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Acknowledgments

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We thank those individuals who provided comments and review throughout a very lengthy and complex endeavor and for the patience from so many. We also thank those generous individuals who provided us the electronic data that made this study possible; they include Janice Thomson (The Wilderness Society), Warren Cohen (Pacific Northwest Research Station), Curtice Jacoby (Legacy), Tom O'Neil (Ecological Analysis Center), Jimmy Kagan (Oregon Natural Heritage Program), and numerous USDA Forest Service and USDI Bureau of Land Management agency personnel. Finally, we are grateful to Environmental Systems Research Institute, Inc. (ESRI) and ERDAS, Inc. for their continuing and generous software support. Without their help, none of this work would have been possible.

SECTION I — INTRODUCTION

Conservationists today generally agree that protecting and restoring biodiversity is their fundamental goal. How one measures biodiversity and evaluates areas for potential inclusion in reserve networks, however, are not straightforward. Most existing protected areas were selected for non-biological reasons such as scenery, recreational potential, and lack of conflict with resource extraction (Noss and Cooperrider 1994). More recently, the principles and techniques of conservation biology have been applied to reserve selection and design (Pressey et al. 1993, Scott et al. 1993, Strittholt and Boerner 1995, Csuti et al. 1997, Noss et al. 1997). Numerous methods have been used to identify areas for protection, but most science-based projects are variants of three basic approaches that, in turn, reflect different goals: (1) protection of special elements, such as rare species hotspots, old-growth forests, and critical watersheds for aquatic biota, (2) representation of all habitats, vegetation types, or species within certain "indicator" or "surrogate" taxa within a network of reserves, and (3) meeting the needs of particular focal species, especially those that are area-dependent or sensitive to human activities (Noss 1996).

These three approaches to conservation planning have been applied by scientists and conservationists for decades, but they have been applied separately rather than together. Each approach arrives at a unique set of conservation priorities, which are often difficult to reconcile with the priorities established by other methods. No previous conservation plan, to our knowledge, has combined all three tracks, which suggests that many plans may omit categories of data necessary to make fully informed decisions about land allocation and management. We believe that a comprehensive conservation evaluation process is needed to meet four basic goals of biological conservation: (1) represent all kinds of ecosystems, across their natural range of variation, in protected areas; (2) maintain viable populations of all native species in natural patterns of distribution and abundance; (3) sustain ecological and evolutionary processes; and (4) maintain a conservation network that is resilient to environmental change (Noss 1992, Noss and Cooperrider 1994).

The Klamath-Siskiyou ecoregion of southwest Oregon and northwest California has long been recognized for its global biological significance (Whittaker 1960, Kruckeberg 1984) and is considered an Area of Global Botanical Significance by the World Conservation Union (IUCN), a global Centre of Plant Diversity (Wagner 1997), and has been proposed as a possible World Heritage Site (Vance-Borland et al. 1995). More recently, World Wildlife Fund US scored the Klamath-Siskiyou as one of their Global 200 sites reaffirming its global importance from the standpoint of biodiversity (Ricketts et al. 1999). For a more thorough review of the global importance of this ecoregion, see DellaSala et al. (in press).

With its extraordinarily high biodiversity and physical heterogeneity, the Klamath-Siskiyou ecoregion warrants an ambitious conservation plan founded on scientifically defensible goals, such as those listed above. The region is well suited to an approach that combines the research and planning tracks of special elements, representation, and focal species. This multi-faceted study is ongoing, with additional focal species studies and socioeconomic analyses forthcoming. In this paper, we report the results of the special elements and representation analyses and of research on one focal species, the Pacific fisher (*Martes pennanti pacifica*).

Our proposed conservation plan serves conservation goals far better than President Clinton's Northwest Forest Plan, but like that plan, is limited by data availability, our understanding of the regional ecology, and by our ability to plan effectively at multiple spatial scales. For these reasons, the proposed plan should not be viewed as the definitive plan –perhaps it is best thought of as a beginning rather than an end product. To guarantee the protection of ecological integrity and biodiversity within the Klamath-Siskiyou ecoregion will take a sustained, long-term commitment to scientific inquiry, understanding the human and non-human components of the region, and an ecocentric vision.

The Data

GIS (geographic information systems) was chosen as the principle tool used to assess the state of the environment in the Klamath-Siskiyou and to develop a reserve design proposal based on the three-tracks. GIS is a computer-based analytical mapping technology that is rapidly becoming the cornerstone for conservation planning at many different spatial scales. The GIS software used to conduct this analysis was Arc/Info™ (version 7.2.1), ArcView™ (version 3.1) with Spatial Analyst™ (version 1.1) , and ERDAS Imagine™ (version 8.3.1).

The proposed work plan called for the analysis to be focused at the 1:100,000-map scale using the best available data. While the 1:100,000 remained our target planning scale, we incorporated larger scaled data (e.g., 1:24,000) wherever possible. Doing so allowed for much more meaningful and reliable analyses. One of the greatest challenges throughout this project was evaluating and integrating the various data layers acquired from numerous sources. Using the best available data for conservation planning is much easier said than done. Numerous layers encountered had incomplete or no metadata (detailed information about each data layer explaining its origin, composition, completeness, and accuracy). Some data layers had to be discarded altogether while others had to be used with a heightened level of caution. Encompassing parts of two states made for a level of complexity not anticipated – some examples will be briefly discussed throughout this report. Furthermore, data obtained from federal databases (even within the same agency) did not necessarily guarantee standardization. For example, 1:24,000 scale road data obtained from the different National Forests in the region were not created and attributed in the same fashion. For some data layers, we had incomplete region-wide coverage (e.g., 1:24,000 roads and streams, late seral forests, and watershed delineations) making for difficulties in conducting analyses. After all of the data searching and review, we settled on the primary data layers presented in Table 1. Numerous intermediate data layers were later generated from these base layers, but because of their shear number, they are not listed.

Table 1. List of GIS data layers used in the Klamath-Siskiyou conservation planning project organized according to feature type (physical, cultural, biological).

Physical Features	**Scale / Resolution**	**Source**
Elevation - Digital Elevation Model (DEM)	1:250,000	U.S. Geological Survey
Hydrography - Digital Line Graphs (rivers and streams)	1:100,000	U.S. Geological Survey
Hydrography (rivers and streams)	1:24,000	U.S. Forest Service
Hydrography (lakes and reservoirs)	1:100,000	U.S. Geological Survey
Hydrography (lakes and reservoirs)	1:24,000	U.S. Forest Service
Serpentine Geology (paper map)	1:500,000	U.S. Geological Survey
STATSGO Soils	1:250,000	U.S. Natural Resource Conservation Service
Watersheds (5th and 6th order)	1:24,000	California Department. of Fish & Game & U.S. Bureau of Land Management
Precipitation	1km x 1km	PRISM (Daly et al. 1994)
Temperature	1km x 1km	PRISM (Daly et al. 1994)
Cultural Features	**Scale / Resolution**	**Source**
County Boundaries	1:100,000	ESRI
Transportation - Digital Line Graph	1:100,000	U.S. Geological Survey
Transportation	1:24,000	U.S. Forest Service & Rogue River Council of Governments
General Ownership	1:100,000	Interior Columbia Basin Ecosystem Management Project (ICBEMP)
Research Natural Areas	1:24,000	U.S. Forest Service
Wild & Scenic Rivers	1:24,000	U.S. Forest Service
Wilderness Areas	1:24,000	U.S. Forest Service
U.S. National Forest Administrative Boundaries	1:24,000	U.S. Forest Service
U.S. BLM Special Management Areas	1:24,000	U.S. Bureau of Land Management
Key Watersheds	1:126,720	FEMAT (1993)
Designated Conservation Areas (DCAs)	1:100,000	FEMAT (1993)

Late Successional Reserves	1:24,000	U.S. Forest Service
Human Population	1:100,000	U.S. Bureau of Census
Cumulative Forest Clearcutting (Oregon)	30m x 30m	Warren Cohen (PNW Research Station)
Major Dams	1:100,000	The Wilderness Society
Biological Features	**Scale / Resolution**	**Source**
Vegetation CA	1:100,000	CA GAP
Vegetation OR	1:100,000	OR GAP
Vegetation CA	1:50,000	Timberland Taskforce
Heritage Elements CA	1:24,000	California Department of Fish & Game
Heritage Elements OR	1:24,000	Oregon Natural Heritage Program
Late-seral Forests CA	30m x 30m	Legacy
Late-seral Forests OR	30m x 30m	Warren Cohen (PNW Research Station)
Salmonid Distribution	1:250,000	The Wilderness Society
Fisher location data	1:24,000	Carlos Carroll
Port-Orford-cedar Occurrence and *Phytophthora* Infestation	1:24,000	U.S. Forest Service

SECTION II — THE SETTING

The study area we examined covered 16,643 sq. miles (43,105 sq. km) or 10.6 million acres (4.3 million hectares) and was originally defined using Diller's Geologic Province (Diller 1902) and later modified to the nearest subwatershed boundary (see Figure 1, Plate 1). There are other equally feasible ecoregional boundaries for the Klamath-Siskiyou (e.g., Bailey 1978, Omernick 1987). In its recent continental assessment, World Wildlife Fund mapped the Klamath-Siskiyou on a map based largely on Omernick's work for this section of North America. Figure 2 compares our Klamath-Siskiyou boundary with the one recently used by World Wildlife Fund US. Our boundary was primarily based on the primary geology of the region, which drives much of the regions' noted species endemism while physically linking the headwaters to the Pacific Ocean.

Ownership and Current Protection Status

The primary land ownership layer used for this project came from the Interior Columbia Basin Ecosystem Management Project (ICBEMP), which was compiled at the 1:100,000 map scale. This file was cleaned in some places and enhanced with other data sources to help better assess and label GAP protection codes. Research Natural Areas and Late Successional Reserve (LSR) boundaries were obtained from the various National Forests

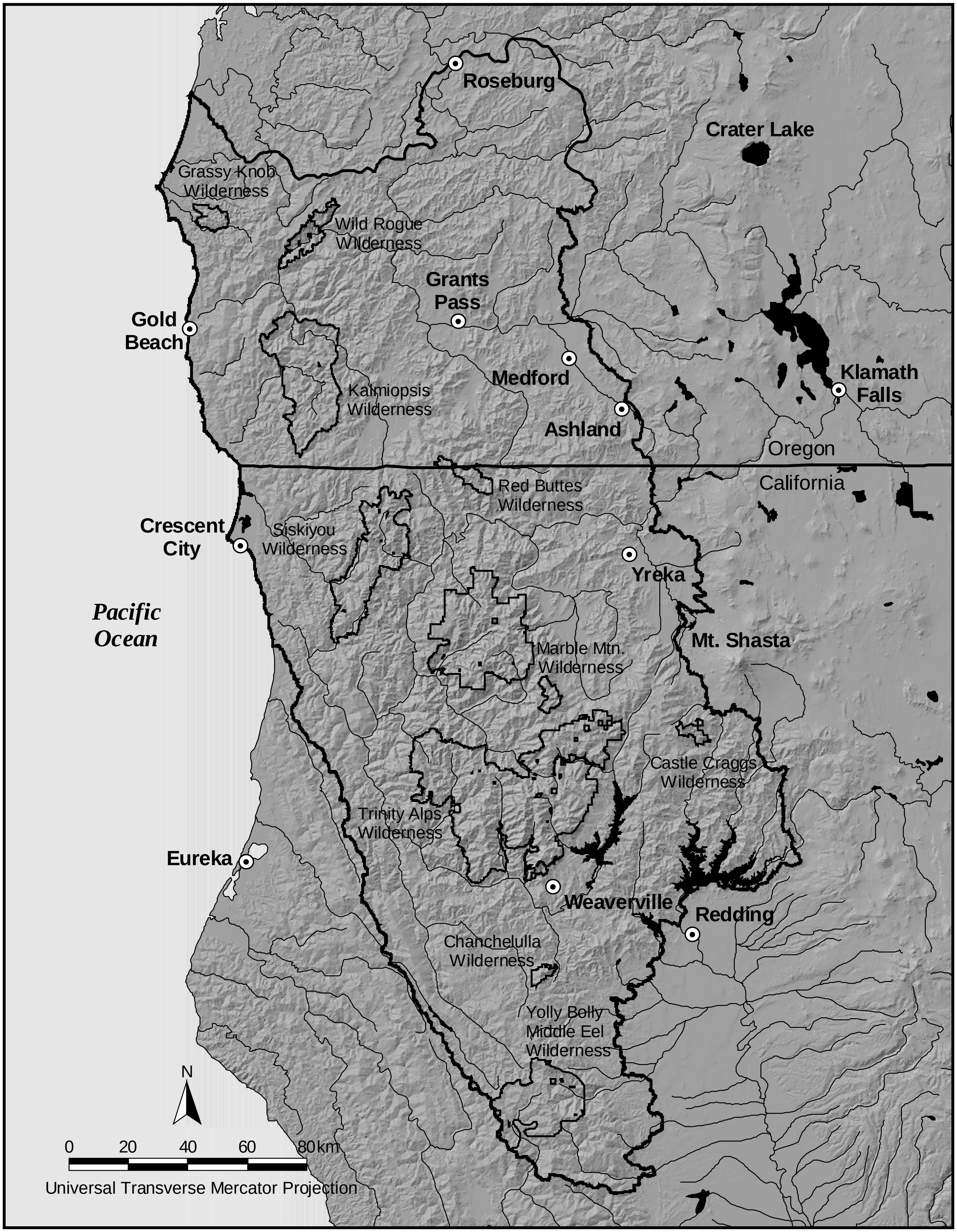

Figure 1. Klamath-Siskiyou study area showing major cities, towns, and wilderness areas.

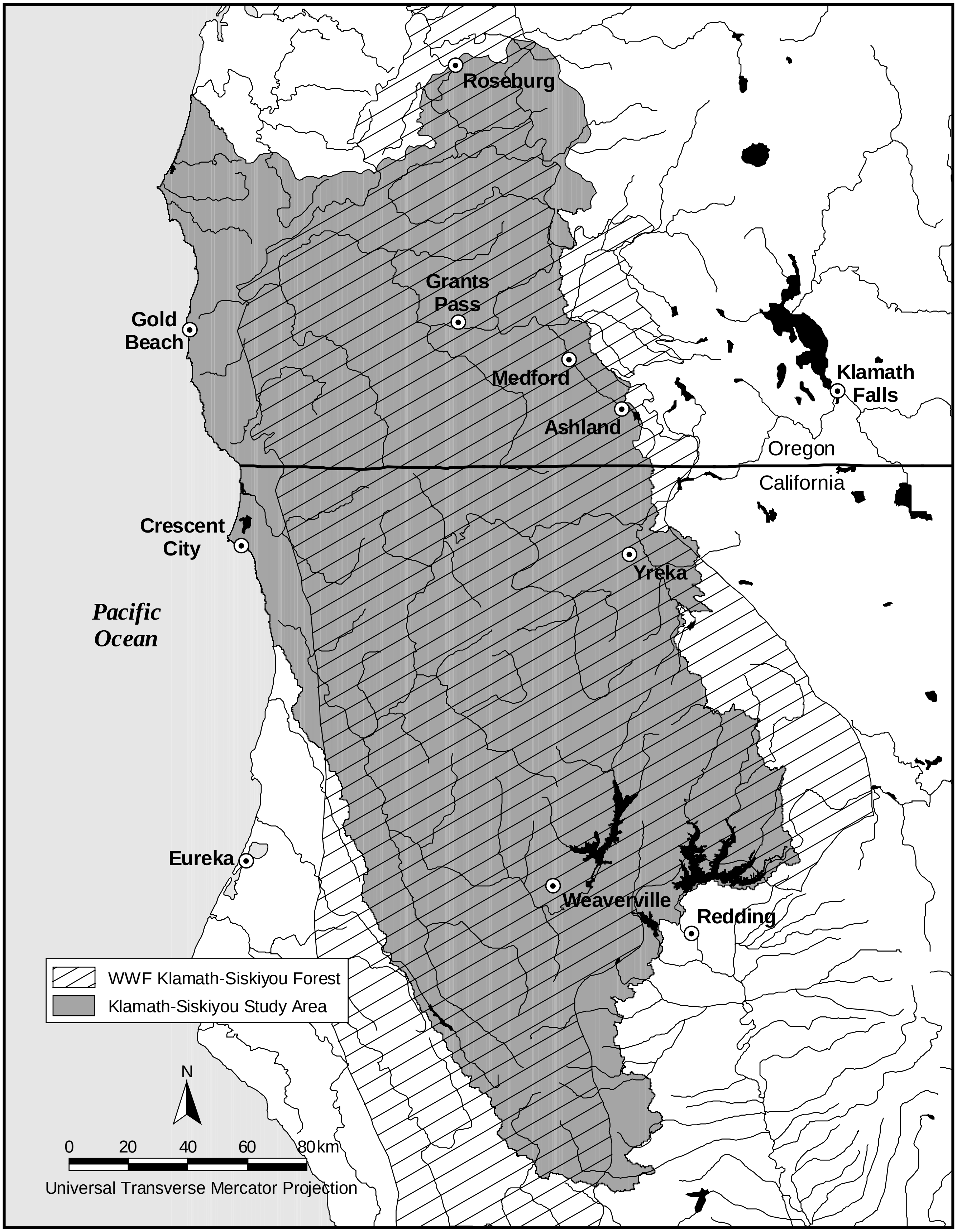

Figure 2. Klamath-Siskiyou ecoregion comparison between World Wildlife Fund and our study area.

with the LSR boundaries present on BLM lands in Oregon obtained from the Forest Ecosystem Management Assessment Team (FEMAT 1993). Special Management Areas in the BLM (Medford District) were added from data layers and maps provided from the BLM data distribution center in Portland, OR. State parks and waysides were attributed to the electronic file from regional recreation maps.

Ownership for the Klamath-Siskiyou study area (Figure 3, Plate 2) was organized into six basic stewardship classes summarized in Table 2. The public land base was found to make up over 62% of the region divided among the USDA Forest Service (including all or portions of eight National Forests –Umpqua, Rogue River, Siskiyou, Klamath, Six Rivers, Shasta, Trinity, and Mendocino), the Bureau of Land Management (BLM), and other Department of Interior lands including: Oregon Caves National Monument, portions of Redwood National Park, and the Whiskeytown Shasta-Trinity National Recreation Area. The remainder of public land is managed by the U.S. Army Corps of Engineers and the states of California and Oregon. The Department of Interior lands other than BLM and the U.S. Army Corps of Engineers were lumped together to form the "Other Federal" category. Non-government land was divided among private and tribal lands making up the remaining 37.4% of the study area.

Table 2. Ownership for the Klamath-Siskiyou study area.

Owner	**Area (ac)**	**Area (ha)**	**Percent**
Forest Service	5,511,397	2,230,432	52.0
Bureau of Land Management	1,006,890	407,483	9.5
Other Federal	52,993	21,446	0.5
State	63,594	25,736	0.6
Total Government	*6,634,874*	*2,685,097*	*62.6*
Private	3,826,180	1,548,434	36.1
Tribal	137,785	55,761	1.3
Total Non-Government	*3,963,965*	*1,604,195*	*37.4*
Grand Total	*10,598,839*	*4,289,292*	*100.0*

Current protection status was assessed using the USGS GAP Analysis coding system assigned to the various land management units. There are four primary GAP protection status codes used in the nationwide system (see Table 3). Using a dichotomous key, Crist et al. (1998) provided a technique and advocated for assigning GAP protection status codes to each stewardship site on an individual basis. While probably a more accurate technique, we did not feel knowledgeable enough about each site to assign protection codes using this method. We therefore elected to base our assignment of GAP codes categorically (Table 4). While simpler, using a categorical approach did not avoid all difficulties. Assigning the proper GAP code to Late Successional Reserves (LSR) was particularly problematic. LSR were established throughout the western forests of the Pacific Northwest in response to the decline of northern spotted owl (*Strix occidentalis*) and other old-growth forest dependent species (e.g., marbled murrelet, *Brachyramphus marmoratus*). The Forest Ecosystem Management Assessment Team, who concluded their work in the

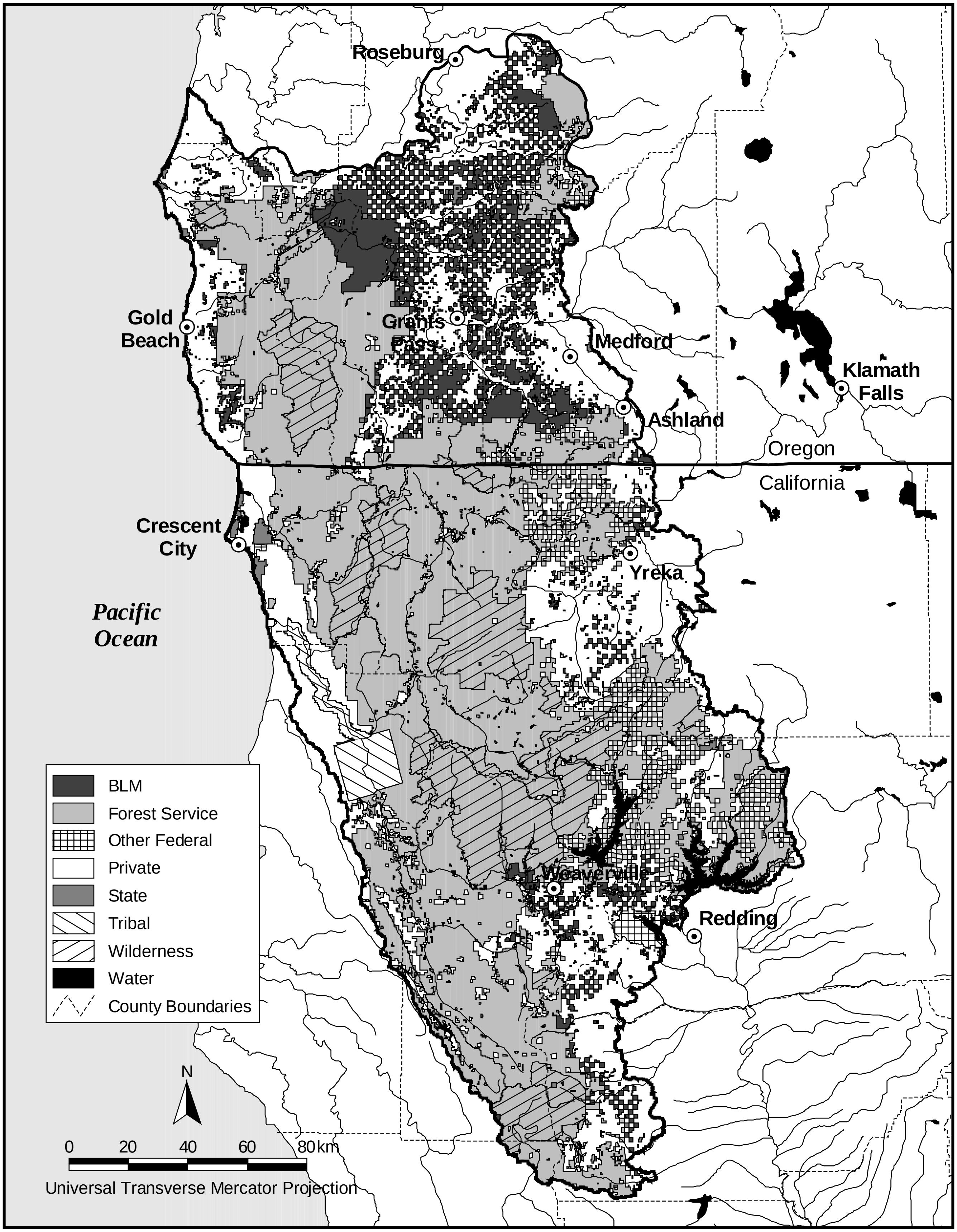

Figure 3. Klamath-Siskiyou ownership.

early 1990s, originated the basic LSR concept (originally called Designated Conservation Areas – DCAs) that later became fundamental to the current general conservation plan for the region – the Northwest Forest Plan. Although selected for implementation in 1994, land allocation and management details continue to be worked out by the various federal resource agencies active in the region, primarily USDA Forest Service and BLM.

The resource agencies contend that LSR will be managed in ways that retain old-growth forest characteristics making them eligible for GAP 2 status, but these areas often do not meet the criteria for GAP Status 2. For example, timber sales (including substantial logging of old growth) have been conducted in some LSR in the region after establishment, and the USDA Forest Service has proposed a major ski development within one LSR just outside our study region in the Winema National Forest in Oregon. In addition, many of these areas have already been significantly degraded (see Late Successional Reserves later in this section), and the degree and permanence of their protection remains uncertain. For these reasons, a compelling argument can be made to classify LSR as GAP 3. On the other hand, LSR often receive more protection than GAP Status 3 lands. Because of the political and ecological importance of LSR and this fundamental classification distinction, we elected to examine conservation of the Klamath-Siskiyou ecoregion under both protection levels whenever feasible. Where only one current protection plan was examined, the more protected alternative (LSR = 2) was used.

Table 3. Descriptions of USGS GAP codes (from Scott et al. 1993).

GAP Code	Description
1	An area having an active management plan in operation to maintain a natural state and within which natural disturbance events are allowed to proceed without interference.
2	An area generally managed for natural values, but which may receive use that degrades the quality of the existing natural communities.
3	Legal mandates prevent the permanent conversion of natural habitat types to anthropogenic habitat types but which is subject to extractive uses. This includes most non-designated public lands.
4	Private or public lands without an existing easement or irrevocable management agreement to maintain native species and natural communities and which are managed for intensive human use.

Table 4. Categorical GAP code assignment for the Klamath-Siskiyou.

GAP Code	Stewardship Types
1	Wilderness, Research Natural Area, National Park/Monument, Wild River.
2	National Recreation Area, State Park, Scenic River, BLM Special Designations (e.g., ACEC and Natural Area), and Late Successional Reserves.
3	All non-designated state and federal land and Late Successional Reserves.
4	All private and tribal land.

The current protection figures for the Klamath-Siskiyou, considering LSR as both GAP code 3 and GAP code 2, appear in Table 5 and are provided in map form in Figures 4 (Plate 3) and 5 (Plate 4) respectively. In this report, lands categorized as GAP code 1 are also referred to as "strictly protected" and GAP code 2 as "moderately protected." The inclusion of LSR as GAP code 2 substantially changes the protection status for the Klamath-Siskiyou nearly doubling the combined protection (strict + moderate) of the region. Table 6 lists all the existing protected areas that make up the GAP 1 lands. A number of USDA Forest Service Research Natural Areas (RNAs), particularly in Klamath National Forest, are in review. We did not include them as protected since their establishment is still pending. Even if all these RNAs were added, it would have only a minor impact of the overall protection status of the ecoregion.

Table 5. Current protection status for the Klamath-Siskiyou with Late Successional Reserves (LSR) classified as both GAP code 2 and GAP code 3.

Status	**GAP 1**	**GAP 2**	**GAP 1+2**	**GAP 3**	**GAP 4**
Existing Protection (LSR = 3)	12.8%	3.9%	16.7%	45.9%	37.4%
Existing Protection (LSR = 2)	12.8%	21.7%	34.5%	29.4%	36.1%

Table 6. List of GAP 1 (strictly protected) lands within the Klamath-Siskiyou study area.

Name	**Area (ac)**	**Area (ha)**
Castle Craggs Wilderness	10,206	4,131
Chanchelulla Wilderness	8,077	3,269
Coquille River Falls RNA	521	211
Grassy Knob Wilderness	17,154	6,942
Kalmiopsis Wilderness	181,312	73,377
Marble Mountains Wilderness	223,585	90,485
Oregon Caves National Monument	452	183
Port Orford Cedar RNA	1,111	450
Red Buttes Wilderness	20,422	8,265
Redwood National Park	9,992	4,044
Russian Wilderness	12,532	5,072
Siskiyou Wilderness	150,616	60,954
Trinity Alps Wilderness	512,499	207,408
Unnamed RNA	423	171
Unnamed RNA	860	348
Unnamed RNA	843	341
Unnamed RNA	45	18
Wheeler Creek RNA	357	145
Wild Rivers (42 segments combined)	32,491	13,149
Wild Rogue Wilderness	34,915	14,130
Woodcock Bog RNA	85	35
Yolly Bolly Middle Eel Wilderness	136,599	55,282
Total	*1,355,101*	*548,409*

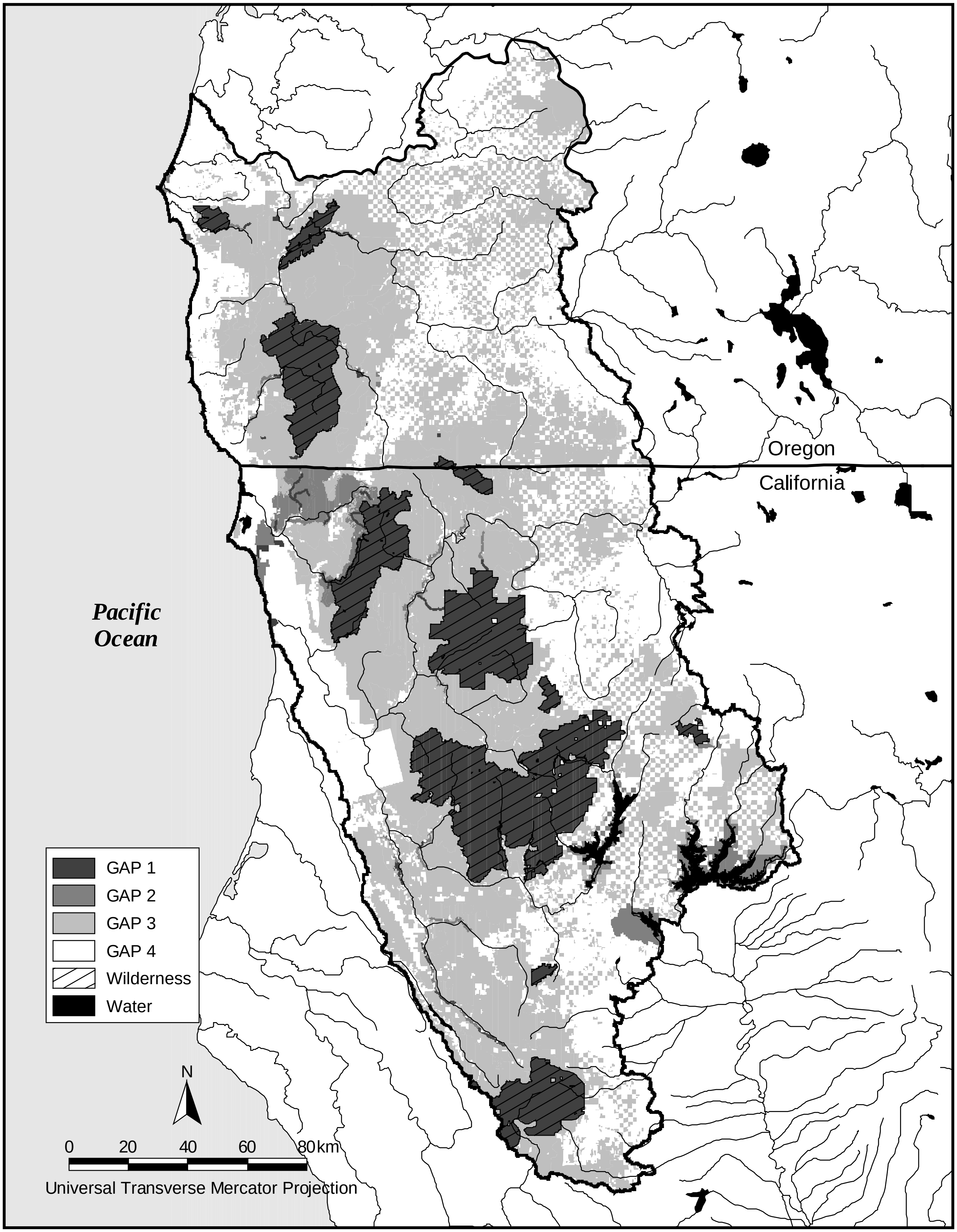

Figure 4. Protection status for the Klamath-Siskiyou based on GAP classification (Late Successional Reserves = 3).

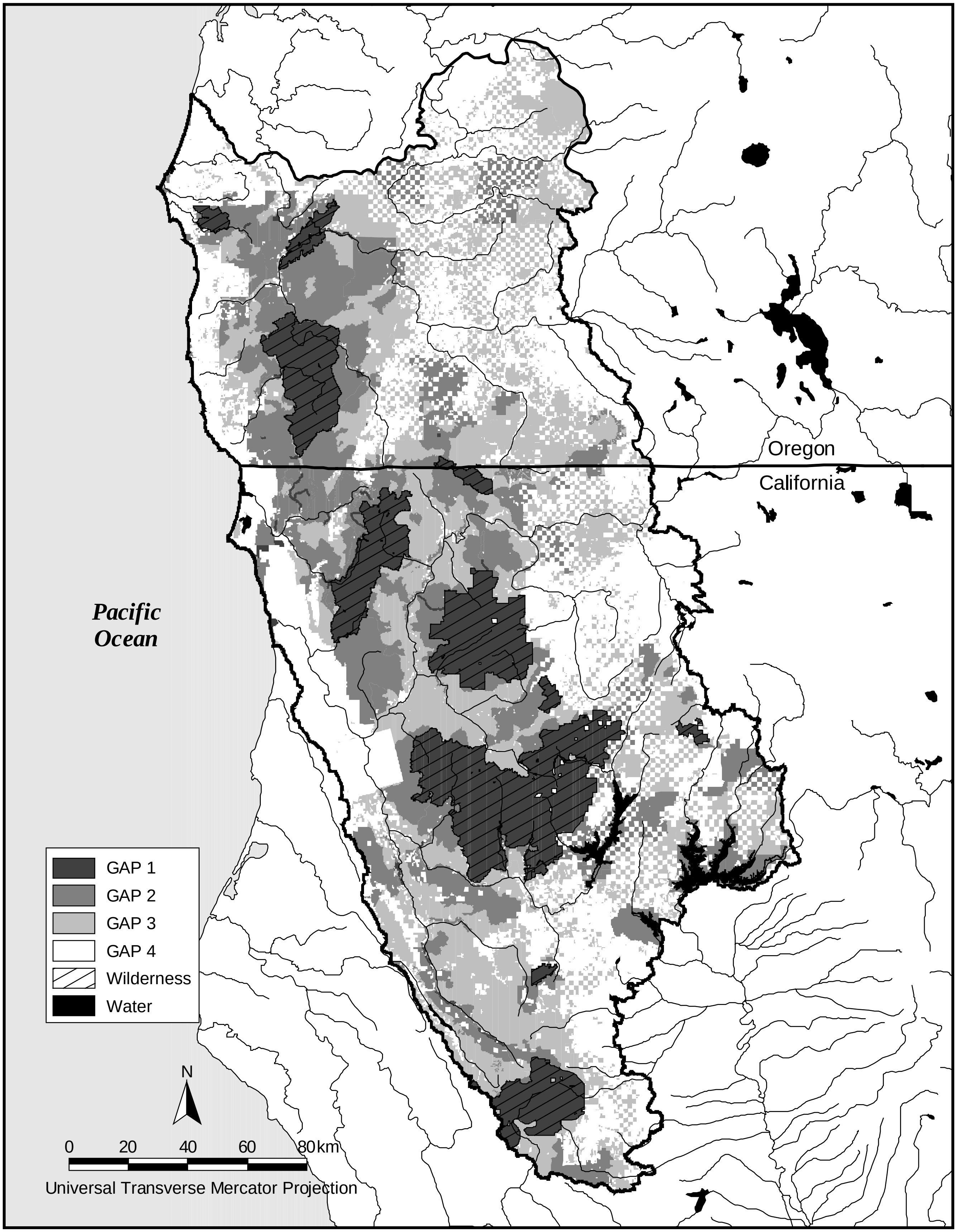

Figure 5. Protection status for the Klamath-Siskiyou based on GAP classification (Late Successional Reserves = 2).

Elevation

Over the last decade, evaluating protected lands against an elevation gradient has been of interest to regional conservationists. In regions with mountainous terrain, a pattern of biased protection of the higher elevations has been consistently reported (Harris 1984, Noss 1990, Scott et al. 1993, Strittholt and Frost 1997). Therefore, a compelling argument can be made to scrutinize protection percentages in regions with mountainous terrain in order to understand fully how well existing reserve networks actually capture the full breadth of biodiversity in a region. An overwhelming body of literature has shown that species richness is generally higher at low and mid-elevations (see Harris 1984, Noss and Cooperrider 1994). For the Klamath Siskiyou, the basic pattern of emphasizing higher elevations in existing protected areas was observed. The elevation gradient for the Klamath-Siskiyou ranges from sea level to approximately 2,700 meters (8,800 feet) and is characterized by rugged terrain in many places (see Figure 6, Plate 5 for a generalized elevation map for the region). Figure 7 summarizes percent protected for each of nine elevation bands defined by equal interval and starting from mean sea level to 1,000 feet (Class #1) to the highest band >8,000 feet (Class #9).

Figure 8 summarizes these same results in a slightly different manner by showing the relative area (in millions of acres) of each elevation band as well as the level of protection under the two different LSR characterizations.

Humans in the Region

According to the 1990 U.S. Bureau of Census figures, the Klamath-Siskiyou study area as defined here contains approximately 853,000 people (Niemi et al. 1999). The majority live in a handful of small, but growing in many cases, cities and towns along the I-5 interstate highway corridor (Roseburg, Grants Pass, Medford, Ashland, Yreka) and along the coast (Gold Beach, Port Orford, Brookings, and Crescent City; see Figure 9). Traditionally, resource extraction (mining and logging) formed the foundation of the regional economy, but this trend is now changing (see Niemi et al. 1999).

As in other regions, humans have taken their toll on the Klamath-Siskiyou regional ecology. While more intact than many other regions of the Pacific northwest, due largely to the rugged nature of the terrain, the Klamath-Siskiyou has still experienced significant ecological degradation. Principally through agriculture and forestry (especially at low elevations), natural communities continue to be converted as we are just realizing the potential ecological impacts from decades of fire suppression and introduction of invasive exotic species. Conversion and overall ecological degradation continues as more sites are logged, more roads built, and more waterways contaminated or diverted. Some species already have been extirpated from the region – most notable are two apex predators (grizzly bear, *Ursus arctos* and gray wolf, *Canis lupus*) and some other large mammals (e.g., bighorn sheep, *Ovis canadensis*). Many species remain rare and endangered throughout the region, but northern spotted owl and salmon retain the highest public profile.

