Petition Received 8/22/91

UNITED STATES FISH AND WILDLIFE SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

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| In the Matter of a Petition for a Rule Listing the Canadian Lynx (Felix Lynx Canadensis), of the North Cascades Ecosystem of Washington, as an Endangered Species pursuant to the Endangered Species Act, | PETITION |
| National Audubon Society, The Humane Society of the United States, Defenders of Wildlife, Greater Ecosystem Alliance, Friends of the Loomis Forest, Methow Valley Forest Watch, Save Chelan Alliance, Lower Columbia Basin Audubon Society, Tonasket Forest Watch, Pilchuck Audubon Society, North Cascades Audubon Society, and Sierra Club Cascade Chapter, | |
| Petitioners, | |


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## INTRODUCTION

Pursuant to the Endangered Species Act ("ACT"), 16 USC Sections 1531 et seq., National Audubon Society, The Humane Society of the United States, Defenders of Wildlife, Greater Ecosystem Alliance, Friends of the Loomis Forest, Methow Valley Forest Watch, Save Chelan Alliance, Lower Columbia Basin Audubon Society Tonasket Forest Watch, Pilchuck Audubon Society, North Cascades Audubon Society and Sierra Club Cascade Chapter (collectively "PETITIONERS"), hereby petition the Office of Endangered Species, United States Fish and Wildlife Service ("FISH AND WILDLIFE SERVICE"), for a rule:

(i) listing the North American lynx (Felix Lynx Canadensis) of the North Cascades Ecosystem of Washington ("LYNX"), as an endangered species, and

(ii) designating critical habitat for the Lynx.

This petition is filed pursuant to 5 USC Section 553(e) and 50 CFR Section 424.14 (1986), which obligate federal agencies to give interested persons the right to petition for promulgation of a rule.

Petitioners are environmental, animal rights, wildlife, preservation and recreation groups, and collectively have thousands of individual members throughout Washington and the United States. The Petitioners' addresses and telephone numbers are listed on Exhibit "A" of this petition. If this petition is not granted, the conservation, environmental, preservation, biological, aesthetic and recreational interests of the individuals who are members of the petitioners, will be significantly adversely affected.

Lynx is currently a category 2 candidate. Personal communication to Mitch Friedman from Larry Schanks, Fish and Wildlife Service, Denver Regional Office, June, 1991. The Lynx is in imminent danger of extinction because of (i) an extremely small population; (ii) an isolated habitat jeopardized by an ongoing practice of fire suppression, and encroachment by logging, roads, trappers and hunters; (iii) a very small prey base to feed on; and (iv) limited or no protection from the Washington State Department of Natural Resources ("DNR") and the U.S. Forest Service ("USFS"). These circumstances satisfy the criteria for protection under the Endangered Species Act. Endangered Species Act, Section 4(a).

Because the risk of extinction is immediate, Petitioners request an emergency listing for the Lynx, as an endangered

species, if the Fish and Wildlife Service will take more than one year to adopt a final rule listing the Lynx.

## EXTREMELY SMALL POPULATION

Prior to the invasion of North America by white people, Lynx inhabited a wide range in the northern 48 contiguous states. See the map which is Exhibit "B" of this petition. Lynx have been (i) extirpated throughout most of their historical range by hunting, trapping, and destruction and alteration of habitat; and (ii) reduced to remnant unsustainable populations in nearly all remaining areas.

According to Dr. Maurice Honocker, a pre-eminent feline biologist: "at the end of the [Koehler] study period, it [the north-central Washington population] was to my knowledge the most viable Lynx population in the lower 48." Personal communication to Mitch Friedman, August 12, 1991. The Okanogan National Forest Plan ("ONF Plan") confirms that the lodgepole pine areas of the Okanogan National Forest ("ONF") may contain the largest concentration of Lynx in the lower 48 states. ONF Plan, 3-10.

But even this population is alarmingly small. Only 15 to 23 Lynx live in isolation in the North Cascades Ecosystem of Washington ("CASCADES"). Koehler, 1988, p. 61.

Scientists believe that such a small population is at grave risk of extinction from multiple causes. Populations of less than 50 to 100 individuals are highly susceptible to inbreeding depression, which reduces the fitness of succeeding generations. Thompson, 1991, p. 7 (copy attached to this Petition as Exhibit "C"). Small populations are also extremely vulnerable to various uncontrollable and unpredictable events such as fire and epidemic, which can kill the entire population. Shaffer, M., 1987, p. 48.

Dramatically higher populations, perhaps numbering thousands of animals, are required to ensure the viability of any given species. See: Thompson, 1991, pp. 8-9, reviewing literature on populations and viability of species. Other researchers have uniformly concluded that the Cascades Lynx population is extraordinarily susceptible to extinction, because of the extremely small number of individuals. Carbyn and Patriguin, 1983, p. 266; Bailey, et al., 1986, p. 287.

species, if the Fish and Wildlife Service will take more than one year to adopt a final rule listing the lynx.

## ENDANGERED SPECIES PROTECTION

Prior to the impacts of North America by white people, lynx inhabited a wide range in the northern 48 contiguous states. See the map which is Exhibit 6A of this petition. Lynx have been (i) decimated throughout most of their historical range by hunting, trapping, and deforestation and alteration of habitat; and (ii) reduced to remnant unsustainable populations in nearly all remaining areas.

According to Dr. Maurice Hornocker, a pro-commercial feller biologist: "At the end of the (Canadian) study period, it (the commercial Washington on population) was to my knowledge the only viable lynx population in the lower 48." Personal communication to Mitch Friedman, August 26, 1993. The Okanogan National Forest Plan (Lynx Plan) confirms that the inadequate plans among of the Okanogan National Forest ("ONF") are certain the Tangent conservation of lynx in the lower 48 states. ONF Plan, 3-10.

But even with population is alarmingly small. Only 10 to 25 lynx live in isolation in the North Cascades. Conservation of wildlife ("CONSERVING"). Hoehler, Lynx p. 61.

Biologists believe that such a small population is at grave risk of extinction from multiple causes. Populations of less than 50 to 100 individuals are highly susceptible to increasing degrees. Minimum viable size filmers of successfully pandemics. "Thompson, 1991, p. 7 (copy attached to this petition as Exhibit 7A). Small populations are also extremely vulnerable to various uncontrollable and unpredictable events such as fire and epidemic, which can kill the entire population. Shaffer, M., 1987, p. 69.

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## ISOLATED POPULATION

Even occasional migration of individuals from other populations, could substantially increase the long-term viability of the Cascades population. Burkey, 1989, p. 79. But for all practical purposes, the Lynx in the Cascades are isolated from the only other populations which could possibly furnish emigrants; namely the populations in British Columbia. Koehler, undated, pp. 5-6 (copy attached to this Petition as Exhibit "D"). See also: Koehler, 1987; Koehler, 1988, p. 61; for locations of other Lynx populations.

The geographic and physical features which serve to isolate the Cascades' Lynx are (i) densely-roaded, low-elevation, arid lands, presently in range and agricultural uses to the East; (ii) a lower elevation forest which is densely roaded and heavily logged to the South; (iii) high alpine areas without suitable habitat to the West; and (iv) a major highway (B.C. Highway 3) traversing both the higher elevation forests and the arid lowlands of the Similkameen Valley to the North. Historically, populations to the North may have been a meaningful source of genetic diversity, or even a substantial source of individuals. Koehler, Exhibit "D", p. 2. But now the Lynx to the North are themselves subject to serious losses resulting from hunting and trapping, and loss of habitat (from pervasive logging). Koehler, 1985, p. 61; Koehler, Exhibit "D", pp. 5-6.

## EXISTING HABITAT AND FOOD SUPPLY

90% of the Lynx habitat in the Cascades is publicly owned and administered by the USFS or the DNR. The balance of the Lynx Cascade habitat is owned by ranchers and others. The critical habitat consists of at least 1795 square kilometers. Koehler, 1988, p. 11.

The Lynx is a predator and the snowshoe hare is almost the only prey of the Lynx. Koehler, 1988, p. 32. The snowshoe hare population is extemely dependent on young lodgepole pine for browse. Koehler, 1988, p. 32. A pattern of extensive fire suppression in the Cascades for more than 50 years, has substantially reduced the area covered by young lodgepole pine, thereby reducing the population of the snowshoe hare. Koehler, 1988, p. 56.

A substantial number of studies have demonstrated that Lynx require more and more habitat as their prey base is further

diminished. Koehler, 1988, p. 43, citing Brittell, unpublished Washington Department of Wildlife report; Koehler, 1988, p. 43; Ward & Krebs, 1985, p. 2821. Koehler found that the sparse prey in the Cascades caused the male Lynx to range over a territory averaging 562 square kilometers. On the other hand, in Newfoundland, where the prey are much more pervasive, the male lynx range over a territory averaging only 10 to 20 square kilometers. Koehler, 1988, p. 43.

Koehler found that the average density of Lynx in the Cascades is 2.2 animals per 100 square kilometers. The sparse density in the Cascades, contrasts ominously with the densities of almost 20 animals per 100 square kilometers found in Alaska (Bailey, et al., 1986, p. 285) and Nova Scotia (Parker, et al, 1982, p. 781), and the 8 to 10 animals per 100 square miles found in Alberta (Brand, et al., 1976, p. 419). The low density in the Cascades is directly related to the low snowshoe hare population. Koehler, 1988, p. 43; Brand, et al., 1976, p. 419.

Low reproduction rates are a direct consequence of the large territories and low prey bases. Parker, et al. 1983, p. 782. The percentage of yearling females who bear young under these conditions range from zero (0) to ten percent (10%). Parker, et al., 1983, p. 782; Brand & Keith, 1979, p. 838. When snowshoe hare are abundant, the birth rate was found to increase to 71% to 79%. Koehler, 1988, p. 55, citing O'Connor, 1986. When the prey become sparse, the adult birth rate has been shown to decline from 88% to 37% (Koehler, 1988, p. 55, citing O'Connor, 1986) and from 73% to 33% (Brand & Keith, 1979, p. 838).

The impact of extraordinarily low birth rates is compounded by very high juvenile mortality rates in the Cascades; namely 87.5% during the first six months of life. Koehler, 1988, p. 46. The high juvenile mortality rates are the result of the low prey base. Koehler, 1988, p. 46.

Evidence of the very low prey base and resulting impact on reproduction and survival rates in the Cascades, is the very high mean average age; namely 4.5 years. Koehler, 1988, p. 45-46. In areas where snowshoe hare were plentiful, the mean average age may be as low as 1.6 years. Brand & Keith, 1979, p. 839.

## IMMEDIATE THREATS TO THE SURVIVAL OF LYNX

Fire, timber harvests and road construction each pose very

serious threats to the survival of the Lynx. Timber harvests and road construction bring on a host of other threats. These other threats are alluded to in this petition and are all directly related to increased human intrusion.

Suppression of naturally occurring fires in the Cascades has been, continues to be, and is slated to remain, an integral part of forest management practices. In the ONF, the level of suppression varies with (i) the management prescription for the zone, and (ii) an evaluation process which weighs the potential loss from a fire, against the cost of suppressing the fire. ONF Plan, 3-3. Under Washington State law, any uncontrolled forest fire, regardless of origin, is declared a public nuisance and must be suppressed. RCW 76.04.750. In fact, DNR's "primary mission [is] to protect forest land and suppress forest fires." RCW 76.04.165.

Continued fire suppression has created a large build-up of fuel comprised of dead woody material. The tinderbox conditions which arise during the Summer months could fan fires of cataclysmic proportions, akin to those which recently ravaged Yellowstone National Park. National Park Service Departmental Manual 910 DMI; Recommendations of Fire Management Policy Review Team, Fed. Reg., Dec. 20, 1988, p. 51196-51205 at p.51199. The USFS acknowledges:

> "Fire suppression may slow natural succession, change species composition, and increase fuel accumulations, which increases the risk of a catastrophic wildlife." ONF Plan Final Evironmental Impact Statement ("FEIS"), IV-50.
>
> [The result of] "[i]creasingly effective fire suppression techniques and capabilities over the past 80 years
>
> ...
>
> will be more large, catastrophic, and stand destructive fires." ONF Plan FEIS, IV-39.

Obviously, any large fire could destroy large numbers of Lynx and dramatically reduce their remaining habitat. In addition, areas destroyed by a significant fire would not provide optimum conditions for snowshoe hare for two to three decades. Koehler & Brittell, 1990, p. 2. Hence, significant fire would kill innumerable Lynx from heat, smoke, loss of habitat and loss of prey.

But neither the USFS nor DNR, plan any prescribed or controlled fires to reduce the threat posed by over 50 years of fire suppression in the Lynx' critical habitat. See for ex-

serious threats to the survival of the lynx. Timber harvests and road construction bring on a host of other threats. These other threats are alluded to in this petition and are all directly related to increased human activity.

Suppression of naturally occurring fires in the cascades has been, continues to be, and is slated to remain, an integral part of forest management practices. In the OMP, the level of suppression varies with (i) the management prescription for the zone, and (ii) an evaluation process which weighs the potential loss from a fire, against the cost of suppressing the fire. OMP Plan, 3-3. Under Washington State law, any unwanted forest fire, regardless of origin, is declared a public nuisance and must be suppressed. RCW 76.04.710. In fact, DNR's "primary mission [is] to protect forest land and suppress forest fires." RCW 76.04.165.

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> "Fire suppression may slow natural processes, change species composition, and increase fuel accumulations, which increases the risk of a catastrophic wildfire." OMP Plan Final Environmental Impact Statement ("FEIS"), IV-30.
>
> [The results of] "[i]ncreasingly effective fire suppression techniques and capabilities over the past 80 years
>
> . . .
>
> will be more large, catastrophic, and stand destructive fires." OMP Plan FEIS, IV-32.

Obviously, any large fire could destroy large numbers of lynx and drastically reduce their remaining habitat. In addition, areas destroyed by a significant fire would not provide optimum conditions for snowshoe hare for two to three decades. Koehler & Hatfield, 1990, p. 8. Hence, significant fire would kill immaterial lynx from heat, smoke, loss of habitat and loss of prey.

But neither the OMP nor DNR plan any prescribed or controlled fires to reduce the threats posed by over 80 years of fire suppression in the lynx' critical habitat. See for ex-

ample, ONF Plan FEIS I-13,14; IV-50.

Moreover, the Tonasket Ranger District in the ONF and the DNR, collectively plan five very large timber sales in critical Lynx habitat in the Cascades. Four of the sites adjoin each other, in the midst of critical habitat. See Exhibit "E" attached to this Petition. The fifth site (the Hell's Hole Sale) is reported to be a known denning area.

In addition, the Twisp and Winthrop Ranger Districts in the ONF, recently issued a public scoping letter for proposed timber sales in the Granite Mountain roadless area. This roadless area is in the southerly portion of the Lynx critical habitat. The details of these proposed sales are presently unavailable, but the scoping letter states there may be as many as 64 miles of road built on 4,400 acres! A copy of the scoping letter is attached to this petition as Exhibit "F".

According to the Department of Wildlife, other recent and pending timber sales:

> "...will result in the severe depletion of the lynx population in the areas from Starvation mountain and Beaver meadows south to the Loup Loup pass area. This area has historically contained good numbers of lynx." Brady, unpublished letter to Winthrop/Twisp Ranger Districts (copy attached to this petition as Exhibit "G".

The ONF Plan FEIS states that the timber harvest can help the Lynx and its prey by furnishing early successional (i.e. young lodgepole) forests. ONF Plan FEIS, I-26. However, the Washington Department of Wildlife (formerly Department of Game) ("DEPARTMENT OF WILDLIFE") previously pointed out that intensive timber management will not protect the existing Lynx population because of "...roads, intrusion and rapid loss of cover...". ONF Plan FEIS, Appendix M-4-50.

According to Koehler:

(i) (Contrary to the USFS's conclusions in the ONF Plan FEIS), the Lynx population will decline, not increase during the first few decades of the ONF Plan;

(ii) Not for 20 or 30 years in the life of the ONF Plan (assuming the Lynx survive that long) is there any prospect that the Lynx population may increase. Koehler, Exhibit "D", p. 5.

In the ONF, the USFS does not adequately address the obvious and permanent impacts from planned road construction; namely disturbance, harassment, trapping and hunting. See for example, ONF Plan 3-4; 4-50; and especially 4-81 which contains the prescription for the management of Lynx Management Area 12 (the only area in the ONF in which the USFS provides any protection for Lynx). The prescription for Lynx Management Area 12 is "...provide habitat to support a stable lynx population...while accessing the area for the purpose of growing and producing merchantable wood fiber." On Washington State lands, the DNR does not even give lip service to addressing the impacts of roads.

Roads provide "a tempting new opportunity...to poachers which cannot be entirely controlled by current levels of law enforcement." Brittel, unpublished memorandum to B. McLaughlin & R. Duff (copy attached to this Petition as Exhibit "H").

Roads provide access for hunters and trappers, destroy habitat for the snowshoe hare, and substantially disrupt Lynx travel and hunting patterns. Koehler & Brittell, 1990, p. 3.

Similarly, Dr. Jack Ward Thomas noted:

> "Not only do agencies lack money to do an adequate job of enforcing road closures, but political pressures often make it difficult for managers to close roads once they are built." Thomas, 1990, page 3.

Even the USFS concedes that:

> "Once roading and prescribed management activities occur the physical, biological and social resource conditions will likely be permanently changed." WNF Plan FEIS, IV-8.

In the ONF Plan FEIS, the USFS acknowledges that once roads are constructed, wildlife are substantially more vulnerable to hunting (legal and illegal) and harassment (especially during periods of reproduction and rearing). FEIS, III-74, 79. The FEIS also acknowledges that closures of roads in the ONF cannot be effectively enforced because of the topography and "public attitudes". FEIS, III-74 and 75.

The Department of Wildlife voices similar concerns about roads:

> "Of all forest management tools, roads are the most impacting...Many species of wildlife, but

particularly big game, avoid roads; effective habitat and carrying capacities are reduced. Populations are lowered..." WNF Plan FEIS, K-325, 326.

"Roads impact wildlife significantly. Their construction removes habitat directly. Their use causes avoidance by many species...[and]...lead[s] to wildlife loss...<u>we strongly recommend retention of the maximum possible roadless area</u>..." (emphasis supplied, ONF Plan FEIS, Appendix M-4-51).

Neither in the ONF or elsewhere, does the USFS employ the recommendations of the WDW concerning roadless areas.

Lynx tracks are virtually indistinguishable from the much larger cougar. Traps legally set for other fur-bearing mammals indiscriminately snare Lynx. Koehler, 1988, p. 60. The traffic generated by hunters and trappers and their hounds, disrupt the Lynx and their travel patterns. Koehler & Brittell, 1990, p. 3.

Nevertheless, to harvest a mere 26 to 30 million board feet of timber, the ONF and DNR collectively plan to construct about 95 to 100 miles of new roads (See <u>Exhibits "E"</u> and <u>"F"</u> attached to this petition) in the critical habitat ("<u>KOEHLER STUDY AREA</u>") studied by Koehler and Brittell (Koehler, 1988, p. 11).

Unless the Lynx is declared a threatened or endangered species, the USFS and the DNR will not scale back or otherwise mitigate their road construction plans. Substantial reductions in the planned road construction are essential to ameliorate the impacts of the planned harvests on the few remaining Lynx.

## <u>GOVERNMENT'S VOLUNTARY RESPONSE TO LYNX PLIGHT IS TERRIBLY INADEQUATE</u>

At the present time, the Department of Wildlife is the agency most responsible for ensuring the survival of the Lynx. This is regrettable, because (i) the Department of Wildlife still authorizes hunting Lynx by any means; (ii) the Department of Wildlife can only advise, and cannot obligate the USFS nor the DNR to comply with the Department of Wildlife's recommendations; and (iii) there is no coordinated effort between the Department of Wildlife, the DNR and the USFS, to protect the remnant Lynx population.

In 1991, the Department of Wildlife will issue three permits for hunting Lynx in Okanogan County. Washington Department of Wildlife 1991-1992 Hunting Seasons & Rules, p. 31. Although the Koehler Study Area was excluded, this represents a 50% increase over the two permits issued in the previous years!

Under current Department of Wildlife regulations, hunting and trapping of Lynx is permitted in Okanogan County, from November 27, 1991 to January 15, 1992. Washington Department of Wildlife 1991-1992 Hunting Seasons & Rules, p. 31. Given the skeletal population which presently exists, and the "unfavorable" prospects for the survival of the population, neither continued hunting nor trapping of the Lynx can be justified. Koehler, Exhibit "D", p. 6.

Local and regional representatives of the Department of Wildlife have made numerous recommendations to the DNR and USFS, to ensure the continued survival of the Lynx, but to no avail. These recommendations include: do not harvest timber until all the Lynx habitat is mapped; do not convert existing stands of timber; build dead-end roads, not loop roads; disperse timber harvests over a longer period of time and over a larger area; and preserve horizontal cover. Koehler & Brittell, 1990; Brady, Exhibit "G".

As examples of the absence of any coordinated effort to address the plight of the Lynx: (i) the DNR offered no input on the ONF Plan; and (ii) nearly all of the recommendations made by the Department of Wildlife concerning the ONF have been disregarded by the USFS. See ONF Plan FEIS; Brady, Exhibit "G"; Brittell, Exhibit "H".

The Lynx presently have limited protection in two portions of the Cascades. One area is Lynx Management Area 12 in the ONF, which is the situs of the most viable concentration of Lynx. Honocker, personal communication to Mitch Friedman, August 12, 1991. But even in the ONF, only 79,400 acres of habitat are to be managed for the benefit of the Lynx. ONF FEIS, II-102. Furthermore, Lynx Management Area 12 does not include all of the essential Koehler Study Area. See Exhibit "I" of this petition. And given the conclusions reached by Koehler (and referred to in subparagraphs (i) and (ii) on page 7 above), there are grave doubts about the benefits realized by the Lynx even in the area designated for their benefit.

Some other protection is afforded the Lynx by the Department of Wildlife's closure of the Koehler Study Area. Washington Department of Wildlife 1991-1992 Hunting Seasons & Rules, p.

57. The closure is limited to a ban on hunting and trapping, and has been in effect for approximately 11 years. Koehler, 1988, p. 59. But this area is only 1795 square kilometers (Koehler, 1988, p. 11), and does not include all of the essential habitat for which protection is sought in this petition.

Neither Lynx Management Area 12 in the ONF, nor the Lynx closure area (Koehler Study Area) established by the WDW, is large enough to ensure the survival of the species. This conclusion is borne out by two studies in Alaska, which demonstrate, the sanctuaries must be large enough to protect the Lynx during their periodic forays from their customary ranges. Bailey, et al., 1986, p. 288; Ward & Krebs, 1985, p. 2823. Furthermore, a study of a substantially larger 2,955 square kilometer preserve (in Riding Mountain National Park, in Manitoba), concluded that the preserve was not large enough to support a viable lynx population. Carbyn & Patriguin, 1983, p. 266.

## CONCLUSION

Given the pending threats to the continued existence of the Lynx of the Cascades, the Department of Wildlife's failure to ban hunting and trapping of Lynx, and the Department of Wildlife's inability to limit actions by the USFS and the DNR which have and will continue to reduce and degrade Lynx habitat (and consequently have and will continue to reduce the Lynx population), it is incumbent upon the Fish and Wildlife Service to adopt a rule listing the Lynx of the Cascades, as an endangered species.

Given the pitiful steps taken by the USFS and DNR which collectively own nearly all the Lynx habitat, it is incumbent upon the Fish and Wildlife Service to designate as critical Lynx habitat, all of the publicly owned lands in the Cascades which are suitable Lynx habitat.

