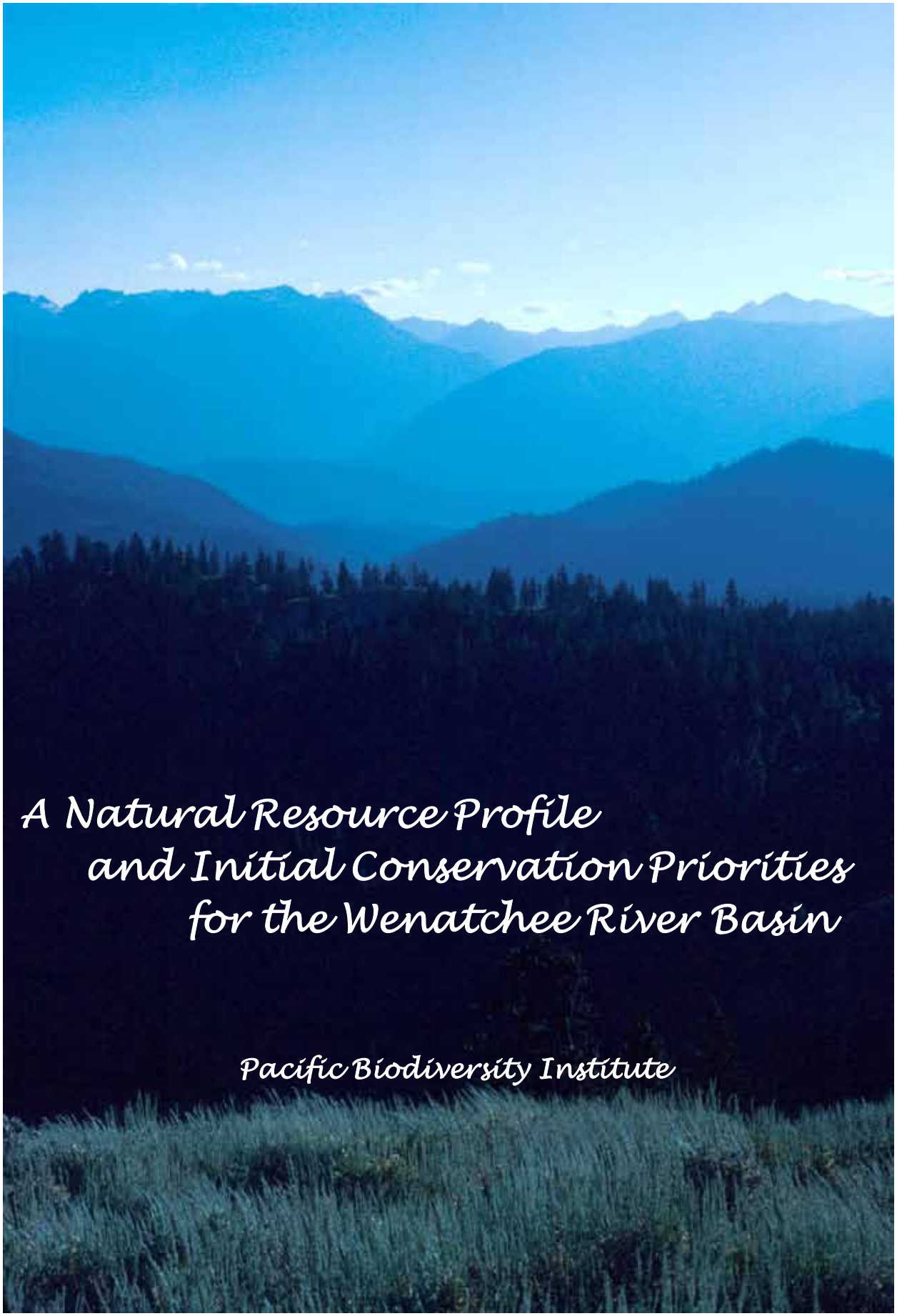

A Natural Resource Profile and Initial Conservation Priorities for the Wenatchee River Basin

Pacific Biodiversity Institute

CREDITS

A report prepared by the Pacific Biodiversity Institute at the request of the Icicle Fund.

August 2001

The **Pacific Biodiversity Institute** conducts scientific research in the fields of ecology, conservation biology and natural resource management. Our activities are focused on the conservation of biodiversity and maintenance of ecological integrity in the Pacific region. We develop advanced analytical tools and methods that aid the conservation of biodiversity and provide access to these tools, as well as research and consultative services, to public agencies, educational institutions and other non-profit conservation organizations. We provide scientific and technical information for use in the public review of public land management policies. Pacific Biodiversity Institute engages in a variety of educational activities including: the production of publications related to conservation and natural resource management issues, the organization of scientific conferences and public symposia, the development of educational materials, and community level environmental education.

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On the Cover: Looking across the Wenatchee River Basin and Icicle Creek into the Enchantments from Chumstick Mountain. Photo by Peter Morrison.

EXCUTIVE SUMMARY

The Icicle Fund has united several conservation organizations that share a mutual interest: the Wenatchee River Basin. These organizations (Chelan-Douglas Land Trust, National Audubon Society, The Nature Conservancy and The Trust for Public Land) all recognize that significant natural resources of conservation value exist in the Basin. While parts of the Basin have formal conservation protected status many of the most biologically rich and ecologically significant portions of the Basin have no protection. Inappropriate activities or unsound land management could adversely alter some of these areas. This report presents an assessment of environmental, biological, recreational and scenic resources in the Basin as well as a description of an initial attempt to determine conservation priorities in the Basin.

Spanning an area larger than the state of Rhode Island, the Wenatchee River Basin contains a broad range of relatively undisturbed ecosystem types. Not only are there considerable amounts of old-growth forests in the Basin, but the area is also home to numerous endangered and threatened species, rare vegetation types and pristine habitat. Additionally, the area is widely popular for its significant scenic and recreational resources -- over 1,300 miles of hiking trails alone traverse the Basin.

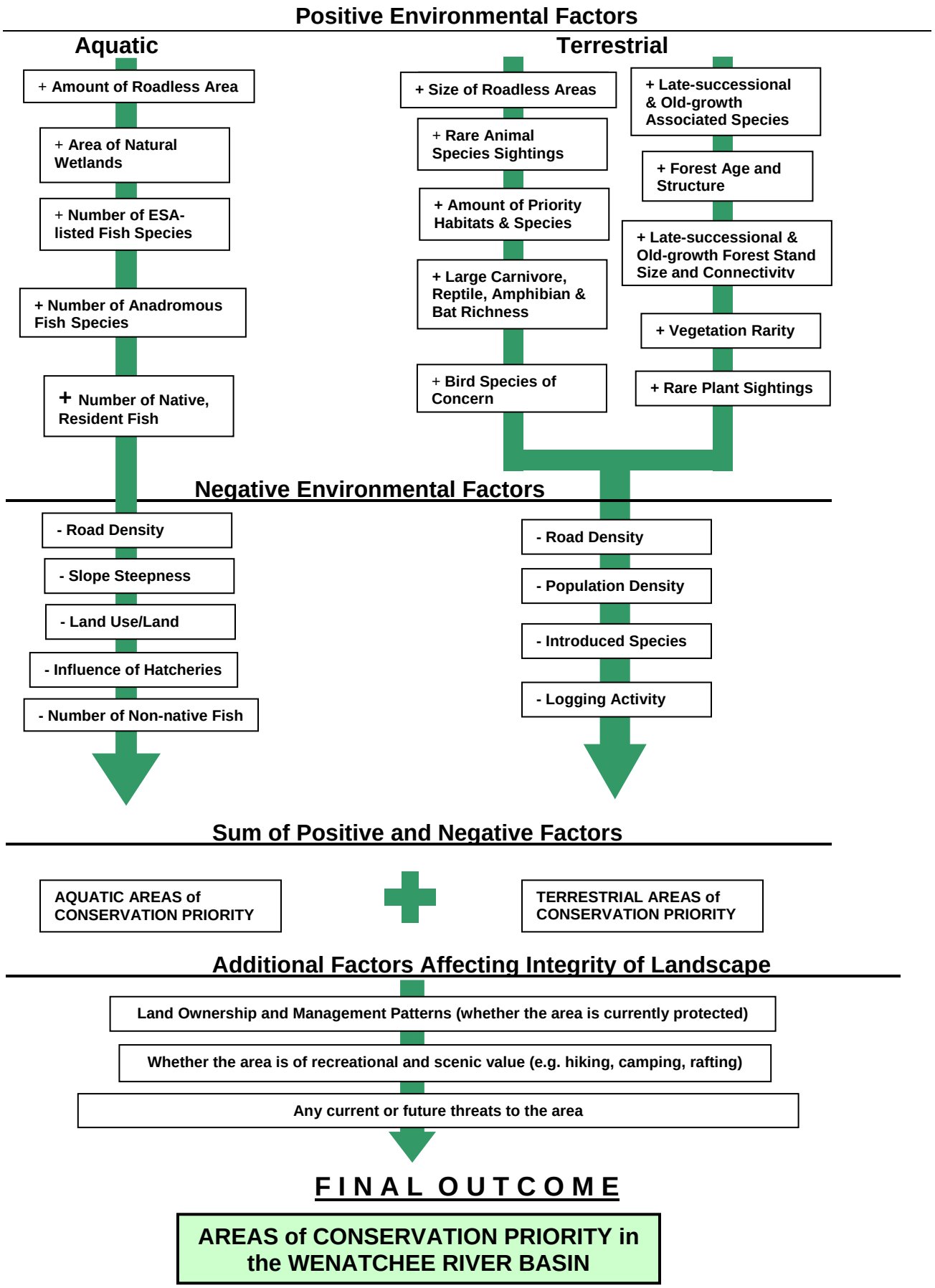
All these factors create an area that is not only of significant value ecologically but also economically. The Wenatchee River Basin is in an area of Washington State that has seen considerable growth over the past decade. The Basin is faced with numerous threats, both current and potential. For this very reason, the Icicle Fund is undertaking an effort to protect what remains of the Basin's tremendous biological, scenic and recreational resources.

This report by the Pacific Biodiversity Institute (PBI) is one piece of a larger project to support the Icicle Fund's decision-making process as it plans a course of action to protect the best remaining habitats in the Basin. This report is a preview of information to be contained in a conservation decision support system. In this report, we present a synthesis of environmental information on the Wenatchee River Basin.

This work provides an initial assessment of the conservation priorities in the Basin, focusing on native, undisturbed ecosystems and rare, threatened, endangered, and special concern species. While not intended to be the final word, the results presented here will enable a focusing of conservation efforts in the Basin and protection of its best remaining habitats. In essence, this report is an initial outline of information and methods to be used to identify and prioritize the most ecologically important and imperiled areas of the Basin -- areas in the greatest need of protection.

To achieve this goal, PBI gathered a vast array of available data on the Basin. Examples include:

- Distributions of threatened, endangered and special concern species of fish, wildlife and plants;
- High-resolution satellite imagery and aerial photography; and,
- Locations and types of threats to the Basin's resources (such as hazardous waste facilities).


Positive Environmental Factors
Aquatic
+ Amount of Roadless Area
+ Area of Natural Wetlands
+ Number of ESA-listed Fish Species
+ Number of Anadromous Fish Species
+ Number of Native, Resident Fish
Terrestrial
+ Size of Roadless Areas
+ Rare Animal Species Sightings
+ Amount of Priority Habitats & Species
+ Large Carnivore, Reptile, Amphibian & Bat Richness
+ Bird Species of Concern
+ Late-successional & Old-growth Associated Species
+ Forest Age and Structure
+ Late-successional & Old-growth Forest Stand Size and Connectivity
+ Vegetation Rarity
+ Rare Plant Sightings
Negative Environmental Factors
- Road Density
- Slope Steepness
- Land Use/Land
- Influence of Hatcheries
- Number of Non-native Fish
- Road Density
- Population Density
- Introduced Species
- Logging Activity
Sum of Positive and Negative Factors
AQUATIC AREAS of CONSERVATION PRIORITY
TERRESTRIAL AREAS of CONSERVATION PRIORITY
Additional Factors Affecting Integrity of Landscape
Land Ownership and Management Patterns (whether the area is currently protected)
Whether the area is of recreational and scenic value (e.g. hiking, camping, rafting)
Any current or future threats to the area
FINAL OUTCOME
AREAS of CONSERVATION PRIORITY in the WENATCHEE RIVER BASIN

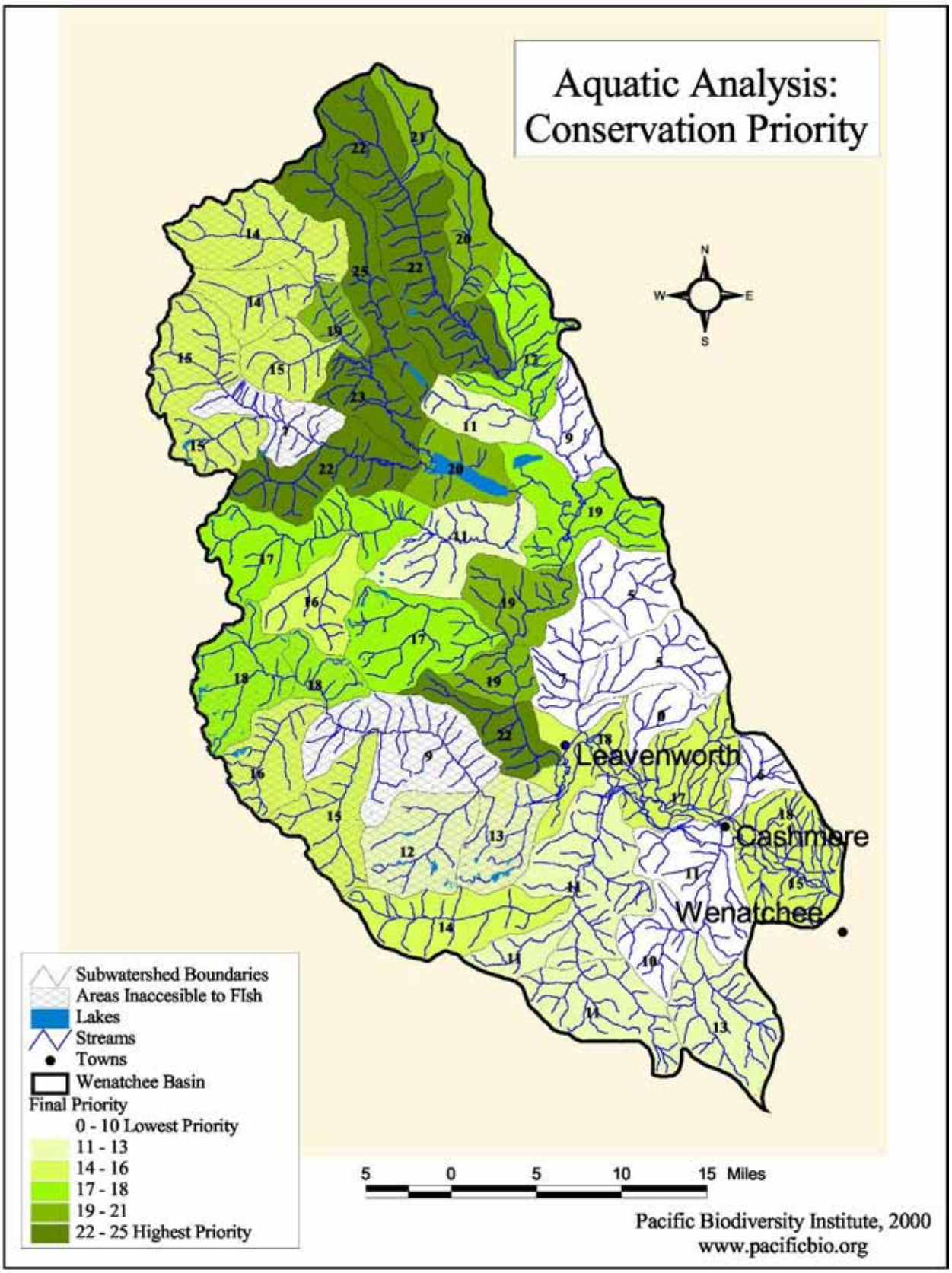
In all, hundreds of pieces of data were collected and synthesized for this report. A visual map of how we integrated the considerable amount of information collected and used to create a conservation prioritization is presented on the preceding page. This flow-chart demonstrates our attempt to present a variety of perspectives on the diverse elements of conservation concern in the Wenatchee River Basin.

In creating this report for the Icicle Fund, PBI first gathered data on the aquatic and terrestrial aspects of the Basin's landscape, focusing on biological and environmental factors that are generally believed to be representative of the full range of conditions for healthy, native ecosystems. From the aquatic standpoint, ten factors were examined, and from the terrestrial viewpoint, fifteen factors were examined.

Each of the aquatic and terrestrial factors was categorized as either positive or negative influences. Positive factors are generally believed to enhance the ecological integrity and/or biodiversity of an area. Negative factors are believed to detract from the ecological integrity and/or biodiversity of an area. The sum of these factors was then overlaid with land ownership patterns, current protection status, and scenic and recreational value. All of this information was then utilized to assess the distribution of high priority areas on each parcel of land in the Basin, in relation to current and future threats.

Collectively, these methods reveal that a considerable portion of the Wenatchee River Basin is of high conservation priority. Specifically, the Chiwawa River, White River, and portions of the Wenatchee River upstream of Lake Wenatchee are of high conservation priority. The Wenatchee River corridor upstream from Leavenworth was also ranked as a high priority area. Many other smaller areas of high conservation priority also exist.

This natural resource profile of the Wenatchee River Basin is a first step toward compiling and analyzing information that is useful in making sound conservation decisions. Many additional pieces of information should also be considered when establishing conservation priorities and taking conservation actions. This document was derived from a report prepared for the Icicle Fund in December 2000.