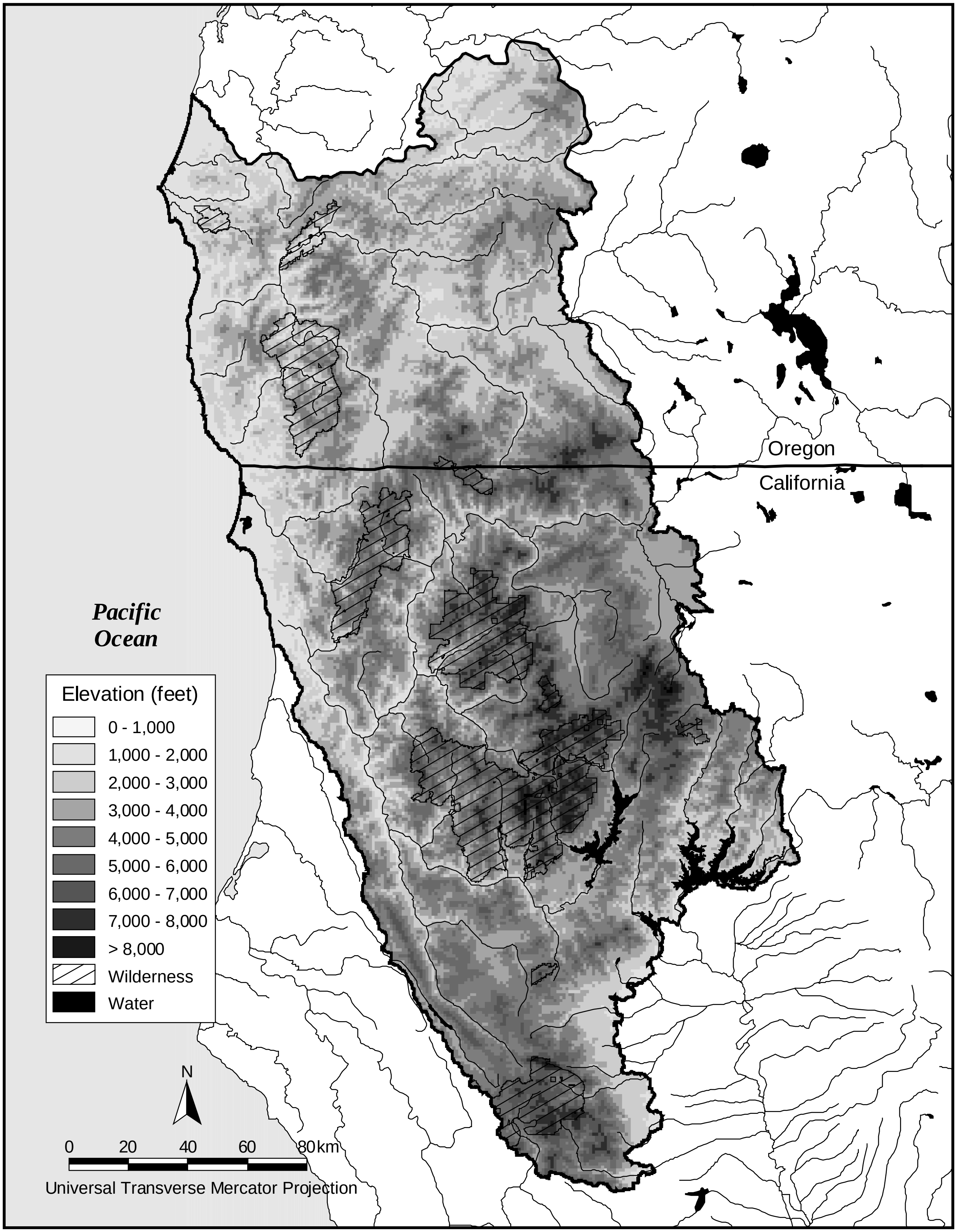

Figure 6. Elevation slice for the Klamath-Siskiyou study area showing existing wilderness areas.

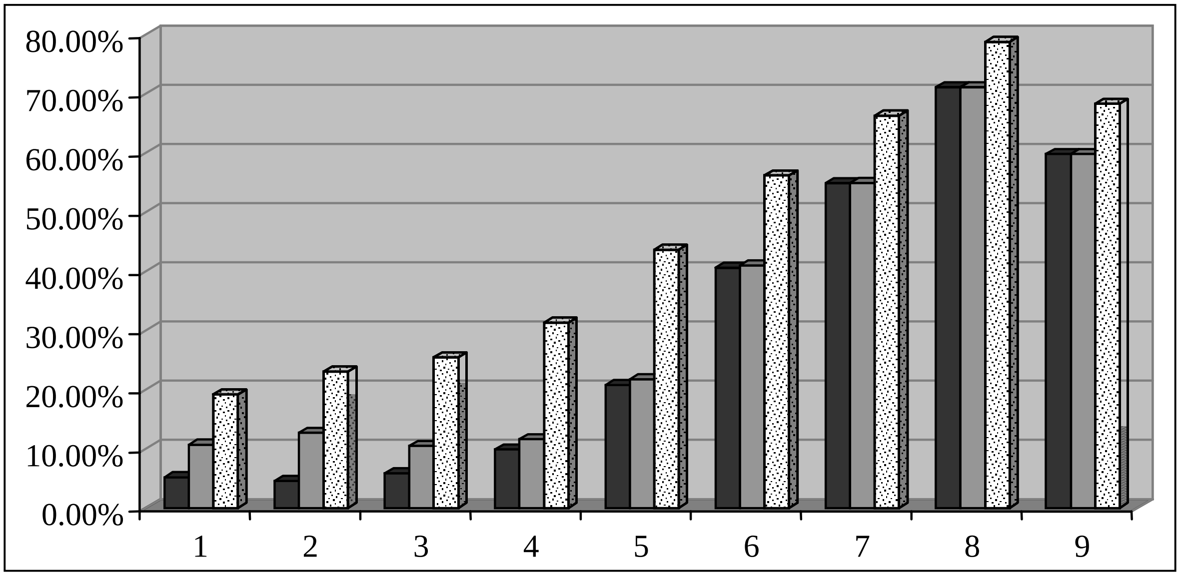

Figure 7. Graph showing percent protection for each elevation band (1-9) for the Klamath-Siskiyou study area. Elevation bands are in approximately 1,000 ft. intervals from mean sea level to 1,000 ft. (Class #1) to the highest band >8,000 ft. (Class #9). Black bars depict GAP 1, gray bars depict GAP 1 + GAP 2 (with LSR = GAP 3), and speckled bars depict GAP 1 + GAP 2 (with LSR = GAP 2).

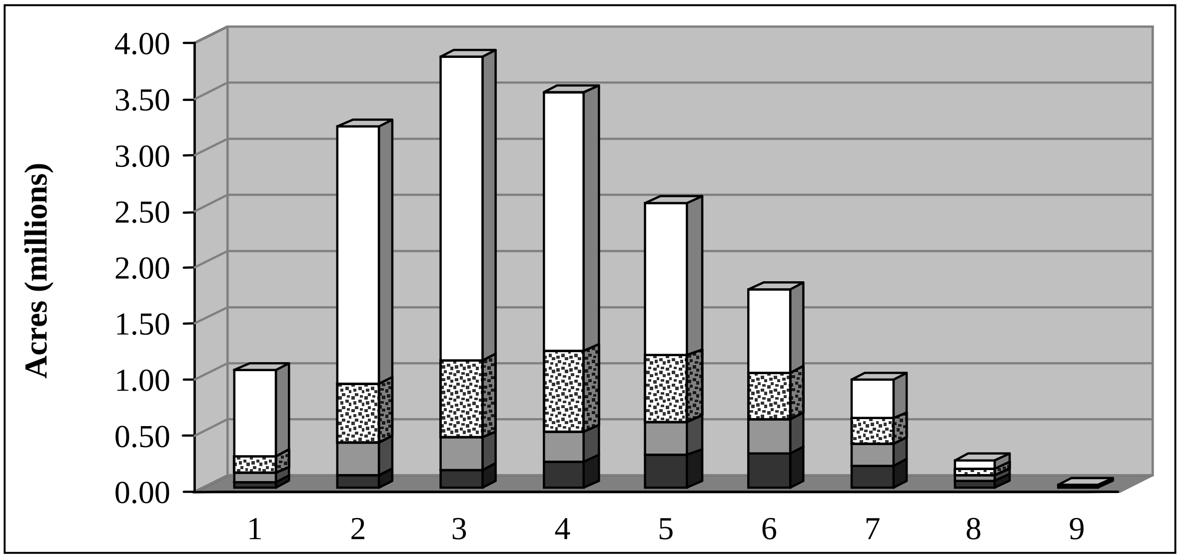

Figure 8. Graph showing relative area (in millions of acres) of each elevation band and its degree of protection for both LSR characterizations. Elevation bands are in approximately 1,000 ft. intervals from mean sea level to 1,000 ft. (Class #1) to the highest band >8,000 ft. (Class #9). Black bars depict GAP 1, gray bars depict GAP 1 + GAP 2 (with LSR = GAP 3), and speckled bars depict GAP 1 + GAP 2 (with LSR = GAP 2), and white bars depict GAP 3 & 4.

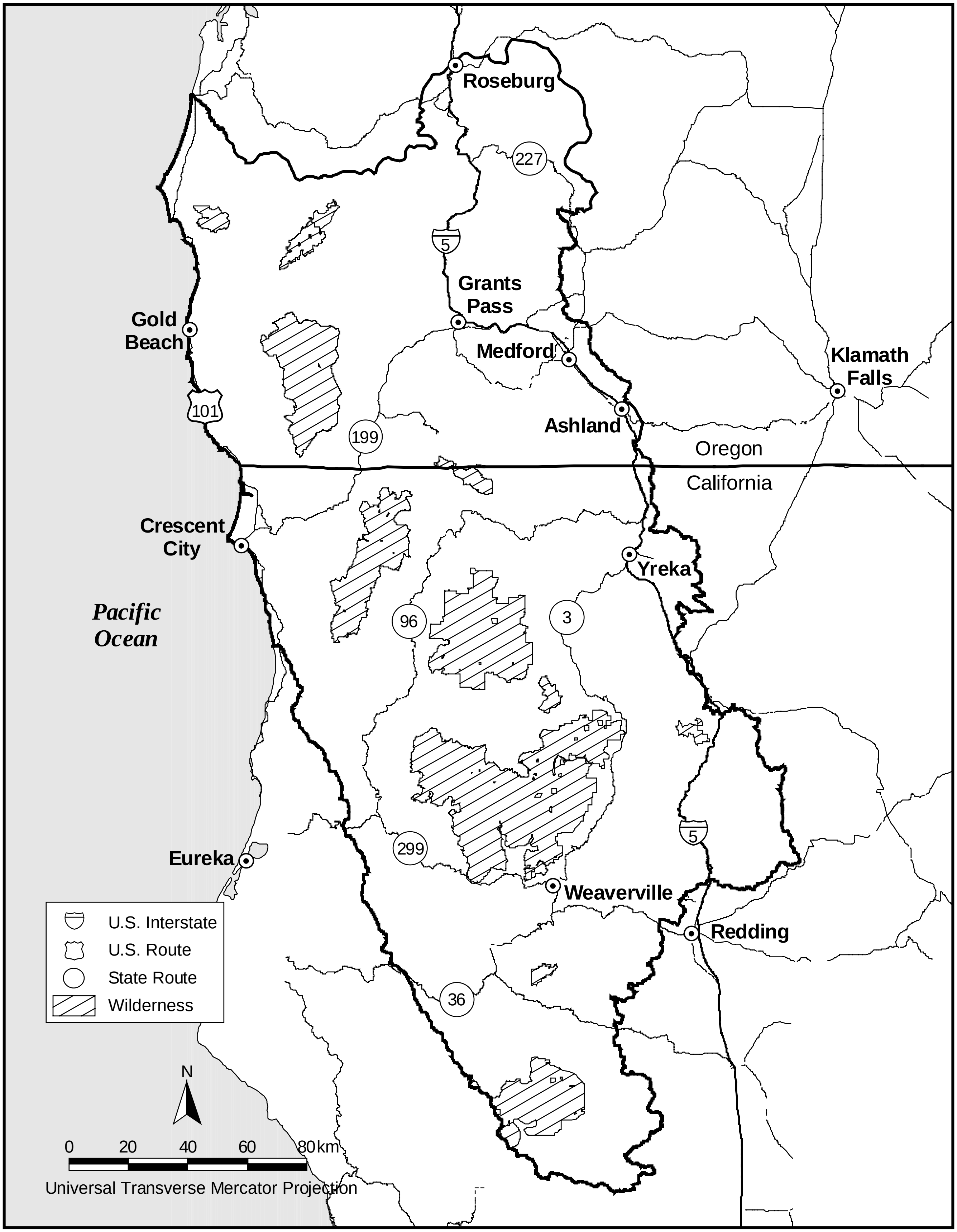

Figure 9. Primary roads and city locations within the Klamath-Siskiyou study area.

The Klamath-Siskiyou ecoregion is at an important crossroad. Although the ecological damage to the region has been significant in some areas, there is still enough natural capitol remaining that it is still possible to reverse the modern pattern of obliterating all that is wild. The management recommendations made in this report and the proposed reserve design in no way intends to exclude humans from the region. There is no proposed taking of any private land. It is our hope that the Klamath-Siskiyou can be one example where human society can loosen its grip on wild nature and find a way to live in a place without destroying its ecological foundation. The challenge for protecting the ecological integrity of the Klamath-Siskiyou rests in our ability to:

(1) understand and describe the regional ecology;
(2) define the needs of native biodiversity and the natural demands of ecosystem dynamics;
(3) describe the ecological ground rules under which human enterprise can operate without causing irreparable ecological damage; and
(4) effectively plan for an ecologically sustainable future at multiple spatial scales in an iterative and responsive fashion.

Roads

Of all the cultural data layers obtained, roads serve as the most useful indicator of human use and disturbance of natural systems. Numerous studies have demonstrated that roads cause damage to natural ecosystems both directly and indirectly. Roads directly impact natural ecosystems by: (1) being a significant factor in landscape conversion and fragmentation (Spellerberg 1988), (2) serving as conduits for invasion by some exotic species (Schowalter 1988), (3) delivering sediment to waterways both during and post construction (Montgomery 1994, Wemple 1994, Sidle et al. 1985), (4) acting as wildlife movement barriers (Oxley et al. 1974, Adams and Geis 1983, Brody and Pelton 1989, Bennett 1991), and (5) acting as direct vectors for roadkill of wildlife (Harris and Gallagher 1989, Paquet et al. 1996). Indirectly, roads provide widespread human access leading to a wide range of human induced impacts on the local flora and fauna (Brocke et al. 1988, Noss and Cooperrider 1994).

For a region the size of the Klamath-Siskiyou (approximately 10.6 million acres), intermediate-scaled data (1:100,000 - 1:250,000) is adequate to get a basic understanding of the distribution pattern and magnitude of roads. Figure 10 shows the U.S. Geological Survey 1:100,000 digital line graphs (DLG) for the study area. A total of 27,665 mi (44,522 km) of roads of all surface types were found to occur in the region. Most of the urban centers are clearly visible as are the very large roadless areas showcased by existing designated wilderness.

For approximately 75% of the region, 1:24,000 scale roads data were acquired from the various National Forests and from the Rogue Basin Council of Governments GIS Lab. Figure 11 shows the study area featuring the 1:24,000 scale roads. The 1:100,000 scale roads also were plotted on this map to help communicate where the larger scale road data were not available. A total of 32,753 mi (52,711 km) of roads were found in this reduced

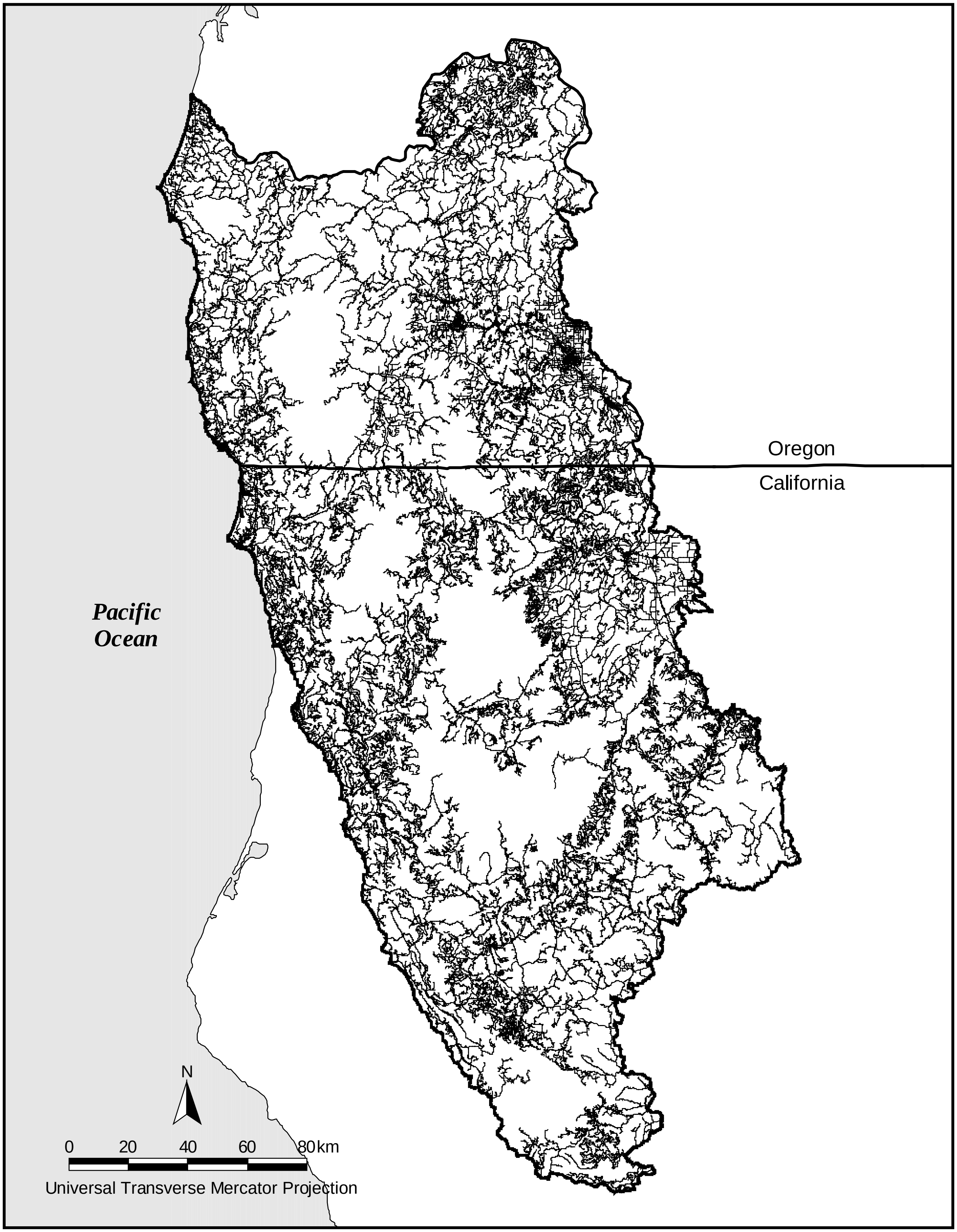

Figure 10. Roads included in U.S. Geological Survey 1:100,000 digital line graphs for the Klamath-Siskiyou study area (all classes except trails).

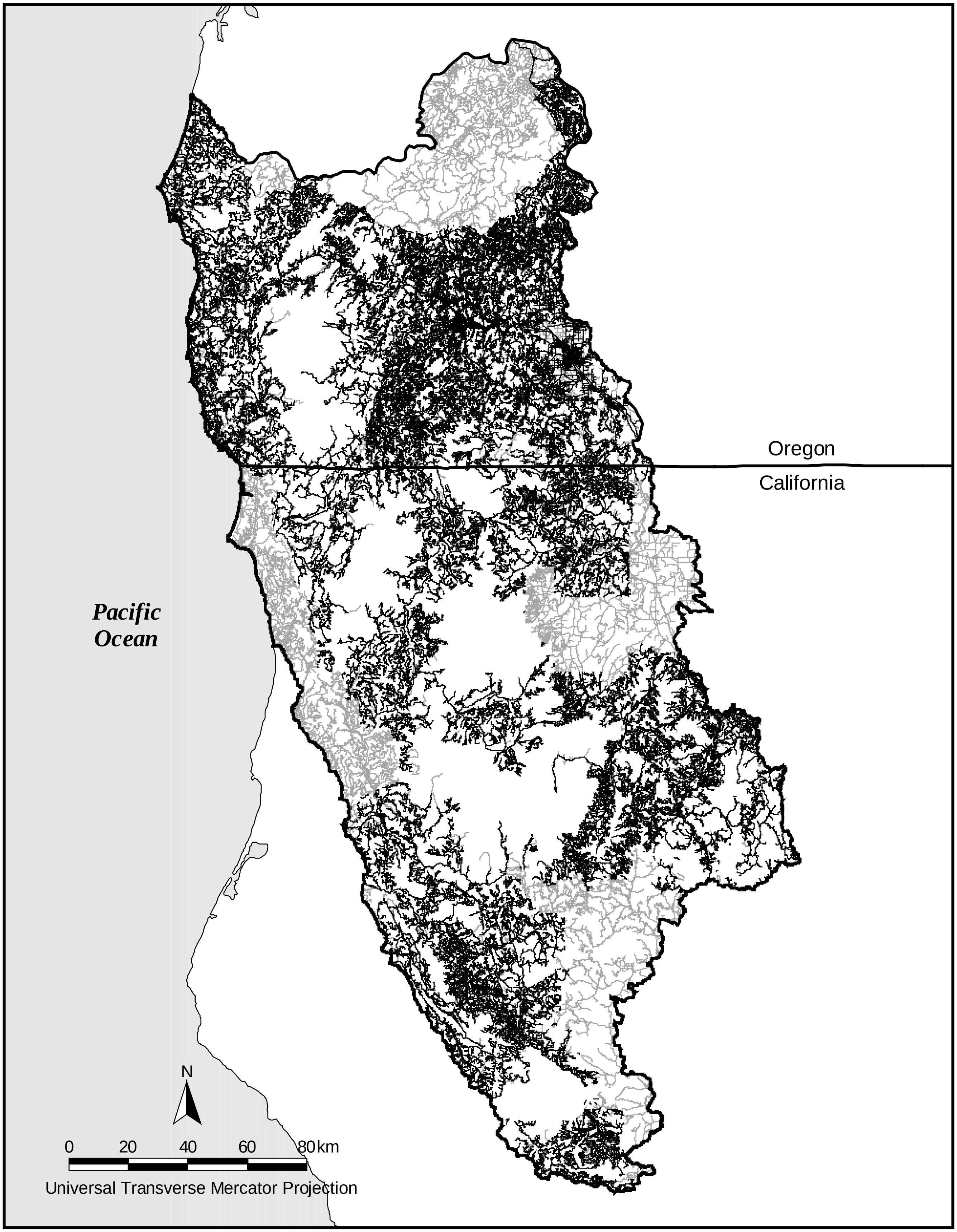

Figure 11. Comparison between 1:24,000 roads (black) and 1:100,000 U.S. Geological Survey digital line graphs (gray) for the Klamath-Siskiyou study area (all classes except trails).

region. If we extrapolate out over the remaining area, the total road length at the 1:24,000 map scale for the region would be approximately 39,146 mi (63,000 km), an increase of approximately 42%. Figure 12 is a close-up view of a region in southern Oregon comparing 1:24,000 and 1:100,000 scale road data. Note the dramatic increase in spatial detail the 1:24,000 scale data provides especially by adding the numerous, important logging roads. For ecological assessments and conservation planning purposes, the 1:24,000 scale road data, while difficult to work with over such large geographic areas, is far superior in predicting potential impacts of roads on natural ecosystems than its more intermediate counterparts.

Roads analyses were involved at various stages in the planning process and will be discussed under the proper headings. Two fundamentally different types of road analyses are road density and roadless areas mapping. Based on the previous few road figures, it is obvious that the utility of either one is largely dependent on the scale and quality of the data.

There is a substantial body of literature that defines density thresholds for the persistence of certain biota making road density a very useful analysis. Large home range predators (e.g., wolves) are the most heavily researched species with regard to road density tolerances – this has resulted in the establishment of some very sound rules-of-thumb (Van Dyke et al. 1986, Mech et al. 1988, Mace et al. 1996). Road density is a relatively simple calculation in the computer mapping environment, but there are many ways to accomplish it. One way is to break up the study area into a fixed regular grid-cell array and then calculate total length of road by area. Figure 13 shows the results of this technique for the Klamath-Siskiyou based on a 1km x 1km grid cell size and the 1:100,000 roads DLG. Classes were based on literature rules-of-thumb for the gray wolf (Thiel 1985, Mech et al. 1988) rather than based on arbitrary density categories. Another approach is to use a moving window calculation instead of a fixed grid. This may be the more useful of the two techniques when attempting to model persistence of a particular species. For example, if we know the average home range needs of an important focal species such as the gray wolf (Peterson et al. 1984, Messier 1985), we can set the moving window function in the GIS to calculate the road density for that size area (see Figure 14). The visual appearance is one of smoothing the results of a smaller celled fixed grid cell array as portrayed in Figure 13.

Mapping roadless areas is very different and is much more complicated to conduct in the GIS environment. Previous attempts have depended largely on vector-based modeling – most specifically on a series of buffering commands. Intuitively, this approach seems ideal, but complications quickly present themselves. These techniques have trouble taking into account sections of proposed roadless areas that are narrow peninsulas of land that are common in areas a high road sinuosity. Technical fixes to this problem have been proposed that rely on merging results from a number of different buffering operations, but we found yet other problems emerging.

After analyzing the issue from the vector domain through a series of buffering techniques, we abandoned the vector modeling approach altogether. We instead converted the

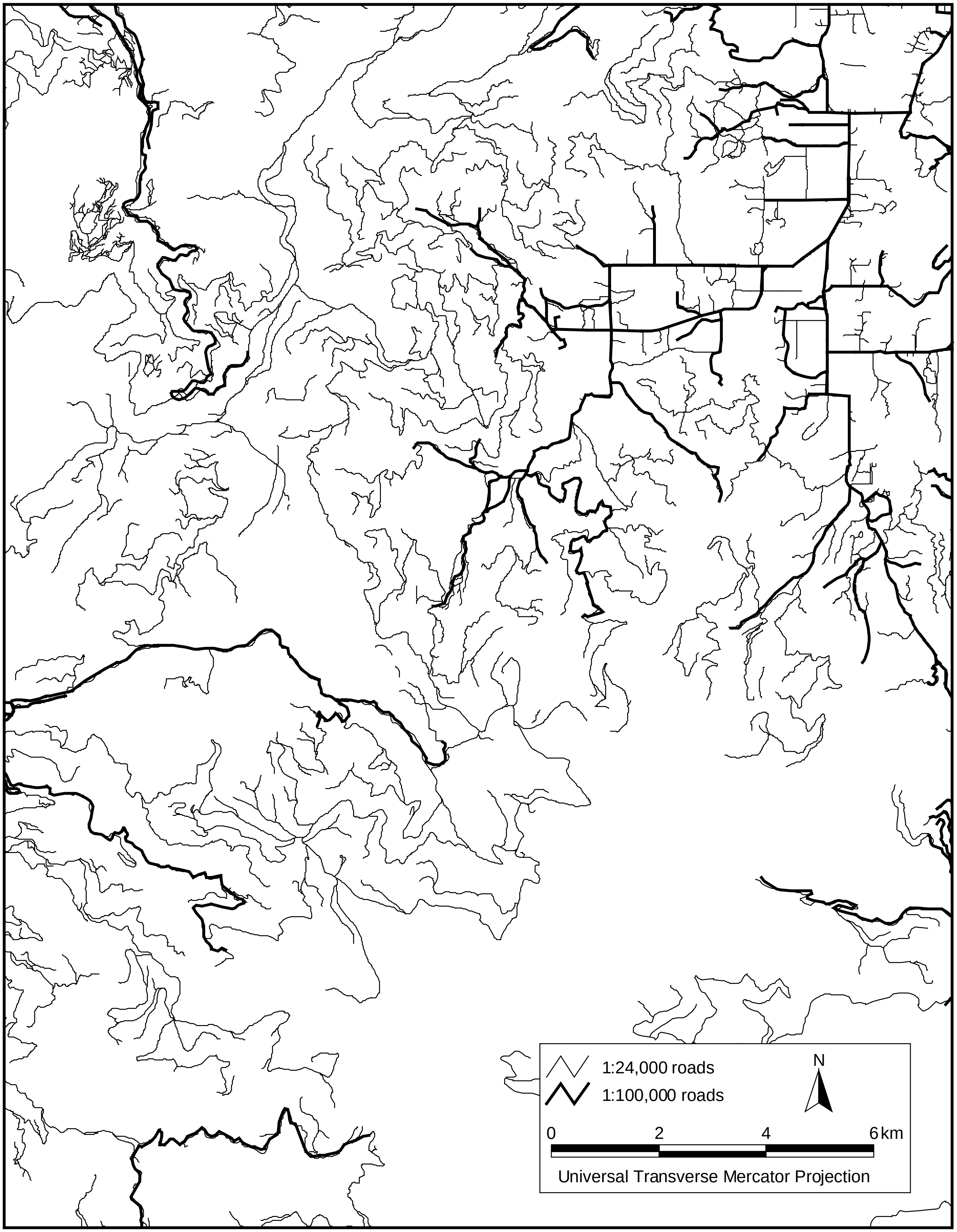

Figure 12. Close-up comparison between 1:24,000 roads and the U.S. Geological Survey 1:100,000 digital line graphs for the Klamath-Siskiyou study area.

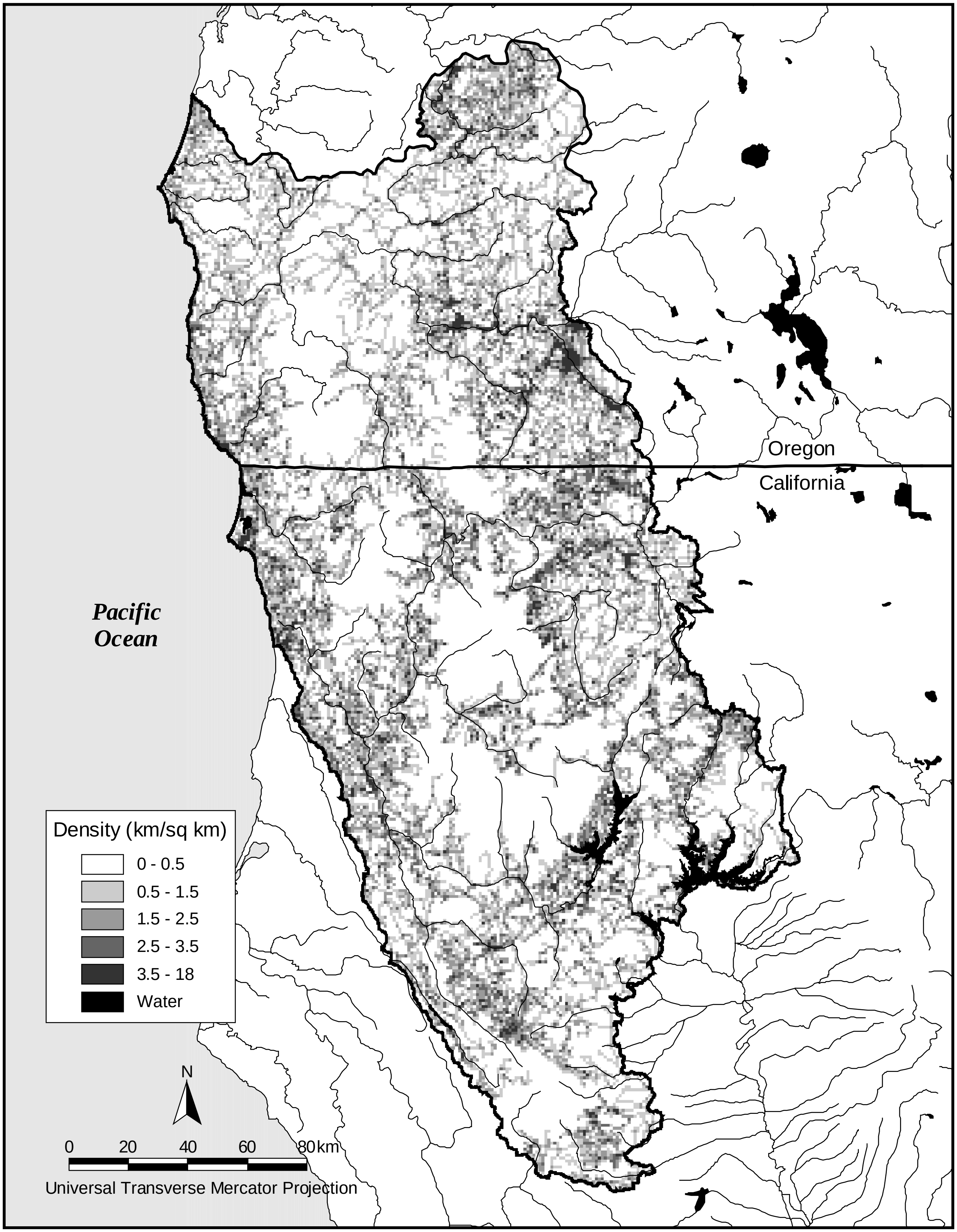

Figure 13. Road density based on a 1km x 1km fixed grid using 1:100,000 scale roads data for the Klamath-Siskiyou study area.

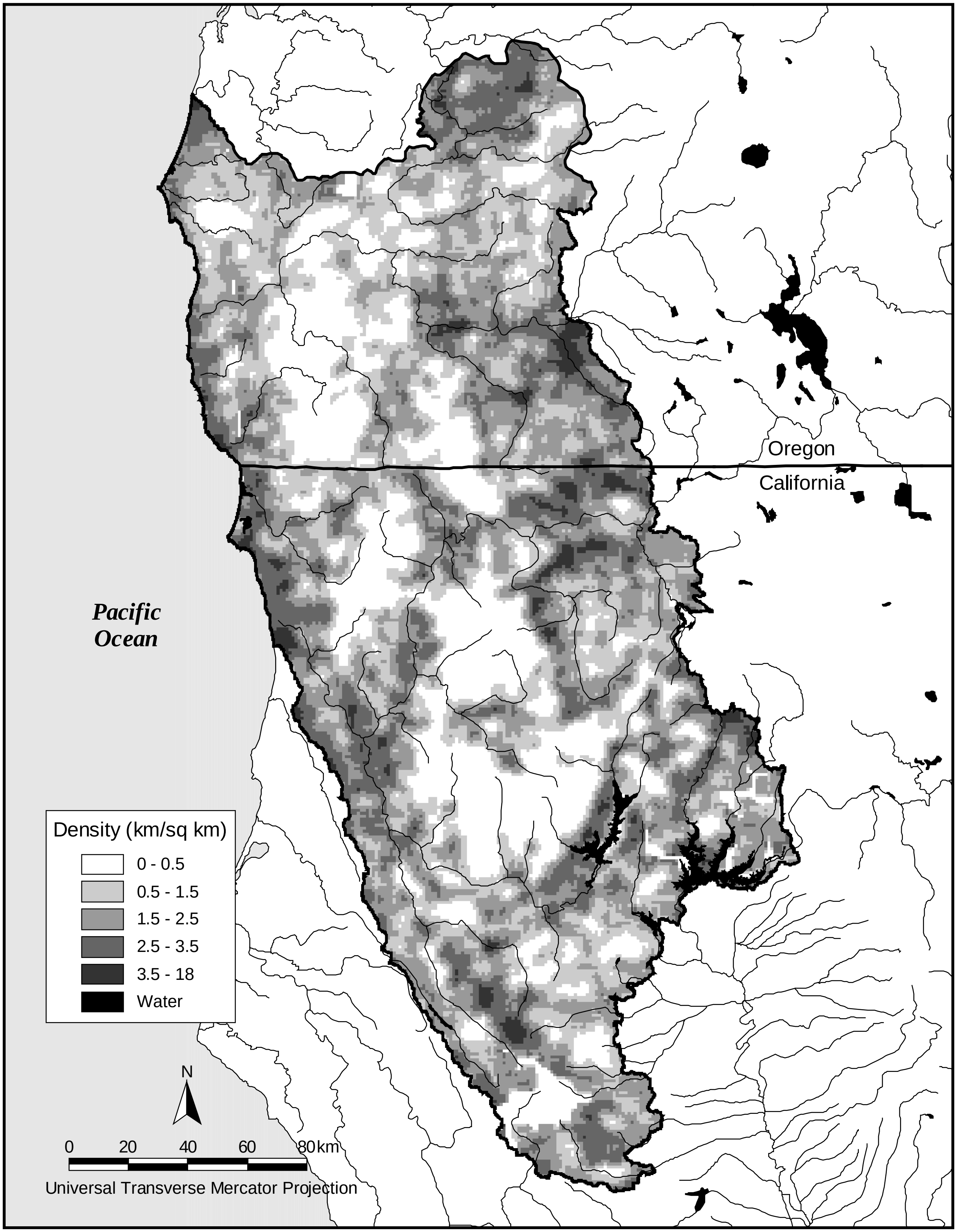

Figure 14. Road density based on a 5km x 5km moving window using 1:100,000 U.S. Geological Survey digital line graphs for the Klamath-Siskiyou study area.

1:24,000 scale road data into 12 raster-based tiles. Twelve tiles were used to improve processing speed. We then applied a series of raster modeling techniques to delineate roadless areas for the study area using a 10m x 10m grid cell size and later returned the results back to the vector domain for the remaining steps in the process (see Appendix A for a full technique description). Only roadless areas 1,000 ac or larger were saved unless the area was immediately adjacent to existing wilderness areas. While not perfect, we found this technique to be superior to other methods. Our modeling technique managed to automatically account for road sinuosity while conserving as much land as possible immediately adjacent to roads.

The roadless areas mapping technique resulted in a total of 590 roadless polygons 498 of which were ≥ 1,000 acres (see Figure 15). As will be seen later in this report, roadless areas were fundamentally important to the design of the proposed reserve network.