Dated: August 16, 1991

Respectfully submitted,

Mark Tipperman,
Attorney for all Petitioners,
Sierra Club, Cascade Chapter
Legal Committee

## LIST OF LITERATURE CITED


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## LIST OF EXHIBITS

Petitioners' names and addresses.....A

Map showing Lynx historial range.....B

Thompson, G., Determining Minimum Viable Populations Under the Endangered Species Act, NOAA, National Marine Fisheries Service, April 8, 1991 draft.....C

Koehler, G., Current and Projected Estimates of Lynx Numbers in Washington.....D

Five year plan for Okanogan National Forest timber sales and attendant roads in critical habitat (also showing DNR sale).....E

Scoping letter for sales and attendant roads planned in ONF Granite Mountain roadless area.....F

Brady, G., Washington Department of Wildlife letter to Lon Schultz, Ann Sprague, Winthrop/ Twisp Ranger Districts, April 3, 1991.....G

Brittell, Washington Department of Wildlife, memorandum to B. McLaughlin & R. Duff, May 24, 1984.....H

Map outlining boundaries of Lynx Management Area 12 in Okanogan National Forest.....I

## EXHIBIT "A"

## PETITIONERS' NAMES, ADDRESSES AND TELEPHONE NUMBERS

National Audubon Society, Washington State Office, P.O. Box 462, Olympia, WA 98507, Attn.: Jim Pissot, (206) 786-8020

The Humane Society of the United States, 2100 L Street NW, Washington, DC 20037, Attn.: Dr. John W. Grandy, Vice President, (202) 452-1100

Defenders of Wildlife, 1244 19th Street NW, Washington, DC 20036, Attn.: Jon Holst, (202) 659-9510

Greater Ecosystem Alliance, P.O. Box 2813, 120 Prospect Street, Suite 9, Bellingham, WA 98227, Attn.: Mitch Friedman, President, (206) 671-9950

Friends of the Loomis Forest, 790 N. Pine Creek Road, Tonasket, WA 98855, (509) 486-4135

Methow Valley Forest Watch, P.O. Box 153, Twisp, WA 98856, Attn.: Mary Lockman, (509) 997-0154

Save Chelan Alliance, P.O. Box 1205, Chelan, WA 98816, Attn.: Sandy Bryant, President, (509) 687-3180

Lower Columbia Basin Audubon Society, 9016 Sunset Trail, Pasco, WA 99301-1675, Attn.: Rick Leaumont, Conservation Chair,

Tonasket Forest Watch, P.O. Box 313, Tonasket, WA 98855, Attn.: Dave Kliegman

Pilchuck Audubon Society, c/o Bonnie Phillips Howard, 7207 Lakewood, Stanwood, WA 98292

North Cascades Audubon Society, P.O. Box 5805, Bellingham, WA 98227, Attn.: Greg Mills, President,

Sierra Club Cascade Chapter, 1516 Melrose, Seattle, WA 98122, Attn.: Mark Lawler, National Forests Chair

Correspondence concerning this petition should be sent to:

## EXHIBIT "A"

### PETITIONERS' NAMES, ADDRESSES AND TELEPHONE NUMBERS

National Audubon Society, Washington State Office, P.O. Box 468, Olympia, WA 98507, Attn.: Jim Pierce, (206) 786-6020

The Nature Society of the United States, 2100 L Street NW, Washington, DC 20037, Attn.: Don John W. Grundy, Vice President, (202) 429-1100

Defenders of Wildlife, 1244 19th Street NW, Washington, DC 20036, Attn.: Don Holes, (202) 659-9510

Center Ecosystem Alliance, P.O. Box 2813, 120 Prospect Street, Suite 9, Bellingham, WA 98227, Attn.: Mick Fredman, President, (206) 671-4991

Friends of the Cosmic Forest, 750 N. Olympic Creek Road, Tenasket, WA 98855, (509) 486-4152

Methow Valley Forest Watch, P.O. Box 147, Twisp, WA 98856, Attn.: Mary Loomera, (509) 997-1155

Five Cedars Alliance, P.O. Box 1205, Cashmere, WA 98815, Attn.: Nancy Bryant, President, (509) 997-1155

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Mitchell Audubon Society, c/o Connie Phillips Howard, 7207 Lakewood, Stanwood, WA 98292

North Cascades Audubon Society, P.O. Box 1800, Bellingham, WA 98227, Attn.: Greg Mills, President,

Sierra Club Cascade Chapter, 1016 Holcomb, Seattle, WA 98122, Attn.: Mark Lawler, National Forests Chair

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-and-

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# HISTORIC AND RECENT DISTRIBUTION OF THE LYNX IN WYOMING

Prepared for the

Wyoming Game and Fish Department
Cheyenne, Wyoming

By the

Wyoming Cooperative Fishery and Wildlife Research Unit
Laramie, Wyoming


Archie Reeve

Frederick Lindzey

Steven Buskirk


July 1986

EXHIBIT "B"

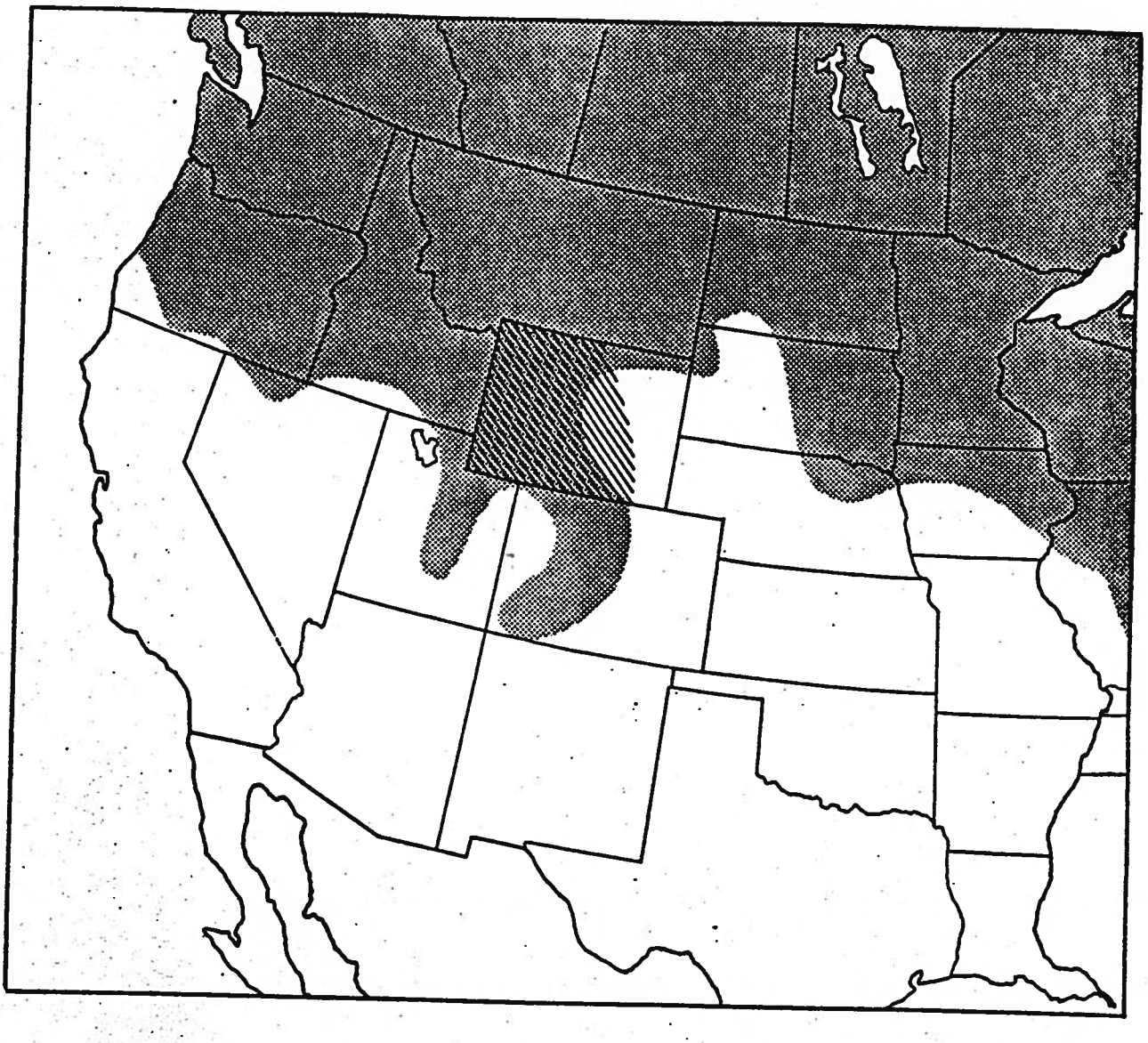

Figure 1. Distribution map of lynx in the western United States and Southwestern Canada (stippled shading after Hall and Kelson 1959) with the Wyoming distribution emphasized (diagonal shading after Long 1965).

DRAFT

# DETERMINING MINIMUM VIABLE POPULATIONS UNDER THE ENDANGERED SPECIES ACT

Grant G. Thompson

National Oceanographic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center
Resource Ecology and Fisheries Management Division
7600 Sand Point Way, Seattle, WA 98115-0070

April 8, 1991

EXHIBIT "C"

DRAFT

# DETERMINING MINIMUM VIABLE POPULATIONS UNDER THE ENDANGERED SPECIES ACT

Grant G. Thompson

National Oceanographic and Atmospheric Administration

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Alaska Fisheries Science Center

Resource Ecology and Fisheries Management Division

7600 Sand Point Way, Seattle, WA 98115-0070

April 8, 1991

## Introduction

The purpose of this paper is to review (briefly) the "state of the art" in conservation biology as it pertains to the determination of minimum viable populations (MVPs), and to provide recommendations for conducting population viability analyses pursuant to petitions filed under the Endangered Species Act (ESA). The paper was prompted by five petitions directed to the National Marine Fisheries Service in the spring of 1990 for protection of certain stocks of Pacific salmon (*Oncorhynchus* spp.), and so may be biased to some extent

towards methods or results of particular relevance to conservation of salmon stocks. One technical point should be noted early on: when the ESA refers to "species," it does not refer to true (i.e., taxonomic) species only, but also to subspecies and even to "distinct population segments." The problem of what constitutes a "species" under the ESA is addressed by Waples (1991), and will not be reconsidered here. The reader should note that the present paper's use of the term "species" in the context of the ESA should be interpreted in the legal, not the biological, sense.

Among the many terms used in the ESA, two of the most important are "endangered" and "threatened." The ESA defines an endangered species simply as one which is "in danger of extinction", while a threatened species is one which is "likely to become an endangered species within the foreseeable future." This language leaves a key question unanswered: what constitutes danger of extinction? According to Webster's dictionary, danger is a generic term implying "exposure or liability to injury, loss, pain, or other evil." It is distinguished from *peril* in that danger does not necessarily imply a sense of immediacy; in other words, danger can encompass events far in the future. Unfortunately, this makes it possible to argue that all species are in danger of extinction, since our solar system has a finite life expectancy. Absent divine intervention, eventual extinction of all species is more of a certainty than a danger (den Boer 1968, Soule and Simberloff 1986). Obviously, this is not what Congress had in mind when it passed the ESA, but it leaves open the question of how soon and how likely extinction must be before a finding of endangerment is warranted.

Beginning with Hooper (1971), Shaffer (1981), and Ginzburg et al. (1982), conservation biologists have argued that the process of extinction is inherently stochastic, and that endangerment should therefore be defined probabilistically; that is, in terms of the probability of persistence over time. Such a definition could take the form of some measure of central tendency of extinction time (as in the birth-and-death process model described below), or by specifying a threshold probability of persistence $p$ over a specified time horizon $t$ (as suggested by Shaffer). For example, MVP might be defined as the population size ($N$) at which the probability of persistence over the next 100 years is 95%. Determining appropriate threshold $p$ and $t$ values, however, is not a trivial undertaking.

Conservation biologists have attempted to simplify the task of understanding population stochasticity by dividing it into a number of subcomponents. May (1973) first distinguished between demographic and environmental stochasticity, and Shaffer (1981) suggested that stochastic effects due to genetics and catastrophes should also be considered separately. Demographic stochasticity arises from the fact that populations consist of individuals, each of which is subject to demographic processes that can be treated probabilistically (e.g., death in any given year). Environmental stochasticity is a means of interpreting unpredictable changes in vital rates. Genetic stochasticity is used to account for changes in gene frequencies due to founder effect, drift, or inbreeding. Catastrophes are extreme events (e.g., floods, fires, and droughts) that can be thought of as occurring randomly. Unfortunately, to date no model has been developed that integrates all four components satisfactorily (Shaffer 1987). For example, models that emphasize demographic

and environmental stochasticity typically define an MVP directly in terms of probability of persistence. However, this relationship is only implicit in models that emphasize genetic stochasticity, which tend to relate MVP directly to threshold levels of inbreeding or genetic variability (Ewens et al. 1987). Undoubtedly, there is a relationship between these two approaches, but it has yet to be formalized.

Although it has so far proven impossible to incorporate the four sources of stochasticity into a single model, it does appear that some consensus exists regarding their relative importance, except for catastrophes. Of the other three sources, the conclusion seems to be that environmental stochasticity is the most important and genetic stochasticity is the least, except in very small ($N<100$) populations (Shaffer 1987, Lande 1988).

Catastrophe-related stochasticity is somewhat problematic, and has not always been handled uniformly in the literature. Usually, catastrophes are ignored or treated on an *ad hoc* or subjective basis (e.g., Marcot and Holthausen 1987), although a few formal modeling efforts have been attempted (Hanson and Tuckwell 1978, Ewens et al. 1987). Goodman (1987a) and Simberloff (1988) suggest that it is not clear how catastrophes are to be distinguished from outliers along the spectrum of environmental variability. Simberloff (1988) and Thomas (1990) contend that the idiosyncratic nature of true catastrophes effectively precludes their inclusion in predictive models.

If the above discussion gives the appearance that key issues surrounding species

endangerment are largely unresolved, it is not without reason. To some extent, the explanation can be found in the fact that the discipline of conservation biology is quite new. Establishing a precise birthdate is difficult, but it has been suggested (Brussard 1991) that the discipline began in 1980 with the publication of *Conservation biology: an evolutionary-ecological perspective* by Soule and Wilcox. It is also interesting to note that the Society for Conservation Biology did not even exist until 1986, with its journal *Conservation Biology* first appearing in 1987.

## Overview of Approaches to Population Viability Analysis

The task of determining whether a population is in danger of extinction is usually accomplished by conducting a population viability (or vulnerability) analysis. Such analyses can be categorized in terms of qualitative and quantitative approaches. Qualitative approaches are less widely used in the literature (an example is given by Beiswinger 1986). These approaches usually involve checklists of characteristics that are thought to be typical of endangered populations (e.g., Ehrenfeld 1970, Adamus and Clough 1978, Soule 1983). If the population exhibits enough of these characteristics, it might be considered a candidate for special protection. However, deciding which characteristics to include or what constitutes a critical number of checks is an open question. Bridging the gap between qualitative and quantitative approaches are scoring systems (e.g., Sparrowe and Wight 1975) that involve the assignment of subjective weights to the characteristics on the checklist. Although qualitative information and subjective judgments can be legitimate and important

tools in assessing population viability (see Discussion), qualitative approaches *per se* will not be considered further in the present study.

Quantitative approaches are more common. These approaches can be categorized conveniently in terms of their relative complexity. Along the simple-to-complex spectrum, quantitative approaches can be divided into three groups: 1) primitive "rules of thumb", 2) analytic approaches, and 3) simulation approaches.

## Rules of Thumb

A number of authors have noted the impossibility of establishing a "magic number" above which populations are "safe" and below which they face an unacceptable risk of extinction (Gilpin and Soule 1986, Soule and Simberloff 1986, Ewens et al. 1987, Goodman 1987a, Simberloff 1988, Thomas 1990). Nevertheless, it has also been argued that "scientists owe it to the rest of society to provide rules of thumb, even when they know that sometimes the rules will be misunderstood and misused" (Soule 1987).

The "50/500" rule of thumb initially advanced by Franklin (1980) and Soule (1980) comes the closest of any to attaining "magic number" status (Wilcox 1986). This rule prescribes a short-term effective population size ($N_e$) of 50 to prevent an unacceptable rate of inbreeding, and a long-term $N_e$ of 500 to maintain genetic variability. The $N_e$=50 prescription (termed "the basic rule" by Soule 1980) corresponds to an inbreeding rate of

1% per generation, approximately half the maximum rate tolerated by domestic animal breeders. The $N_e$=500 prescription is an attempt to balance the rate of gain in genetic variation due to mutation with the rate of loss due to drift, and is based on a genetic study of bristles in *Drosophila*.

Aside from the fact that both parts of the 50/500 rule can be attacked on theoretical grounds (e.g., the $N_e$=500 prescription is based on a model that assumes no natural selection [Simberloff 1988]), it is beset by another difficulty: the rule is cast in terms of effective population size $N_e$, which often differs greatly from actual population size $N$. A vast literature addresses the problem of relating $N_e$ to $N$. A standard text is Crow and Kimura (1970); Franklin (1980), LaCava and Hughes (1984), Lehmkuhl (1984), Reed et al. (1986), and Simberloff (1988) also present accessible introductions to the subject. Factors that cause $N_e$ to diverge from $N$ include fluctuation in population size, existence of overlapping generations, variance in progeny number, and skewness in the sex ratio. Still another problem with the 50/500 rule is that effective population size is defined differently in the contexts of inbreeding and variance (e.g., Ewens 1982), meaning that the two parts of the rule are not strictly comparable.

Thus, even if the 50/500 rule is accepted, an important question remains: what is MVP? Soule (1980) indicates that the $N_e/N$ ratio is commonly 25%-33%, giving short- and long-term MVPs of 150-200 and 1500-2000, respectively. Salwasser et al. (1984) prescribe an average population of at least 1000 adults. Wilcox (1986) suggests that 25% is "a good

guess" for the $N_e/N$ ratio in most natural populations, translating into a short-term MVP of 200 and a long-term MVP of 2000. More conservatively, Nelson and Soule (1987) indicate that the $N_e/N$ ratio might be in the neighborhood of 10% for fish populations, giving a short-term MVP of 500 and a long-term MVP of 5000. Belovsky (1987) indicates that an MVP in the range of 1,000-10,000 should be sufficient for a mid-sized vertebrate species. Shaffer (1987) suggests that "the actual number of individuals necessary to provide effective populations of several hundred will range from the upper 100s to the 1000s, perhaps rarely to the 10,000s." Soule (1987) suggests that MVPs for vertebrate species should be in the "low thousands" or higher (although he also insists that this "is not a rule of thumb"). Thomas (1990) offers 5,500 as "a useful goal," but suggests that where uncertainty is extreme "we should usually aim for population sizes from several thousand to ten thousand." Appendix B presents an approach based on the concept of elasticity wherein 5,000 again emerges as a reasonable MVP. As Soule (1987) points out, it is reassuring that the results of these studies tend to be confirmatory, converging on a generic MVP within the 1,000-10,000 range.

It should be noted that although the 50/500 rule turns out to be somewhat ambiguous, it has been used in a number of practical applications (e.g., Reed et al. 1986, Reed et al. 1988, Salwasser et al. 1984, Lehmkuhl (1984), LaCava and Hughes (1984), and the recovery plan for the red-cockaded woodpecker [cited by Lande 1988]).

## Analytic Approaches

Two types of models have received by far the most attention of the various possible analytic approaches: the birth-and-death process model and diffusion models.

### The Birth-and-Death Process Model

The basic assumption of the birth-and-death process model is that the numbers of births and deaths occurring within a population (over a sufficiently short time increment) can be thought of as independent Poisson distributed variables. For a population of size $N$, the probabilities of a birth or a death occurring during a short time increment $\Delta t$ are $b_N N \Delta t$ and $d_N N \Delta t$, respectively, where $b_N$ and $d_N$ are density-dependent per capita birth and death rates.

The expected time to extinction for a population of size $N$, $T(N)$, is equal to the mean time needed to reach a size of either $N$-1 or $N$+1, plus a weighted sum of the expected times to extinction corresponding to populations of size $N$-1 and $N$+1:

$$T(N) = \frac{1}{(b_N + d_N)N} + \left[\frac{b_N}{b_N + d_N}\right] T(N+1) + \left[\frac{d_N}{b_N + d_N}\right] T(N-1) . \qquad (1)$$

The recursive nature of Equation (1) allows it to be solved as follows:

$$T(N) = \sum_{i=1}^{N} \sum_{j=1}^{K} \frac{1}{jd_j} \prod_{k=1}^{j-1} \frac{b_k}{d_k}, \tag{2}$$

where $K$ is an upper reflecting barrier that may or may not be finite (note that $K$ is not simply carrying capacity; it is an absolute upper limit to population size).

The birth-and-death process model dates from the work of Feller (1939), who treated the birth and death rates as density-independent constants and set $K$ at infinity. Kendall (1948) introduced the idea of variable birth and death rates, but viewed them as time- rather than density-dependent. Bartlett (1960) introduced the idea of density-dependent birth and death rates. MacArthur and Wilson (1967) introduced the concept of finite $K$, but again viewed the birth and death rates as being density-independent below this ceiling. Richter-Dyn and Goel (1972) and Goel and Richter-Dyn (1974) presented a particularly thorough analysis of the model in its general form.

Leigh (1981) and Goodman (1987a, 1987b) noted that the treatment of births and deaths as independent Poisson distributed variables permits $b_N$ and $d_N$ to be reparametrized in terms of an expected instantaneous growth rate $r_N$ and the variance in that growth rate $V_N$:

$$r_N = b_N - d_N, \tag{3}$$

and

$$V_N = \frac{b_N + d_N}{N}. \tag{4}$$

Substituting Equations (3) and (4) into Equation (2) gives

$$T(N) = \sum_{i=1}^{N} \sum_{j=1}^{K} \left[ \left( \frac{2}{j(jV_j - r_j)} \right) \prod_{k=1}^{j-1} \frac{kV_k + r_k}{kV_k - r_k} \right], \tag{5}$$

Although Equations (2) and (5) are formally identical (via Equations [3] and [4]), the formulation given by Equation (5) is generally credited with taking the model out of the realm of mere demographic stochasticity by emphasizing the role of environmental stochasticity in determining the instantaneous growth rate (Goodman 1987a and 1987b, Shaffer 1987).

Because the probability density function (pdf) of persistence time is usually highly skewed, the mean time to extinction is sometimes difficult to interpret (Goodman 1987b, Lande and Orzack 1988, Ferson et al. 1989, Dennis et al. in press). The main reason for characterizing the birth-and-death process model by $T(N)$ rather than $p$ and $t$ is that an explicit formula for the pdf of extinction time is unavailable for this model (although Richter-Dyn and Goel [1972] did give formulae for an arbitrary moment of the pdf, the

possibility of constructing the full pdf from its moments apparently has not been explored in depth [Shaffer and Samson 1985]).

**Diffusion Models**

Precursors to the diffusion approach include works by Kerner (1957 and 1959), and Lewontin and Cohen (1969). In the diffusion approach, a deterministic differential equation is modified by incorporating a term that represents Gaussian white noise. Density-dependent models have been considered by Levins (1969), Goel et al. (1971), May (1973), Goel and Richter-Dyn (1974), Tuckwell (1974), Feldman and Roughgarden (1975), Ludwig (1975), Beddington and May (1977), Turelli (1977), Hanson and Tuckwell (1978), May et. al. (1978), Polansky (1978), Roughgarden (1979), Tier and Hanson (1981), Ginzburg et al. (1982), Braumann (1983), and Dennis and Patil (1984). Although the stationary pdfs of many density-dependent models have been derived, the pdfs of extinction time are not typically obtainable in explicit form (an exception is the logistic model with random variation in the intrinsic growth rate, as shown by Goel and Richter-Dyn [1974], Tuckwell [1974], Tier and Hanson [1981], and Ginzburg et al. [1982]).

