HABITAT FRAGMENTATION AND THE EFFECTS OF ROADS ON WILDLIFE AND HABITATS

Background and Literature Review
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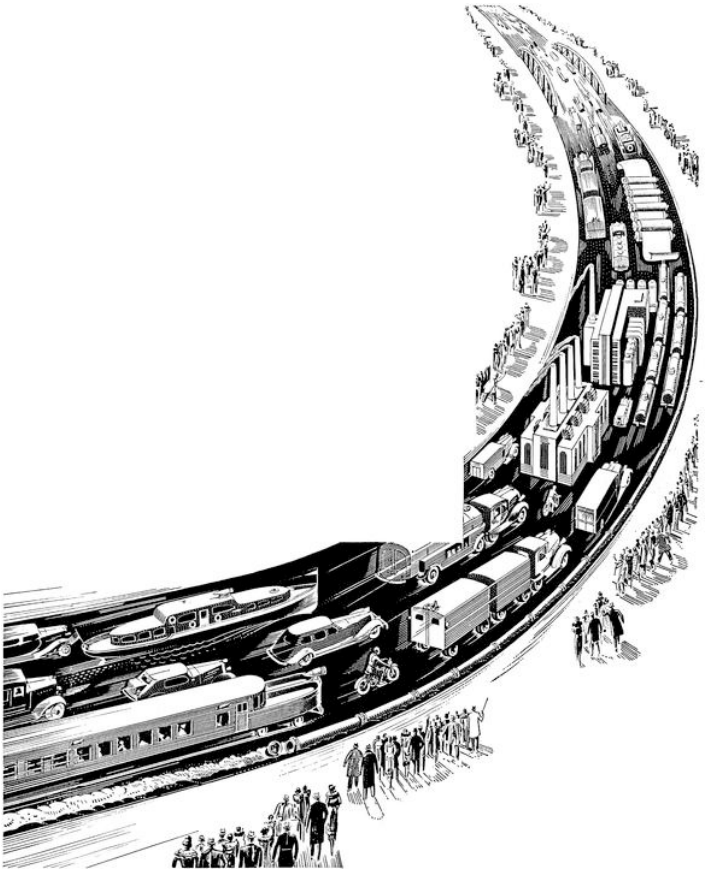

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Introduction

This document is intended for use as a resource to assist in assessing the potential impacts of roads and highways on terrestrial and aquatic habitats, species, and ecosystem processes. This review is compiled of relatively current peer-reviewed and scientific "grey" literature, and is not meant to be all-inclusive, but presents a range of potential impacts of roads and highways to species, habitats, and ecological processes.

I. Habitat Fragmentation:

By far, the largest single threat to biological diversity worldwide is the outright destruction of habitat, along with habitat alteration and fragmentation of large habitats into smaller patches (Meffe et al. 1997). The two components of habitat fragmentation are 1) the reduction of the total amount of a habitat type in a landscape; and 2) the reapportionment of the remaining habitat into smaller, more isolated patches of habitat (Harris 1984; Wilcove et al. 1986; Saunders et al. 1991 *in* Meffe et al. 1997).

II. Adverse effects of habitat fragmentation to populations/species:

Habitat fragmentation creates landscapes made of altered habitats or developed areas fundamentally different from those shaped by natural disturbances that species have adapted to over evolutionary time (Noss and Cooperrider 1994 *in* Meffe et al. 1997). Adverse effects of habitat fragmentation to both wildlife populations and species include:

- Increased isolation of populations or species, which leads to:
  - Adverse genetic effects; i.e. inbreeding depression (depressed fertility and fecundity, increased natal mortality) and decreased genetic diversity from genetic drift and bottlenecks;
  - Increased potential for extirpation of localized populations or extinction of narrowly distributed species from catastrophic events such as hurricanes, wildfires or disease outbreaks;
- Changes habitat vegetative composition, often to weedy and invasive species;
- Changes the type and quality of the food base;
- Changes microclimates by altering temperature and moisture regimes,
- Changes flows of energy and nutrients;
- Changes availability of cover and increases edge effect, bringing together species that might otherwise not interact, potentially increasing rates of predation, competition and nest parasitism;
- Increases opportunities for exploitation by humans, such as poaching or illegal collection for the pet trade;

III. The Role of Roads

Roads are a major contributor to habitat fragmentation because they divide large landscapes into smaller patches and convert interior habitat into edge habitat. As additional road construction and timber harvest activities increase habitat fragmentation across large areas, the populations of some species may become isolated, increasing the risk of local extirpations or extinctions (Noss and Cooperrider 1994). Appendix 1 is an

excerpt from the May 2000 Forest Service Roadless Area Conservation Draft Environmental Impact Statement Vol. 1 and presents information related to ecological benefits of roadless areas. Appendix 2 is a literature review pertinent to road impacts to wildlife and habitats and tied by reference numbers to specific literature citations that are included within that section.

