolved under the influence of recurrent fire, including stand replacing events, and their long-term persistence relies heavily on the maintenance of important habitat components by these disturbance events. For example, wildland fires that create habitat mosaics can improve foraging habitat for lynx (USDA Forest Service and others 2000a), wild turkey, black bear, elk, and northern goshawk (Smith 2000).

Alternative 1 - No Action

Approximately 40% of the 58.5 million acres of inventoried roadless areas are covered by land management-plan prescriptions that currently prohibit road construction and reconstruction, while the other 60% does not. Projecting future roaded entry using historic levels of road construction, an additional 5% to 10% of inventoried roadless areas are likely to be entered within the next 20 years under Alternative 1. If this rate of entry continues, over the next century, this could equal 50% of inventoried roadless areas being

affected by roaded entry. The actual amount, however, would probably be much lower due to rugged terrain in many of these areas, and public controversy over entry into inventoried roadless areas.

An estimated 1,160 miles of permanent and temporary road construction or reconstruction is planned through 2004. Table 3-32 displays total planned offer volumes and miles of road construction and reconstruction through 2004, by alternative, both with and without the Tongass exemption. Timber harvest under this alternative would occur on an estimated 18,000 acres of inventoried roadless areas per year initially, dropping to about 14,000 acres annually in the long term.

The type and extent of impacts to terrestrial species and habitats from this road construction would depend on road location and design, mitigation measures applied, the activities that are enabled, the amount and kinds of other activities occurring in adjacent areas, current condition of species populations, and the kinds and intensities of natural and human-induced disturbances in the area. With application of current design standards and best management practices, the effects of these kinds of activities have been mitigated or avoided in many situations. Some effects, however, cannot be mitigated, such as increased levels of habitat fragmentation.

Table 3-32. Total planned timber offer and miles of road construction and reconstruction for all activities through 2004, by alternative.

	Total planned offer (MMBF [a])		Total miles road construction/reconstruction	
Alternative	With Tongass National Forest exemption	Without Tongass National Forest exemption	With Tongass National Forest exemption	Without Tongass National Forest exemption
1	1,100	1,100	1,160	1,160
2	840	300	597	293
3	700	160	597	293
4	0	0	597	293

[a] Million board feet

Some of the potential direct and indirect adverse effects of road construction and timber harvest include:

- Increased fragmentation and loss of connectivity,
- Adverse edge effects for some species,
- Habitat loss, and losses of habitat suitability and effectiveness for some species,
- Increased risk of introduction and establishment of nonnative invasive species, and
- Increased potential for negative interactions with humans and illegal collection or over harvest of some species.

Some of the potential beneficial effects of road construction and timber harvest include:

- Enhanced access for some plant and wildlife management activities (for example, census survey and collection, and structure maintenance),

- Easier access for habitat restoration and enhancement for some species through stand manipulation,
- Creation of edge habitat and early successional habitat used by some species, and
- Easier access for hunting and wildlife viewing activities.

Almost all roads present some level of benefits and risks. These effects can vary greatly in degree (USDA Forest Service 2000h), and can shift over time. Some effects are immediately apparent, but others may require external events, such as a large storm, to become visible. Still other effects may be subtle, such as increased susceptibility to invasion by nonnative species or pathogens noticed only when they become widespread in the landscape, or with increased road use as recreation styles and motor vehicles change (USDA Forest Service 2000h). A road-related beneficial effect for one species, may, in fact, represent an adverse effect for another. For example, although forest edges, such as those created by road construction and timber harvest, may benefit some species, such as deer and bobwhite quail, they also provide access to interior forest patches for opportunistic or predator species (Norse and others 1986).

Beneficial effects to terrestrial species from timber harvest activities are often due to creating or maintaining some specific habitat condition. Timber harvest creates forest age-class diversity and mosaic habitats used by some species (Wisdom and others 2000; USDA and others 2000; Southern Appalachian Man and the Biosphere 1996c; USDA Forest Service 1995a; USDI Fish and Wildlife Service 1990; USDI Fish and Wildlife Service 1976). Some species require early seral or open-forest habitats that can be created and maintained by properly planned, restorative timber harvest. Timber harvest activities may also reduce the risk of uncharacteristic large stand-replacing insect and disease outbreaks and severe wildland fires. These disturbance events, can present both benefits and risks to some species (Wisdom and others 2000; USDI Fish and Wildlife Service 1995a; USDA and others 1993), at least at a local level. Some examples of timber harvest potential beneficial effects include the following:

- Timber harvest can be used to benefit species like the red-cockaded woodpecker (USDA Forest Service 1995a), Florida scrub jay (USDI Fish and Wildlife Service 1990), and Kirtland's warbler (USDI Fish and Wildlife Service 1976) by creating and maintaining open forest or early seral conditions.
- The Mexican spotted owl may benefit from timber harvest activities that maintain and develop large old-growth pine habitats, and alleviate risk from wildland fire, insects, and disease (USDI Fish and Wildlife Service 1995a).
- The snowshoe hare, a primary lynx prey species, can benefit from properly planned regeneration harvests (USDA Forest Service and others 2000).
- Reynolds and others (1991) suggest that active management activities like tree thinning may be beneficial in producing and maintaining the desired conditions for sustaining goshawks and their prey species.

Fragmentation and Connectivity – Landscape fragmentation and loss of connectivity from road and timber harvest causes habitat loss, increases in edge effects, and increases in habitat isolation (British Columbia Ministry of Forest Research Program 1997). As described under the previous section on fragmentation, roads can increase forest fragmentation by breaking up large patches and converting interior forest into edge habitat (Reed and others 1996).

Forest fragmentation affects terrestrial species to different extents and at different scales. In studying fragmentation in Douglas fir forests in northwestern California, Rosenberg and Raphael (1986) found that species showing the most sensitivity to fragmentation included fisher, gray fox, spotted owl, and pileated woodpecker. As road construction, reconstruction, and timber harvest activities increase habitat fragmentation across large areas, populations of some species may become isolated into smaller groups, which increase the risk of local extirpations or extinctions (Noss and Cooperrider 1994). In examining the effects of road construction on wetland biodiversity, Findlay and Bourdages (2000) found increases in local extinction rates and decreases in re-colonization rates, with effects sometimes taking decades to be apparent.
Roads can fragment habitat for some invertebrates, particularly for less mobile, ground dwelling species. In the Klamath-Siskiyou province, researchers have identified habitat fragmentation for common land snails caused by roads and other land-disturbing activities (Frest personal communication). Reasons cited included microclimate changes on the road surface, loss of habitat complexity and structure, effective width of roads greater than actual width, and avoidance of exhaust residues, petroleum products, and other chemicals. Baur and Baur (1990) documented similar road avoidance findings for the land snail *Arianta arbustorum*, which avoids crossing even small, unpaved roads. Timber harvest, particularly where associated with extensive ground disturbance and canopy removal, may have adverse effects on some invertebrate populations (Frest 1993; Frest and Johannes 1995).

Edge Effects – Roads create environmental edges whose effects may extend well beyond the actual road. Loss of canopy along road corridors may result in greater temperature extremes, more exposure to winds, more direct sunlight within adjacent zones, and changes in relative humidity (Chen and others 1996; Chen and others 1993). The distance that this effect may extend is highly variable. The zone of disturbance related to road noise is estimated to be as great as one-half mile in forested areas (Forman and Deblinger 2000). Haskell (2000) found a large drop in abundance and diversity of macro invertebrate soil fauna close to NFS roads, with effects extending up to 100 meters into the forest.

Forest edges, such as those created by timber harvest and road construction, may benefit some species, such as deer and bobwhite quail. The close proximity of cover and forage areas at forest edges provides ideal habitat for many game species (see Game Species). However, edges also provide access to interior forest patches for opportunistic species, such as the brown-headed cowbird, with effects extending into forest interiors as far as 600 meters from an edge (Norse and others 1986). Cowbirds are implicated in the decline of certain songbirds in the Sierra Nevada, including the willow flycatcher, least Bell's vireo, yellow warbler, chipping sparrow, and song sparrow (Sierra Nevada Ecosystem Project 1996).

Habitat Suitability and Effectiveness – For some mammals, open road density has been shown to be indicative of habitat suitability, with increases in road density related to declines in habitat effectiveness and population viability (Noss and Cooperrider 1994). Some research has shown that the presence of a few large areas with low road density, even when found within an area with an overall high road density, is a key indicator of

suitable habitat for large vertebrates (Rudis 1995). Unroaded areas may provide important security habitat for some species year round. Black bear population size was shown to be negatively associated with road density in the Adirondack Mountains (USDA Forest Service 2000h). Road density is a major determining factor for suitability of habitat for grizzly bear, a species with a home range size of 50 to 300 square miles for females and 200 to 500 square miles for males (USDI Fish and Wildlife Service 1993).

With an expected increase in roaded access into these areas, a corresponding increase in human disturbance is expected. Potential for harassment, disruption, and poaching of some species would increase. Species, such as forest carnivores, that require sites free from human disturbance are likely to be adversely affected. Habitat effectiveness for deer and elk has been shown to decrease with increases in open road density in some areas (Thomas and others 1979). Rowland and others, (in press) found that female elk in the Starkey Experimental Forest consistently used areas away from open roads in spring and summer, and that spatial distribution and distance to roads were more accurate predictors of habitat effectiveness than overall road density.

In their proposal to list the Canada lynx under the ESA, the U.S. Fish and Wildlife Service (USDI Fish and Wildlife Service 1998b) found that this species is threatened by human alteration of forests and by increased levels of human access into lynx habitats. Factors identified as threats to this species included timber management, forest and **backcountry** roads and trails, fragmentation and degradation of lynx **refugia**, and habitat degradation by nonnative invasive plant species. The lynx was listed as threatened on March 24, 2000.

In evaluating species-road relationships for 91 vertebrate species in the Interior Columbia River Basin, Wisdom and others (2000) found that more than 70% of those species could be negatively affected by one or more factors associated with roads. They concluded, from their review of scientific literature, that there are numerous potential adverse effects related to road construction and use. Some of their findings include:

- Road construction converts large areas of habitat to nonhabitat (Hann and others 1997; Reed and others 1996).
- Loss of large trees, snags, and logs in areas adjacent to roads through commercial harvest or firewood cutting has adverse effects on cavity dependent birds and mammals (Hann and others 1997).
- Roads facilitate poaching (Cole and others 1997) of many large mammals such as caribou, pronghorn, mountain goat, bighorn sheep, wolf, and grizzly bear (Dood and others 1985; Knight and others 1988; McLellan and Shackleton 1988; Mech 1970; Stelfox 1971; Yoakum 1978).
- Roads provide access for chronic, negative interactions of humans with wolves and grizzly bears (Mace and others 1996; Mattson and others 1992; Thiel 1985), which increases mortality of both species and often causes high-quality habitats near roads to serve as population sinks (Mattson and others 1996; Mech 1973).
- Reptiles seek roads for thermal cooling and heating and experience substantial mortality from motorized vehicles (Vestjens 1973). Roads facilitate human access into habitats for collection and killing of reptiles.

- Many species are sensitive to harassment or human presence during particular seasons, with potential reductions in productivity, increases in energy expenditures, or displacements in population distribution or habitat use (Bennett 1991; Mader 1984).
- Roads often restrict the movements of small mammals (Mader 1984; Merriam and others 1988; Swihart and Slade 1984) and function as barriers to population dispersal (Oxley and Fenton 1974).

Trombulak and Frissell (2000) drew similar conclusions in their review of scientific literature on the ecological effects of roads. They identified seven general, potential effects of roads: mortality related to construction, mortality from being hit by vehicles, behavioral modifications, changes in the physical environment, changes in the chemical environment, introduction and establishment of nonnative species, and increased human use of roaded areas. They concluded that, although not all species and ecosystems are affected to the same degree by roads, in general, the presence of roads in an area is associated with negative effects for both terrestrial and aquatic ecosystems. These effects included detrimental changes in species distribution, composition, and population size.

Although only used for relatively short periods, temporary roads present most of the same risks posed by permanent roads, although some may be of shorter duration. Many of these roads are designed to lower standards than permanent roads, are typically not maintained to the same standards, and are associated with additional ground disturbance during their removal. Also, use of temporary roads in an area to support timber harvest or other activities often involves construction of multiple roads over time, providing a more continuous disturbance to the area than a single, well-designed, maintained, and use-regulated road. While temporary roads may be used for periods ranging up to ten years, and are then decommissioned, their short- and long-term effects can be extensive to terrestrial species and habitats.

In addition to posing many of the same risks as road construction, road reconstruction could result in substantial changes in the kinds and amount of human uses in an area. Improvements such as realignment or improving road surfacing or gradient to provide easy access for low clearance vehicles may promote increases in the amount of human disturbances and disruptions to species and habitats, exceeding those previously experienced before reconstruction.

Early Successional Habitat – Although early successional habitat is well represented in many parts of the country, questions have been raised in some areas relative to the potential effects of the road and timber harvest prohibitions on the availability of this type of habitat, particularly in the Eastern and Southern Forest Service regions. Early successional communities are characterized and shaped by differences in structure, composition, and successional pathways. Such communities can include grasslands, shrublands, semi-forested habitat, and open land communities within larger forest patches.

Types of disturbance affecting the development, availability, and distribution of some early successional habitat include natural processes and events such as fire, wind, insect and disease, and management-induced disturbance associated with land use practices,

such as timber harvest, road construction, and prescribed fire (USDA Forest Service 1999e; Southern Appalachian Man and the Biosphere 1996c). When human-induced disturbances reset the successional clock to an earlier stage, they frequently affect larger areas and result in increased mean patch size, with adverse effects on habitat suitability for many species (Verner 1986). Natural disturbances, such as wildland fires, can also affect large areas of land and modify habitat suitability. In many cases, wildland fires blend into larger landscapes, and the adverse impacts are less severe or negligible.

In the United States, the abundance and distribution of many early-successional species before European settlement is unknown. It is estimated that by 1820 in New England, less than 25% of the original forest was left on land that was suitable for agriculture. By the middle of the 19th Century, New England was experiencing wood shortages. This sizeable increase in early successional habitat was likely followed by corresponding increases of populations and distributions of species using such habitat. As forested habitats have become reestablished in this century in some areas, there has been a corresponding decline in some species directly or indirectly dependent on early successional habitat. For example, as forest cover increased in New Hampshire by 40% between 1880 and 1980, New England cottontail populations decreased from a continuous distribution throughout 60% of the State, to a fragmented distribution covering less than 20%; bobcat populations were affected by this decrease in available prey (Trani-Griep 1999; Martin 1999).