The simple case of stochastic exponential growth was considered by Levins (1969), Goel et al. (1971), Capocelli and Riccardi (1974), Tuckwell (1974), Keiding (1975), Turelli (1977), Ginzburg et al. (1982), Braumann (1983), and Lande and Orzack (1988). Most recently, it has been explored thoroughly by Dennis et al. (in press). The main assumption

in the density-independent diffusion model is that $X(t)=\ln[N(t)]$ can be modeled as a Wiener process (Brownian motion) with drift (in this section, upper case letters will denote state variables, while lower case letters will denote particular values of those variables). The process is characterized by an infinitesimal mean $\mu$ and an infinitesimal variance $\sigma^2$ that define a normal transition pdf for $X(t)$. Specifically, the pdf of $X(t)$ given an initial condition $x_0$ is normal with mean $x_0+\mu t$ and variance $\sigma^2 t$.

The diffusion process can also be expressed as a stochastic differential equation:

$$dN(t) = rN(t)\,dt + \sigma N(t)\,dW(t), \tag{6}$$

where $dW(t)$~normal$(0,dt)$, and (in the Ito calculus) the instantaneous rate of increase $r$ is given by

$$r = \mu + \frac{\sigma^2}{2}. \tag{7}$$

The pdf of extinction ("first passage") time can be written explicitly; it is the inverse Gaussian distribution (e.g., Johnson and Kotz 1970), which is very similar to the lognormal for a given mean and variance. If $x_e$ is the log population size corresponding to effective extinction (e.g., a single individual), define $x_d$ as $x_0$-$x_e$. Then the pdf of first passage time is given by

$$g(t; x_d, \mu, \sigma^2) = \frac{x_d}{\sigma t}\left[\frac{1}{\sqrt{2\pi t}}\right]\exp\left[-\frac{(x_d - |\mu| t)^2}{2\sigma^2 t}\right]. \tag{8}$$

The mean of Equation (8) is

$$E(T) = \frac{x_d}{|\mu|}, \tag{9}$$

and the variance is

$$Var(T) = \frac{x_d \sigma^2}{|\mu|^3}, \tag{10}$$

with a mode at

$$t^* = \left(\frac{x_d}{|\mu|}\right)\left(\sqrt{1 + \left(\frac{3}{2y}\right)^2} - \frac{3}{2y}\right), \tag{11}$$

where

$$y = \frac{x_d|\mu|}{\sigma^2}. \tag{12}$$

One of the most important contributions of the paper by Dennis et al. (in press) is its presentation of methods for obtaining maximum likelihood estimates of $\mu$ and $\sigma^2$:

$$\hat{\mu} = \frac{\ln\left(\frac{n_q}{n_0}\right)}{t_q}, \tag{13}$$

and

$$\hat{\sigma}^2 = \sum_{i=1}^{q} \frac{[\ln(n_i/n_{i-1}) - \hat{\mu}(t_i - t_{i-1})]^2}{q(t_i - t_{i-1})}, \tag{14}$$

where $n_i$ is the size of the population at time $t_i$, and $q$ is the index of the terminal observation in the time series.

Dennis et al. also present methods for conducting a variety of statistical tests, along with an algorithm for calculating the cumulative form of Equation (8).

**Simulation Approaches**

Included in this category are a number of fairly generic computer programs. Among these is the model known as ONEPOP (Gross et al. 1973), which has been applied to populations of elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), and bighorn sheep (*Ovis canadensis*) (Pojar 1981). The POPDYN model of Samson et al. (1985) has been applied to species as diverse as grizzly bear (*Ursos arctos*), gopher tortoise (*Gopherus polyphemus*), and northern spotted owl (*Strix occidentalis caurina*) (Simberloff 1988). The RAMAS model (Ferson et al. 1988) has been applied to populations of brook trout (*Salvelinus fontinalis*, Ferson et al. 1989), Atlantic cod (*Gadus morhua*, Ginzburg et al. 1990), and giant kelp (*Macrocystis pyrifera*, Burgman and Gerard 1990). In addition to these more-or-less generic models, many simulations have been developed for specific populations, for example Yellowstone grizzly bear (Shaffer 1978, 1983; Knight and Eberhardt 1985, Shaffer and Samson 1985), New Mexico bighorn sheep (*Ovis canadensis mexicana*, Watts and Conley 1981), northern spotted owl (Marcot and Holthausen 1986), Wichita Mountains bison (*Bison bison*, Shull and Tipton 1987), and Snake River chinook salmon (*Oncorhynchus tshawytscha*, Lee and Hyman 1991).

Since each of the above models is slightly different from the others, it is probably not instructive to summarize the details of any particular model here. Instead, it might be more helpful to consider a generic example of how different types of stochasticity are dealt with in a typical simulation approach. The treatment of survival rates provides such an example.

To begin with, a survival rate $s$ is defined. In a deterministic model, the number of survivors is obtained simply by multiplying the pre-mortality number $N$ by $s$, as if the survival rate were acting on the population *en masse*. One way to stochasticize this simple process is to assume that the given survival rate acts as a probability of survival applied to *each individual* (as opposed to the aggregate population). In this case, the number of survivors is a binomially distributed event (e.g., Deriso and Parma 1988). Although the expected number of survivors is the same as in the deterministic model ($sN$), the variance is no longer zero but $s(1-s)N$. Basically, this approach involves incorporating demographic stochasticity into the model.

Alternatively, one could incorporate environmental stochasticity into the model by allowing $s$ to vary randomly from year to year (where $s$ is once again applied to the aggregate population). Since by definition $s$ is between zero and one, a natural way to incorporate environmental stochasticity into the survival process is to draw $s$ at random from a beta distribution with a specified mean and variance (given by the $a$ and $b$ parameters of the distribution).

Yet again, one could incorporate both demographic and environmental stochasticity into the model by viewing the pdf of survivorship as a binomial-beta distribution (e.g., Boswell et al. 1979), wherein the rate term in the binomial distribution is mixed via a beta distribution. For example, this is the approach used by Lee and Hyman (1991). In the special case where the $a$ and $b$ parameters of the beta distribution take integer values, the

binomial-beta distribution is equivalent to the negative hypergeometric (Boswell et al. 1979). Use of the binomial-beta increases the variance in the number of survivors (relative to either the binomial or beta), but again preserves the integrity of the mean.

An alternative to the above methods is to treat the survival rate as constant and apply a multiplicative, lognormal error term (e.g., Peterman 1981). However, using any of the above methods has a logical advantage over the lognormal noise approach in that the above approaches prevent the number of survivors from exceeding *N*.

Finally, it is important to remember that although the discussion here has focused on a single survival rate, in principle every parameter governing every population process (e.g., growth, fecundity, migration, survival, etc.) could be considered probabilistically. At the extreme, one could even treat the variance estimates themselves probabilistically.

## Discussion

### Evaluation of Alternative Approaches

The relative merits of the three general quantitative approaches outlined above (rule of thumb, analytic approaches, and simulation approaches) have been argued in the literature at some length. A brief summary of these evaluations follows.

**Evaluation of Rules of Thumb**

Rules of thumb are routinely criticized on the grounds that they might not apply particularly well in specific cases (e.g., Shaffer 1981, Shaffer and Samson 1985, Ligon et al. 1986, Dawson et al. 1987, Ewens et al. 1987, Soule 1987, Burgman et al. 1988, Lande 1988). These critics argue that population-specific viability analyses need to be conducted on a case-by-case basis. On the other hand, the plight of endangered species is so urgent and widespread that it may be logistically impossible to undertake viability analyses on more than a relative few of them in the time available (Diamond 1984, Groves and Clark 1986, Gilpin 1987). In a *triage*-type situation, rules of thumb may be the only practical option.

**Evaluation of Analytic Approaches**

The analytic approaches have also been criticized, for example by Shaffer and Samson (1985). Perceived problems include lack of realism (e.g., exclusion of density dependence in the simpler diffusion models), exclusion of environmental stochasticity (e.g., in early versions of the birth-and-death process model) and problems of interpretation (e.g., the Ito vs. Stratonovich solutions to stochastic differential equations).

While all of these criticisms have some merit in principle, it is not so clear that they have merit in practice (Simberloff 1988). Several studies have shown that simple analytical models can model complex age-structured dynamics quite well (Tuljapurkar and Orzack

1980, Heyde and Cohen 1985, Goodman 1987b, Lande and Orzack 1988). While the exclusion of density dependence in the simpler diffusion models may be unrealistic, this may not pose a problem in terms of conservation, since extinction risks seem generally to be higher in density-independent models than in density-dependent ones (Ferson et al. 1989, Ginzburg et al. 1990). Of course, analytic models also have the advantages of tractability, reliance on a relatively small number of parameters, and compactness of solution.

**Evaluation of Simulation Approaches**

Models of this type generally contain a large number of parameters, some or all of which are drawn from probability distributions with [illegible] and variances. Shaffer (1981) states, "At a minimum, such models (for vertebrates) require knowledge of the mean and variance of age and sex-specific mortality and fecundity rates, age structure, sex ratios, dispersal, and the relationship of these various parameters to density." Estimation of these parameters is usually considered to be difficult at best (although, see Ferson et al. 1989 for a contrary opinion).

In particular, variances in these models can be so difficult to estimate that it is often necessary to specify them on a purely subjective basis (Dennis et al. in press). This practice disturbed the spotted owl scientific advisory panel to such an extent that the panel rejected all simulation results that were based on subjectively estimated variance parameters (Dawson et al. 1987). The estimation problems that tend to accompany the simulation

approach can be illustrated by the model of Lee and Hyman (1991), which uses 32 parameters (only three of which are variances or coefficients of variation). In the sample configuration given by the authors, it was not uncommon to find an estimate described as "an outright guess" or a value that "seems reasonable."

Rigorous estimation of parameters often requires large amounts of both time and money, and even then acceptable results are not always forthcoming, even for the most basic vital rates. For example, Brussard (1991) notes, "Tens of millions of dollars are spent annually on grizzly bear research, but there are no reliable data on male mating success in this species."

A further problem with the simulation approach is computation time. Typically, a large number of runs is necessary to achieve convergence on the pdf of extinction time. At the low end, Harris et al. (1987) say that a minimum of 200 runs is necessary, while Lande and Orzack (1988) contend that a reliable analysis "must involve many thousands of independent simulations."

Finally, the simulation approach is problematic because it typically is not subject to independent validation. The source code is almost never published, and even when it is, thorough validation is an extremely time-consuming task (Simberloff 1988).

On the other hand, the simulation approach profits from its extreme flexibility

(Shaffer 1981, Shaffer and Samson 1985). Any quantifiable assumption can be built into the model, and the model can be tailored to suit the needs of particular situations. As a result, the simulation approach is fast becoming the method of choice among managers (Simberloff 1988).

## The Use of Models in Population Viability Analysis

Part of the problem in evaluating the various approaches can be traced to confusion regarding the role that models should play in population viability analysis, or more precisely, in management decisions based on population viability analysis. This role is defined to a large extent by how scientists and managers view models in general. For example, if models are interpreted as literal representations of reality, it is easy to abdicate all responsibility for decision-making to the model. While this view certainly has its advocates, it is by no means universal. When dealing with a model of some natural system, it is important to realize that the model is not the natural system itself (or, in the words of Rosenblueth and Wiener [1945], "The best material model of a cat is another, or preferably the same, cat"). Given this, it is not at all obvious that nature should possess any literal equivalent in mathematics or anyplace else (Wigner 1960). An alternative to the literalist perspective is to view models as scientific metaphors (Black 1962, Hesse 1965, Poythress 1983). In such a view, models are things to be used, involving interaction between model, scientist, and nature. This type of approach would find sympathy with Soule's (1987) contention that "models are tools for thinkers, not crutches for the thoughtless."

It has been argued that scientific understanding inevitably involves information that exists independently of any formal model (Polanyi 1962). By emphasizing the nonliteral nature of models, the metaphoric view also speaks to the legitimate role of subjective judgment in the scientific process. Marcot and Holthausen (1987) address this idea in the context of conservation biology, stating, "There is much to be said for using subjective assessments and professional judgments for evaluating population viability, as the basic quantitative tools are still being hewn." Soule and Simberloff (1986) argue similarly, writing, "Intuition, common sense and the judicious use of available data are still the state of the art." Likewise, Zimmerman and Bierregaard (1986) advocate reliance on "intuitive guessing... made by the field biologists involved."

This point is particularly important in an area such as conservation biology, where crisis is the norm rather than the exception. "In crisis disciplines, one must act before knowing all the facts" (Soule 1985). Stated alternatively, "The luxuries of confidence limits and certainty are ones that conservation biologists cannot now afford" (Soule 1980). Roughgarden (1983) describes the scientific process as one of building a convincing case, as distinguished from establishing proof by formal rules. In this context, the relevant question is not whether a state of endangerment can be *proven*; rather, the question concerns the appropriate response to whatever amount of information exists (or can be gathered expeditiously). If this view is accepted, it becomes clearly inappropriate to require that a finding of endangerment be corroborated by any particular model before taking action.

**Determining Appropriate Persistence Criteria**

Shaffer's (1981) original definition of MVP was the population size that gives a 99% chance of persistence over a time horizon of 1000 years. However, he noted that this suggestion was made "tentatively and arbitrarily" and that other values (e.g., $p=0.95, t=100$) could be just as useful. He also emphasized, "I have offered one tentative definition in this paper, but it is not to be taken literally. It is intended as an example for consideration, not a standard for application." Thus, it is not clear that the (0.99,1000) standard is theoretically superior to any other, but the same could be said just as well for a variety of other possible candidates.

Appendix A illustrates one problem common to any choice of threshold ($p,t$) values. In brief, any given ($p,t$) combination will fall onto a locus defined by some common level of social utility (a social indifference curve). The problem arises from the fact that the nominal utility associated with the threshold ($p,t$) value will almost certainly be different than the expected utility of the corresponding MVP. Fortunately, the error resulting from equating the two is likely to fall on the side of conservation if the threshold $p$ value is sufficiently high (i.e., greater than about 90%).

Even if threshold $p$ values are restricted to the upper end of the possible range, however, another problem presents itself: MVP estimates resulting from thresholds within this range can still be radically different. For example, MVPs resulting from thresholds of

(0.95,100) and (0.99,1000) can differ by orders of magnitude. Therefore, the choice between these two (or other) thresholds should not be made lightly. It has been suggested that decision theory might be helpful in evaluating tradeoffs between protection against extinction and the cost of obtaining such protection (Thibodeau 1983, Maguire 1986). However, since costs will likely vary on a case-by-case basis, a decision-theoretic approach might likely be unwieldy and incapable of giving any kind of general solution. Although theoretical grounds for a choice appear to be lacking, perhaps some guidance can be taken from the relatively frequent use of the (0.95,100) standard, which has been employed (at least approximately) by Shaffer (1983 and 1987), Shaffer and Samson (1985), Suchy et al. (1985), Belovsky (1987), Marcot and Holthausen (1987), Lande (1988), and Soule and Kohm (1989).

## Recommendations

Perhaps the best advice is to use all of the information and methods available to the maximum extent feasible. Rules of thumb can provide a preliminary, order-of-magnitude diagnosis. If a population contains more than, say, 10,000 individuals, it would probably take some fairly extreme extenuating circumstances to consider it endangered. Examples of such extenuating circumstances might be a continuing and severe rate of decline, or extreme variability in population numbers. Detailed simulation is helpful where time and data permit; in the context of petitions filed under the ESA, however, this is likely to be the exception rather than the rule, particularly where multiple filings are concerned. For

example, it has been reported that one conservation group is considering filing 195 petitions for protection of Pacific salmon stocks under the ESA (Williams 1991). Given the one-year legal time limit prescribed in the ESA, and allowing sufficient time for administrative processing of the petitions, such a filing would require that population viability analyses be conducted at the rate of about one per working day.

**Using a Diffusion Model to Estimate MVP**

Although conducting viability analyses at the rate of one per day is out of the question, some constructive modeling efforts can be undertaken in a relatively short amount of time if necessary. For example, the density-independent diffusion model and estimation procedures described by Dennis et al. (in press) can provide useful information with a minimum of time and data. Importantly, the only data needed to implement this model consist of a time series of abundance estimates (or even indices of relative abundance).

Once a data set has been specified, some decisions need to be made regarding how the model treats the data and how the results are to be interpreted. First, it may be important to use a running sum as the index of abundance, rather than the raw data themselves. In their examination of the Yellowstone grizzly bear population, for example, Dennis et al. used a three-year running sum of observed mothers with cubs because grizzlies are unlikely to reproduce any more frequently than once every three years. Pacific salmon would be another example where running sums are appropriate, perhaps basing the interval

on the maximum spawning age of the run (this would help to insure that the Markovian assumption underlying the diffusion model is not violated).

Second, as discussed earlier, it is necessary to choose threshold $p$ and $t$ values. Actually, two sets of threshold values are required, since the ESA defines two levels of jeopardy (endangered and threatened). While the ESA does not provide much guidance as to $p$ and $t$ values for endangerment, it does give some indication of how "threatened" $p$ and $t$ values should relate to their "endangered" counterparts. Since a threatened species is defined as one which is "likely to become endangered within the foreseeable future," one need only interpret the terms "likely" and "foreseeable future." A reasonable interpretation of a "likely" event would be one which has at least a 50% chance of occurring. Quantifying "foreseeable future" is not so straightforward, but perhaps something like ten years would be satisfactory. Given these values, a threatened species is one which has a 50% chance of becoming endangered within ten years. For endangerment, no corresponding argument can be constructed; perhaps the best decision is to accept the conventional wisdom that sets $p=0.95$ and $t=100$.

Finally, it is necessary to specify an abundance index value corresponding to extinction ($N_e$). Zero is not a possibility, since the model of Dennis et al. operates in terms of $\ln(N)$. If the abundance index is thought to be a good estimate of total population size, setting $N_e=1$ makes some biological sense, at least for sexually reproducing species. However, if the index measures only relative population size, setting $N_e=1$ is not quite so

logically compelling. It is also important to remember that the model assumes density-independent dynamics; that is, it assumes that parameter values do not change at small (or large) population sizes. Such an assumption is likely to be most useful if $N_e$ is restricted to the range above some critical population size where parameter values are likely to change (Capocelli and Riccardi 1974, Dennis et al. in press). This is good advice for some applications, but where the goal is to estimate MVP, it begs the question. Perhaps, given that the ESA defines endangerment in terms of extinction (not just low numbers), setting $N_e=1$ is the best alternative, at least for indices that measure the total population. For relative indices, setting $N_e=1$ might be viewed a reasonable default.

One of the advantages of a density-independent diffusion model is that it facilitates straightforward estimation of the pdf of extinction time for any given $N$. However, it should be emphasized that while this estimate is the product of a rigorous and well developed theory, it is still only a point estimate. Unfortunately, the confidence intervals around the estimated pdf of extinction time tend to be quite broad. For example, in examining the dynamics of the California condor (*Gymnogyps californianus*), Dennis et al. (in press) estimated that the wild population censused in 1980 had a 22% chance of extinction by 1995, with a 95% confidence interval ranging from 2% up to 86%. (For simulation studies, the problem of establishing confidence intervals around MVP estimates is addressed by Harris et al. [1987].)

**Other Considerations**

Another problem to consider is the role that MVP should play in a recovery plan. In other words, suppose that MVP is estimated for a given population at 5,000 individuals, and that current $N$ is estimated to be 2,000 and falling, thereby prompting an ESA listing. Is the goal of a recovery plan simply to achieve $N \geq 5{,}000$? To answer this question, consider the density-independent diffusion model, where MVP is defined (for given threshold $p$ and $t$ values) by the parameters $\mu$ and $\sigma^2$. If the management regime changes significantly in response to a listing under the ESA (as is required), this will undoubtedly cause $\mu$ or $\sigma^2$ to change as well, in which case MVP will also change. For example, if a management action caused $\mu$ to increase (thus tending to slow or reverse a long-term decline), MVP would decrease, assuming that $\sigma^2$ did not increase along with $\mu$. Thus, if a population viability analysis determines that $N<$MVP, the focus should shift immediately from that particular MVP to $\mu$ and $\sigma^2$. In other words, when using a model of this type, the focus should not be so much on achieving MVP as on changing it.

- implies continual mgt.

This leads to the question of whether "delisting" criteria should be specified at the time of an initial ESA listing. If these criteria include only policy decisions such as threshold $p$ and $t$ values or statistical significance levels, the suggestion to make these explicit is worthwhile, and would tend to reinforce the idea that the purpose of a listing is to effect recovery, not to guarantee special protection forever. However, if delisting criteria also include such things as particular models or a particular MVP, the suggestion is more

problematic because it tends to place constraints on the role of information that might become available after the initial listing. For example, what seems like a reasonable MVP today might seem either needlessly conservative or recklessly optimistic ten years from now.

A final cautionary note: endangerment is not necessarily the same as depletion. In the case of harvested fish stocks, for example, the fact that a stock may be well below the abundance level necessary to generate maximum sustainable yield does not necessarily mean that an ESA listing is in order. In the context of the ESA, the question is not whether the stock could be managed better, but whether the stock is in danger of extinction.

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# APPENDIX A: EVALUATION OF NOMINAL AND EXPECTED UTILITIES FROM A MINIMUM VIABLE POPULATION

Given an initial size, a population's probability of persistence ($p$) can be plotted as a function of time ($t$). The probability of persistence for any self-reproducing population of positive initial size $N$ declines from a value of $p=1$ at $t=0$, approaching $p=0$ as $t$ becomes sufficiently large. Goodman (1987b) and Lande and Orzack (1988) have suggested that the plot of $p$ against $t$ may often be approximated by a negative exponential function. For any given value of $t$, $p$ would presumably increase with $N$. The following equation may thus be an appropriate first approximation:

$$p = e^{-\alpha_1 t/N^{\alpha_2}}, \tag{A1}$$

where $\alpha_1$ is a positive constant and $\alpha_2$ is a constant between 0 and 2 (the reason for the upper bound on $\alpha_2$ will become apparent later). Figure A1 shows an example corresponding to parameter values $\alpha_1=50.275625$ and $\alpha_2=1.6637656$.

Shaffer (1981) suggested defining the minimum viable population (MVP) as the value of $N$ that results in a threshold $p$ value at some given value of $t$. The values $p=0.95$ and $t=100$ are often used for this purpose. Those who employ this definition are generally quick to point out that although it is highly subjective, the need to select some ($p$,$t$) reference

point is inescapable. One way of looking at the question of an appropriate reference point is from the perspective of a social utility function (e.g., Thibodeau 1983, Maguire 1986). That is to say, it can be argued that society would derive some amount of satisfaction, or utility, from realizing a given probability of persistence over a specified time horizon. A suitably general form for such a social utility function is the Cobb-Douglas production function:

$$U = \beta_1 p^{\beta_2} t^{\beta_3}, \tag{A2}$$

where $U$ represents utility, $\beta_1$ is a positive constant, and $\beta_2$ and $\beta_3$ are constants between 0 and 1 (the upper bound insures diminishing marginal utility). Because it simplifies the ensuing mathematics considerably, Equation (A2) will be restricted here by setting $\beta_3 = 0.5$.

Equation (A2) implies a set of indifference curves consisting of $(p,t)$ loci along which $U$ is constant. Figure A2 shows an example corresponding to parameter values $\beta_1 = 10.383474$ and $\beta_2 = 0.73363276$.