Aquatic Analysis:
Conservation Priority
N
W
E
S
Leavenworth
Cashmere
Wenatchee
Subwatershed Boundaries
Areas Inaccesible to FIsh
Lakes
Streams
Towns
Wenatchee Basin
Final Priority
0 - 10 Lowest Priority
11 - 13
14 - 16
17 - 18
19 - 21
22 - 25 Highest Priority
5 0 5 10 15 Miles
Pacific Biodiversity Institute, 2000
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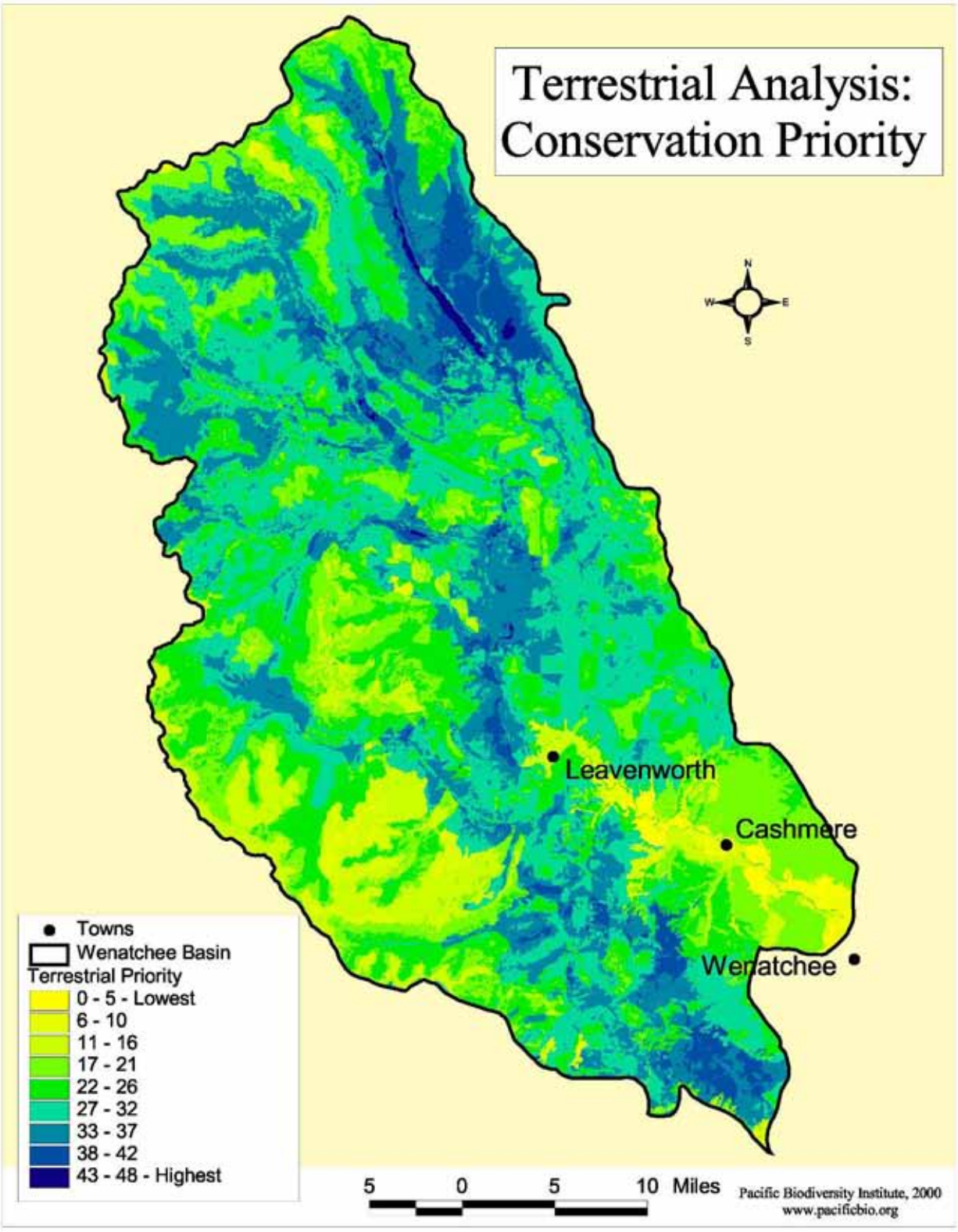
Terrestrial Analysis:
Conservation Priority
N
W
E
S
Leavenworth
Cashmere
Wenatchee
Towns
Wenatchee Basin
Terrestrial Priority
0 - 5 - Lowest
6 - 10
11 - 16
17 - 21
22 - 26
27 - 32
33 - 37
38 - 42
43 - 48 - Highest
5 0 5 10 Miles
Pacific Biodiversity Institute, 2000
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INTRODUCTION

Sunset at Asgard Pass. Photo by Peter Morrison

The conservation of ecological integrity and biodiversity is a challenge that will define this new century. While human alteration of the world's ecosystems has increased (Vitousek et al. 1986, Sisk et al. 1994), significant progress has been made toward conserving species and their habitats at local levels. Historically, although with notable exceptions, conservation efforts have been somewhat opportunistic (e.g., conserving lands that were of high scenic, but not economic potential) and reactive (e.g., lobbying for protection when a species or habitat was greatly imperiled) in nature (Pressey et al. 1993, Scott et al., unpublished manuscript). This has lead to a system of protected areas in the United States, and throughout the world, that is not very representative of the full range of ecological conditions (Pressey 1995, Scott 1999), even though a representative system of reserves has been advocated since at least 1890 (F. Von Meuller address to the Australian Association for the Advancement of Science). An excellent example of this can be seen in the Wenatchee River Basin where the majority of the conservation efforts have been in high-alpine or low productivity areas.

In the Wenatchee River Basin, it is now time to assess the degree to which the system of protected areas that has been established is representative of the full range of environmental conditions. With this information, conservation efforts can be efficiently targeted to areas of highest value. Without this kind of information, conservation efforts will continue to be haphazard and reactive, and the most critical of the Basin's resources may slip away unnoticed.

To aid in the identification of the best and most imperiled habitats in the Wenatchee River Basin, the Icicle Fund commissioned the Pacific Biodiversity Institute (PBI) to conduct an environmental inventory and conservation prioritization for the Basin. Our objective was to conduct an information inventory and complete and initial conservation prioritization for the Wenatchee River Basin from the following information categories:

1. Biologically significant natural areas;
2. Recreational and scenic resources;
3. Land ownership, management and conservation status; and
4. Current and future threats to ecosystem integrity.

In this report, we define the areas of conservation priority for the Wenatchee River Basin, assess the threats to these areas, and make recommendations for ways to use this information and future research needs. This report represents the first phase of PBI's cooperation with the Icicle Fund to provide information resources to facilitate protection of the best remaining habitats in the Wenatchee River Basin.

GEOGRAPHY of the WENATCHEE RIVER BASIN

The Wenatchee River Basin can be defined as all land that drains into the Wenatchee River, a tributary of the Columbia River in central Washington (Figure 1). It lies at the southeast of what is commonly referred to as the Greater North Cascades Ecosystem and covers over 850,000 acres. The major cities and towns in the area are Wenatchee, Cashmere, and Leavenworth. Washington State Route 2 bisects the Basin from east to west. State Route 97 runs from Wenatchee to Cashmere and then up to Blewett Pass at the south of the Basin.

Figure 1. The Wenatchee River Basin, in central Washington.

The Wenatchee River originates in the high-mountains of the Henry M. Jackson Wilderness and flows east into the Columbia River. Other major tributaries in the Wenatchee River Basin are: the Chiwawa River, originating in the Glacier Peak Wilderness and flowing into the Wenatchee River below Lake Wenatchee; the White River, also originating in the Glacier Peak Wilderness and flowing into Lake Wenatchee; Nason Creek, paralleling State Route 2 from its origin near Stevens Pass and flowing into the Wenatchee River below Lake Wenatchee; and Icicle Creek, originating in the Alpine Lakes Wilderness and flowing into the Wenatchee River at Leavenworth.

The area is characterized by a variety of land cover types, from alpine peaks and glaciers to lowland wetlands and shrub-steppe (Figure 2). Most of the area is covered by coniferous forest. The majority of the Basin is in federal ownership (79.4%). Privately owned land (17.2%) is concentrated along the valley bottoms and in the eastern half of the basin (Figure 3). There are also small percentages of Washington State (3.0%) and Bureau of Land Management (BLM) (0.4%) lands in the Basin.

DEFINING CONSERVATION PRIORITIES

Devil's Gulch in the Wenatchee River Basin. Photo by Evan Frost.

Recently, many researchers and conservationists have taken a renewed interest in assessing the relative merit of different pieces of land in an attempt to guide conservation efforts. This has given rise to many different methods for prioritizing landscapes for conservation. Pressey (in press) defined a conservation *priority* as the value assigned to an area combined with an assessment of the urgency with which it should be conserved.

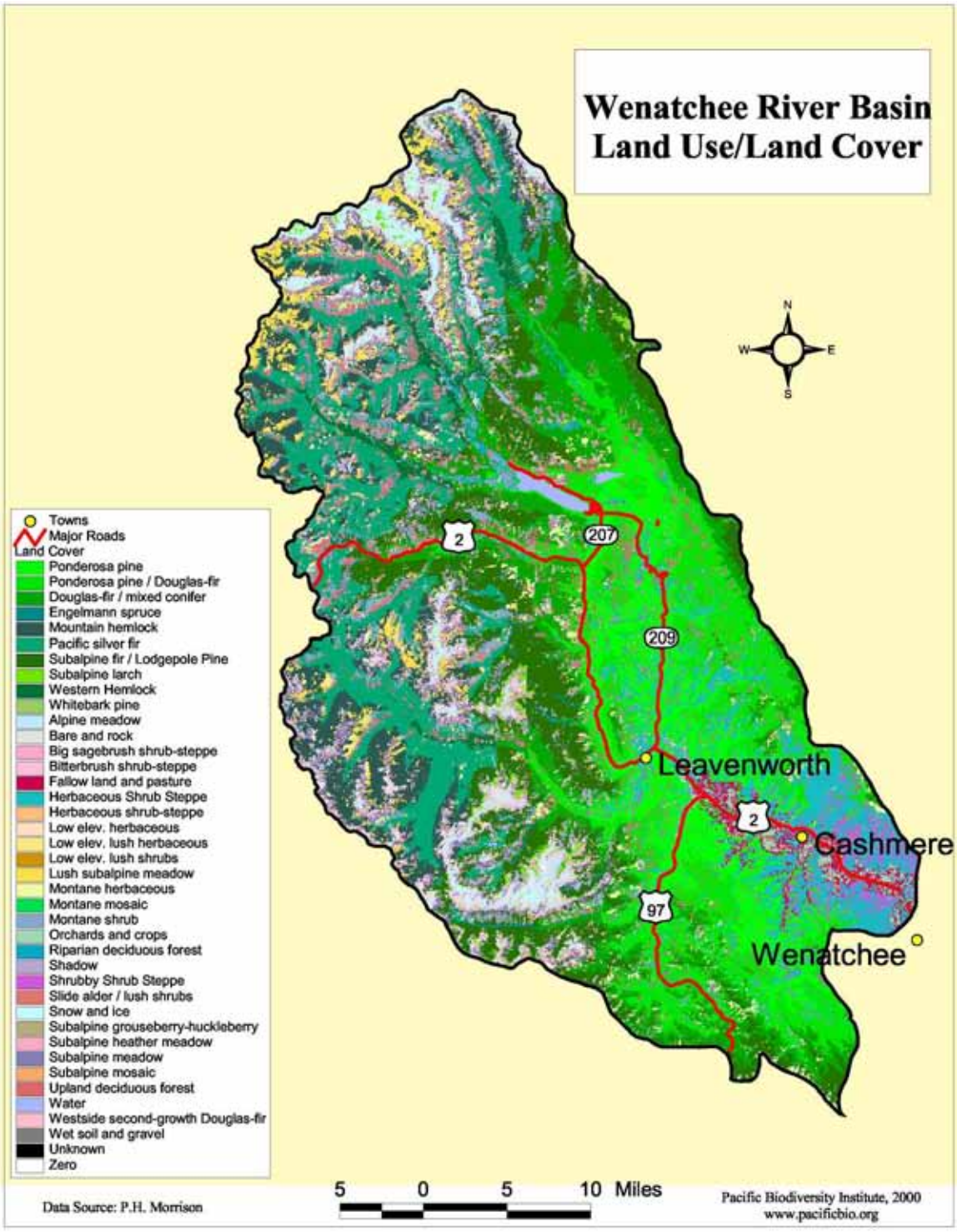


Figure 2. Land Cover in The Wenatchee River Basin.
The Basin is characterized by a variety of land cover types from alpine peaks and glaciers to lowland wetlands and shrub-steppe. The majority of the basin is coniferous forest with some large remaining late-successional and old-growth forests.

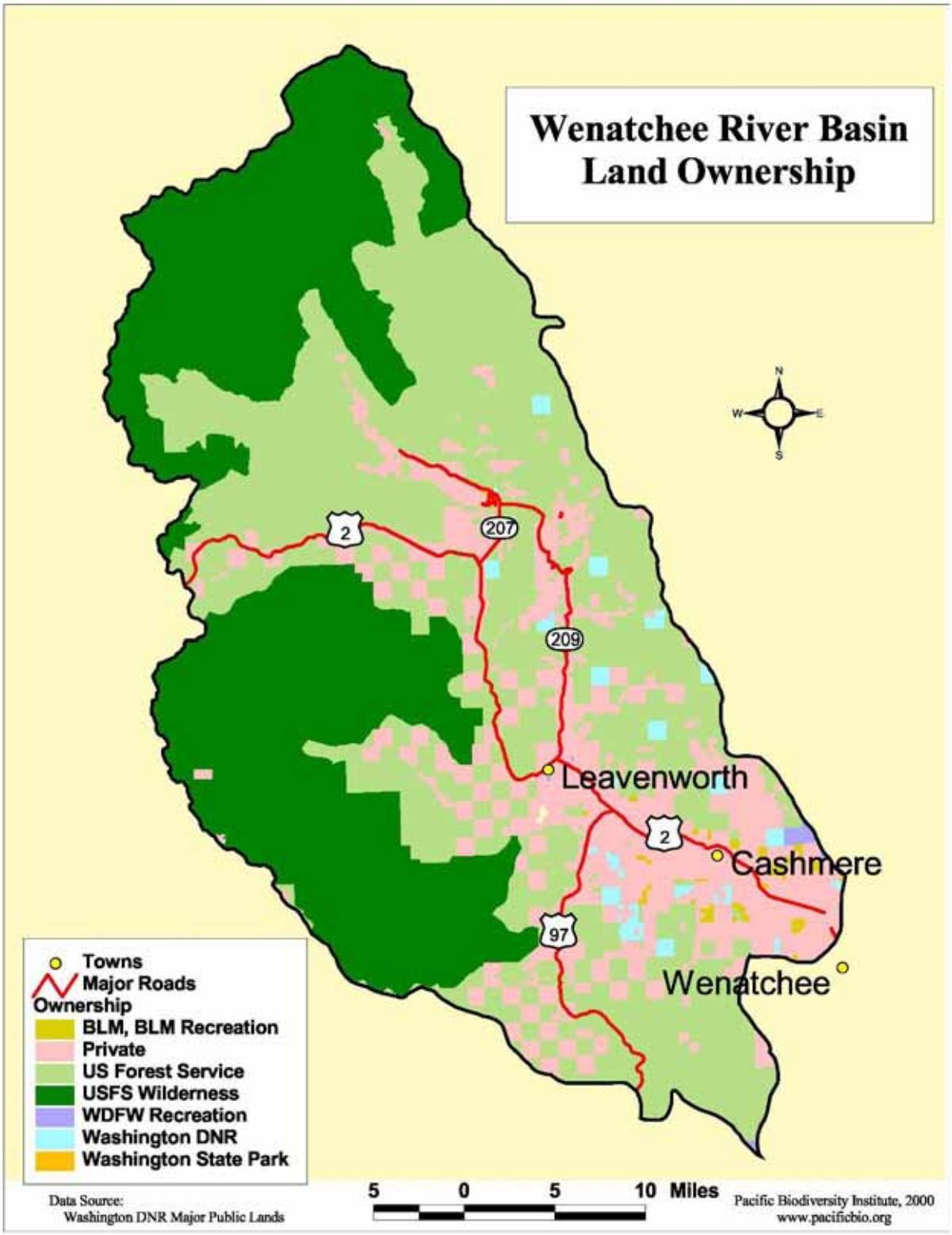


Figure 3. Ownership of the Wenatchee River Basin.
The majority of the Basin is US Forest Service Ownership (79.4%). Private ownership (17.2%) is concentrated along the lower portion of the Wenatchee River.

Thus, in the true sense of the term, a conservation prioritization, the process of assigning to a landscape priorities for protection, takes into account not only the ecological integrity and biodiversity of an area, but also any potential threats.

PBI's prioritization of the Wenatchee River Basin was completed in a series of phases. In the first phase, we conducted an inventory of all available Geographic Information System (GIS) and database information covering the Wenatchee River Basin that would be useful in the conservation prioritization and the forthcoming decision support system. The second phase consisted of evaluating the ecological integrity and biodiversity of the Basin from two different viewpoints: aquatic and terrestrial. The third phase looked at the scenic and recreational resources in the Basin. The fourth phase assessed the current and future threats to ecological integrity and biodiversity in the Basin. The final phase integrated the previous phases into a comprehensive prioritization of the best and most threatened habitats in the Wenatchee River Basin.

Conservation prioritization of a landscape requires decisions about which aspects of the environment to look at and include. However, the choice of different aspects may lead to different results. For example, a prioritization of habitat for late-successional and old-growth species would emphasize different parts of a landscape that one focusing on shrub-steppe species. This does not mean than one prioritization is right and the other is wrong; it simply reflects differences in opinion as to which are the most important aspects to conserve. Thus it is important that clear objectives be defined before a prioritization is implemented and land-management decisions are made.

In crafting our conservation prioritization for the Wenatchee River Basin, we have made several decisions as to which elements of the environment are in need of conservation, and those factors imperiling them. Our prioritization focuses on native, undisturbed ecosystems and rare, threatened, endangered, and special concern species. We do not intend for this to be the final prioritization of the Wenatchee River Basin, just an example of methods of ranking the value of the land within it so that the best remaining habitats in the Basin may be conserved.

Because of the variability associated with different conservation prioritizations, it is often helpful to conduct two or more independent prioritizations and look for areas that receive high priority in each. This does not mean that areas receiving high priority in one but not another are not of significant conservation value. A dam or barrier to fish passage may exclude anadromous salmonids from a portion of the landscape that has high ecological integrity and biodiversity values. Thus each prioritization should be carefully evaluated in the context of those factors included in and the objectives of the prioritization.

Wenatchee River riparian forest
Photo by Peter Morrison.

DATA INVENTORY

PBI conducted an extensive search of the spatial (GIS) and database data available to conduct a conservation prioritization of the Wenatchee River Basin. PBI constructed a database in Microsoft Access to organize information for each data set on the following topics: data type, general theme of data (Table 1), source, date of publication, resolution, projection (for spatial data), accuracy, completeness, and coverage of the Wenatchee River Basin. We then evaluated each data set, providing detailed descriptions, comments, and suggested appropriate uses for the Icicle Fund's projects. The data were then clipped to the Wenatchee River Basin boundary and organized in directories in preparation for the conservation prioritization and their eventual use in a decision support system created by PBI for the Icicle Fund. All data were converted to several standard formats: Arc/Info coverages for vector GIS data, Arc/Info grids for raster-based GIS data, and ERDAS Imagine files for imagery. Complete metadata documenting the origin, date, attributes, and scale of each data set was collected or generated by PBI.

Table 1. General data themes used for organizing data collected for the Wenatchee River Basin data inventory.