Late Successional Reserves

According to the most recent data layers, 1,887,629 ac (763,923 ha, 17.8%) have been designated as Late Successional Reserve (LSR). While these areas have been given special management designation, one that favors the enhancement of late seral-forest conditions, they are not necessarily areas with high ecological integrity. We examined two ecological criteria for assessing relative LSR quality: road density and percent late-seral forest. Results for each criterion were assigned ordinal scores using an equal area algorithm (1-5), with "5" being most desirable – road densities low and percent late seral forest high (see Table 7). These two scores were added together and LSR ranked in terms of overall quality (Figure 16). Using 1:24,000 scale road data, most LSR were found to be roaded (some heavily) with road densities ranging from 0 to 9 km/km^2. For example, Figure 17 shows a close-up view of the road network within several different LSR between the Siskiyou, Marble Mountains, and Trinity-Alps wilderness areas. Setting a road density threshold at ≤ 0.5 km/km^2, above which some animal species cannot be sustained (e.g., most carnivores), only 12.6% of the existing LSR areas fulfill this requirement.

Many LSR did not score highly with regard to high late-seral forest concentrations either. Comparing LSR boundaries with the mean late seral forest data, we found that 30% of the LSR areas did not contain late seral forest at concentrations >25% (Table 7). To help illustrate this observation, Figure 18 shows the cumulative clearcutting results from 1973 – 1995 both in and around one LSR in Oregon. Landscape change data (Cohen et al. 1995) was only available for the Oregon side of the study and therefore could not be applied to all LSR in the study area.

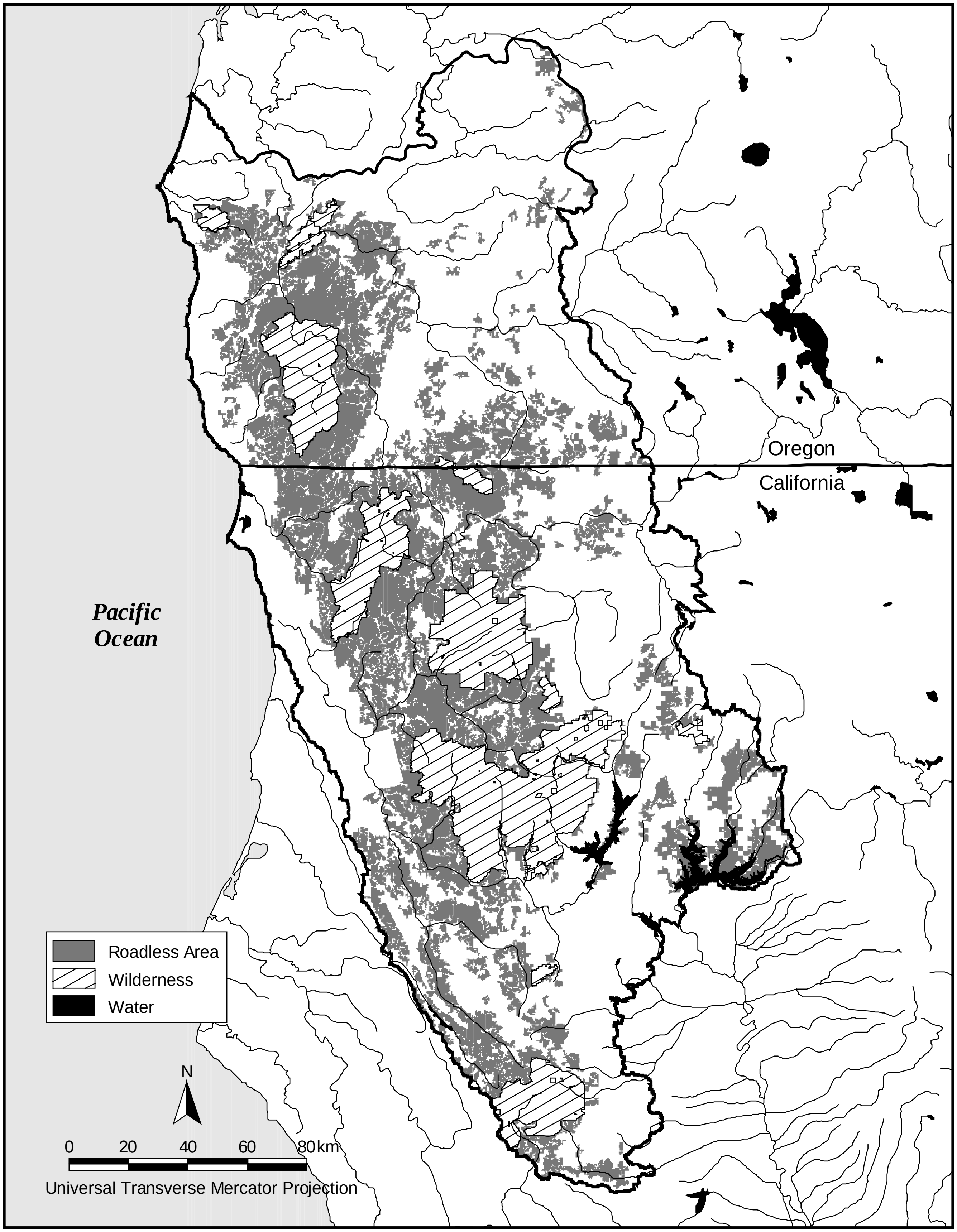

Figure 15. Mapped roadless areas (1,000 ac or larger) within the Klamath-Siskiyou study area.

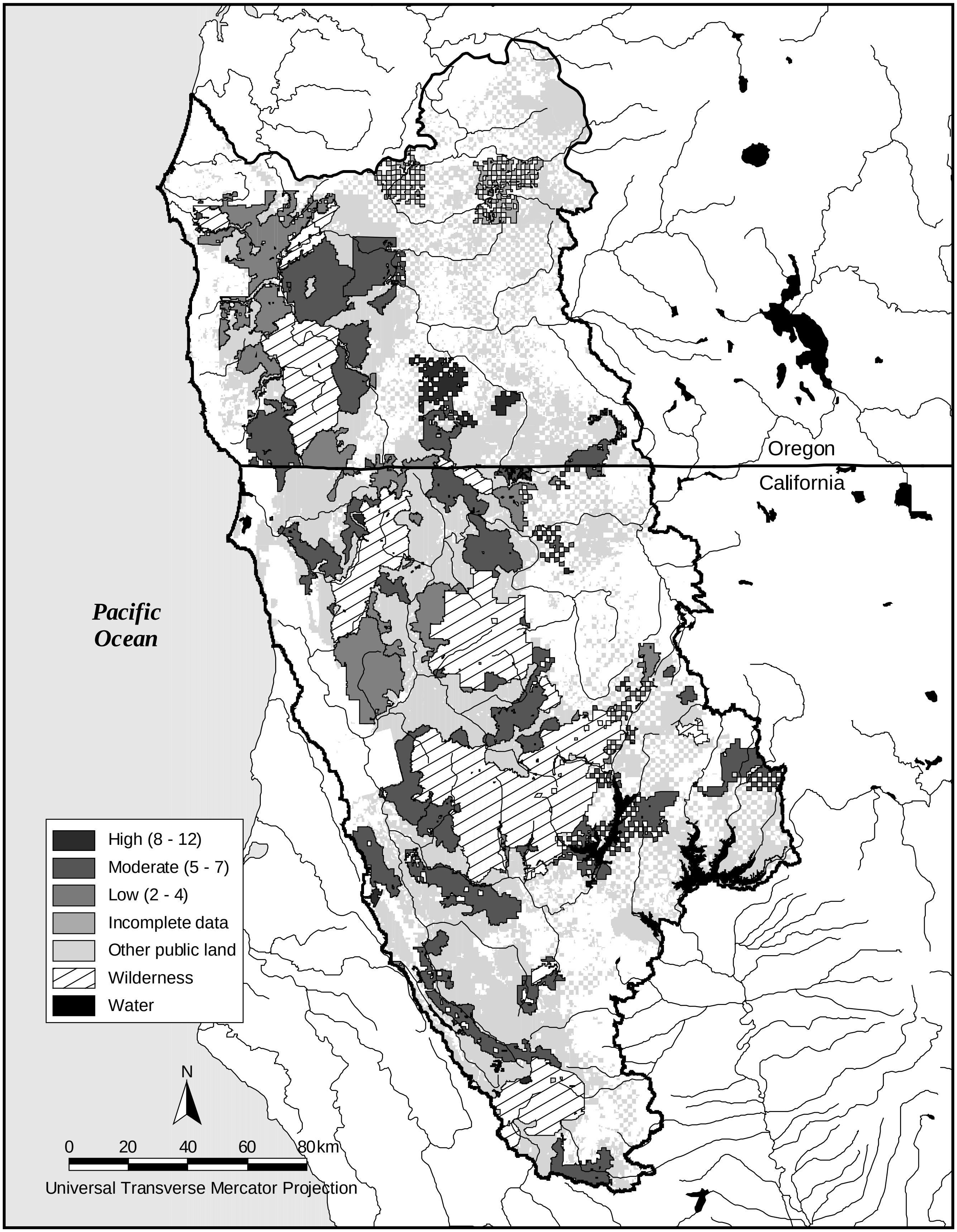

Figure 16. Late Successional Reserve relative quality based on combined score of road density and mean density of late-seral forest.

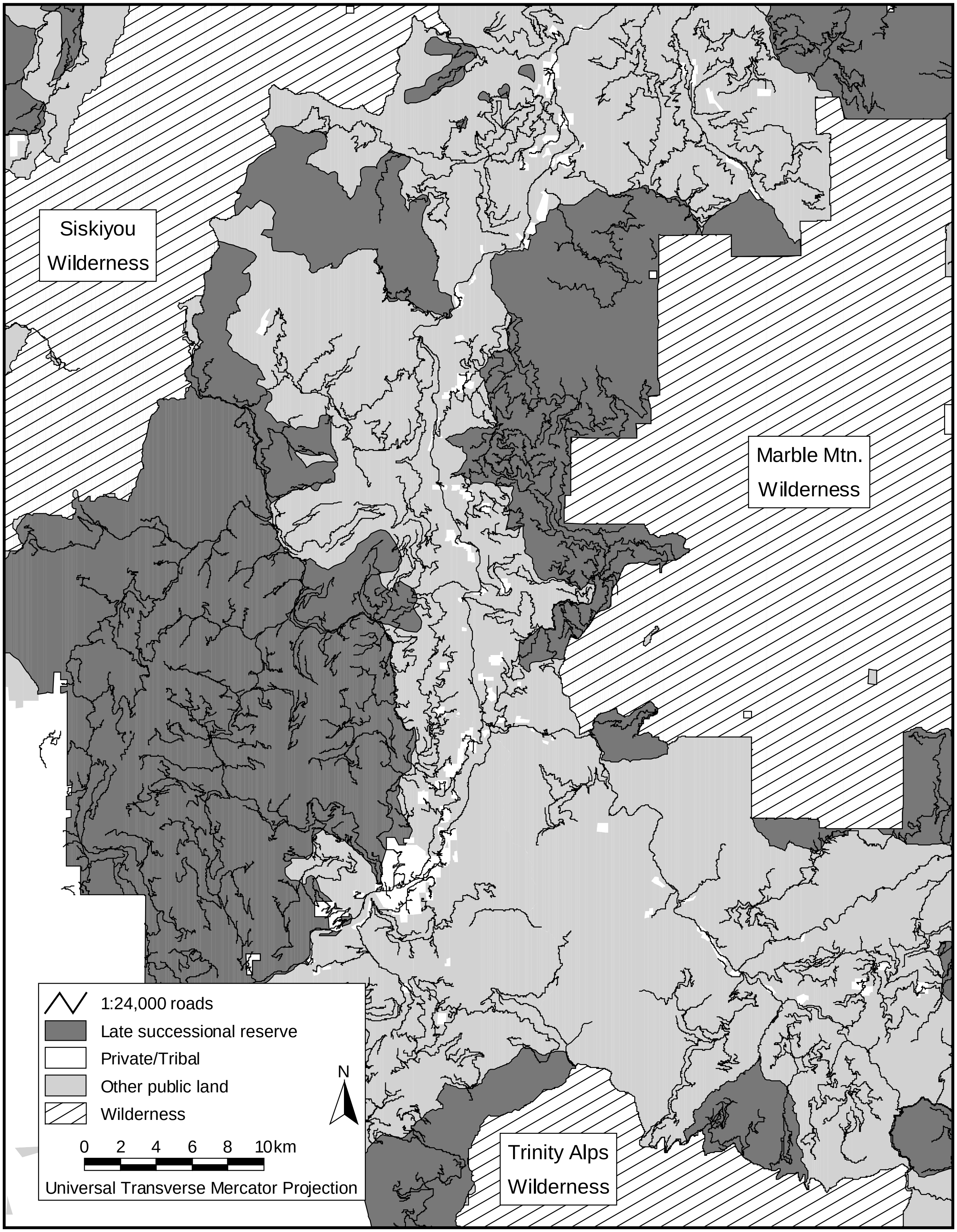

Figure 17. Close-up of Late Successional Reserves showing 1:24,000 road distribution.

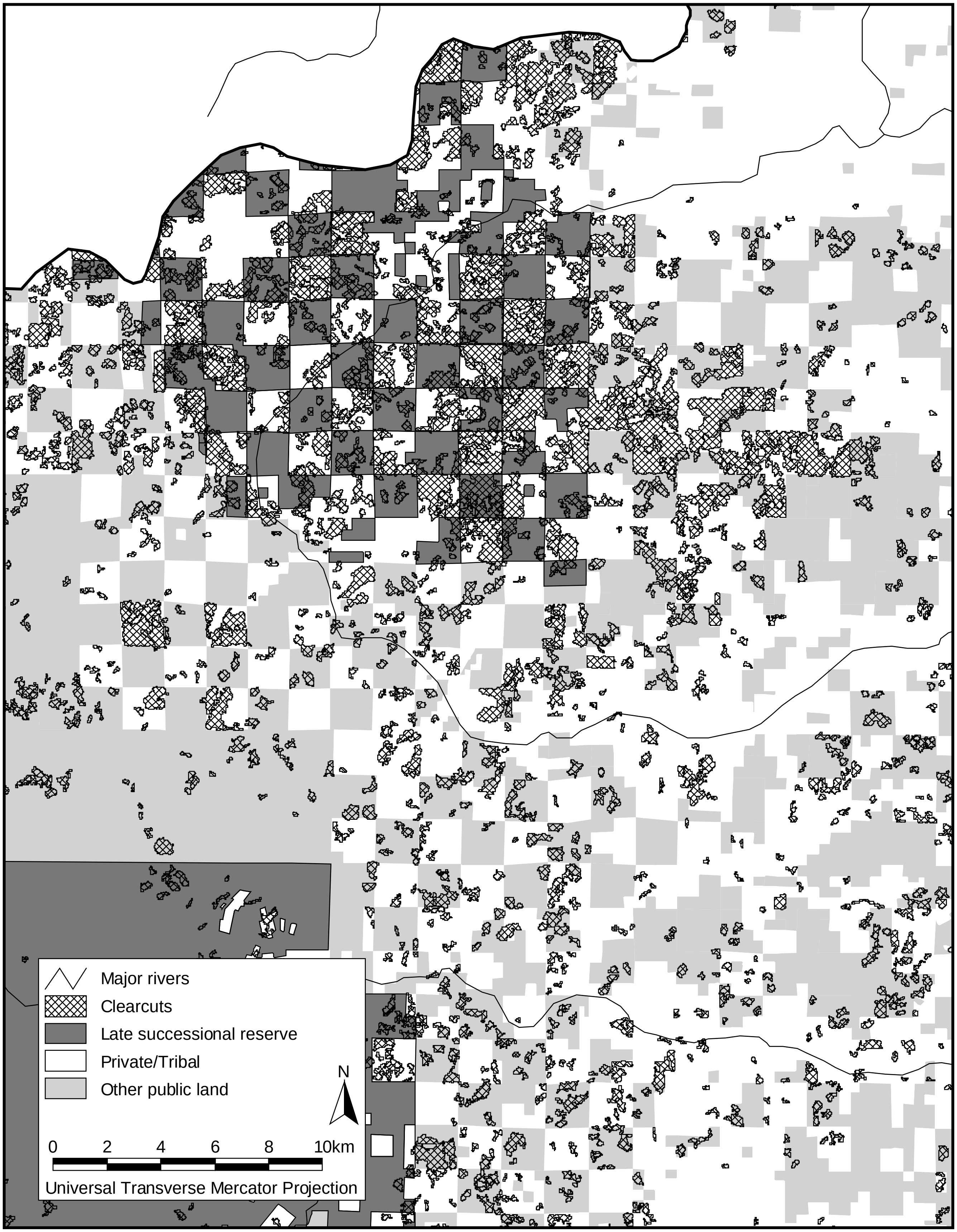

Figure 18. Close-up of Late Successional Reserve showing extent and distribution of cumulative clearcutting (1973-1995).

Table 7. Ordinal score assignment for road density and percent late seral forest for LSR within the Klamath-Siskiyou.

Road Density	**Range**	**Area (ac)**	**Area (ha)**	**Percent**
5	0-0.809	396,581	160,496	21.01
4	0.809-1.161	396,117	160,308	20.98
3	1.161-1.425	390,337	157,969	20.68
2	1.425-1.674	378,326	153,108	20.04
1	1.674-8.998	326,267	132,040	17.28
Totals		*1,887,629*	*763,921*	*100.00*
Late Seral Forest Concentration	**Range**	**Area (ac)**	**Area (ha)**	**Percent**
1	0-0.217	386,466	156,403	20.47
2	0.217-0.25	384,198	155,485	20.35
3	0.25-0.302	383,194	155,079	20.30
4	0.302-0.35	300,298	121,531	15.91
5	0.35-0.802	433,473	175,426	22.96
Totals		*1,887,629*	*763,924*	*100.00*

SECTION III — SPECIAL ELEMENTS

Heritage Element Occurrences

The most obvious component of a special elements analysis is an examination of heritage element occurrences in general and known threatened and endangered (T&E) species records. The Klamath-Siskiyou is well known for its species richness and endemism (see DellaSala et al. in press) and heritage records were relatively plentiful for the region and available electronically. We actually were able to acquire specific heritage datasets from the various national forests (dominated by vertebrate records, particularly birds), as well as the portion of the BLM management areas, but we elected to drop them due to the large degree of duplication with the heritage programs from both states. Not every record was shared between the state heritage databases and the agency files, but enough so that to add them made for a degree of complexity that offered little if any new insight. We therefore opted for the simpler data handling approach.

Data Sources:

❶ 1999 Oregon Natural Heritage Program (1:24,000)
❷ 1999 California Natural Diversity Database, California Department of Fish and Game (1:24,000)

Methods:

All element occurrences were mapped as points and included into the reserve design in three ways. First, all records were considered together and weighted according to their endangered status (G1/G2 were assigned a weighted score of "50," S1/S2 a weighted score of "10," and all other elements a score of "1"). We constructed a 1km x 1km fixed grid cell array and scored each cell by combining the weighted heritage records. The results were then smoothed using a 3km x 3km moving window operation. The moving window results were subdivided into three classes (low, medium, and high) using a natural break algorithm called Jenks' optimization, which identifies break points between classes using a statistical formula that minimizes the sum of variance within each of the classes to help find groupings and patterns inherent in the data (Jenks and Caspall 1971). This technique identified concentrations of the most endangered elements. The "high" category was added directly to the reserve design irrespective of ownership. The portion of this area on private land is meant to represent land targeted for negotiation for acquisition or alternative land agreement (e.g., conservation easement) – not for taking. We also used the weighted heritage scores organized by roadless areas rather than by the fixed grid cell array. Additional methods and the results for this application of heritage data are discussed under the roadless areas section.

Finally, G1/G2 records were selected out of the two databases and given special treatment. Those records found on public land were buffered 1,000 meters and added directly to the reserve design.

Results:

A total of 8,793 records were found within the study area organized around six taxonomic groups (Table 8). DellaSala et al. (in press) contains a full species list for the combined Oregon-California database.

The fixed grid cell scoring results are presented in Figure 19 where a few somewhat obvious concentrations are visible. The rest of the records seem just scattered throughout the study area. Figure 20 shows the results from the moving window smoothing function with high and moderate T&E concentrations displayed and easily observable including: (1) areas along the Upper Illinois River Valley; (2) the North Medford Plain above Medford, OR; (3) area northeast of the Trinity Alps Wilderness; and (4) the area southwest of the Marble Mountain Wilderness. The first two of these areas also were highlighted as conservation opportunity areas by the Oregon Biodiversity Project (1998). Note the simplified modeling of the heritage results made it easier to incorporate the data into a regional reserve design. Only the high concentration areas were directly added to the reserve design. The moderate concentration areas should be more fully investigated at a finer spatial scale for future consideration.

A total of 1,415 records were labeled as G1/G2 species. Figure 21 shows the location of all G1/G2 records and highlights those added directly to the reserve design. Note that many

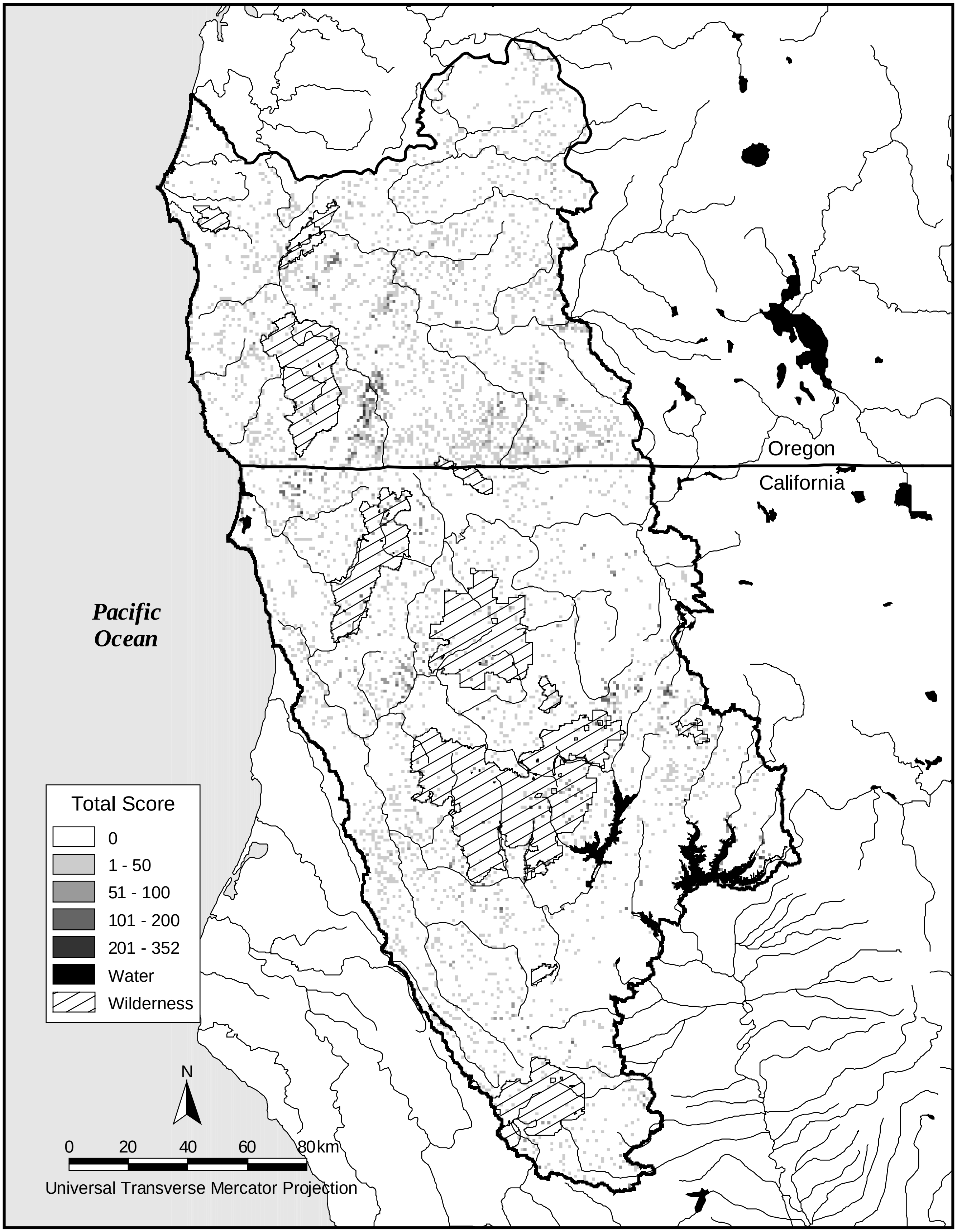

Figure 19. Total heritage score organized by 1km x 1km grid cells for the Klamath-Siskiyou study area.

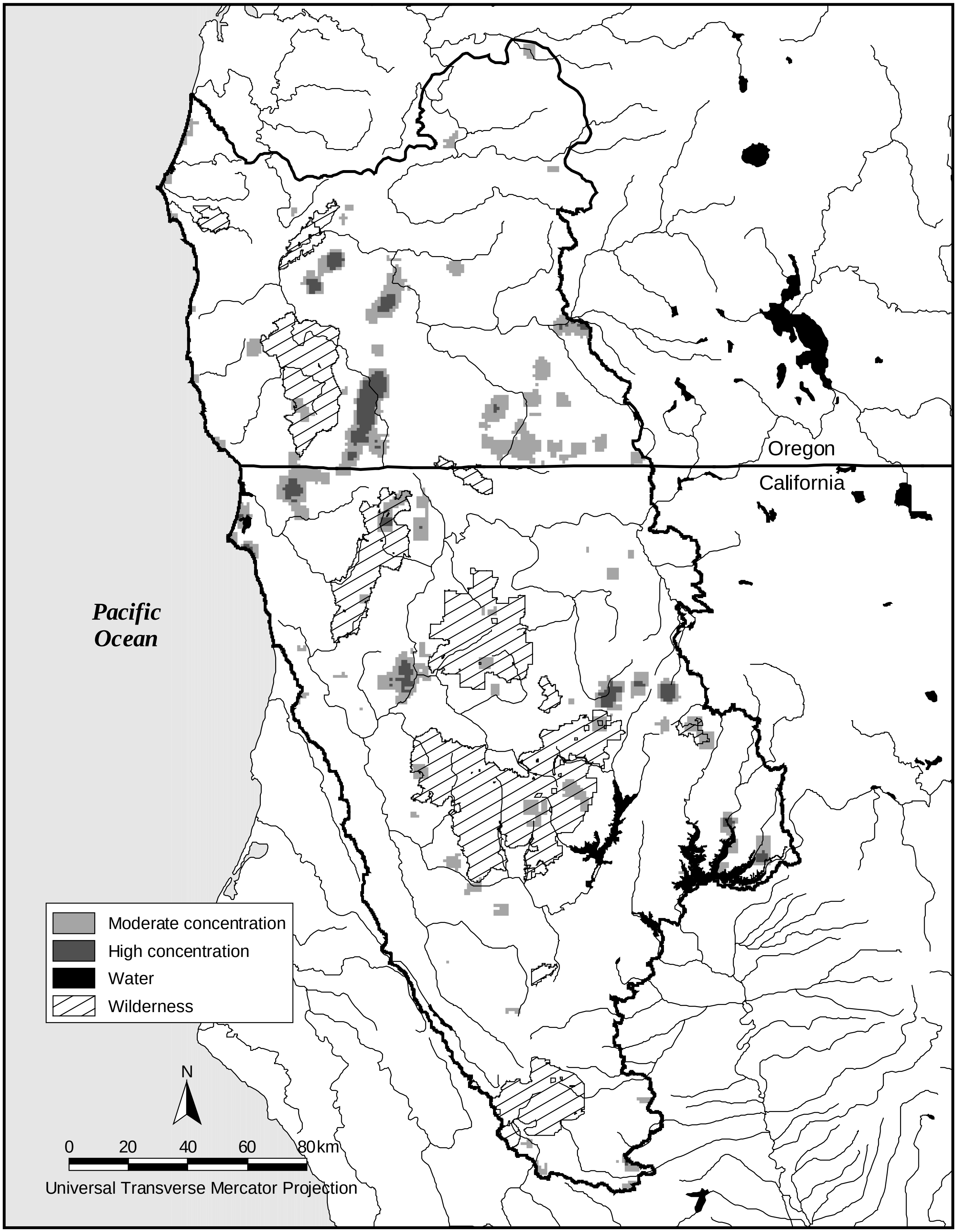

Figure 20. Known concentrations of threatened and endangered species within the Klamath-Siskiyou study area.

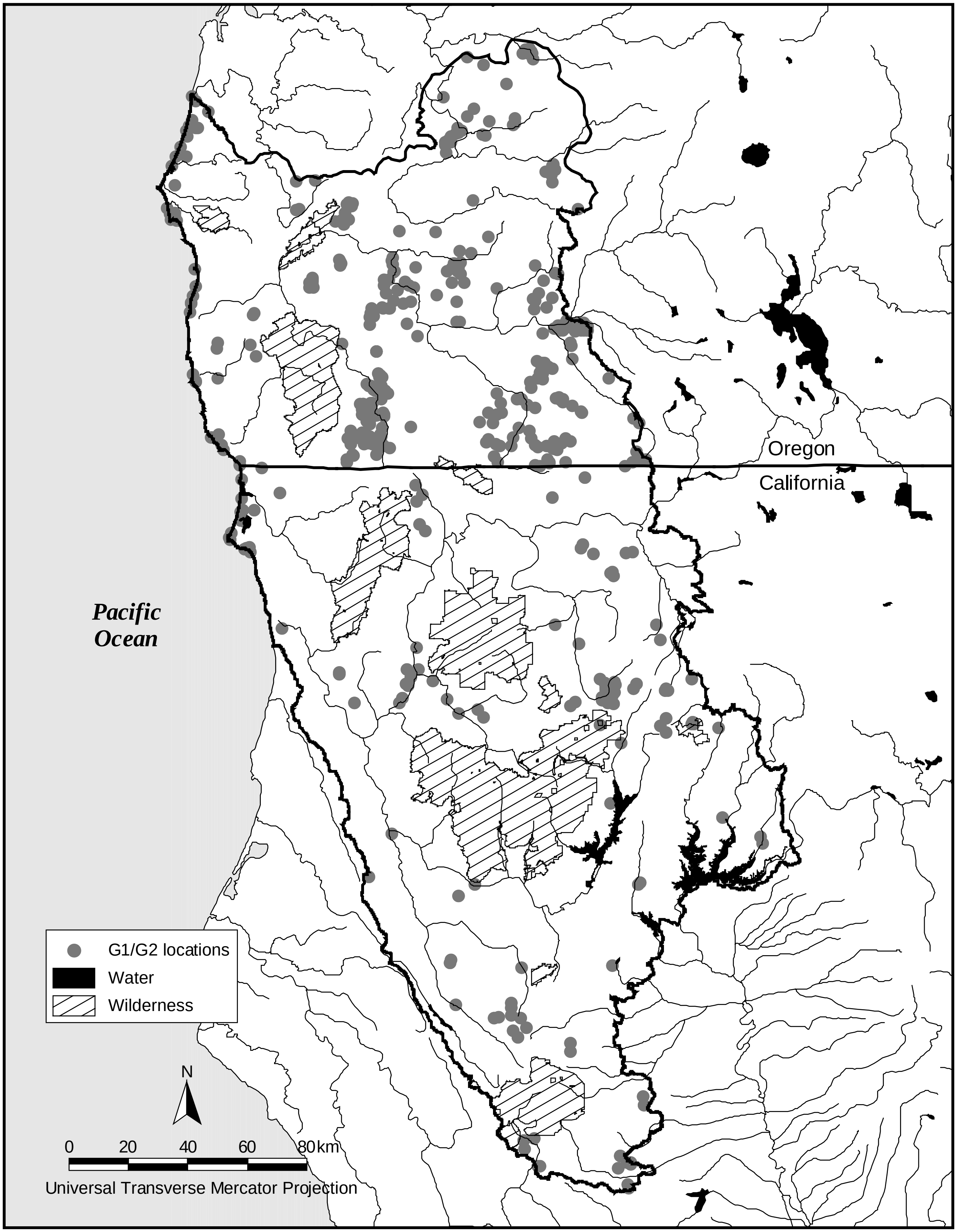

Figure 21. Known locations of G1/G2 species occurrences on public land within the Klamath-Siskiyou study area.

match the concentration pattern observed in Figure 19, but some are not concentrated at all. Without this additional step, many G1/G2 species locations would be missed altogether.

Table 8. Number of element occurrence records according to taxonomic group for the Klamath-Siskiyou study area.

Taxon	**Number of Records**
Plants	3,837
Vertebrates	4,652*
Invertebrates	132
Community	8
Aquatic	6
Special Feature	158
Total	*8,793*

* - Over half were Northern spotted owl records.

Discussion:

The inclusion of heritage data into regional conservation planning is very important, but care must be taken in conducting the analyses and interpreting the results. While the many caveats about the nature of heritage databases are becoming increasingly common knowledge, a quick review of them might be helpful:

1. There is often a time lag between the fieldwork and data entry.
2. Heritage databases are always being improved.
3. Level of sampling effort is highly variable and rarely known.
4. Most databases do not indicate where surveys have been done and no new elements found.
5. Most databases do not indicate where surveys have not yet been performed.

Unless included as a focal species (e.g., Pacific fisher, *Martes pennanti pacifica*) the regional nature of our conservation planning approach did not allow for detailed T&E species-specific considerations. However, it will be useful, and in some cases even critical, to review the existing distribution and ecological requirements for particular T&E species more carefully as a follow-up companion to this work. In such cases, more detailed planning will be required to assure the survival of these species over time. With few exceptions, however, the basic reserve design proposed in this report would stand.

Late-Seral Forests

Older forests are another fundamentally important special element deserving attention in the Klamath-Siskiyou ecoregion. Originally, we intended to consider forest age from the standpoint of old growth (see Hunter 1989), but found available data sources not so narrowly focused. We therefore elected to be more general in our description of "old forest," hence the use of the term late seral.

Both data sources we used were based on Landsat Thematic Mapper (or TM) imagery, which is not always ideal for detecting some of the more subtle characteristics of old growth (see Perry 1994). We had a number of databases to choose from, and we decided to base our assessment on the ones that were most adequately assessed for accuracy and covered the fullest extent of the region.

Data Sources:

❶ Oregon – Classified 1995 satellite TM satellite imagery courtesy of Warren Cohen, PNW Research Station, Oregon State University. Used size class > 24” diameter to define late seral. Accuracy assessment conducted and published (see Cohen et al. 1995).

❷ California – Classified 1994 satellite TM satellite imagery courtesy of Curtis Jacoby of Legacy, Arcata, CA. Used size classes >24” diameter to define late seral. Accuracy assessment underway.

Methods:

The two classified images were simplified to depict late seral/non-late seral and merged into one raster data layer (cell size was 25m x 25m). After comparing the results against the basic ownership pattern in the region, we identified concentrations of late seral by calculating mean late seral using a 3km x 3km moving window operation. Resulting grid cells with late seral making up 30-50% and publicly owned were added to the reserve design as GAP 2 lands unless already assigned as GAP 1 based on another criterion. All resulting grid cells >50% late seral and on public land were added to the reserve design with GAP 1 status. Mean late seral also was calculated for each roadless area and factored into their overall conservation score. More details on this are discussed in the roadless areas section.

Results:

Approximately 22% of the Klamath-Siskiyou study area contained late seral forest based on the mid-1990s satellite image interpretation (see Figure 22). By ownership, approximately 80% was found on public lands with the remainder on private and tribal lands (see Table 9).

Table 9. Late seral forest areas by ownership for the Klamath-Siskiyou study area.

Ownership	**Area (ac)**	**Area (ha)**	**% of Total Old Growth**
Private	27,363	191,078	20.6
Forest Service	1,479,155	598,848	64.5
BLM	291,020	117,822	12.7
Other Federal	2,722	1,102	0.1
State	29,277	11,853	1.3
Tribal	18,903	7,653	0.8
Total	*2,293,039*	*928,356*	*100.0*

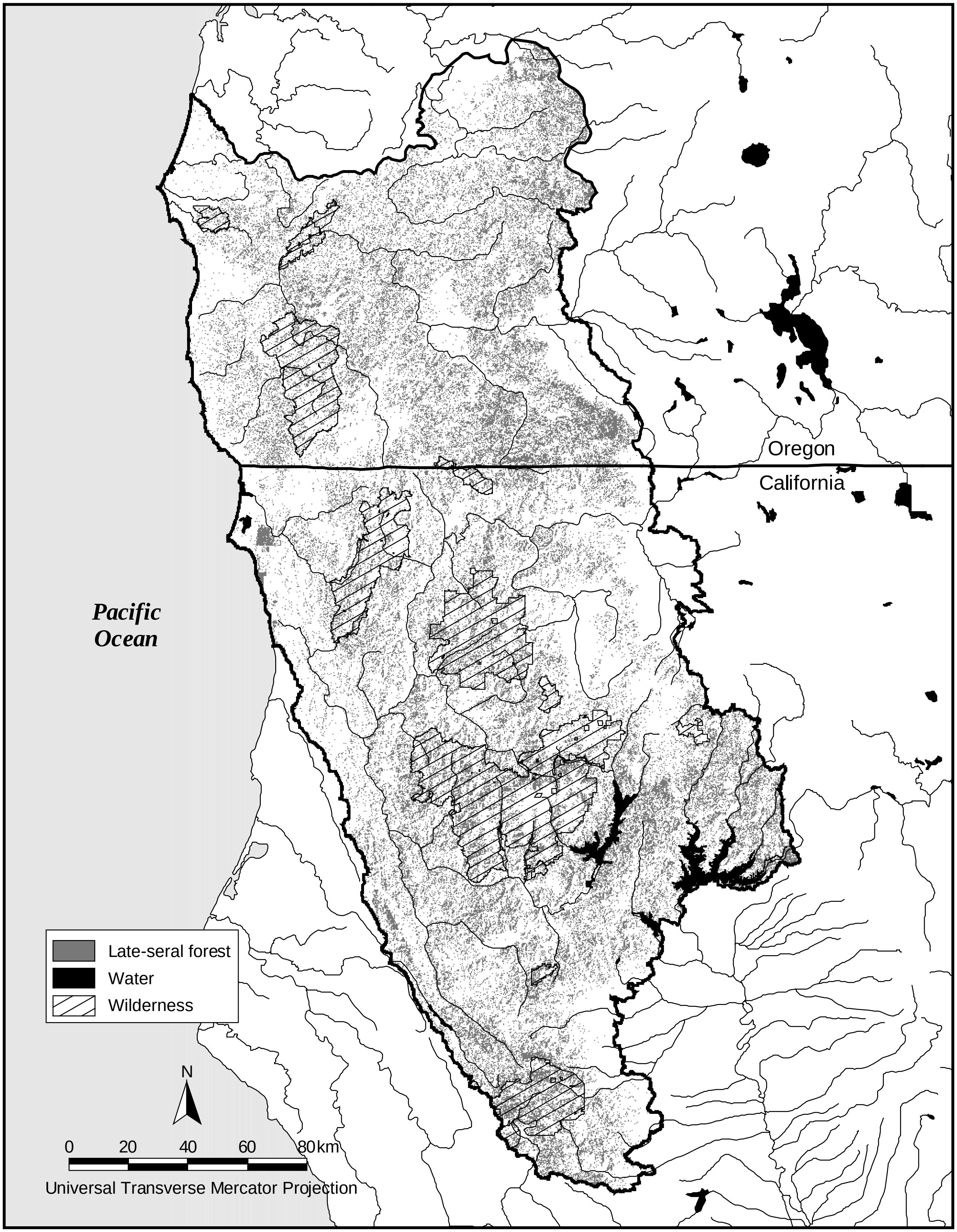

Figure 22. Late-seral forest distribution throughout the Klamath-Siskiyou study area based on 30m x 30m resolution satellite imagery (1994-95).