Thus, for any combination of $p$ and $t$ (such as $p = 0.95$ and $t = 100$), Equation (A2) defines a single value for the utility derived by society. For example, under the parameter values used to generate Figure A2, the utility derived from the suggested criterion of $p = 0.95$ and $t = 100$ is 100 (Figure A2). However, the problem is more complicated than this, because deciding on an appropriate MVP results in not a single $(p,t)$ pair but an entire locus

of $(p,t)$ pairs as described by Equation (A1). This raises an important question: is the utility that society can expect from a given value of $N$ (the expected utility) equal to the utility associated with any arbitrary $(p,t)$ pair that occurs along Equation (A1) (the nominal utility)?

The first step in deriving the expected utility for a given value of $N$ is to convert Equation (A1) into a probability density function, giving

$$P = \frac{\alpha_1 e^{-\alpha_1 t/N^{\alpha_2}}}{N^{\alpha_2}}, \tag{A3}$$

where $P$ is the probability of persistence rescaled so that the area under the curve equals 1.

The second step is to substitute Equation (A1) into Equation (A2) so that $p$ is eliminated from the computation of utility:

$$U = \beta_1 \sqrt{t} e^{-\alpha_1 \beta_2 t/N^{\alpha_2}}. \tag{A4}$$

The third step is to integrate the product of Equations (A3) and (A4) over $t$ from zero to infinity, giving

$$EU = \int_0^{\infty} PU\,dt = \left[\frac{\beta_1}{2(1+\beta_2)}\right]\left[\frac{\pi N^{\alpha_2}}{\alpha_1(1+\beta_2)}\right]^{1/2}, \tag{A5}$$

where $EU$ is expected utility. Note that the upper bound of 2 placed on $\alpha_2$ insures diminishing marginal expected utility. Figure A3 gives an example corresponding to the same parameter values used to generate Figures A1 and A2.

Although Equation (A5) describes $EU$ as a function of $N$, it can be rewritten in terms of $p$ and $t$. To see this, first solve Equation (A1) for $N$ as follows:

$$N = \left[\frac{\alpha_1 t}{-\ln(p)}\right]^{1/2}. \tag{A6}$$

Equation (A6) can then be substituted into Equation (A5), yielding

$$EU = \left[\frac{\beta_1}{2(1+\beta_2)}\right]\left[\frac{\pi t}{-\ln(p)(1+\beta_2)}\right]^{1/2}. \tag{A7}$$

The ratio between nominal utility and expected utility can be obtained by dividing Equation (A2) by Equation (A7), which eliminates $t$ and $\beta_1$. To find the locus of points along which nominal utility and expected utility are identical, Equations (A2) and (A7) can

be equated, giving

$$\frac{-4(1+\beta_2)^3 p^{2\beta_2}\ln(p)}{\pi} = 1. \tag{A8}$$

Equation (A8) describes the curve shown in Figure A4. For values of $p$ below the curve, nominal utility will exceed expected utility, while for values of $p$ above the curve, the reverse will hold.

As an example, Figure A5 shows a case where an $N$ value of 1000 results in $p=0.95$ at $t=100$, which corresponds to a $U$ value of 100 (parameter values used to generate this figure were the same as those used to generate Figures A1 and A2). Although the nominal utility is 100, the expected utility is about 178 (Figure A3). According to Equation (A8), the $\beta_2$ value used to generate Figure A5 implies that any $p$ greater than about 0.82 will result in expected utility exceeding nominal utility (Figure A4). Thus, the example shown in Figure A5 tends to confirm the result given by Equation (A8).

To achieve an expected utility equal to the nominal utility of 100 attained at $p=0.95$ and $t=100$, $N$ would have to be reduced considerably. The $N$ value corresponding to a given level of $EU$ can be obtained by rearranging Equation (A5) as follows:

$$N = \left[\left(\frac{2(1+\beta_2)EU}{\beta_1}\right)^2\left(\frac{\alpha_1(1+\beta_2)}{\pi}\right)\right]^{1/\alpha_2}. \tag{A9}$$

For the example shown in Figure (A5), $N$ would have to be reduced to a value of 500 in order to reduce $EU$ to the nominal level of 100 corresponding to $p=0.95$ and $t=100$. (At $t=100$, an $N$ value of 500 corresponds to a $p$ value of 0.85 and a nominal utility of about 92).

Figure A6 shows an example from the opposite side. Here it is assumed that the threshold values of $p$ and $t$ are 0.75 and 500, respectively. The other parameter values used are the same as those used to generate Figure A5. In this example, an $N$ value of about 933 is required to achieve the threshold $p$ and $t$ values. This corresponds to a nominal utility of about 188, but an expected utility of only about 168. To increase the expected utility up to the nominal level of 188, an $N$ of about 1068 is required, corresponding to a new nominal utility of about 196 and a new threshold $p$ of about 0.79 (at the same threshold value of $t$).

Because only the threshold $(p,t)$ combination is usually reported when an MVP is being determined, society (or those making decisions for society) may incorrectly assume that the nominal utility associated with the threshold combination represents the expected utility of the corresponding MVP. If the threshold $p$ is sufficiently high, such an assumption would always err on the safe side; that is, society would never overestimate its expected utility. According to Equation (A8), the breakeven value of $p$ reaches a maximum of about

0.88 when $\beta_2=1$. At the other extreme ($\beta_2=0$), $p$ values less than about 0.46 will always result in an overestimate of *EU*, while $p$ values between 0.46 and 0.88 may result in overestimates or not, depending on the value of $\beta_2$. Thus, the safe range of $p$ values runs from about 0.88 to 1.0. Interestingly, the mid-point of this range is about 0.94, quite close to the threshold $p$ value of 0.95 often suggested in the literature.

The central conclusion to be drawn from this analysis is that the threshold value of $p$ should be relatively high, regardless of the threshold value of $t$ or the value of any other parameter. For example, although $p=0.45$ and $t=300$ give virtually the same nominal utility as $p=0.95$ and $t=100$ in Figure A2, these should not be used as threshold values, because the low $p$ value guarantees that nominal utility will exceed expected utility.

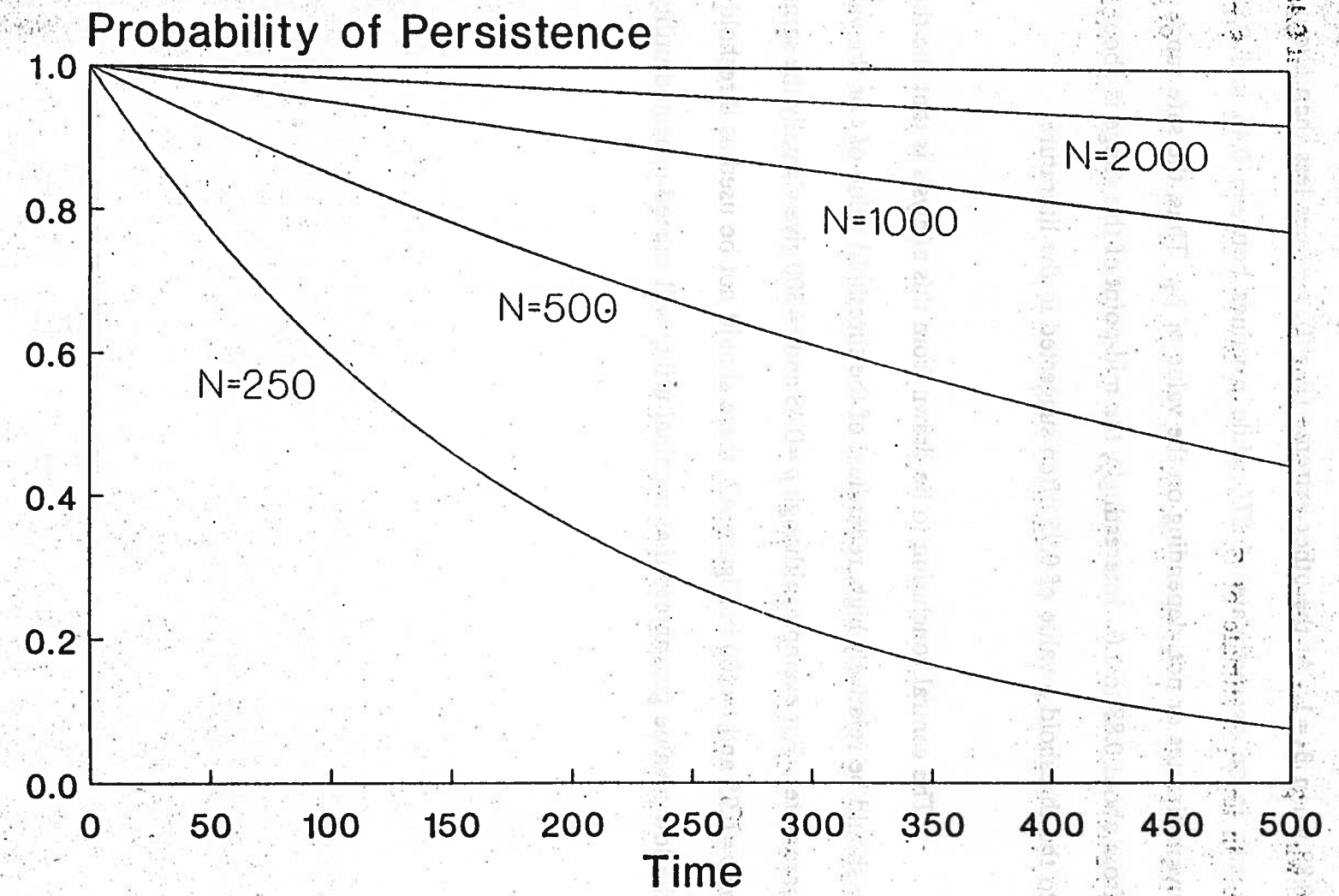

Probability of Persistence
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
350
400
450
500
Time
N=2000
N=1000
N=500
N=250

Figure A1.

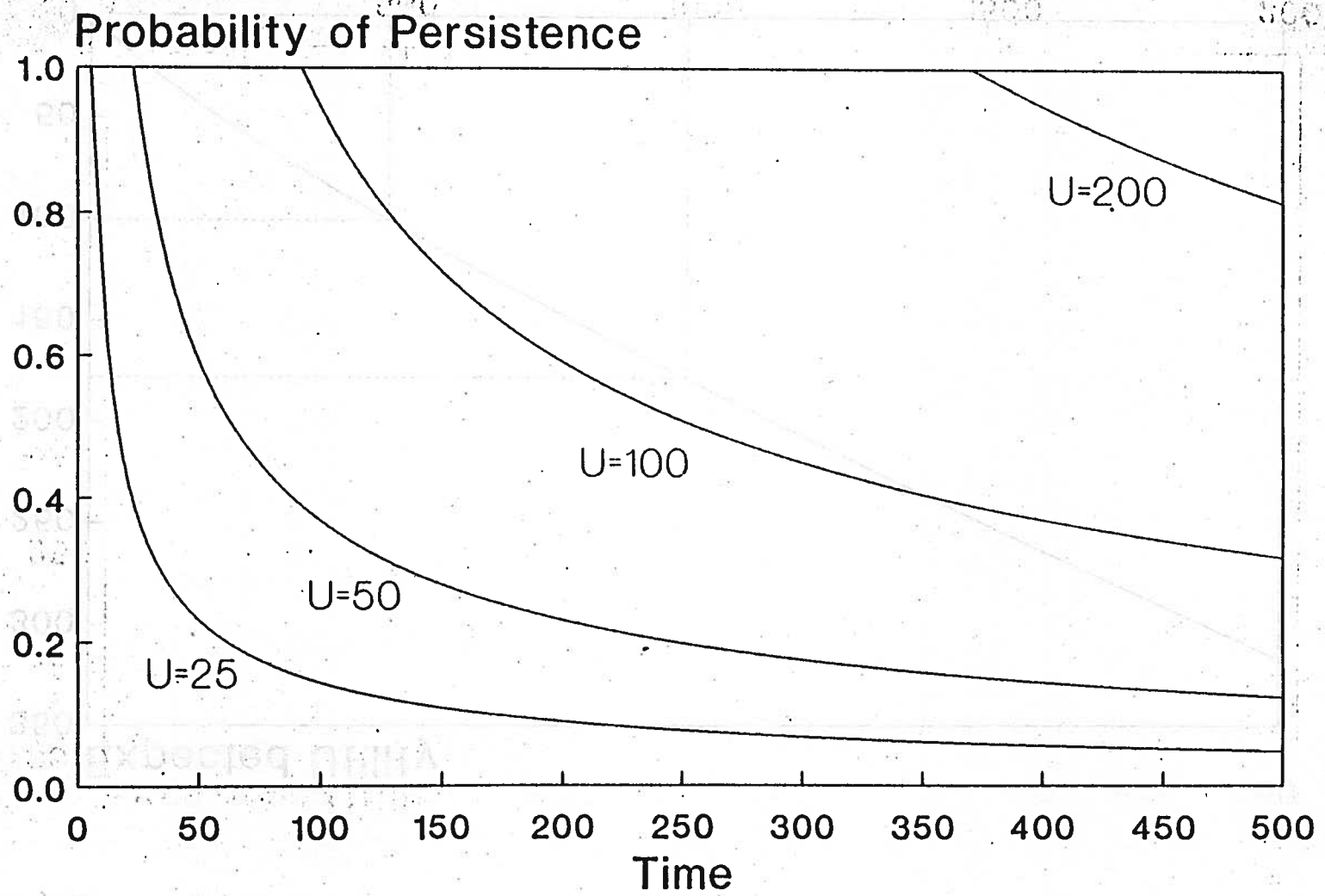

Probability of Persistence
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
350
400
450
500
Time
U=200
U=100
U=50
U=25

Figure A2.

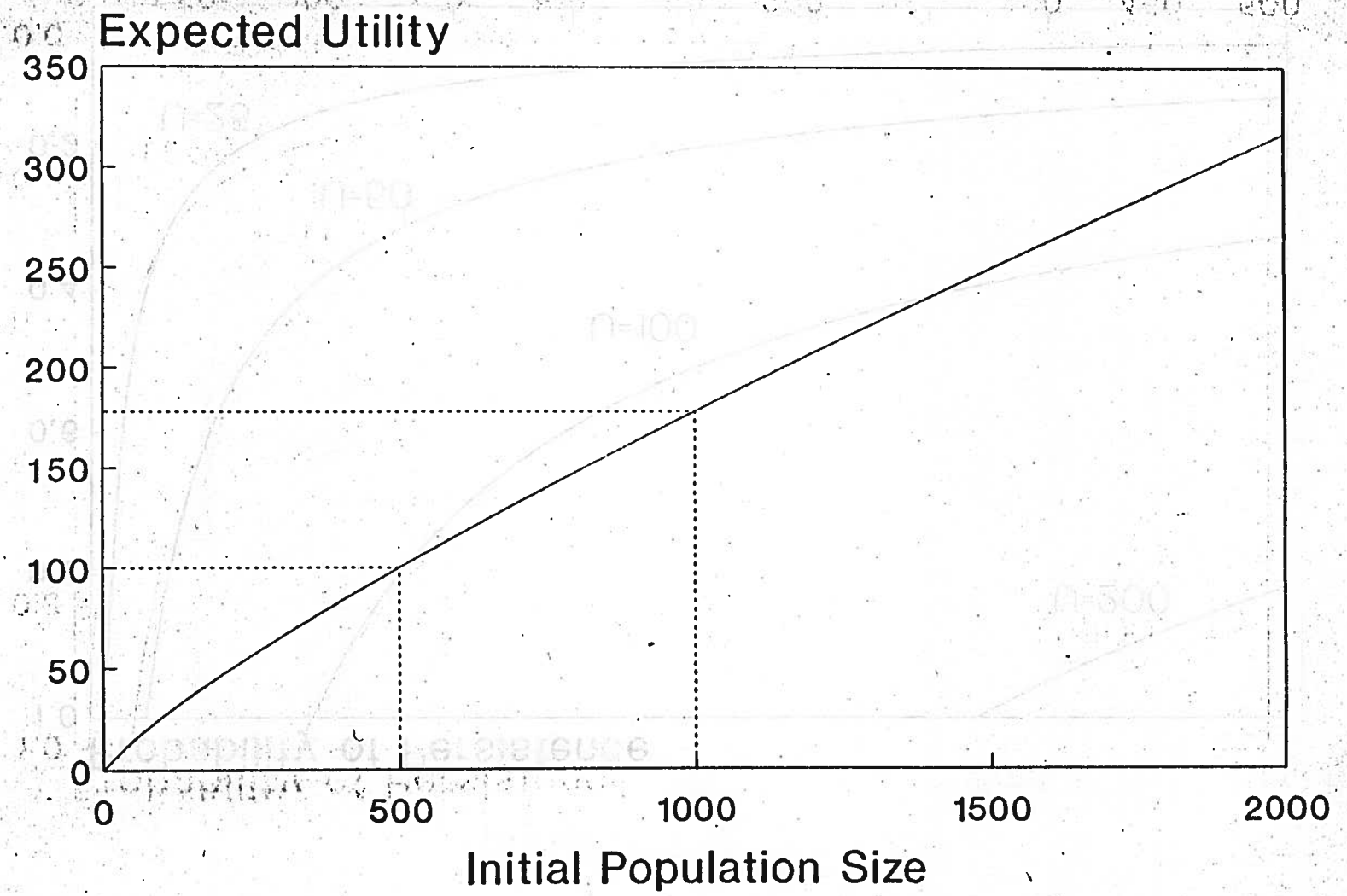

Expected Utility
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
Initial Population Size

Figure A3.

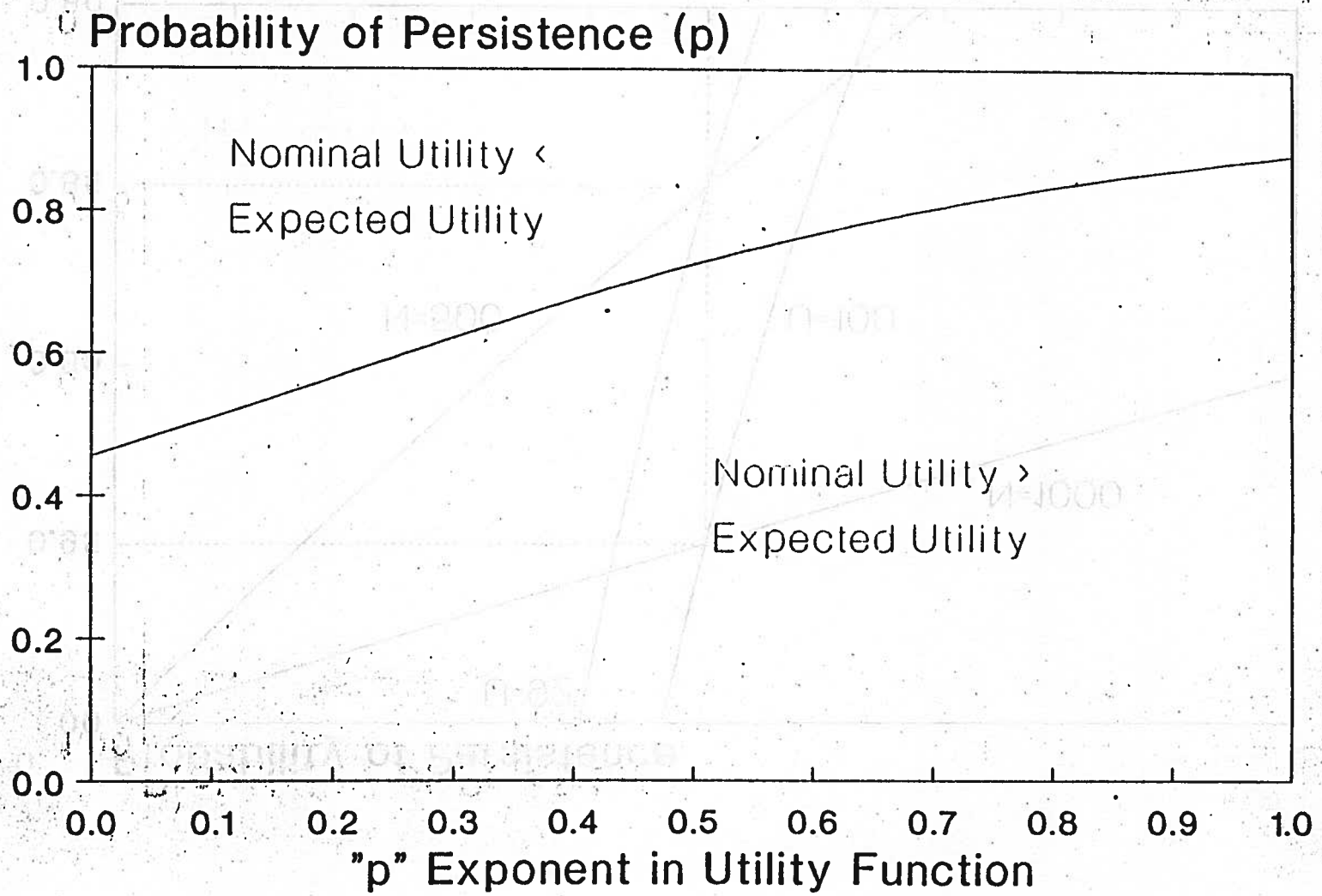

Probability of Persistence (p)
1.0
0.8
0.6
0.4
0.2
0.0
Nominal Utility <
Expected Utility
Nominal Utility >
Expected Utility
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
"p" Exponent in Utility Function

Figure A4.

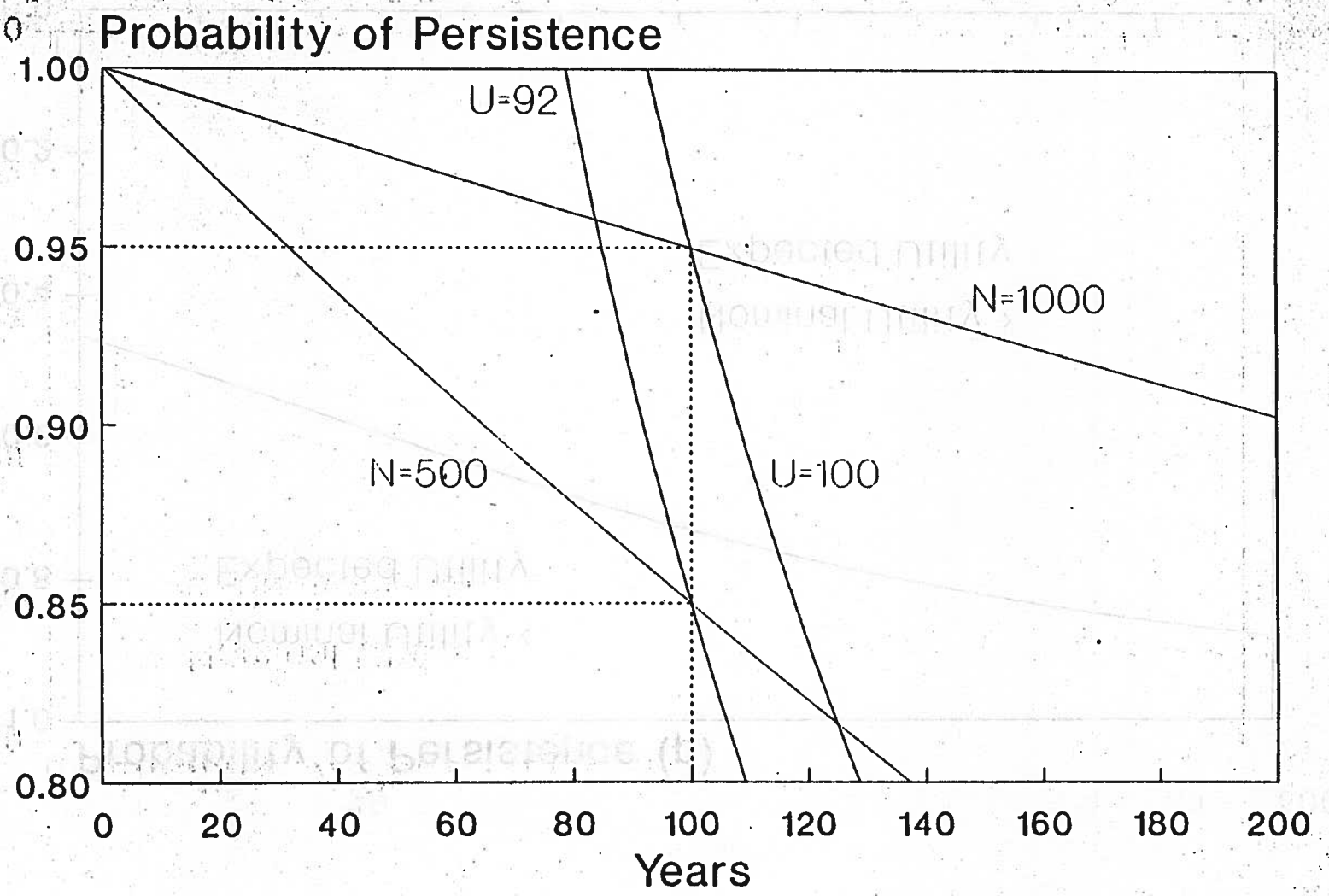

Probability of Persistence
1.00
0.95
0.90
0.85
0.80
U=92
N=1000
N=500
U=100
0
20
40
60
80
100
120
140
160
180
200
Years

Figure A5.