Information in the Southern Appalachian Assessment (Southern Appalachian Man and the Biosphere 1996c) indicates that as of 1995, NFS **timberlands** within the approximately 37 million acre assessment area provided about 11% of the habitat in the grass/seedling/shrub successional stage. Non-industrial private lands at that time provided approximately 69% of this stage. Examples of species within the Southern Appalachian Assessment area using early successional habitat include bobwhite quail, ruffed grouse, Bachman's sparrow, and prairie warbler. The Southern Appalachian Assessment identified no T&E species that were principally associated with early successional habitat in the assessment area. A comparison of the habitat information from the Southern Appalachian Assessment with the distribution of inventoried roadless areas shows that less than .09% (approximately 1,380 acres out of 1,570,000 acres) of early successional grass shrub habitat are currently provided by inventoried roadless areas in the assessment area.

Game species – These species are wild animals that people hunt or fish for food or recreation according to prescribed seasons and limits (USDA Forest Service 1999u; USDA Forest Service and USDI Bureau of Land Mangement 2000). They are generally described in terms of either big game (including white-tailed deer, mule deer, elk, bear, wild boar, and turkey) or small game (including ruffed grouse, blue grouse, hare, cottontail rabbits, gray squirrel and quail).

Game species are generally associated with mixed habitat mosaics or patterns that include a variety of habitat types and age classes. In forested areas, early seral patches, natural openings, and open woodlands are important habitat components. Many game species are habitat generalists (for example deer, elk and ruffed grouse,) using a variety of habitats

and therefore, cannot be easily associated with a single habitat type (Southern Appalachian Man and the Biosphere 1996c).

In many areas of the United States, NFS lands, including inventoried roadless areas, are a significant source of high quality game species habitat, given the influences of private land conversions, including urbanization, agriculture, and development. In some cases, NFS lands are strongholds for some game species. For example, black bear populations are increasing in some areas of the Eastern United States in part because of security within NFS lands (Vaughan and Pelton 1995). Lands outside of inventoried roadless areas have important influences on game species populations. As an example, deer and elk winter ranges on many non-NFS lands are critical in maintaining stable populations.

The public interest in providing and maintaining game species habitat on NFS lands is evidenced by the various program initiatives that focus on these species. The Forest Service has partnered with a number of organizations (for example Wild Turkey Federation, Rocky Mountain Elk Foundation, Quail Unlimited) to implement wildlife program initiatives such as: “Answer the Call,” “Elk Country”, “Dancers in the Forest”, “A Million Bucks”, and “Making Tracks.” These initiatives have resulted in substantial amounts of game species-habitat improvement, including the creation and maintenance of early seral habitats in some areas.

A number of factors can influence game populations. For example, State harvest strategies and regulations are an important management tool for achieving desired population levels, especially in big game management (Flather and others 1999). In addition, other factors like predation and disease can influence some game species populations. In recent years, game species population trends have varied, with some species exhibiting declines, while others have increased or remained stable (Flather and others 1999). It is reasonable to assume that many of these game species-population trends are substantially influenced by changes in their habitat.

Flather and others (1999) in *Wildlife Resource Trends in the United States* concluded that a nation-wide (but most evident in the 20 northern States) decrease in species that are associated with early seral stages (and grasslands) could be expected in the next 20 years. However, this conclusion is not necessarily indicative of what would happen to game species populations. In fact, Flather and others (1999) predict that many game species populations are expected to remain relatively stable to the year 2045 (the 50 year outer benchmark for their long-term population projections), including black bear, wild turkey, pronghorn, and deer. Elk are expected to decrease slightly after recent population increases and range expansion (Flather and others 1999). Many small game species like ruffed grouse and bobwhite quail appear to be declining in some parts of the country (USDA Forest Service 1999u; Southern Appalachian Man and the Biosphere 1996c). These declines in part may be due to reductions in the amount of early seral and shrub dominated sites.

Roads can serve a number of purposes relative to game management. They can provide access for timber harvest activities that can improve or enhance game species habitats. Some roads provide access for other kinds of game species-habitat improvements,

including, construction and maintenance of water developments (for example guzzlers, ponds and spring boxes). In addition, roads are often used to facilitate the maintenance of natural and created openings.

Timber harvest activities can fundamentally change the composition and configuration of game species habitats. These changes can alter and modify animal behavior, causing changes in population numbers and distribution. Whether the impacts are adverse or beneficial depends on species needs, and the extent, duration, timing and intensity of timber harvest activities and associated roads.

Timber harvest activities that create, restore, and maintain a mixture of habitats and a variety of age classes are generally beneficial to most game species. Thus, timber harvest activities can be designed to meet specific game species habitat needs, and have positive impacts (Brown 1985; Hoover and Wills 1984; Thomas 1979). For example, timber harvest designs that create and maintain edge, early seral patches, natural openings, and open woodland habitats, are beneficial for most game species (Southern Appalachian Man and the Biosphere 1996c; USDA 1999u; Flather and others 1999; USDA Forest Service and USDI Bureau of Land Management 2000). In some managed forest areas, deer and elk populations have benefited from improved forage conditions created by some timber harvest activities (USDA Forest Service and USDI Bureau of Land Management 2000). Turkey (Dickson 1992), forest grouse, and quail have benefited from openings and saplings created by some timber management activities. Generally, timber harvest activities in combination with access management strategies that reduce road densities are more effective at providing high quality game species habitats.

Conversely, when timber activities are poorly placed on the landscape, and road densities are not managed, game populations can decline due to poaching, concentrated legal hunting (USDA Forest Service 1999p), reduced habitat quality or habitat loss (Brown 1985; Hoover and Wills 1984; Thomas 1979). There is evidence that inventoried roadless areas are important security areas and linkages for some game species.

Late Successional Habitat – Inventoried roadless areas encompass a variety of cover types and age classes, including late successional habitats. Late successional or old-growth forest has been defined as forest stands that are greater than 100 years old (Southern Appalachian Man and the Biosphere 1996c; USDA 1999u). They are also defined as the later stages of stand development with large trees, large-size dead trees standing and on the ground, multiple canopy layers, canopy gaps and decadence in the form of broken or deformed tree tops, boles and root decays (USDA Forest Service and USDI Bureau of Land Management 2000). Forest Ecosystem Management Assessment Team 1993 defined late successional habitats as “forests older than 80 years.” Some late successional habitats have developed with frequent disturbances (such as fires) resulting in large tree single story structure.

Various efforts at defining and delineating late successional habitats have occurred for NFS lands. For example, the Forest Ecosystem Management Assessment Team (USDA and others 1993) estimated that approximately 4.5 million acres of medium/large multistoried conifer late successional habitat occurred within the 57 million acre range of the northern spotted owl. The Southern Appalachian Assessment (Southern Appalachian

Man and the Biosphere 1996c) estimated that approximately 1.1 million acres of late successional habitat occurred in the assessment area in 1995. Some late successional habitats are considered critically endangered, such as Eastern deciduous and Western ponderosa pine forests (Noss and others 1994).

Much of the late successional habitat remaining on NFS lands is highly fragmented and poorly connected because of past management activities and natural disturbances. Late successional habitats associated with inventoried roadless areas are often better connected than those found in roaded areas, and are often linked to larger intact forests in Wilderness and other protected areas. This connectivity provides benefits for a number of late successional associated species such as the northern spotted owl, marbled murrelet, fisher, white-headed woodpecker, and American marten.

Timber harvest to improve late successional habitat could be implemented under Alternatives 2 and 3. Alternative 4 prohibits timber harvest activities, but provides an exception for timber harvest activities needed for the protection or recovery of T&E species. In addition, prescribed fire continues to be an acceptable management tool for maintaining some single-storied late successional habitats.

Summary of Effects – Relative to Alternatives 2, 3, and 4, the No Action Alternative would result in a greater likelihood of measurable losses of habitat quality and quantity in inventoried roadless areas. Assuming that roaded entry and timber harvest would continue in these areas at rates approximating that occurring in the past 20 years and given the risks associated with timber harvest and other road-dependent activities, the No Action Alternative would have the greatest potential for adverse effects to some species and to overall biodiversity,

Mitigation measures offsetting some adverse effects would undoubtedly be identified as part of site-specific NEPA decisions and ESA consultations. However, some adverse effect, such as increased habitat fragmentation and loss of connectivity, cannot be effectively mitigated.

Alternative 2

With a prohibition on road construction and reconstruction in inventoried roadless areas, the potential for increased levels of human-caused disturbance and degradation of terrestrial habitat quality, quantity and distribution would be substantially reduced relative to Alternative 1, particularly in those inventoried roadless areas currently open to road construction. A description of the potential adverse effects of road construction is provided under Alternative 1. This alternative does not prohibit any type of timber harvest, but the overall level of timber harvest would be reduced by a prohibition on road construction and reconstruction.

Alternative 2 would offer a greater degree of assurance than Alternative 1 that current biodiversity would be maintained. Based on estimates provided by each national forest, there would be approximately a 75% reduction in the total miles of road that would be constructed or reconstructed in inventoried roadless areas through 2004 under

Alternatives 2, 3, and 4. Under the exceptions common to all action alternatives (as described in Chapter 2), approximately 300 miles of road would be constructed or reconstructed. See Table 3-32 for a comparison of planned timber offer volume and miles of road construction and reconstruction by alternative both with and without the Tongass National Forest exemption.

Even though there could continue to be stewardship and commodity-purpose timber-harvest activities in inventoried roadless areas, information collected from the forests indicates that much of the timber harvest currently planned in these areas would require road construction and reconstruction and hence, would not occur under this alternative, as shown in Table 3-32. The remaining timber harvest in inventoried roadless areas would potentially occur on an estimated 8,000 acres per year, dropping to half that level in the long term. Approximately 2.8 million acres of inventoried roadless areas have had classified roads constructed since the time of inventory, under land management plan prescriptions that allowed road construction. In addition, in some areas, one or more roads were present at the time of inventory. Prohibiting further road construction in these areas would provide some level of benefits to the overall area, by avoiding the additional risks inherent with new road construction or reconstruction, such as additional landscape fragmentation and loss of connectivity, increased levels of human activities, and nonnative species introductions.

Wildlife management activities that are not dependent on new or reconstructed road access would be feasible under this alternative. Information submitted by each national forest on terrestrial wildlife projects that would potentially be precluded if road construction and reconstruction were prohibited in inventoried roadless areas indicates that, within the next 5 years, seven projects are planned nationwide that, as currently designed, could not be implemented. Almost 15 miles of road construction or reconstruction would be associated with these projects. Types of projects identified include thinning and fuels management in late successional reserves, aspen regeneration, other stewardship timber harvest for habitat improvement, and prescribed fire. It is likely that at least some of these projects could be redesigned so that they could proceed without road construction or reconstruction in inventoried roadless areas.

Nationally, the average number of wildlife projects precluded per year by this alternative is less than 2, which is estimated to be substantially less than 1% of the overall national program, based on the 1999 Wildlife, Fish and Rare Plants reporting system database (USDA Forest Service 2000d). It appears that few roads are built into inventoried roadless areas to support wildlife management activities. As a result, this alternative would not limit the current overall ability of the Agency to manage wildlife habitat in inventoried roadless areas, including the ability to maintain or enhance early or late successional habitat or create and maintain mixed habitat mosaics where such need is demonstrated or to implement other stewardship-timber harvest activities.

The prohibition on road construction and reconstruction under Alternative 2 would have a negligible effect on management of game species and their habitats. While this alternative would prohibit new roads, it would not affect existing transportation systems. Existing access for wildlife management activities would not be affected. The current

capabilities and tools to design and implement habitat-improvement methods and techniques would be retained under Alternative 2, although alternative means of access may be needed for implementation. In addition, other timber harvest projects planned and implemented in inventoried roadless areas, but not necessarily driven by game species objectives (for example threatened, endangered, and proposed (TEP) species objectives, forest health or fuels management objectives) may also benefit some game species.

Summary of Effects – The prohibition on road construction and reconstruction would avoid many of the potential adverse affects of roads to terrestrial animal species and habitats, as described under Alternative 1. This includes habitat loss and fragmentation, negative edge effects, increased fire risk, access for poaching, increased potential for excessive hunting pressure, harassment and disturbance, movement barriers, displacement or avoidance behavior, increased potential for establishment of nonnative invasive species, and greater risk of chronic negative interactions with people (Wisdom and others 2000; USDA Forest Service 2000h). No adverse effects to terrestrial animal species and habitats would be expected, as this alternative does not directly authorize any ground disturbing activities, nor does it preclude any activities essential for management of these species or their habitats by this Agency or other government agencies with jurisdictional responsibilities. Overall, beneficial effects to conservation of biological diversity would be expected.

Alternative 3

By prohibiting road construction and reconstruction and non-stewardship timber harvest, Alternative 3 would provide a greater likelihood that terrestrial habitats, species, and their associated plant and animal communities, would be maintained at current levels, relative to Alternative 1. A description of the potential adverse effects of road construction and timber harvest is provided under Alternative 1. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative. An estimated 4,400 acres per year would be harvested under this alternative, dropping to about 1,300 acres per year in the long term.

Relative to Alternative 2, the additional prohibition of non-stewardship timber harvest would further reduce the potential for adverse effects to species and habitats. Over time, this additional prohibition could provide important cumulative beneficial effects relative to conservation of terrestrial species and habitats, beyond those described under Alternative 2.

By retaining the ability to harvest timber for stewardship purposes, the Agency's capability to enhance habitat directly and indirectly would be maintained, making this alternative potentially somewhat more ecologically beneficial compared to Alternative 4. Timber harvest for stewardship purposes is described in the Timber Sale Program Information Reporting System as " . . . sales being made primarily to help achieve desired ecological conditions and/or to attain some non-timber resource objective that requires manipulating the existing vegetation – for example, improving forest health or reducing forest fuels" (USDA Forest Service 1998b). Projects where the primary objective would be restoring wildlife habitat would be included in this category. This could potentially

have beneficial effects for some species on a site-specific basis. An example of stewardship timber harvest beneficial to a species would be mid-story vegetation removal for enhancement of foraging habitat for red-cockaded woodpecker (USDA Forest Service 1995a).