The mean late seral density results based on the 3km x 3km moving window are presented in Figure 23. The late seral concentrations that directly affected the reserve design were recoded into two classes are shown in Figure 24. A total of 2,430,023 ac (983,815 ha, or 23% of the region) was found to contain 30-50% late seral forest. Approximately 4% (389,119 ac, 157,538 ha) contained >50% late seral forest.

Discussion:

Determining forest age from satellite imagery is never a simple task, but it is even more difficult when mapping in rugged terrain as found in the Klamath-Siskiyou. Traditionally in remote sensing, tree size is often used as a surrogate for age providing a reasonably good data layer but with some unavoidable inaccuracies. For example, old but stunted trees are fairly common in the Klamath-Siskiyou region due to the influence of serpentine geology on tree growth. We were therefore unable to capture the older forests in these particular regions adequately. Deciduous old growth distribution also is less accurate, particularly on the Oregon side where the focus of the classification was to examine basic landscape change. Because of the inherent difficulties in classifying satellite imagery in this very complex region, we purposely chose to include the diameter tree size of >24" in order to capture many areas that otherwise would have been left out and are known to contain substantial old-growth characteristics. In less complicated regions, a size class of >36" would have been preferred. For this reason, we use the term "late seral" instead of "old growth" since it is highly probable that a portion of the data layer is not "true" old growth. Even after missing some areas on serpentine and some portions of certain deciduous forest types, we predict the actual percent of late seral forest remaining should probably be inflated by as much as 2-5%.

Serpentine Geology

One of the reasons the Klamath-Siskiyou is so rich in local endemics is the presence of serpentine geology that is very harsh on many species but tolerated and even obligatory for others (e.g., Howell's mariposa lily *Calochortus howelli*, Trinity buckwheat *Erogonum alpinum*, and Western senecio *Senecio hesperius*). This is one of only two criteria (the other one being the physical zone mapping) where we were forced to use smaller scale data layers.

Data Sources:

❶ U.S. Geological Survey Geology maps for Oregon and California manually digitized from paper maps (1:500,000)
❷ STATSGO soils data from the U.S. Natural Resource Conservation Service (1:250,000)

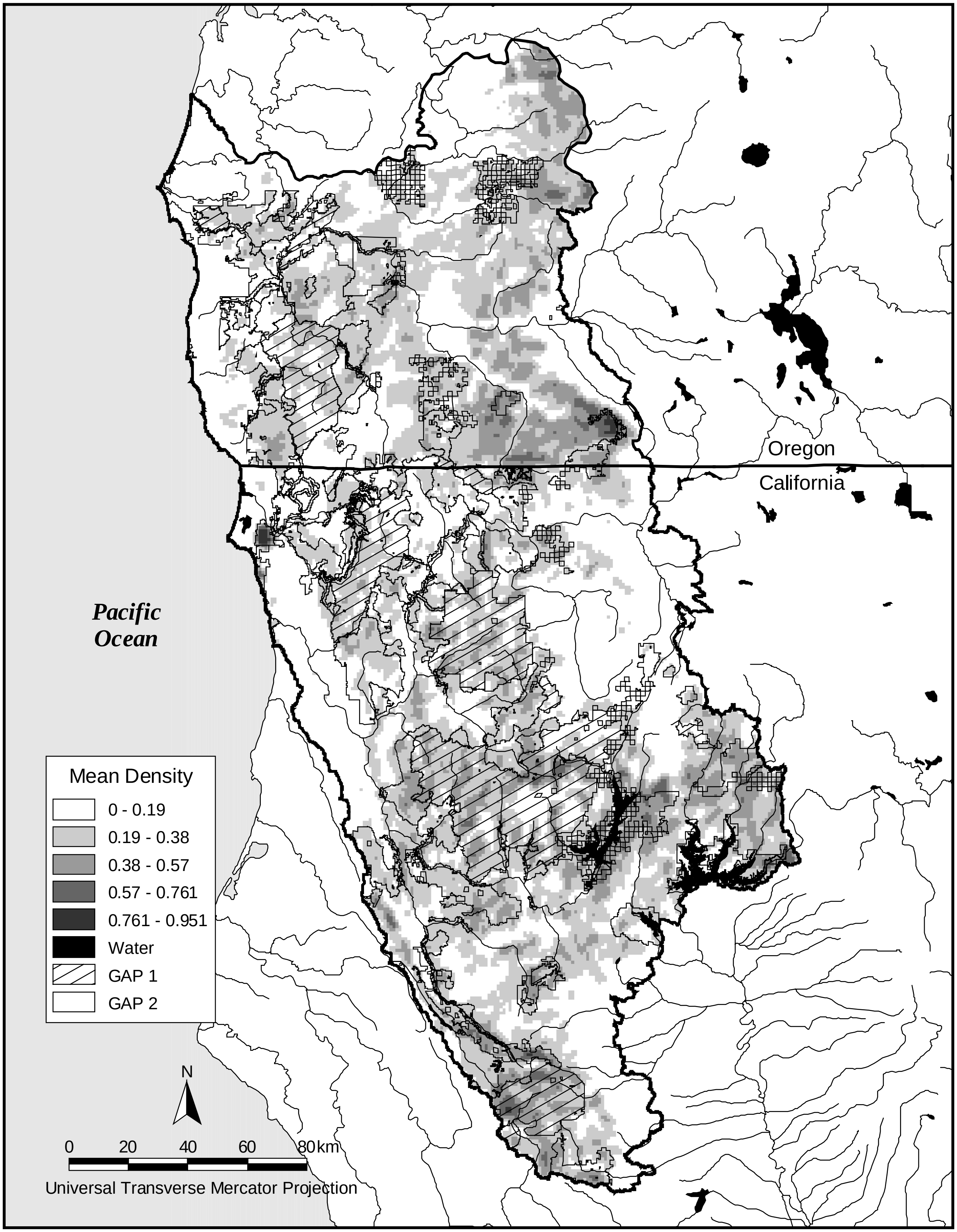

Figure 23. Mean late-seral forest density throughout the Klamath-Siskiyou study area displayed with current protection plan (LSR = GAP 2).

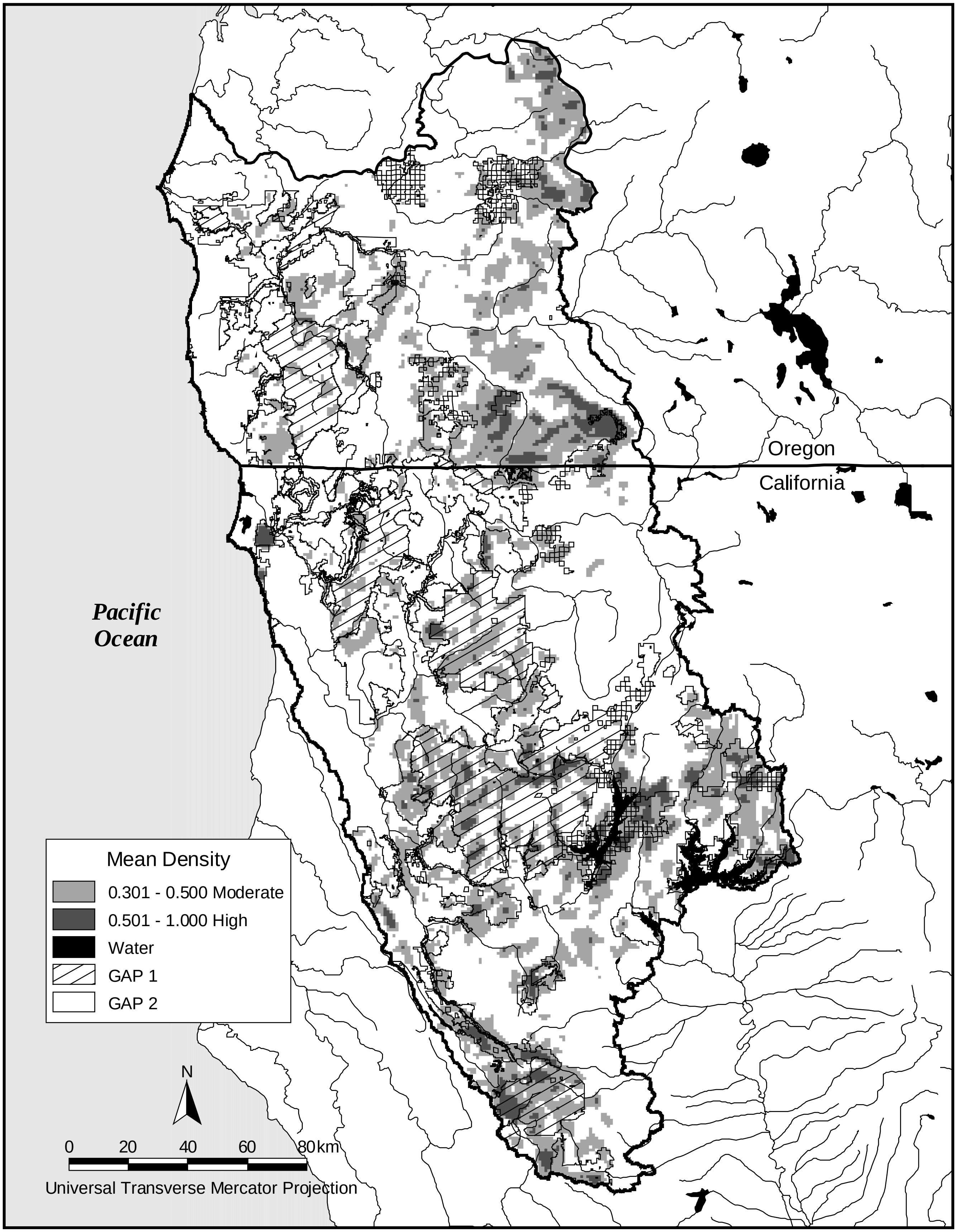

Figure 24. Moderate and high mean late-seral forest densities throughout the Klamath-Siskiyou study area displayed with current protection plan (LSR = GAP 2).

Methods:

Because of the powerful influences serpentine has on biodiversity in the region, we elected to make every effort to avoid type II errors (errors of omission). This was accomplished by merging some of the STATSGO polygons into the manually digitized geology map. We originally thought the STATSGO data (being 1:250,000 scale) would generally be more inclusive than the 1:500,000 geology maps, but that was not the case. Mean area of serpentine also was calculated for each roadless area for scoring these landscape features. Because of the close association between T&E occurrences and serpentine, we elected not to emphasize serpentine further.

Results:

Serpentine was found to occupy 13.4% (1,421,608 ac, 575,550 ha) of the study area (see Figure 25), and approximately 43% of that was found to be captured by the existing protected areas network with LSR equal to GAP 2.

Roadless Areas

Roadless areas are becoming increasingly recognized as important landscape elements in conservation. The rationale being that roadless areas have a better chance of supporting fully intact and functional natural ecosystems than any other landscape unit. Not all conservation targets could be reached with roadless areas protection exclusively in the Klamath-Siskiyou (e.g., late-seral forests, T&E species, ecosystem representation, landscape connectivity), but they did provide an excellent nucleus around which a comprehensive reserve design could be formulated. The foundation of the proposed reserve design was based on the highest-ranking roadless areas based on a number of different conservation measures followed by the inclusion of individual conservation criteria that filled in the remainder of the protection targets.

Data Sources:

Roadless Areas Mapping

❶ 1995 roads from Mendocino National Forest (1:24,000)
❷ 1995 roads from Klamath National Forest (1:24,000)
❸ 1995 roads from Shasta Trinity National Forest (1:24,000)
❹ Roads from Siskiyou National Forest (1:24,000)
❺ 1995 roads from Six Rivers National Forest (1:24,000)
❻ Roads from Umpqua National Forest (1:24,000)
❼ 1998 roads from Rogue River Basin Council of Governments (1:24,000) – all areas within the Rogue River Basin outside of National Forests.

Heritage Element Occurrences

❶ 1999 Oregon Natural Heritage Program (1:24,000)
❷ 1999 California Natural Diversity Database, California Department of Fish & Game (1:24,000)

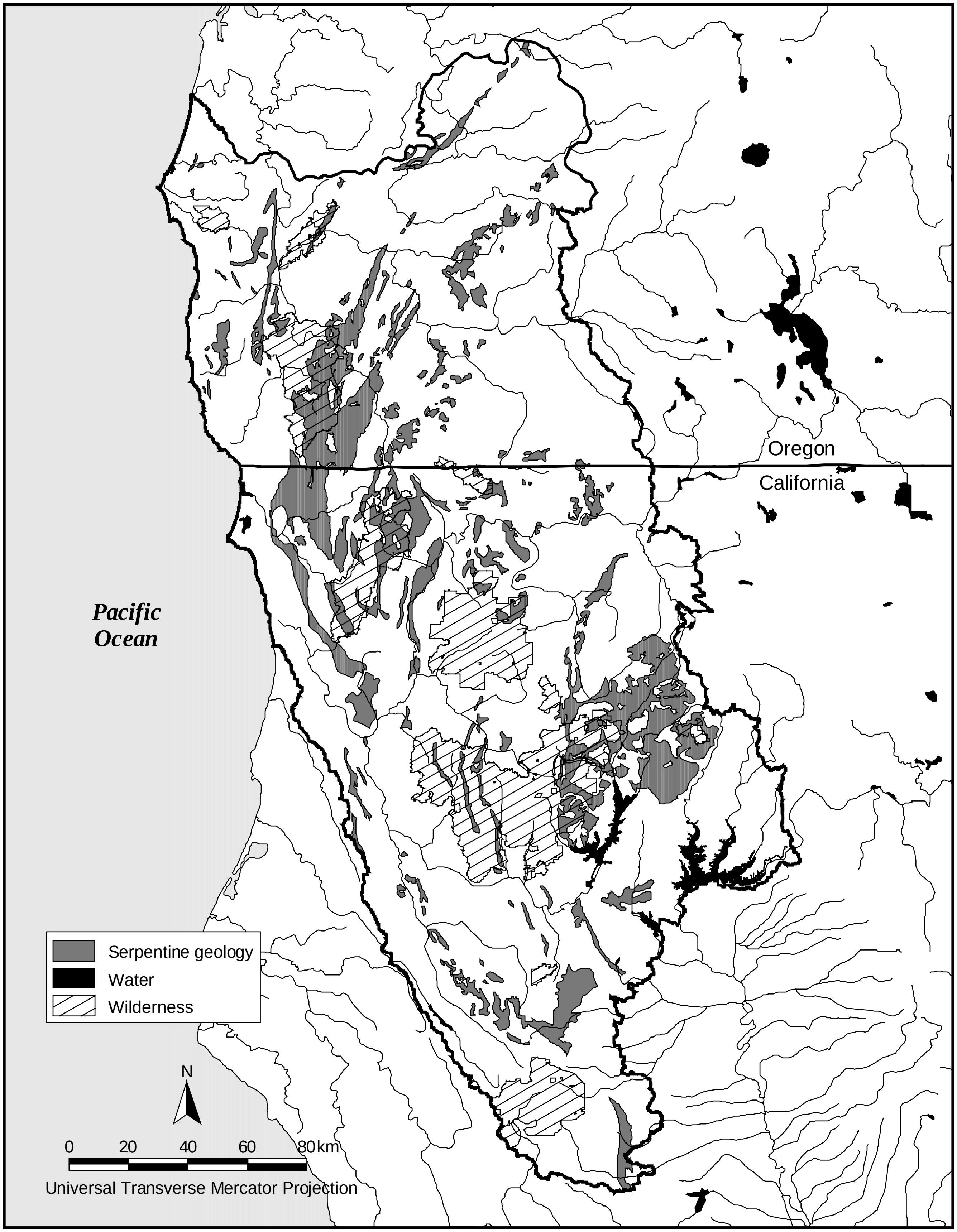

Figure 25. Serpentine geology within the Klamath-Siskiyou study area displayed with wilderness areas.

Late-Seral Forests

❶ Oregon – Classified 1995 TM satellite imagery courtesy of Warren Cohen, PNW Research Station, Oregon State University. Used size class > 24” diameter to define old growth. Accuracy assessment conducted and published (see Cohen et al. 1995).
❷ California – Classified 1994 TM satellite imagery courtesy of Curtis Jacoby of Legacy, Arcata, CA. Used size classes >24” diameter to define old growth. Accuracy assessment underway.

Representation

❶ STATSGO Soils for Oregon and California from Natural Resource Conservation Service (1:250,000)
❷ Digital Elevation Model (DEM) from U.S. Geological Survey (90 meter resolution)
❸ Mean annual precipitation and temperature from PRISM data (see Daly et al. 1994).
❹ Oregon GAP vegetation data courtesy of Tom O’Neil, Ecological Analysis Center, Corvallis, OR (1:100,000).
❺ California GAP draft vegetation data courtesy of David Stoms, UC Santa Barbara, CA (1:100,000).

Serpentine

❶ Geology maps for California and Oregon from U.S. Geological Survey Geology (1:500,000)
❷ STATSGO soils data for Oregon and California from Natural Resource Conservation Service (1:250,000)

Fisher

❶ 1993 Land Management Plans (LMP) from FEMAT
❷ 1993 vegetation data based on TM imagery from the Timberland Task Force (TTF)
❸ Classified 1995 TM satellite imagery courtesy of Warren Cohen, PNW Research Station, Oregon State University. Used size class > 24” diameter to define old growth. Accuracy assessment conducted and published (see Cohen et al. 1995).
❹ Roads and Hydrography from U.S. Forest Service (1:24,000)
❺ Digital Line Graph roads from U.S. Geological Survey (1:100,000)
❻ Digital Elevation Model (DEM) from U.S. Geological Survey (90 meter resolution)
❼ Mean annual precipitation from PRISM data (see Daly et al. 1994).
❽ Public lands boundaries from U.S. Forest Service (1:24,000)
❾ LSR boundaries from U.S. Forest Service (1:24,000)

Habitat Effectiveness

❶ Digital Line Graph from U.S. Geological Survey (1:100,000)
❷ 1990 Census Data from U.S. Bureau of Census (1:100,000)

Methods:

A new GIS-based roadless areas mapping technique was developed for this project (see Appendix A for specific details). Resulting roadless areas were organized by size class and analyzed separately. The four size classes included: (1) >10,000 ac (> 4047 ha),

(2) 5,000 – 10,000 ac (2023 – 4047 ha), (3) 1,000 – 5,000 ac (405 – 4047 ha), and (4) <1,000 ac (<405 ha). Class four (<1,000 ac) was included to capture those areas immediately adjacent to existing wilderness areas that are smaller than the 1,000 ac cutoff but only because of the location of artificial administrative boundaries. Eight different criteria were examined for all roadless areas including:

1. Size
2. Shape – perimeter to area ratio
3. Heritage element occurrences
4. Late-seral forests
5. Representation
6. Serpentine
7. Fisher habitat quality
8. General habitat effectiveness

Size and Shape

Each of the eight criteria was analyzed separately and assigned an ordinal score using the equal area technique provided in ArcView to break the data into five discrete classes. During the course of the analysis, the first two criteria (roadless area size and shape) were dropped from the assessment. Size was essentially considered by assigning each roadless area to one of the four size classes. After evaluating preliminary results, we realized shape was proving to be less important than the other criteria examined and therefore just added an unnecessary level of complexity.

Heritage Element Occurrences

As outlined in the previous heritage special element section, all records were considered together and weighted according to their endangered status (G1/G2 were assigned a weighted score of “50,” S1/S2 a weighted score of “10,” and all other elements a score of “1”), but instead of being summarized by a 1km x 1km fixed grid cell array, heritage scores were tallied according to roadless area polygons. Heritage scores were then ordinated 1-5 using the equal area option for each roadless area size class independently.

Late-Seral Forests

Using the basic late seral data, late seral percentages were calculated for each roadless area. Ordinal scores (1-5) using the equal area option were then assigned to each roadless area size class independently.

Representation

Representation classes were mapped for the study area by combining physical habitat modeling results with the dominant vegetation classes from the OR and CA GAP vegetation data layers (see Representation section for details). Nineteen different physical habitat types were modeled for the study area. The physical habitat layer was combined with the composite GAP vegetation layer (26 different natural vegetation types) to form 215 combined physical/vegetation classes (or repclasses). Any repclass <500 ac (202 ha) was eliminated from the final repclass file. Current representation percentages were calculated for each of the 215 repclasses considering both GAP 1 and GAP 2 lands together as protected (LSR = GAP 3). From these results, each roadless area was assigned an overall representation percentage based on the actual representation percentages for each repclass. For an example of how roadless areas were assigned overall representation percentages see Figure 26.

Roadless Area #24

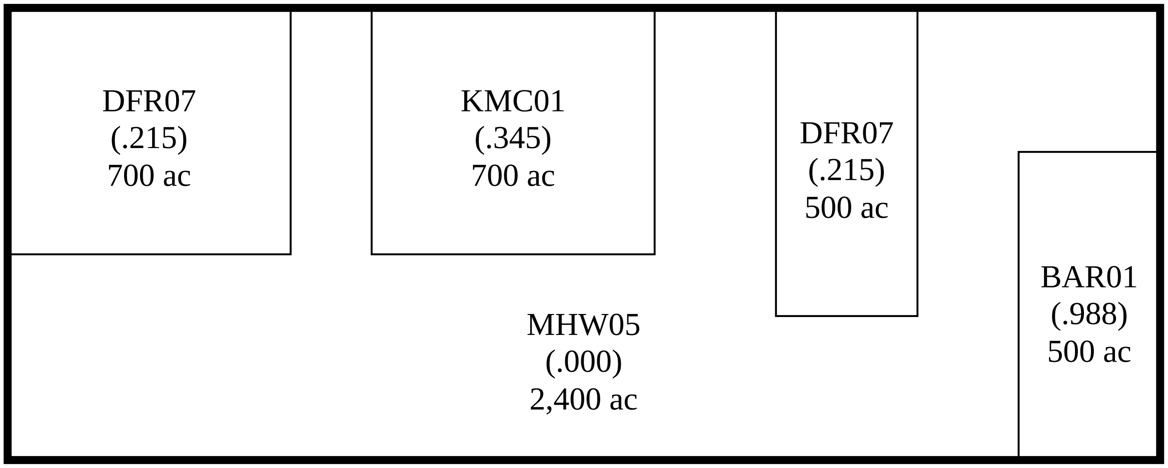

Figure 26. Diagram and description of an example roadless area showing how overall representation percentages were calculated.

In this example, roadless area #24 totaled 4,800 acres and included five polygons of four repclasses (DFR07, KMC01, BAR01, and MHW05). "DFR07" is the repclass code for Douglas-fir forests growing on physical habitat type #7 (low warm soils). The other codes are: "KMC01" – Klamath Mixed Conifer on high interior cold soils, "BAR01" – Barren on high interior cold soils, and "MHW05" – Montane Hardwood on low moderate soils. Figures in parentheses denotes the proportion of protection throughout the study area for that repclass. The final number is the total area for that polygon. Average represented proportion for each roadless area was then calculated. For roadless area #24, the average representation proportion was .207 or 20.7%. Representation results were assigned ordinal scores (1-5) using the equal area option for each roadless area size class independently.

Serpentine
Using the serpentine data layer derived from the 1:500,000 geology maps and 1:250,000 scale STATSGO data, we calculated the percent area of serpentine for each roadless area. Ordinal scores (1-5) using the equal area option were then assigned for each roadless area size class independently.

Fisher Habitat
Final fisher habitat modeling results were averaged according to roadless area polygons and assigned ordinal scores 1-5 using the equal area option for each roadless area size class independently. See Carroll (1998) and Carroll et al. (in press) for details on how fisher habitat suitability was modeled using GIS and extensive field validation.

Habitat Effectiveness

Habitat effectiveness draft modeling results modified from Merrill et al. (1998) were averaged according to roadless area polygons and assigned ordinal scores (1-5) using the equal area option for each roadless area size class independently.

Ordinal scores from these six criteria were added together making a composite total score for each roadless area. It was from this total score that we intended to rank relative conservation value of the different roadless areas. We instead elected to rank them based on the presence/absence of high scores. Using this technique, roadless areas could fall into one of four possible priority classes.

Priority 1 (Very High) – Roadless area with two or more high scores of "5" for any of the six criteria. Roadless areas recommended for the proposed reserve system and assigned a GAP protection status of "1."

Priority 2 (High) – Roadless area with only one high score of "5" for any of the six criteria or three or more "4s." Roadless areas recommended for the proposed reserve system and assigned a GAP protection status of "1."

Priority 3 (Moderate) – Roadless area with two or more scores of "4" for any of the six criteria – no scores of "5." Roadless areas recommended for the proposed reserve system and assigned a GAP protection status of "2."

Priority 4 (Low) – Includes all remaining roadless areas. Roadless areas not immediately recommended for the proposed reserve system as roadless areas.

<u>Results</u>:

Table 10 provides the number and total area for each roadless area class. Figure 27 (Plate 6) shows the distribution of the first three roadless area size classes from Table 10 – the 92 polygons <1,000 ac making up category #4 were too small and fragmented to show at this map scale.

Table 10. Number and total area of roadless area size classes as mapped for the Klamath-Siskiyou study area.

Category	**Size Class Range**	**Number**	**Total Area (ac)**	**Total Area (ha)**
1	≥ 10,000 ac	70	1,705,516	690,222
2	5,000 – 10,000 ac	61	448,711	181,593
3	1,000 – 5,000 ac	367	777,383	314,607
4	< 1,000 ac	92	25,590	10,356
Total		*590*	*2,957,200*	*1,196,779*

In part because of their small size, but largely because of their landscape position, roadless fragments mapped under category 4 were directly assigned as priority 1 areas. Roadless

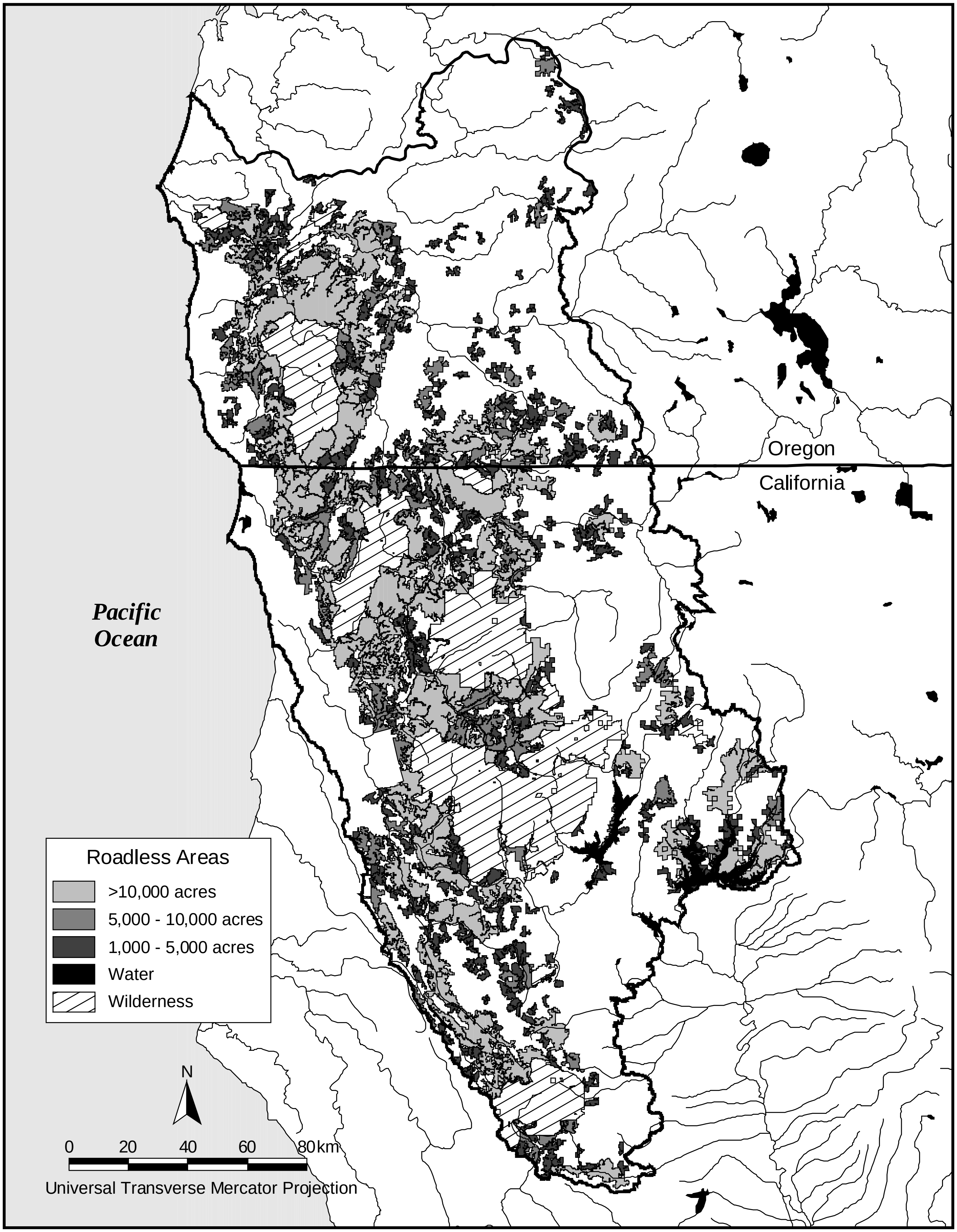

Figure 27. Mapped roadless areas (1,000 acres or larger) by analysis size class within the Klamath-Siskiyou study area.

areas in the remaining three classes were evaluated for each of the six criteria and assigned ordinal scores as summarized in Table 11.

Table 11. Summary of roadless areas mapping criteria for each of the roadless area size categories in the Klamath-Siskiyou (category #1 is >10,000 ac, category #2 is 5,000 – 10,000 ac, category #3 is 1,000 – 5,000 ac).

Special Element	**Range Category #1**	**Range Category #2**	**Range Category #3**	**Ordinal Score**
Heritage	0-36	0-2	0	1
(total score)	37-69	3-13	1-2	2
	70-223	14-37	3-12	3
	224-1198	41-200	13-101	4
	1198-3502	210-1714	102-1714	5
Late Seral	0-6.1	0-4.7	0-10.8	1
(percent area)	6.1-19.7	4.7-21.0	10.8-23.4	2
	19.7-28.8	21.0-31.1	23.4-34.5	3
	28.8-39.6	31.1-45.5	34.5-50.2	4
	39.6-63.3	45.5-64.5	50.2-83.2	5
Representation	0-9.5	0-3.0	0-2.1	5
(rep percent)	9.5-16.1	3.0-11.8	2.1-8.5	4
	16.1-23.9	11.8-24.3	8.5-17.0	3
	23.9-27.3	24.3-31.4	17.0-26.6	2
	27.3-49.4	31.4-48.0	26.6-68.1	1
Serpentine	0-2.4	0-2.8	0-8.4	1
(percent area)	2.4-8.8	2.8-19.2	8.4-27.3	2
	8.8-22.6	19.2-41.1	27.3-48.7	3
	22.6-51.8	41.1-64.4	48.7-79.8	4
	51.8-87.1	64.4-89.8	79.8-100	5
Fisher Habitat	0-1.1	0	0	1
(avg. percent)	1.1-5.8	0-1.8	0-1.1	2
	5.8-9.4	1.8-7.4	1.1-6.3	3
	9.4-17.2	7.4-14.7	6.3-20.4	4
	17.2-73.7	14.7-52.7	20.4-87.3	5
Habitat Effectiveness	0-48.8	0-44.7	0-38.0	1
(avg. percent)	48.8-56.3	44.7-50.9	38.0-48.0	2
	56.3-61.4	50.9-56.9	48.0-56.0	3
	61.4-66.9	56.9-61.8	56.0-65.0	4
	66.9-76.9	61.8-69.1	65.0-79.0	5

Figures 28 – 33 show the mapped results of the ordinal scoring as outlined in Table 11 for each of the six conservation criteria. Roadless areas became the foundation for the proposed reserve system, the process of which is outlined in Section IV. Table 12 summarizes the prioritization results. Roadless areas assigned as priority class "1" or "2" were added together since they were both recommended for strict protection in the final proposed reserved design. Priority class "3" areas were originally assigned a moderate level of protection in the proposed reserve design but later elevated to Gap 1 status due to connectivity issues. Priority class "4" were not recommended for inclusion in the reserve system as roadless areas. If the inclusion of the roadless areas into the reserve design were incremental, we recommend they be sought after according to their prioritization (see Figure 34, Plate 7).

Table 12. Roadless area prioritization results for inclusion in the proposed reserve design for the Klamath-Siskiyou.

Priority	**1&2 (high)**			**3 (medium)**			**4 (low)**		
	#	Area (ac) Area (ha)	%[1]	#	Area (ac) Area (ha)	%[1]	#	Area (ac) Area (ha)	%[1]
>10,000 ac (n = 70)	47	1,221,104 494,181	72	12	302,598 122,461	18	11	181,814 73,580	10
5,000 – 10,000 ac (n = 61)	46	343,745 139,114	77	5	34,223 13,850	8	10	70,743 28,630	15
1,000 – 5,000 ac (n = 367)	204	410,343 166,066	53	43	102,382 41,434	13	120	264,658 107,107	44
<1,000 ac (n = 92)	92	25,890 10,478	100	-	-	-	-	-	-
Totals	*389*	*2,001,082* *809,839*	*68*	*60*	*439,203* *177,745*	*15*	*142*	*517,215* *209,317*	*17*

[1] – Percent by area.

Some caution must be taken when considering these numbers – these areas are not all new to the existing protected areas network. For example, some of the highly ranked roadless areas added to the reserve system are already part of other protected areas other than wilderness areas (e.g., national recreation area). That means that some previously GAP 2 lands were elevated to GAP 1 via the roadless areas assessment.

Discussion:

Based on the six criteria used, approximately 83% of the existing roadless areas were recommended as the nucleus of the reserve design. Of course, the final scoring outcome would certainly vary if different criteria were examined, additional criteria added, or the existing criteria scores ordinated differently. This certainly will be an ongoing area of research before rules-of-thumb can be established after further experimentation and testing both in the Klamath-Siskiyou and elsewhere.

No attempt was made to accurately assess the existing ecological condition of the roadless areas mapped. Some areas (perhaps many) will require significant management directed at improving ecological integrity. For example, one management objective should be to

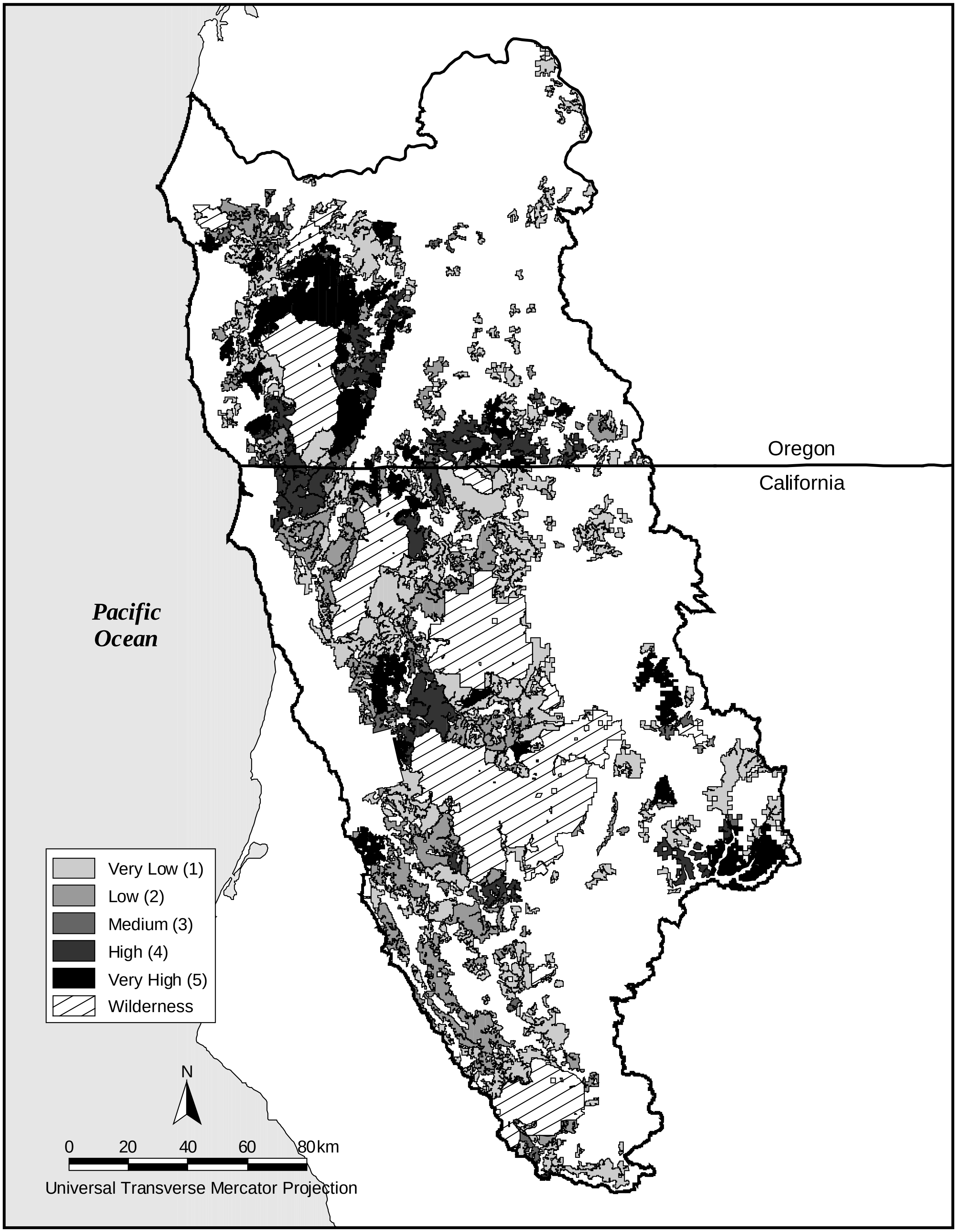

Figure 28. Scored heritage element results for mapped roadless areas (1,000 acres or larger) within the Klamath-Siskiyou study area.