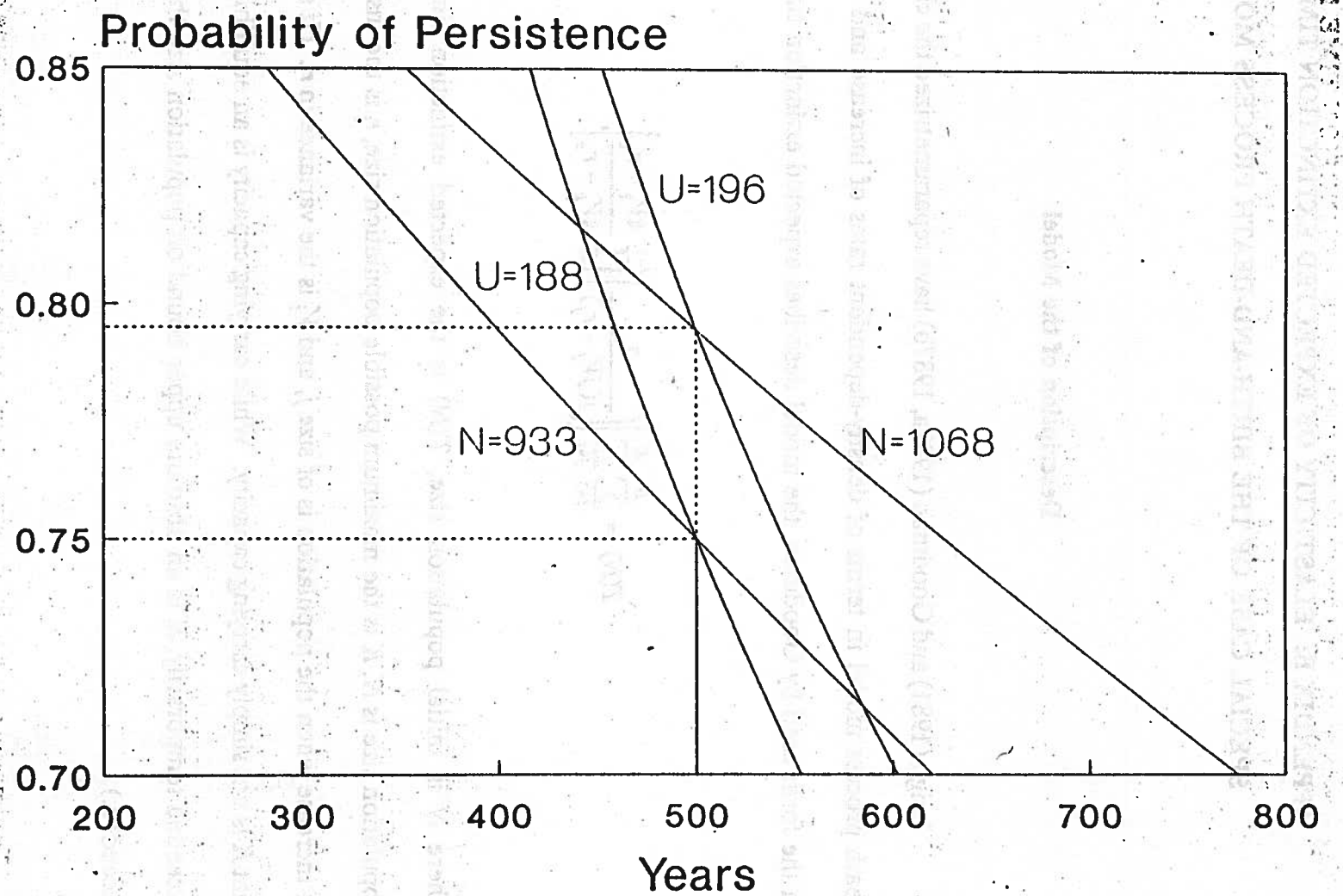

Probability of Persistence
0.85
0.80
0.75
0.70
200
300
400
500
600
700
800
Years
U=196
U=188
N=933
N=1068

Figure A6.

# APPENDIX B: ELASTICITY OF EXPECTED EXTINCTION TIME IN A SPECIAL CASE OF THE BIRTH-AND-DEATH PROCESS MODEL

## Description of the Model

Leigh (1981) and Goodman (1987a, 1987b) have reparametrized the classic birth-and-death process model in terms of density-dependent rates of increase and their variances. In the form used by Goodman, the model describes expected extinction time as follows:

$$T(N) = \sum_{i=1}^{N} \sum_{j=i}^{K} \left[ \left( \frac{2}{j(jV_j - r_j)} \right) \prod_{k=i}^{j-1} \frac{kV_k + r_k}{kV_k - r_k} \right], \tag{B1}$$

where $N$ is initial population size, $T(N)$ is the expected extinction time when initial population size is $N$, $K$ is the maximum possible population size, $r_j$ is the instantaneous rate of increase when the population is of size $j$, and $V_j$ is the variance in $r_j$. (It should be noted that $K$ is not simply carrying capacity. While carrying capacity is an equilibrium that can be exceeded temporarily, $K$ is an absolute upper bound on population size that can never be exceeded.)

To simplify matters, let density dependence be eliminated by assuming constant $r$ and $V$. In a population managed for sustained yield, it might be reasonable to set the constant

$r$ value at zero. These two assumptions reduce the complexity of Equation (B1) considerably, giving

$$T(N) = \left(\frac{2}{V}\right)\sum_{i=1}^{N}\sum_{j=i}^{K}\frac{1}{j^2}. \tag{B2}$$

Although less awkward than Equation (B1), Equation (B2) still requires a number of computations that quickly becomes prohibitive as $N$ or $K$ increase. This number can be reduced appreciably by rewriting Equation (B2) as

$$T(N) = \left(\frac{2}{V}\right)\left(N\sum_{i=1}^{K}\frac{1}{i^2} - \sum_{i=2}^{N}\sum_{j=i}^{i-1}\frac{1}{j^2}\right). \tag{B3}$$

As $K$ becomes large, further changes in $K$ cause very little change in Equation (B3). Thus, for populations with high $K$ values, little accuracy is sacrificed by taking the limit of Equation (B3) as $K$ approaches infinity (this, in fact, was the original approach used by Leigh [1981]). In the case of Equation (B3), taking this limit involves computing the sum of reciprocal squares from 1 to infinity. This sum is Riemann's "zeta" function evaluated at $n=2$, $\zeta(2)$, which converges to a value of 1.644934.... Equation (B3) then becomes

$$T(N) = \left(\frac{2}{V}\right)\left(N\zeta(2) - \sum_{i=2}^{N}\sum_{j=i}^{i-1}\frac{1}{j^2}\right). \tag{B4}$$

## Elasticity

A unit increment in $N$ increases Equation (B4) as follows:

$$\begin{aligned} T(N+1) - T(N) &= \left(\frac{2}{V}\right)\left((N+1)\zeta(2) - \sum_{i=2}^{N}\sum_{j=1}^{i-1}\frac{1}{j^2} - \sum_{j=1}^{N}\frac{1}{j^2}\right) - \\ &\quad \left(\frac{2}{V}\right)\left(N\zeta(2) - \sum_{i=2}^{N}\sum_{j=1}^{i-1}\frac{1}{j^2}\right) \\ &= \left(\frac{2}{V}\right)\left(\zeta(2) - \sum_{i=1}^{N}\frac{1}{j^2}\right). \end{aligned} \tag{B5}$$

Let the elasticity of $T(N)$, $E(N)$, be defined as

$$E(N) = N\left(\frac{T(N+1) - T(N)}{T(N)}\right) = \frac{\zeta(2) - \sum_{j=1}^{N}\frac{1}{j^2}}{\zeta(2) - \left(\frac{1}{N}\right)\sum_{i=2}^{N}\sum_{j=1}^{i-1}\frac{1}{j^2}}. \tag{B6}$$

Equation (B6) describes the proportionate gain in expected extinction time relative

to a proportionate increase in initial population size, as shown in Figure B1 for values of $N$ up to 10,000. For example, at an initial population size of 1000, a unit increase in $N$ would represent a relative change of 0.1%. This would correspond to a relative change in expected extinction time of about 0.0118%, for an elasticity of 0.118 (0.0118% divided by 0.1%). In Figure B1, elasticity declines from a value of 0.392 at $N=1$ to a value of 0.092 at $N=10{,}000$. A value of 0.1 is obtained at $N=4534$.

An important difference between $E(N)$ and $T(N)$ is that the former does not depend on $V$, whereas the latter is inversely proportionate to $V$ in the simplified model developed here. Thus, if one desired a relatively robust value of $N$ to serve as a default minimum viable population size in cases where data are limited, it might be wise to select it on the basis of the corresponding elasticity of expected extinction time rather than the expected extinction time itself.

Although there is nothing "magic" about an elasticity of 10%, it is a round number to which people can easily relate. It should also be noted that choosing a pragmatic cutoff point is not without precedent in natural resource management. In fisheries management, for example, the harvest strategy known as $F_{0.1}$ is based on a purely pragmatic 10% cutoff, but it nevertheless enjoys considerable support among fisheries managers and scientists (e.g., Deriso 1987, Clark in press). Furthermore, the population size corresponding to an elasticity of 10% lies squarely within the range of minimum viable population sizes that have been suggested in the literature.

## An Approximation

It has been suggested that expected extinction time should increase approximately with the logarithm of $N$ (Leigh 1981, Ewens et al. 1987, Pimm et al. 1988). An approximation of Equation (B2) can serve to confirm this. Replacing the summations in Equation (B2) with integrals gives

$$T(N) \approx \left(\frac{2}{V}\right)\int_1^N \int_y^K \frac{dx}{x^2}\,dy = \left(\frac{2}{V}\right)\left[\ln(N) - \left(\frac{N-1}{K}\right)\right]. \tag{B7}$$

As $K$ approaches infinity, Equation (B7) increases exactly as the logarithm of $N$. For this special case, Equation (B7) tends to underestimate Equation (B4) by a fairly constant amount. At $N=1$, the difference is equal to $2\zeta(2)$, or 3.289868.... As $N$ becomes large, the difference declines to a value of $2(1+\gamma)$, where $\gamma$ is Euler's constant (0.577216...). Thus, a good approximation of Equation (B4) for large $N$ (i.e., greater than about 10) is

$$T(N) \approx \left(\frac{2}{V}\right)[\ln(N) + 1 + \gamma]. \tag{B8}$$

The elasticity implied by Equation (B8) is simply

$$E(N) \approx \left(\frac{N}{T(N)}\right)\left(\frac{dT}{dN}\right) = \frac{1}{\ln(N) + 1 + \gamma}. \tag{B9}$$

Equations (B8) and (B9) are obviously much less computationally intensive than their exact counterparts. For example, it is easy to see from Equation (B9) that $E(N)$ declines quite slowly at large $N$, not reaching a value of 0.05 until $N$ exceeds 100,000,000. Thus, the elasticity of expected extinction time shares one of the characteristics common to all methods used to calculate minimum viable populations: there is no obvious point at which a population passes from being viable to being nonviable; instead, a judgement call must be made. As a fallback for use in data-poor situations, the population size corresponding to an elasticity of 10% (about 5000 individuals) seems to be a reasonable candidate.

## References

Clark, W. G. In press. Choosing an exploitation rate on the basis of life history parameters. Can. J. Fish. Aquat. Sci. 00:0000-0000.

Deriso, R. B. 1987. Optimal $F_{0.1}$ policies and their relationship to maximum sustainable yield. Can. J. Fish. Aquat. Sci. 44(Suppl. 2):339-348.

Pimm, S. L., H. L. Jones, and J. Diamond. 1988. On the risk of extinction. Am. Nat. 132:757-785.

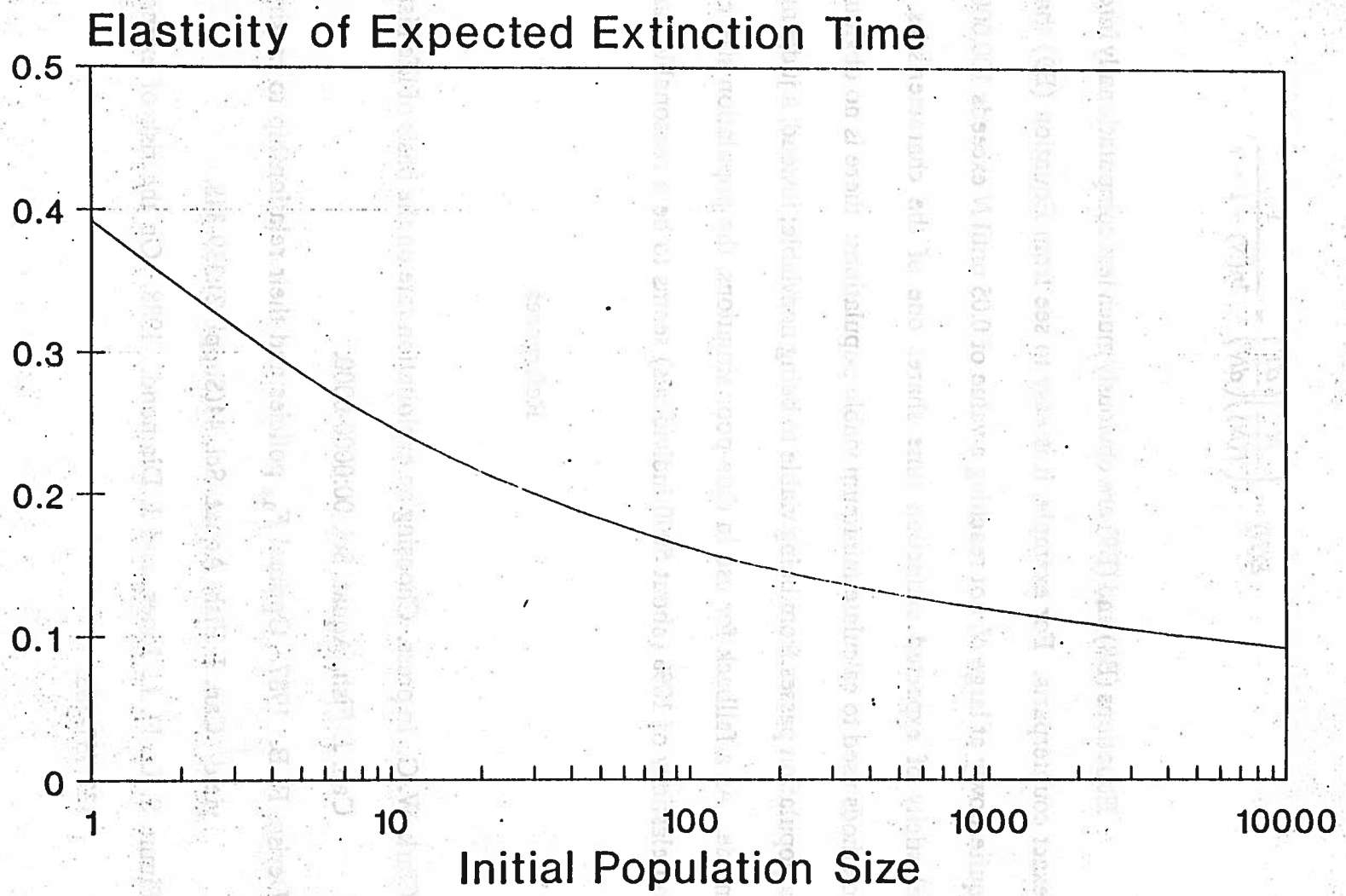

Elasticity of Expected Extinction Time
0.5
0.4
0.3
0.2
0.1
0
1
10
100
1000
10000
Initial Population Size

Figure B1.

File under Mead vs Area Analysis

# CURRENT AND PROJECTED ESTIMATES OF LYNX NUMBERS IN WASHINGTON

Gary M. Koehler

Lynx population dynamics and ecology were studied in Okanogan County of Washington state from 1980 to 1988. The Washington Department of Wildlife conducted research from 1980 through 1983 and the Wildlife Research Institute continued this research from 1984 through 1987. The study area was located between the Okanogan and Methow-Chewack Rivers, with intensive work conducted above 4,500 feet elevation.

Twenty-eight lynx were captured and radio-collared since studies began. Estimates of the number of lynx in the study area from 1981 through 1983 were 20 resident adults, or approximately 1 lynx/13 $mi^2$. From 1985 through 1987, 15 resident animals occupied the study area, for a density of 1 lynx/17 $mi^2$. These densities are equivalent to low lynx densities in Alaska and Canada when snowshoe hare populations, their dominant prey, have declined.

Lynx populations in Washington and the rest of the Pacific Northwest are at the southern edge of the species range. Low densities are characteristic of populations occurring along the periphery of a range.

Factors which affect population stability include mortality, recruitment, immigration, and emigration rates.

EXHIBIT "D"

In the past, lynx populations in Okanogan County may have been augumented by lynx immigrating from British Columbia. This is true for lynx populations in Minnesota, which increase as a result of immigration during cyclic increases of lynx numbers in Canada.

Lynx numbers in the study area have decreased since 1981. The reason for the population decline is unknown. There is no evidence that this decrease is a result of a "lynx-snowshoe hare cycle". In fact, studies elsewhere show that snowshoe hares may not cycle in this part of their range. The relatively constant recruitment rate during this period suggests that lynx are not responding to increases or decreases in prey abundance.

An average of 2 kittens have been produced annually on the study area since 1981. The annual recruitment rate is 12%, based on a mean population of 17 lynx. Kitten survival is low, with only a 12% survival rate among kittens. The annual mortality rate for adults, determined from radio-collared animals, averaged 16%. The low kitten survival and low recruitment rate is characteristic of lynx populations at northern latitudes when prey is scarce, and as determined for the study area, is apparently characteristic of peripheral populations as well.

From a knowledge of lynx habitat requirements and inventories of forest cover types, based on LANDSAT generated maps, the numbers of lynx on the entire Okanogan National Forest were estimated. Lynx in Okanogan County

prefer lodgepole pine forest communities above 4,500 feet elevation. Habitat inventories include all lodgepole pine stands, some of which may be too small and isolated to support lynx. Therefore, these inventories would result in a higher estimate of lynx habitat than is actually available to lynx.

For example, in the study area the home range areas of females and males averaged 19.5 $mi^2$ and was comprised of 58% lodgepole pine forests. Therefore, each lynx requires 7,200 acres of lodgepole pine forests. Forest cover types inventories show 140,911 acres of lodgepole pine on the study area. This suggests that the study area may support 19 females and 19 males, or 38 lynx. This is greater than twice the average of 17 lynx estimated for the area as determined by radio-telemetry and snow-tracking. The discrepancy in estimates may be due to biases of forest cover type inventories. West of the Methow-Chewack Rivers, habitat inventories indicate 84,195 acres of lodgepole pine habitat exist, or enough habitat to support 11 females and 11 males. Here, too, habitat inventories may be biased because of inclusions of small, isolated, or disjunct pockets of habitat. Therefore, an estimate of 22 animals should be considered maximum.

The combined habitat inventories indicate there may be a maximum of 60 lynx in western Okanogan County. However, as demonstrated for the study area, actual numbers of lynx may be 44% of the estimates calculated from habitat

inventories. Therefore, population estimates for western Okanogan County would be closer to 27 animals, with an estimates of 60 animals being maximum.

The best habitat for lynx in Washington state is found in western Okanogan County, including the study area, because it contains the largest contiguous area of habitat. Habitats for lynx within the Pasayten Wilderness and areas between the Methow and Stehekin Rivers (Lake Chelan) occur as isolated pockets and peninsulas, with rugged peaks and alpine meadows dominating the landscape. Even though lynx habitat is marginal in these areas, it is superior to habitat conditions in eastern Okanogan County and the remainder of northern Washington.

According to 1977 timber inventory estimates, the Wenatchee National Forest has about 77,000 acres of lodgepole pine habitat. However, since 1977 much of it has been logged. The area near Lake Chelan that burned in 1970 should provide good prey habitat for lynx, but of 18,000 acres of lodgepole habitat occurring within the burn, 13,000 acres, or 72%, have been precommercially thinned. Thinned stands provide little cover for lynx and poor habitat for snowshoe hares, its dominant prey. Furthermore, these thinned and logged areas may not become suitable habitat for lynx for 15-20 years. At best, because of timber harvesting, the Wenatchee National Forest may support a maximum of 20 lynx.

Intensive timber management practices, clearcut timber harvesting and precommercial thinning, may benefit lynx in the long term by creating habitat favorable for prey. If timber harvesting is limited and if dense stands of lodgepole pine are allowed to become established after harvesting, habitat conditions for lynx could improve resulting in increased carrying capacity and recruitment in lynx populations. However, the impacts on lynx for 15 to 20 years following timber management activities will be negative. The short term effect is to remove habitat for prey and cover of lynx. Removing 20 to 30% of mature lodgepole pine stands to promote young aged lodgepole pine stands will decrease the carrying capacity for lynx by 20-30%, for up to 2 decades. Road construction, too, will have negative impacts on lynx populations because of destruction of habitat and increased access for the legal and illegal harvest of lynx. However, some of these short term impacts may be mitigated by increased prey numbers over the long term (> 20-30 years).