Some of the primary adverse impacts of roads and highways on wildlife and wildlife habitats include:

A. Direct loss of habitat (see Forman et al. 2003):

- 3.9 million miles of roads in the U.S.
- 2.3 million miles are paved.
- Nationwide, 71 million acres of habitat have been lost to primary highways.
- U.S. Forest Service currently maintains and administers ca. 386,000 miles of roads on Forest Service lands, which would circle the equator fifteen times.
- Roads remove two acres of habitat per mile of sixteen-foot-wide road.
- Seven million acres of national forest lands are under roads.
- New Mexico has over 206,000 miles of major and minor roads, including U.S. Forest Service classified roads on National Forest lands in New Mexico (data sources: Earth Data Analysis Center, RGIS, U.S. Forest Service Region 3, Tiger Data).

B. Reduction of effective (useable) habitat near roads for deer and elk:

- Rost and Bailey (1979) found that deer and elk in Colorado avoided roads, particularly areas within 200 meters of a road.
- Berry and Overly (1976) found that roads reduce big game use of adjacent habitat from the road edge to over 0.5 miles away.
- Leege (1976) found that logging and road-building activity along major migration routes changed the winter distribution of elk.
- Thiessen (1976) found that elk occurred in greater densities in roadless area compared to roaded areas. Hunter success was higher in roadless areas compared to roaded areas in Unit 39 in west central Idaho.
- Lyon (1979) found that elk in Montana avoided habitat adjacent to open forest roads, and that road construction creates habitat loss that increases impacts to elk as road densities increase.

C. Direct mortality (see Forman et al. 2003):

- An estimated one million vertebrates are killed daily on roads in the United States.
- Nationally, researchers hired by the Insurance Institute for Highway Safety estimate that more than 1.5 million deer/vehicle collisions occur annually, resulting in more than 29,000 human injuries and 150 deaths.
- In New Mexico, accident report data compiled by the UNM Department of Government Research documented 914 large game animal/vehicle collisions in 2002 and an annual average of 828 large game animal/vehicle collisions since 1998. This number represents only a fraction of the total large game animal/vehicle collisions that actually occur in New Mexico annually, as many go unreported.

- Nationally, annual property damage to vehicles from collisions with deer is $1.1 billion.

D. Increased noise and visual disturbance for deer and elk:

- Yarmaloy (1988) found that mule deer experimentally harassed by an ATV altered feeding and spatial-use patterns, and produced fewer offspring the following year.
- Repeated human disturbance or harassment of big game populations on crucial winter ranges can change activity patterns, increase predation, reduce access to resources, and increase energy expenditures necessary for survival (Geist 1978 and Hobbs 1989 *In* Easterly et al. 1991).
- Lyon and Vasile (1980) found that an expanding network of logging roads made elk more vulnerable to hunters and harassment, and higher road densities caused a reduction in the length and quality of the hunting season, loss of habitat, overharvest, and population decline.
- Dorrance et al. (1975) found that home-range size and daily movement of white-tailed deer increased with increasing snowmobile activity in Minnesota.
- Wray (1990) found that logging roads made nearby elk herds more vulnerable to human interference year-round, not just during hunting season.

E. **Increased illegal killing of deer and elk:**

- Bancroft (1990) revealed the widespread illegal practice of road hunting in Arizona using decoy deer and elk. Eleven of 19 archery elk and deer hunters and 41 of 53 firearms hunters committed violations by attempting illegal take after observing a decoy from their vehicle.