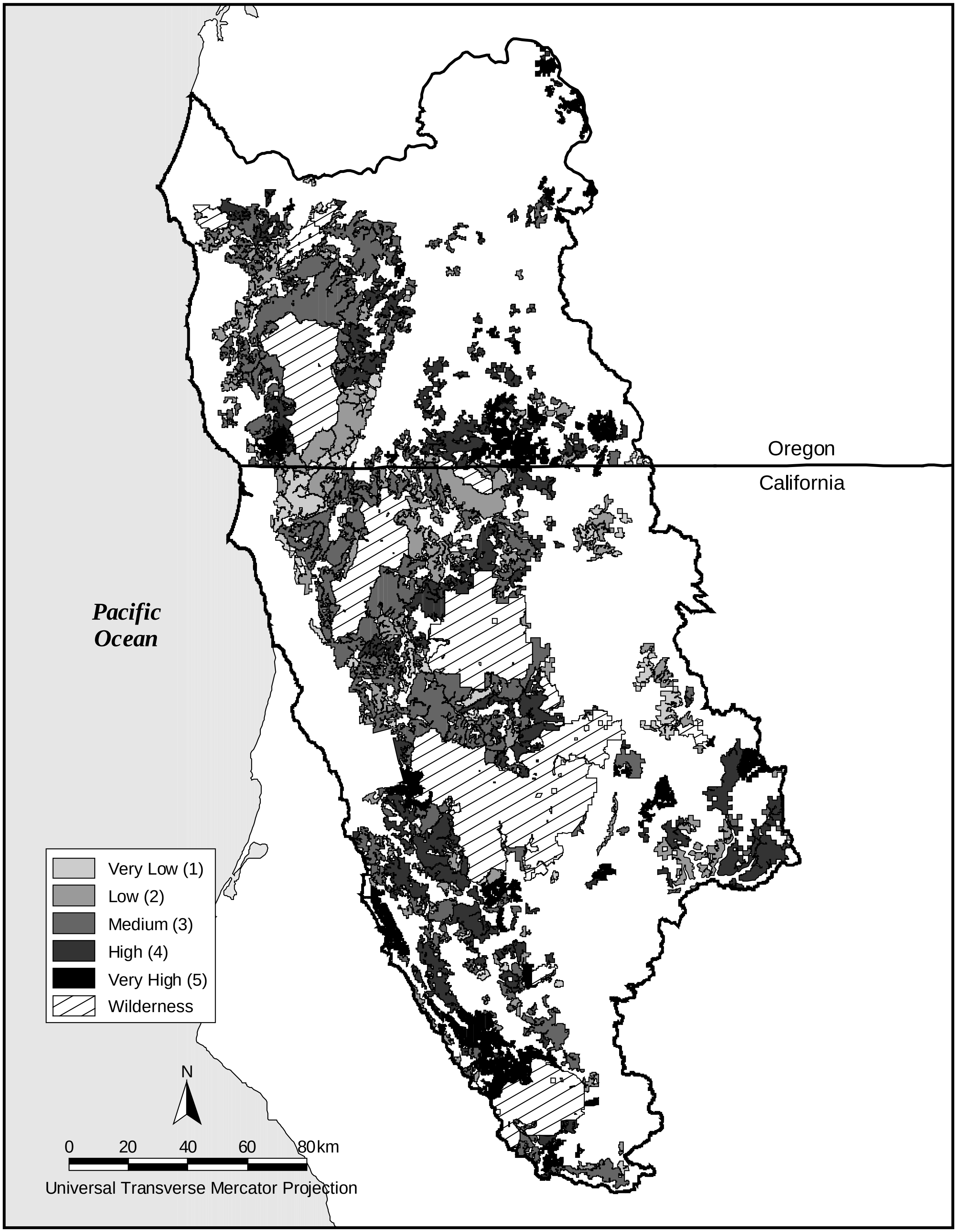

Figure 29. Scored late-seral forest results for mapped roadless areas (1,000 acres or larger) within the Klamath-Siskiyou study area.

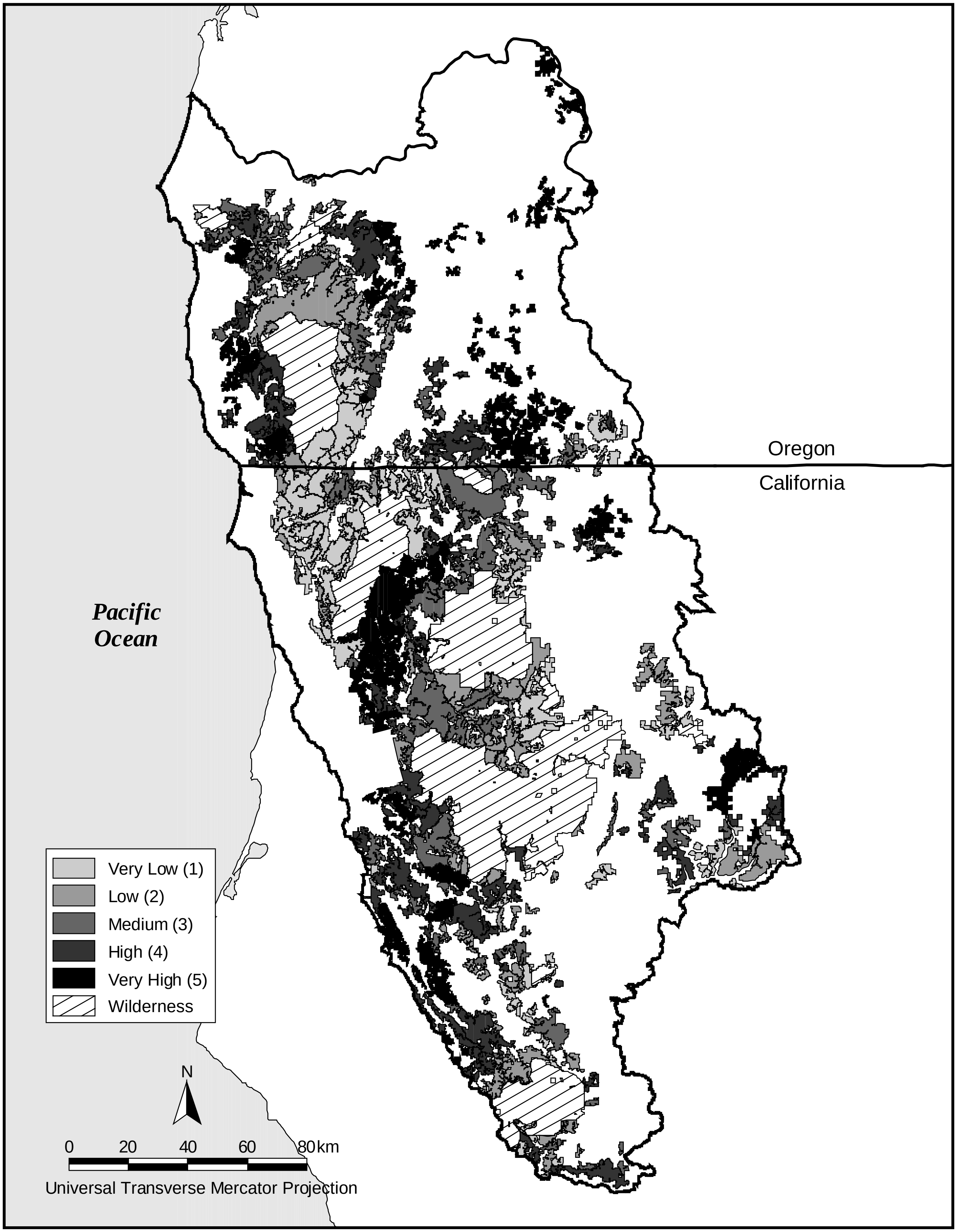

Figure 30. Scored representation results for mapped roadless areas (1,000 acres or larger) within the Klamath-Siskiyou study area.

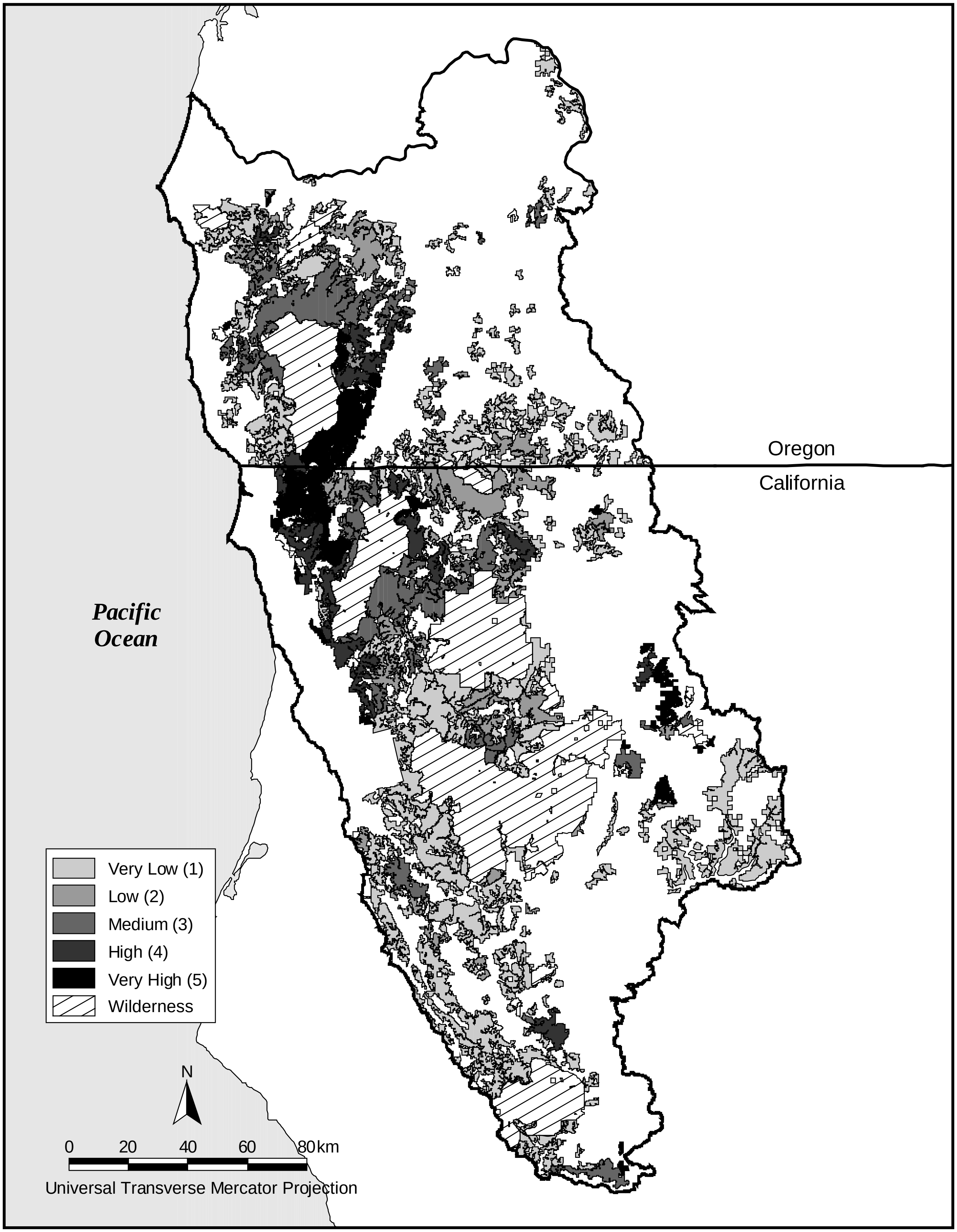

Figure 31. Scored serpentine results for mapped roadless areas (1,000 acres or larger) within the Klamath-Siskiyou study area.

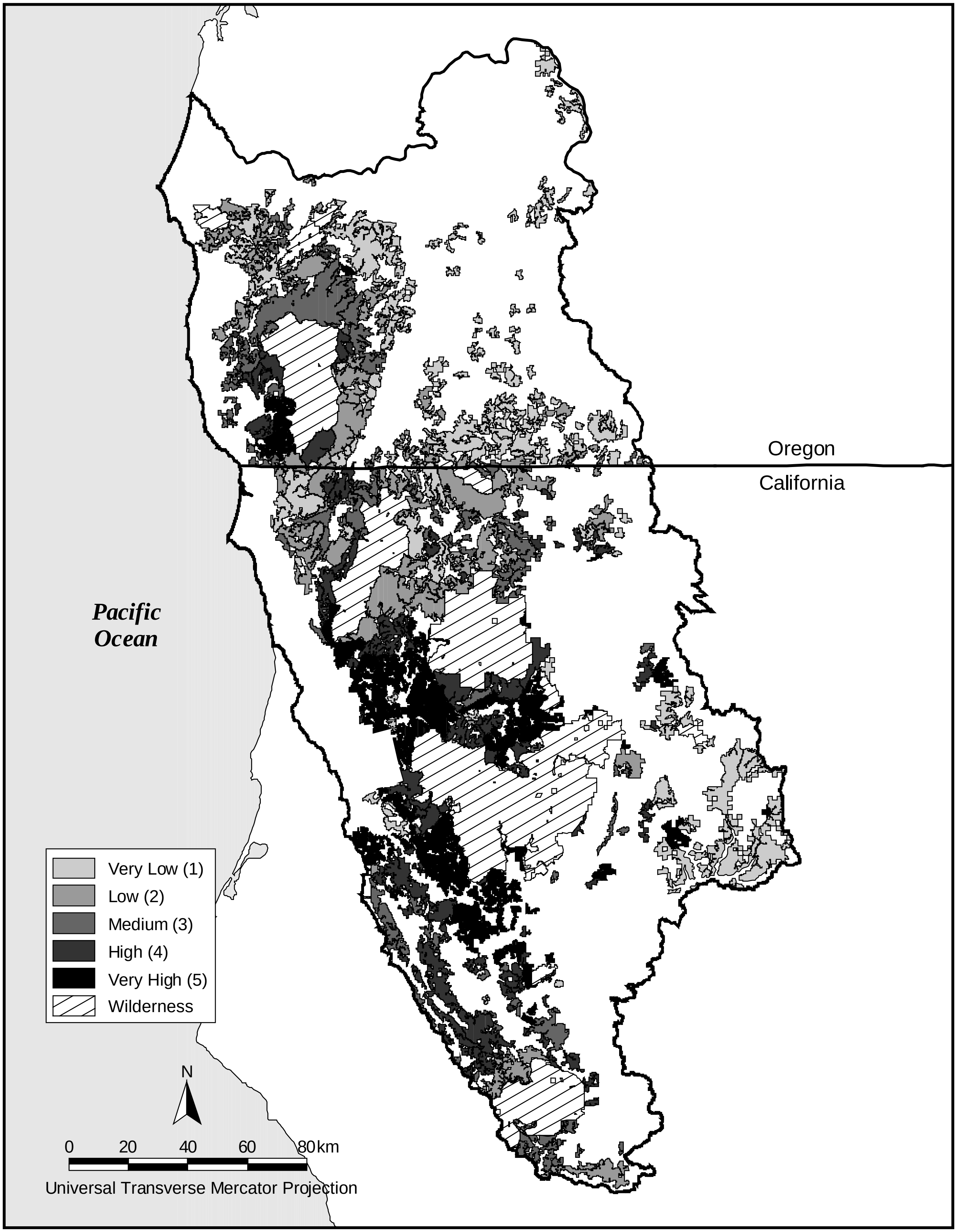

Figure 32. Scored fisher results for mapped roadless areas (1,000 acres or larger) within the Klamath-Siskiyou study area.

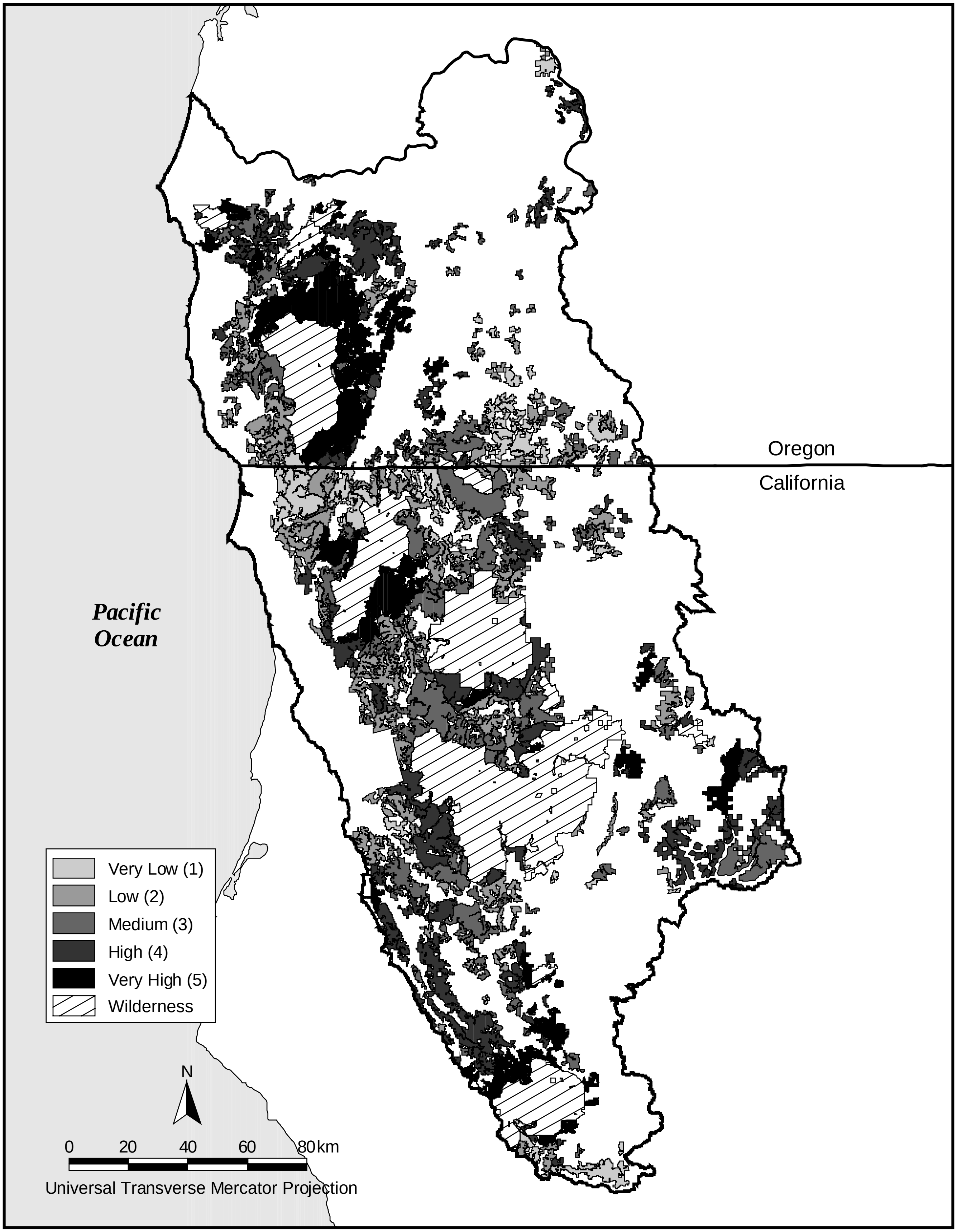

Figure 33. Scored habitat effectiveness results for mapped roadless areas (1,000 acres or larger) within the Klamath-Siskiyou study area.

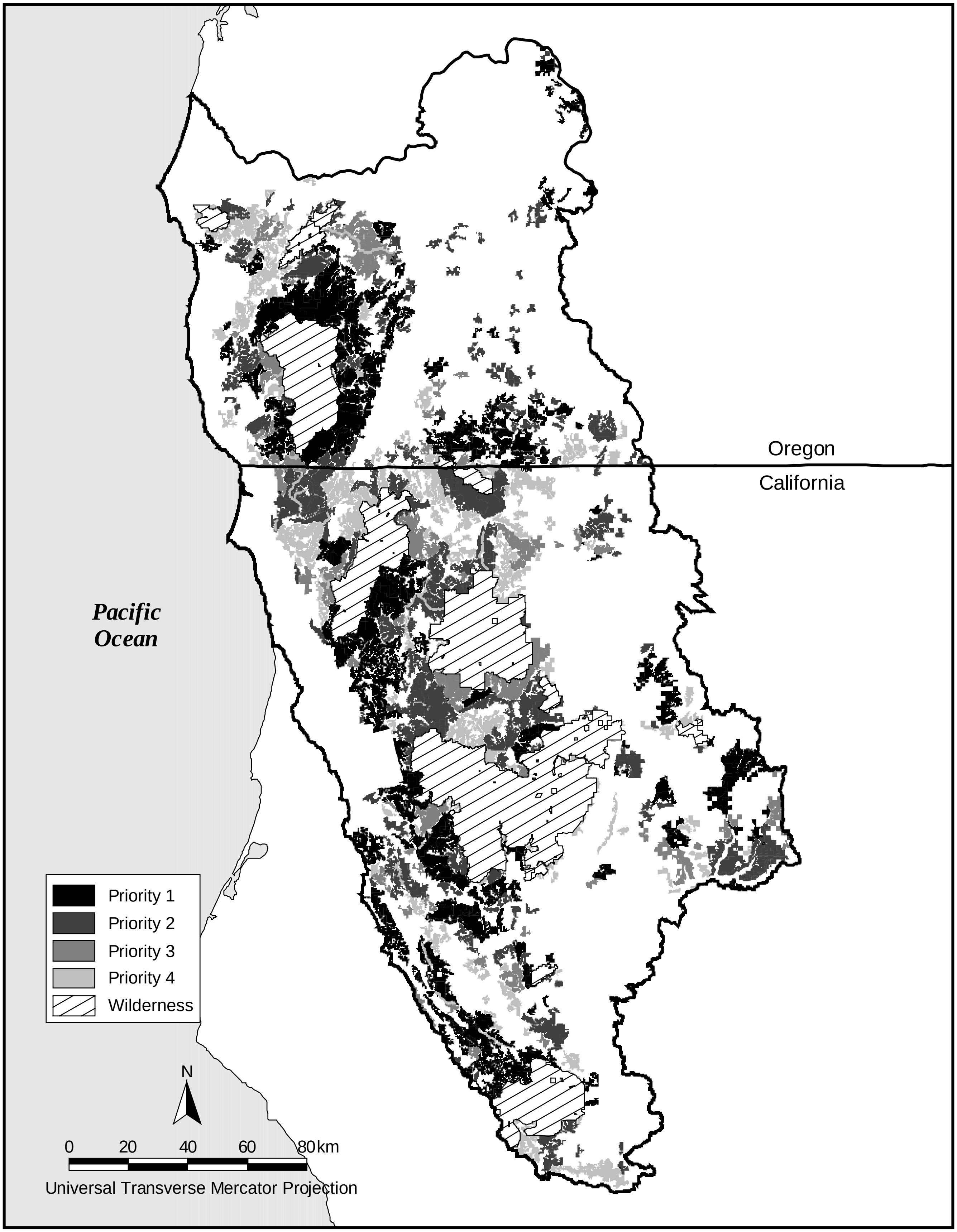

Figure 34. Roadless areas prioritization for the Klamath-Siskiyou study area. Priority 1 through 3 recommended for GAP 1 protection.

removing as many roads as feasible between important clusters of roadless areas; however, determining which roads and the timing of their removal will require additional research. Until this work is performed, we will not know the optimal road removal strategy. Some, perhaps many, roads will have to be maintained over the short-term to allow access for applying a variety of restoration activities. The return of fire to the landscape and the control of exotic invaders, which often use roads to reach new sites, are two management actions that will be prominent management prescriptions for the Klamath-Siskiyou.

Port-Orford-cedar

Port-Orford-cedar, or POC (*Chamaecyparis lawsoniana*), is of particular conservation interest in the Klamath-Siskiyou because of its ecological importance in the region, particularly in its contribution to streamside habitats, and its continuing decline due to the spreading infestation of the exotic root-rot disease, *Phytophthora* (Trione 1959, Zobel et al. 1985, Roth et al. 1987). Our original intent was to develop a spatially explicit model to assess infestation risk to uninfected subwatersheds containing Port-Orford-cedar which could then be directly linked to a reserve design proposal. Some progress was made, but we elected to not incorporate this component as originally planned due to the poor quality and limited geographic extent of the data and the knowledge that work is now underway by other researchers to address the same deficiencies we encountered. We did, however, attempt with what data were available to begin to piece together a picture (albeit incomplete) of the state of Port-Orford-cedar in the Klamath-Siskiyou.

Data Sources:

➊ CALWATER, which contains 6th order subwatershed information based on mapping from California Department of Fish and Game (1:24,000)
➋ Oregon – Rogue River 5th order subwatershed information from BLM (1:100,000)
➌ Port-Orford-cedar distribution and disease data from the Siskiyou National Forest, Six Rivers National Forest, Klamath National Forest, and Shasta Trinity National Forest (1:24,000)

Methods:

Percent area of Port-Orford-cedar in each watershed was calculated and given ordinal scores (1-5, 5 = highest presence of POC) by slicing the results by natural breaks. The same was done using the percent area of *Phytophthora* disease occurrence with watersheds given ordinal scores (1-5, 5 = lowest disease occurrence present) again using natural breaks. The two components were then added together and the higher rankings checked against the current and proposed conservation plan. Since *Phytophthora* is a waterborne disease, we summarized the results by subwatershed.

Results:

Table 13 lists the ordinal rankings used in this rudimentary examination. Figures 35 and 36 show relative distribution of POC and percent infected by *Phytophthora* respectively.

Table 13. Summary of POC assessment components for the Klamath-Siskiyou.

Component	**Range**	**Ordinal Score**
Percent POC	0-6.1	1
	6.1-18.5	2
	18.5-36.7	3
	36.7-65.4	4
	65.4-100	5
Percent Infected	0-1.6	5
	1.6-5.6	4
	5.6-12.2	3
	12.2-19.6	2
	19.6-48.4	1

Figure 37 shows the top three composite scores from adding ordinal values from the percent POC distribution map with those from the percent POC infected map as summarized in Table 13.

Discussion:

The data for POC is inadequate in many ways, but most importantly, it only included POC distribution and disease on national forest land. POC could not be included explicitly into the actual reserve selection and design process for many of the same reasons key watersheds were difficult to incorporate. Combined with incomplete datasets, POC is threatened by factors difficult to examine at this level of analysis and planning. Stopping the spread of *Phytophthora* will require several management actions that go beyond just identifying high quality conservation lands. Hopefully, improvements in our understanding now underway will be able to get incorporated into future iterations of the proposed reserve design and improve management prescriptions.

Watersheds

One final special element dealt with watersheds important to protect aquatic biodiversity within the Klamath-Siskiyou, most notable of which are the various salmon species and stocks that persist in the region although several are now threatened or endangered (Frissell 1993). We spent considerable effort trying to assess the region from the perspective of aquatic organisms, but, due to the lack of a uniform aquatic biodiversity database, we only can provide coarse level results at this time (organized by subwatershed). Aquatic species are often poorly represented in heritage databases and that is certainly true for the Klamath-Siskiyou. We did evaluate the best available region-wide aquatic biodiversity information, which was based primarily on salmon data supplied by The Wilderness

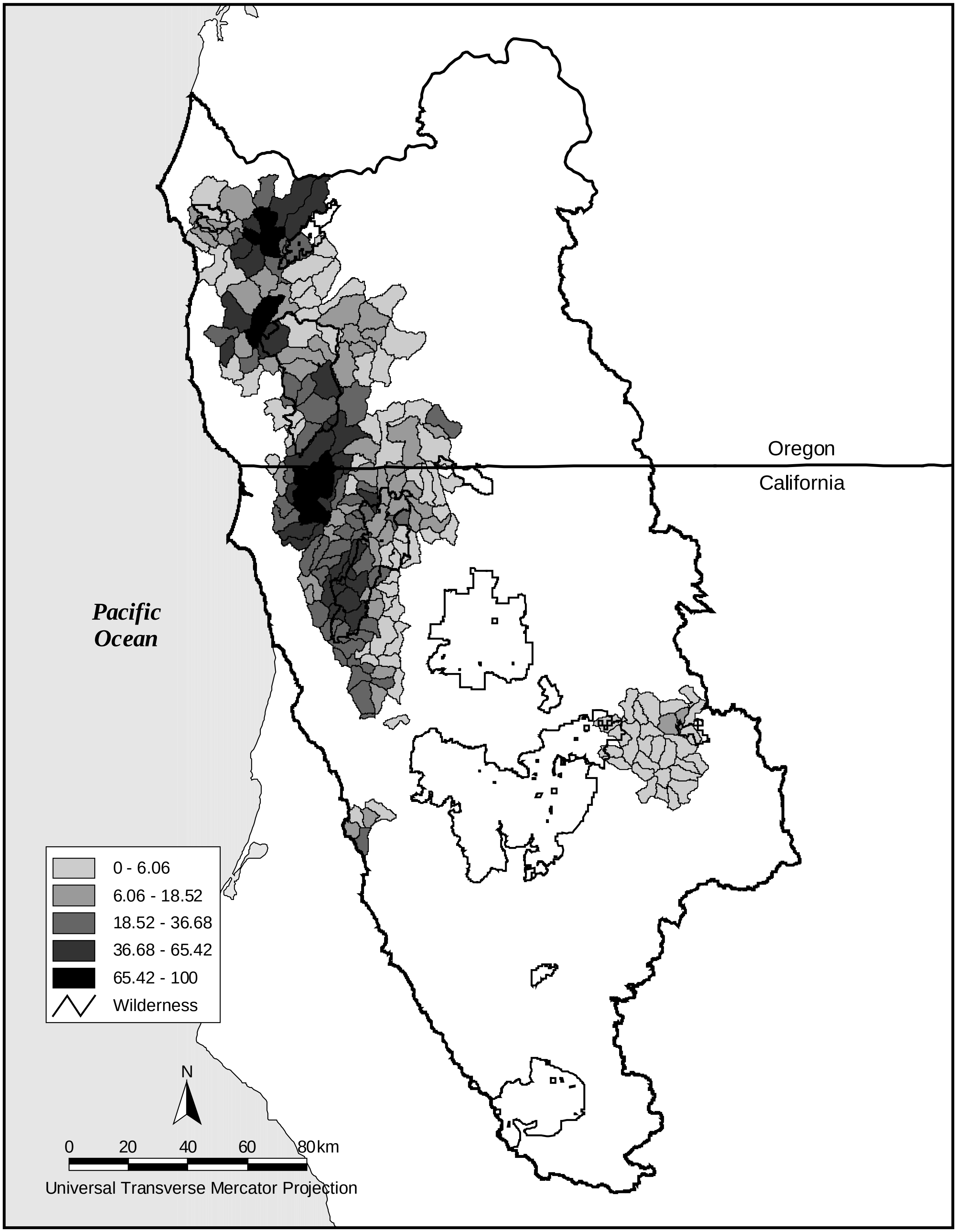

Figure 35. Percent area of Port-Orford-cedar calculated by subwatershed within the Klamath-Siskiyou study area.

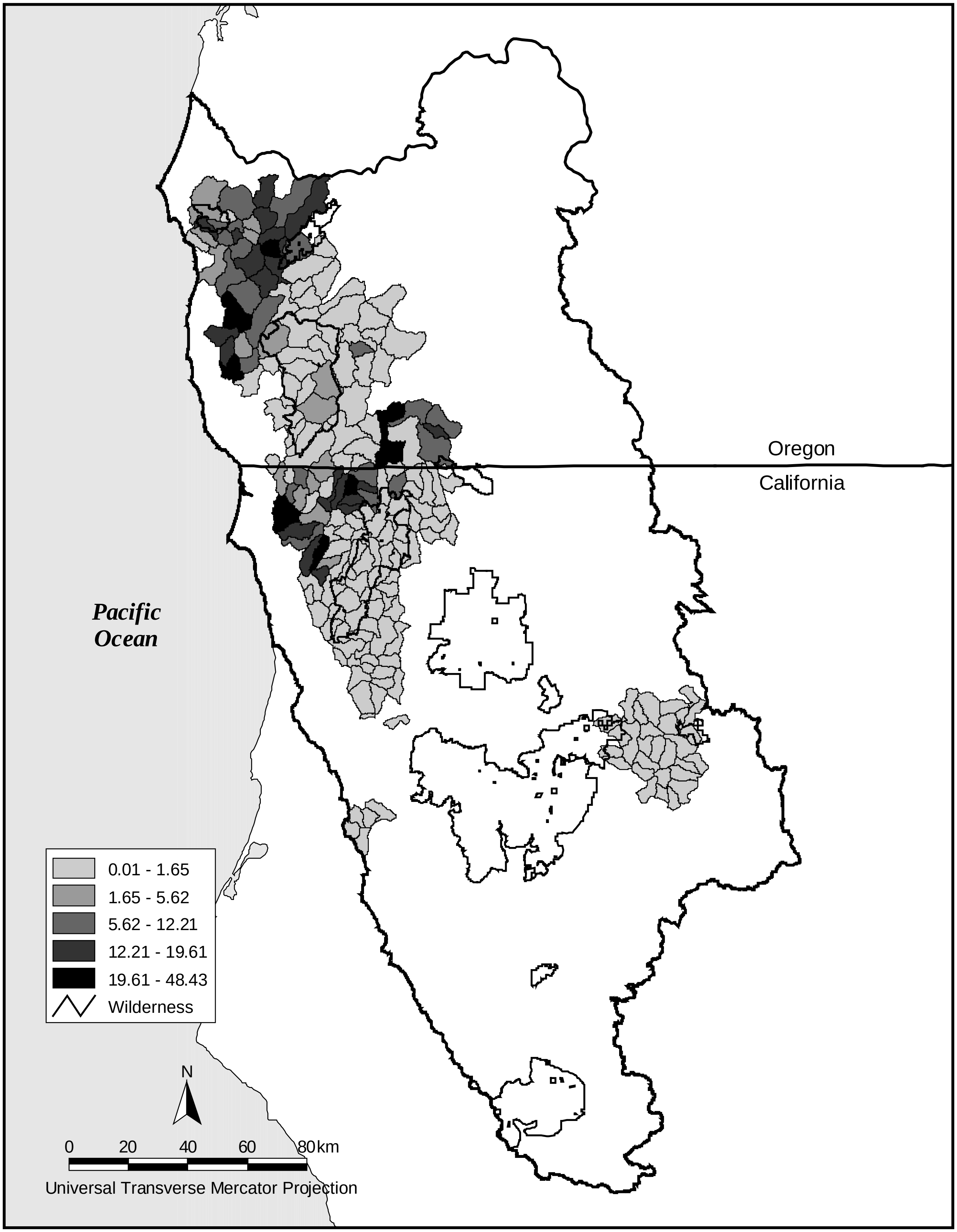

Figure 36. Percent of Port-Orford-cedar infected by *Phytophthora* calculated by subwatershed within the Klamath-Siskiyou study area.

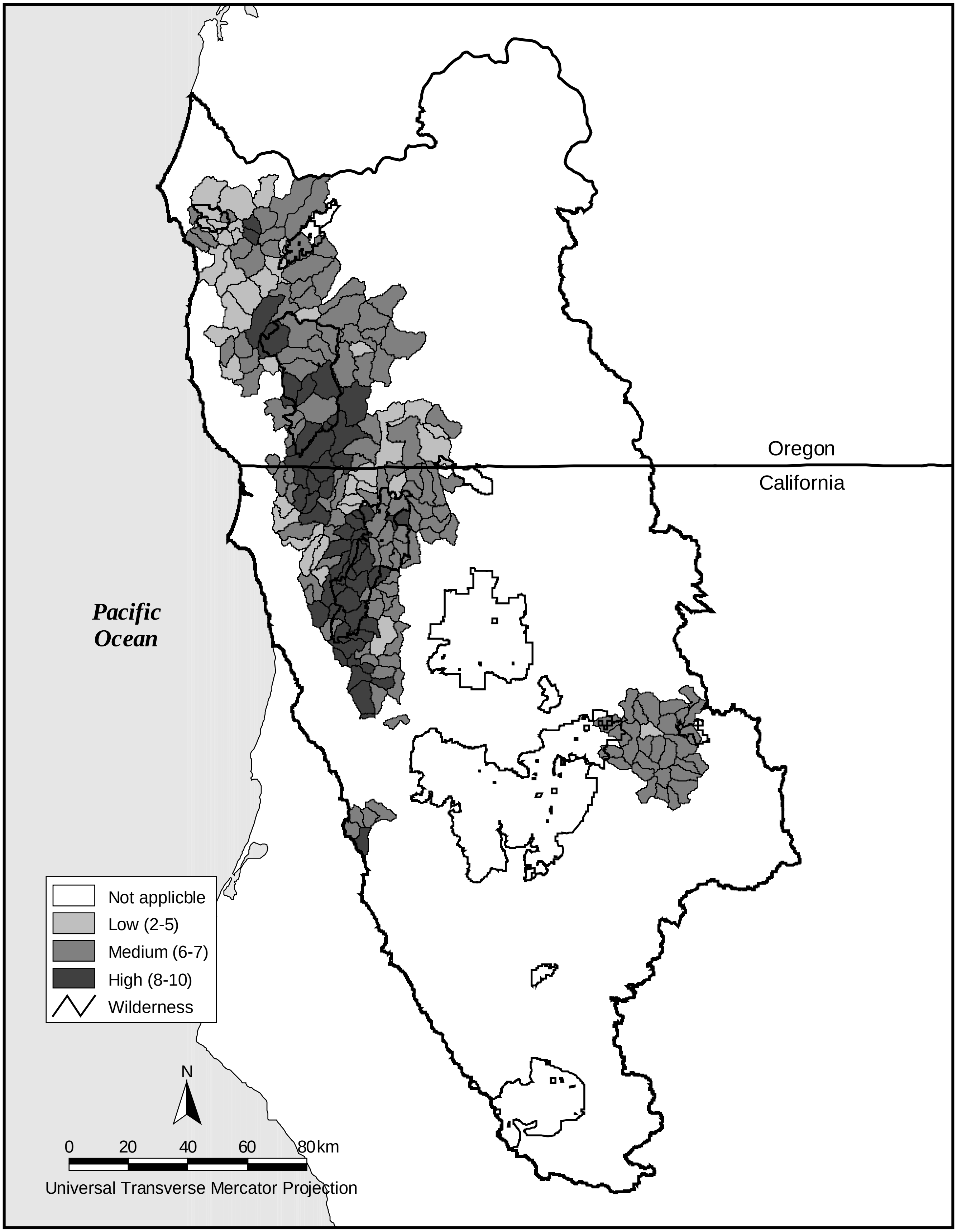

Figure 37. Priority protection subwatersheds for Port-Orford-cedar conservation within the Klamath-Siskiyou study area.