Increased timber harvesting and thinning over the next 5 decades, as projected in Forest Management Plans, may result in a net decrease in lynx habitat and resultant decreases of lynx numbers in the next few decades. Populations in Washington may not be augmented by lynx immigration from British Columbia, as may have occurred in the past. Extensive timber harvesting and heavy trapping pressure, in response to high prices for pelts, in British

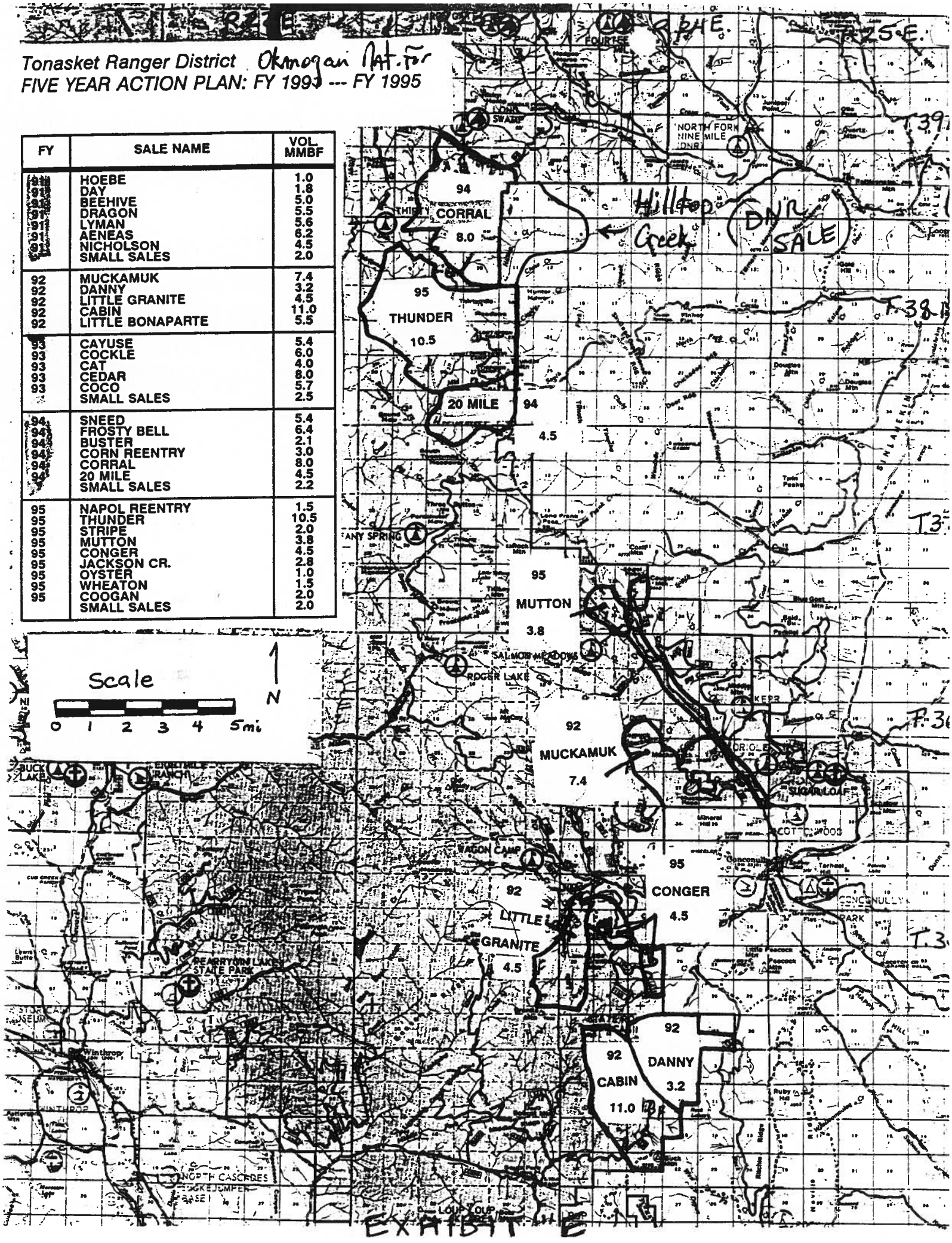
Columbia may decrease lynx immigration into Washington. Already, heavy trapping pressure has resulted in lower lynx numbers in eastern Canada in recent years.

Hunting and trapping mortality, too, may put additional stress on lynx populations in Washington. As shown from studies of lynx in Alaska and Canada, hunting and trapping caused mortality is additive to natural mortality. As found in the Okanogan study area, the majority of natural mortality occurs during the summer. Fall or winter harvest mortality would then be additive to the natural mortality. Also, females that are harvested may not be replaced until the following summer, the period of dispersal and immigration. This would result in loss of a potential source of recruitment for one year. Female kittens produced on the area may or may not remain and become reproductively viable, even if a vacancy is available. Juvenile females are not reproductively active, particularly when the prey base is low, as may occur in Washington.

In my view, the outlook for lynx populations in Washington is not favorable. Harvest of lynx in Washington would further impact a population that will already be stressed by loss of habitat from timber harvesting. I believe that it is necessary to suspend lynx harvest seasons for the immediate future. This would allow lynx to cope better with the impacts on its habitat and, hopefully, increase in response to any habitat improvements.

*Tonasket Ranger District* Okanogan Nat. For
*FIVE YEAR ACTION PLAN: FY 1993 --- FY 1995*

| FY | SALE NAME | VOL MMBF |
|---|---|---|
| 91 | HOEBE | 1.0 |
| 91 | DAY | 1.8 |
| 91 | BEEHIVE | 5.0 |
| 91 | DRAGON | 5.5 |
| 91 | LYMAN | 5.6 |
| 91 | AENEAS | 6.2 |
| 91 | NICHOLSON | 4.5 |
| | SMALL SALES | 2.0 |
| 92 | MUCKAMUK | 7.4 |
| 92 | DANNY | 3.2 |
| 92 | LITTLE GRANITE | 4.5 |
| 92 | CABIN | 11.0 |
| 92 | LITTLE BONAPARTE | 5.5 |
| 93 | CAYUSE | 5.4 |
| 93 | COCKLE | 6.0 |
| 93 | CAT | 4.0 |
| 93 | CEDAR | 8.0 |
| 93 | COCO | 5.7 |
| | SMALL SALES | 2.5 |
| 94 | SNEED | 5.4 |
| 94 | FROSTY BELL | 6.4 |
| 94 | BUSTER | 2.1 |
| 94 | CORN REENTRY | 3.0 |
| 94 | CORRAL | 8.0 |
| 94 | 20 MILE | 4.5 |
| | SMALL SALES | 2.2 |
| 95 | NAPOL REENTRY | 1.5 |
| 95 | THUNDER | 10.5 |
| 95 | STRIPE | 2.0 |
| 95 | MUTTON | 3.8 |
| 95 | CONGER | 4.5 |
| 95 | JACKSON CR. | 2.8 |
| 95 | OYSTER | 1.0 |
| 95 | WHEATON | 1.5 |
| 95 | COOGAN | 2.0 |
| | SMALL SALES | 2.0 |



Tonasket Ranger District- Okanogan Nat. For.
FIVE YEAR ACTION PLAN: FY 1991 --- FY 1995

| FY | SALE NAME | TOTAL VOL. MMBF | LPP VOL MMBF | HELI LOGGING MMBF | CABLE LOGGING MMBF | ROAD CONST. MILES | ROAD RECONST. MILES |
|---|---|---|---|---|---|---|---|
| 91 | HOEBE | 1.0 | - | - | - | - | 1.5 |
| | DAY | 1.8 | - | - | 0.6 | 0.5 | 1.0 |
| | BEEHIVE | 5.0 | - | - | 0.5 | 4.9 | 4.7 |
| | DRAGON | 5.5 | 1.5 | - | 1.8 | 1.0 | - |
| | LYMAN | 5.6 | - | - | 0.5 | 1.0 | 8.1 |
| | AENEAS | 6.2 | 1.2 | - | 2.3 | 1.0 | - |
| | NICHOLSON | 4.5 | - | - | 2.3 | 0.5 | - |
| | SMALL SALES | 2.0 | 2.0 | - | - | - | - |
| | | 31.6 | | | | | |
| 92 | ✓MUCKAMUK | 7.4 | 3.0 | - | 1.5 | 1.5 | - |
| | DANNY | 3.2 | - | - | 0.9 | - | 2.0 |
| | ✓LITTLE GRANITE | 4.5 | - | - | 1.5 | 4.0 | 1.0 |
| | ✓CABIN | 11.0 | 2.0 | - | 3.4 | 6.0 | 1.0 |
| | LITTLE BONAPARTE | 5.5 | 1.5 | - | 1.0 | 1.0 | - |
| | | 31.6 | | | | | |
| 93 | CAYUSE | 5.4 | 2.5 | - | - | 1.0 | - |
| | COCKLE | 6.0 | - | - | 2.0 | 2.0 | - |
| | ✓CAT | 4.0 | - | - | 3.4 | 15.0 | - |
| | ✓CEDAR | 8.0 | - | - | 5.6 | 13.8 | - |
| | COCO | 5.7 | - | - | 2.6 | 1.0 | - |
| | SMALL SALES | 2.5 | 2.0 | - | - | - | - |
| | | 31.6 | | | | | |
| 94 | SNEED | 5.4 | - | - | 1.5 | 2.0 | - |
| | FROSTY BELL | 6.4 | - | - | 1.4 | 2.0 | - |
| | BUSTER | 2.1 | 0.7 | - | - | 1.0 | - |
| | CORN REENTRY | 3.0 | - | - | 1.6 | - | - |
| | ✓CORRAL | 8.0 | 8.0 | - | 4.7 | 10.0 | - |
| | ✓20 MILE | 4.5 | 4.5 | - | - | 4.0 | - |
| | SMALL SALES | 2.2 | 1.4 | - | - | - | - |
| | | 31.6 | | | | | |
| 95 | NAPOL REENTRY | 1.5 | - | - | - | - | - |
| | ✓THUNDER | 10.5 | 10.0 | - | - | 15.0 | - |
| | STRIPE | 2.0 | - | - | - | - | - |
| | MUTTON | 3.8 | 0.8 | - | - | 1.0 | - |
| | CONGER | 4.5 | 2.5 | - | - | - | - |
| | ✓JACKSON CR. | 2.8 | - | - | - | 6.0 | - |
| | OYSTER | 1.0 | - | - | - | - | - |
| | WHEATON | 1.5 | - | - | - | 4.0 | - |
| | COOGAN | 2.0 | - | - | - | 3.0 | - |
| | SMALL SALES | 2.0 | 1.0 | - | - | - | - |
| | | 31.6 | | | | | |

✓ [illegible]

Tonasket Ranger District - Okanogan Nat'l For.
FIVE YEAR ACTION PLAN: FY 1991 --- FY 1995

| FY | SALE NAME | TOTAL VOL. MMBF | LPP VOL. MMBF | HELI LOGGING NMBF | CABLE LOGGING MMBF | ROAD CONST. MILES | ROAD RECONSTR. MILES |
|---|---|---|---|---|---|---|---|
| 91 | ROBBE- | 1.0 | - | - | - | - | 1.5 |
| | DAY | 1.8 | - | - | 0.6 | 0.5 | 1.0 |
| | BUCKHIVE-WAC | 5.0 | - | - | 0.5 | 4.5 | 0.7 |
| | DRAGON | 5.3 | 1.5 | - | 1.5 | 1.0 | - |
| | LYMAN | 5.6 | - | - | 0.5 | 1.0 | 8.1 |
| | ABRAS | 6.2 | 1.2 | - | 2.3 | 1.0 | - |
| | NICHOLSON | 4.5 | - | - | 2.3 | 0.5 | - |
| | SMALL SALES | 2.0 | 2.0 | - | - | - | - |
| | | 31.6 | | | | | |
| 92 | MOUNTAINNUK | 7.4 | 3.0 | - | 3.5 | 1.5 | - |
| | BANNY | 3.2 | - | - | 0.9 | - | 2.0 |
| | LITTLE GRANITE | 5 | - | - | 1.5 | 4.0 | 1.0 |
| | CASTIN | 11.0 | 2.0 | - | 3.4 | 6.0 | 1.0 |
| | LITTLE BONAPARTE | 5.7 | 1.5 | - | 1.0 | 1.0 | - |
| | | 37.6 | | | | | |
| 93 | CAUSE | 5.4 | 2.5 | - | - | 1.0 | - |
| | COCKLE | 5.0 | - | - | 2.0 | 2.0 | - |
| | MOAT | 4.0 | - | - | 3.5 | 15.0 | - |
| | MITCHAN | 8.0 | - | - | 3.0 | 13.8 | - |
| | COLD | 3.7 | - | - | 2.6 | 1.0 | - |
| | SMALL SALES | 2.5 | 2.0 | - | - | - | - |
| | | 31.6 | | | | | |
| 94 | SNEED | 5.4 | - | - | 1.5 | 2.0 | - |
| | MOSTY BELL | 6.4 | - | - | 1.4 | 2.0 | - |
| | BUSTER | 2.1 | 0.7 | - | - | 1.0 | - |
| | DOUG REENTRY | 3.0 | - | - | 1.6 | - | - |
| | CRYSTAL | 8.0 | - | - | 4.7 | 10.0 | - |
| | 20 MILE | 4.5 | 4.5 | - | - | 0.0 | - |
| | SMALL SALES | 2.2 | 1.1 | - | - | - | - |
| | | 31.6 | | | | | |
| 95 | MAPOL REENTRY | 1.5 | - | - | - | - | - |
| | THUNDER | 10.5 | 10.0 | - | - | 15.0 | - |
| | STRIPE | 2.0 | - | - | - | - | - |
| | MUSTON | 3.8 | 0.8 | - | - | 1.0 | - |
| | GONDER | 4.5 | 2.5 | - | - | - | - |
| | JACKSON CRK | 5.8 | - | - | - | 6.0 | - |
| | OYSTER | 1.0 | - | - | - | - | - |
| | WINDATON | 1.5 | - | - | - | 4.0 | - |
| | GOODAN | 5.0 | - | - | - | 3.0 | - |
| | SMALL SALES | 2.0 | 1.0 | - | - | - | - |
| | | 31.6 | | | | | |

United States
Department of
Agriculture
Forest Service

OKANOGAN
NATIONAL
FOREST

1240 South Second
P.O. Box 950
Okanogan, WA 98840
(509) 826-3275

Reply To: 1950 NEPA
2430 Commercial Timber
Sales-GRANITE MOUNTAIN SALES-
Analysis

Date: July 19, 1991

To Interested Persons:

The Okanogan National Forest is designing three timber sales in the Granite Mountain Analysis Area. The analysis area includes the Granite Mountain Roadless area, and is indicated on the attached maps. The Little Granite proposed action is located on the Tonasket Ranger District, and the Pebble and Baldy proposed actions are located on the Winthrop Ranger District. We have started the issue scoping for our analysis. I am asking you to submit any ideas, comments or concerns about the sales that you may have. Your comments will help us implement a well designed timber sale.

There will be two public meetings for further information and scoping. One meeting will be held in Conconully, Washington at the Town Hall (next door to Vicki's Restaurant on Main Street) on July 25, 1991. The meeting will start at 7:00 P.M. The other meeting will be held at Twisp, Washington at the Community Center, Room 1 on July 31, 1991. The meeting will start at 7:00 P.M.

As an integral part of this analysis process, we will be looking at alternatives for controlling noxious weeds, slash, and other competing and unwanted vegetation. Various methods will be evaluated including mechanical treatment, biological treatment, hand treatment, and chemical treatment for noxious weeds. Treatment alternatives for reduction of slash and site preparation will include burning, mechanical treatment, hand treatment, and no action. Post harvest treatments including precommercial thinning and precommercial sanitation of stands will also be evaluated. Guidelines for this are included in the Final Environmental Impact Statement and Mediated Agreement for Managing Competing and Unwanted Vegetation.

The Granite Mountain Analysis area contains about 40,000 acres. Approximately 27,700 acres of this is in the Granite Mountain Roadless Area. The Analysis Area is allocated to the following Management Areas (MA):

-63% in MA 25, the goal within Management Area 25 is to intensively manage the timber and range resources using both even-aged and uneven-aged Silvicultural practices, while protecting the basic productivity of the land and providing for the production of wildlife, recreation opportunities and other resources.

EXHIBIT "F"

United States
Department of
Agriculture
Forest Service

OKANOGAN
NATIONAL
FOREST

1240 South Second
P.O. Box 950
Okanogan, WA 98840
(509) 826-3275

Reply To: 1950 NEPA
2430 Commercial Timber
Sales-DEAVITT MOUNTAIN SALES-
Analysis

Date: July 10, 1991

To Interested Persons:

The Okanogan National Forest is designing three timber sales in the Granite Mountain Analysis Area. The analysis area includes the Granite Mountain Roadless area, and is indicated on the attached map. The Little Granite proposed action is located on the Tonasket Ranger District, and the Peebles and Bailey proposed actions are located on the Methow Ranger District. We have started the issue scoping for our analysis. I am asking you to submit any ideas, comments or concerns about the sales that you may have. Your comments will help us implement a well designed timber sale.

There will be two public meetings for further information and scoping. One meeting will be held in Conconully, Washington at the Town Hall (next door to Wendel's Restaurant on Main Street) on July 29, 1991. The meeting will start at 7:00 P.M. The other meeting will be held at Twisp, Washington at the Community Center, Room 1 on July 31, 1991. The meeting will start at 7:00 P.M.

As an integral part of this analysis process, we will be looking at alternatives for economically feasible roads, slash, and other logging and onsite operation. Various methods will be evaluated including mechanical treatment, biological treatment, hand treatment, and chemical treatment for noxious weeds. Treatment alternatives for reduction of slash and site preparation will include burning, mechanical treatment, hand treatment, and no action. Post harvest treatments including precommercial thinning and precommercial maintenance of stands will also be evaluated. Guidelines for this are included in the Final Environmental Impact Statement and Mediated Agreement for Managing Coniferous and Hardwood Vegetation.

The Granite Roadless Analysis area contains about 60,000 acres. Approximately 47,700 acres of this is in the Granite Mountain Roadless Area. The Analysis area is allocated to the following Management Areas (MA):

-65% in MA 25, the Pool Habitat Management Area 25 is to intensively manage the timber and range resources using both even-aged and uneven-aged silvicultural practices, while protecting the basic productivity of the land and providing for the production of wildlife, recreation opportunities and other resources.

EXHIBIT "F"

-22% in MA 12, the goal of Management Area 12 is to provide habitat to support a stable lynx population over the long term while accessing the area for the purpose of growing and producing merchantable wood fiber.

-13% in MA 5, the goal of Management Area 5 is to provide opportunities for recreation and viewing scenery in a roaded natural setting with a visual quality objective of retention or partial retention. Approximately 2,500 acres will be managed with a visual quality objective of retention, and the remaining 2,816 acres will be managed with a visual quality objective of partial retention.

-2% in MA 14, the goal of MA 14 is to provide a diversity of wildlife habitat, including deer winter range, while growing and producing merchantable wood fiber.

The analysis will evaluate a range of alternatives. Alternatives to be evaluated range from no-action, with no timber harvest or road construction to alternatives that may propose timber harvest up to 26.5 MMBF and 62 miles of road construction or more.

Descriptions of Proposed Actions:

Little Granite

The Little Granite proposed sale area is located approximately 7 miles southwest of Conconully, Washington in sections 7, 8, 17,18, 19, 20, 28, 29, 30, 31, 32, and 33, T. 35 N., R. 24 E., sections 4, 5, 6, 7, 8, 9, 16, and 17, T. 34 N., R. 24 E., and sections 13, 23, 24, and 25, T. 35 N., R. 23 E. The proposed Sale Area includes approximately 7,000 acres. The Okanogan National Forest Land and Resource Management Plan (Forest Plan) identifies the entire proposed sale area as Management Area 25.

The preliminary proposed action for the Little Granite Area is a timber sale of approximately 11.5 MMBF. This proposal would include shelterwood harvests, seedtree harvests, overstory removals, and slash treatments over approximately 2,300 acres. About 57% of the proposal would be tractor logged, 36% would be skyline logged, and the remainder would be helicopter logging. The preliminary proposed action would require approximately 26 miles of road construction.

Pebble

The Pebble proposed sale area is located approximately 9 miles northeast of Winthrop, Washington in sections 1, 2, 3, 4, 5, 9, 10, 11, 12, and 13, T. 35 N., R. 22 E., and sections 22, 26, 28, 32, 33, 34, 35, and 36, T. 36 N., R. 22E. The area is approximately 9,700 acres. The Forest Plan identifies 2 Management areas for the area; About 94 % of the area is in Management Area 25 with the remainder as Management Area 5.

The preliminary proposed action for the Pebble proposed sale area is a timber sale of approximately 14.0 MMBF. This proposal would include shelterwood, clearcut, and seedtree regeneration harvests, partial removals, overstory removals, and slash treatments over approximately 1,700 acres. About 23% of the proposal would be tractor logged, and 77%

-22% in MA 12, the goal of Management Area 12 is to provide habitat to support a stable lynx population over the long term while accessing the area for the purpose of growing and producing merchantable wood fiber.

-11% in MA 5, the goal of Management Area 5 is to provide opportunities for recreation and viewing scenery in a roaded natural setting with a visual quality objective of retention or partial retention. Approximately 2,320 acres will be managed with a visual quality objective of retention, and the remaining 4,816 acres will be managed with a visual quality objective of partial retention.

-2% in MA 14, the goal of MA 14 is to provide a diversity of wildlife habitat, including deer winter range, while growing and producing merchantable wood fiber.

The analysis will evaluate a range of alternatives. Alternatives to be evaluated range from no-action, with no timber harvest or road construction to alternatives that may propose timber harvest up to 26.5 MMBF and 62 miles of road construction or more.

Descriptions of Proposed Activity:

Little Granite

The Little Granite proposed sale area is located approximately 7 miles southwest of Plummer, Washington in sections 7, 8, 17, 18, 19, 20, 28, 29, 30, 31, 32, and 33, T. 39 N., R. 24 E., sections 4, 5, 6, 7, 8, 9, 16, and 17, T. 38 N., R. 24 E., and sections 13, 23, 24, and 25, T. 39 N., R. 25 E. The proposed sale area includes approximately 7,800 acres. The Coeur d'Alene National Forest Land and Resource Management Plan (Forest Plan) identifies the entire proposed sale area as Management Area 25.

The preliminary proposed action for the Little Granite Area is a timber sale of approximately 13.5 MMBF. This proposal would include ponderosa harvesting, selective harvesting, overstory removals, and slash treatments over approximately 2,320 acres. About 57% of the proposal would be thinning logged, 38% would be shelterwood logged, and the remainder would be hydrologic logging. The preliminary proposed action would require approximately 22 miles of road construction.

Fossil

The Fossil proposed sale area is located approximately 9 miles northwest of Winthrop, Washington in sections 1, 2, 3, 4, 5, 9, 10, 11, 12, and 13, T. 35 N., R. 22 E., and sections 32, 26, 28, 32, 33, 34, 35, and 36, T. 36 N., R. 22E. The area is approximately 9,700 acres. The Forest Plan identifies 2 Management areas for the area. About 94 % of the area is in Management Area 25 with the remainder as Management Area 5.

The preliminary proposed action for the Fossil proposed sale area is a timber sale of approximately 14.0 MMBF. This proposal would include shelterwood, clearcut, and seedtree regeneration harvests, partial removals, overstory removals, and slash treatments over approximately 1,700 acres. About 23% of the proposed would be clearcut logged, and 77%

harvested with sk ne logging. The preliminary p osed action would require approximately 30 miles of road construction.

Baldy

The Baldy proposed sale area is located approximately 11 miles northeast of Winthrop, Washington in sections 19, 20, 28, 29, 31, 32, and 33, T. 36 N., R. 23 E., and sections 4, 5, 8, and 9, T. 35 N., R. 23E. The area is approximately 9,300 acres. Two management areas are designated by the Forest Plan for the area; Management Area 12 comprises 84% amd the remainder is in Management Area 5.

The preliminary proposed action for the Baldy proposed sale area is a timber sale of approximately 3.6 MMBF. This proposal would include shelterwood, clearcut, and seedtree regeneration harvests, partial removals, overstory removals, and slash treatments over approximately 400 acres. The timber would be tractor logged. The preliminary proposed action would require approximately 6 miles of road construction.

The preliminary proposed actions will be adjusted and modified to meet Forest Plan Standards and Guidelines. Field work has not been sufficiently completed to determine old growth locations and wildlife habitat information at this time.