Summary of Effects – This alternative would not affect the current overall ability of the Agency to manage wildlife habitat including the ability to maintain or enhance early or late successional habitat, create, or maintain mixed habitat patches, where such need is demonstrated. No adverse environmental effects to terrestrial species would be expected from this alternative, as it would not directly authorize any ground-disturbing activities, nor would it preclude activities essential for management of these species, and their habitats, by this or other government agencies with jurisdictional responsibility. The overall ability of the Agency to implement management actions for conservation of terrestrial animal communities would not be affected.

Alternative 4

This alternative would prohibit road construction, reconstruction, and all timber harvest except for that needed for protection or recovery of TEP species. Alternative 4 would provide a greater likelihood that terrestrial habitats, species and their associated communities, would be maintained at current levels, relative to Alternative 1. A description of the potential adverse effects of road construction and timber harvest that could be avoided is provided under Alternative 1. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative.

Overall, the current need for timber harvest specifically to manage terrestrial wildlife habitat within inventoried roadless area appears to be minimal. In fiscal year 1997, approximately 15% of the total **volume harvested** for stewardship purposes on all NFS lands was for wildlife or TEP species habitat management objectives (USDA Forest Service 1998b). The current national capability of the Agency to manage such habitat would not be measurably affected by a prohibition on timber harvest. Alternative 4 does not preclude use of other restorative tools like prescribed fire, which under some conditions can be used without prior timber removal, to benefit early seral and open forest species.

Timber Harvest to Reduce Fuels – Timber harvest to reduce fuel loading may be desirable in some areas where there is an abnormally high risk of high intensity, large-scale fires. Uncertainties about the magnitude and extent of beneficial effects of such activities have to be carefully weighed against the well-documented risks of adverse effects associated with timber harvest and associated road construction. Even though some timber harvest activities are intended to mimic the effects of natural disturbance processes such as fire, there is little known about the long term ecological legacies of such treatments. It is not clear how those legacies would compare to areas where natural disturbance processes have played a more dominant role in controlling successional pathways, landscape mosaics, and ecosystem composition. Analysis conducted by the fire specialist on the FEIS team showed minimal landscape level differences between

Alternatives 2 through 4 and Alternative 1, relative to the likelihood of timber harvest providing significant reductions in the risk of uncharacteristic wildfire effects in inventoried roadless areas.

Regardless of the alternative selected, wildland fires will continue to play a dominant role in shaping terrestrial species habitats in many areas, including many fires that are of a much higher intensity and greater size than those historically occurring within an area. Many terrestrial and aquatic species evolved under the influence of recurrent fire, including stand-replacing events, and their long-term persistence relies heavily on the maintenance of important habitat components by these disturbance events. While wildland fires may negatively affect individuals of some species, the overall effects on species populations are less likely to be adverse in nature.

Game Species – The prohibition of timber harvest would probably have limited local impacts on the ability of the Agency to actively manage for the mixed pattern habitats used by game species, although other tools, such as prescribed fire, would continue to be feasible in many areas. Natural disturbances are likely to continue creating and maintaining mixed pattern habitats in inventoried roadless areas for a number of game species.

The prohibitions on timber harvest are not likely to detrimentally impact mule deer, white-tailed deer, and elk populations. Elk populations have been increasing across the west and are expected to continue to increase for the next four decades. In the east, white-tailed deer density information for the Southern Appalachian Assessment (Southern Appalachian Man and the Biosphere 1996c) indicates that the highest densities of deer in the Southern Appalachian Assessment area are found in association with private croplands and agricultural lands. Because of poaching (USDA Forest Service in press), increased hunting pressure (Flather and others 1999), and continuing land use development in many areas, deer and elk populations may benefit from the security and isolation provided by inventoried roadless area protection.

Black bears are habitat generalists utilizing early seral patches, edge, and open forested habitats (Hoover and Wills 1984; Wisdom and others 2000; USDA Forest Service 1999u) in juxtaposition with mid to late seral-forested habitats. Black bears tend be absent for portions of the Southern Appalachians where large amounts of nonforested habitat and limited forested habitat occur. Dense forest cover and security areas, and remoteness provide protection from poaching and hunting and are a key habitat parameter (Southern Appalachian Man and the Biosphere 1996c).

Timber harvest prohibitions would likely benefit bear populations. In the east where poaching, intense hunting pressure and land development are threatening bear populations, one of the primary limiting factors for bears is availability of relatively undisturbed tracts of land habitats. The remaining large tracts of roadless area in the east are important strongholds for bear populations, and may help stabilize bear populations over the long term. In the West, bear populations are expected to remain stable in the Rocky Mountains and increase along the Pacific coast. Eliminating timber harvest and associated new road construction in inventoried roadless areas would avoid habitat

modifications and changes in animal behavior that can detrimentally impact large mammals like bears (USDA Forest Service 2000c; Fredrick 1991). While early seral habitats are important components of bear habitat, the security and isolation provided by inventoried roadless areas are likely more significant at maintaining stable bear populations than are the potential forage opportunities created by timber harvest activities.

Turkeys prefer habitat where openings are interspersed with mature forests (Dickson 1992; USDA Forest Service 1999u). The inventoried roadless areas likely have only a minor influence on changes in turkey populations in the Southern and Northeast regions. Only 6% (1.6 million out of almost 25 million acres) of NFS lands in Regions 8 and 9 are in inventoried roadless areas, therefore the management of areas outside of inventoried roadless areas would likely have the most significant impact on turkey populations. In addition, the prohibitions would likely maintain important security areas, and minimize potential increases in illegal hunting.

It is unlikely that a timber harvest prohibition on the 6% of NFS lands in inventoried roadless areas in Regions 8 and 9 would have an adverse impact on small game populations. The management of NFS and other lands outside of inventoried roadless area would likely have the most significant impact on these populations. Grouse populations have declined since the 1970s possibly due to regional decreases in the amount of sapling/pole seral stages, which grouse favor (Flather and others 1999; Southern Appalachian Man and the Biosphere 1996c; Hoover and Wills 1982; Wisdom and others 2000) or to a decline in winter range higher elevation coniferous forests. Some grouse populations would benefit from protection of upper elevation winter-range habitats. For ruffed grouse in the east, NFS lands provide a significant amount of habitat (Southern Appalachian Man and the Biosphere 1996c), but only about 6% of Region 8 and 9 NFS lands are in inventoried roadless areas.

Squirrel numbers show steady but slight gains in the North, declines in the Rocky Mountains, and declines since 1985 in the South. Gray squirrel populations in the Southern Appalachian Assessment area (1996c) have remained stable and have benefited from increased acorn production from maturation of oak forests. In the West, gray squirrels have declined as interior ponderosa pine and Oregon white oak habitats are converted to human uses (Wisdom and others 2000). Other small game species (e.g., sharp-tailed grouse, bobwhite quail and cottontail rabbits) are found in heavily fragmented forested habitats, but are more closely associated with rangelands, highly interspersed forests, and agricultural and/or croplands (Wisdom and others 2000; Klimstra and Roseberry 1975; Flather and others 1999); these species therefore are not likely to be impacted by the prohibitions.

Summary of Effects – By eliminating the ability to harvest timber for stewardship purposes except when needed for protection or recovery of TEP species, the current capability of the Agency to enhance habitat directly and indirectly would potentially be impaired at the stand level, but it is unlikely to have much impact at larger scales. This would hinder the Agency's ability to use timber harvest to manage for early successional or other structural stages in some areas, where such a need is identified, although prescribed fire is an effective tool under certain conditions. In fiscal year 1997,

approximately 15% of the total volume harvested for stewardship purposes on NFS lands was for wildlife or TEP species habitat-management objectives (USDA Forest Service 1998b). Although adverse effects associated with timber harvest would not occur, this limitation of the Agency's ability to manipulate stand structure and successional stage for habitat improvement would make this alternative potentially less ecologically beneficial compared to Alternative 3.

Aquatic Animal Habitat and Species

Affected Environment

Inventoried roadless areas support a diversity of aquatic habitats and communities, providing or affecting habitat for more than 280 TEPS species, and numerous other aquatic species. Without the disturbances caused by roads and the activities that they enable, stream channel characteristics are less likely to be adversely altered compared with stream channel conditions in roaded areas. Important characteristics that influence habitat quality for aquatic species include channel and floodplain configuration, amount of fine sediment in stream substrate, riparian condition, amount and distribution of woody debris, streamflow, water quality, and temperature regime (Furniss and others 1991). Smaller streams, such as many of those found in inventoried roadless areas, provide important habitat for resident and migratory aquatic species and also influence the quality of habitat in larger, downstream reaches (Chamberlin and others 1991).

Illegal introduction and harvest of aquatic species is less likely to occur in these areas due to lack of ready access. Poaching of large, migratory bull trout, a native char found in the Northwest, has been described as an important cause of mortality (Lee and others 1997). Illegal introduction of nonnative fish species has had measurable effects on native aquatic communities in many parts of the country. For example, the Sierra Nevada Ecosystem Project (SNEP) report (Moyle and others 1996) identified illegal introductions of predatory fish, such as northern pike and white bass, and other nonnative fish, as important causes of disruptions in native fish communities in Sierran waters.

The nonnative fish most commonly established through bait bucket introductions in Sierra Nevada waters was the golden shiner, a species able to survive in many high elevation lakes. Thirty species of nonnative fish have been introduced (both legally and illegally) or have invaded most waters in the Sierra Nevada Range. The SNEP determined that less than half of the 40 fish species native to those waters seem to have stable or expanding populations. Adverse effects to native species included hybridization, increased predation, and competition (Moyle and others 1996.)

Waters in inventoried roadless areas have been shown to function as biological strongholds and refuges for many fish species. The size of an area, kinds and intensity of management-induced and natural disturbances that have occurred, and the landscape context in which it is found, all affect the quality, distribution, and extent of these habitats. Some of these waters may now play a relatively much greater role in supporting aquatic species viability and biodiversity than in the past due to cumulative degradation and loss of other, potentially more biologically rich habitat within associated drainages.

The Nature Conservancy and the Association for Biodiversity Information identified the United States as a global center of freshwater biodiversity (Chaplin and others 2000). In examining the distribution of 307 fish species and 158 mussel species that are imperiled or vulnerable, they identified 87 watersheds as aquatic biodiversity hotspots, supporting 10 or more vulnerable or imperiled species. The majority of these watersheds are in the Southeastern United States, with one occurring west of the 100th meridian (Figure 1-1). Inventoried roadless areas are found within 29 of these watersheds, and likely play a role in supporting the continued survival of these species either directly through providing habitat or indirectly by contributing to water quality within the drainage.

Analysis done for the ICBEMP (Lee and others 1997) indicates that strong fish populations are often associated with areas of low road density. That analysis showed that increasing road densities (miles of road per square mile) and their attendant effects were associated with declines in the status of bull trout, westslope cutthroat trout, yellowstone cutthroat trout, and redband trout. Approximately 60% of unroaded or very low road density subwatersheds within the assessment area supported strong salmonid populations. In contrast, less than 25% of subwatersheds with moderate and 18% with high road densities supported strong populations (Quigley and others 1996).

As shown in Table 3-33, approximately 2 million acres of inventoried roadless areas contain high priority watersheds identified in the ICBEMP for conservation of threatened Snake River Chinook, with about half of those acres falling in inventoried roadless areas where road construction is not prohibited by current management direction. An additional 5 million acres of inventoried roadless areas contain identified priority watersheds[9] for conservation of bull trout and other species. Cumulatively, the data indicate that more than 30% of the acreage in designated priority and high priority watersheds for aquatic species are in inventoried roadless areas.

A substantial amount of inventoried roadless areas provide important habitat for Pacific anadromous fish species. Table 3-34 shows the acreage of inventoried roadless areas that lie within the habitat range of Pacific salmonids including those for chinook, chum, coho, and sockeye salmon, as well as steelhead and coastal cutthroat trout. This table also shows acreages of inventoried roadless areas specific to federally listed Pacific salmonids.

In considering the contributions of large unroaded areas for conservation of aquatic habitats and species, comparisons can be drawn from research in other areas lacking roads and with minimal levels of human disturbance. For example, in evaluating the role of Wilderness Areas in conserving aquatic biological integrity in Western Montana, Hitt and Frissell (1999) concluded that, although the presence of designated Wilderness does

[9] Priority Watersheds were identified in the ICBEMP (Quigley and Arbebide 1997a) as those important for conservation of bull trout (from the Inland Fish Strategy), or with potentially "critical habitat" for anadromous species not listed as threatened or endangered under the Endangered Species Act as of March 1996 (from PACFISH); or as watersheds containing high quality habitat but no listed species as of March 1996.

Table 3-33. Inventoried roadless areas (in thousand acres) in ICBEMP [a] priority and high-priority watersheds.

State	Inventoried roadless areas in ICBEMP priority watersheds	Inventoried roadless areas in ICBEMP high-priority watersheds
Idaho	2,952	1,937
Montana	1,527	Not Applicable
Nevada	10	Not Applicable
Oregon	429	92
Washington	174	45
Total	**5,092**	**2,074**

[a] Interior Columbia Basin Ecosystem Management Project
(Roadless Database 2000)

Table 3-34. Pacific anadromous fish habitat in inventoried roadless areas (in thousand acres).

Species	Inventoried roadless areas within the range of Pacific salmonids	Inventoried roadless areas within the range of threatened and endangered Pacific salmonids
Chinook Salmon	8,869	6,314
Chum Salmon	1,401	95
Coho Salmon	1,823	1,175
Sockeye Salmon	258	179
Steelhead	7,593	6,033
Coastal Cutthroat Trout	1,884	156

(National Marine Fisheries Service [NMFS]; Roadless Database 2000)

not guarantee aquatic biological integrity due to factors such as fish stocking practices and impacts from adjacent roads, "the importance of Wilderness in aquatic conservation is extraordinary." Their analysis showed that more than 65% of waters that were rated as having high aquatic biological integrity were found within subwatersheds containing Wilderness. They also concluded that, given the relative rarity of unprotected areas that support a relatively greater degree of aquatic biological integrity, undisturbed areas warrant permanent protection.

For many aquatic ecosystems, fire has played an important role in creating and maintaining suitable habitat at varying temporal and spatial scales. Many species evolved under the influence of recurrent fire, including stand-replacing events, and their long-term persistence relies heavily on the maintenance of important habitat components by these kinds of disturbance events. For example, fire-killed trees provide an important and continuing supply of large woody debris to many aquatic systems, an important habitat attribute essential for many salmonid and other aquatic species.