Theme	Examples of Data Sets
Demography	US Census blocks and population data
Digital Elevation Models (DEM)	Topographic data
Environmental Quality	Washington Department of Ecology licensed hazardous waste facilities
Fish and Wildlife	Distribution of fish and wildlife species and habitats
Geology	Mineral deposits and mines
Hydrography	Streams and rivers, lakes
Imagery	Aerial photography and satellite imagery
Management	USFS management designations, logging activity
Other	Town locations, USGS 7.5' quadrangle boundaries
Ownership	Land ownership, parcel boundaries and data
Recreation	Trails
Transportation	Roads, railroads
Vegetation	Land cover, late-successional and old-growth forest mapping

At the date of this report, PBI had collected and documented 84 data layers (some were general data sources that consist of 100 or more individual data layers) that were either used in this prioritization or would be of general use to the Icicle Fund's conservation

efforts across the Wenatchee River Basin (Table 2). Figure 4 shows an example from the Wenatchee River Basin Data Inventory Database.

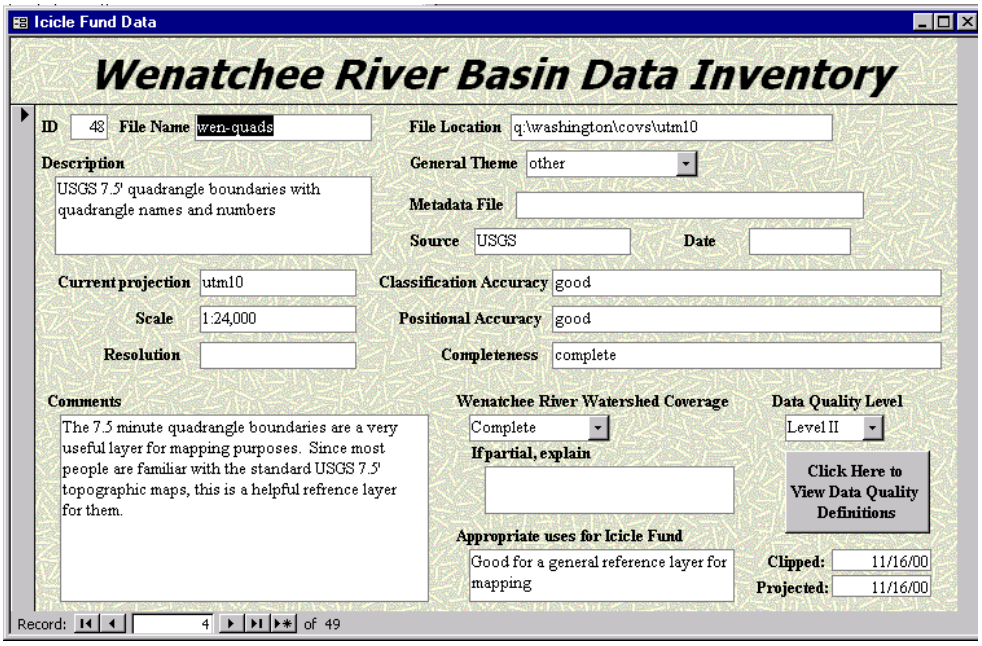


Figure 4. Example data evaluation sheet from the Wenatchee River Basin Data Inventory.

Table 2. Distribution of data layers in the Wenatchee River Basin Data Inventory Database by general data theme.

Theme	Number of Datasets
Demography	5
DEMs	6
Environmental Quality	1
Fish and Wildlife	5[1]
Geology	6
Hydrography	12
Imagery	8[2]
Management	14
Other	5
Ownership	6
Recreation	2
Transportation	5
Vegetation	9

[1.] Number of general data sources (e.g., WDFW Streamnet, WA-GAP) actual number of data layers is several hundred.

[2.] Includes some general data sources (e.g., 7.5' USGS Digital Raster Graphics, 7.5' Digital Ortho-photography). Actual number of data files is over 100.

Demography data came from the 1990 census data from the US Census Bureau. Census data from 2000 is not expected to be available until fall of 2001. When it becomes available, however, these data should be obtained and entered into the Wenatchee River Basin Data Inventory. Year 2000 census data would not only give more reliable estimates of population demography in the Basin, but would also allow calculations of growth rates that could be used as an indicator of potential threat to the Basin's natural systems.

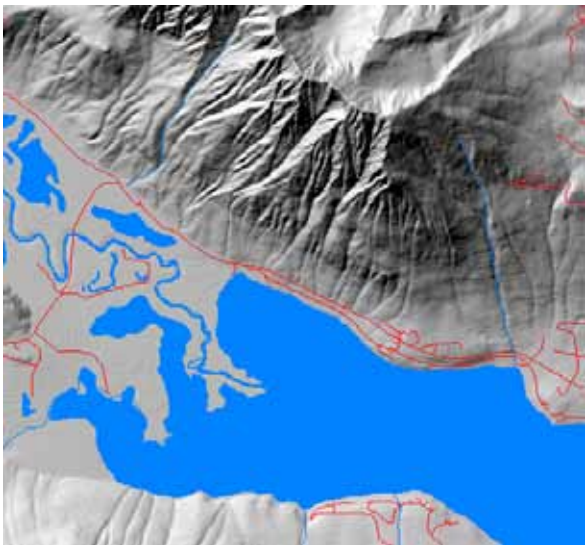


Figure 5 An example of a shaded relief map derived from a 10m DEM for the western portion of Lake Wenatchee. Lakes and streams are shown in blue and roads are shown in red for reference.

Digital Elevation Models (DEMs) are GIS layers representing the elevation of a given area. These data can be (and were) converted into many other useful products such as contour lines, slope and aspect calculations, and shaded relief maps (Figure 5). The highest resolution DEMs have 10m cell size (meaning each cell or pixel in the data layer has dimensions of 10m by 10m). These give the best topographic views of the Basin. Because the 10m DEMs (and its derived products) are so large, we have included a 30m DEM and shaded relief layer for the Basin. These are adequate for applications across the entire Basin.

Figure 6. 1998 Digital Ortho-photograph of the upper end of Lake Wenatchee where the White and Wenatchee Rivers empty into the lake.

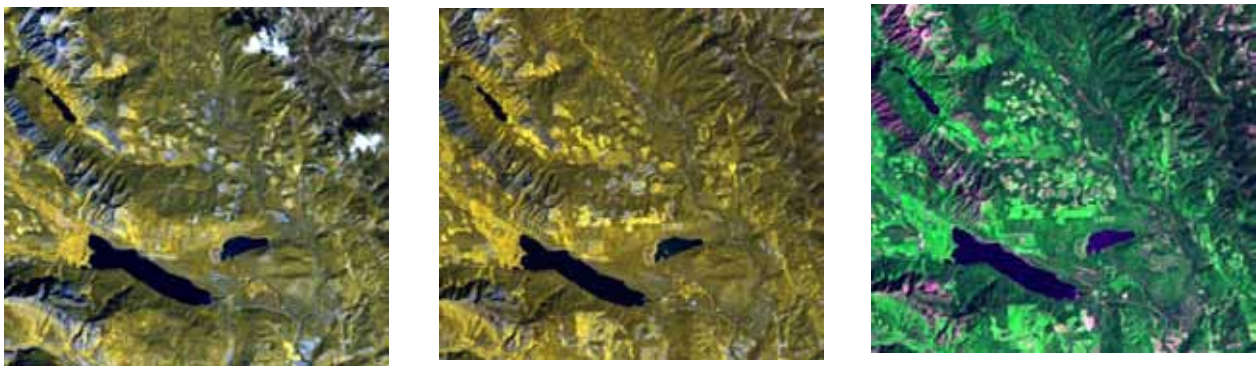
The environmental quality data consists of the Washington Department of Ecology's database of licensed hazardous waste facilities. This database included all of the U.S. Environmental Protection Agency's licensed facilities as well. This database tracks those facilities that produce, store, and dispose of hazardous wastes. This information is useful for assessing current pollution sources and potential sources of pollution in the Basin.

The fish and wildlife data category contains several hundred data layers describing the distribution of fish and wildlife species in the Basin. Data on fish distribution came from the Washington Department of Fish and Wildlife's (WDFW) Streamnet database that records stream segments with known fish populations. Rare, threatened, endangered and sensitive wildlife species observations are recorded in WDFW's Heritage database. Predicted distributions for all terrestrial vertebrates in Washington were collected from the Washington Gap Analysis Program (Cassidy et al. 1997).

Geology data for the Wenatchee River Basin consists of information on mines, mineral deposits, soils (for the Wenatchee National Forest only), and major rock types.

Hydrography data consists of information describing waterways and their location in the landscape. Information on streams, rivers, wetlands, and lakes was obtained from several sources and at differing scales. The boundaries of the Wenatchee River Basin and its sub-basins (or subwatersheds) were taken from the Interior Columbia Basin Ecosystem Management Project (ICBEMP). PBI also collected information on dams and other natural barriers to fish passage (e.g., waterfalls).

Imagery for the Wenatchee River Basin came from several different sources. The highest resolution imagery, digital ortho-photography, has a resolution of 1 m (Figure 6). This type of imagery is very useful for visual interpretation of GIS data and site analyses. The ortho-photography for the Wenatchee River Basin was taken mostly in 1998. A few sections of the Wilderness Areas were taken in 1990. Other imagery for the Basin comes from earth-observing satellites. This imagery was acquired for the time period of 1972 to 1999. Although it is not as high resolution as the digital ortho-photography, it is quite useful for assessing land use and land cover and their change over time (Figure 7).



1973 **1985** **1992**

Figure 7. Satellite image sequence for the Lake Wenatchee area from 1973 to 1992 showing the progression of logging activity around the lake.

Information on the management of land was most readily available for the Wenatchee National Forest lands. This information describes the current management designations of the land as well as areas of past logging activity. PBI is currently trying to get management designations and past logging information for Washington State lands in the Basin. Management information and prior logging activities are not widely available for private lands. While some management information can be inferred from land ownership (i.e., lands owned by logging companies tend to be logged), this information is often inconclusive and difficult to quantify. PBI has, using digital ortho-photography and satellite imagery, digitized most of the large-scale logging activities on private lands. We included in this category roadless areas inventoried by the US Forest Service as well as those delineated by PBI.

The other category includes themes of general reference that could not be fit into any of the other categories. These included USGS topographic map boundaries, common-place names for geographic features such as mountain peaks and canyons, town names, and county boundaries.

Ownership information for the Wenatchee River Basin was obtained from several sources. The best source of ownership information across the Basin is the Washington DNR's Major Public Lands layer. The Major Public Lands layer included in the inventory (and upon which some of our analyses was based) was current as of March 2000. We are currently in the process of obtaining a more recent update from Washington DNR.

There is little existing information on recreation and scenic potential in the Wenatchee River Basin. For this category, we included a layer of hiking and four-wheel-drive trails, campgrounds, popular rock climbing areas, popular whitewater rafting rivers, and potential fishing areas. PBI developed many of these data layers based off of our knowledge of the Basin. This is one of the poorest of the data categories and much effort should be invested in acquiring or compiling data for this category.

Transportation information for the Wenatchee River Basin came largely from two sources: Washington DNR, and the Wenatchee National Forest. The Wenatchee National Forest maintains information on roads within its administrative boundaries. Washington DNR maintains roads information for state, and private lands. For many of our analyses, we used a combination of these two data sources. We also included a layer of railroads in the Basin.

Vegetation data consisted of both general layers, such as land-cover types (see Figure 2), and specific layers, such as locations of rare, threatened or endangered plant species, from many sources. Data on rare, threatened, or endangered plant locations came from the Washington DNR Heritage database. This category also included several late-successional and old-growth layers and a vegetation rarity index.

LAND OWNERSHIP AND PROTECTION STATUS

Protection status is an important factor to consider when determining conservation priorities in a landscape. Obviously, if an area is already protected then it doesn't need further major conservation action. For most purposes one can mask out the protected areas and only consider the unprotected part of the landscape. But it is also important to consider the conservation values contained within protected areas as they may greatly influence surrounding areas. The proximity to a protected area may be an important factor to consider when prioritizing a landscape.

We created three GIS layers of protected areas. The primary protection layer consisted of Wilderness Areas, USFS Research Natural Areas, and Washington State Parks. These areas receive permanent protection from all of the categories of threat listed above with the exception of alien plant invasions. The secondary protection layer contained administratively withdrawn areas such as Late-successional Reserves, USFS Inventoried Roadless Areas, and Riparian Reserves. These are areas that currently receive some degree of protection, but are open to some of the threat categories listed below and their protection status could change as the political climate changes in the United States. The tertiary protection layer consists of the distribution of all public lands (without regard to their 1^{st} and 2^{nd} order protection status).

Protection status of lands in the Wenatchee River Basin can be divided into four categories. Approximately 322,943 ac receive permanent protection as Wilderness, State Park, Research Natural Area, Natural Area Preserve, or Wild and Scenic River (Table 3, Figure 8). PBI gave these lands the designation of Protection Level 1. An additional 258,205 ac currently receive some degree of administrative protection from the US Forest Service. These areas include riparian reserves, late-successional reserves, and official inventoried roadless areas on National Forest land. While there are management mandates restricting the management activities that can occur in these areas such as logging and road building, some management can occur when it is deemed to be in accordance with the management objectives of the land's designation (e.g., thinning of forests in an attempt to promote old-growth forest characteristics, or motorized recreation use). PBI has defined these areas as Protection Level 2. With Level 2 lands, there is a possibility that their status could easily be changed by administrative edict. The third protection category is unprotected public lands. These lands usually will not be subject to intensive development (residential, commercial or industrial development) but are unprotected from many management activities that can greatly alter their natural condition. The fourth protection category is unprotected private lands. As of the date of this report, there were no finalized conservation easements on private lands in the Wenatchee River Basin. Hence, all of the private lands fall into this last protection category and currently are unprotected from all development.

Table 3. Protection Level 1 lands in the Wenatchee River Basin. Protection Level 1 status was assigned to any area with a management mandate that provides permanent protection against management practices that negatively impact their natural environments.

Management Designation	**Acres**
USFS Wilderness	318,510
USFS Research Natural Area	189
USFS Natural Area Preserve	501
USFS Special Interest Area	1,072
Washington State Park	340
USFS Wild and Scenic River	2,331

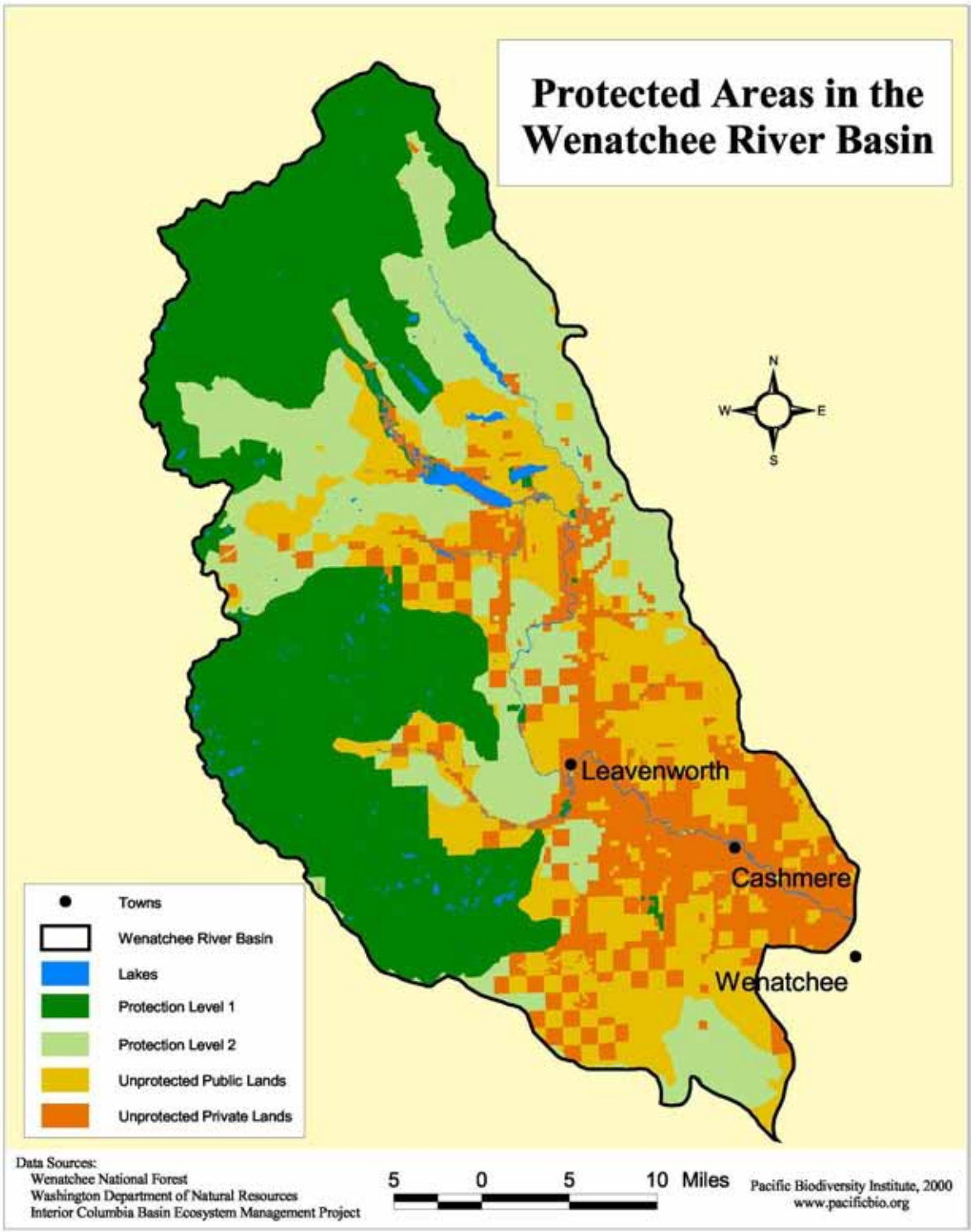


Figure 8. Protection status of lands in the Wenatchee River Basin.
Protection Level 1 status was assigned to any area with a management mandate that provides permanent protection against practices that negatively impact their natural environments. Protection Level 2 status was assigned to any area with non-permanent management mandates providing some degree of protection from practices that negatively impact their natural environments.

BIOLOGICAL RESOURCES

Looking southeast from Buck Creek Pass. Photo by Peter Morrison.

Although they are very much integrated in reality, for the purposes of conservation prioritization it is useful to analyze aquatic and terrestrial systems separately. Aquatic and terrestrial systems are sensitive and react differently to different types of environmental factors. Additionally, aquatic systems account for only a small portion of the landscape and their significance is often overlooked in terrestrial habitat prioritizations. For these reasons, we have prioritized the Wenatchee River Basin using two distinct methods: aquatic and terrestrial.

Aquatic Prioritization

The first prioritization was aquatic-based, focusing on those features of the environment that contribute to or detract from fish habitat (primarily native salmonids). Because many factors affecting water quality operate outside of the immediate stream/river channel, we have used 6th field hydrologic unit code (HUC) watersheds developed by the US Environmental Protection Agency (EPA) as our prioritization unit. Each subwatershed was analyzed according to ten factors that serve as indicators of, or contributors to, the overall health, diversity, and productivity of aquatic ecosystems and the species inhabiting them (Table 4). The factors were categorized as either positive factors, those that contributed to ecological integrity, or negative factors, those that diminished the ecological functioning of a subwatershed.