F. **Road closure benefits for elk:**

- Leptich and Zager (1991) reported that no bull elk in highly roaded areas in Montana lived more than 5.5 years, and only 5% lived to maturity. Closing roads extended the age structure of the bull population to 7.5 years, and 16% of the bull population consisted of mature animals. One result of road construction is the decreased capacity of the habitat to support elk from decreased habitat effectiveness. Loss of habitat effectiveness can be at least partially reversed by road closures.
- Basile and Lonner (1979) found that travel restrictions on roads appeared to increase the capability of the area to hold elk in Montana.
- Irwin and Peek (1979) found that road closures allowed elk to remain longer in preferred areas.
- Johnson (1977) studied road closures in the Tres Piedras area in New Mexico during big game season with general public acceptance and increased elk harvest.
- Although the Forest and Rangeland Renewable Resources Planning Act of 1974 requires that temporary roads be closed and revegetated after use, Forest roads are generally difficult to close and maintain as closed, especially when Forests are managed as “Open Unless Designated Closed", such as the Carson National Forest (18 Feb. 1997 NMGF memo) (see Department Guidelines on Effective Closure of Roads-to be developed).

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Appendix 1
Ecological Benefits of Roadless Areas

From May 2000 Forest Service Roadless Area Conservation
Draft Environmental Impact Statement Vol. 1

A. Protection of overall watershed health. 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 flow, and temperature regime, are less likely to be altered (Furniss et al. 1991). Illegal introduction and excessive harvest of fish species are also less likely to occur in these areas due to lack of easy access. The timing of water runoff can change as roads and related drainage structures intercept, collect, and divert water. These factors can accelerate water delivery to the stream; therefore, more water becomes storm runoff, increasing the potential for runoff peaks to occur earlier, be of greater magnitude, and recede quicker than in unroaded watersheds (Wemple et al. 1996). While mass wasting (landslides) is a natural process in some regions, extensive research in the West has closely linked land management practices, primarily roading and timber harvest, with accelerated incidence of mass wasting by several orders of magnitude (Swanston 1974, Anderson et al. 1976, Swanston and Swanson 1976, Sidle et al. 1985, Swanston 1991). All of these watershed effects can have direct impacts on salmonid fish species and their habitats (Furniss et al. 1991).

B. Maintenance of water and soil quality. Roads have long been recognized as the primary human-caused source of soil and water disturbances in forested environments (Patric 1976, Egan et al. 1996). Generation of sediment within timber harvest units is most strongly related to roading and associated facilities needed to remove the trees, rather than to the act of cutting the trees (Anderson et al. 1976). The New Mexico Water Quality Control Commission states "Almost 1,204 miles of New Mexico's waters have been assessed and determined to fully support all designated uses. The majority of these waters are in wilderness areas or in watersheds protected from anthropogenic impacts" (NMWQCC 2000). Degraded water and soil quality from roading adversely affect salmonid fish species and their habitats (Furniss et al. 1991).

C. Conservation of habitat important to wildlife by reducing the potential for fragmentation, degradation and human disturbance. Habitat in roadless areas is generally less fragmented and better-connected than in roaded areas of similar size. Reed et al. (1996) found that roads added to forest fragmentation more than clearcuts by dissecting large patches into smaller pieces and by converting forest interior habitat into edge habitat. Edge habitat created by roads was 1.54-1.98 times the edge habitat created by clearcuts. Clearcut timber harvest units and associated roads affect 2.5-3.5 times more landscape than surface area occupied by the actual activities themselves (Reed et al. 1996). Over the past 50 years, landscapes have been appreciably impacted from fragmentation caused by road construction and clearcutting (Harris 1984, Saunders et al.

1991, Noss and Csuti 1994, Forman and Alexander 1998). Loss of large trees, snags, and logs in areas adjacent to roads through commercial harvest or firewood cutting has had adverse effects on snag and cavity dependent birds and mammals (Hann et al. 1997). Roads facilitate poaching of many large animals such as caribou, pronghorn, mountain goat, bighorn sheep, wolf and grizzly bear (Cole et al. 1997, Dood et al. 1985, Knight et al. 1988, McLellan and Shackleton 1988, Mech 1970, Stelfox 1971, Yoakum 1978).