In certain parts of the country, some types of past timber harvest combined with the effectiveness of past wildland fire suppression over the past century, have caused

significant ecological shifts in vegetation composition and structure, resulting in altered fire regimes by increasing fuel loads and flammability. As discussed under the Terrestrial Habitats and Species section, response activities for fire suppression in inventoried roadless areas have likely been more limited in the past due to a lower priority placed on rapid suppression of fires in these areas, relative to fires in roaded and more developed areas. When this is considered in conjunction with the lower level of past timber harvest activities in many of these areas, it is likely that stand conditions within these areas may lie within or closer to the historic range of variability, with more normal levels of fuel loading and stand composition and structure, as compared to conditions within roaded and more heavily timbered areas.

Alternative 1 - No Action

Alternative 1 would have the greatest potential for additional aquatic habitat loss, degradation, and disturbance associated with roads, timber harvest, and other activities. Approximately 40% of the 58.5 million acres of inventoried roadless areas are covered by land-management plan prescriptions that currently prohibit road construction and reconstruction. Projecting future roaded entry using historic levels of road construction, an additional 5% to 10% of inventoried roadless areas are likely to be entered within the next 20 years under Alternative 1, predominantly in those areas currently open to road construction. The planned timber harvest offer of 1.1 BBF through 2004 would occur on approximately 90,000 acres. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction through 2004, both with and without the Tongass exemption, for each alternative.

Potential Effects from Roads – Road construction, maintenance, use, and even the presence of roads in a watershed, can have numerous adverse effects to aquatic systems and the species they support. Recent changes in road designs and application of best management practices have been effective in some instances at moderating or avoiding many adverse effects. The discussion in this section captures the principal effects that have been associated with roads, but these are potential effects, and not every road would necessarily exhibit each or even many of these effects. The Physical Resources section provides a full discussion of potential geomorphic and hydrologic effects of roads on watershed and stream channel conditions.

These effects can potentially include (Furniss and others 1991; USDA Forest Service 2000h):

- Increasing sediment loads in streams;
- Modifying watershed hydrology and stream flows;
- Altering stream channel morphology;
- Increasing habitat fragmentation and loss of connectivity;
- Degrading water quality, including increasing chance of chemical pollution;
- Altering water temperature regimes.

These physical alterations can potentially result in a variety of adverse effects to aquatic species including:

- Loss of spawning and rearing habitat, and deep pools, from excess sediment deposition;
- Increased mortality of eggs and young from lower levels of oxygen in stream gravels;
- Increased susceptibility to disease and predation;
- Increased reproductive failure;
- Shifts in macro invertebrate communities to those tolerating increased sediment or other types of diminished water quality;
- Increased susceptibility to over harvest and poaching;
- Loss of protective cover and resting habitat through changes in channel structure including large woody debris, overhanging banks, and deep pools;
- Competition from nonnative species;
- Loss of habitat caused by habitat degradation, barriers to passage, increased gradient, high temperatures, and other factors; and
- Increased vulnerability of subpopulations to catastrophic events and loss of genetic fitness, related to loss of habitat connectivity.

Trombulak and Frissell (2000) concluded that, although all species and ecosystems are not affected to the same degree by roads, in general, the presence of roads in an area is associated with negative effects for both terrestrial and aquatic ecosystems including changes in species composition and population size.

Temporary roads present most of the same risks posed by permanent roads, although some may be of shorter duration. Many of these roads are designed to lower standards than permanent roads, are typically not maintained to the same standards, and are associated with additional ground disturbance during their removal. Also, use of temporary roads in a watershed to support timber harvest or other activities often involves construction of multiple roads over time, providing a more continuous disturbance to the watershed than a single, well-designed, maintained, and use-regulated road. While temporary roads may be used temporarily, for periods ranging up to 10 years before decommissioning, their short- and long-term effects on aquatic species and habitats can be extensive.

Potential Effects of Timber Harvest - The effects of activities associated with timber harvesting (e.g., tree felling, yarding, landings, site preparation by burning or scarification, fuels reduction, brush removal and whip felling, and forest regeneration) are often difficult to separate from the effects of roads and road construction. The road systems developed to harvest timber are often a significant factor affecting aquatic habitats, as discussed above. Some of the potential effects to aquatic habitat from timber harvest can include the following (Chamberlin and others 1991, Hicks and others 1991, Beschta and others 1987):

- Increasing sediment supply and storage in channels,
- Modifying watershed hydrology and streamflow, including the timing or magnitude of runoff events,
- Decreasing stream bank stability, and altering stream channel morphology,
- Degrading water quality,
- Altering energy relationships involving water temperature, snowmelt and freezing,
- Diminishing habitat complexity, and
- Altering riparian composition and function

If present, these physical changes in habitat would have may of the same biological effects as previously listed under the effects of roads, above. With the recent increased emphasis on use of best management practices and other protective measures in the design and implementation of timber harvest activities, the effects can often be mitigated to some extent. Cumulatively, however, timber harvest activities within a watershed can have pronounced and lasting effects to aquatic habitat (Chamberlin and others 1991).

Extent and Duration of Effects – For aquatic habitats, the indirect effects of disturbances associated with road construction and timber harvest could extend well beyond those areas directly impacted, given the influence that upslope areas and upstream reaches have on the condition of downstream habitat (Chamberlin and others 1991). The types and extent of impacts on aquatic habitats would depend on road location and design, proximity to accessible habitat, mitigation measures applied, and the activities enabled. For fish populations, habitat alterations can adversely affect all life-stages, from egg to adult, and habitat essential for migration, spawning, incubation, emergence, rearing, feeding, and security (Furniss and others 1991).

The duration of effects, or recovery time, is dependent on a variety of factors. Site productivity, rainfall, and length of growing season influence the rate and success of vegetation regrowth. The type, location, extent and duration of an activity, magnitude of adverse effects, dominant hydrologic and geomorphic processes within the watershed, overall watershed condition, and the effectiveness of mitigation and reclamation activities are some of the other factors influencing the duration of physical effects on a watershed and associated stream channels. The duration of biological effects can extend beyond the recovery time for the physical environment, and can be irreversible if a species is extirpated from the watershed.

Sedimentation – Roads can cause direct and indirect effects to important habitat factors for fish and other aquatic species. They contribute more sediment to streams than any other land management activity. The majority of sediment from timber harvest is related to road construction and use. Roads also increase the potential for erosion and slope failure in many areas. This can increase sedimentation of aquatic systems and adversely affect aquatic communities (Furniss and others 1991). Past timber harvest and road construction on unstable slopes in the South Fork Salmon River watershed in Idaho resulted in massive amounts of sediment being heavily deposited in spawning gravels during the 1960s, which substantially impacted spawning success for anadromous and resident fish populations (Platts and Megahan 1975).

Sediment entering stream channels can clog streambed gravels, reducing oxygen concentrations critical to incubating eggs, young fish, and macro invertebrates, fill deep pools, and change channel shape and form, all of which can have adverse effects on aquatic species (Bjornn and Reiser 1991; Hicks and others 1991; Furniss and others 1991). Populations of tailed frogs can be severely reduced or eliminated by increased sedimentation (Corn and Bury 1989; Welsh 1990). In the Clearwater Basin of Washington, the amount of fine sediment from roads was equal to that contributed by landslides and cumulatively resulted in degraded spawning habitat for coho salmon (Chamberlin and others 1991).

A general picture of the effects of sedimentation on aquatic populations like salmon can be constructed from investigations in the Pacific Northwest. Fine sediment can directly reduce egg-to-fry survival, food production, summer rearing area, and winter survival; it can also change the morphology and stability of stream channels, causing long-term reductions in the **carrying capacity** and the survival of salmon in the stream (Murphy 1995). Holtby and Scrivener (1989) concluded that increased sedimentation following timber harvest reduced escapement by chum salmon (*Oncorhynchus keta*) by 25% in a stream in British Columbia. Scrivener (1991) concluded that sedimentation associated with logging over a 40-year period contributed to the decline of the chum salmon population on Western Vancouver Island. Cederholm and Reid (1987; cited in Murphy 1995) found that sediment from a debris torrent and a streamside salvage operation caused a stream in Washington to aggrade to the point at which the stream dried up during the summer. The yield of coho salmon smolt in that stream declined 60% to 80%.

Increases in turbidity from suspended fine sediment can cause direct mortality to aquatic species, reduce growth and feeding activity (Nelson and others 1991), and can affect the abundance and diversity of benthic invertebrates (Lee and others, 1997).

Habitat Fragmentation and Loss of Connectivity –Large blocks of unroaded areas, such as inventoried roadless areas, while having relatively more intact aquatic habitat, may still support isolated aquatic populations because of road-related effects and other causes of habitat alteration in adjacent areas. Ground-disturbing activities, including timber harvest, can result in further loss of habitat connectivity. Improperly placed culverts can result in migration barriers. Gucinski and Furniss (USDA Forest Service 2000h) cited studies showing that:

- Thirteen percent of the historical coho habitat in a large river basin in Washington was lost because of improper culvert barriers (Beechie and others 1994);
- Total taxa richness and some species-specific richness were negatively related to the number of stream crossings (Hawkins and others in press); and
- There were significant differences between macroinvertebrate assemblages above and below road stream crossings (Newbold and others 1980).

Areas where changes in riparian vegetation have reduced shading may present thermal barriers to movement of aquatic species (Furniss and others 1991) including many salmonid species such as bull trout.

When habitat connectivity is lost, sub-populations lose the ability to interact, making these species more vulnerable to local extirpations and extinction from any cause. The lack of genetic interchange in an isolated subpopulation or in one with severely restricted size can lower its ability to adapt or respond to changing environmental conditions, resulting in an increased long-term risk to species viability (Gilpin and Soule 1986; Lee and others 1997). While the localized effect of an individual road-stream crossing may not have a substantial adverse effect, the cumulative effect of road networks and multiple crossings increases the potential for major adverse effects to aquatic habitats.

Watershed Hydrology and Stream Channel Morphology – Accelerated changes in stream channel morphology and alterations in flow can adversely affect aquatic species by causing a loss of important habitat attributes such as overhanging banks, spawning substrate, deep pools and riffles, winter refugia, and suitable water temperature and volume, affecting virtually all life stages and the overall quality of habitat.

Timber harvest activities can have significant effects on the hydrologic processes that determine streamflow. Increased peak flow can be detrimental to aquatic species, including salmon, because the resulting bedload overturn can scour stream channels, kill incubating eggs, and displace juvenile salmon from winter cover (McNeil 1964; Tschaplinski and Hartman 1983).

Timber harvest can weaken channel banks by removing the source of large woody debris, altering the frequency of channel modifying flows, and changing sediment supply. Riparian tree roots provide bank stability. Streambank instability often increases when these trees are removed, leading to loss of overhanging banks, which is an important habitat attribute for rearing Pacific salmonids (Murphy 1995) and other aquatic species. Streambank destabilization from vegetation removal adds to sediment supply and causes a loss of the channel structures that provide the habitat diversity needed to support healthy fish populations (Harris 1984; Scrivener 1988).

Habitat Complexity – Hicks and others (1991) found that a primary consequence of past timber harvest activities was the simplification of fish habitat. Example of such activity included changes in stream flow velocities and depth (Kaufmann 1987), reductions in large wood (Bisson and others 1987; Bilby and Ward 1989), changes in stream and floodplain interaction (Naiman and others 1992), and loss of habitat types and certain substrates (Sullivan and others 1987). The consequence of these changes has been a reduction in the diversity and quality of habitats. In Pacific Northwest streams, habitat simplification resulting from timber harvest and associated activities has diminished diversity of the anadromous salmonid complex (Bisson and Sedell 1984; Hicks 1990).

Water Quality – Road construction and timber harvest can result in measurable reductions of water quality by introducing sediment, nutrients, and chemical pollutants, and by causing abnormal temperature fluctuations. Some pollutants are from road construction and maintenance equipment, or are brought into the watershed through public road use.

Road construction and timber harvest may cause water temperature to change where groundwater is intercepted and brought to the surface or where loss of tree cover in riparian areas reduces shading (Hornbeck and Leak 1992). Removal of riparian canopy associated with road construction and maintenance can elevate stream temperatures to levels that have adverse physiological effects on aquatic species, and can result in increased mortality rates and lowered reproductive success. Elevated temperatures can inhibit upstream migrations, increase disease susceptibility, reduce metabolic efficiency, and shift species assemblages (Beschta and others 1987; Hicks and others 1991).

Pools – In the broad scale assessment of aquatic species and habitats in the Columbia River Basin (Lee and others 1997), sizeable losses of large pools, critical habitat features

for many fish species, and deep pools were found in streams in managed areas (multiple-use, roaded areas) over the last 50 to 60 years, compared with streams in unmanaged areas. This analysis showed that streams in 20 managed watersheds in the Central Idaho Mountains ecological reporting unit (ERU) had a 40% decrease in the frequency of large pools, whereas large pools in 11 unmanaged streams in the same ERU showed no noteworthy change. A substantial decrease was also found in the frequency of deep pools in managed streams, in contrast to a considerable increase in streams in unmanaged areas. Pools showed a clear decline in size and frequency with increasing road density.

Riparian Vegetation – Timber harvest and road construction can affect riparian vegetation through removal, soil compaction, changes in drainage pattern and floodplain function, and introduction of nonnative invasive plant species. Riparian vegetation is a controlling factor of stream habitat quality, particularly in smaller streams. It contributes organic materials that supply nutrients and affects productivity, insects that serve as a food source, and logs and branches that affect channel morphology and habitat complexity. Riparian vegetation retains organic matter and provides cover for fish. Roots stabilize stream banks and maintain undercut banks. The protective canopy provided by riparian vegetation helps to regulate temperature by shading the channel in summer and insulating from heat loss in winter (Murphy and Meehan 1991).

Introduction of Nonnative Species and Diseases – Introductions of nonnative fishes and other aquatic species, whether authorized or unauthorized, have the potential to affect the distribution and abundance of native fishes, amphibians, and other aquatic organisms through competition, hybridization, predation, and introduction of parasites and diseases. Nonnative aquatic plants may also be inadvertently introduced to lakes and streams from boats and boat trailers. Unauthorized releases of aquarium fishes, bait fishes, nonnative amphibians and reptiles, and nonnative plants to streams and lakes are strongly influenced by the presence of roads (USDA Forest Service 1999p; Lee and others 1997; Allan and Flecker 1993).