Accessibility and biogeographic distribution factors were considered separately. We mapped naturally inaccessible areas and areas above dams. These factors influence the use of subwatersheds by fish. Areas of high ecological integrity inaccessible to fish may provide off-site functions that are important to sustaining downstream ecological integrity. Landscape ratings for all areas of the Wenatchee Basin are provided in this report.

Our approach was based on a quantitative analysis and ranking of the above factors across individual subwatersheds. We based our study on digital spatial databases (GIS layers) that uniformly covered the entire Wenatchee Basin. In this study, the selected GIS coverages were used to assess the condition of each subwatershed. This study resulted in a ranking of ecological integrity, from an aquatic standpoint, of all subwatersheds in the Basin.

Table 4. Factors used in the aquatic prioritization of the Wenatchee River Basin. Positive factors contributed to the overall priority of an area, whereas negative factors detract from it. Each of these factors were calculated for each subwatershed and summed to get the overall priority for the Basin.

Factor	Influence	Rank
Ecological Integrity		
Area of Natural Wetlands	Positive	0 to 5 based on area of natural wetlands per subwatershed
Amount of Roadless Areas	Positive	0 to 5 based on amount roadless in subwatershed
Road Density	Negative	0 to 5 based on total length of roads per subwatershed
Slope Steepness	Negative	0 to 5 based on the percent of subwatershed with greater than 30 percent slope
Land Use/Land Cover	Negative	0 to 5 based on the amount of developed land per subwatershed
Fish		
Number of ESA-listed Fish Species	Positive	0 to 5 based on the number of ESA-listed fish species present per subwatershed
Number of Anadromous Fish Species	Positive	0 to 5 based on the number of anadromous fish species present per subwatershed
Number of Native, Resident Fish Species	Positive	0 to 5 based on the number of native, resident fish species present per subwatershed
Hatchery Influence	Negative	0 to 5 based on the proximity and number of hatcheries, net pens and rearing ponds per subwatershed.
Number of Non-native Fish Species	Negative	0 to 5 based the number of non-native fish species present per subwatershed

The following layers were developed and used in the landscape-level subwatershed prioritization GIS analysis of aquatic habitat in the Wenatchee Basin:

Aquatic Landscape Condition Factors

Total Area In Natural Wetlands

Naturally functioning wetlands contribute to aquatic productivity and population health through their beneficial effects on water quality and quantity, as well as the fact that many wetlands serve directly as habitat for salmon. Natural wetlands that have not been drained or unduly modified were selected from the National Wetland Inventory GIS data and intersected with the subwatershed layer, attributing each wetland polygon with the number of the subwatershed in which it was situated. The total area of inventoried natural wetlands in each subwatershed was then calculated. The total values for all subwatersheds in the

Wenatchee River Basin were then grouped into five equal-area divisions plus a zero class, and coded as such (Figure 9). The total natural wetland value was then used as a positive factor in the subsequent landscape-level subwatershed prioritization.

Roadless Areas

This GIS layer was created by PBI from a combination of road data from the Forest Service and DNR. Roadless and undeveloped habitat areas were defined to be areas beyond a road-effect zone of 10 m from a road centerline (Forman 2000, Forman and Deblinger 2000, Haskell 2000) and greater than 1,000 ac (400 ha) in size (Henjum et al. 1994). Undeveloped habitat areas were mapped on all ownerships.

This layer was then intersected with the subwatershed layer and the percentage of each subwatershed in roadless and undeveloped condition was calculated. The result was grouped into five equal-area categories, plus a zero category (Figure 10). This resulted in each subwatershed receiving a code ranging from 0 to 5 representing its undeveloped habitat condition based on the amount of undeveloped habitat. This variable was use as a positive factor in the subsequent landscape-level subwatershed prioritization.

Road Density

Roads pose a wide range of threats to aquatic habitats (Trombulak and Frissell 2000). Road density is a reasonable direct or indirect measure of these combined influences (e.g., see Baxter et al. 1999). The Washington DNR road layer was intersected with the subwatershed layer so that each road segment was attributed to the number of the subwatershed in which it is situated. The total road length in each subwatershed was then calculated. The total length was then divided by the total subwatershed area to arrive at the road density for each subwatershed, expressed in kilometers per square kilometers. The calculated road density for all subwatersheds in the Wenatchee River Basin was grouped into five equal area classes and coded from one to five (Figure 11). Subwatersheds with no roads were coded as zero. This final road density value was then used as a negative factor in the subsequent landscape-level subwatershed prioritization.

Subwatershed Slope Steepness

PBI assumed that the proportion of a watershed with relatively steep slopes (greater than 30 percent) represented its proneness to accelerated landslides and other slope erosion as a result of human disturbance. Another way to view this assumption is that watersheds with fewer erosion-prone areas may be more resistant or resilient to a given level of disruption of natural land cover. A slope-steepness GIS layer was calculated from 10-m digital elevation data from the US Geological Survey (USGS). The original 7.5 minute USGS quad level digital elevation model (DEM) data was merged and resampled by H. Greenberg at the University of Washington's Department of Geological Sciences. PBI calculated the percent of each subwatershed with a slope of more than 30 percent and attributed the subwatersheds with this value. The result was then grouped into five equal-area categories (Figure 12). The resulting slope steepness value was used as a negative factor in the subsequent landscape-level subwatershed prioritization.

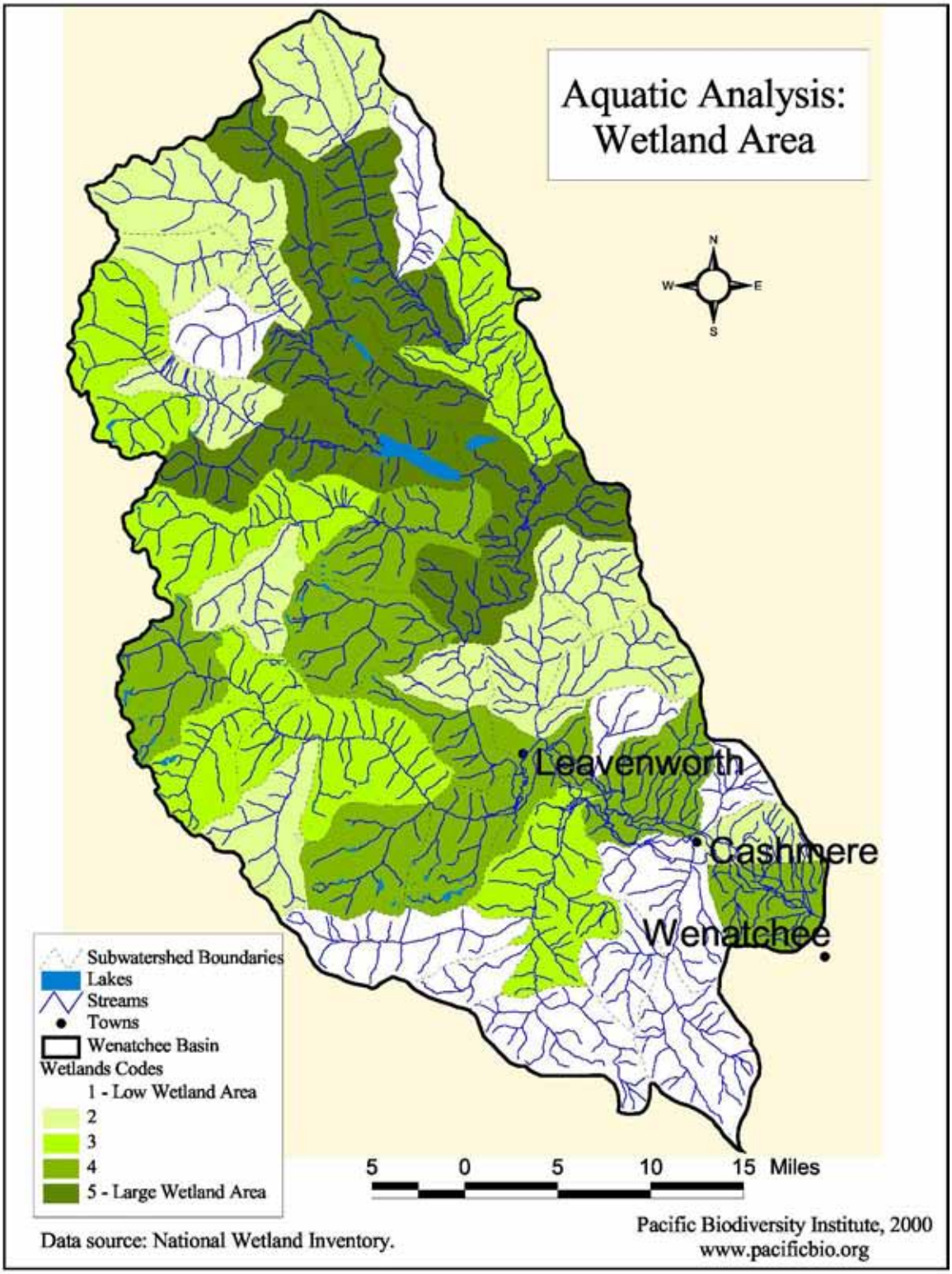


Figure 9. Total wetland area rankings for Wenatchee River Basin subwatersheds. High values (dark green) indicate subwatersheds with a high percentage of natural wetlands, adding to aquatic priority. This was used as a positive factor in the aquatic analysis.

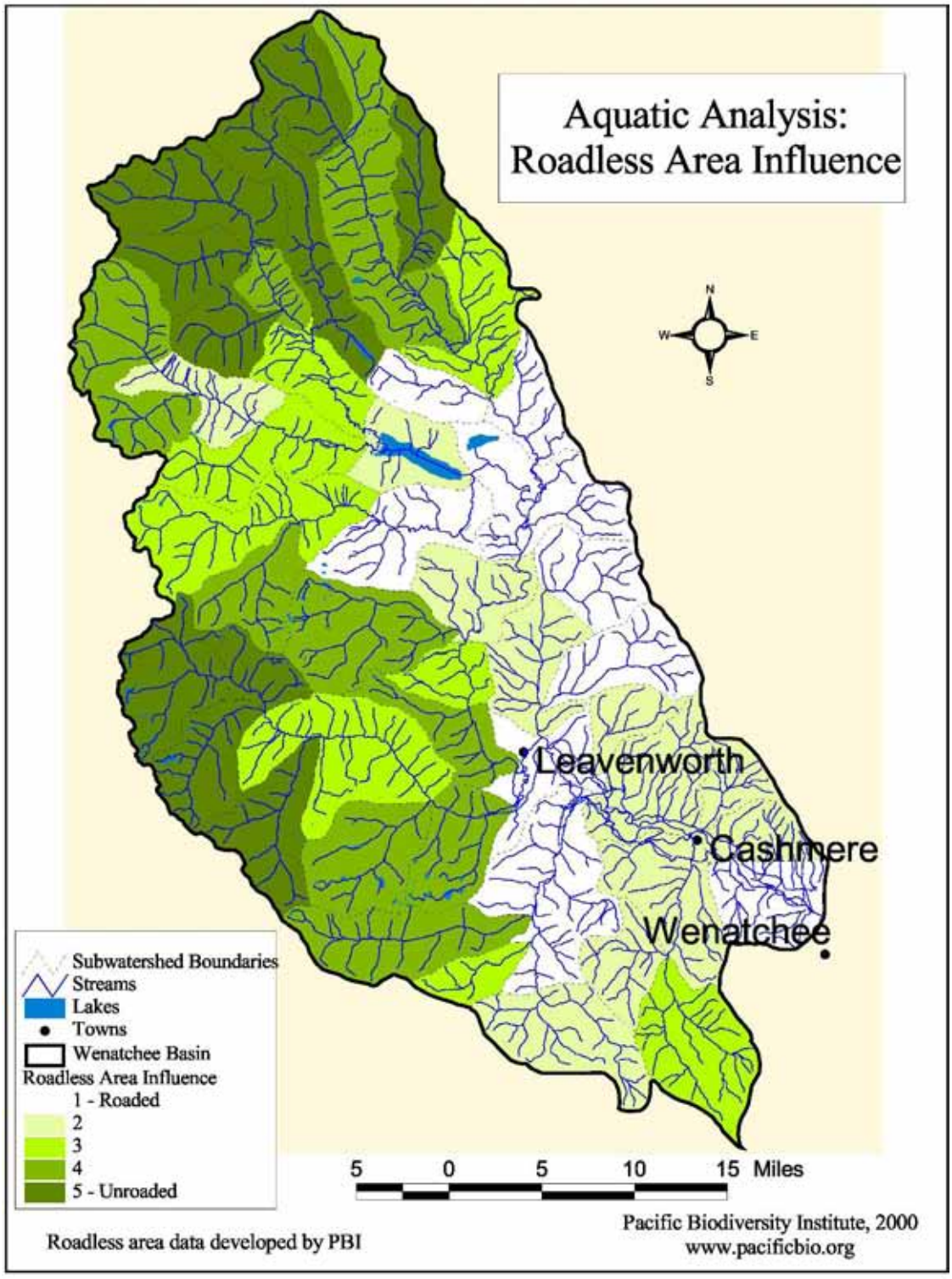


Figure 10. Roadless area influence for Wenatchee River Basin subwatersheds. High values (dark green) indicate subwatersheds with a high percentage of roadless areas, adding to aquatic priority. This was used as a positive factor in the aquatic analysis.

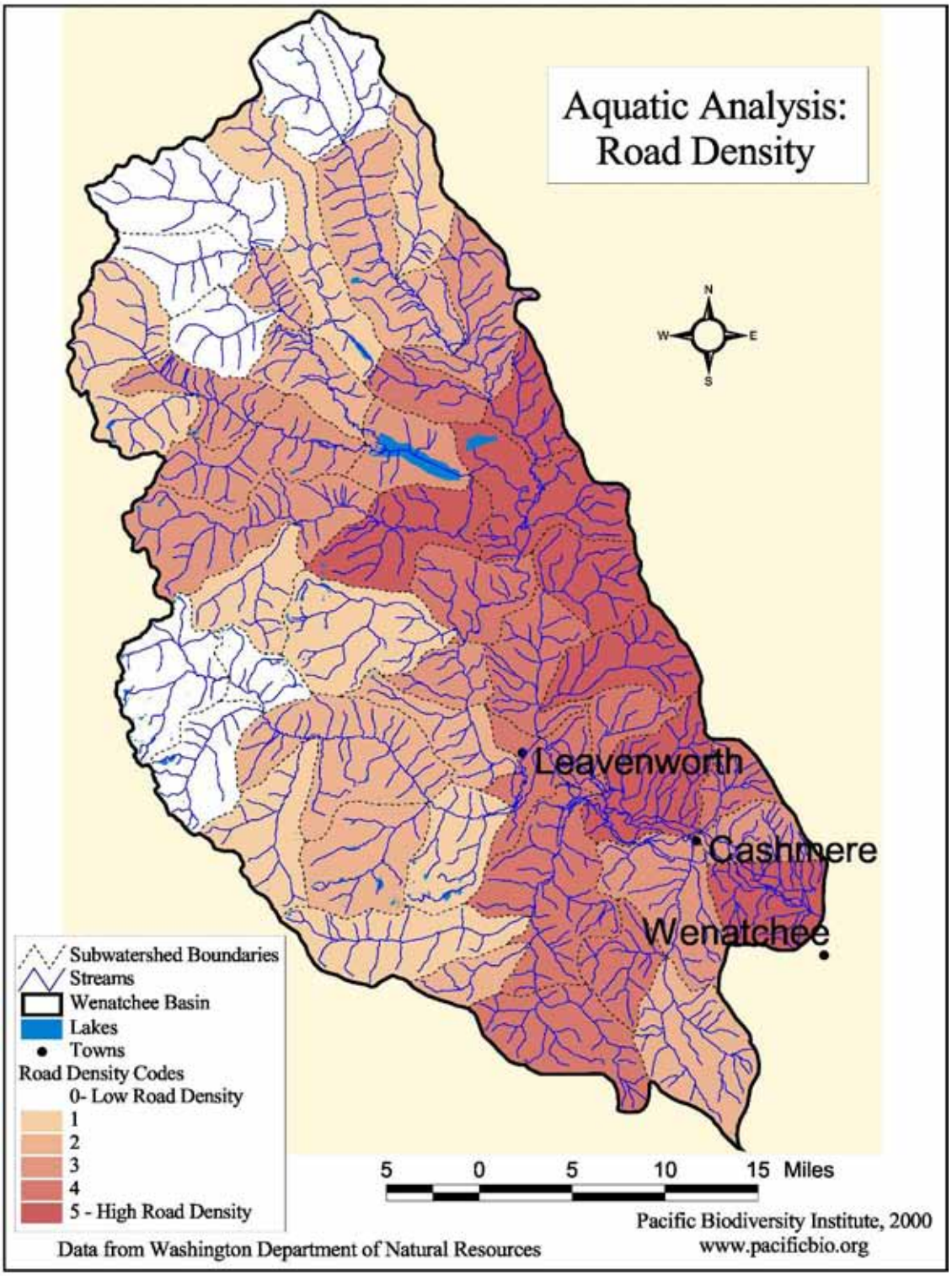


Figure 11. Road density rankings for Wenatchee River Basin subwatersheds. High values (dark red) indicate subwatersheds with the greatest amount of roads, detracting from aquatic priority. This was used as a negative factor in the aquatic analysis.