Alternatives to the proposed actions will be developed and analyzed using current issues, additional issues raised in scoping, and management direction from the Forest Plan.

Foreseeable future actions include two sales on the Twisp Ranger District which are proposed for sale in 1995. Impacts from these foreseeable actions will be included in this analysis.

All Forest Plan Standards and Guidelines apply to this analysis area. Those areas we have identified of particular importance to this analysis include:

There is a need to assess the impacts to the roadless character of the area.

There is a high level of Dwarf Mistletoe infection in the timber stands.

There is a high potential for mountain pine beetle infestation in the lodgepole pine stands.

Potential impacts of a road crossing on Boulder Creek to access the Pebble Creek drainage.

Visual quality objectives of Partial Retention and Retention need to be met within Management Area 5 along the Middle Salmon Boulder Creek Road (Road 37).

There are potential cumulative effects on water quality and effects to fish habitat. The analysis area lies within the West Okanogan, Beaver, and Chewuch Watersheds.

Intervened with ski lodging. The preliminary 1 mile section would require approximately 30 miles of road construction.

## Baldy

The Baldy proposed sale area is located approximately 11 miles northeast of Winthrop, Washington in sections 19, 20, 28, 29, 31, 32, and 33, T. 30 N., R. 23 E., and sections 4, 5, 6, and 9, T. 29 N., R. 23E. The area is approximately 5,300 acres. Two management areas are designated by the Forest Plan for the Winthrop Ranger District: Area 12 comprises 88% and the remainder is in Management Area 5.

The preliminary proposed action for the Baldy proposed sale area is a timber sale of approximately 3.5 MMBF. This proposal would include shelterwood, clearcut, and seedtree regeneration harvests, partial removals, overstory removal, and slash treatments over approximately 400 acres. The timber would be tractor logged. The preliminary proposed action would require approximately 6 miles of road construction.

The preliminary proposed actions will be adjusted and modified to meet Forest Plan Standards and Guidelines. Field work has not been sufficiently completed to determine old growth locations and wildlife habitat information at this time.

Alternatives to the proposed actions will be developed and analyzed using current issues, additional issues raised in scoping, and management direction from the Forest Plan.

Foreseeable future actions include the sale on the Twisp Ranger District which are proposed for sale in 1995. Impacts from these foreseeable actions will be included in this analysis.

All Forest Plan standards and Guidelines apply to this analysis area. These areas are here identified of particular importance to this analysis including:

There is a need to assess the impacts to the aquatics character of the area.

There is a high level of Forest Wildlife Interest in the Lester vicinity.

There is a high potential for noxious plant habitat infestation in the Lookingglass Pine stands.

Potential impacts of a road crossing on Boulder Creek to access the Pebble Creek drainage.

Visual quality objectives of Partial Retention and Retention need to be met within Management Area 5 along the Middle Salmon Twisted Creek Road (Road 37).

There are potential cumulative effects on water quality and effects on fish habitat. The analysis area lies within the West Chewaucan, Beaver, and Chewuch Watersheds.

A need exist o identify and analyze potenti effects to threatened, endangered, and sensitive plant and animal species which includes grizzly bear, gray wolf, wolverines, and Canada lynx.

There is an opportunity to change access by eliminating a portion of Road 42 which lies within a riparian area, and connecting 42 with the 4200300 Road (Cabin Creek Road). This could provide safer and a longer season of use for forest users as well as reduce impacts to the riparian area.

There may be potential impacts to existing trails and recreation use.

There may be stands of existing old growth, as well as areas suitable for replacement old growth.

There is a need to assess potential impacts to riparian areas and identify opportunities to enhance these areas.

There are concerns about potential increases in noxious weeds, and an opportunity to treat existing problem areas. Alternative strategies will be developed according to Guidelines established by the Final Environmental Impact Statement and Mediated Agreement for Managing Competing and Unwanted Vegetation. Alternatives will include no treatment, mechanical treatment, biological treatment and chemical treatment.

There is a need to provide deer summer range habitat and winter range habitat consistent with Management Area guidelines.

A large majority of the Granite Mountain Analysis Area has had no recent timber management activities. The Forks Burn occurred in 1970 and covered approximately 5,000 acres.

Responses for the analysis may be directed to either the project coordinator, Craig Bobzien (Winthrop Ranger District, P.O. Box 579, Winthrop, Wa 98862- 996-2266), or the project public information coordinator, Teresa Wurschmidt (Tonasket Ranger District, P.O. Box 466, Tonasket, Wa 98855- 486-2186). The maps of the Preliminary Proposed Actions are attached. If you would like to be kept informed as we complete the evaluation process, please let us know in your response letter. A response by August 15, 1991 would be most helpful. We anticipate completing the Analysis by June 1, 1992. I look forward to reading your suggestions and comments about this project.

Sam Gehr

SAM GEHR
Forest Supervisor

Enclosure
TW/taw

A need exists to identify and analyze potential objects to be protected, endangered, and conservative plant and animal species which includes grizzly bear, gray wolf, wolverine, and Canada lynx.

There is an opportunity to change access by eliminating a portion of Road 42 which lies within a riparian area, and connecting 42 with the 42000000 Road (Cable Creek Road). This could provide safer and a longer season of use for forest users as well as reduce impacts to the riparian area.

There may be potential impacts to existing trails and recreation use.

There may be stands of existing old growth, as well as areas suitable for replacement old growth.

There is a need to assess potential impacts to riparian areas and identify opportunities to enhance these areas.

There are concerns about potential increases in noxious weeds, and an opportunity to treat existing problem areas. Alternative strategies will be developed according to guidelines established by the Final Environmental Impact Statement and Mediated Agreement for Managing Controlling and Treating Vegetation. Alternatives will include no treatment, mechanical treatment, biological treatment and chemical treatment.

There is a need to provide deer summer range habitat and winter range habitat consistent with Management Area guidelines.

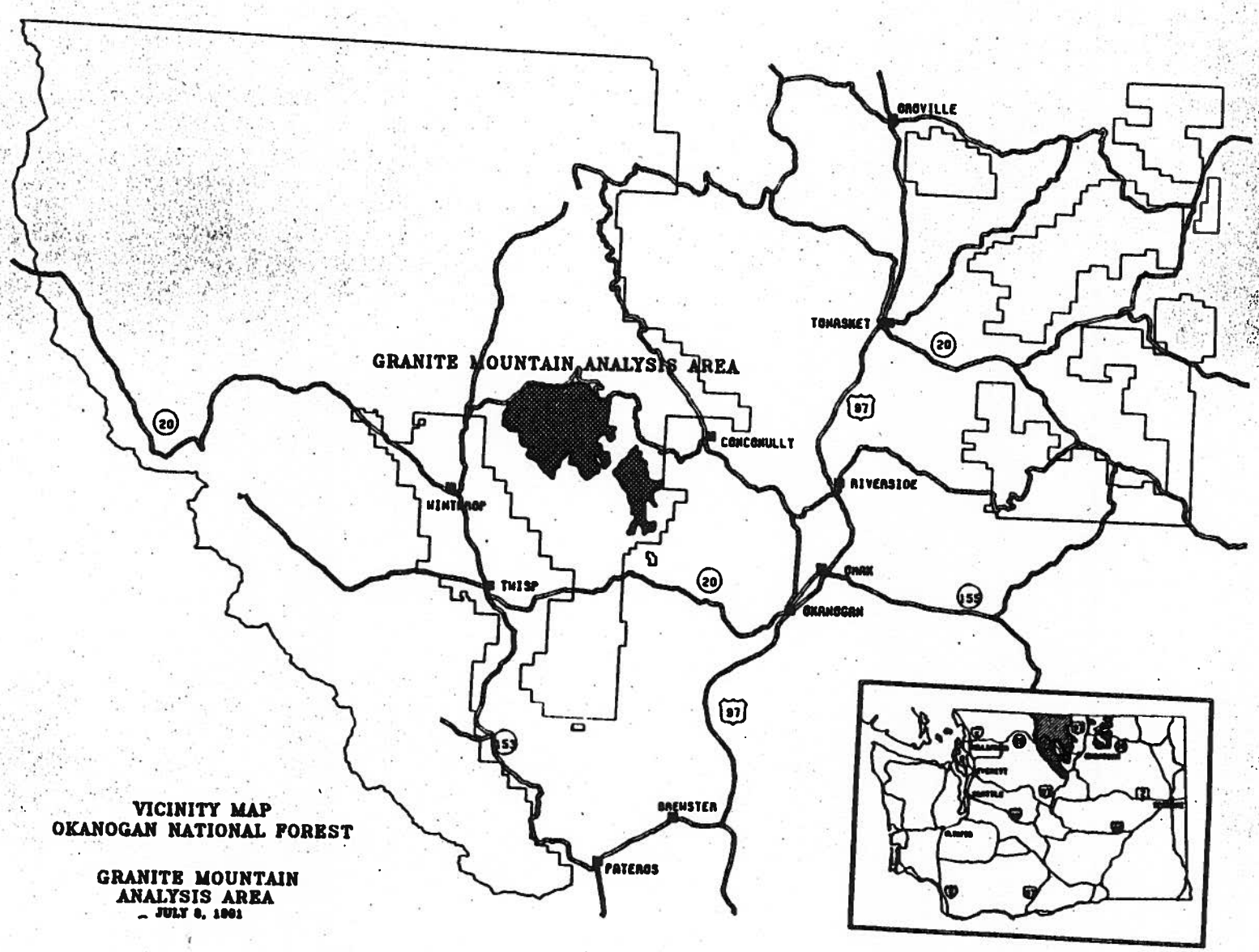
A large majority of the Tenmile Mountain Analysis Area has had no recent timber management activities. The Tenmile Burn occurred in 1970 and covered approximately 5,000 acres.

Responses for the analysis may be directed to either the project coordinator, Craig Foster (Winthrop Ranger District, P.O. Box 579, Winthrop, WA 98862-0579), or the project public information coordinator, Teresa Wordsmith (Tonasket Ranger District, P.O. Box 966, Tonasket, WA 98855- 486-2186). The maps of the Preliminary Proposed Actions are attached. If you would like to be kept informed as we complete the evaluation process, please let us know in your response letter. A response by August 15, 1991 would be most helpful. We anticipate completing the Analysis by June 1, 1992. I look forward to reading your suggestions and comments about this project.

Sincerely,

SAM DEAN
Forest Supervisor

Enclosure
TW/kam




VICINITY MAP
OKANOGAN NATIONAL FOREST

GRANITE MOUNTAIN
ANALYSIS AREA
- JULY 8, 1991

SCALE 1: 600000.

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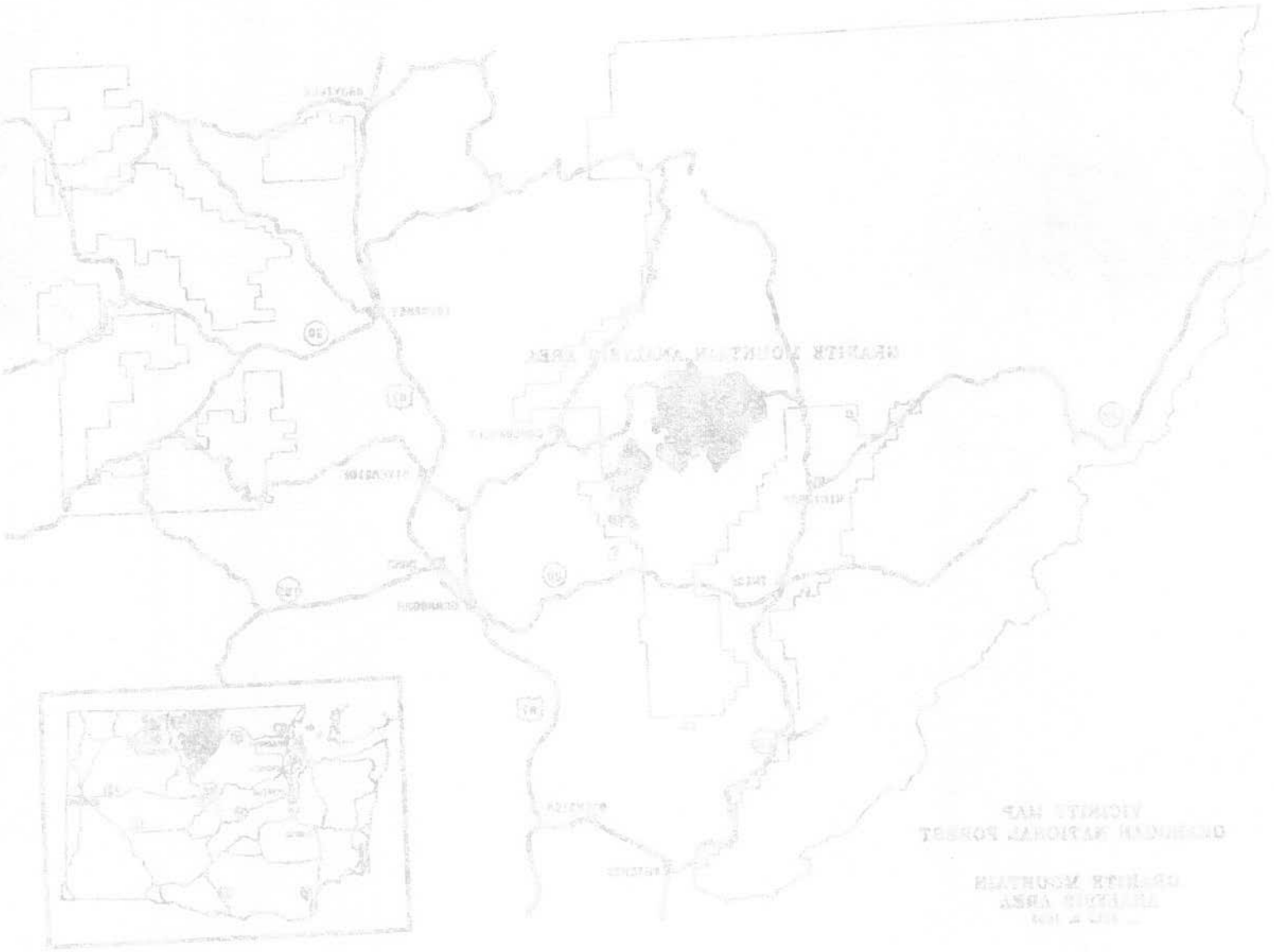
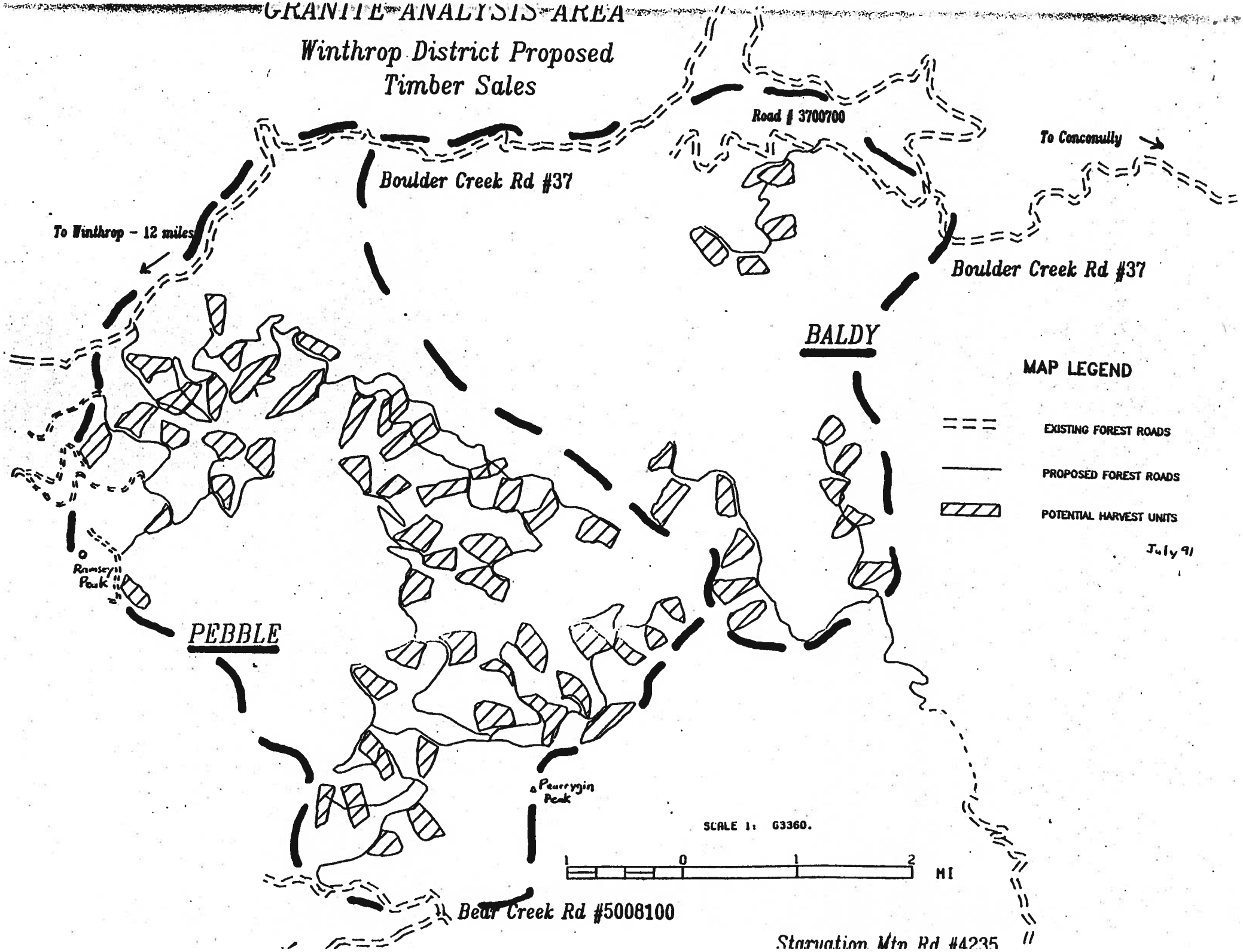
7/ 8/91 13:20:12

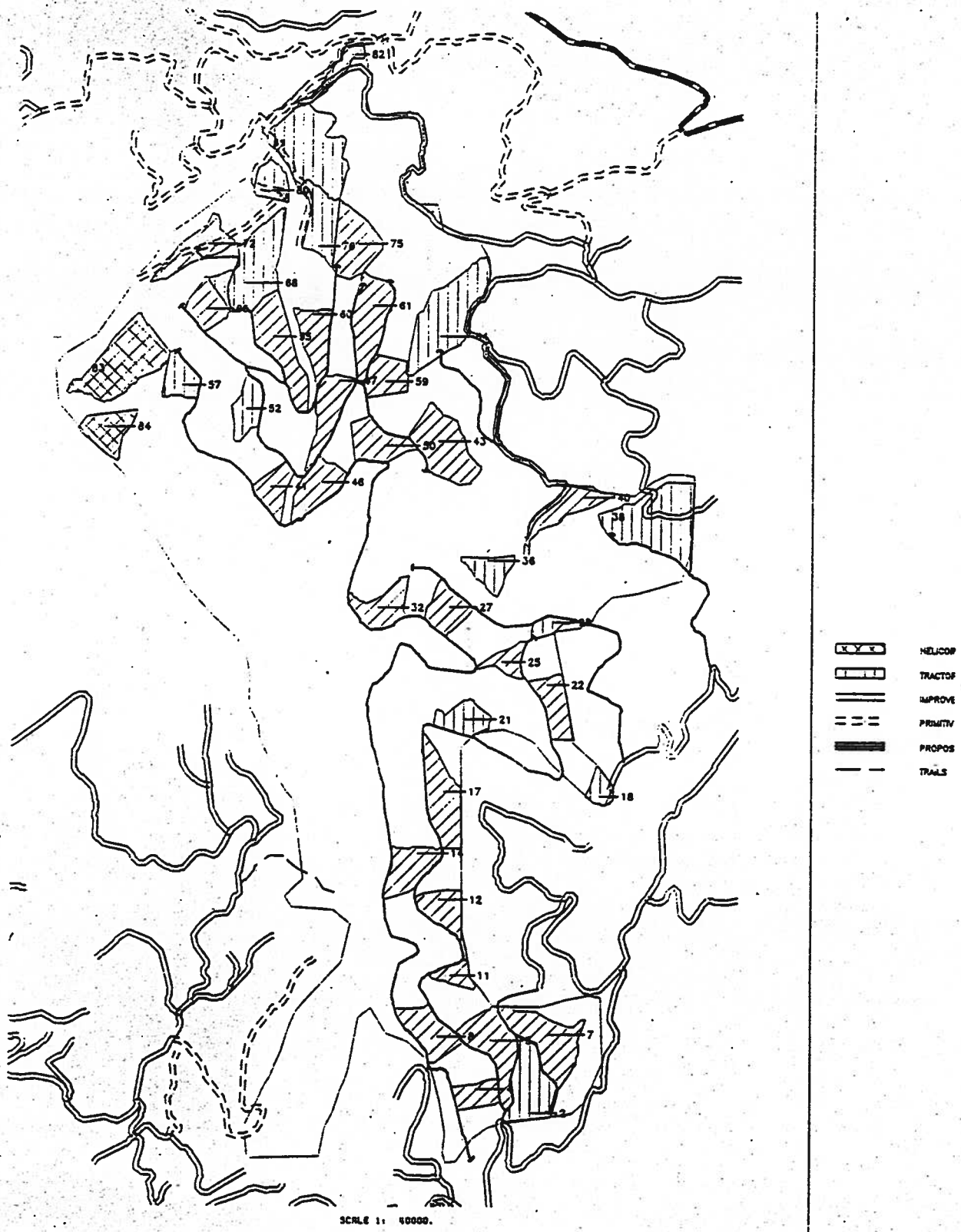


# GRANITE ANALYSIS AREA

## Winthrop District Proposed Timber Sales



# LITTLE GRANITE PROPOSED ACTION




AUTOGIS

5/29/91 16:30:25

CURT SMITCH
Director

Copy

STATE OF WASHINGTON

# DEPARTMENT OF WILDLIFE

1540 Alder St. N.W., Ephrata, WA 98823 Tel. (509) 754-4624

April 3,1991

Lon Schultz, Ann Sprague
Winthrop/Twisp Ranger Districts
P.O. Box 188
Twisp, WA 98856

Dear Lon and Ann:

I am following up on my phone call I had with each of you on March 25, 1991 in which I voiced my objection to the Old Tom, Middle, and Bea timber sales that are currently being proposed. My fear is that the cumulative impact of these sales, occuring next to previous sales already completed in that area, will result in the severe depletion of the lynx population in the area from Starvation mountain and Beaver meadows south to the Loup Loup pass area. This area has historically contained good numbers of lynx. While not directly in the lynx study area trapped by Brittell and later Koehler, several lynx trapped and monitored by them utilized parts of the area I am concerned about, and I have routinely seen lynx tracks on the Starvation mountain road and in the Buck pass area when working there after snows. During one trip in December 1987, I saw five lynx tracks on the Beaver lake loup portion of this area.

This past winter John Danielson, Fred Wiltse, and I conducted four surveys in this area (map enclosed) and these show a shift in lynx distribution away from the Beaver lake area, which has been clear-cut significantly the past several years.

I feel a reduction in the number of lynx in this area is certain if clear-cutting continues in the near future in this area. Brittell (1989) points out that "large stands of cover are needed" to maintain lynx in a given area and other studies show that clear-cuts should be in 6-7 feet tall regrowth lodgepole before additional cuts are made in adjacent areas. Koehler and Brittell (1990) note that these cuts may require 20-25 years before hare populations achieve high densities. A check of the previously cut areas showed no regrowth even remotely approximating the conditions needed for hares and lynx. Brittell also advised that while these small clear-cuts can have a beneficial effect on lynx, they must be distibuted over time and space. Neither appear to be happening in the Starvation area.