Over Harvest and Illegal Introduction – he presence of a road system and associated facilities accessing streams, lakes, and wetlands can contribute substantially to declines in rare and unique native vertebrate populations (USDA Forest Service 1999p) due to over harvest and illegal collection. Increased access can increase the likelihood of disruption of aquatic native communities with illegal or inadvertent introductions of nonnative species, as discussed under the affected environment section.

Recent Studies – Analysis done for the Interior Columbia Basin Ecosystem Management Project (Lee and others 1997) indicates that strong fish populations are often associated with low road density. The Sierra Nevada Ecosystem Project documented a negative correlation between the abundance of roads in a watershed and the integrity of native stream biota (Moyle and Randall 1996).

The U.S. Fish and Wildlife Service (USDI Fish and Wildlife Service 1998a) found that bull trout are exceptionally sensitive to the direct, indirect, and cumulative effects of roads. Dunham and Rieman (1999) demonstrated that disturbance from roads was associated with reduced bull trout occurrence. They concluded that conservation of bull

trout should involve protection of larger, less fragmented, and less disturbed (lower road density) habitats to maintain important strongholds and sources for naturally recolonizing areas where populations have been lost.

Road construction and timber harvest were identified as important factors in the regional decline and loss of populations of some inland cutthroat trout subspecies (Young 1995; Duff 1996). Adverse effects related to roads were identified for Colorado River, westslope, Bonneville, and Yellowstone cutthroat. Timber harvest was identified as a cause of habitat degradation for westslope, Rio Grande, Bonneville, and Yellowstone cutthroat trout.

The biological opinion issued by the National Marine Fisheries Service for PACFISH[10] (USDA Forest Service and USDI Bureau of Land Management 1995) identified roads as a primary cause of salmonid decline, and indicated that roads may have unavoidable effects on streams, regardless of how well they are located, designed, or maintained. In discussing the effects of management activities in inventoried roadless areas in the Pacific Northwest, the scientific analysis team headed by Jack Ward Thomas (Thomas and others 1993) concluded that such activities would increase the risk of damage to aquatic and riparian habitat and could potentially reduce the capacity and capability of key watersheds important for maintaining salmonid populations.

Beneficial Effects of Roads and Timber Harvest – Provided a road is located, designed, constructed, and maintained to the standards needed to protect aquatic habitat, roads can have positive aspects for a fisheries management program for a particular stream or lake (Furniss and others 1991). Roads provide access to lakes and streams, facilitating both fishing and law enforcement. They also provide easier access for inventory and assessment of stream habitat and populations, for habitat improvement and enhancement projects, and for State stocking and population management activities.

Stewardship timber harvest may provide some potential beneficial effects to some aquatic species. For example, careful thinning to reduce fuel loading in some areas where there is an abnormally high risk of high intensity, large-scale fires, may lower the risk of extirpation of an isolated fish population from a watershed, particularly where habitat complexity and spatial diversity have already been diminished, and where recolonization would not be possible due to a lack of habitat connectivity.

Summary of Effects – With the expectation that roaded entry and timber harvest will continue in these areas at rates approximating those in the past, and given the numerous negative direct, indirect, and cumulative effects identified in the literature associated with these activities, the No Action Alternative has the greatest potential for increased risk of adverse effects to aquatic and riparian habitat and species, relative to Alternatives 2, 3, and 4.

[10]Implementation of Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and portions of California

Alternative 2

This alternative offers a greater degree of assurance than Alternative 1 that current aquatic biodiversity would be maintained, due to the prohibition on road construction and reconstruction. Based on estimates provided by each national forest, there would be approximately a 75% reduction in the total miles of road that would be constructed or reconstructed in inventoried roadless areas through 2004 under this alternative. Under the exceptions common to all action alternatives (as described in Chapter 2), about 300 miles of road could be constructed or reconstructed. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative.

Even though timber harvest activities could continue in inventoried roadless areas, information collected from the forests indicates that much of the timber harvest currently planned in these areas would require road construction and reconstruction and hence, would not occur under this alternative as shown on Table 3-32. Therefore, much of the potential adverse effects associated with road construction would be avoided, and a lower level of risk associated with less timber harvest would be expected, compared to Alternative 1.

Aquatic habitat management activities that are not dependent on new or reconstructed road access could be implemented under this alternative. Forests identified approximately 4 miles of road construction or reconstruction in inventoried roadless areas associated with fisheries habitat improvement projects within the next 5 years. These projects included limestone applications in two streams in Region 8 to reduce acidic conditions, road reconstruction in Region 6 to reduce sedimentation, mine reclamation in Region 8 to reduce stream sedimentation, and stream barrier construction in Region 3 to prevent movement of nonnative fish species into habitat occupied by threatened loach minnow and Apache trout, as well as other native fish species.

These projects represent substantially less than 1% of the annual national program (USDA Forest Service 2000d). One or more of them could likely be redesigned so that road construction or reconstruction would not be necessary in inventoried roadless areas by using aerial access or by walking heavy equipment into the site. For instance, the Region 3 project-feasibility study presented two alternatives that would not require road construction – using a site 8 miles upstream with current road access at a 20% cost savings, or using helicopter access to a site about 3 miles upstream at an 18% increased cost (USDI Bureau of Reclamation 1998).

All action alternatives offer an exception to prohibitions for situations where an existing road needs to be realigned to prevent resource damage, caused by the road itself. For example, this exception could be invoked to prevent substantial adverse effects to aquatic habitat caused by excessive sedimentation from an adjacent road. The Region 6 road reconstruction project listed above could potentially fall under this exception.

Overall, the need for additional road access to manage aquatic habitat within inventoried roadless area appears to be minimal. The current national capability of the Agency to manage aquatic habitat would not be measurably affected.

Summary of Effects – No adverse environmental effects to aquatic animal species would be expected from this alternative, since it does not directly authorize any ground disturbing activities, and this and other government agencies with jurisdictional responsibilities would retain the tools necessary to manage these resources. Overall effects to aquatic species and biodiversity would be beneficial.

Alternative 3

With the added prohibition against non-stewardship timber harvest, this alternative presents a lower risk than Alternatives 1 and 2 of additional degradation or loss of aquatic habitat quality, quantity, and distribution resulting from timber harvest, particularly in those inventoried roadless areas that are currently open to road construction. A description of the potential adverse effects of road construction and timber harvest is provided under Alternative 1.

As discussed under Alternative 2, a reduction of approximately 75% in the total miles of road that could be constructed or reconstructed in inventoried roadless areas through 2004 would be expected under this alternative. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative.

By restricting timber harvest to activities necessary for resource stewardship, many of the adverse effects of timber harvest would be minimized, while maintaining a management tool potentially needed for ecological restoration. Mechanical vegetation manipulation to reduce fuel loading may be desirable in some areas where there is an abnormally high risk of high intensity, large-scale fires. Fuels reduction stewardship activities may be indirectly beneficial to some aquatic populations, if such activities are implemented with minimal impacts to aquatic habitats. Other types of stewardship timber harvest to meet objectives for aquatic habitat could include watershed restoration and enhancement of riparian vegetation (USDA Forest Service and USDI Bureau of Land Management 1995).

As described under Alternative 2, aquatic habitat management activities that are not dependent on new or reconstructed road access could be implemented under this alternative. Overall, the need for additional road access to manage aquatic habitat within inventoried roadless area appears to be minimal. This alternative would not measurably affect the current ability of the Agency to manage aquatic habitat.

Summary of Effects – No adverse environmental effects to aquatic animal species would be expected from this alternative, since it does not directly authorize any ground disturbing activities. This Agency and other government agencies with jurisdictional responsibilities would retain the tools necessary to manage these resources. Overall, the effects on biodiversity would be beneficial.

Alternative 4

The potential beneficial effects of this alternative on aquatic communities would be similar to those described in Alternatives 2 and 3, but potentially somewhat greater. By prohibiting all timber harvest, except for that needed for protection or recovery of TEP species, this alternative would provide the greatest assurance that these areas would not experience increased levels of human-caused disturbance and associated degradation of aquatic habitat quality, quantity, and distribution, associated with road construction and timber harvest.

However, by prohibiting all timber harvest, the Agency would loose a management tool that may be desirable for ecological restoration in some areas. Vegetation manipulation using mechanical means to reduce fuel loading may be desirable where there is an abnormally high risk of high intensity, large-scale fires, but could not be implemented under this alternative.

Whereas the benefits of less ground disturbance from road construction and timber harvest are well documented in the literature, it is less clear whether failure to reduce fuel loading would constitute a substantially increased level of risk to aquatic communities. Even though some timber harvest activities are intended to mimic the effects of natural disturbance processes such as fire, there is little known about the long term ecological legacies of such treatments. It is not clear how those legacies would compare with areas where natural disturbance processes have played a more dominant role in controlling successional pathways, landscape mosaics, and ecosystem composition.

Although Rieman and others (1997) documented that large fires can adversely affect aquatic systems, and can result in fish mortality and even extirpation, they concluded that the resilience and persistence of salmonid populations are heavily influenced by the complexity and spatial diversity of habitats. A complex, well-dispersed network of habitats is likely to be an important element in the persistence of fish populations during and after large fires. They concluded that some aquatic species, such as bull trout and redband trout, appear to be well-adapted to “pulsed” disturbances, such as fire and its associated hydrologic effects, as opposed to more continual or “press” effects linked to roads and extended timber harvest. They recommended that where small or isolated sensitive fish populations occur in watersheds at high risk of uncharacteristic wildland fire, management actions should be implemented only after careful site-specific risk evaluation. When a need to reduce fuel loading is identified, silvicultural prescriptions emphasizing low-impact logging and yarding and prescribed fire would be preferable.

Research on the Boise National Forest after large intense fires in 1994 showed rapid recolonization of reaches by bull trout (Rieman and others 1997). Burns (2000a) found that risks to fish populations from prescribed fire or wildland fire are low where fish populations can freely migrate and ecosystems are not severely fragmented. Research on fish recolonization after large disturbances or experimental removal indicates that full population recovery can occur quickly, often within a few years (Niemi and others 1990; Detenbeck and others 1992) or even in much shorter periods (Sheldon and Meffe 1995; Peterson and Bayley 1993). These studies support a determination that, provided aquatic

populations are not functionally isolated, this alternative would not result in a greater risk of adverse effects to aquatic communities from prescribed or wildland fire.

Overall, the need for additional road access and timber harvest to manage aquatic habitat within inventoried roadless area appears to be minimal. Although there may be some local limitations, this alternative would not affect the overall current ability of this Agency or other Federal, State, or local government agencies with jurisdictional responsibility to manage aquatic species and habitat. Existing access would not be affected by this or the other prohibition alternatives.

Summary of Effects – No adverse environmental effects to aquatic animal species would be expected from this alternative, since it does not directly authorize any ground disturbing activities. This Agency and other agencies with jurisdictional responsibilities would retain the tools necessary to manage these resources. Overall effects relative to conservation of aquatic species and biodiversity would be beneficial.

Terrestrial and Aquatic Plant Species

Affected Environment

Inventoried roadless areas provide large, relatively undisturbed blocks of important habitat for a wide variety of native terrestrial and aquatic plants including, more than 1,400 sensitive and almost 100 TEP plant species. Many of these are endemic species, with narrowly limited geographical ranges determined by soil types, climatic conditions, and other environmental conditions. Endemic species, due to their limited distribution, are often at a relatively higher risk of extinction from either natural or human-induced causes. Areas in the United States with sizeable numbers of endemic plant species include California, Texas, Alaska, the Pacific Northwest, the Southwest, the Intermountain West, and the South (Gentry 1986). Appendix C includes a list of TEP plant species found on NFS lands and identifies which species may be affected by inventoried roadless areas. A list of potentially affected sensitive species can be found in the biological evaluation for the project or at the project website **roadless.fs.fed.us**.

These inventoried roadless areas may provide important biological strongholds for native plant species and communities. In comparing the distribution of these inventoried roadless areas with centers of biodiversity identified in the Interior Columbia Basin Ecosystem Management Project (ICBEMP) (Lee and others 1997), inventoried roadless areas cover approximately 10% (2,810,000 acres) of the identified acreage for centers of biodiversity for plants. In addition, almost 10% (1,370,000) of the acreage identified in ICBEMP as centers of endemism for plants is contained in inventoried roadless areas.

Because access to many inventoried roadless areas is relatively difficult, and there are typically fewer projects and activities requiring rare-plant inventories, areas that are more accessible are often better surveyed than inventoried roadless areas. Therefore, inventoried roadless areas are more likely to yield new distributional records and even previously unknown species.

Compared to roaded areas, plants in inventoried roadless areas are less likely to be exposed to disruption from a variety of human activities such as collection, trampling, and other surface disturbance. This lower level of disruption may make inventoried roadless areas important references for understanding the natural composition and dynamics of native plant communities.

Roads are also avenues for invasion by nonnative invasive plant species that frequently compete with or displace native vegetation. Competition by nonnative invasive species is one of the leading causes for plant species being listed as T&E (Pimental and others 1999; Fay personal communication). More than 3,700 nonnative plant species have become established in the United States (Williams and Meffee 1998). Table 3-35 shows the estimated numbers of established nonnative species in this country, providing an indication of the magnitude of this issue. Areas subjected to intense and wide spread natural disturbances, such as high intensity stand-replacing wildland fire, can be susceptible to nonnative plant invasions for a period. However, the risk is significantly less than in roaded areas where human activities and disturbances associated with roads can exacerbate the problem. Lacking roads and many of the disturbances associated with them, inventoried roadless areas are less likely to experience problems with nonnative invasive species and are more likely to be able to maintain intact native plant communities.

Table 3-35. Estimated number of established nonnative species in the United States.

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

(Williams and Meffe 1998)

Alternative 1 - No Action

This alternative would have the greatest potential for additional ground disturbance associated with roads, timber harvest, and other management activities. Approximately 40% of the 58.5 million acres of inventoried roadless areas are currently covered by land management-plan prescriptions that prohibit road construction and reconstruction. Projecting future roaded entry using historic levels of road construction, an additional 5% to 10% of inventoried roadless areas are likely to be entered within the next 20 years under Alternative 1, predominantly in areas currently open to road construction. The type and extent of impacts to native plant species and communities from this road construction would depend on road location and design, mitigation measures applied, and the activities that occur. Approximately 90,000 acres (18,000 acres per year) would be directly

impacted by the planned level of timber harvest offer of 1.1 BBF through 2004. Over the long term, the average annual acreage affected is expected to drop to about 14,000. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative.