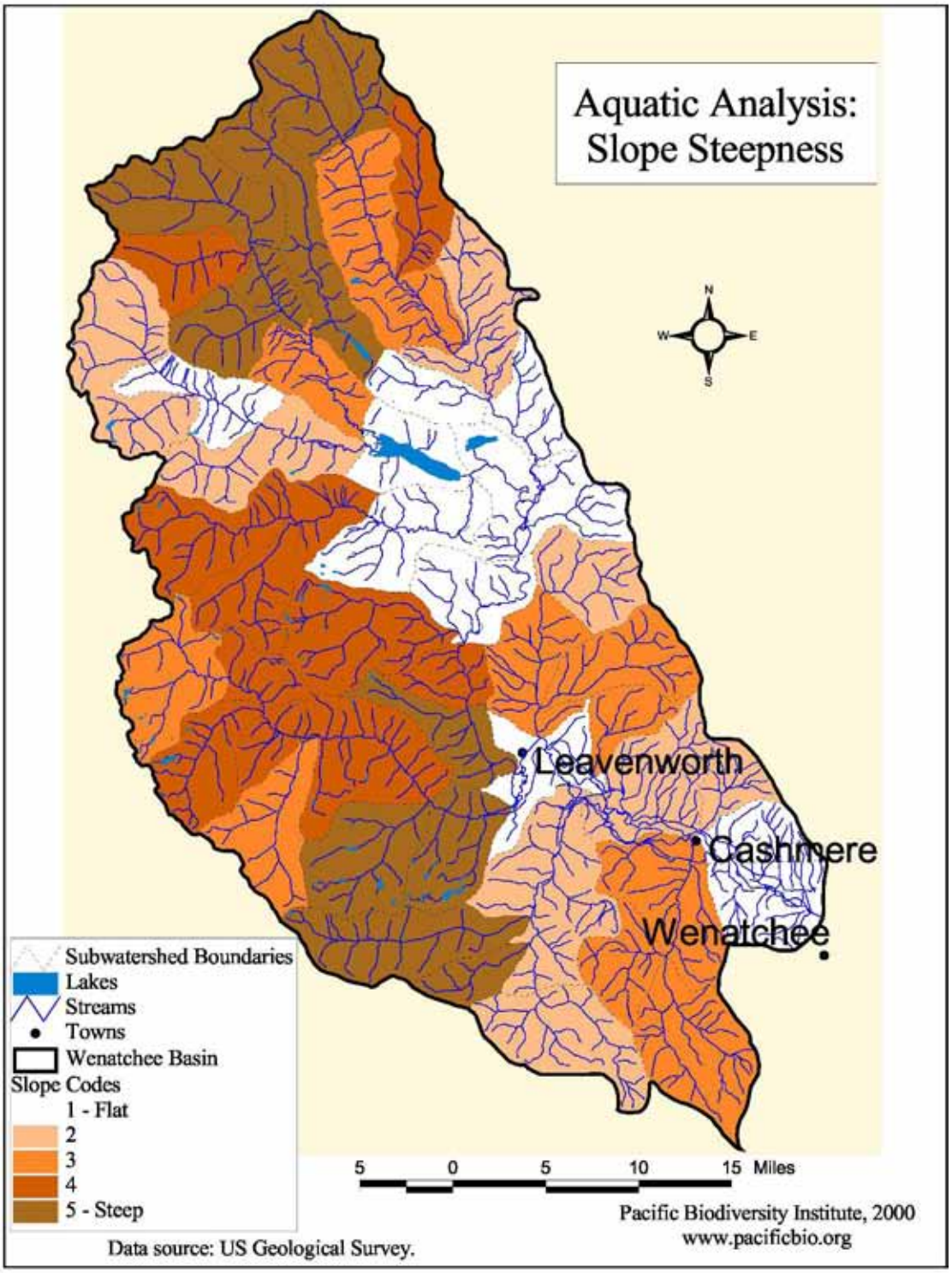


Figure 12. Subwatershed slope steepness rankings for Wenatchee River Basin subwatersheds. High values (dark red) indicate subwatersheds with a high percentage of steep slopes, detracting from aquatic priority. This was used as a negative factor in the aquatic analysis.

Land Use/Land Cover

PBI used Land Use/Land Cover data developed by the USGS from Landsat Thematic Mapper 30-m imagery acquired in 1993. This data identifies 21 land use and land cover types. We grouped the developed areas into two habitat groups, which reflect the potential influence of each class on aquatic integrity in the subwatershed (Table 5). We calculated the percentage of each subwatershed in codes one and two. This gives greater weight to the more detrimental effects of land use class two. These values were then sliced into three categories; values from 0 to 5 were coded as 0, values from 5 to 10 were coded as 3, and values over 10 were coded as 5. (Figure 13). The resulting factor was used as a negative factor.

Table 5. Land use / Land cover code groupings

Land Use / Land Cover Type	Habitat Group
Developed	2
Quarries/Strip Mines/Gravel Pits	2
Transitional Forest Upland (clearcuts)	1
Orchards/Vineyards	1
Agricultural Land	1

ESA-Listed and Special Concern Fish Species

Waterways with threatened, endangered, or special concern species and the lands contributing to these should be protected to ensure the long-term survival of these species in the Wenatchee River Basin and throughout their range. Data from the Washington Department of Fish and Wildlife's (WDFW) Streamnet database was used to map threatened, endangered and special concern fish distribution in the Wenatchee River Basin (Table 6, Figure 14). The number of threatened, endangered, and special concern fish species occurring in each subwatershed was used as a positive factor in our analysis.

The Streamnet data are recorded by stream reach using event tables in ArcInfo. A layer was created for each fish species. These individual species layers were appended into a single layer, which was then intersected with the subwatershed layer. It was then possible to sum the number of species present for each subwatershed.

Table 6. Threatened or Endangered Fish Present in the Wenatchee River Basin.

Common Name	Scientific Name
Dolly Varden/Bulltrout	*Salvelinus confluentus*
Kokanee Salmon	*Oncorhynchus nerka*
Rainbow Trout	*Oncorhynchus mykiss*
West Slope Cutthroat	*Oncorhynchus clarki*
Spring Run Chinook Salmon	*Oncorhynchus tschawytscha*
Summer Run Chinook Salmon	*Oncorhynchus tschawytscha*
Sockeye Salmon	*Oncorhynchus nerka*
Summer Run Steelhead Salmon	*Oncorhynchus mykiss*

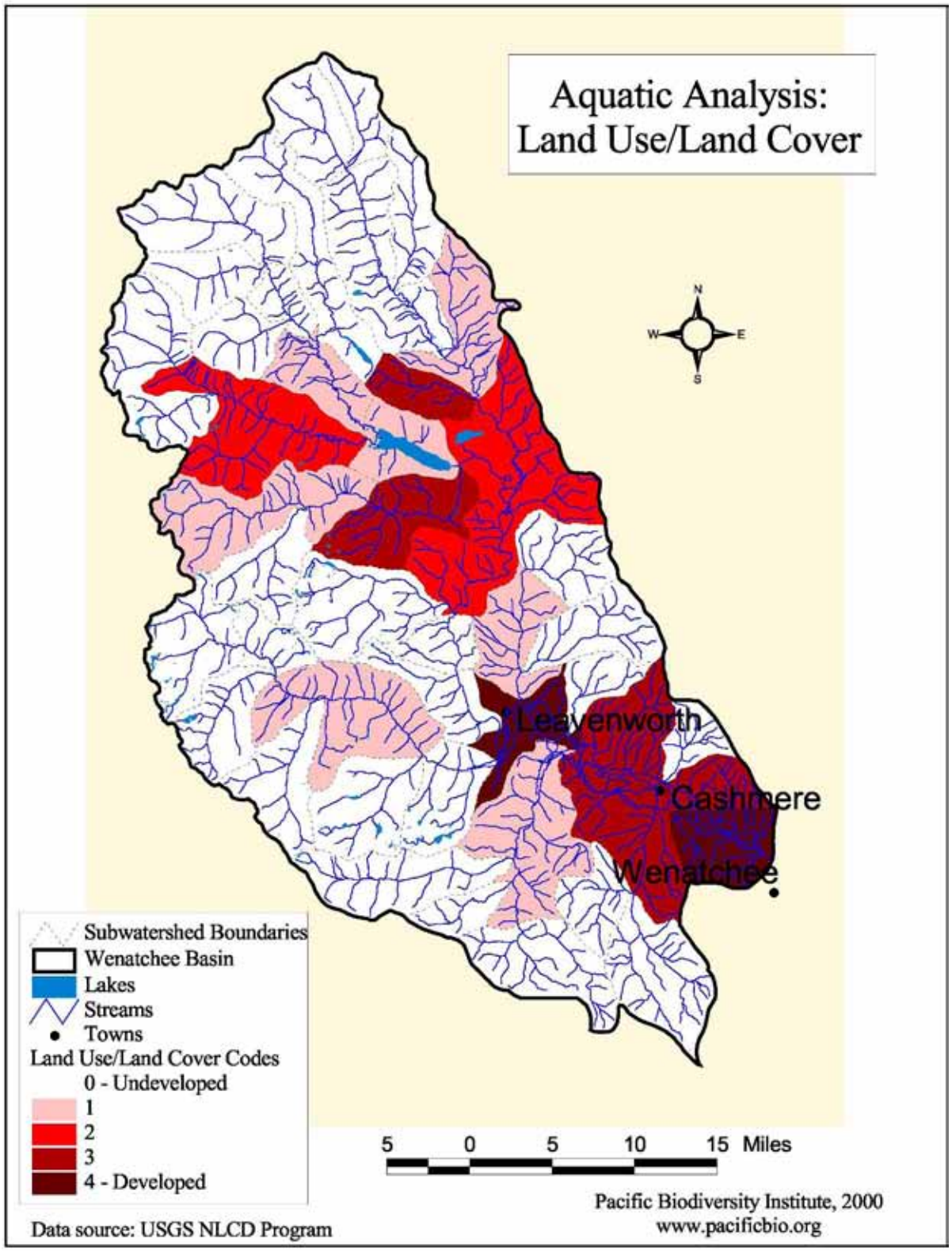


Figure 13. Land use/land cover rankings for Wenatchee River Basin subwatersheds. High values (dark red) indicate subwatersheds with a high percentage of developed land, detracting from aquatic priority. This was used as a negative factor in the aquatic analysis.

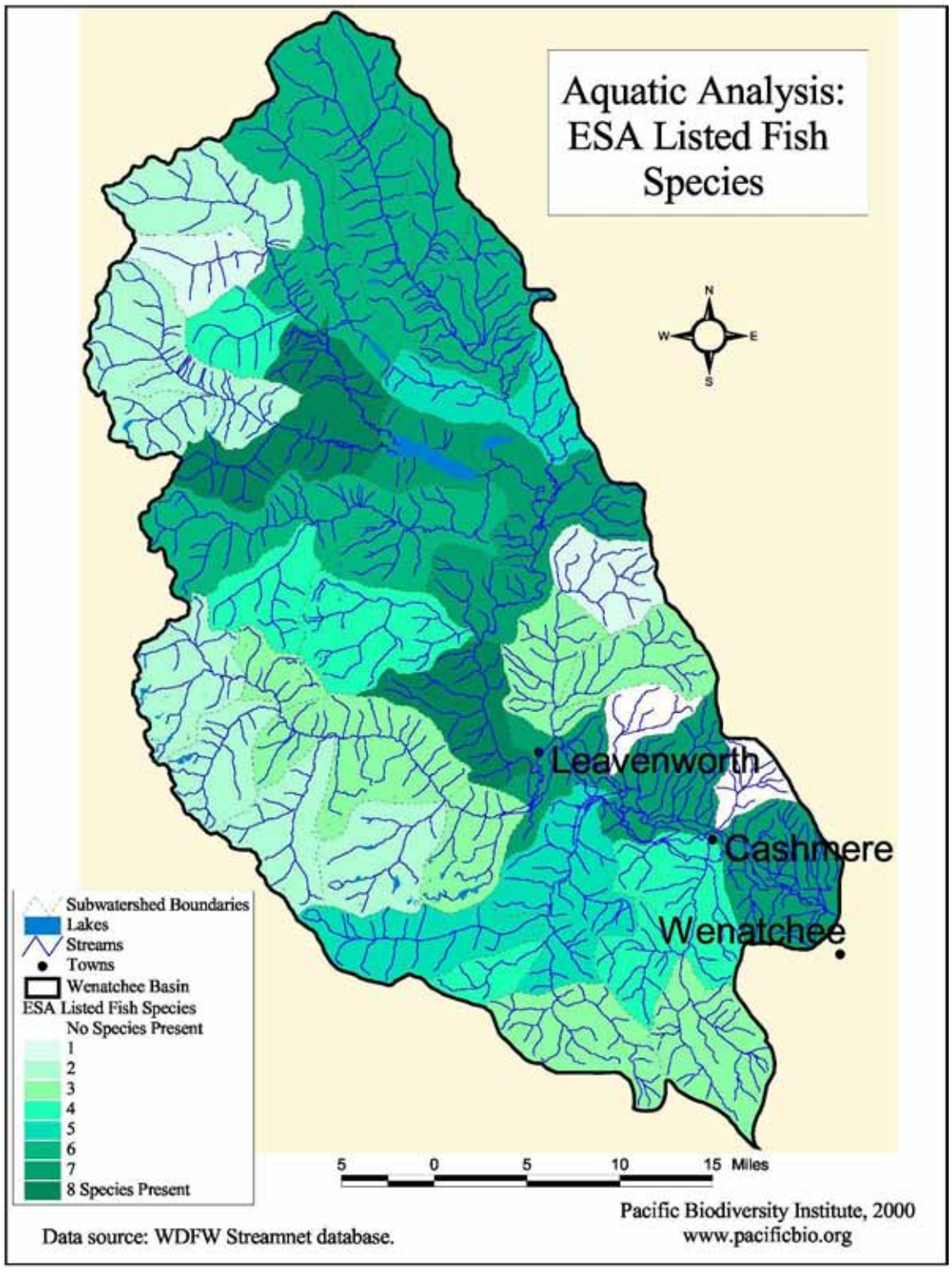


Figure 14. Presence of threatened, endangered, and special concern fish by subwatershed in the Wenatchee River Basin. High values (dark green) indicate subwatersheds with a high number of fish species, adding to aquatic priority. This was used as a positive factor in the aquatic analysis.

Anadromous Fish Presence

Populations of anadromous salmonids have declined precipitously over the last century. Protection of streams and rivers with remaining runs of anadromous fish and the land contributing to these waterways is essential to the long-term survival of these species. PBI used the number of anadromous fish species occurring in a subwatershed as a positive factor in our aquatic analysis (Figure 15). The same process as described for the threatened and endangered fish species was followed for anadromous fish species. Table 7 lists the anadromous fish species recorded in the Wenatchee River Basin by WDFW Streamnet.

Table 7. Anadromous Fish Present in the Wenatchee River Basin

Common Name	Scientific Name
Spring Run Chinook Salmon	*Oncorhynchus tschawytscha*
Summer Run Chinook Salmon	*Oncorhynchus tschawytscha*
Sockeye Salmon	*Oncorhynchus nerka*
Summer Run Steelhead Salmon	*Oncorhynchus mykiss*
Unspecified Anadromous Fish	*Oncorhynchus* spp.

Native, Resident Fish Presence

Native fish species have evolved with the ecosystems in which they occur, and they serve functional roles within those ecosystems. Table 8 lists the native, resident fish species resident fish species occurring per subwatershed was used as a positive factor in the analysis (Figure 16).

Table 8. Resident Fish Present in the Wenatchee River Basin

Common Name	Scientific Name
Bridgelip Sucker	*Catostomus columbianus*
Sculpin, General	*Cottus* spp.
Dolly Varden/Bulltrout	*Salvelinus confluentus*
Kokonee Salmon	*Oncorhynchus nerka*
Largescale Sucker	*Catostomus macrocheilus*
Northern Pikeminnow	*Ptychocheilus oregonensis*
Rainbow Trout	*Oncorhynchus mykiss*
Redside Shiner	*Richardsonius balteatus*
Speckled Dace	*Rhinichthys osculus*
West Coast Cutthroat	*Oncorhynchus clarki*
Mountain Whitefish	*Prosopium williamsoni*

The number of resident fish species ranged from 0 to 9. The number of fish species occurring in each subwatershed was halved and rounded up, yielding a range of 0 to 5, to be consistent with the other codes.

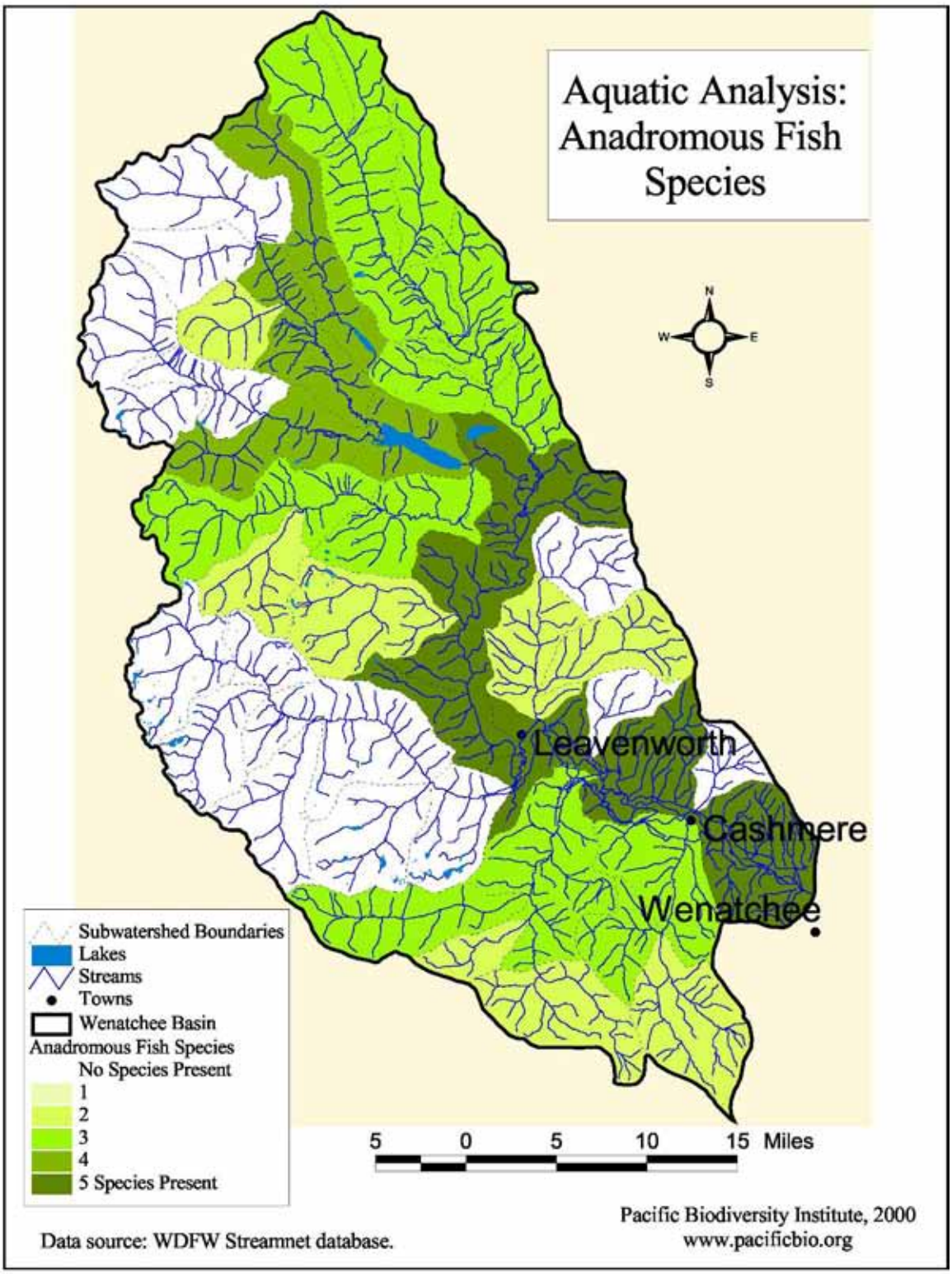


Figure 15. Presence of anadromous fish species by subwatershed in the Wenatchee River Basin. High values (dark green) indicate subwatersheds with the most anadromous fish species, adding to aquatic priority. This was used as a positive factor in the aquatic analysis.