Society and the identification of key watersheds (habitat of potentially threatened or endangered fish species or stock, particularly salmonids, or >6 square miles with high quality water and fish habitat) as defined by the Gang of 4 Scientific Panel (FEMAT 1993). We also evaluated the relative subwatershed condition from the perspective of aquatic species at the 1:24,000 scale where we had available datasets (approximately 75% of the study area).

Data Sources:

Aquatic Biodiversity

➊ 1993 Key Watersheds – Identified watersheds that contain at-risk fish species or stocks and are either good habitat or have a high restoration potential from FEMAT (1:126,720)
➋ Salmon distribution data from The Wilderness Society (based on 1:100,000 - 1:250,000 hydrographic data)

Subwatershed Assessment

➊ DLG roads from U.S. Geological Survey (1:100,000)
➋ 1:24,000 Roads (see page 40 *Roadless Areas Mapping*)
➌ DLG streams from U.S. Geological Survey (1:100,000)
➍ Streams from U.S. Forest Service and Rogue River Basin Council of Governments (1:24,000)
➎ Oregon – Classified 1995 TM satellite imagery courtesy of Warren Cohen, PNW Research Station, Oregon State University. Used size class > 24” diameter to define old growth. Accuracy assessment conducted and published (see Cohen et al. 1995).
➏ California – Classified 1994 TM satellite imagery courtesy of Curtis Jacoby of Legacy, Arcata, CA. Used size classes >24” diameter to define old growth. Accuracy assessment underway.
➐ California – CALWATER, which contains 6th order subwatershed information from California Department of Fish and Game (1:24,000)
➑ Oregon – Rogue River 5th order subwatershed information from BLM (1:100,000)
➒ Locations of major dams from The Wilderness Society (1:100,000)

Methods:

Aquatic Biodiversity

Salmon species and stock data supplied by The Wilderness Society had to be merged with our subwatershed data layer for the entire study area (1,136 subwatersheds). To produce the watershed file, we used 6th order watersheds (or subwatersheds) from the CALWATER file from the California Department of Fish and Game for all the California side of the study area. Mapping subwatersheds on the Oregon side required more manipulation. A watershed file was obtained from the BLM for the entire Rogue Basin and clipped to fit the study area. The watershed level mapped was closer to 5th order, which are a little larger than the 6th order ones on the California side. For the small region not covered by either file, we manually delineated the watersheds to approximate 5th order level of detail using 1:100,000 streams data and a digital elevation model.

There were nine salmonid species/stocks found in the Klamath-Siskiyou (see Table 14a), and each distribution data layer was accompanied by general condition information. These condition rankings were assigned a weight (see Table 14b) and a composite score determined for each subwatershed. The final scores were then generalized into four classes using a natural breaks formula – Jenks' optimization algorithm, which identifies breakpoints between classes using a statistical formula that minimizes the sum of the variance within each of the classes to help find groupings and patterns inherent in the data. Key watersheds, as mapped by the Gang of 4 Scientific Panel (FEMAT 1993), also were transferred to the watershed data layer created for the Klamath-Siskiyou and assigned a code of "10."

Table 14. (a) List of salmonid species/stocks present in the Klamath-Siskiyou, and (b) condition information provided by The Wilderness Society with assigned weighted scores.

(a) Salmonid Species/Stocks

Common Name	**Scientific Name**
Fall Chinook Salmon	*Oncorhynchus tshawytscha*
Spring Chinook Salmon	*Oncorhynchus tshawytscha*
Winter Chinook Salmon	*Oncorhynchus tshawytscha*
Chum Salmon	*Oncorhynchus keta*
Coho Salmon	*Oncorhynchus kisutch*
Pink Salmon	*Oncorhynchus gorbuscha*
Sea-run Cutthroat Trout	*Oncorhynchus clarki clarki*
Summer Steelhead	*Oncorhynchus mykiss spp.*
Winter Steelhead	*Oncorhynchus mykiss spp.*

(b) Condition and assigned weighted score

Description	**Assigned Weighted Score**
Ok	1
Special Concern	2
Threatened	3
Endangered	4
Extremely endangered	5
Extinct	X

Subwatershed Assessment

We attempted to produce a coarse level assessment of subwatershed condition for the entire study area at 1:100,000 map scale, but felt that the data were too inaccurate and generalized for this purpose. The only component we had any confidence in was the 1:100,000 scale road density layer as organized by subwatershed. For the portion of the study area where 1:24,000 scale data were available (877 subwatersheds or 7,954,310 ac, 3,220,368 ha - 75% of the ecoregion), we considered four criteria: (1) road density, (2) road/stream intersections, (3) late-seral forests along streams, and (4) dam obstructions.

Road density was simply calculated for each subwatershed using all 1:24,000 transportation data minus foot trails. The higher the road density, the higher the likelihood the subwatershed will be impacted by human activity such as logging (Hauer and Blum 1991). Road/stream intersections were calculated per subwatershed using a weighted system based on road surface type (paved surface = 1, gravel surface = 2, improved dirt = 3 and unimproved dirt = 4) providing a rough estimate of potential sedimentation impacts on stream quality. More sophisticated modeling could be conducted using topographic arrangement and soil erodibility as other important factors. Total weighted scores were calculated for each subwatershed with the higher the value, the higher the likelihood of detrimental sedimentation impacts to streams (Montgomery 1994, Wemple 1994, Sidle et al. 1985). The 1:24,000 scale streams layer was buffered by 50 meters and combined with the old growth layer. Mean area of old growth along the buffered streams was calculated for each subwatershed. The lower the amount of older riparian forest, the greater the potential impacts on water quality. This criterion would not be suitable for all landscapes, but is appropriate for most of the Klamath-Siskiyou, which is dominated by forest. After examining each criterion, ordinal scores (1-5) were assigned to the results using an equal area delineation. The three ordinal scores were then added resulting in scores ranging from 3 – 15, and then modified by dam influences. Dam point locations were mapped onto the 1:100,000 streams layer and affected upper watersheds labeled according to presence/absence of fish ladders. Salmon are essentially cutoff from subwatersheds above dams that do not have fish ladders. In these subwatersheds, all scores were reassigned a total score of zero. Subwatersheds above dams with fish ladders were demoted by “3” from the total score because of the increased difficulty fish must overcome to gain access to the upper reaches. The ordinal scoring results were then generalized into three primary watershed condition classes: good, fair, and poor. Finally, a layer showing the combined aquatic biodiversity values within the Klamath-Siskiyou (salmon scores + key watersheds) was combined with the primary subwatershed condition results. The outcome allowed us to assign relatively coarse level conservation recommendations for each subwatershed.

Results and Discussion:

Aquatic Biodiversity

Salmon scoring results are presented in Figure 38. Scores ranged from 0 – 24 and were reclassed into one of four general salmon value categories using the natural breaks formula. Summary totals are presented in Table 15. Recommended key watersheds from FEMAT (1993) are presented in Figure 39.

Table 15. Summary totals for scored salmon values for the Klamath-Siskiyou.

Category	**Frequency**	**Area (ac)**	**Area (ha)**	**Percent**
very low (0-2)	197	1,728,298	699,716	16.31
low (3-8)	332	3,166,521	1,281,992	29.88
medium (9-14)	379	3,827,249	1,549,494	36.11
high (15-24)	228	1,876,545	759,735	17.71
Totals	*1,136*	*10,598,613*	*4,290,937*	*100.00*

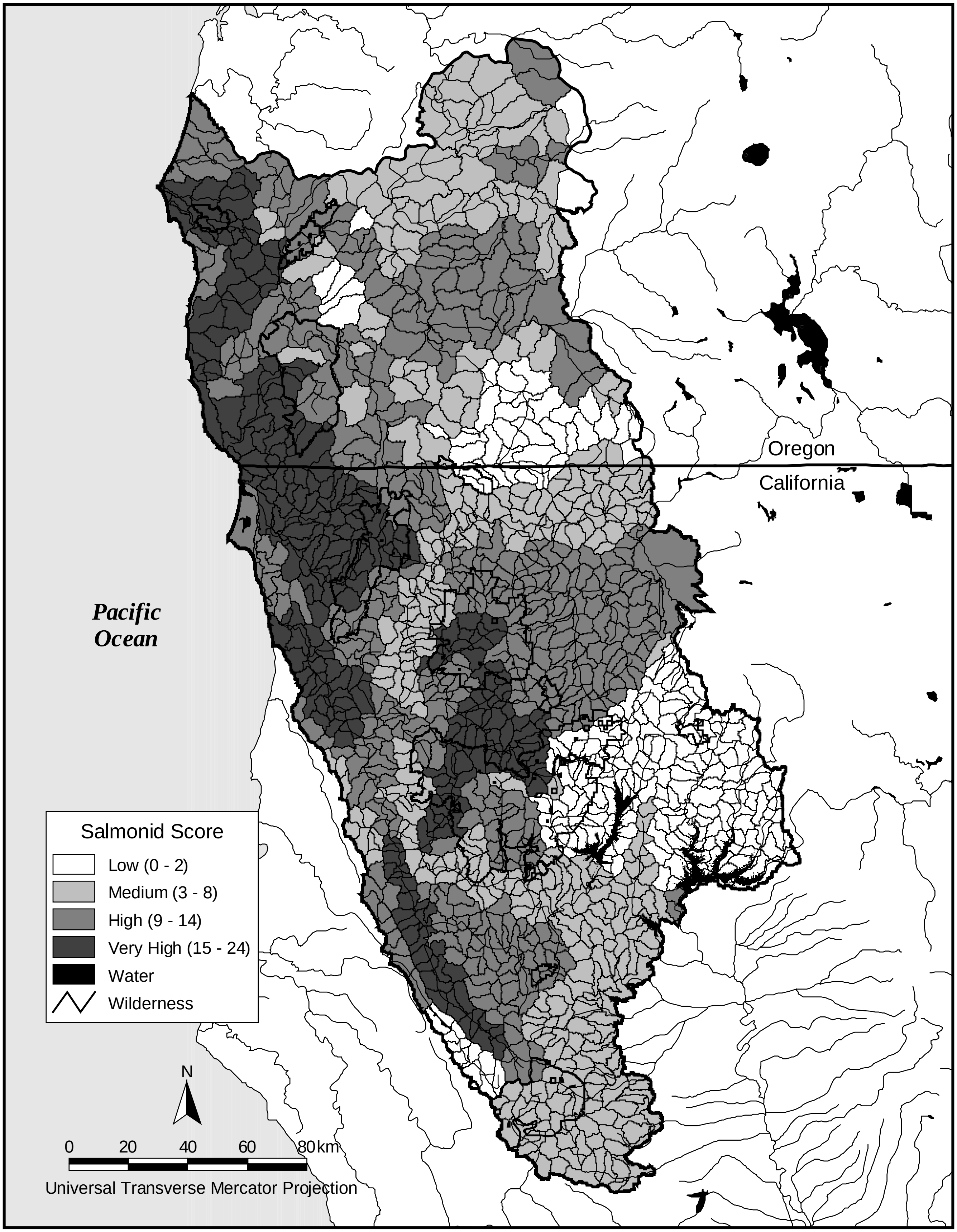

Figure 38. Salmonid occurrence score for the entire Klamath-Siskiyou study area organized by subwatershed.

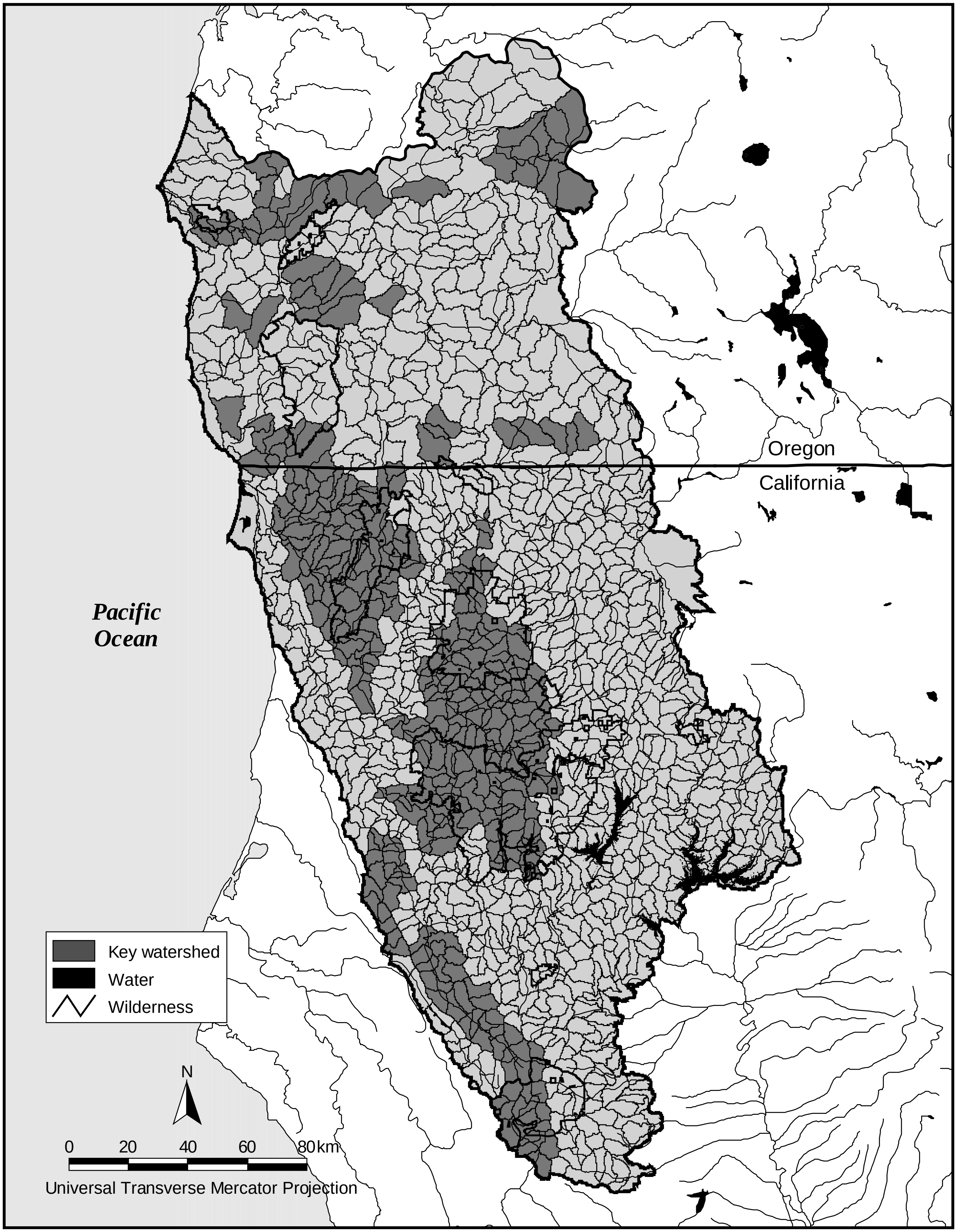

Figure 39. Key watersheds identified by FEMAT (1993) for the Klamath-Siskiyou study area.

Approximately 3 million acres (1.2 million hectares - 28%) of the Klamath-Siskiyou were classified as essential watersheds (high) for aquatic biodiversity from this identification exercise. Figure 40 shows the relationship between the salmon scoring results and the key watersheds.

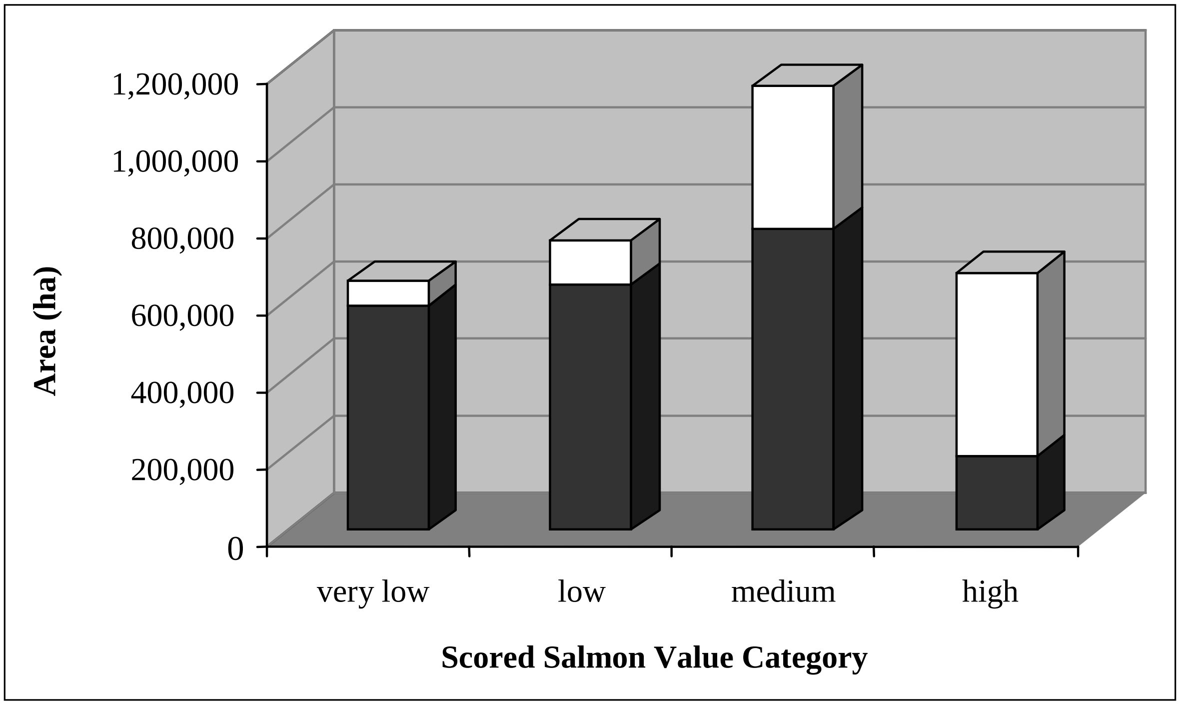

Figure 40. Graph depicting the relationship between scored salmon value categories and key watersheds as defined by the Gang of 4 Scientific Panel (FEMAT 1993) for the Klamath-Siskiyou. Black portion represents salmon results only, white portion represents area within each salmon value class also classified as a key watershed.

The data used for this coarse level mapping of salmonid distribution is the best available that covers the entire ecoregion. High quality aquatics data is difficult to find, and when it is available, it covers only small areas of the region of conservation interest. A few databases that are more detailed exist for the Klamath-Siskiyou (e.g., KRIS/DB – Klamath Resource Information System Data Base), but they do not cover enough of the ecoregion to make it easily applicable. One of the biggest hurdles we ran into repeatedly throughout this study was dealing with the inconsistencies and incompatibilities of data and information between political jurisdictions – most notably in this case, between Oregon and California.

Other regional aquatic assessment techniques have been developed in other regions, but are usually conducted within a single state, and better data exists for aquatic species distributions and numbers (Frissell et al. 1996, Moyle and Randall 1998). Because of the lack of ecoregion-wide aquatic biological data, we elected to not apply any of the watershed assessment results directly to the reserve design process.

Subwatershed Assessment

Scoring ranges for each of the first three model components are provided in Table 16. The combined ordinal scores were modified for those subwatersheds impacted by dams (170/877) in the region as outlined in the methods section. Figure 41 (Plate 8) shows the results of the generalized watershed condition assessment for the 877 subwatersheds.

Table 16. Summary of subwatershed assessment components for that part of the Klamath-Siskiyou study area where 1:24,000 scale data were available.

Component	**Range**	**Ordinal Score**
Road Density	0-0.57	5
(km/km^2)	0.57-1.24	4
	1.24-1.73	3
	1.73-2.39	2
	2.39-5.08	1
Road/Stream Intersections	0-12	5
(total score)	13-49	4
	50-114	3
	116-300	2
	306-1,707	1
Old Growth Along Streams	0-10.8	1
(mean percent)	10.8-13.2	2
	13.2-16.1	3
	16.1-19.2	4
	19.2-32.9	5

Table 17 shows the relationship between salmon scores and the subwatershed assessment. Recommendation labels were assigned after a review of this matrix. General management prescriptions include: (1) protection emphasis (good condition), (2) combined protection/restoration emphasis (moderate condition), (3) restoration I emphasis - no dams (poor condition), and (4) restoration II emphasis with dam mitigation (dams). In this case, protection does not necessarily mean land acquisition. It means protecting the necessary aquatic resources in whatever ways possible. The prioritization aspect of the management prescription (high, medium, low, very low) was based on relative scored salmon value. For this initial organization of the data, we elected to let the composite score determine priority without modification. Upon further review of the details at a more subregional level, prioritization may be changed to accommodate a special situation that is not clearly highlighted using these data and approach. For example, it is possible that a series of subwatersheds support only one salmon species. If that one species or stock is endangered, the subwatersheds would be given a total value score of “5,” which translates into relative “low priority.” In situations like this, prioritization should be elevated to reflect their subregional importance.

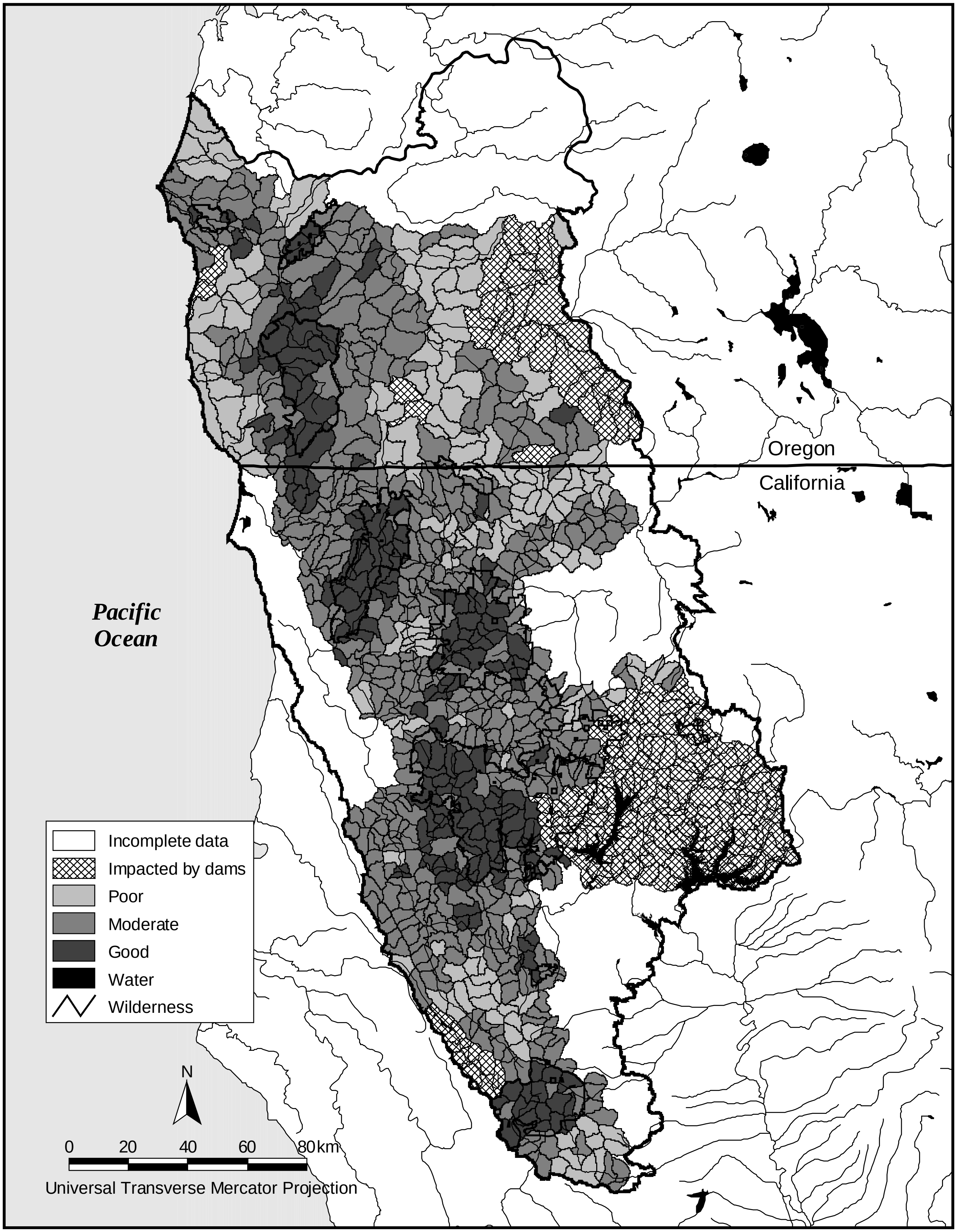

Figure 41. Relative watershed condition for that part of the Klamath-Siskiyou study area where 1:24,000 scale data was available.

Table 17. Matrix between salmon scores and presence of key watershed (KW) and generalized results from subwatershed condition assessment. Values are in numbers of subwatersheds (n=877).

	Subwatershed Condition			
Priority	**Good**	**Moderate**	**Poor**	**Dams**
Very low	1	15	21	137
Very low - KW	1	7	2	0
Low	22	64	78	18
Low - KW	11	15	7	0
Medium	23	52	77	15
Medium - KW	46	49	19	0
High	4	14	20	0
High - KW	60	70	29	0
Totals	*168*	*286*	*253*	*170*

Another way to visualize these results is through a bar graph (Figure 42). There are four bars displayed – one for each basic management prescription. Each of these bars is further subdivided according to the level of prioritization. Unlike Table 17, which shows number of subwatersheds under each category, Figure 42 is summarized by percent area.

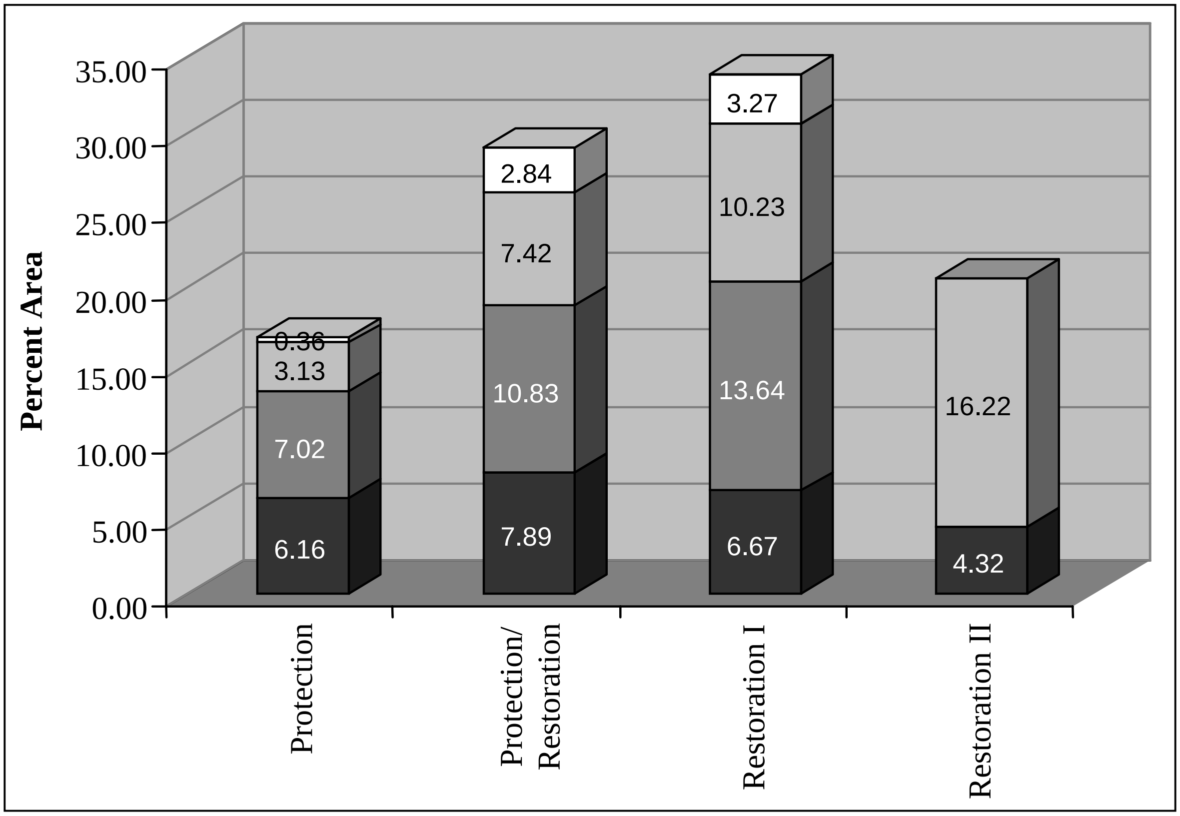

Figure 42. Bar diagram showing management recommendation and percent area for each priority (black = high, dark gray = medium, light gray = low, and white = very low) for the 877 subwatersheds portion of the Klamath-Siskiyou.

Approximately 17% (1,325,983 ac - 536,625 ha) of the analysis area was recommended for protection based on current relative subwatershed condition. Twenty-nine percent of the area was classified as needing some combination of protection and restoration (2,305,159 ac - 932,898 ha), 34% (2,689,352 ac - 1,088,381 ha) restoration excluding any dam mitigation, and 20% (1,633,815 ac - 661,205 ha) dam mitigation restoration. Priority summaries, which are far more provisional include: (1) 25.0% high, (2) 31.5% medium, (3) 37.0% low, and (4) 6.5% very low.

The terms “matrix” or “no recommendation” were purposefully not included as a possible management recommendation. Because of the very nature and importance of water, all water resources should be considered subject to some form of conservation, whether it be through protection or restoration measures.

Moyle and Yoshiyama (1994) present conservation strategies for protecting aquatic biodiversity throughout California. One major component of their strategy is the establishment of watersheds where management for the protection of aquatic biodiversity receives the highest priority. Unlike many terrestrial-focused conservation planning efforts, which usually strive to blend core reserves, buffer areas, corridors, and matrix lands (Noss and Cooperrider 1994), protecting aquatic species and processes may require a departure from this model. While setting aside entire watersheds for aquatic biodiversity protection is one strategy that needs to be fully explored, it is likely that land protection strategies alone, even ambitious ones, will be adequate to protect aquatic biodiversity. Because of the direct physical connectedness and biological importance of aquatic systems, we believe the term “matrix” has no place. For the aquatic world, it only takes a few point source perturbations (e.g., dams and mines) or chronic non-point source perturbations (e.g., widespread pesticide use) to cause significant degradation to aquatic resources for humans and non-humans alike.

For aquatic biodiversity to persist and flourish in a region, understanding how water moves over the land and into waterways in a spatially explicit way (i.e., hydrologic model) seems fundamentally important. We know how humans impact the quality and allocation of water (both directly and indirectly), and these impacts would need to be included in any hydrologic model at some point. The final component would be to attempt to tie as much biology to this prescriptive spatial model as possible using a variety of techniques (e.g., Index of Biological Integrity, see Karr and Dudley 1981, Karr 1991, Moyle and Randall 1998). If these three components (hydrologic model, human use, and biotic response) could be successfully integrated, we would have a powerful new predictive and management tool that could provide a much more comprehensive conservation plan for the Klamath-Siskiyou – one that ties aquatic and terrestrial concerns in a much more meaningful way. Based on the current data and analytical techniques, this simply could not be done at this time. Integrating aquatic and terrestrial conservation in an integrated fashion is one of the biggest challenges facing conservation planning. With the increase in concern about widespread salmon declines throughout the Pacific Northwest, financial resources must be directed at this fundamentally important issue.

SECTION IV — ECOSYSTEM REPRESENTATION

Perhaps the most comprehensive of all conservation criteria is the concept of ecological representation (Noss and Cooperrider 1994). Representation has long been a primary focus of the conservation community. As early as 1926, when the Committee on the Preservation of Natural Conditions of the Ecological Society of America attempted to assess the protection status of biomes in the U.S., ecologists have examined the question of representation (Shelford 1926). Planning for representation for this study meant "capturing the full spectrum of biological and environmental variation with the understanding that this variation is dynamic" (Noss and Cooperrider 1994). Ideally, a representative nature reserve network should: (1) maintain or restore viable populations of all native species in natural patterns of abundance and distribution; (2) sustain key geomorphological, hydrological, ecological, and evolutionary processes within normal ranges of variation, while making it adaptable to a changing environment; and, (3) encourage human uses that are compatible with the maintenance of ecological integrity (Noss and Cooperrider 1994).

Assessing representation is a complicated issue that is largely influenced by spatial scale. At one end of the spatial hierarchy lies the very coarse level delineations and assessments. At these spatial scales (e.g., 1:2,000,000 – 1:7,500,000), representation can be assessed at the ecoregional level – the Klamath-Siskiyou being only one of many ecoregions within the U.S. A number of biogeographers have worked on refining this level of mapping for the U.S. and elsewhere. Bailey (1978) combined land-surface form, climate, soils, and potential vegetation to formulate an ecoregion map for the country that is very well known. Omernick (1987) produced the most recent ecoregion map for the conterminous U.S. by integrating land use, land surface form, soils, and potential vegetation. His technique also factors in major watershed basins to help define ecoregional boundaries.

At the opposite extreme, some groups are attempting to classify and map individual natural community types throughout the U.S. For example, The Nature Conservancy has recognized 81 different natural community types in Florida alone. Of course, ecosystems can become endangered at any level of classification (Noss and Cooperrider 1994); therefore, the conservation community must be willing to view ecoregion (or community) classification in a hierarchical fashion. Using a global UNESCO framework, The Nature Conservancy has been involved in developing just such a hierarchical classification approach (see Bourgeron and Engelking 1992).

At intermediate spatial scales (e.g., 1:100,000 to 1:500,000), some form of ecological land classification has been completed for nearly every U.S. state (see McMahon 1993) which can be used to form the basis of a representation assessment. For the Klamath-Siskiyou, we focused at the intermediate spatial scale (1:100,000 – 1:250,000) to address representation.

Besides scale, there is another important topic when considering ecosystem representation – what does one use to describe ecosystem variability? Two basic approaches have been developed. The most common approach used in the U.S. is biologically based and depends on dominant plant community mapping. This is the approach adopted by the GAP (Gap Analysis Project), a nationwide assessment of present biodiversity protection (see Scott et al. 1993).

The second approach focuses on the physical variability of ecoregions and is often used when biological data is incomplete or nonexistent. World Wildlife Fund Canada has been working over the last ten years on assessing ecosystem representation throughout Canada using a physically-based classification system (see Hummel 1989). After first defining approximately 400 natural regions throughout Canada, "enduring features" have been mapped and their protection status evaluated. Enduring features have been defined by assembling combinations of topographic relief, surficial geology, edaphic conditions, and climate (Kavanagh et al. 1995).

Few examples in the scientific literature exist that analyze the pros and cons of considering the two basic analytical approaches outlined here. For a relatively small area of Tasmania compared to the Klamath-Siskiyou, Kirkpatrick and Brown (1994) found a biologically based and physically based representation analysis to yield different results. Because of the physical and biological variability that defines the Klamath-Siskiyou, we elected to combine a biological and physical approach to access representation.

A new physical habitat classification for the region was developed (Vance-Borland 1999) and merged with dominant plant vegetation classes as defined by the GAP programs from Oregon and California. We hypothesized that the physical habitat gradients represent the range in variation (beta diversity) within each vegetation type defined by overstory vegetation. The protected areas data layer used to evaluate representation of physical, biological, and combined physical-biological types were assembled from data that ranged from 1:24,000 – 1:100,000.

Data Sources:

➊ PRISM precipitation and temperature (Daly et al. 1994).
➋ STATSGO soils from U.S. Geological Survey (1:250,000)
➌ Vegetation data from California GAP (1:100,000)
➍ Vegetation data from Oregon GAP (1:100,000)
➎ Land ownership from Interior Columbia Basin Ecosystem Management Project (1:100,000)
➏ Wilderness areas from U.S. Forest Service (1:24,000)
➐ Special Management Areas from U.S. Forest Service and BLM (1:24,000 – 1:50,000)
➑ Late Successional Reserves from U.S. Forest Service and FEMAT (1:24,000)

Methods:

The physical habitat classification proceeded from the assumption that climate is the primary factor influencing the distribution and abundance of organisms at the scale of our study, and soils are an important secondary factor (Whittaker 1960, Waring and Major 1964, Waring 1969, Ohman and Spies 1998). We used GIS layers of mean monthly precipitation, mean minimum monthly temperature, and mean maximum monthly temperature data from the Precipitation-elevation Regressions on Independent Slopes Model or PRISM (Daly et al. 1994). These data layers are based on weather stations having at least 30 years of data. We used principal components analysis to find the major components of regional climate variation: mean annual precipitation, December/July precipitation difference, mean annual temperature, and July/January temperature difference. Soils data were from STATSGO. We used mean soil depth and available water capacity (awc: cm^3 H_2O/cm^3 soil) because the National Soil Survey Handbook (Soil Survey Staff 1993) includes those two variables for interpreting suitability of soils as wildlife habitat. We used the ISOCLUSTER and MLCLASSIFY routines in the GRID module of ARC/INFO™ GIS (ESRI 1997) for the physical habitat classification after first converting each of the six data layers to grids having a 1 km^2 cell size.