Nonnative Invasive Plants – With the expectation that roaded entry would continue at approximately the same rate in inventoried roadless areas and given the disturbances and uses associated with roads, this alternative poses the greatest degree of risk for increased introduction and spread nonnative invasive species, with a corresponding increase in risk of all of the adverse ecological effects associated with establishment of such species. Roads serve as a means of entry for many nonnative invasive plant species, with seeds or plant parts inadvertently transported into previously unaffected areas. Ground disturbance associated with roads and with other road activities provides additional opportunity for establishment or expansion of nonnative invasive plant populations (Parendes and Jones 2000).

A recent survey conducted by the U.S. Department of the Interior found that nonnative invasive plants have invaded more than 17 million acres of public rangelands within the Western United States, more than quadrupling their range from 1985 to 1995. At this rate of expansion, Western wildlands are being lost at a rate of 4,600 acres per day to invasive plants such as leafy spurge and yellow starthistle (Westbrooks 1998). The source of many of these infestations has been traced to roads, trails, railroads, and other travel corridors. When vehicles are driven through a **noxious weed**-infested area, seeds from these plants may become lodged in tire treads, in a winch, and in other cracks and crevices on the chassis of a vehicle. Such seeds may become dislodged hundreds of miles away, infesting new areas (Westbrooks 1998). Many nonnative invasive plants are dispersed through transportation of contaminated hay or seed along roads. Spotted knapweed and yellow starthistle are just two examples of plants that are dispersed throughout roadways by the transportation of contaminated alfalfa and clover seed.

Site disturbance by road construction and the transport of contaminated soil and gravel have been identified as a major contributors to long distance seed dispersal for yellow starthistle (Thomsen and others 1996). Additionally, within California, scotch broom has been found to be dispersed by vehicles through the transportation of seed in mud and debris (USDI 1994). Routine roadside mowing aids in the elimination of some noxious weeds, but can accidentally spread the seeds of others, like knapweed in the Midwest and the dust-like seeds of parasitic weeds such as small broomrape in South Georgia (Westbrooks 1998). Gorse has been recognized as a significant nonnative invasive plant occurring within Oregon and California (Amme 1983). Subsequent use of roadways in close proximity to gorse facilitates its spread by serving as a mechanism for seed dispersal (Hill 1949). Now widely distributed throughout North America (Whitson and others 1991; Young 1991), cheatgrass has been identified as a common species along many roadsides. The highly flammable cheatgrass alters the frequency and intensity of fires on Western rangelands, and therefore alters vegetative communities important for many big game species.

Aggressive nonnative invasive plant species generally undermine native plant diversity through competition and habitat alteration. For example, the Sierra Nevada, an area

historically rich in plant diversity with more than 3,500 native species, now supports hundreds of nonnative species, many of which have had considerable detrimental ecological effects (Sierra Nevada Ecosystem Project 1996). Other parts of the country show similar situations. Areas infested with invasive species, such as spotted knapweed and leafy spurge, can have low grass productivity (Hillis 1999) affecting the quality and amount of forage available to many species. Once established, many of these nonnative species are extremely difficult or impossible to eradicate. The use of herbicides in eradication or control efforts can have unintended adverse effects to populations of other terrestrial and aquatic species (Norris and others 1991).

Fragmentation – While most studies of forest fragmentation have focused on animal species, some research has addressed plants. In studying the effects of forest fragmentation from timber harvest clearcuts on trillium (*Trillium ovatum),* a common herbaceous understory plant, Jules (1998) documented continuing adverse effects (high mortality during initial disturbance and a continuing lack of new plants) even in sites that had been clearcut more than 30 years ago. Although he found individual plants as old as 72 years, study areas showed few plants younger than the age of the clearcut. His study also demonstrated that populations in remaining forest remnant patches that were within 65 meters of the edge of a clearcut experienced similar adverse effects, most likely due to a combination of reduced seed set and reduced survival of seeds and seedlings near edges. He speculated that, given the severe effects from fragmentation demonstrated for this common species, it is likely that the distribution and abundance of other understory plants were similarly altered. Jules concluded that the likelihood of maintaining biodiversity would be greater in areas that have never been harvested and where landscape fragmentation has not increased.

Isolation or severely restricted subpopulation size due to habitat fragmentation may also have adverse effects due to the lack of genetic interchange that can lower a species ability to adapt or respond to changing environmental conditions. This would constitute an increased long-term risk to species viability (Gilpin and Soule 1986).

Effects of Temporary Roads – Temporary roads present most of the same risks posed by permanent roads, although some may be of shorter duration. Many of these roads are designed to lower standards than permanent roads, are typically not maintained to the same standards, and are associated with additional ground disturbance during their removal. Also, use of temporary roads to support timber harvest or other activities often involves construction of multiple roads over time, providing a more continuous disturbance to an area than a single, well-designed, maintained, and use-regulated road. Rare plant populations can be lost during road construction, whether roads are temporary or permanent. While temporary roads may be used temporarily, for periods ranging up to 10 years, and are then decommissioned, their short and long-term effects can be extensive to rare plant populations.

Summary of Effects – Increased access into inventoried roadless areas would present an increased risk to rare plant populations and communities due to increased level of habitat disturbance, habitat fragmentation, introduction of nonnative invasive plant species, and

collection or trampling of individual rare plants. Alternative 1, therefore, would pose the greatest threat to conservation of native plant species and communities.

Additional discussions on the effects of road construction and timber harvest relevant to plant species are in the Terrestrial, and Aquatic Animal Species sections, and in the biological evaluation.

Alternative 2

This alternative would offer a greater degree of assurance than Alternative 1 that current plant diversity would be maintained, due to lower levels of disturbance, less potential for additional forest fragmentation, and less development of road access.

Based on estimates provided by each national forest, there would be an approximate 75% reduction in the total miles of road that could be constructed or reconstructed in inventoried roadless areas through 2004 under this alternative. Under the exceptions common to all action alternatives (as described in Chapter 2), approximately 300 miles of road would be constructed or reconstructed.

The amount of potential additional forest fragmentation associated with timber harvest would be reduced under this alternative. Timber harvest activities and road construction would continue in inventoried roadless areas, but at much-reduced levels. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative.

Without the ground disturbance, ecological edges, and uses created or enabled by additional road construction and reconstruction in inventoried roadless areas, these areas would be less vulnerable to establishment of nonnative invasive species than roaded areas of similar size. Relative to Alternative 1, this alternative would provide a lower risk of adverse effects to native plant species and communities from establishment of nonnative invasive species, providing greater protection of existing biodiversity and site productivity. All action alternatives are consistent with and help further the intent of Executive Order 13112 on invasive species.

Through 2004, two projects were identified for restoration of native plant communities that as currently designed would require 2.5 miles of road construction in inventoried roadless areas. These projects in Region 8 involve boreal habitat enhancement and variable sedge restoration. Alternative means of access could potentially be developed for both projects. Overall, the need for road construction and reconstruction for native plant projects appears to be minimal.

Summary of Effects – No adverse environmental effects to terrestrial and aquatic plant species would be expected from this alternative, as this alternative does not authorize any ground disturbing activities. Existing access to inventoried roadless areas would not be affected. The overall ability of this Agency or other Federal, State, or local government agencies with jurisdictional responsibilities to implement management actions for conservation of rare plant communities would be unaffected, including those actions

needed for control or eradication of nonnative invasive plants. Overall effects to terrestrial and aquatic native plant communities would be beneficial.

Alternative 3

With a prohibition of non-stewardship timber harvest and of road construction and reconstruction in inventoried roadless areas, this alternative would provide a greater degree of assurance than Alternatives 1 and 2 that these areas would not experience increased levels of human-caused disturbance and degradation of native plant habitat quality, quantity and distribution. The overall beneficial effects of this alternative to native plant species and communities would be similar to those described under Alternative 2, but would be somewhat greater with the additional prohibition on non-stewardship timber harvest.

Information collected from each national forest indicates that much of the timber harvest currently planned in these areas would either require road construction and reconstruction or was not classified as "stewardship.", and hence, would not occur under this alternative. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative.

With a reduced level of planned timber harvest, there would be less potential for increased ground disturbance, ecological edges, fragmentation, and other associated timber effects. This alternative would provide additional assurance beyond Alternative 2 that inventoried roadless areas would retain current levels of resistance to the introduction and establishment of many nonnative invasive species. (See the discussion on nonnative invasive species under Alternative 2 above.) All action alternatives would be consistent with and would help further the intent of Executive Order 13112 on invasive species.

Summary of Effects – No adverse environmental effects to terrestrial and aquatic plant species would be expected from this alternative, as this alternative does not authorize any ground disturbing activities, and the overall ability of this Agency or other government agencies to implement management actions for conservation of rare plant communities would be unaffected. Overall effects to native plant communities would be beneficial.

Alternative 4

The beneficial effects of this alternative on native plant communities would be similar to those described in Alternatives 2 and 3, but potentially somewhat greater. This alternative would provide additional assurance that these areas would not experience increased levels of human-caused disturbance and degradation of native plant habitat quality, quantity, and distribution. Without any of the ground disturbance and ecological edges associated with timber harvest and combined with a 75% reduction in road construction and reconstruction, this alternative would provide the greatest assurance that these areas would retain current levels of resistance to the introduction and establishment of many nonnative invasive species. This alternative is consistent with and would help further the intent of Executive Order 13112 on invasive species.

This alternative would provide an exception to the prohibition on timber harvest, if needed, to protect or recover a T&E species or a species that has been proposed for listing under the ESA.

Summary of Effects – No adverse environmental effects to terrestrial and aquatic plant species would be expected from this alternative, as this alternative does not authorize any ground disturbing activities. Although there may be some local limitations, the overall ability to implement management actions for conservation of rare plant communities would not be affected. Overall effects to native plant communities would be beneficial.

Threatened, Endangered, Proposed, and Sensitive Species

The worldwide rate of extinction is estimated to be approximately 400 times that of recent geologic time, and is apparently increasing (Wilson 1985). Based on estimates made by the Nature Conservancy (Stein and Flack 1997), 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 occurrences. They estimate that about one-third of the United States plant and animal species have an increased risk of extinction. It is conceivable that the number of species in the United States that merit listing early in the 21st Century may be 2 or 3 times that of the number currently listed (Wisdom and others 1999). These statistics indicate the importance of conserving the remaining relatively undisturbed, large blocks of habitat for species whose continued viability may be at risk.

A high percentage of federally listed T&E species, and species proposed for listing under the ESA, as well as Forest Service designated sensitive species, are affected by inventoried roadless areas. Statistics generated from Forest Service species lists indicate that:

- More than 55% of TEP species, with habitat on or affected by NFS lands, are directly or indirectly affected by inventoried roadless areas. This percentage represents approximately 25% of all animal species and 13% of all plant species listed under the ESA within the United States.
- More than 65% of all Forest Service sensitive species are directly or indirectly affected by inventoried roadless areas. This percentage is composed of birds (82%), amphibians (84%), mammals (81%), plants (72%), fish (56%), reptiles (49%), and invertebrates (36%).

These statistics suggest the important role that inventoried roadless areas fill, both individually and cumulatively, in maintaining species viability and biodiversity in all parts of the country. It is likely that some inventoried roadless areas are more important now than in the past in supporting species viability and biodiversity, due to cumulative degradation and loss of other potentially more biologically rich habitat in adjacent landscapes. With extinction risk for many species directly correlated to habitat loss and degradation (Stein and Flack 1997), the data in Table 3-36 indicate the numbers of species that may be at increased risk of endangerment or extinction if the relatively

undisturbed habitat provided by these areas is not maintained. Even though the numbers vary between species group and parts of the country, nationally these inventoried roadless areas play an important role in providing habitat for TEP and sensitive species.

Table 3-36. Estimated number and percent of threatened, endangered, proposed, and sensitive species within each Forest Service region affected by inventoried roadless areas.

	Threatened, endangered, and proposed species		Sensitive species	
Region	Number of species	Percent by region	Number of species	Percent by region
Northern (1)	15	75	245	82
Rocky Mountain (2)	27	100	135	83
Southwestern (3)	45	57	245	57
Intermountain (4)	31	89	222	99
Pacific Southwest (5)	60	63	313	77
Pacific Northwest (6)	30	83	329	75
Southern (8)	65	38	346	54
Eastern (9)	29	85	276	42
Alaska (10)	1	25	26	93

(Roadless Database 2000)

Wilcove and others (2000) examined available information for 1880 imperiled and listed species and determined that habitat destruction and degradation contributed to the endangerment of 85% of those species. Other important contributing factors included competition with or predation by nonnative species (49%), pollution (24%), and overexploitation (17%).

Nationally, on NFS lands, there are approximately 400 proposed, threatened and endangered species, and 2,930 sensitive species. Inventoried roadless areas provide or affect habitat for approximately 220 TEP and 1,930 sensitive species. Forty-four species have designated critical habitat on NFS lands, along with proposed critical habitat for an additional eight species. Inventoried roadless areas provide or affect critical habitat for approximately 75% of these species. These species are identified in Appendix C.

The Forest Service Roadless Area Conservation Biological Evaluation for Threatened, Endangered, Proposed, and Sensitive Species (biological evaluation or BE) was completed for the alternatives in the FEIS and is part of the project record. As part of ESA consultation, the biological evaluation was provided to the National Marine Fisheries Service and the U. S. Fish and Wildlife Service, along with other supporting documentation. The level of analysis in the biological evaluation was commensurate with the national scale and non-ground disturbing nature of the action alternatives. It does not take the place of specific, project-level or forest-plan level planning and analysis for future decisions regarding other activities in these areas, but it does provide an important overall context for such analyses. The list of TEP species is included in Appendix C. This

list, the sensitive species list and the BE are available on the project website at **roadless.fs.fed.us**.

The overall determination of effects in the BE was the same for all action alternatives:

- May affect, but are not likely to adversely affect T&E species or adversely modify designated critical habitat; and are not likely to jeopardize **proposed species** or adversely modify proposed critical habitat. Furthermore, these alternatives may beneficially affect TEP species and critical habitat.
- May affect individuals, but are not likely to cause a trend towards Federal listing or a loss of viability for any sensitive species. Furthermore, these alternatives may beneficially affect sensitive species and their habitat.

The Terrestrial Animals and Habitat, Aquatic Animals and Habitat, and Terrestrial and Aquatic Plant Species sections provide additional description of the affected environment and environmental consequences of the alternatives including discussions on nonnative invasive species.