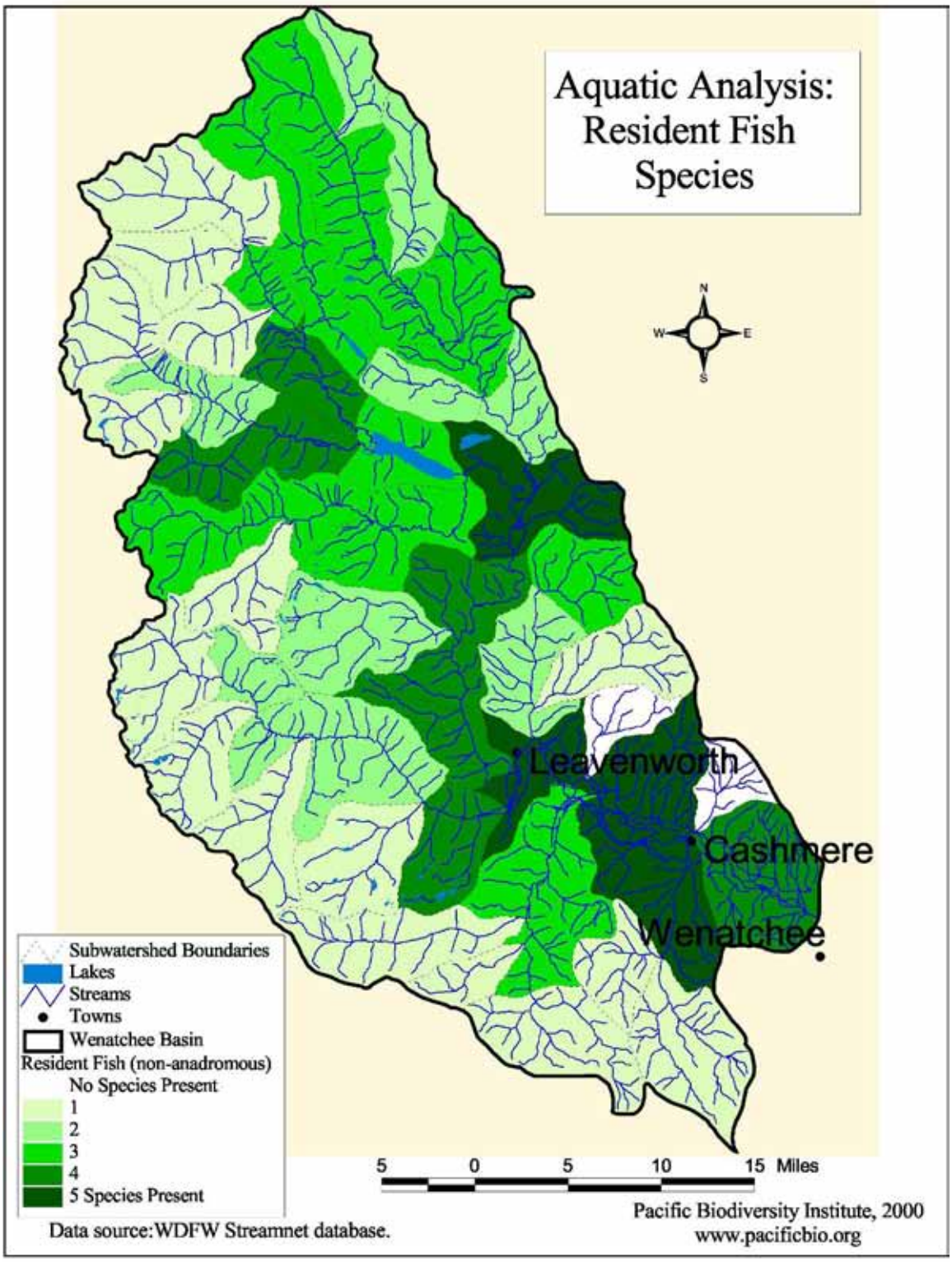


Figure 16. Presence of resident fish species by subwatershed in the Wenatchee River Basin. High values (dark green) indicate subwatersheds with more resident fish species, adding to aquatic priority. This was used as a positive factor in the aquatic analysis.

Hatchery, Net Pen, And Rearing Pond Influence

A ten-mile zone was created around all hatcheries. This area was assumed to reflect a general zone of influence within which outplanting and escape of juvenile fish, and straying of returning adult fish of hatchery origin are most likely to be concentrated and adversely affect natural fish populations through competition, predation, disease, predator attraction, or genetic introgression. Where zones from neighboring facilities overlapped, the resulting polygons, referred to as hatchery areas, were coded with the total number of zones to record influence from multiple facilities. This layer was then intersected with the subwatershed layer and the proportion of each subwatershed within each hatchery zone was calculated and multiplied by the number of hatcheries. For example, if one-half of a subwatershed fell within the ten-mile zone of two hatcheries, this proportion was doubled; if it fell within ten miles of three hatcheries the proportion was tripled, etc. These numbers were then totaled for each subwatershed and the resulting figure multiplied by two to give it weighting over the net pens and rearing ponds (Figure 17). The same process was followed for net pens and rearing ponds except that the resulting total was not multiplied by two. Hatchery, net pen and rearing pond data came from the WDFW Streamnet database.

The resulting values for hatchery influence and net pen/rearing pond influence were totaled. This value was then grouped into five equal-area categories, plus a zero category. This final value was then used as a negative factor in the subsequent landscape-level subwatershed prioritization.

Non-Native Fish Species

Many fish species from the eastern United States and other parts of the world were introduced into waterways of western United States for game fish. These species can compete for resources with, prey upon, or hybridize with native fish. Table 9 lists the non-native fish reported by WDFW Streamnet as occurring in the Basin. Number of non-native fish species was used as a negative factor in the analysis (Figure 18).

Table 9. Non-native Fish Present in the Wenatchee River Basin.

Common Name	Scientific Name
Crappie, General	*Pomoxis* spp.
Eastern Brook Trout	*Salvelinus fontinalis*
Yellow Perch	*Perca flavescens*

Inaccessible Subwatersheds

WDFW Streamnet data was used to map subwatersheds that are inaccessible to fish because of dams or water falls (Figure 19). This information was not incorporated as part of the ranking process, but was added as an overlay or “screen” in the final prioritization map. The final map represents landscape scores calculated and categorized for all subwatersheds in the region. This global ranking helped place the ecological integrity of salmon-accessible lands in the context of the overall landscape.

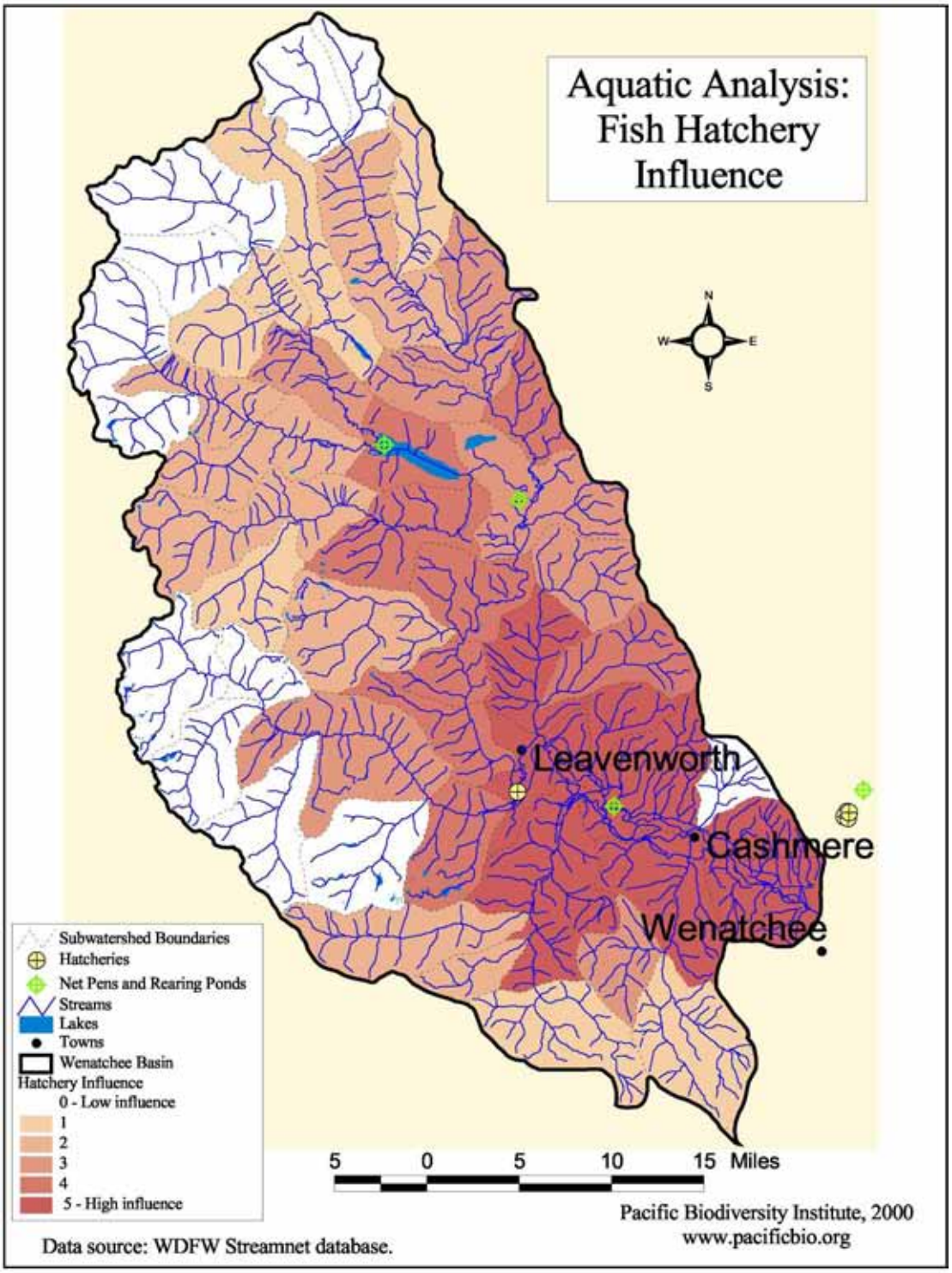


Figure 17. Hatchery influence rankings for Wenatchee River Basin subwatersheds. High values (dark red) indicate subwatersheds influenced by fish hatcheries. Fish hatcheries negatively impact native fish populations through outplanting and escape of juvenile fish, straying of returning adult fish of hatchery origin, competition, predation, disease, predator attraction, and genetic introgression. This was used as a negative factor in the aquatic analysis.

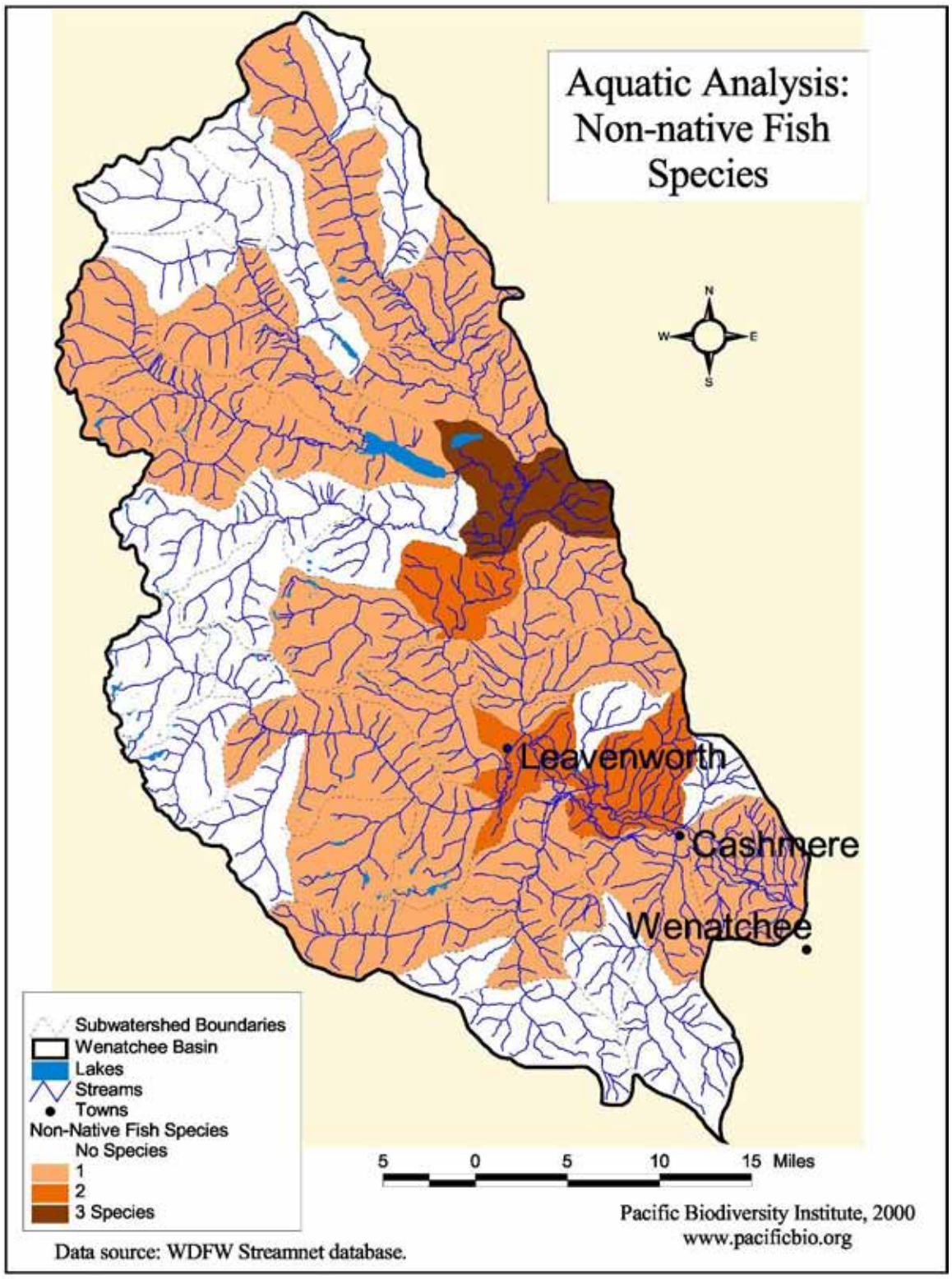


Figure 18. Presence of non-native fish species by subwatershed in the Wenatchee River Basin. High values (dark red) indicate subwatersheds with more non-native fish species, detracting from aquatic priority. This was used as a negative factor in the aquatic analysis.

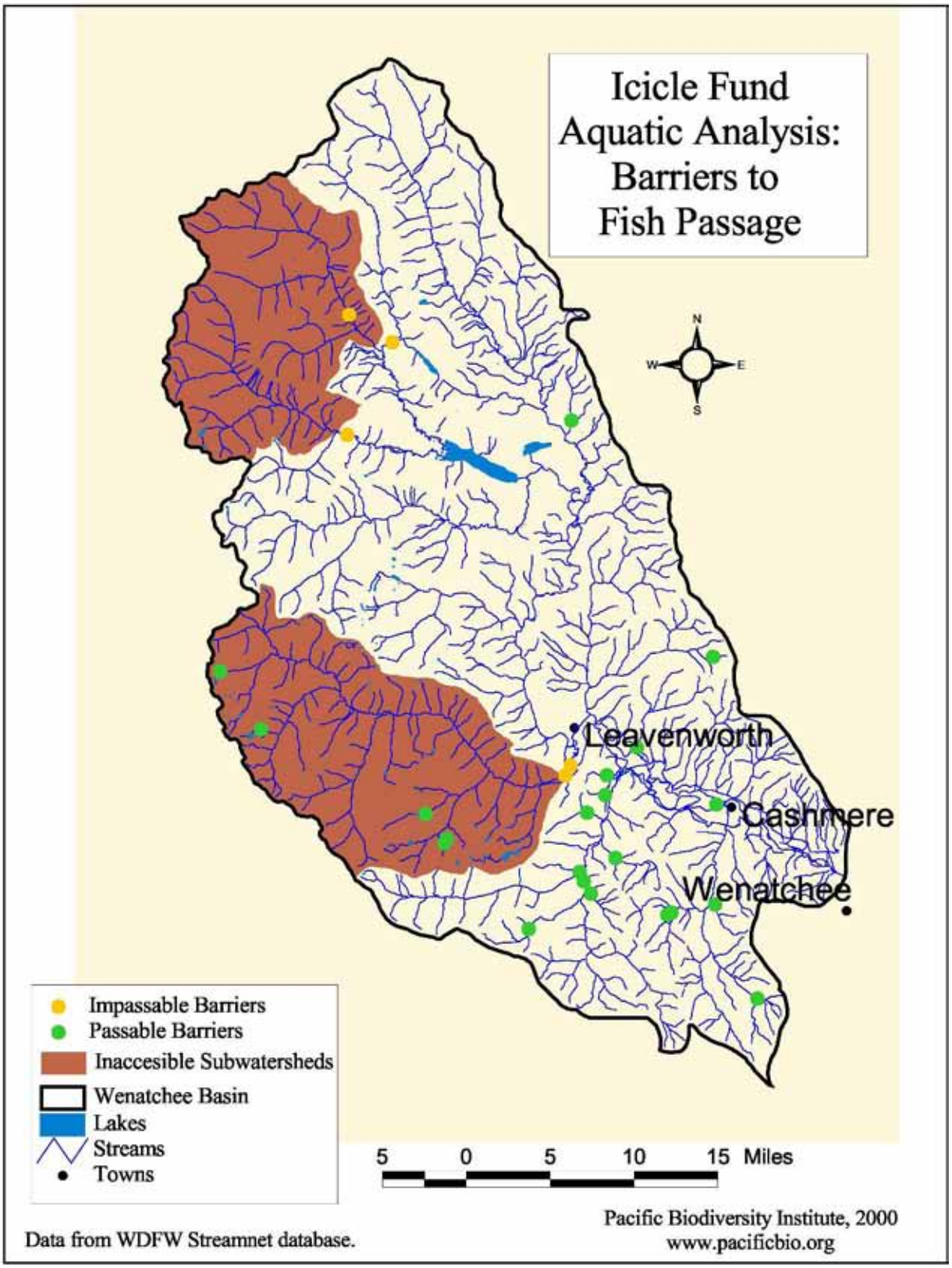


Figure 19. Inaccessible drainages to anadromous fish species due to impassible barriers and dams in the Wenatchee River Basin. Inaccessible drainages were used as an overlay to aid in interpretation of the aquatic priority results.

Evaluation of Aquatic Habitat Condition

To assess the overall subwatershed condition, we subtracted the sum of all of the negative factors (described above) from the sum of all of the positive factors. The sum was then normalized to fall within a range of values starting at zero.

The overall range of values for the aquatic-based prioritization of subwatersheds was negative 5 to positive 20 before standardization of the values. After standardization (adding eight to each score so that minimum score was zero), values ranged from 0 to 25 (Figure 20). Forty-three of the 48 subwatersheds had positive factors that were greater than their negative factors, resulting in a net positive value before standardization of the priority values. After standardization, these subwatersheds had values greater than eight.