California and Oregon GAP vegetation data layers were merged into one file and an attempt was made to crosswalk the vegetation classes used between the states. California data was component-based and in vector format, while Oregon was not component-based and in raster format making the integration of the two databases extremely difficult. We elected to use the dominant WHR (Wildlife Habitat Relationship) component of the CA data to act as vegetation type descriptors and tried to assign appropriate WHR classes to the OR data. Some new classes had to be added for the OR data (e.g., Oregon White Oak Forest). To simplify the analysis, all WHR types that were not natural cover types (e.g., agricultural land, urban areas, water, etc.) were reclassed into a single class (NN, not natural) and not considered in the representation analysis – shown in all maps as fully represented.

Representation was first examined based on the existing reserve system (LSR = 3) with percent representation values calculated for each repclass. As part of the reserve design modeling process, representation was incorporated into the roadless areas assessment by assigning percent representation values for each roadless area. The lower the values, the more desirable the roadless area based on representation. Highest scoring roadless areas were added to the reserve design and overall representation examined again.

After all other criteria were added to the reserve design (roadless areas assessment, G1/G2 species occurrences, heritage element concentrations, and late-seral forests), representation was considered more directly for the entire region. Representation targets of 10%, 25%, and 50% were examined for and evaluated against several options: (1) the current protection network with LSR as GAP “3”; (2) the current protection network with LSR as GAP “2”; (3) the current protection network with LSR as GAP “3” plus all remaining roadless areas; and (4) our proposed alternative. Deficiencies identified for all possible protection options were then evaluated.

Results and Discussion:

A total of 19 physical zones (Table 18) were delineated for the entire study area (see Plate 9). Note that some of the classes are contained within only a few polygons, while others are composed of as many as 30 distinct polygons that share the same physical characteristics. The physical habitat types could be characterized into one of three primary zones: coastal, interior lowland, and highlands. Table 19 summarizes the 19 physical habitat types as they occurred in the study area. Percent areas ranged from 1.54 (class #19, coastal rich lowlands) to 10.52 (class #8, low interior with fertile soils) with all of the classes covering a significant area.

Table 18. Nineteen physical habitat types named by sub-region and distinguishing characteristics.

Class	Habitat Type	Annual Precip. (cm)	Dec-July Precip. Diff. (cm)	Annual Temp. (°C)	July-Jan Temp. Diff. (°C)	Soil Depth (cm)	Soil Water Capacity cm^3/cm^3
1	High cold	120	19	6.6	17.2	78	0.08
2	High cool poor	191	34	7.8	16.2	47	0.07
3	High cool	100	16	8.6	17.6	83	0.09
4	High cool moist	168	29	8.4	16.6	84	0.10
5	Low moderate	114	20	10.1	17.4	72	0.09
6	Low dry cool	64	11	9.7	19.0	82	0.11
7	Low warm	103	17	12.3	17.9	90	0.09
8	Low fertile	97	15	10.3	16.1	83	0.14
9	Low hot	112	19	14.6	19.0	58	0.12
10	Low warm moist	159	28	11.5	17.6	83	0.09
11	High moist fertile	134	22	9.6	16.5	117	0.12
12	Low dry fertile	79	14	10.7	17.5	149	0.13
13	Low warm moist fertile	159	29	12.6	17.4	116	0.13
14	Coastal warm moist fertile	213	36	11.1	14.6	89	0.14
15	Coastal cool moist	240	41	9.6	14.0	92	0.11
16	Coastal moist fertile lowlands	229	38	11.0	9.3	138	0.15
17	Coastal wet highlands	352	59	9.9	14.8	85	0.12
18	Coastal wet fertile	282	47	10.6	13.9	106	0.14
19	Coastal rich lowlands	201	33	10.9	10.8	118	0.26

Table 19. Frequency and area summaries for the 19 physical habitat types described for the Klamath-Siskiyou ecoregion (based on Vance-Borland 1999).

Class	Frequency	Area (ac)	Area (ha)	Percent
1	9	537,966	217,715	5.08
2	15	179,170	72,510	1.69
3	16	673,126	272,414	6.35
4	18	539,644	218,394	5.09
5	30	621,202	251,400	5.86
6	14	630,940	255,341	5.95
7	15	783,237	316,976	7.39

8	15	1,114,716	451,125	10.52
9	3	483,503	195,674	4.56
10	12	681,163	275,666	6.43
11	20	917,206	371,193	8.65
12	22	389,821	157,760	3.68
13	10	521,395	211,009	4.92
14	11	420,606	170,219	3.97
15	11	486,093	196,722	4.59
16	8	791,606	320,363	7.47
17	5	322,829	130,649	3.05
18	14	341,313	138,130	3.22
19	8	163,460	66,152	1.54
Totals		*10,598,995*	*4,289,413*	*100.00*

After conversion to natural WHR (Wildlife Habitat Relationship) types, 26 vegetation classes were delineated and analyzed for representation (Table 20). All vegetation classes smaller than 500 total acres were dropped from the analysis and recoded to the nearest neighbor vegetation class.

Plate 10 shows the distribution of the major vegetation types within the Klamath-Siskiyou and Table 21 provides the frequency and area totals for each vegetation type. A total of 8.5% of the study area was mapped as being either not natural (e.g., urban and converted agriculture) or water and were removed from the analysis. All of the remaining 26 vegetation types were analyzed. Unlike the physical habitat map, the vegetation data layer is dominated by only a few dominant vegetation types (MHC – Montane Hardwood Conifer, DFR – Douglas-fir forests, and MHW – Montane Hardwood). The other vegetation types, while covering much smaller areas, are equally important to assess and adequately capture in a reserve design network. Another striking difference between the physical habitat and vegetation type summaries were in the frequencies, the later showing a much wider range 9-5,399. This can be attributed, in part, from the difference in scale (1:250,000 for the physical habitat mapping and 1:100,000 vegetation mapping), but more importantly because the Oregon data was based exclusively on Landsat TM (Thematic Mapper) satellite imagery and not generalized in the same way as the California side of the study area. In order to match the Oregon and California vegetation databases, we elected to smooth the raster-based Oregon data and then convert it to a polygon file. Converting raster files to polygon files, even after some generalization (minimal mapping unit equals ten 30m x 30m pixels in this case), can result in a large number of polygons as observed in Table 21.

Table 20. Natural vegetation types defined for the Klamath-Siskiyou.

Class Code	**Description**
AGS	Annual Grasslands
BAR	Barren
BOP	Blue Oak – Foothill Pine
BOW	Blue Oak Woodlands

CRC	Chamise-Redshank Chaparral
DFR	Douglas-fir
DHC	Douglas-fir, Western Hemlock, Red Cedar
DUN	Dunes
JPN	Jeffrey Pine
JNP	Juniper Woodlands
KMC	Klamath Mixed Conifer
MCH	Mixed Chaparral
MCP	Montane Chaparral
MHC	Montane Hardwood-Conifer
MHW	Montane Hardwood
OWO	Oregon White Oak
PPN	Ponderosa Pine
RDW	Redwood
RFR	Red Fir
SER	Serpentine Shrublands
SIT	Sitka Spruce-Western Hemlock
SMC	Sierran Mixed Conifer
SPL	Subalpine Parkland
VRI	Valley-Foothill Riparian
WET	Wetlands
WFR	White Fir

Table 21. Frequency and area summaries for the 28 physical habitat types described for the Klamath-Siskiyou ecoregion. The two classes not included in the representation analysis were not natural (NN) and water (WAT).

Class	**Frequency**	**Area (ac)**	**Area (ha)**	**Percent**
AGS	99	135,668	54,905	1.28
BAR	66	84,490	34,193	0.80
BOP	204	207,982	84,170	1.96
BOW	9	11,018	4,459	0.10
CRC	89	82,760	33,493	0.78
DFR	3,479	1,597,922	646,679	15.08
DHC	496	331,900	134,320	3.13
DUN	11	4,687	1,897	0.04
JPN	353	243,076	98,373	2.29
JUN	194	194,542	78,731	1.84
KMC	409	369,692	149,615	3.49
MCH	67	51,395	20,799	0.48
MCP	95	88,712	35,902	0.84
MHC	5,399	4,034,553	1,632,784	38.07
MHW	2,248	987,204	399,522	9.31
NN	2,050	860,728	348,337	8.12
OWO	136	14,675	5,939	0.14

PPN	478	322,223	130,404	3.04
RDW	66	126,250	51,093	1.19
RFR	68	74,798	30,271	0.71
SER	53	37,782	15,291	0.36
SIT	45	16,855	6,821	0.16
SMC	581	560,150	226,693	5.28
SPL	11	8,138	3,293	0.08
VRI	17	8,183	3,312	0.08
WAT	269	47,880	19,377	0.45
WET	353	29,623	11,988	0.28
WFR	57	66,107	26,753	0.62
Totals		*10,598,995*	*4,289,413*	*100.00*

The combination of the 19 physical habitat classes and 26 vegetation classes yielded 215 types ("repclasses," which are not named individually). Preliminary observations suggest that repclasses represent a broad range of variation (beta diversity) within vegetation types, potentially including variation in secondary overstory species, understory woody species, and herbaceous plants, as well as variation in animal assemblages utilizing each vegetation type. Rigorous field studies are needed to test this hypothesis. Representation of vegetation types along environmental gradients also might help conserve genetic variation of major woody species defining vegetation types.

The number of physical habitat classes in which a vegetation type occurs is variable. Two vegetation types (montane hardwood and montane hardwood-conifer) occur in all 19 physical habitat types, which suggests that considerable variation in community composition exists within these types. At the other extreme, two vegetation types (blue oak woodlands and subalpine parklands) occur in only one physical type (low interior hot and high interior cold, respectively), suggesting more uniformity (Vance-Borland 1999). The other 24 vegetation types lie between these extremes. We stress the importance of representing vegetation types not only in physical habitat types where they are most abundant but also in physical types where they are uncommon. A map showing all 215 combinations of physical and vegetation classes is extremely complex visually; therefore, it is not provided. Appendix B lists all 215 repclasses analyzed for the Klamath-Siskiyou.

Before reviewing the results of the combined physical-biological gap analysis, a more detailed discussion about the underlying rationale for assessing representation in this way would be helpful. At this point in our knowledge, it is difficult to say which technique (physical alone, biological alone, or a combined physical-biological) is most useful in conservation planning, but it is our hypothesis that a much improved representation analysis can be reached when considering physical and biological classes together. For example, if conservation efforts focus on dominant vegetation types alone when assessing representation, they are assuming that each mapped class (e.g., Douglas-fir forest) is uniform enough throughout its range that further differentiation would not yield additional important ecological insights. We know from more detailed vegetation classification efforts (e.g., mapping to the association level which includes understory variations) and genetics work on single species that there is a great deal more variability in nature than is captured by relatively coarse level physical or vegetation classification and mapping. A big part of the problem is the incredible level of effort required to generate even coarse level vegetation maps, and so researchers, often overwhelmed by the data assembling portion of the work, have so far failed to critically review the level of ecologically understanding obtained by these and other gap analysis methods. Two basic questions need to be examined:

(1) What is the optimal spatial scale to map and assess representation in regional conservation planning?
(2) What data best describes natural variability in a way that provides the most ecologically meaningful gap analyses?

Based on our experience with the Klamath-Siskiyou and other comparably sized regions, we believe that an intermediate map scale (e.g., 1:100,000) is probably the optimal scale for regional assessments and that an improved gap analysis can be achieved by blending physical and biological classification schemes. It may be true that just a more detailed vegetation mapping would be adequate to capture the variability we seek to represent, but this level of mapping is extremely difficult over large geographic areas. Our working hypothesis is that by merging physical habitat classes with basic vegetation types, we can better account for vegetation types across their range of physical variability thereby strengthening our ability to assess representation at intermediate spatial scales. Nature operates at many different spatial scales (Forman 1997) and these fine-scaled processes are ecologically important, but to try to assess this level of variability simply would be too overwhelming in many ways and inappropriate for regional conservation planning. The challenge then is to find the most robust and cost-effective way to account for natural variability suitable at intermediate map scales. A great deal of empirical testing is still required to validate the basic assertion we have presented, and that will include considerable fieldwork and even some population genetics surveys. However, because of the foundation already laid through this work, the Klamath-Siskiyou is an excellent candidate for future exploration of this topic.

Table 22 summarizes the representation results for five different plan options for the Klamath-Siskiyou using the three representation targets of 10%, 25%, and 50%. The first two options consider the current reserve network considering LSR as GAP 3 in the one case and LSR as GAP 2 in the other. Another option analyzed representation based on current protected areas (LSR = GAP 3) and all remaining roadless areas >1,000 acres. The option entitled Proposed Reserve Design – Phase I summarizes representation based on the proposed reserve design including all of the different conservation considerations up to this point including the consideration of representation through the remaining roadless areas. The option entitled Proposed Reserve Design – Phase II reflects targets met if a private land initiative were achieved. These results are also expressed as a bar graph in Figure 43. Repclass representation results are also mapped for the existing protection with LSR = 3 (Figure 44), existing protection with LSR = 2 (Figure 45), and for the proposed reserve design – Phase I (Figure 46). Additional observations are discussed in Section IV.

Table 22. Summary representation results for various conservation options for three different targets (10%, 25%, and 50% repclass representation). Row percentages do not equal 100 since targets are additive. Total number of repclasses = 215.

Conservation Option	**<10%**		**10%**		**25%**		**50%**	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Existing Protection LSR = 3	106	49.3	109	50.7	75	34.8	45	20.9
Existing Protection LSR = 2	59	27.4	156	72.5	128	59.5	82	38.8
Existing Protection LSR = 3 + All Roadless Areas	52	24.2	163	75.8	141	65.6	105	48.8
Proposed Reserve Design – Phase I	33	15.3	182	84.6	165	76.7	126	58.6
Proposed Reserve Design – Phase II	0	0	215	100	215	100	126	58.6

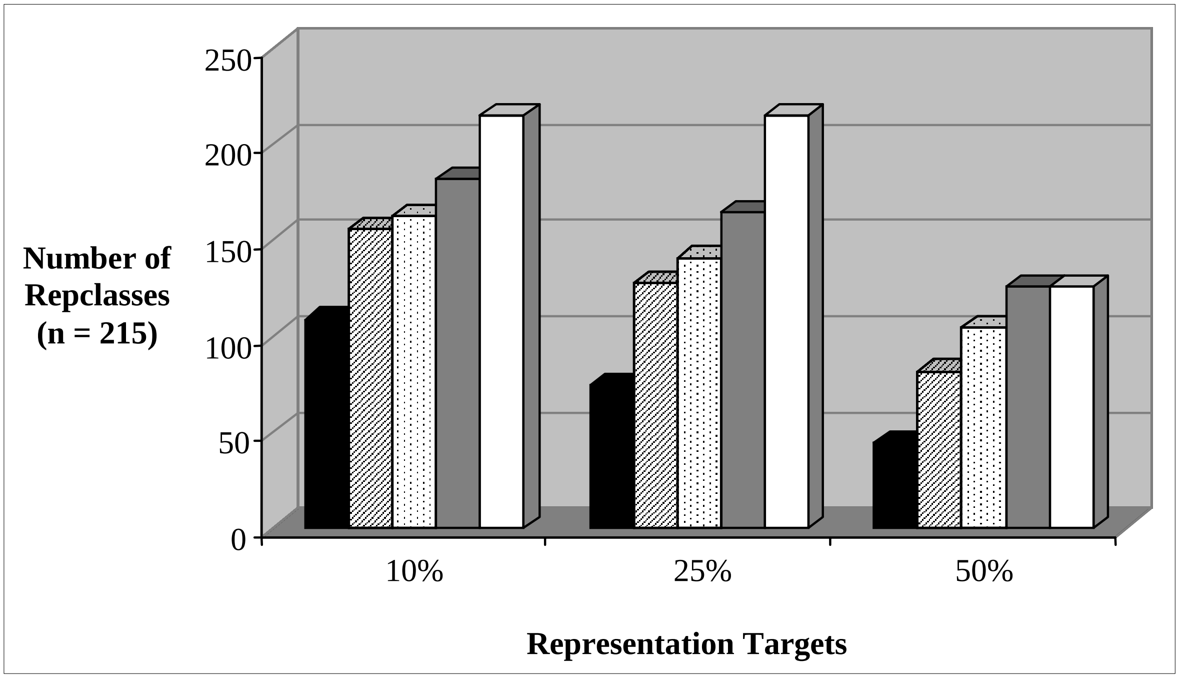

Figure 43. Representation summaries using three conservation targets for five protection options. Black bar = Existing Protection, LSR = 3, Diagonal line bar = Existing Protection, LSR = 2, Dotted pattern bar = Existing Protection + All Roadless Areas, Dark Gray bar = Proposed Reserve Design – Phase I, White bar = Proposed Reserve Design – Phase II.

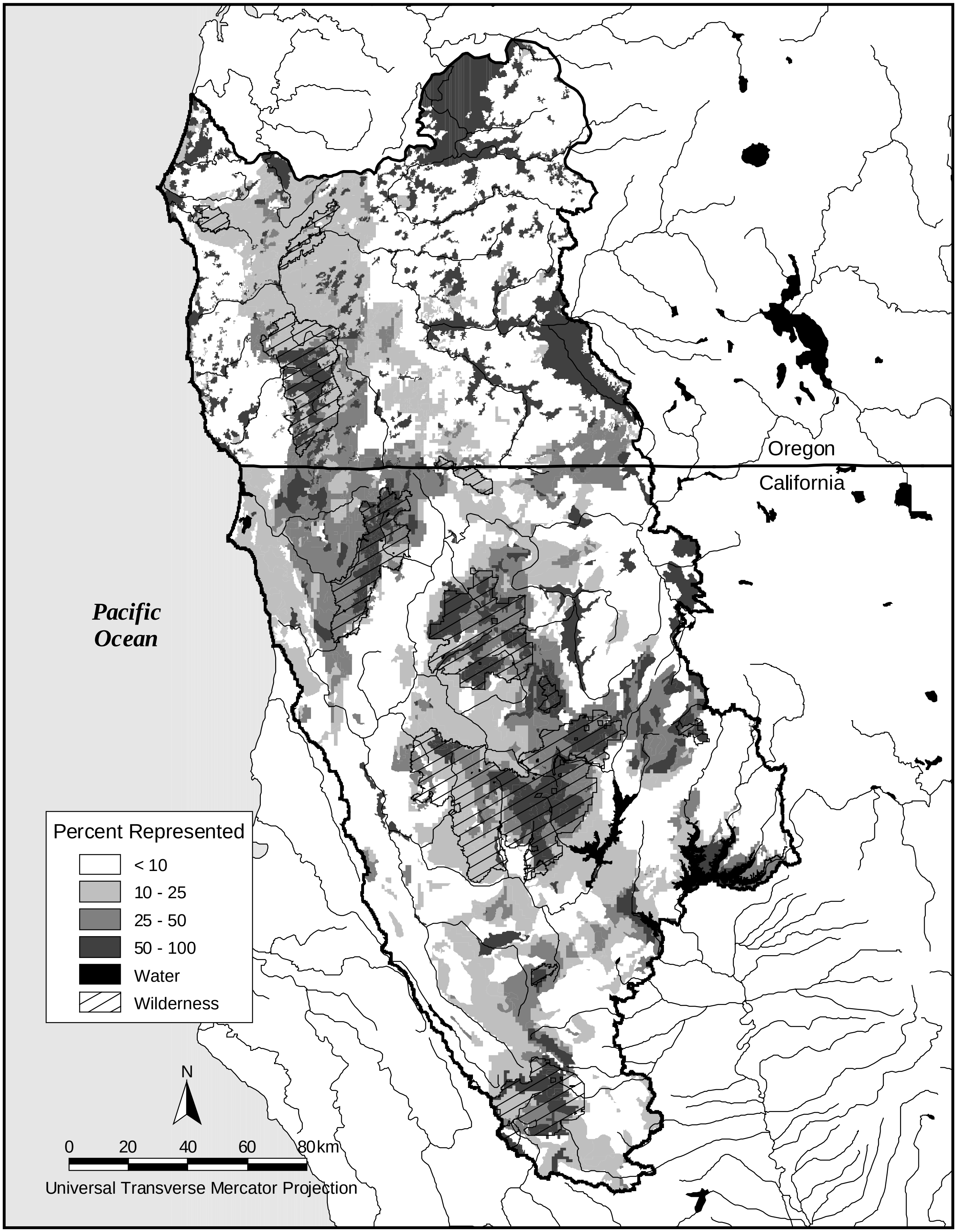

Figure 44. Percent of repclasses represented in protected areas (GAP 1+2) based on current protection (LSR = 3).

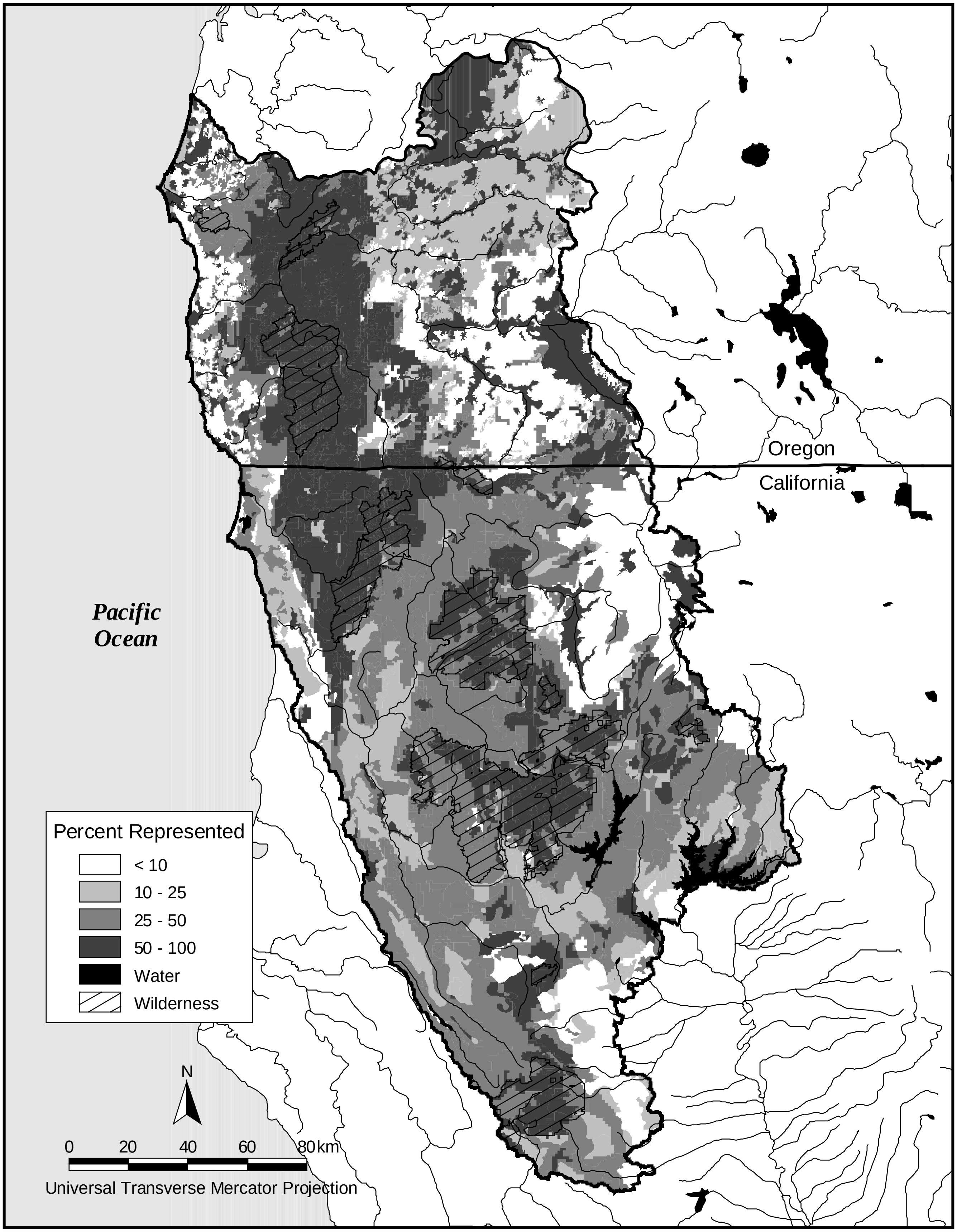

Figure 45. Percent of repclasses represented in protected areas (GAP 1+2) based on current protection (LSR = 2).

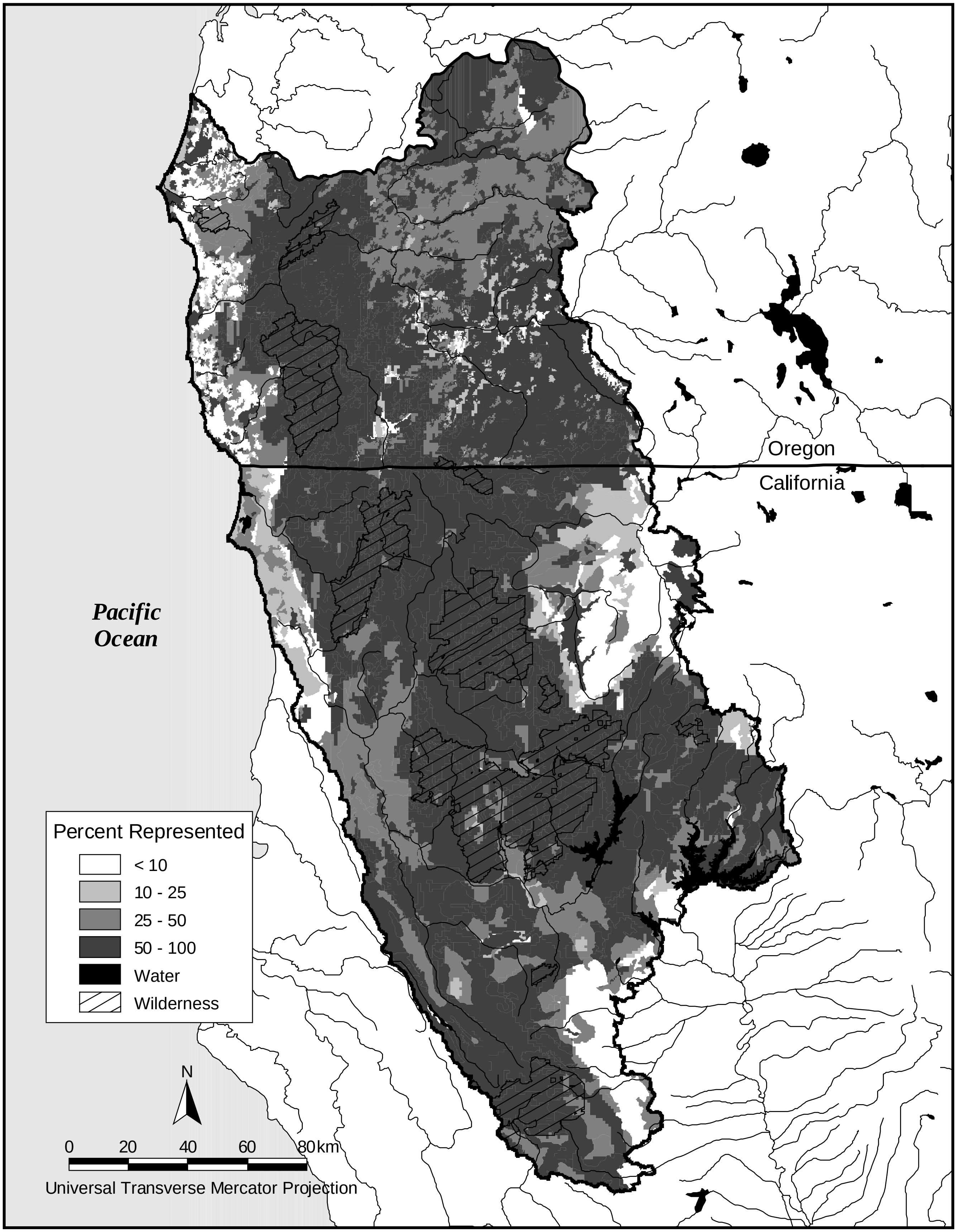

Figure 46. Percent of repclasses represented in protected areas (GAP 1+2) based on proposed reserve design – phase I.

SECTION V – FOCAL SPECIES

Focal species modeling was the third and final research component used in developing a reserve design for the Klamath-Siskiyou. Use of focal species is becoming a popular criterion upon which a reserve design can be developed (see Miller et al. 1998 for a review), but caution must be taken not to rely on focal species modeling exclusively. Undertaking focal species examination requires considerable time and resources when done properly. Which species to include and how many species to include are fundamentally important questions. Because of the expense of developing validated spatially explicit focal species models, we addressed this component for the Klamath-Siskiyou with just one species initially, the Pacific fisher (*Martes pennanti pacifica*). As part of his Masters degree program, Carlos Carroll conducted all the work for this component. Carlos is now engaged in developing regional habitat suitability models for several other regional carnivores (largely extirpated from the region), including wolverine (*Gulo gulo*), gray wolf (*Canis lupus*), and grizzly bear (*Ursus arctos*). For this report, we briefly review the fisher work, particularly as it pertains to the proposed reserve design, and some of the preliminary planning for habitat suitability (or habitat effectiveness) for larger carnivores.

Pacific Fisher

The Klamath-Siskiyou is one of the last refuges for the Pacific fisher. The fisher makes an excellent candidate to be considered as a focal species for several reasons. Fishers: (1) have relatively large home ranges, (2) are habitat specialists (older forests), (3) are sensitive to human altered landscapes, and (4) display limited dispersal capability (see Buskirk et al. 1994).

Data Sources:

❶ Land Management Plans (LMP) from FEMAT (1:100,000)
❷ 1993 vegetation data based on classified TM satellite imagery from California Timberland Task Force
❸ Classified 1995 satellite TM satellite imagery courtesy of Warren Cohen, PNW Research Station, Oregon State University. Used size class >24” diameter to define old growth. Accuracy assessment conducted and published (see Cohen et al. 1995).
❹ Roads and Hydrography from U.S. Forest Service (1:24,000)
❺ Roads digital line graph from U.S. Geological Survey (1:100,000)
❻ Digital Elevation Model (DEM) from which aspect and slope were derived from U.S. Geological Survey (90 meter resolution)
❼ PRISM mean annual precipitation (see Daly et al. 1994).
❽ Public lands boundaries from U.S. Forest Service (1:24,000)
❾ LSR boundaries from U.S. Forest Service (1:24,000)

Methods:

The most direct way fisher data was incorporated into the proposed reserve design was through the roadless areas assessment. Mean fisher habitat suitability was calculated for each roadless area according to the four size classes and given ordinal scores based on equal areas. All roadless areas that scored high in fisher habitat were included in the proposed reserve system. For more detail on how the habitat modeling was achieved see Carroll 1998 and Carroll et al. in press.

Results and Discussion:

Figure 47 shows the results of the fisher habitat modeling within the Klamath-Siskiyou and surrounding region. Note the highest concentrations fall outside of the existing strictly protected areas, and in some cases, outside the study area itself. Within the Klamath-Siskiyou, a large proportion of the highest concentration of fisher habitat lies within the Hoopa reservation and on private lands at lower elevations. The area along the Trinity River will prove very important in promoting conservation on non-public lands for this species. Other than being included in the roadless areas assessment, fisher habitat was not added directly to the reserve design. The high degree of contiguity in Phase I of the proposed reserve design helps provide the regional connectivity needed to accommodate dispersal of fisher, but more work is required to design functional interregional linkages for this and other species. Effort was made for identifying potential connectivity within the region in a general way and discussed under the next heading, Habitat Effectiveness.

Habitat Effectiveness

"Habitat effectiveness" is a term introduced by Merrill et al. (1998) who used roads, human populations, and vegetation characteristics to define suitable habitat for the grizzly bear in the northern Rocky Mountains. Their technique was adapted to fit the circumstances in the Klamath-Siskiyou. By changing the modeling emphasis away from the specifics for grizzly bear and toward a more general measurement, a useful model was created. The results used to predict relative isolation and potential landscape connectivity were draft and were dependent on the road and human population data only.

Data Sources:

❶ Roads digital line graph from U.S. Geological Survey (1:100,000)
❷ 1990 Census Data from U.S. Bureau of Census (1:100,000)

Methods:

Habitat effectiveness was modeled for the Klamath-Siskiyou and surrounding region using roads and human population data using a modified technique described by Merrill et al. (1998). Results were summarized for the roadless areas component that was previously reported on. These modeling results also were used to determine where inter-ecoregional linkages should be examined at a more detailed spatial scale.

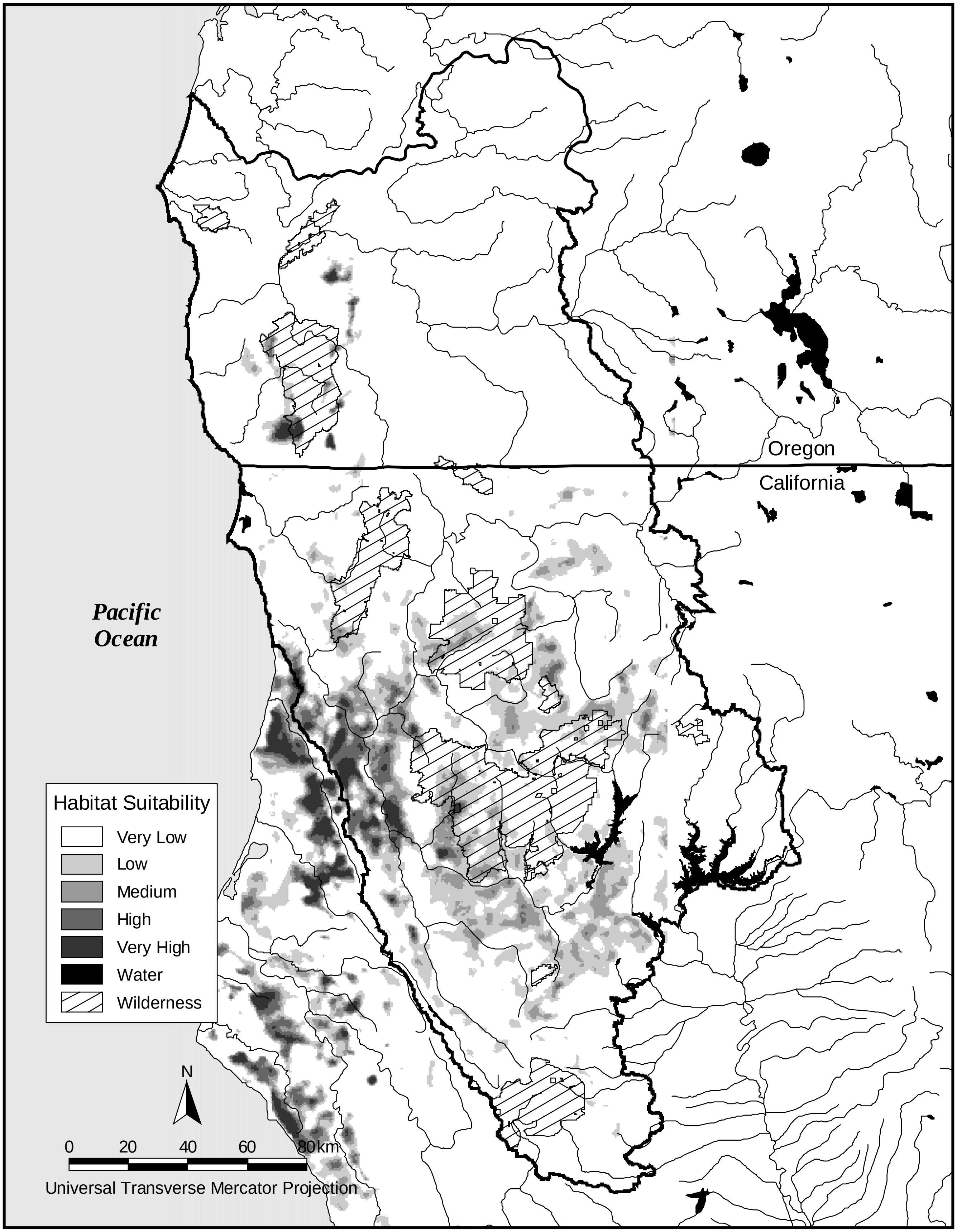

Figure 47. Habitat suitability for Pacific fisher within the greater Klamath-Siskiyou study area.

Results and Discussion:

Figure 48 provides a draft model for habitat effectiveness for the greater Klamath-Siskiyou region. The lines without arrow heads depict where more detailed work is required within the Klamath-Siskiyou to establish functional connectivity that was not fully addressed in the proposed reserve design. Lines shown leaving the Klamath-Siskiyou to the north, east and south depict the most favorable locations where inter-regional linkage for terrestrial organisms could occur but needs to be more fully researched.

As stated above, the habitat effectiveness result is an early draft of just one aspect of ongoing habitat suitability modeling for carnivores in the region. Later versions, which will include the incorporation of additional data layers, will be forthcoming. The potential linkage sites identified in this report are not likely to change; however, it is highly probable that a much better justification and prioritization will be available in the near future.

SECTION VI – PROPOSED RESERVE DESIGN

It became apparent during this study that roadless areas in the Klamath-Siskiyou region can function as the primary “building blocks” of a reserve design, especially in the immediate future. Conservationists can come close to meeting conservation objectives for the region through protecting and linking key roadless areas with high biological values. These areas generally representing the last remaining undisturbed habitats outside of existing, strictly protected areas (i.e., wilderness), are of great interest to the public for primitive recreation as well as aesthetic and spiritual values, and their protection is more politically feasible than alternative measures such as massive acquisition of private lands. Important habitats and other natural features not represented in roadless areas can be protected through conservation actions on a relatively small area of additional public and private lands (approximately 10% of the total land area). The Chief of the USDA Forest Service has applied a moratorium on road-building and logging in roadless areas on national forests in most regions of the country. Unfortunately, this moratorium does not apply in the area covered by the Northwest Forest Plan, and roadless areas in this region remain highly threatened.