Alternative 1 - No Action

Refer to the Alternative 1 sections under Terrestrial Animals and Habitat, Aquatic Animals and Habitat, and Terrestrial and Aquatic Plant Species for a comprehensive discussion of the principal effects from road construction and timber harvest, and to the biological evaluation.

Relative to the No Action Alternative, all of the action alternatives would have the potential for important beneficial impacts to TEPS species, by reducing risks of future habitat degradation and disturbance, and conserving existing biological strongholds. The degree of beneficial effects would vary by alternative, in response to the level of prohibitions applied.

Past road construction and timber harvest practices have had substantial impacts on TEPS species and habitats in many areas. Recent changes in project designs and specifications, along with application of best management practices, have been effective at moderating or avoiding many adverse effects. Some effects, however, cannot be completely mitigated or avoided. The following summary lists the principal effects that have been associated with roads and timber harvest, but these are potential effects, and not every project would necessarily give rise to one or more of these effects. These effects are discussed in detail under the Terrestrial animal Habitat and Species, the Aquatic Animal Habitat and Species, and the Terrestrial and Aquatic Plant Species sections.

Potential Effects of Roads

- Habitat loss
- Habitat fragmentation and loss of connectivity
- Adverse edge effects
- Displacement and avoidance behavior
- Access for poaching and illegal collection

- Increased potential for chronic negative interactions with humans
- Direct mortality from vehicles and recreational shooting
- Harassment and disturbance
- Dispersal and movement barriers for some species
- Lethal toxicity
- Introduction and spread of nonnative invasive species and diseases
- Increases sediment loads in streams
- Adverse changes in watershed hydrology and stream flows
- Alterations of stream channel morphology
- Degradation of water quality, including increasing chance of chemical pollution.
- Alteration of water temperature regimes

Potential Effects of Timber Harvest

- Habitat loss, fragmentation, and negative edge effects.
- Habitat loss of snags and down logs
- Degradation of rare and unique communities such as those found in talus slopes, cliffs, caves, and wetlands
- Disruption of dispersal and species migration
- Lowered success in reproduction and rearing of young
- Increased levels of physiological stress for some species
- Introduction and spread of nonnative invasive species
- Changes in streamflow and the timing or magnitude of runoff events
- Loss of stream bank stability
- Increases in sediment supply and sediment storage in channels
- Degradation of water quality
- Altered energy relationships involving water temperature, snowmelt and freezing
- Loss of habitat complexity
- Alterations in riparian composition and function

Summary of Effects – The No Action Alternative would result in a greater likelihood of measurable losses of habitat quality and quantity in inventoried roadless areas, with the increased potential for adverse effects to some TEPS species.[11] Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative. This alternative poses the greatest likelihood of increased risk cumulatively to species viability, although mitigation measures offsetting some adverse effects would undoubtedly be identified as part of site-specific national NEPA decisions, and where TEP species may be affected, ESA consultations and conferencing.

Alternative 2

With a prohibition on road construction and reconstruction in inventoried roadless areas, the potential for increased levels of human-caused disturbance and degradation of habitat quality, quantity, and distribution would be greatly reduced relative to Alternative 1,

[11] Assuming that roaded entry and timber harvest would continue in these areas at rates approximating that occurring in the past and given the disturbances from other road-dependent activities.

particularly in those areas currently open to road construction. Given the numbers, diversity, and distribution of TEPS species that have habitat in inventoried roadless areas, this alternative would provide important local, regional, and national conservation for these species and their habitats.

All of the action alternatives offer an exception to the prohibition on road construction and reconstruction for situations where an existing road needs to be realigned to prevent irreparable resource damage, which is being caused by the road itself. For example, this exception could be invoked to relocate a road to prevent substantial adverse effects to habitat for a threatened or sensitive fish species caused by excessive sedimentation from the existing road location, when such effects could not be avoided through maintenance.

With a 75% reduction in planned road construction and an associated reduction in many activities, including road-dependent timber harvest, habitat degradation and fragmentation, harassment, disruption, and illegal capture or harm would be less likely, relative to Alternative 1. Overall effects to conservation of species and maintenance of biodiversity would be beneficial, with no adverse effects anticipated.

A comprehensive description of the principal effects from road construction and timber harvest is in the sections on Terrestrial Animal Habitat and Species, Aquatic Animal Habitat and Species, and Terrestrial and Aquatic Plant Species, and in the biological evaluation for this project. Table 3-32 provides the planned timber harvest and miles of road construction projected under this alternative.

Through 2004, no planned activities from conservation strategies for sensitive species were identified that would require road construction and reconstruction in inventoried roadless areas. Of the general (that is, not specifically targeted at TEPS) wildlife, fish, and rare plants projects planned, four fisheries projects and eight terrestrial species projects were identified that would require road construction or reconstruction as currently planned. It is likely that some of these projects would directly or indirectly benefit one or more TEPS species. If redesigned, some of these projects could likely be implemented without road construction and reconstruction.

One project was identified for recovery of T&E species that would require road construction in an inventoried roadless area. This involves stream barrier construction in the Forest Service Southwest Region to prevent movement of nonnative fish species into habitat occupied by threatened loach minnow and Apache trout, as well as other native fish species. As currently designed, it would require 1 mile of temporary road construction in an inventoried roadless area. A feasibility study for this project presented two alternatives that would not require road construction: using a site 8 miles upstream with current road access at a 20% cost savings, or using helicopter access to a site about 3 miles upstream at an 18% increased cost (USDI Bureau of Reclamation 1998).

In general, it appears that the need for road construction or reconstruction for recovery or protection of TEPS species would be minimal. There is no reason to expect that this would change in the upcoming decades. It is unlikely that alternate means of access could not be found to accomplish recovery or conservation objectives, although costs may increase in some situations. With the exception provided under all prohibition action

alternatives that an existing road may be realigned to prevent irretrievable resource damage, adverse effects to TEPS and other species from existing roads may be mitigated.

Summary of Effects – No adverse environmental effects to these species would be expected from this alternative, since it does not authorize any ground disturbing activities. The current capability of the Forest Service and of other agencies with jurisdictional responsibilities to manage species or habitat within these areas would not be measurably affected by such a prohibition. None of the alternatives would reduce existing access. The Agency would retain the tools necessary to manage these resources. Overall effects relative to conservation of TEPS species and biodiversity would be beneficial.

Alternative 3

This alternative would provide important national conservation for TEPS species and their habitats given the diversity and distribution of these species affected by inventoried roadless areas. Without road construction and reconstruction, non-stewardship timber harvest, and many of the activities that roads enable, there would be a lower likelihood of harassment, disruption, illegal take, and habitat degradation, relative to Alternatives 1 and 2. Table 3-32 displays planned offer volumes and miles of road construction or reconstruction, both with and without the Tongass exemption, for each alternative. Overall effects to conservation of TEPS species would be beneficial, and would be somewhat greater than those of Alternative 2.

A comprehensive description of the potential effects from road construction and timber harvest that would be reduced or avoided under this alternative can be found in the sections on Terrestrial Animal Habitat and Species, Aquatic Animal Habitat and Species, and Terrestrial and Aquatic Plant Species, and in the biological evaluation for this project.

As described under Alternative 2, through 2004, no planned activities from conservation strategies for sensitive species were identified that would require road construction in inventoried roadless areas, and only one project requiring road construction was identified for recovery of T&E species, for which alternate designs not requiring road construction are available. There is apparently little need for road construction or reconstruction in inventoried roadless areas for recovery or protection of TEPS species.

Summary of Effects – The current ability of this Agency and of other government agencies with jurisdictional responsibilities relative to these species would be unimpaired. Under the exception that an existing road may be realigned to prevent irretrievable resource damage, adverse effects to TEPS and other species from existing roads may be mitigated. No adverse environmental effects to these species would be expected from this alternative, since it does not authorize any ground disturbing activities. The overall effects relative to conservation of TEPS species and biodiversity would be beneficial.

Alternative 4

Given the numbers, diversity, and distribution of TEP and sensitive species that have habitat in inventoried roadless areas, this alternative would provide important local, regional, and national protection for these species and their habitats. Without road construction, reconstruction, or timber harvest, and many of the activities that roads enable, there would be a lower likelihood of harassment, disruption, illegal take, and habitat degradation. The beneficial effects of this alternative would be similar to those described for Alternatives 2 and 3.

This alternative includes an additional exception for TEP species, as described in Chapter 2. The responsible official may authorize an exception to the prohibition on timber harvest if it is determined that such harvest is:

- Necessary to prevent degradation or loss of habitat for a TEP species to the extent that such loss or degradation would increase the risk of extinction; or
- An important action needed to promote recovery of a T&E species.

In all cases, agreement that a project is warranted would need to be obtained from the NMFS or U.S. Fish and Wildlife Service, as applicable. It is not anticipated that this exception would be used frequently or for large-scale projects, but rather for conservation of specific habitat components necessary for continued species viability where a clear need is identified. This exception would not apply to sensitive species.

An example of why the exception may be applied is for recovery of the red-cockaded woodpecker (RCW). In their biological opinion on the revised land management plan for NFS lands in Texas, the U.S. Fish and Wildlife Service (USDI Fish and Wildlife Service 1996) identified concerns about the limited ability of the Forest Service to cut trees to maintain or improve habitat for RCW within Wilderness areas, which would permit midstory encroachment and uncontrolled southern pine beetle infestations. They concluded that several RCW clusters were likely to be lost and six more would be adversely affected by loss of foraging habitat. These same needs may exist for RCW habitat in inventoried roadless areas. Another possible scenario would be a thinning project to reduce fuel loading and risk of high-intensity stand replacing wildland fire to protect a single remaining endangered plant population. This exception would permit such activities, providing the appropriate regulatory agency concurs.

A comprehensive description of the potential effects from road construction and timber harvest avoided under this alternative can be found in the sections on Terrestrial Animal Habitat and Species, Aquatic Animal Habitat and Species, and Terrestrial and Aquatic Plant Species, and in the biological evaluation.

Potential for Adverse Effects from the Prohibition on Timber Harvest – An important objective of this analysis was to determine whether a prohibition on timber harvest in inventoried roadless areas would have any adverse effects on the ability of Agency to take actions needed to conserve or protect TEPS species and their habitats. For example, there may be situations where excessive build up of fuels could result in an increased incidence of uncharacteristically large, stand-replacing wildland fires. Pretreatment of

areas through thinning may be desirable to safely use prescribed fire. There may also be a need to restore or enhance stand structure and composition to sustain suitable habitat for some TEPS species, such as previously described for the red-cockaded woodpecker.

The indirect effects of a prohibition on timber harvest, therefore, would have potential implications to management of TEPS species in inventoried roadless areas. Given that concern, the exception for timber harvest for conservation or recovery of TEP species was added to this alternative. As described above, Alternative 4 would not preclude use of timber harvest for stand enhancement, successional stage management, or fuels reduction when needed for recovery or protection of TEP species, provided the applicable Federal agency with ESA oversight responsibilities supports the need. As there is essentially, then, no prohibition of timber harvest that would preclude activities needed for recovery or conservation of TEP species, none of the action alternatives would pose an increased risk of adverse effects, relative to the No Action Alternative. This exception, however, would not apply to sensitive species.

In evaluating the potential need for fuels reduction efforts for conservation of sensitive species, it is important to recognize that, for many terrestrial and aquatic ecosystems, fire has played an important role in creating and maintaining suitable habitat at varying temporal and spatial scales. Many terrestrial and aquatic species evolved under the influence of recurrent fire, including stand replacing events, and their long-term persistence relies heavily on the maintenance of important habitat components by these disturbance events. For example, wildland fires that create habitat mosaics can improve foraging habitat for lynx (USDA and others 2000). Fire-killed trees provide an important and continuing supply of large woody debris to many aquatic systems, which is an essential habitat feature for many salmonid and other aquatic species. While such disturbance events may have negatively affected individuals of some TEPS populations, the overall effects on species population viability are less likely to have been adverse in nature.

The effects of wildland fires on terrestrial and aquatic species can vary depending on fire occurrence, intensity, severity, uniformity, size, and season. The effects of fire may be both direct and immediate, as well as indirect and sustained over an extended period (Minshall and others 1989; Niemi and others 1990; Smith 2000). Some impacts may result in short term habitat loss, but long-term habitat enhancement. For example, fires may destroy some northern goshawk nest sites. However, these same fires may also create the habitat mosaics that enhance goshawk habitat. Species with limited ranges or low population numbers may be more vulnerable. For example, adverse effects to fish populations have been limited to areas where native fish populations have declined and become increasingly isolated because of human activities (Gresswell 1999).

The analysis in the FEIS showed that some types of past timber harvest and the effectiveness of past wildland fire suppression have caused significant ecological shifts in vegetation, fuel loading, and fire regimes in some areas, increasing the risk of high-intensity, large-scale, stand-replacing fires in many areas. However, as previously discussed in the Fuel Management section, there appear to be minimal landscape level differences between alternatives, relative to the likelihood of timber harvest providing

significant reduction in the risk of uncharacteristic wildland fire effects in inventoried roadless areas, at projected harvest levels. There is also a lack of current scientific literature addressing the feasibility, effectiveness, and ecological legacies of landscape-level fuels reduction efforts.

Regardless of the alternative selected, wildland fires of increased severity and size will continue to impact habitat for some species. While wildland fires may negatively affect individuals in some TEPS populations, the overall effects on population viability are less likely to be adverse in nature. None of the alternatives would preclude the use of other restorative tools like prescribed fire, which under some conditions can be used without prior thinning, to benefit early seral and open forest species.

Summary of Effects – Based on the information provided by each national forest, the need for road construction or reconstruction for recovery or protection of TES species appears to be minimal. Alternate means of access could likely be found to accomplish recovery or conservation objectives. With the exception provided in the proposed rule that an existing road may be realigned to prevent irretrievable resource damage, adverse effects to TEPS and other species from existing roads may be mitigated.

As previously discussed, the prohibition of timber harvest could be waived to permit needed for recovery or conservation of TEP species. This alternative would prohibit timber harvest that may be desirable to enhance or restore habitat for some sensitive species at the local level. However, it is unlikely that this inability would represent a substantial change in the overall level of risk to continued species viability from that expected under the No Action Alternative. Overall, this alternative would be beneficial to conservation of TEPS species and biodiversity.