Six subwatersheds had very high ratings (23 to 25). Only two of these subwatersheds are currently in protected status, falling within Glacier Peak Wilderness. An additional six subwatersheds had moderately high ratings (21 and 22). Two of these subwatersheds fall partly within wilderness areas.

The subwatersheds with the highest landscape integrity ratings were almost entirely found in the northern mountainous parts of the Wenatchee River Basin within the Wenatchee National Forest ownership (Table 10). One of the moderately rated subwatersheds is only partially within National Forest ownership, and another one does have some private inholdings. The highest ranking subwatersheds all had high ratings for the amount of wetland area, as well as the number of threatened and endangered fish species (See Appendix A for table of factor rankings for each subwatershed). They also ranked highly for the presence of anadromous and resident fish species. These factors increased their positive factor rating, while the negative factors were generally low to moderate. There was little influence from hatchery populations, and the number of non-native fish was also low. The road density and slope steepness varied across subwatersheds.

Subwatersheds containing private lands also ranged in value from 0 to 28 (Figure 21). Of these 39 subwatersheds, the highest-ranking ones were located along the Chiwawa River, at the confluence of the Chiwawa River and the Wenatchee River, and upstream from Lake Wenatchee (See Appendix B for a listing of the Chelan County parcel with high ratings). These are areas that the full complement of anadromous salmonids in the Basin, low road density, natural land use/land cover types, and shallower slopes. The lowest ranking subwatersheds were associated with smaller, steep-sloped tributaries that do not support populations of anadromous fish.

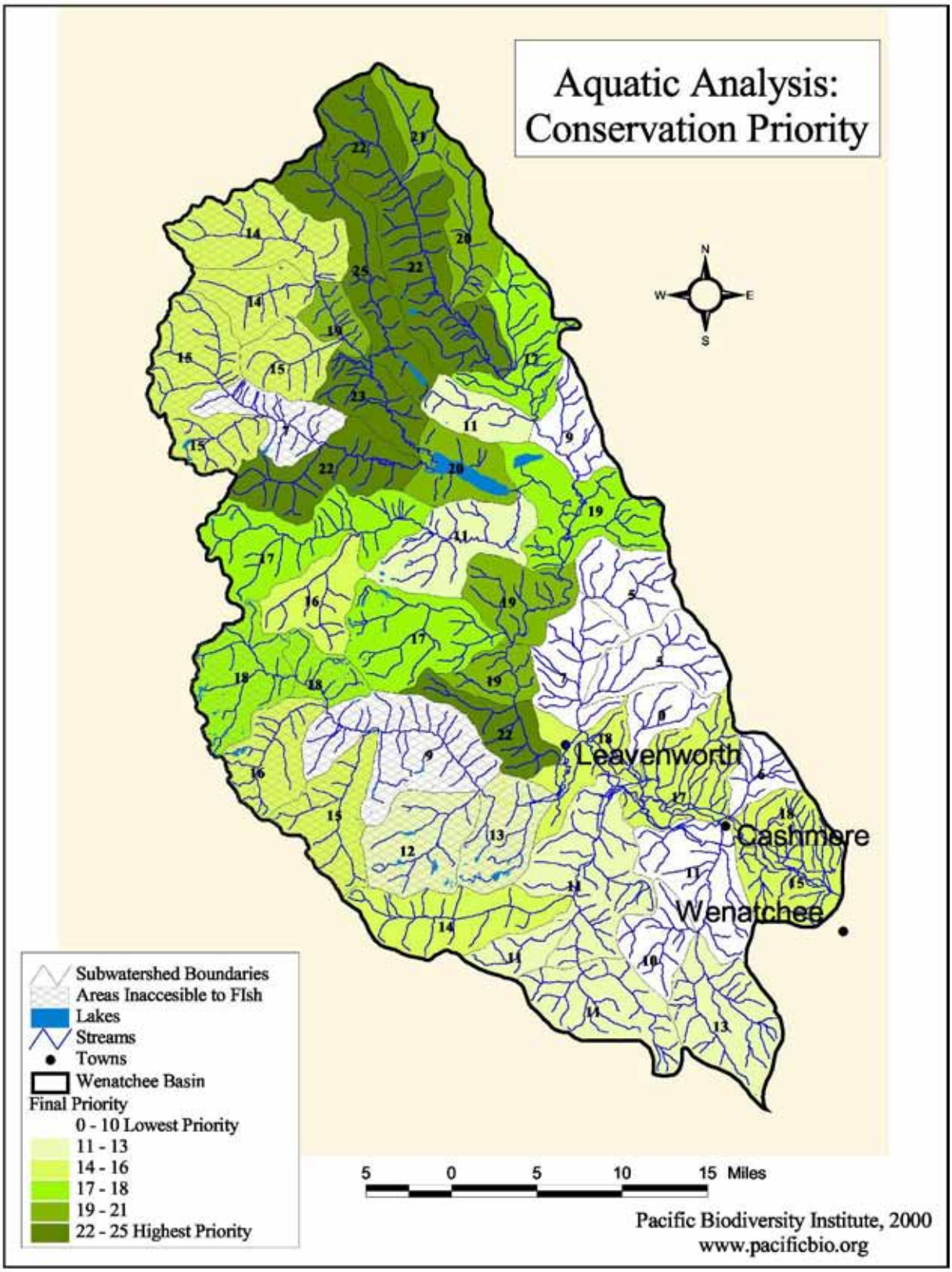


Figure 20. Final aquatic habitat conservation priorities for the Wenatchee River Basin. The highest priority subwatersheds (dark green) have the highest values for positive factors and lowest values for negative factors.

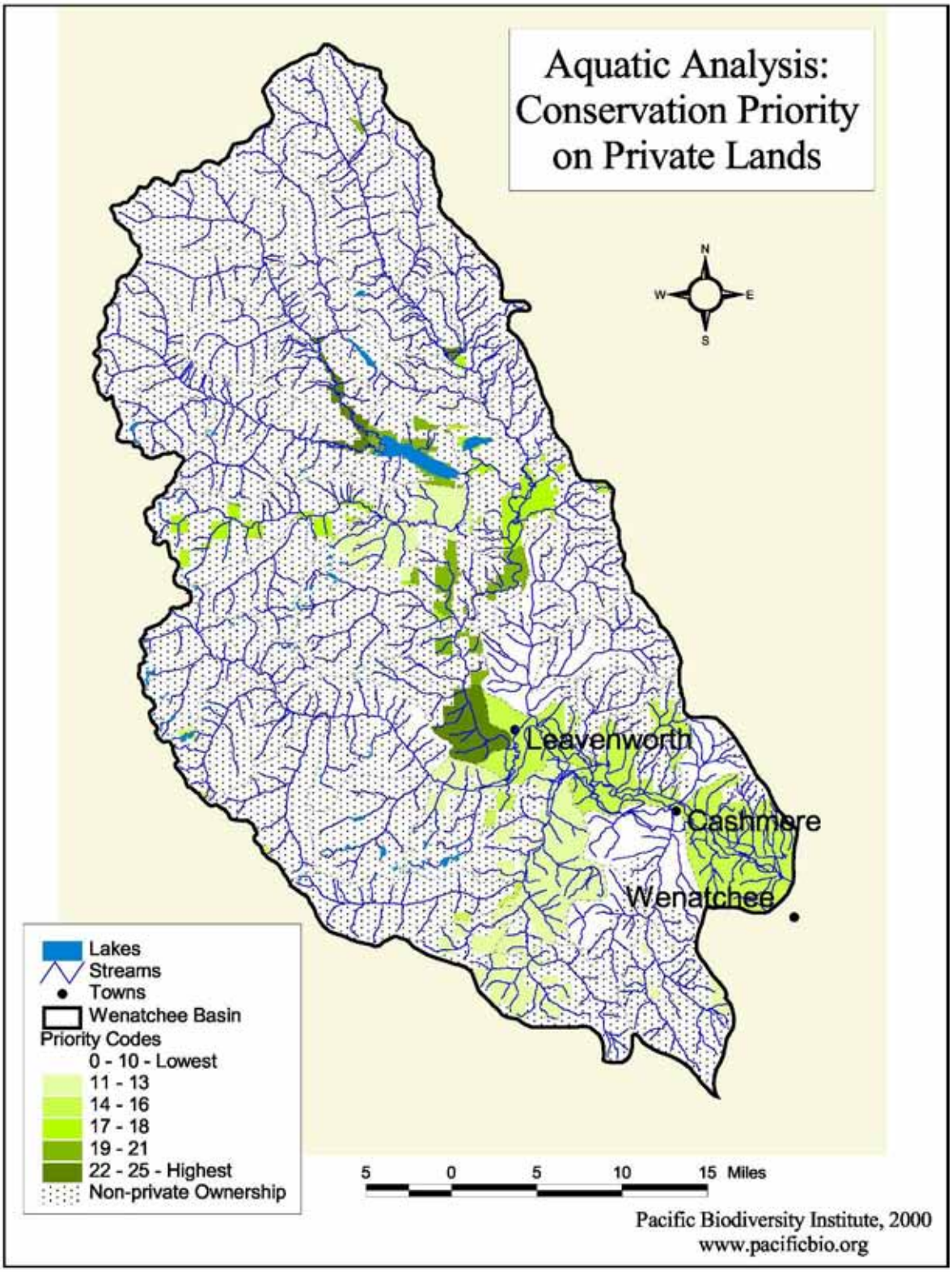


Figure 21. Aquatic habitat conservation priorities for private lands in the Wenatchee River Basin. The highest priority private lands are shown in dark green. Although private land accounts for only 17.2% of the Basin, it contains significant portions of high aquatic priority land.

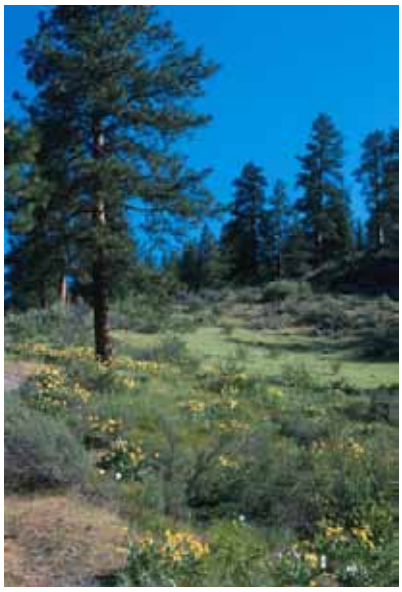
The Icicle Creek drainage received only a moderate ranking, mainly due to the fact that anadromous salmonids are prevented from entering the drainage by the dam near the mouth of Icicle Creek. Thus its positive ratings were not very high, as it ranks low in the presence of anadromous and ESA-listed fish. The influence of the hatchery also increased its minus factors, as did the slope steepness factor. Only one subwatershed in the drainage had a high land use/land cover code. Icicle Creek provides an example of an area where localized change in the Basin (e.g., removal of the dam and hatchery, and restoration of native salmonids to the drainage) may have a profound effect on the ecological integrity of a large area.

This aquatic-based, subwatershed prioritization yielded a coarse-scale, but comprehensive assessment of the factors influencing the integrity of aquatic ecosystems across the Wenatchee River Basin. This assessment identifies areas that should be targeted for additional aquatic-based analyses on a finer scale.

Table 10. Percentage of land ownership for each subwatershed in the Wenatchee River Basin.

Subwatershed Code	BLM	Private	US Forest Service	USFS Wilderness	State of Washington
2		2.16%	21.15%	76.70%	
3		0.05%	1.33%	98.62%	
4			49.19%	50.81%	
5		0.32%	3.03%	96.65%	
6		0.90%	78.83%	20.27%	
7				100.00%	
8		1.59%	97.71%		0.70%
9				100.00%	
10			48.39%	51.61%	
11			19.87%	80.13%	
12			2.97%	97.03%	
13		13.79%	86.11%	0.09%	
14		4.74%	90.79%		4.47%
15		2.96%	95.86%	1.19%	
16			91.17%	8.83%	
17		2.71%	91.61%	5.67%	
18		34.34%	63.05%		2.61%
19		25.84%	73.71%		0.44%
20		14.30%	75.99%	9.71%	
21		45.51%	45.77%	7.04%	1.68%
22		0.34%	5.21%	94.45%	
23		19.83%	72.44%		7.74%
24		31.71%	65.18%	0.04%	3.08%
25		1.36%	5.26%	93.38%	
26		42.11%	57.38%		0.50%
27				100.00%	
28		26.78%	66.95%		6.27%
29				100.00%	
30		19.75%	51.11%	29.14%	
31		28.09%	33.27%	38.64%	
32		7.34%	84.00%	0.00%	8.65%
33	1.54%	57.89%	37.31%	0.00%	3.26%
34		14.68%	41.76%	43.57%	
35	0.01%	71.43%	27.45%		1.10%
36		2.92%		97.08%	
37		0.73%	4.85%	94.42%	
38	0.32%	75.07%	24.28%		0.33%
39		19.46%	21.08%	59.47%	
40	0.13%	45.28%	47.90%	0.26%	6.43%
41	11.94%	66.03%	4.01%		18.02%
42		0.02%	19.90%	80.08%	
43	3.45%	63.14%	30.22%		3.20%
44	5.02%	90.67%	1.88%		2.43%
45		36.37%	58.72%		4.92%
46		2.52%	5.24%	92.24%	
47		35.70%	64.22%	0.08%	
48		6.98%	91.85%		1.17%
49		24.94%	75.06%		

Terrestrial Prioritization



Ponderosa pines and balsamroot in the Mission Creek drainage. Photo by Peter Morrison.

The second prioritization was terrestrial-based, focusing on native, undisturbed portions of the Basin; late-successional and old-growth forests; and rare, threatened, endangered, or special concern species. This prioritization was based on a series of grid surfaces with 100m cells, giving a finer-detailed look at the lands in the Basin. We prioritized the Wenatchee River Basin by 15 factors relating to the ecological integrity or biodiversity of the landscape. These factors were selected because they are generally believed to be representative of the full range of conditions for healthy, native ecosystems. However, each of these factors is a unique perspective for prioritizing the landscape. PBI has combined all of these factors into an overall prioritization for the Basin, but choice of prioritization factors should be driven by the specific objectives of any initiative.

Each factor was created as a grid surface with 100m cells and ranked from 0 to 5. The factors were then divided into positive and negative influences (Table 11). Positive influences are generally believed to enhance the ecological integrity and/or biodiversity of an area. Negative influences are believed to detract from the ecological integrity and/or biodiversity of an area. Methods for each of these factors are described below. All of the factors were summed to create the overall prioritization for the Wenatchee River Basin. In certain instances, the priority value for an area can be negative. To correct for this, we added the minimum negative value to all of the cells in the priority surface.

To assess the conservation priorities on private lands in the Wenatchee River Basin, we converted the Chelan County parcel database to a 100m grid surface based on the parcel id number and calculated the mean, minimum, maximum and range of conservation priority values for each parcel. This information was exported into a database to be used with the original parcel database.

Terrestrial Landscape Condition Factors

Roadless Areas

Roadless areas, because of their limited human disturbance, have a higher degree of natural integrity than roaded portions of the landscape. PBI mapped roadless areas in Washington in 2000 as support work for the Wild Washington Campaign. These roadless areas are an update of Morrison et al. (1998). We used a combination of road data from each USFS National Forest, Washington DNR Transportation Database, and other sources (including roads digitized by PBI from aerial photography and satellite imagery that were not in other datasets). Roadless areas were defined as those areas further than approximately 10m from a digitized road, not narrower than 200m, and greater than 1000 acres.

PBI converted the roadless area polygons to a grid surface with 100m cells for the Wenatchee River Basin. Since the roadless area ranking was to be used as a positive factor, all roaded areas were given a value of 0. Roadless areas were ranked from 1 to 5

based on the size of the roadless area: larger roadless areas receiving a higher rank (Figure 22).

Table 11. Factors used in the terrestrial prioritization of the Wenatchee River Basin.
Positive factors contributed to the overall priority of and area; whereas, negative factors detract from it. Each of these factors were applied to a grid surface of 100m cells and summed to get the overall priority for the basin.

Factor	Influence	Rank
Ecological Integrity		
Roadless Areas	Positive	0 for roaded areas, 1 to 5 for roadless areas based on size of roadless area
Wetlands	Positive	5 for all wetland types
Road Density	Negative	0 for no roads/km^2 to 5 for highest roads/km^2
Population Density	Negative	0 for lowest population density to 5 for highest population density by census block group.
Terrestrial Vertebrates		
Heritage Species Sightings	Positive	0 to 5 based on the number of species observed at or near each cell.
Priority Habitats and Species	Positive	0 to 5 based on the number and type of WDFW priority habitat or species occurring in each cell
Large Carnivore Richness	Positive	0 to 5 based on the number of large carnivore species *predicted* to occur in each cell
Amphibian Richness	Positive	0 to 5 based on the number of amphibian species *predicted* to occur in each cell
Reptile Richness	Positive	0 to 5 based on the number of reptile species *predicted* to occur in each cell
Bat Richness	Positive	0 to 5 based on the number of bat species *predicted* to occur in each cell
Bird Species of Concern	Positive	0 to 5 based on the number of bird species of concern *predicted* to occur in each cell.
Late-successional and Old-growth Associated Species	Positive	0 to 5 based on the number of late-successional and old-growth associated species *predicted* to occur in each cell.
Introduced and Invasive Animal Species	Negative	0 to 5 based on the number of invasive, non-native species *predicted* to occur in each cell.
Plants and Vegetation		
Age of Forest	Positive	0 to 5 based on the age of forest in each cell
Size and Proximity of Late-successional and Old-growth Forest Patches	Positive	0 to 5 based on the size of the older forest stand in which each cell resides and its proximity to other old forest stands.
Vegetation Rarity	Positive	0 to 5 based on the rarity of vegetation types in the Greater North Cascades Ecosystem.
Natural Heritage Plants	Positive	0 to 5 based on the number of plant species in the WADNR Heritage Database
Logging Activity	Negative	5 for all areas with previous logging