Using the methodology described earlier, we distinguished 70 roadless areas >10,000 acres (>4,047 ha), 61 between 5,000 and 10,000 acres (2,023 - 4,047 ha), 367 between 1,000 and 5,000 acres (405 - 2,023 ha), and 92 areas smaller than 1,000 acres (405 ha) but contiguous with existing wilderness and other strictly protected areas. After scoring and ranking roadless areas as described in Section I, we recommend protection of many of these areas as GAP Status 1 and 2 reserves (refer to Table 12). Altogether, we recommend protection of 90% of the largest roadless areas (>10,000 acres), 85% of those between 5,000 and 10,000 acres, 56% of the areas between 1,000 and 5,000 acres, and 100% of the small roadless areas (<1,000 acres) directly adjacent to existing protected areas. Including

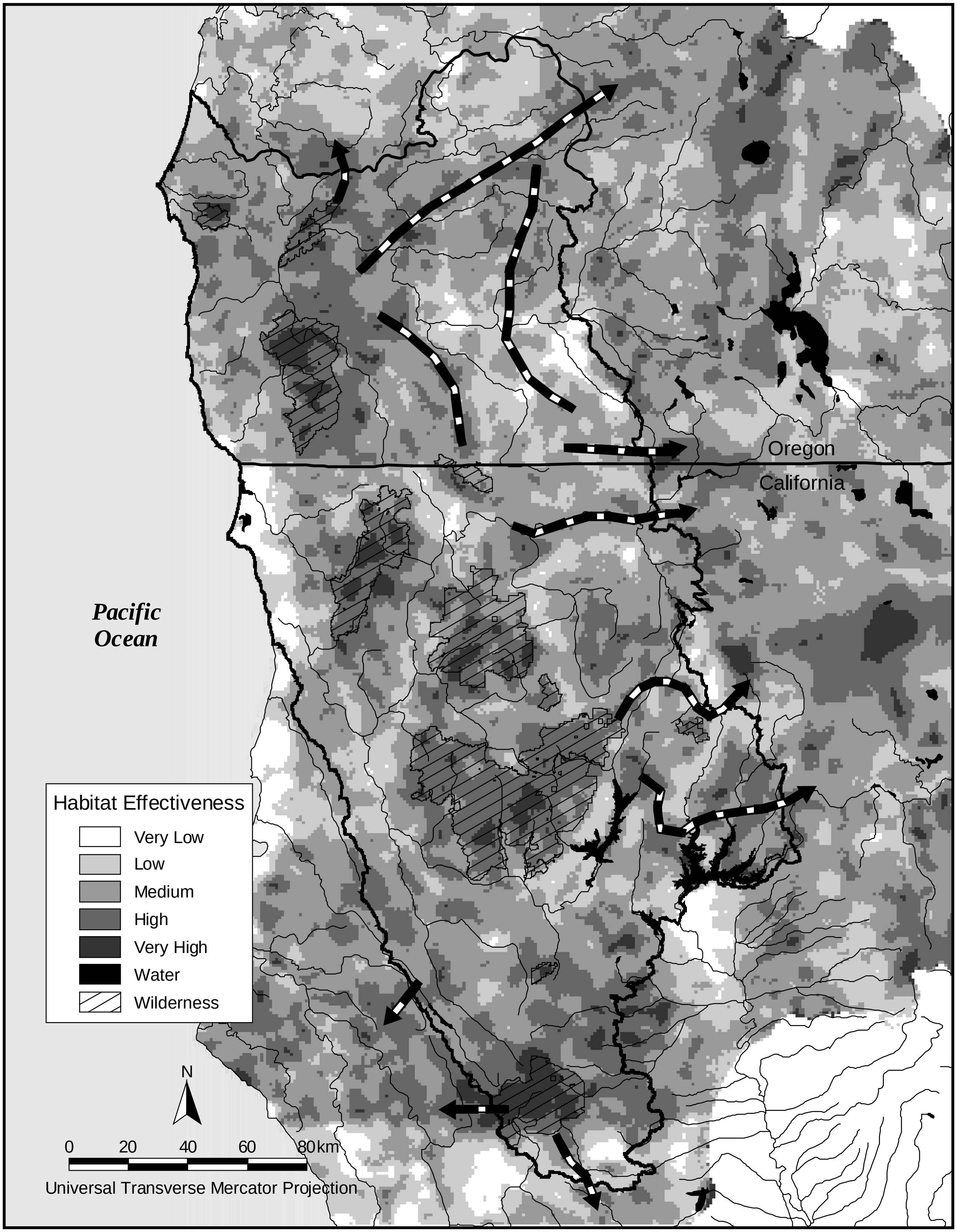

Figure 48. Habitat effectiveness modeling results using only roads and human population for the greater Klamath-Siskiyou study area.

existing protected areas, protection of these roadless areas would place 3,393,298 ac or 1,373,805 ha (32% of the region) in GAP 1 reserves and an additional 1,131,449 ac or 457,891 ha (11% of the region) in GAP 2 reserves.

In addition to the roadless areas, we propose extending GAP 1 protection to approximately 38,594 ac (15,619 ha) of public lands with G1/G2 element occurrences, 44,263 ac (17,913 ha) with concentrations of element occurrences, and 86,566 ac (35,033 ha) with >50% late-seral forest. These extensions add approximately 1.6% of the region to GAP 1. We also propose extending GAP 2 protection to 620,231 ac (251,004 ha) with 30-50% late-seral forest and to approximately 247,100 ac (100,000 ha) of land between roadless areas (2% of the region) to achieve connectivity, as defined by contiguity of protected land. This plan, our "Phase I" reserve design, would place 34% of the Klamath-Siskiyou ecoregion under strict GAP 1 protection (compared to 12.8% under current management) and another 16.5% under moderate GAP 2 protection (see Figure 49, Plate 11).

It is important to note that some of the areas we are suggesting for permanent protection are already marginally protected as LSR, national recreation areas, or other designations. Our proposal would elevate their status to true GAP Status 1 or 2, hence assuring that they will not be subject to timber sales, road-building, ski resort development, and other activities incompatible with their biological values. We recommend elevating protection of the remaining LSR, many of which are not roadless, to true Status 2 and undertaking vigorous restoration, including road closures and obliteration, within these areas.

Our proposed Phase I reserve network (Figure 49, Plate 11) meets conservation objectives for the Klamath-Siskiyou ecoregion much better than the Northwest Forest Plan and other conservation measures currently in place by offering improved protection to a number of important natural features (Table 23). Thus, our proposal will come much closer than existing management to attaining the goals of conservation planning that we articulated as explicit objectives for this project: representing all kinds of ecosystems in protected areas, maintaining viable populations of all native species, maintaining ecological and evolutionary processes, and building a conservation network resilient to environmental change. For example, the greater protection given to imperiled species (i.e., element occurrences such as endemic plants and spotted owls, as well as the carnivore focal species) by our plan should improve probabilities for long-term population persistence. The greater connectivity and reduced fragmentation of habitats provided by the contiguity of reserves and closures of roads in our plan will foster a less-constrained operation of natural processes such as hydrological and fire regimes and the natural movements of organisms. Movements of organisms along elevational gradients and into suitable microhabitats during climate change also will be enhanced, hence making the conservation network more resilient to change.

In order to bring this plan into compliance for the various representation target levels, some additional land will need to be added (see Table 24). Appendix C provides a more detailed summary of the repclass deficiencies and needs. Approximately 220,762 ac (89,341 ha) of additional land, >90% of which is private, is required to meet the 25% representation target for all repclasses, which is our recommended representation goal.

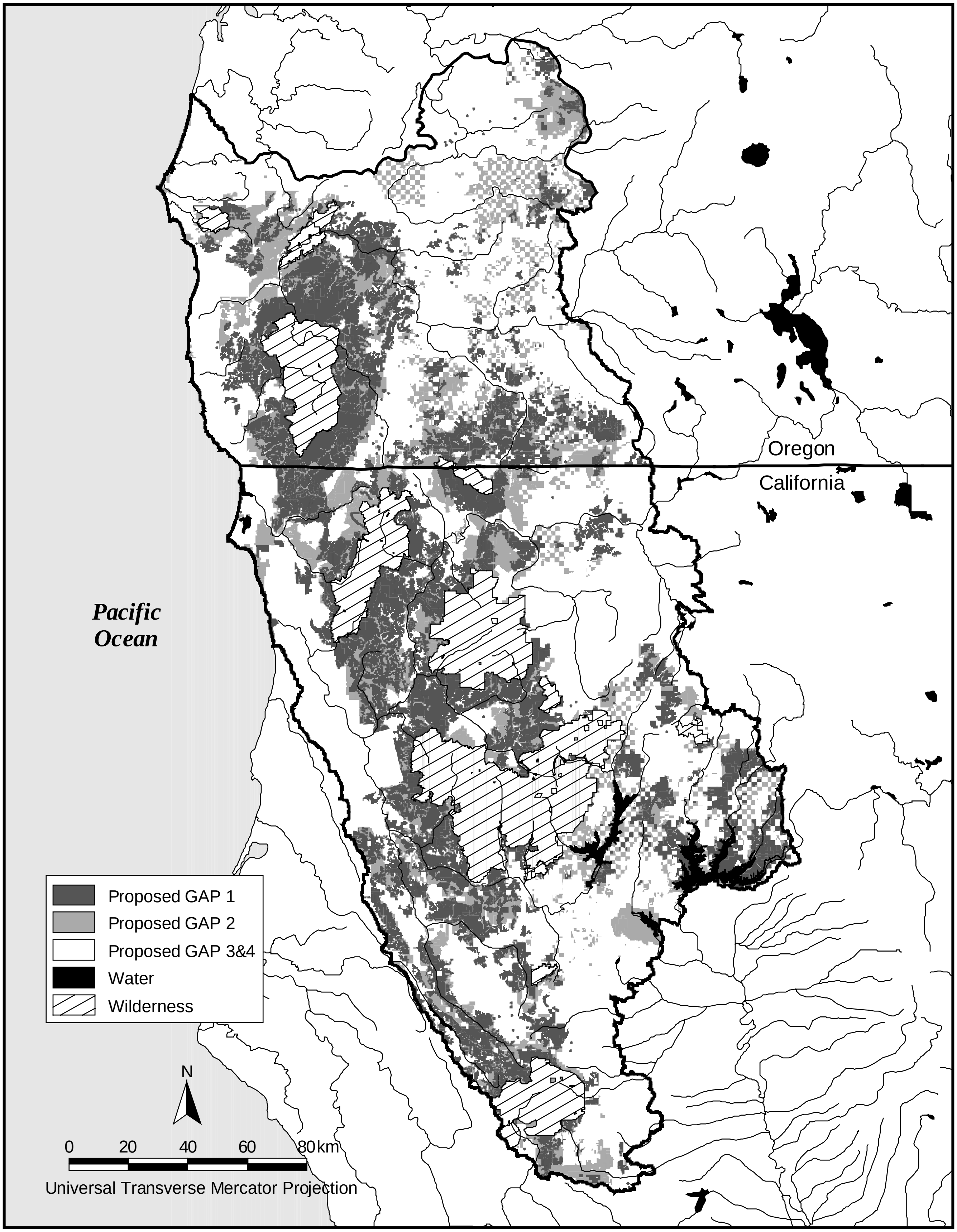

Figure 49. Proposed phase I reserve design for the Klamath-Siskiyou study area. Wilderness is also categorized as GAP 1 status.

Only 11 repclasses require more than 4,942 ac (2,000 ha) to reach the target. This land can be selected from several concentration areas in the region (Figure 50, Plate 12).

Table 23. Comparison between the current protection network (LSR = 2) and our proposed reserve design – Phase I for the Klamath-Siskiyou ecoregion for analyzed conservation criteria. Values are in percent area and include combined GAP 1 and 2 (strict and moderate protection, respectively) for both alternatives. GAP distinctions are not available (na) for representation and fisher components. The column on the far right (Δ) indicates the difference or change in percent coverage from the current condition to the proposed Phase I design.

	Current Condition			**Proposed Phase I**			
Criterion	**GAP 1**	**GAP 2**	**GAP 1+2**	**GAP 1**	**GAP 2**	**GAP 1+2**	**Δ**
G1/G2 species occurrences	11.0	25.0	36.0	68.0	14.0	82.0	+46.0
All heritage elements	8.0	30.0	38.0	45.0	21.0	66.0	+28.0
Late-seral forests	16.5	27.0	43.5	50.0	18.0	68.0	+24.5
Serpentine	18.0	25.0	43.0	50.5	11.0	61.5	+18.5
Port-Orford-cedar:							
High presence, low disease	36.0	46.5	82.5	88.0	8.0	96.0	+13.5
Mod. Presence, low disease	31.0	42.0	73.0	73.0	12.0	85.0	+12.0
Key watersheds	27.0	32.0	59.0	62.0	16.0	78.0	+18.0
Roadless areas (designated wilderness excluded)	1.0	48.0	49.0	83.0	9.0	92.0	+43.0
Representation:							
≥ 10%	na	na	72.5	na	na	86.0	+13.5
≥ 25%	na	na	59.5	na	na	77.0	+17.5
≥ 50%	na	na	39.0	na	na	59.0	+20.0
High-quality fisher habitat	na	na	36.0	na	na	50.0	+14.0

Table 24. Number of repclasses and total area required to bring the proposed reserve design – Phase I up to meet each of the three representation targets examined for the Klamath-Siskiyou.

Target	**Number of Repclasses**	**Total Area (ac)**	**Total Area (ha)**
50% representation target	90	809,669	327,673
25% representation target	50	220,759	89,341
10% representation target	33	51,206	20,723

Protecting habitats outside the Phase I reserve design to meet representation objectives is a key element in Phase II of our conservation plan. Protection of private lands (which in Phases I and II together constitute approximately 4% of the ecoregion) can be accomplished by several mechanisms, including fee-simple acquisition, conservation easements, management agreements, and land trades. Ongoing socioeconomic studies in

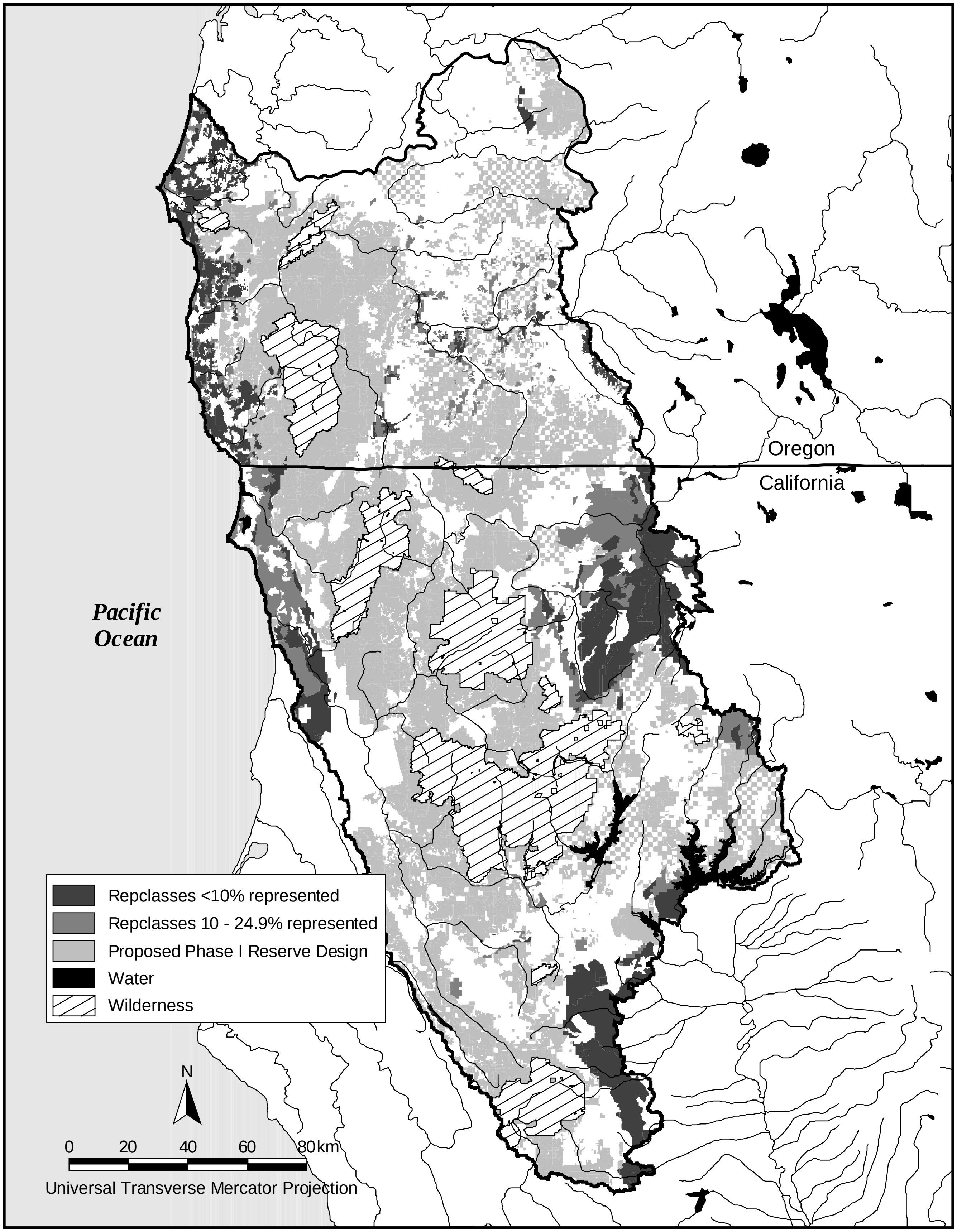

Figure 50. Phase I reserve design for the Klamath-Siskiyou study area showing areas where repclasses are still underrepresented – one emphasis for Phase II planning.

the region should help determine the appropriate strategies for protection of private lands. Assuming no lands were swapped, meeting the 25% representation targets would result in a reserve design with approximately 37% of the region strictly protected and another 17% moderately protected.

Another crucial component in Phase II of the reserve design is provision of connectivity to surrounding ecoregions. From a terrestrial perspective, linkages to surrounding regions are especially needed to assure population viability of wide-ranging animals, such as the fisher and the large carnivores that may be reintroduced to the region. From an aquatic perspective, especially with regard to salmonids, linkages are needed to connect headwater areas with the Pacific Ocean (Figure 51, Plate 13). Although our carnivore habitat modeling and linkage analyses are not complete and a more thorough consideration of aquatic-terrestrial interactions are needed, we estimate that an additional 5-10% of public and private land in the region is required to meet these objectives. In many cases, linkage and representation objectives can be met by protection of the same lands. Protection should include road closures and other restrictions in human access to provide security to carnivores. In addition, underpasses and other highway modifications in strategic places will be necessary to allow animals to travel safely among regions (Noss and Cooperrider 1994). These actions become more urgent as development and traffic along the Interstate-5 corridor increase. Phase II of our reserve design would enlarge the area protected as GAP 1 and 2 to approximately 60% of the region.

SECTION VII – CONCLUSIONS

Our study indicates that the biological and ecological values of the Klamath-Siskiyou ecoregion can be enhanced by a conservation plan that integrates a broader set of conservation criteria than those considered in current management plans. Most strictly protected reserves in the region (i.e., wilderness areas) were established for scenic and recreational reasons and poorly represent the range of habitats available (Vance-Borland 1999). The Northwest Forest Plan offered what appeared to be a modest improvement in conservation status, but it has not fulfilled its promise. Not only were the LSR established under the Plan based on limited criteria, many of them do not appear to meet even their restricted goals. For example, some contain little late-seral forest and are heavily fragmented. Furthermore, these “reserves” have been open to logging, even of old growth, and some are now being proposed for intensive development. A region as rich and distinctive as the Klamath-Siskiyou (DellaSala et al. in press) deserves better.

We have emphasized a protected areas approach to conservation in our plan, despite the recent popularity of ecosystem management and its frequent reliance on changes in management practices outside reserves (Noss 1999). We followed this course for several reasons. First and foremost, the history of resource management on federal and other lands in the region do not provide much confidence that irreplaceable biological values will be safeguarded. As noted, even the Northwest Forest Plan, ostensibly based on principles of ecosystem management and conservation biology (FEMAT 1993), has been disappointing. Reserves can be managed in virtually any way agency managers and Congress see fit. The outstanding biological values of the Klamath-Siskiyou region should not be jeopardized

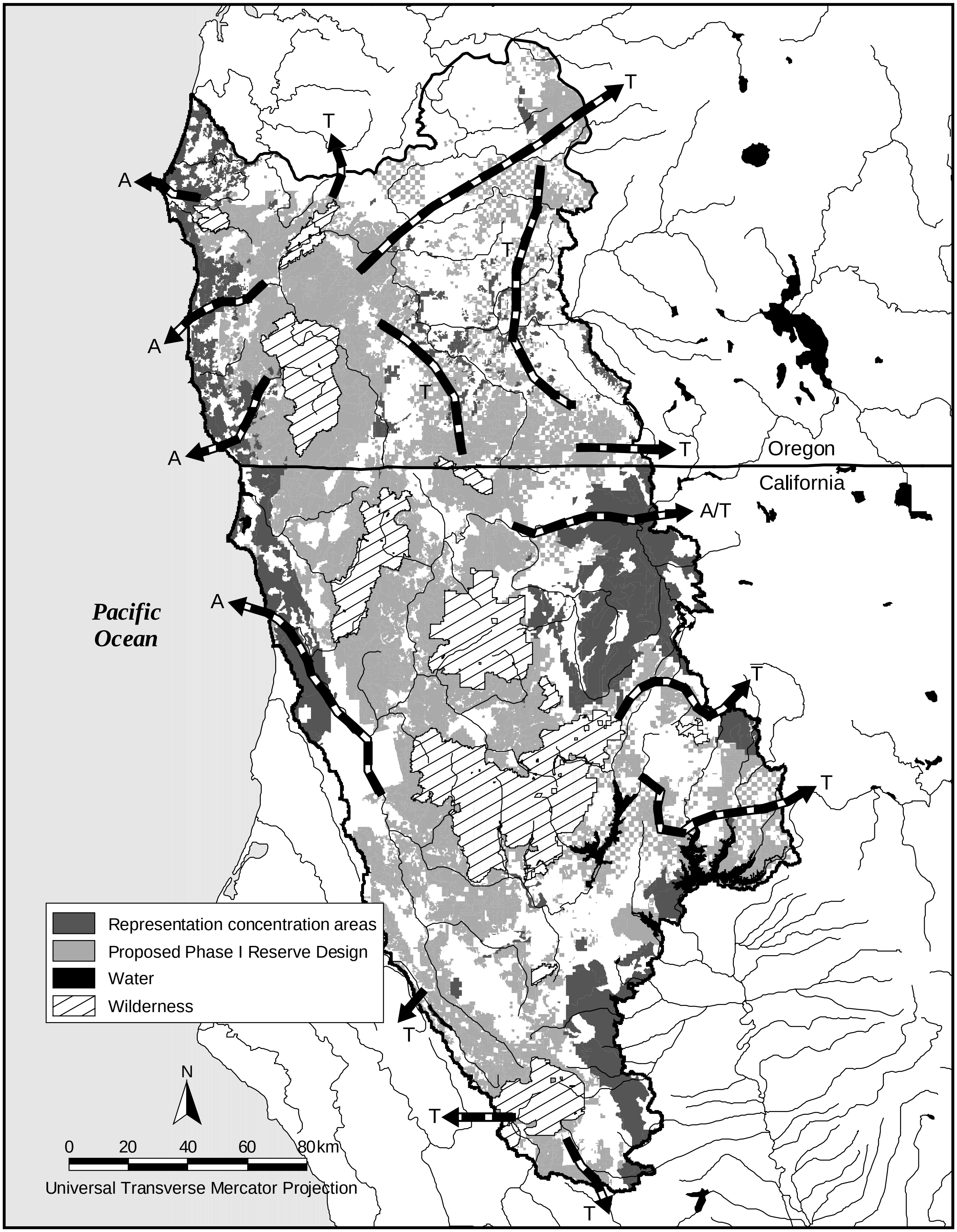

Figure 51. Phase I reserve design for the Klamath-Siskiyou study area with phase II components – representation concentration areas and aquatic (A) and terrestrial (T) linkage zones.

through reliance on the discretion of land-managing agencies or the good will of politicians.

Furthermore, true protected areas serve essential and well-documented functions in conservation strategy (Noss and Cooperrider 1994, Terborgh and Soulé 1999), too often ignored by proponents of ecosystem management. For example, they serve as habitat for species unlikely to persist in multiple-use landscapes and as refugia from which disturbance-sensitive species can recolonize the broader landscape after disturbance. Reserves, especially when large and roadless, also serve as reference sites and control areas for management experiments (Leopold 1941). Although scientists universally recognize the need for controls, some ecosystem managers assume that they understand ecosystems well enough to manipulate them for long-term commodity production and other uses without losing biodiversity and other values. Reserves are necessary to test the validity of this assumption by comparing treated areas to untreated or natural areas. When ecosystem management experiments are carried out on a landscape scale, as they generally are, control areas (reserves) that span broad landscapes are required. Finally, among the major values of reserves for many people are the opportunities they provide for solitude, spiritual inspiration, and wilderness recreation. These values and experiences, increasingly rare in our modern world, are not attained in a heavily manipulated landscape. Experiences in wild areas provide a sense of humility, a reminder that nature is bigger than we are.

Some 80% of the public land in the Klamath-Siskiyou ecoregion, or 50.5% of the entire ecoregion, would be protected under Phase I of our proposal. We arrived at these figures empirically, by evaluating and ranking specific sites for protection based on their biological values, without a preconceived, specific idea of how much land would need to be protected in the region. Not surprisingly, however, our proposal falls in line with previous estimates of how much land should be secured to meet conservation goals; most estimates fall in the range of 25-75%, averaging around 50% (Odum 1970, Odum and Odum 1972, Margules et al. 1988, Noss 1992, Ryti 1992, Saetersdal et al. 1993, Noss and Cooperrider 1994, see discussion in Noss 1996). Our proposed design is only a little above the percent of “forever wild” lands in the Adirondack Park (AP) of upstate New York (45%) although our plan differs significantly in how management decisions are made. For example, in the AP, many private land decisions need approval from the Adirondack Park Agency. That mechanism is not being recommended for the Klamath-Siskiyou. What is noteworthy is that people live and work in the AP as they do in the Klamath-Siskiyou. Protecting 50-60% of the ecoregion does not necessarily translate into excluding people. The Adirondacks is a crown jewel of New York and the amount of protected lands is impressive. The Klamath-Siskiyou is also a crown jewel and deserves much better protection than it currently receives.

We furthermore recommend that public lands outside our proposed reserves be managed to maintain or enhance existing ecological values (e.g., with no logging of old growth or destruction of populations of imperiled species), while permitting sustainable resource extraction. We encourage the development of tax incentives and other positive measures to foster sustainable management of private lands.

Questions about specific management practices appropriate within reserves and in the surrounding matrix, not addressed in this phase of our research, deserve urgent attention. We do not envision protected areas as “hands-off” or “human-free” zones; rather, ecological management is generally essential in these areas (Noss 1999). Even the entire network of proposed reserves across the region is arguably too small to manage itself with a natural disturbance regime (see Baker 1992, Noss and Cooperrider 1994). In the Klamath-Siskiyou ecoregion, a long period of restorative management, including obliterating and revegetating roadbeds, recontouring slopes, restoring streams and watersheds, controlling invasive exotic species, reintroducing extirpated species, and other practices will be necessary to redevelop natural conditions. The fire ecology of the region is complex, variable, and not well understood (Agee 1993); hence, proposed actions to restore fire-suppressed stands that may be prone to unnaturally intense fires are controversial. Undoubtedly, some combination of understory thinning and prescribed burning is needed, especially for oak savannas, woodlands, and other “endangered ecosystems” in the region that depend on frequent fire (Agee 1993, Noss et al. 1995, Noss 1999).

Ecological research, combined with the socioeconomic studies presently ongoing, will refine and help answer questions about how to implement our proposal, as well as aiding the development of guidelines for management and human uses of the reserve network. Protection of the areas recognized as priorities for Phase I of our plan should not wait until all studies are completed, however, as options to maintain their natural or semi-natural character may be precluded. We recommend a conservative approach in which analyses of conservation options based on biological and ecological data, as we have done here, set the “sideboards” within which socioeconomic options are evaluated. In such a strategy, the persistence of native species and ecosystems is the major concern. Socioeconomic options are assessed, in large part, for their compatibility with biological goals; options incompatible with biological goals are rejected. This approach is in line with the historical observation that human cultures are much more adaptable to rapid environmental change than many non-human species.

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Appendix A

Mapping Roadless Areas for the Klamath-Siskiyou using ARC/INFO™

1. Mapping of roadless areas was performed using 1:24,000 scaled vector data. Roads files were obtained from each National Forest in the study area and from the Rogue River Council of Governments GIS office for all of the remaining area of Southwest Oregon south of the Umpqua River Basin including most of the BLM lands on the Oregon side of the study area. All arcs labeled as "trails" were removed from the databases for this analysis.

2. Because of the size of the study area and the scale at which the analysis was performed, 12 tiles were broken out and analyzed separately then rejoined later to produce the final map. Unlike many other techniques used to map roadless areas, buffering of the road network at various distances was NOT utilized. We elected, instead, to perform a number of neighborhood operations in the raster domain using a 10-meter x 10-meter grid cell size.

3. All of the raster modeling was accomplished using ArcView™ Spatial Analyst™, version 1.0a. Each of the 12 roads tiles were loaded into ArcView and two operations performed. First, the Euclidean distance was calculated from the roads to all other locations in the area yielding a measurement of how far every 10 m^2 grid cell was from the nearest road. The Distance command in Spatial Analyst was used to perform this function. Secondly, the Neighborhood Statistics command was used and was set to calculate the maximum value using a 10 x 10 moving rectangular shaped window across the entire file.

4. The results from these two operations were then examined and the following region cutoffs selected and mapped. All cells ranging between 10 to 70 were coded with a "1" and labeled as being directly influenced by roads. The "70" cutoff was enough to take into account the sinuosity of the road network which is often a problem encountered when analyzing roads using just a series of buffer functions. This technique resulted in defining a region around roads from between 10 meters to hundreds of meters depending on the curvature and density of roads across the landscape. Cells with values between 70 to 200 were coded with "2" and used to identify pinch points between unroaded polygons. This translated into having a corridor cutoff width between two roads at approximately 300 meters. Distances between two roads less than that were considered too narrow to be considered viable for wildlife movement. Empirical data on determining this optimal distance is severely limited and the 300-meter value was chosen as a very general rule-of-thumb based on Harris and Scheck (1991) and could be adjusted up or down depending on the situation. All cells with neighborhood maximum values of greater than 200 were coded "3" and were used to define existing unroaded areas within each tile.

5. The raster files (with a 10-meter x 10-meter resolution) made up of cells labeled with a 1, 2, or 3 were then converted to vector files (polygons in this case) using the GRIDPOLY command in ARC/INFO™. Each polygon file was then put together into one seamless file for the entire study area. Margins between tiles were manually checked and cleaned forming an error-free composite polygon file. All polygons labeled as "3" (unroaded areas) were selected from the composite file and placed in its own file using the RESELECT command in ARC/INFO.

6. Another RESELECT command was used to make a polygon file of the unroaded areas greater than 500 acres. Five hundred acres was chosen rather than 1,000 to take into account the shrunken nature of the unroaded polygons due to the class “2” areas. The resulting polygons were then buffered out by 100 meters, which pushed the unroaded areas edges to within 10 meters of existing roads. All unroaded areas ≥ 1,000 acres were then placed in one polygon file.

7. The polygon file containing unroaded areas ≥ 1,000 acres was then erased with the private lands from the ownership layer for the region (ownership data from the Interior Columbia Basin Management Project). All public land was considered as open to roadless areas designation and, at this point, agency or district jurisdiction were viewed to have no impact on the results. For example, if one roadless polygon was partially in one National Forest and partially in another, the polygon was not artificially divided into two even though the agencies like to do that. Again, the sizes were checked and polygons still ≥ 1,000 acres were preserved. New pinch points brought about by ownership patterns have been ignored at this point, but may want to be considered in the future.

8. Finally, existing wilderness areas were used to erase the roadless areas polygons areas ≥ 1,000 acres producing the final roadless areas map for the region. Note those areas immediately adjacent to existing wilderness areas, originally classified as roadless but now below the 1,000 cutoff, were retained.

Appendix B

List of Repclasses within the Klamath-Siskiyou

Numbers correspond to physical habitat types (1-19) as explained in Table 18.

Annual Grasslands	**Barren**	**Blue Oak – Foothill Pine**	**Blue Oak Woodlands**
AGS01	BAR01	BOP03	BOW09
AGS03	BAR02	BOP05	
AGS06	BAR03	BOP07	
AGS07	BAR04	BOP09	
AGS08	BAR05	BOP12	
AGS09	BAR16	BOP13	
AGS12			
AGS16			
Chamise-Redshank Chaparral	**Douglas-fir**	**Douglas-fir, Western Hemlock, Red Cedar**	**Dunes**
CRC03	DFR01	DHC04	DUN16
CRC05	DFR02	DHC08	
CRC07	DFR03	DHC11	
CRC09	DFR04	DHC14	
CRC13	DFR05	DHC15	
	DFR07	DHC16	
	DFR08	DHC17	
	DFR10	DHC18	
	DFR11	DHC19	
	DFR12		
	DFR13		
	DFR14		
	DFR15		
	DFR16		
	DFR17		
	DFR18		
	DFR19		
Jeffrey Pine	**Juniper Woodlands**	**Klamath Mixed Conifer**	**Mixed Chaparral**
JPN01	JUN01	KMC01	MCH05
JPN02	JUN12	KMC02	MCH09
JPN03	JUN03	KMC03	MCH16
JPN04	JUN06	KMC04	
JPN05	JUN08	KMC05	
JPN06		KMC06	
JPN07		KMC07	
JPN10		KMC08	
JPN11		KMC10	
JPN12		KMC11	

JPN13		KMC12	
JPN14		KMC15	
JPN15			
JPN16			
JPN17			
JPN18			
Montane Chaparral	**Montane Hardwood-Conifer**	**Montane Hardwood**	**Oregon White Oak**
MCP01	MHC01	MHW01	OWO08
MCP02	MHC02	MHW02	OWO11
MCP03	MHC03	MHW03	OWO12
MCP04	MHC04	MHW04	
MCP05	MHC05	MHW05	
MCP06	MHC06	MHW06	
MCP09	MHC07	MHW07	
MCP10	MHC08	MHW08	
MCP13	MHC09	MHW09	
MCP15	MHC10	MHW10	
	MHC11	MHW11	
	MHC12	MHW12	
	MHC13	MHW13	
	MHC14	MHW14	
	MHC15	MHW15	
	MHC16	MHW16	
	MHC17	MHW17	
	MHC18	MHW18	
	MHC19	MHW19	
Ponderosa Pine	**Redwood**	**Red Fir**	**Serpentine Shrublands**
PPN01	RDW14	RFR01	SER06
PPN02	RDW15	RFR02	SER08
PPN03	RDW16	RFR03	SER11
PPN04		RFR04	SER14
PPN05		RFR05	SER15
PPN06		RFR06	SER17
PPN07		RFR08	
PPN08		RFR11	
PPN09		RFR14	
PPN10		RFR15	
PPN11			
PPN12			
PPN13			
PPN15			

Sitka Spruce-Western Hemlock	**Sierran Mixed Conifer**	**Subalpine Parkland**	**Valley-Foothill Riparian**
SIT16	SMC01	SPL01	VRI15
SIT19	SMC02		VRI16
	SMC03		VRI18
	SMC04		VRI19
	SMC05		
	SMC06		
	SMC07		
	SMC08		
	SMC09		
	SMC10		
	SMC11		
	SMC12		
	SMC13		
	SMC15		
	SMC16		
	SMC17		
	SMC18		
	SMC19		
Wetlands	**White Fir**		
WET02	WFR01		
WET07	WFR02		
WET09	WFR03		
WET10	WFR04		
WET11	WFR05		
WET12	WFR07		
WET13	WFR10		
WET16	WFR11		
	WFR15		

Appendix C

Repclass Area Needs to Meet 25% Representation Target

Negative numbers indicate representation target has been met.

Repclass	10% of repclass (ac)	10% acres needed	25% of repclass (ac)	25% acres needed
AGS06	5438.45	5435.16	13596.11	13592.83
AGS07	757.49	-210.13	1893.72	926.10
AGS08	1744.98	1744.98	4362.46	4362.46
AGS09	914.15	914.15	2285.38	2285.38
AGS12	3110.16	3110.16	7775.39	7775.39
AGS16	424.24	203.64	1060.60	840.00
BAR16	683.42	297.41	1708.55	1322.54
BOP09	11190.87	4416.38	27977.16	21202.68
BOP13	1545.08	-2101.90	3862.70	215.72
CRC07	772.36	512.46	1930.90	1671.01
CRC09	5832.77	5436.38	14581.92	14185.54
CRC13	164.77	164.77	411.92	411.92
DHC08	823.35	369.13	2058.37	1604.15
DHC19	1830.77	-771.36	4576.92	1974.79
DUN16	468.70	-462.57	1171.76	240.48
JPN06	1408.43	561.07	3521.08	2673.71
JPN12	179.44	179.44	448.59	448.59
JUN12	2511.84	2511.84	6279.61	6279.61
JUN06	15863.62	13321.47	39659.04	37116.89
JUN08	257.27	216.87	643.19	602.79
KMC06	929.27	-994.35	2323.18	399.56
KMC12	90.40	90.40	225.99	225.99
MCH05	133.56	97.23	333.91	297.57
MCH09	4814.76	3168.23	12036.90	10390.37
MCH16	191.23	191.23	478.07	478.07
MCP06	771.48	-812.31	1928.71	344.92
MHC12	6148.57	-1923.67	15371.42	7299.18
MHC16	22595.97	1362.94	56489.93	35256.90
MHC19	7454.75	4178.93	18636.88	15361.06
MHW06	11055.46	-16353.37	27638.66	229.83
MHW08	4363.48	-878.59	10908.70	5666.63
MHW12	2267.78	1225.50	5669.46	4627.18
MHW15	917.69	-1002.27	2294.23	374.27
OWO08	1319.52	1098.60	3298.79	3077.88
OWO11	106.86	106.86	267.16	267.16
PPN08	560.33	560.33	1400.82	1400.82
PPN12	785.83	785.83	1964.57	1964.57
RDW14	50.17	50.17	125.43	125.43
RDW16	11699.35	-8171.93	29248.38	9377.10
SIT16	1164.13	-1234.15	2910.32	512.04

SMC06	5503.55	887.97	13758.88	9143.30
SMC12	560.22	550.82	1400.55	1391.15
SMC19	2874.56	-1647.31	7186.39	2664.52
VRI16	445.94	330.88	1114.85	999.79
VRI19	146.73	135.10	366.83	355.20
WET02	222.60	126.39	556.51	460.29
WET11	235.27	143.24	588.16	496.14
WET12	259.94	259.94	649.86	649.86
WET13	171.57	141.78	428.93	399.13
WET16	1189.08	-353.91	2972.69	1429.71