Effects of Social and Economic Mitigation on Biodiversity

These mitigation measures could result in an additional 65 miles of road construction (none expected on the Tongass) in inventoried roadless areas over the next 5 years. This would increase the miles of road construction and reconstruction under Alternatives 2, 3, and 4 from 293 to 358 (662 miles with the Tongass exemption).

It is impossible to predict the amount or location of road reconstruction that would be excepted for reasons of public health and safety. Realignment or upgrade of roads would likely result in additional ground disturbance, but it is unlikely that the environmental effects of such reconstruction would substantially expand the area affected beyond that of the original construction, especially given the current emphasis on environmentally sensitive design and use of best management practices. Such reconstruction could result in substantial changes in the kinds and amount of human uses in an area, with potential adverse effects on biodiversity as previously described.

Estimates of the miles of road construction that may be excepted for Federal Aid Highway projects over the next 5 years indicate that few additional miles would likely be constructed in inventoried roadless areas. There is no reason to anticipate a substantial increase in the future. Only one 6-mile project is currently planned on the Chugach

National Forest. While this project may have local effects on the characteristics and values associated with the affected inventoried roadless area, this limited level of activity would not result in a substantial change in the overall environmental effects of the alternatives.

As currently projected for the next 5 years, requests for new leasable mineral activities in inventoried roadless areas are expected on six national forests, requiring an estimated 59 miles of road construction. There would likely be additional activities on other forests in the future, in response to changing economic conditions and shifts in supply and demand for these resources. The types of activities that would be eligible under this exception include exploration and development of geothermal, oil and gas, coal, and phosphate resources.

There appears to be limited potential in the near future for geothermal development activity associated with inventoried roadless areas, based on data submitted by the national forests and grasslands. Only one forest anticipated lease applications in the next 5 years, with 3 miles of associated temporary road construction. Although the magnitude of effects from geothermal exploration and development would depend on a variety of factors, impacts from such activities do not appear to pose substantial or widespread risks to biodiversity. Geothermal exploration activity in many areas has been restricted in extent and has often resulted in little disturbance to areas around drilling sites. As the location of drilling sites for exploration is often somewhat flexible, environmentally sensitive areas usually can be avoided (USDA Forest Service and USDI Bureau of Land Management 1994b).

Oil and gas exploration and development activity within inventoried roadless areas is anticipated on four national forests in the next 5 years, with an estimated 34 miles of road construction. Nationally, the demand for these resources is increasing. Therefore, there may be increases in this activity within inventoried roadless areas on these four forests and other NFS lands. The associated road systems would likely account for a substantial portion of potential environmental effects, including increased risk of spread and establishment of nonnative plant species.

Other effects of these activities would be determined by the:

- location and size of areas disturbed,
- duration of the activity,
- mitigation measures used for environmental protection including containment of toxic materials used in the drilling process,
- type and effectiveness of site reclamation,
- overall level of exploration and development activity within an area, and
- persistence of any post-project activities.

Ten projects on two national forests were identified that would involve exploration or development of coal or phosphate resources, with an estimated 22 miles of road construction. In addition to the potential effects of road construction associated with these

projects, these kinds of activities can have adverse effects to aquatic and terrestrial species, some of which can be substantial and long term.

Environmentally, application of the social and economic mitigation measures to the prohibition alternatives would diminish the potential beneficial effects of a prohibition on road construction and reconstruction, given the greater amount of area disturbed and the kinds of activities enabled. Depending on a variety of factors, leasable mining activities supported by road access would potentially have detrimental effects to aquatic and terrestrial habitats and species. However, at current levels of activity and given the application of best management practices, the potential extent of these activities and their impacts do not appear to be widespread and it is unlikely that most effects would extend much beyond local levels. Decisions on whether to permit such activities, and if so, what environmental mitigation measures would be required, would be made using current land management planning and decision-making processes. Overall, even with application of these measures, Alternatives 2, 3, and 4 would still provide important benefits relative to conservation of biological diversity.

Other Indirect and Cumulative Effects on Biodiversity

The cumulative effects of the prohibitions, and past, present, and reasonably foreseeable actions on biodiversity were considered in this analysis for several time intervals and geographical scales. Short-term effects were considered to occur in the next 5 years. Long-term effects were considered generally to be two or more land management planning cycles (30 to 40+ years). Where applicable the cumulative effects were assessed at local, regional, and national scales, including local inventoried roadless areas, all NFS lands, regions of the United States, and the entire United States. Various land ownership patterns and land designations were also considered.

Several ecological and biological resource indicators discussed in the Biodiversity section of this chapter were used to assess the cumulative effects of the prohibitions, land uses and conversions, laws, regulations, policies, and nonnative species invasions on biodiversity. Biodiversity resource indicators used were the habitat and population trends for terrestrial and aquatic plant and animal species, and communities (including TEPS) and **landscape characteristics**.

Based on current literature (Flather and others1999; Noss and Cooperrider 1994; Stein and others 2000) and data from Forest Service regions, it is possible to conclude that with or without conservation of inventoried roadless areas, biodiversity is at an increased risk of adverse cumulative effects from increased population growth and associated land uses, land conversions, and nonnative species invasions. Conservation of inventoried roadless areas provided by the alternatives, however, may lessen this risk at least in the short term (20 years) by reducing the level of potential adverse impacts on inventoried roadless areas, some of the last relatively undisturbed large blocks of land outside of designated Wilderness. The action alternatives would increase conservation of inventoried roadless areas and therefore, could have beneficial effects on biodiversity conservation at the local, regional, National Forest System, and national levels. There would be similar incremental beneficial effects on biodiversity conservation when any one of the

prohibition alternatives is combined with the past, present, and reasonably foreseeable land uses and conversions, laws, regulations, policies, and nonnative species invasions. The local, regional, and national cumulative beneficial effects could include:

- Conserving and protecting large contiguous blocks of habitat that provide habitat connectivity and biological strongholds for a variety of terrestrial and aquatic plant and animal species including TEPS species.
- Providing important local and regional components of conservation strategies for protection and recovery of listed TEPS species.
- Providing increased assurances that biological diversity would be conserved at a landscape level, including increased area of ecoregions protected, improved elevational distribution of protected areas, decreased risk of additional timber harvest and road caused fragmentation, and maintenance and restoration of some natural disturbance processes.
- Providing increased assurance that biodiversity would be supported within inventoried roadless areas including the maintenance of native plant and animal communities where nonnative species are currently rare, uncommon, or absent.

The value of inventoried roadless areas in conserving biodiversity is likely to increase as habitat loss and habitat degradation increase in scope and magnitude. With these increasing trends, the importance of roadless area conservation and other laws, regulations, and policies in the management of biodiversity is also likely to increase.

The action alternatives when considered alone may not be as important on a national level as when considered in combination with other land conservation laws, policies, and strategies. For example, many inventoried roadless areas in combination with Wilderness Areas, Nature Conservancy Preserves, some National Forest System land allocations, national parks, or conservation easements provide large contiguous habitat blocks with national significance for biodiversity conservation.

The beneficial effects of the prohibitions may be most noticeable at an inventoried roadless area, regional, or NFS level, but there are also beneficial effects for the United States. For instance, in the Southeastern United States, because of the magnitude of land use and land conversion, and the relatively small size of existing protected areas, inventoried roadless areas are especially important for local species like the Louisiana black bear. Similarly, inventoried roadless areas in some areas of the Forest Service Intermountain and Northern regions of the Western United States, contribute to habitat connectivity, which is an important feature of northern Rocky Mountain ecosystems for species like the grizzly bear, wolf, and lynx. In these examples, the local protection and conservation of T&E species habitat is also important in terms of conserving biodiversity at a national level.

Whether the cumulative beneficial effects of the prohibitions and other past, present and reasonably foreseeable actions would fully offset predicted future increases in land uses, land conversions, and nonnative species invasions is difficult to assess. Yet, it is possible to conclude that without the prohibitions, there would likely be an increased risk of adverse cumulative effects to biodiversity. When compared to the No Action Alternative, the prohibition action alternatives would help conserve management options over the

next 20 or more years, so society would have time to make choices on biodiversity conservation.

At some point in the future, projected habitat loss and degradation, from the direct and indirect effects of increasing population growth could potentially surpass the contribution of inventoried roadless areas to biodiversity conservation. In this scenario, habitat loss and loss of viable plant and animal populations may be of a magnitude such that the beneficial effects of the prohibitions and other laws, regulations, and policies relative to biodiversity conservation may be lost or overwhelmed. Even under this scenario, inventoried roadless areas would still likely convey some beneficial effects relative to conservation of individual species locally, regionally, and nationally.

Research, Monitoring, and Reference Landscapes

Widespread interest exists in obtaining information about large-scale ecological patterns, processes, and management activities (Bormann and others 1999). Issues, such as viability of wide-ranging animals, watershed cumulative effects, and restoration of fire dependent ecosystems, require research and monitoring at large scales to significantly address this interest. Inventoried roadless areas enable monitoring of long-term environmental change, an improved understanding of the affect of past events and activities on the landscape, and help to establish emerging management policies, programs, and activities and evaluate the effects of past policies.

Unique opportunities to gather information about ecological systems and human related impacts exist in these areas because, unlike wilderness, national parks, and other restrictive areas, roadless areas provide large expanses where a range of management treatments may be applied and tested. Gathering this information is possible through research and monitoring activities conducted in partnerships between scientists, the public, and managers (Bormann and others 2000).

Large areas for the long-term study of trends in ecosystem health are available in inventoried roadless areas. For example, inventoried roadless areas may be used to study changes in neo-tropical migratory bird populations, climate change, global warming impacts on forest ecosystems, and impacts of nonnative invasive species on natural ecosystems. This type of research and monitoring typically involves establishment of measurement plots and installation of equipment to periodically measure change.

Inventoried roadless areas also serve as valuable reference points for comparison of the effects of past activities on adjacent lands; especially in larger areas adjacent to wilderness or parks. Comparison of long-term effects that roads have had on watersheds, recreation, forest health, and other resources is only possible if roadless areas are available as a basis for comparison.

Inventoried roadless areas provide an opportunity for research and monitoring efforts to help Agencies understand the consequences of their land management policies. Public

land management policies have a history of change. Future policies will likely be different from present and past policies. The past policy of intensive clearcutting and roading is giving way to a widely supported program focusing on small trees and fuel reduction to restore ecosystems damaged by continued fire suppression. Future choices, to a large degree, will be dependent on the results of trials and knowledge gained through research and monitoring as policies and programs change.

As an example, well-designed landscape scale management experiments are needed to evaluate methods for restoring historical fire regimes and fuel loads in the Intermountain West. Important questions to consider include:

- Can ecological effects from large, uncharacteristic wildland fires be reduced through prescribed fire, mechanical treatments, or a combination of these fire treatments? Which approach will best suit the needs of which ecosystem?
- What are the long-term landscape effects from continued wildland fire suppression in fire-dependent ecosystems? Can these effects be mitigated through management? What is the recovery time of severely burned ecosystems?
- Should land managers use an active or "natural" approach to restoring fire regimes? What are the consequences of both of these choices?
- Are roads needed to restore historical fuel conditions and fire behavior?

These questions might be answered by applying several different treatments to roadless, roaded, or a combination of these areas. Treatments might include total fire suppression, allowing only wildland fires to burn, fuel reduction with prescribed fire only, or using a combination of mechanical fuel cutting and prescribed fire. All treatments would require application time sufficient to obtain the desired information. At a minimum, such large-scale management experiments would require reevaluation when land management plans are revised. The commitment of scientists, managers, and the public is critical to sustaining long-term research and monitoring success.

Inventoried roadless areas provide different opportunities for study than are found in other designations, such as Wilderness Areas, Research Natural Areas, Experimental Forests, or general forestland. In Wilderness and Research Natural Areas, learning opportunities are limited because it may be impossible to apply certain management prescriptions; particularly the more intensive ones. Conversely, in Experimental Forests or general forestland, a broad range of treatments, such as roading, clearcutting, or other intensive management, may occur.

Long-term commitment to learning is essential to achieve sustainable ecosystem management. The next generation of scientists, citizens, and managers may benefit from the information derived from today's land management experiments. Working collaboratively with scientists, managers, and the public in development of research and monitoring activities could help ensure that the right questions and values are considered and that long-term commitments to learning are made.

Alternatives 1 through 4

No alternative precludes the use of inventoried roadless areas for future research and monitoring. The No Action Alternative would reduce the opportunity for long-term study where comparisons of natural settings are needed since many inventoried roadless areas would be subject to commodity production and development. Alternatives 2 and 3 place progressively greater limits on human activities, which will narrow the range of possible management experiments. For example, under Alternative 3, clearcutting experiments would be unacceptable since this alternative promotes stewardship related activities. Alternative 4, which does not allow timber harvest including thinning before prescribed fire, places the most limits on the range of possible management experiments. Alternative 4 would affect ongoing research projects that require mechanical vegetation treatments. Alternative 4 would place greater limits on research than Alternatives 2 or 3.

Human Uses

Timber Harvest

Affected Environment

American forests have a wide variety of forest types and ages, including old-growth stands, naturally regenerated forests, and planted forests. Areas of old growth remain in the Pacific Northwest, parts of California, and much of the Rockies. East of the 100th meridian (Figure 1-1), most of the forests are second growth, naturally regenerated stands. In some cases, these lands were never fully converted to agricultural use, but selective logging was common. The tree species found in these stands are usually similar to those that would have existed there before European settlement. Even in most forest plantations, the species composition mimics the forest that would have naturally regenerated there (Sedjo 1991).

Of the 747 million acres of forestland in the United States, about 490 million acres are considered commercial forestland, capable of growing 20 cubic feet or more per acre per year. About 72% of all commercial forestland is found in the Eastern United States and 28% is found in the West. Private lands account for 71% of the total commercial forestland. National forests account for another 19% of the total commercial forestland, the remaining 10% are in other public or Tribal ownerships. The volume of timber on all forestlands has been increasing since 1952 when inventory data first became available. Much of the hardwood timber volume is in the East, while much of the softwood volume is in the West. In the West, 46% of the softwood timber resource is on NFS lands (USDA Forest Service 1999j).

In 1997, the volume of growing stock on all NFS lands was approximately 1,260 billion board feet. Net annual timber growth in 1996 on all NFS lands was about 20.5 billion board feet. Removal of timber volume from all NFS lands due to harvest, mortality, or land clearing for the same year totaled about 4.1 BBF. Removal for 1996 was