D. **Protection of stream and lake habitat for fish and other aquatic species, conserving habitat for numerous threatened, endangered and sensitive plant and animal species.** Waters within roadless areas have been shown to function as biological strongholds and refuges for many species of fish. Some of these headwaters may now play a relatively greater role in supporting viable populations of aquatic species, due to cumulative degradation and loss of downstream aquatic habitats. Lee et al. (1997) demonstrated a negative correlation between increasing road densities and viable native bull, redband, and Yellowstone and westslope cutthroat trout populations in the Columbia River Basin. Information from studies in the Columbia River Basin, an area that encompasses 144 million acres, 7 states and 35 National Forests, found that over 70% of 91 wildlife species analyzed were negatively affected by roads (Wisdom et al 2000). Findlay and Bourdages (2000) found that evidence is accumulating that road construction may result in significant loss of biological diversity at both local and regional scales due to 1) restricted movement of species between local populations; 2) increased mortality; 3) habitat fragmentation and edge effects; 4) invasion by exotic species; and 5) increased human access to wildlife habitats, all of which are expected to increase local extinction rates or decrease local recolonization rates. In the Forest Service's Southwestern Region 3, 57% of Threatened, Endangered and Proposed species under the federal Endangered Species Act, and 54% of Forest Service Sensitive species are dependent on habitat within or affected by inventoried roadless areas.

E. **Maintaining area resilience to invasion by non-native species.** Roads serve as a means of dispersal for many non-native invasive plant species, with seed or plant parts inadvertently transported into previously unaffected areas. Ground disturbance associated with roads and other road-related activities provides additional opportunities for establishment of invasive non-native plant species (Parendes and Jones 2000). Continued roading in National Forests poses the greatest risk for increased spread of non-native invasive species due to the disturbance associated with roads. Continued roading would allow a corresponding increase in the adverse ecological effects associated with establishment of invasive species, such as habitat alteration, replacement of native species, and alteration of ecosystem processes.

Appendix 2
Literature Review of Road Effects to Wildlife and Habitats

(From NMGF, 14 July 2000, comments on U.S. Forest Service Roadless Area Conservation Draft Environmental Impact Statement (NMGF Doc. No. 7094)).

1) **Adverse impacts of roads on aquatic and terrestrial habitats from fragmentation or disruption of dispersal and migration corridors:** [31, 23, 33, 35, 37, 39, 48, 54, 57, 61, 103, 106, 107, 109, 134, 139, 145, 150, 152].
2) **Adverse impacts of roads to terrestrial wildlife species from mortality (from roadkill, road construction, increased illegal take, etc.):** [3, 4, 16, 19, 23, 24, 25, 31, 33, 35, 51, 60, 61, 68, 71, 74, 76, 77, 78, 86, 94, 117, 121, 129, 130, 134, 148, 149, 151, 156].
3) **Adverse impacts of roads to terrestrial wildlife species by altering reproductive behavior or affecting reproductive success (other categories of effects in this review can also affect reproductive success):** [2, 32, 33, 61, 92, 96, 134, 149, 158].
4) **Adverse impacts of roads to terrestrial wildlife species by 1) reducing or eliminating habitat effectiveness from road presence and associated human disturbance; or 2) significantly altering habitat use by avoidance of areas previously used (beyond a temporary habituation response):** [4, 5, 7, 12, 13, 14, 15, 18, 19, 22, 26, 29, 33, 42, 49, 53, 59, 63, 64, 65, 66, 67, 68, 70, 72, 81, 85, 94, 98, 99,100, 105, 109, 111, 112, 113, 114, 120, 122, 127, 131, 132, 134, 137, 138, 147, 149, 156, 157].
5) **Landscape scale adverse impacts of roads to fishes and other aquatic species' population viability and aquatic habitats from 1) declining watershed health and function from increased erosion, sedimentation and altered chemical composition that degrade water quality; 2) bridge and culvert alteration of stream channels, floodplains and wetlands morphology and function; and 3) altered runoff quantities, timing and patterns:** [8, 9, 11, 17, 27, 28, 29, 35, 36, 40, 45, 46, 50, 55, 56, 58, 62, 79, 80, 83, 84, 87, 88, 89, 91, 102, 103, 108, 110, 115, 118, 126, 133, 134, 142, 143, 153, 154].
6) **Adverse impacts of roads on terrestrial and aquatic wildlife and habitats by acting as dispersal mechanisms for non-native and invasive species. Nonindigenous species are thought to be the second major cause (habitat loss being the first) for the listing of all threatened and endangered species in the United States (Belsky and Gelbard 2000):** [33, 34, 38, 41, 47, 73, 75, 82, 95, 134, 135, 140, 141, 144, 155].

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