King and Brady (both in 1990) sent letters expressing concern over cuts in this area and opposing site conversion to other species of trees.

McLaughlin (1989) promises a stable and increasing lynx population within the Okanogan National Forest; however, this noble promise can hardly be met with high timber harvest levels on a sustained basis as seems to be the trend here.

With lynx as a candidate species under the Endangered Species act, not only should timber harvest in this area proceed very cautiously, no harvest should be done until there is a full habitat mapping of the entire area to determine what is and what isn't lynx habitat and where it is located.

I haven't seen any comprehensive forest plan for this area that shows what areas are being set asside for denning, travel, or cover by lynx, to connect with the foraging areas that will be created over the long term by the clear cutting strategy being used. Repeated letters (Brittell, Lowry, Koehler) show the need for horizontal cover in the form of down logs, stumps, and logging residue; but I haven't observed any Forest Service response to these concerns in the sales.

I hope we can get together and arrive at a suitable system to allow for both a harvest of timber and enhancement of lynx habitat, rather than degradation of

EXHIBIT "G"

the existing habitat and a dramatic lowering of lynx numbers in this important area.

Sincerely,

George L. Brady

George L. Brady
Wildlife Agent
Box 535
Pateros, WA 98846

cc: J. King
B. Steele
M. Quinn
J. Danielson
F. Wiltse
D. Brittell

AREA LOCATION MAP
BEA, OLD TOM and OVERWOOD
ANALYSIS AREAS
BEA ANALYSIS AREA
OLD TOM
ANALYSIS AREA
OVERWOOD
ANALYSIS AREA
scale
1/2 inch
equals
1 mile
N
Middle Mtn
Muckamuck Mtn
Muckamuck Pass
Mineral Hill
Conconully
Starvation Mtn
Pearrygin Peak
Blue Buck Mtn
Beaver Mtn
Rock Lakes
ROCK LAKES (DNR)
Buck Mtn
BEAVER (W.D.O.W.)
Little Buck Mtn
Loup Loup Summit
Woody Mtn
Pole Pick Mtn
Cook Mtn
Little Peacock Mtn
Peacock Mtn
Ruby Hill
ORIOLE
KERR
COTT
Pelican Pass
Buckhorn
Old Baldy
Beaver Meadows
North Granite
West Fork
Granite Creek
Lightning Creek
Middle Fork
South Fork
Beaver Ridge
Bobcat Mtn
South Ridge
Wolf Ridge
Coyote Ridge
Piper Creek
Pipestone Canyon
Campbell Lake
Frazer Creek
Finley Creek
Loup Loup Creek
Loup Loup Summit
Central Creek
Summit Creek
Ritchie Ridge
Rock Ridge
Chilliwist
Salmon Falls
Peacock Meadows
Reed Ranch
Rusty Canyon
Blue Ridge
Bear Mtn
Sugar Mtn
Loup Loup Ski Area
Electronic Site
Ditch
Wrayl Spr
Johnson
Burlington

MEMORANDUM

May 25, 1984

Subject: Lynx/Lodgepole Management (Revision to January 16, 1984 memo)

To: Bill McLaughlin and Ray Duff

At the last interagency wildlife meeting and in input to the Draft Forest Plan, Washington Game Department expressed concern over the management of lodgepole pine (Pinus contorta) ecosystems and the subsequent effects on wildlife, specifically lynx (Lynx canadensis). Since the Draft Forest Plan was issued, more research data and insight into the needs of lynx have become available. The understanding of relationships between lynx and their habitat is far from complete. However, due to the immediate need, a basis for designing logging activities in lodgepole has been formulated largely from research data and suggestions provided by Dave Brittell. cont has one of the largest concentrations of Lynx in lower 48 states

The following principles and suggestions have already been applied to timber sales involving lodgepole and will serve as management guidelines for future sales until revisions or refinements are found more appropriate. These guidelines, or further refinements, should also be part of the Final Forest Plan.

## Management for Lynx in Lodgepole Dominated Plant Communities

The quality of lynx habitat fluctuates with the condition of high elevation lodgepole pine ecosystems. Generally, lynx prefer areas of lodgepole pine in early successional stages where conditions are favorable for snowshoe hare (Lepus americanus). Since it provides edge diversity and a more consistant presence of appropriate aged lodgepole, a mosaic of various-aged lodgepole stands is preferred over single-aged expanses.

Historically, change occurred by forest fires and more recently forest management practices. Currently, the quality of lynx habitat in the Okanogan Forest is declining as lodgepole stands, that developed as a result of fires in the early 1900's, mature. This expanse of lodgepole is vulnerable to rapid change by mountain pine beetle (Dendroctonus ponderosa) and forest fires. Because of inadequate food and cover, these rapid large scale changes to early successional stages would be detrimental to lynx and snowshoe hare for the first 10 to 20 years. However, at a later date habitat conditions in large areas would be favorable. Forest and wildlife management plans should seek to avoid such boom and bust situations.

EXHIBIT "H"

MEMORANDUM

Subject: Lynx/Lodgepole Management (Revision to January 16, 1984 memo)

To: Bill McLaughlin and Ray Duff

At the last interagency wildlife meeting and in input to the Draft Forest Plan, Washington Game Department expressed concern over the management of lodgepole pine (Pinus contorta) ecosystems and the subsequent effects on wildlife, specifically lynx (Lynx canadensis). Since the Draft Forest Plan was issued, more research data and insight into the needs of lynx have become available. The understanding of relationships between lynx and their habitat is far from complete. However, due to the immediate need, a basis for assigning logging activities in lodgepole has been formulated largely from research data and suggestions provided by Dave Brittell. Only two of the Draft Forest Plan alternatives, alternatives 2 and 3, are in accord.

The following principles and suggestions have already been applied in timber sales involving lodgepole and will serve as management guidelines for future sales until revisions or refinements are found more appropriate. These guidelines, or further refinements, should also be part of the Final Forest Plan.

Management for Lynx in Lodgepole
Dominated Plant Communities

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EXHIBIT H

There is opportunity to avoid such boom and bust situations. The eminent harvest and management of lodgepole may assure stability of cover, populations of snowshoe hare and lynx, even though there are limitations, concerns and risks.

Vegetative Manipulations

1) Habitat management for lynx and snowshoe hare are interrelated. Dense lodgepole thickets provide cover (forest canopy) and food (bark of young trees) for snowshoe hare. Accordingly, the lynx, which is basically a forest dweller and largely dependent on snowshoe hare for food, is closely tied to habitats that support snowshoe hare.

2) Lynx management guidelines should apply to existing ecosystems between Buck Pass and the Pasayten Wilderness occuring above 4,500 feet elevation. This is key lynx habitat, representing the primary lynx area in Okanogan County and a major part of Washington State's lynx habitat.

For quality lynx/snowshoe habitat, perpetuation of lodgepole is mandatory. The importance to lynx of associated ecotypes, including subalpine fir (Abies lasiocarpa) and Engelmann spruce (Pices engelmanni) is unknown. Man-caused conversion from current lodgepole conditions to other tree species or to lodgepole conditions differing from the descriptions which follow in Sections 3 and 4 would be detrimental to lynx.

all growth densities habitat

3) A mosaic (different sized and shaped units) of successional stages is needed with not all one stage located in a given area. Different successional stages are needed to provide both cover and a food source. Major structural differences which are important to lynx usage (or lack of use) are: (a) grass-forb-shrub-seedling, (b) sapling, (c) poles, and (d) small sawtimber. In order to perpetuate cover (described in following Section 4) overtime, a balance in the above conditions is needed (i.e. 1/4 of each a, b, c, and d). Given that condition (a) is avoided by lynx due to lack of cover, it is a prerequisite to conditions (b), (c) and (d) which are capable of providing cover. Condition (a) resulting from clearcutting or seed tree cutting generally needs to be limited to 20-40 acre units.

4) Cover has to be contiguous over large areas. Cover for lynx is typically for seclusion and hunting. It can be described as vegetation capable of hiding a standing adult lynx from view of a human at 200 feet or less (hiding cover). Vegetation may be live or dead and composed of vertical stems (i.e. a dense stand of small trees), horizontal stems (i.e., a managed stand with wide tree spacing and low horizontal branches), down material (i.e., down logs common in older stands of lodgepole), or a mixture of these (see 4b for stands which qualify). Downmaterial is a key component of cover. Its importance increases with less vertical or horizontal stems, and during heavy snowfall.

——— New since Jan. 1984

There is opportunity to avoid such boom and bust situations. The sustained harvest and management of lodgepole may assure stability of cover, populations of snowshoe hare and lynx, even though there are limitations, conditions and risks.

Tentative Recommendations

1) Habitat management for lynx and snowshoe hare are interrelated. Dense lodgepole thickets provide cover (forest canopy) and food (bark of young trees) for snowshoe hare. Accordingly, the lynx, which is basically a forest dweller and largely dependent on snowshoe hare for food, is closely tied to habitats that support snowshoe hare.

2) Lynx management guidelines should apply to existing conservation areas [illegible] Vi-Cedarwood conductor [illegible] [illegible] This is key lynx habitat, representing the primary lynx area in Okanogan County and a major part of Washington State's lynx habitat.

Our quality lynx/snowshoe habitat, [illegible] The importance to lynx of associated habitats, including [illegible] suitability for (Alpine Larch/Cedar) and [illegible] (Pacific Silver Fir) is unknown. Man-caused conversion from current lodgepole conditions to other tree species or to lodgepole conditions differing from the [illegible] conditions which follow in Sections 3 and 4 would be detrimental to lynx.

3) [illegible] (different stand and species ages) [illegible] with [illegible] all due space limited in a given area. Different successional stages are needed to provide both cover and a food source. Major structural differences which are important to lynx usage (or lack of use) are: [illegible] seedlings, (b) [illegible] and [illegible]. In order to perpetuate cover (description in following section 4) overtime, a balance in the above conditions is needed (i.e. [illegible]). Given that condition (a) is avoided by lynx due to lack of cover, it is a prerequisite to conditions (b), (c) and (d) which are capable of providing cover. [illegible] resulting from clearcutting or seed tree cutting generally needs to be [illegible].

4) Cover has to be continuous over large areas. [illegible] lynx is typically for ambush and hunting. It can be described as [illegible] of less (hiding cover). [illegible] adult lynx from view [illegible] vertical stems (i.e. a dense stand of small trees), horizontal stems (i.e., a managed stand with wide tree spacing and low horizontal branches), down material (i.e., down logs common in older stands of lodgepole), or a mixture of these (see 3b for stands which qualify). [illegible] cover, its importance increases with less vertical or horizontal stems, and during heavy snowfall.

[illegible] Since Dec. 1984

It must be recognized that hiding cover fluctuates seasonally as snow depth varies. The [redacted] is estimated to generally provide cover when snow is present.

The [redacted] for lynx is estimated to approach [redacted] and varies from 15 to 40. Home ranges of non-breeding individuals are smaller. Lynx, like other forest cats, generally will not frequent or travel across large openings. Therefore, cover patches and travel corridors connected in a relatively continuous manner over the large area described in Section 2 are considered necessary to maintain lynx where they now exist.

(a) [redacted] and [redacted]

(b) Cover units and cover corridors are described as follows:

[redacted]

Lodgepole stands providing cover (x):

| Managed Stands (Regenerated) | Unmanaged Stands | | |
|---|---|---|---|
| | | Saplings | |
| | x | 1" diameter | - at least 900 stems/acre |
| x | x | 2" diameter | - at least 550 stems/acre |
| x | x | 3" diameter | - at least 400 stems/acre |
| | x | 4" diameter | - at least 250 stems/acre |
| | | Poles | |
| | x | 5" DBH | - at least 200 stems/acre |
| | x | 6" DBH | - at least 150 stems/acre |
| | x | 7" DBH | - at least 125 stems/acre |
| x | x | 8" DBH | not more than 100 stems/acre |
| | | Small sawtimber | |
| x | x | 9" DBH | not more than 100 stems/acre |
| x | x | 10" DBH | not more than 100 stems/acre |
| x | x | 12" DBH | not more than 100 stems/acre |

As indicated in the foregoing specifications, cover is provided by a variety of stand conditions. However, thickets of small diameter trees provide a food source for snowshoe hare (and snowshoes in turn a food source for lynx) in addition to cover.

(c) Cover amounts necessary are 50% minimally and 70% or more optimally per 160 acres of lodgepole type.

It must be recognized that hiding cover fluctuates seasonally as snow depth varies. The [illegible] is estimated to generally provide cover when snow is present.

The [illegible] for lynx is estimated to approach [illegible] and varies from 15 to 20. Home ranges of non-breeding individuals are smaller. Lynx, like wolves forest cats, generally will not frequent or travel across large openings. Therefore, cover patches and travel corridors connected in a relatively continuous manner over the large areas described in Section 2 are considered necessary to maintain lynx where they now exist.

(a) [illegible] 300 feet in width [illegible] and [illegible] or less.

(b) Cover units and cover corridors are described as follows:

[illegible]

Indeterminate [illegible] providing cover (x):

| | Managed Stands (Regenerated) | Unmanaged Stands |
|---|---|---|
| **Saplings** | | |
| 1" diameter - at least 900 stems/acre | x | |
| 2" diameter - at least 850 stems/acre | x | x |
| 3" diameter - at least 800 stems/acre | x | x |
| 4" diameter - at least 250 stems/acre | x | |
| **Poles** | | |
| 5" DBH - at least 200 stems/acre | x | |
| 6" DBH - at least 150 stems/acre | x | |
| 7" DBH - at least 125 stems/acre | x | |
| 8" DBH not more than 100 stems/acre | x | x |
| **Small sawtimber** | | |
| 9" DBH not more than 100 stems/acre | x | x |
| 10" DBH not more than 100 stems/acre | x | x |
| 12" DBH not more than 100 stems/acre | x | x |

As indicated in the foregoing specifications, cover is provided by a variety of stand conditions. However, thickets of small diameter trees provide a food source for snowshoe hare (and snowshoes in turn a food source for lynx) in addition to cover.

(c) Cover amounts necessary are 50% minimally and 10% or more optimally per 100 acres of lagopodic habitat.

There is opportunity to avoid such boom and bust situations. The eminent harvest and management of lodgepole may assure stability of cover, populations of snowshoe hare and lynx, even though there are limitations, concerns and risks.

Vegetative Manipulations

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all growth stages desirable habitat

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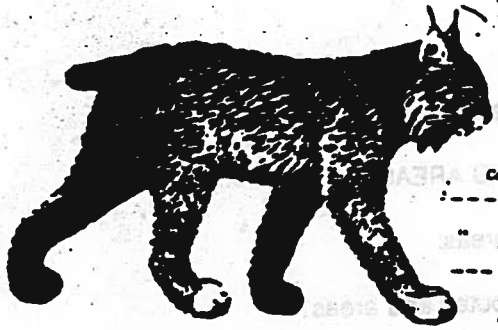
New Since Jan. 1984



LYNX

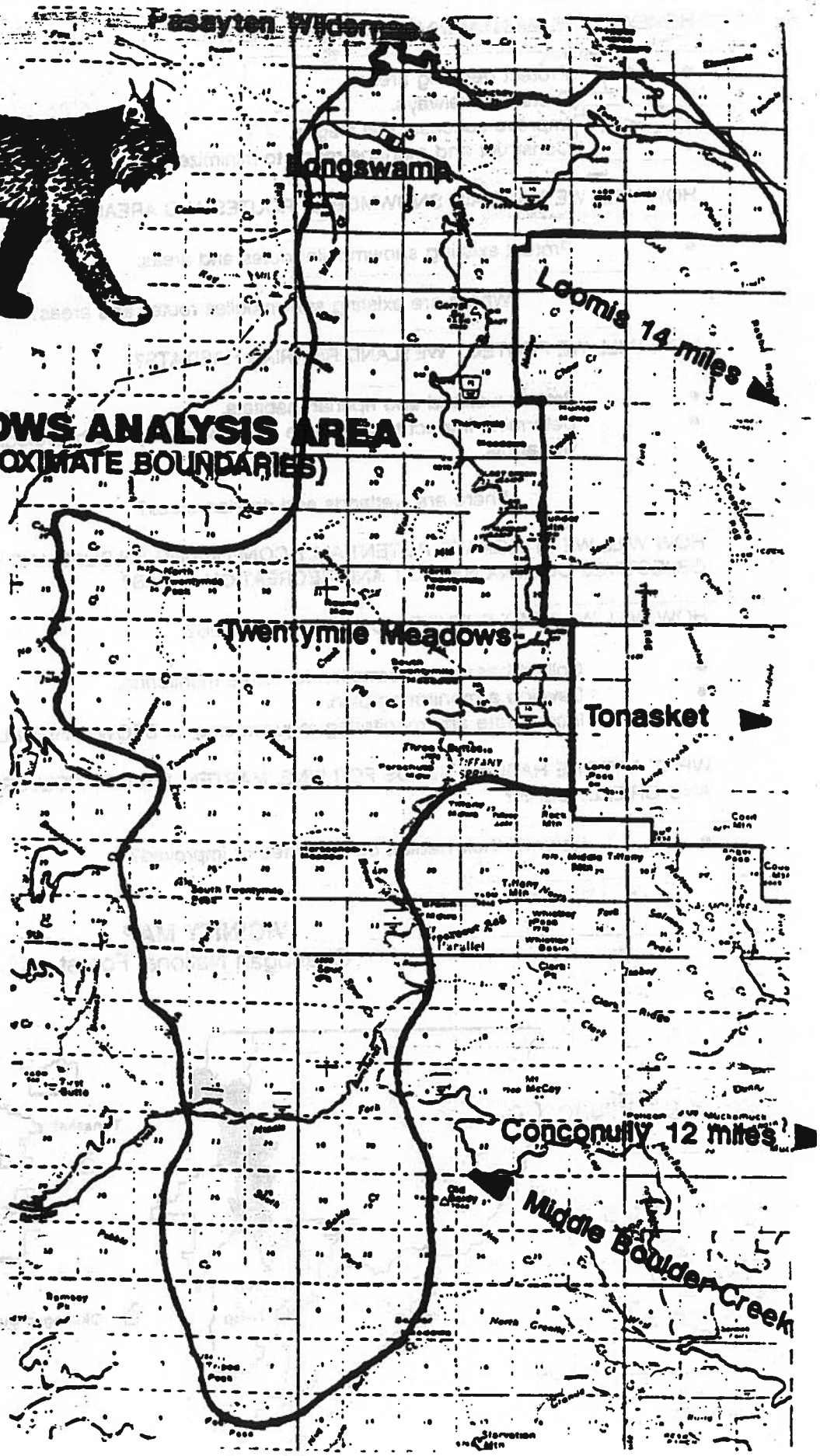



EXHIBIT "I"

HOW WILL WE MAINTAIN/IMPROVE LYNX HABITAT?

- Protect denning areas.
- Protect travelways.
- Improve successional stages.
- Construct and manage roads to minimize disturbance to lynx.

HOW WILL WE MAINTAIN SNOWMOBILE ROUTES AND AREAS?

- Protect existing snowmobile routes and areas.

Where are existing snowmobiles routes and areas?

HOW WILL WE PROTECT WETLAND RIPARIAN HABITATS?

- Protect wetland and riparian habitats.
- Determine impact to long term site productivity and hydrologic impacts of roading harvesting in wet areas.

Where are wetlands and riparian areas?

HOW WILL WE INTEGRATE POTENTIALLY CONFLICTING WILDLIFE AND RECREATION MANAGEMENT OBJECTIVES OF LYNX HABITAT AND RECREATION AREAS?

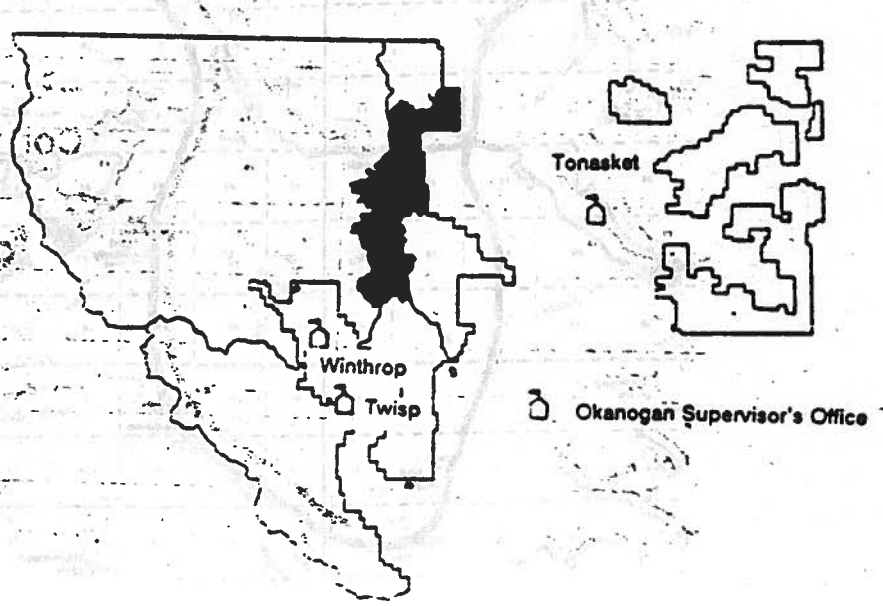
HOW WILL WE MEET FUTURE MONITORING NEEDS?

- Collect baseline information for future monitoring.
- Develop a monitoring plan.
- Incorporate any monitoring requirements for BROWN, HUMBUB, LP, and HARDT timber sales.

WHAT ARE THE HABITAT NEEDS FOR PINE, MARTEN, FISHER, WOLVERINE, GRAY WOLF AND GRIZZLY BEAR?

- How will their habitat be protected or improved?

**VICINITY MAP**
Okanogan National Forest



DO NOT REMOVE THIS CONTROL SLIP FROM CORRESPONDENCE

FISH AND WILDLIFE SERVICE
CORRESPONDENCE CONTROL UNIT
ROOM 3012, MAIN INTERIOR
208-6231 (FTS-268-6231)

BUREAU NO: 91- 4255
EXEC SEC NO:
DATE RCVD: 08/22/91

==========

DATE DUE EXEC SEC: / /

DATE DUE CCU: / /
DATE DUE WO: / /

==========

ASG TO/INT BY: FWE ACTION: 2 SIGNATURE LEVEL:

FROM/TO: TIPPERMAN DATE OF INCOMING: / /

SUBJECT: REQUEST FOR AN EMERGENCY LISTING FOR THE LYNX AS AN ENDANGERED SPECIES

INFO CYS TO: AUTHOR: OFFICE:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ROUTED TO: | FWE | DES | | | | | | | | |
| ACTION: | 2 | | | | | | | | | |
| DATE: | 0822 | 8/22 | | | | | | | | |

COMMENT: DES - For your appropriate action.

==========

ACTION CODES:

1 PREPARE REPLY
2 FOR APPROPRIATE ACTION
3 SURNAME
4 SIGNATURE
5 FOR INFORMATION
6 REVISE
7 OBTAIN ADDITIONAL SURNAMES
8 OTHER - SEE COMMENTS
9 MAIL/DISTRIBUTE
0 PREPARE DRAFT REPLY

==========

FOR CHANGES IN ACTION OFFICE OR SIGNATURE LEVEL, CONTACT CCU: 208-6231 (FTS-268
FOR CHANGES IN DUE DATES, AD/RD MUST CONTACT DIRECTOR AND NOTIFY CCU

DO NOT REMOVE THIS CONTROL SLIP FROM CORRESPONDENCE