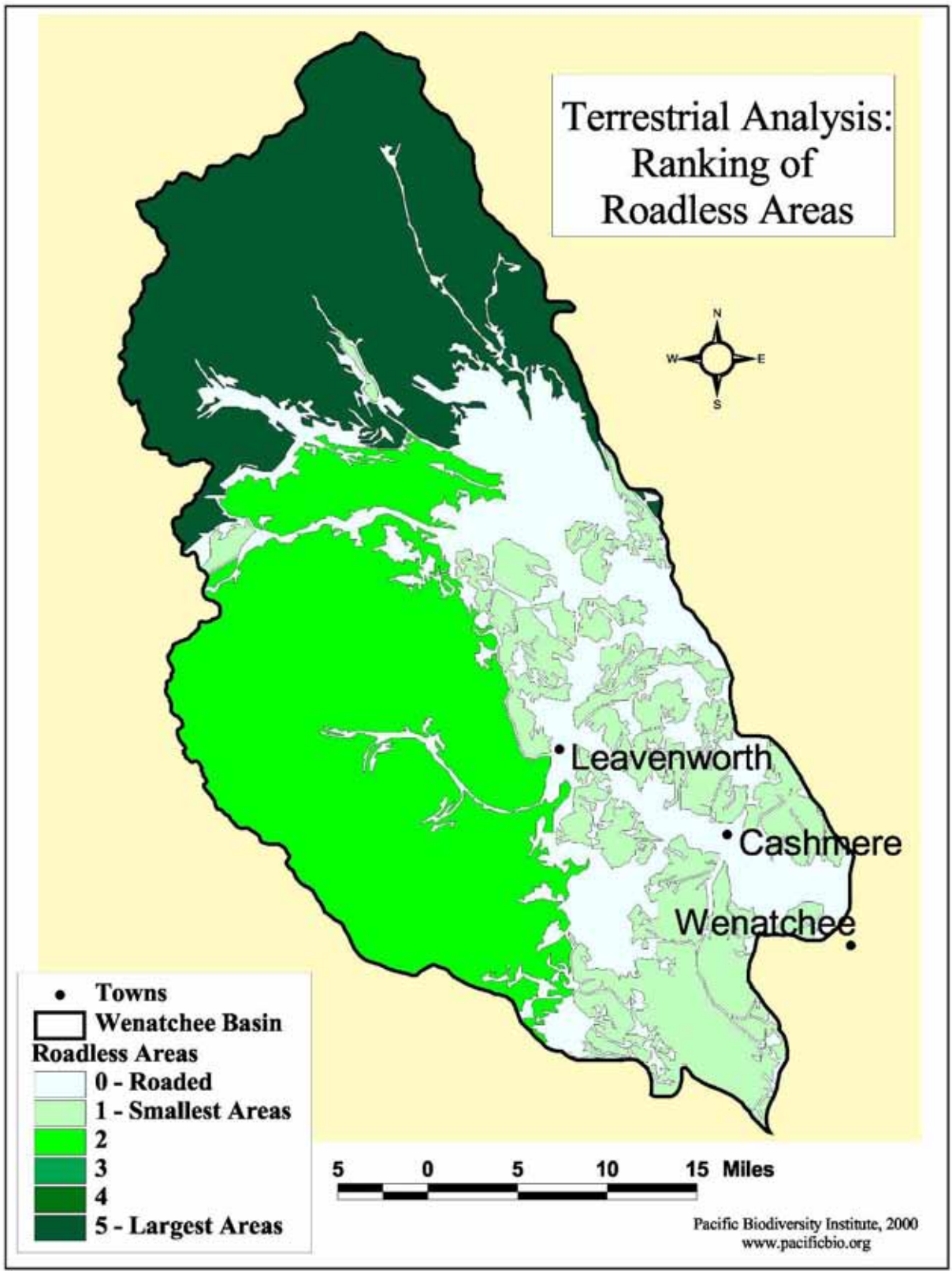


Figure 22. Roadless area size rankings used in the terrestrial prioritization of the Wenatchee River Basin. Roadless areas were prioritized based on their size: large roadless areas (dark green) receiving higher priority than small ones (light green). This was used as a positive factor in the terrestrial analysis.

Wetlands
Wetlands serve many important ecosystem functions such as filtration of sediment and pollutants from water and regulation of stream flows. Additionally, they are habitat for a great number of species that occur in no other conditions. Due to their small size, however, they are often missed in large-scale vegetation mapping efforts. Wetlands locations were taken from USGS National Wetlands Inventory (NWI) data for Washington. Polygons delineating wetlands were converted to a grid surface with 100m cells for the Wenatchee River Basin. Although the NWI defines many different types of wetlands, we did not attempt to differentiate them in this ranking. Since wetlands serve important ecological functions and are hotspots for local biodiversity (Wooten et al. 1998), all wetlands were given a rank of 5 (Figure 23).

Road Density
Roads have many effects on an ecosystem that extend beyond the road cut (Trombulak and Frissell 2000). Estimates of road density (the total length of road per unit of area) provide an indication of the area influenced by road effects. Density of roads was estimated using a combination of Wenatchee NF and Washington DNR roads data. We used the linedensity function in Arc/Info Grid (ESRI 2000) to estimate the total length of roads within a 1 km radius of each cell of a 100m grid surface. Since roads are deleterious to ecological integrity, this layer was used as a negative factor. Cells with 0.0 calculated road density were given the rank of 0. Cells with greater than 0.0 calculated road density were assigned a rank of 1 to 5 (1 being the lowest road density and 5 being the highest) so that there were approximately an equal number of cells in each category (Figure 24).

Population Density
Population density was used as an indicator of development and development pressure. We used the population density calculations by block group from the US Census Bureau 1990 census. The block groups for the Wenatchee River Basin were converted to a grid surface with a 100m cell size and attributed with population density. The resulting grid surface was ranked from 0 to 5. Since population density was used as a negative factor, cells with the lowest population density were given a value of 0: cells with the highest population density were given a value of 5 (Figure 25).

Heritage Species Sightings
Known habitat locations for threatened, endangered, rare, or special concern species deserve special attention and protection. The Department of Fish and Wildlife maintains a database of sightings for threatened/endangered species and species of conservation concern, their Heritage database. This database, while not exhaustive, is updated regularly, and is one of the best available information sources on where these species are. PBI obtained the most recent version of the Heritage database (as of 12/01/00) for use in the Wenatchee River Basin Conservation Prioritization. For the Wenatchee River Basin, 33 species have been recorded since 1978 (Table 12). This list includes 2 amphibians, 2 reptiles, 20 birds, and 9 mammals. Since each point only represents a single sighting of a species, and is not associated with any particular habitat area, inclusion of only the observation points in the prioritization would not adequately represent the significance of these species observations or contribute significantly toward overall conservation priority of that area. Observation of a

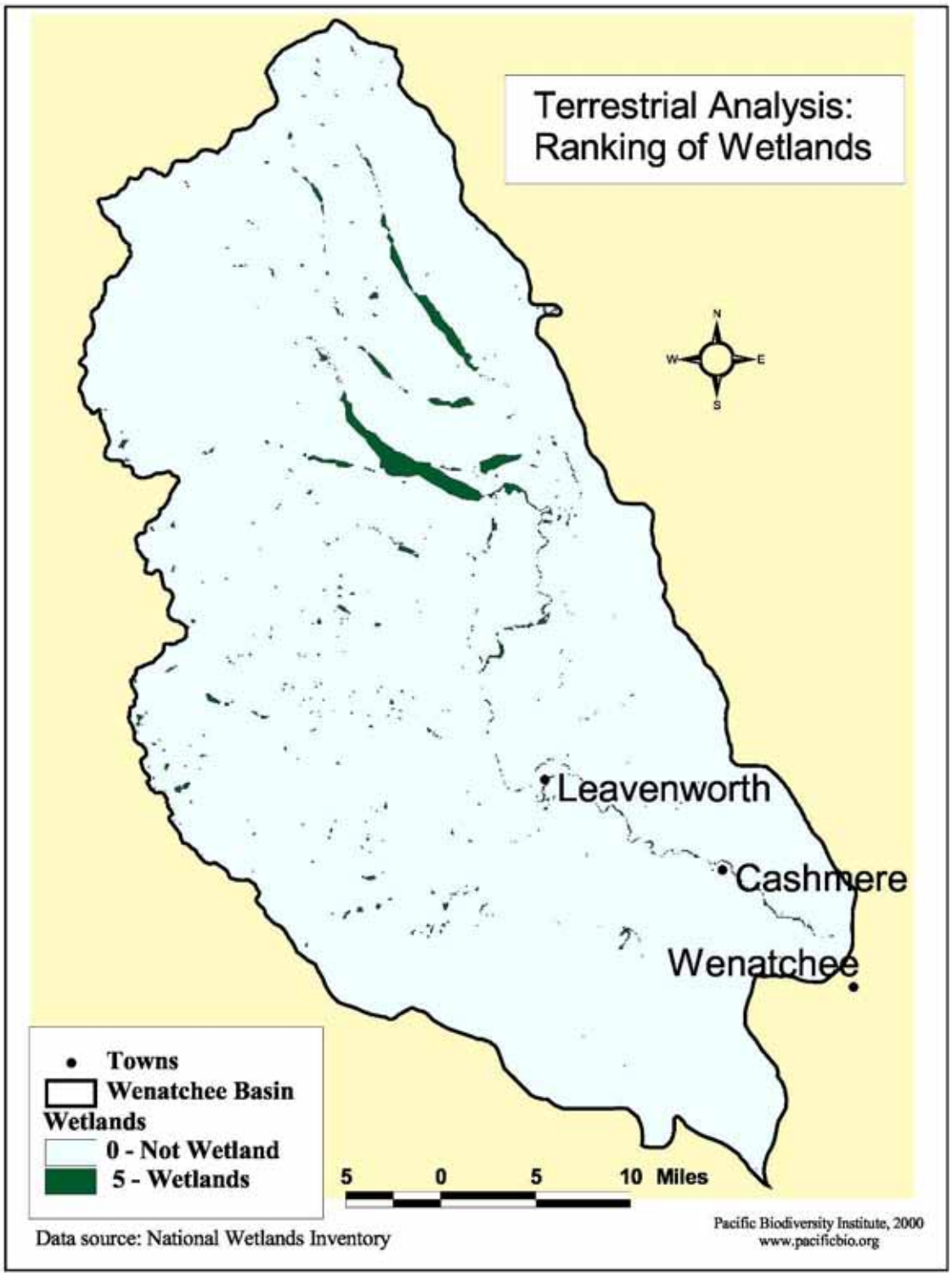


Figure 23. Wetlands rankings used in the terrestrial prioritization of the Wenatchee River Basin. Because of their importance to terrestrial ecosystems, a rank of 5 was given to any natural wetland (dark green). This was used as a positive factor in the terrestrial analysis.

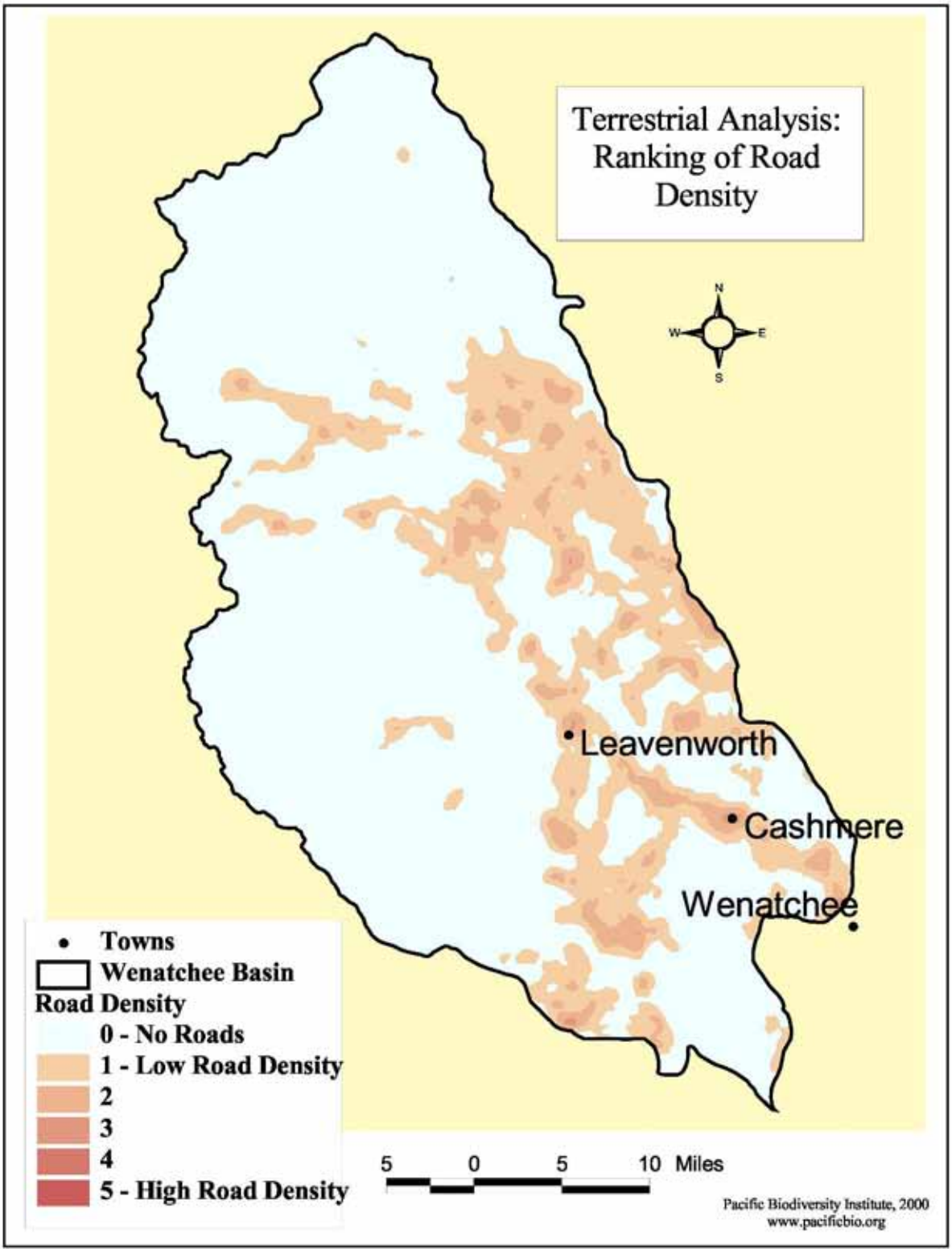


Figure 24. Road density rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark red) indicate areas with high density of roads per km^2, detracting from terrestrial priority. This was used as a negative factor in the terrestrial analysis.

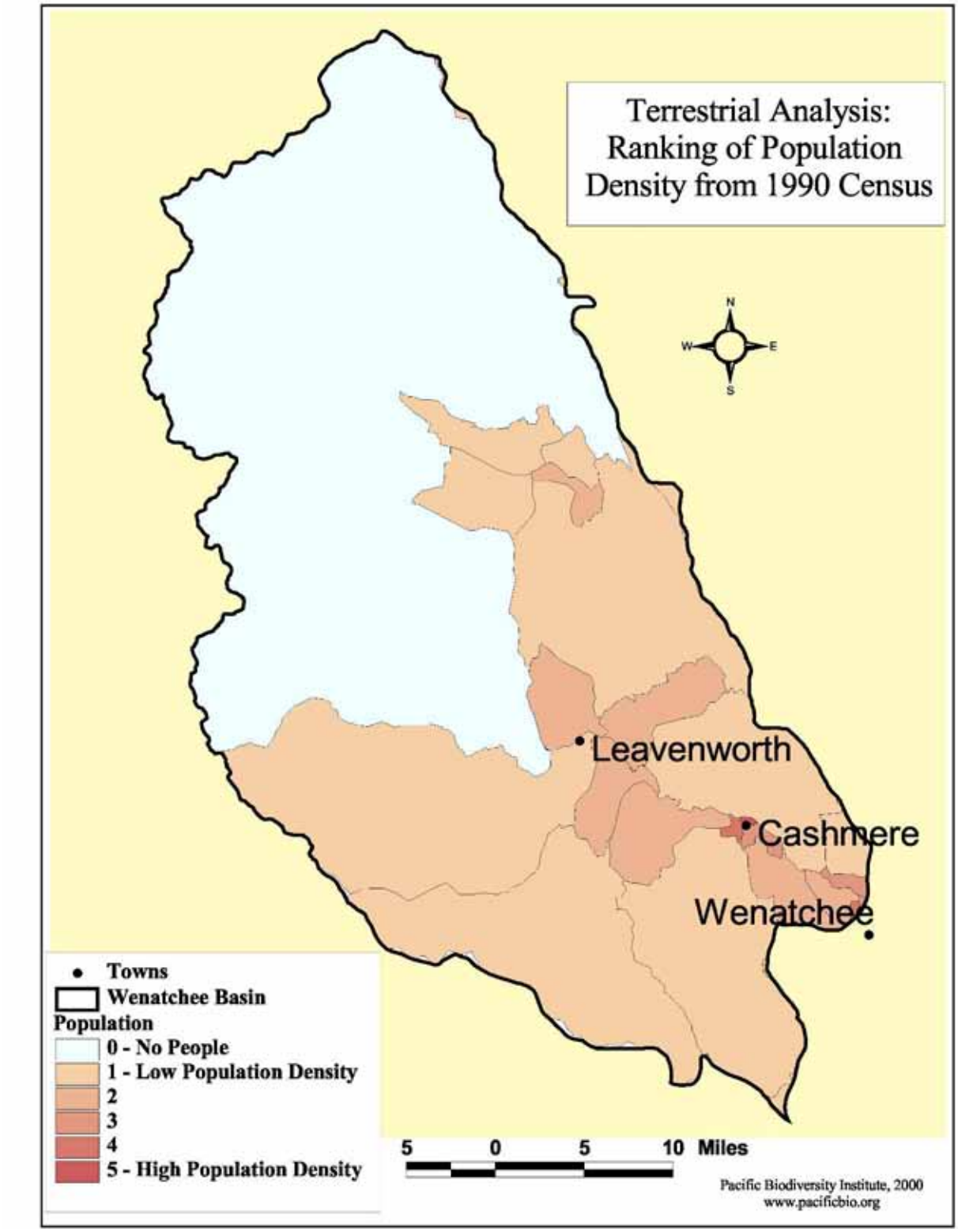


Figure 25. Population density rankings used in the terrestrial prioritization of the Wenatchee River Basin.

High values (dark red) indicate areas with high human population density, detracting from terrestrial priority. This was used as a negative factor in the terrestrial analysis.

species at a given point denotes that area as habitat for that species. Due to a variety of reasons (mostly associated with that fact that animals move around and most are somewhat cryptic), failure to observe a species does not necessitate unsuitable habitat. To overcome this, we relied on combination of observations and habitat modeling techniques and a fundamental rule of geography: things close together are more similar than things farther apart. Applied to prioritization of threatened, endangered, or sensitive species, this means that the area adjacent to a given observation, if it falls within the parameters of general habitat associations for that species (e.g., you don't normally find [alive] fish on land), is very likely to also be suitable habitat for that species. The farther away from the observation, the less sure we can be that the area is suitable habitat.

The methods for accomplishing this are as follows: for each species, we extracted its observation points from the Natural Heritage database and converted them to a grid surface with 100m cells (each observation coded as 1 with surrounding cells not given a value). We then calculated the distance for each cell in the grid surface to the nearest observation (the point of observation would have a value of 0.0). We then standardized the distance calculations according to the following formula:

$$x_2 = 100 - [100 * (x_1 / x_{max})]$$

where x_1 is the original distance to the nearest observation point, x_2 is the normalized distance to the nearest observation point, and x_{max} is the maximum distance away from the point that the individual observed is likely to travel. We used four maximum distance values: 1km, 2.5km, 5km, and 10km. Distance of likely travel was estimated based on the dispersal capability and average home range values for each species (Table 12). The resulting grid surface was rounded to the nearest integer. We used the Washington Gap Analysis (WA-GAP) wildlife habitat models (see Cassidy et al. 1997) to eliminate areas that were outside of the species general habitat associations (where the species was unlikely to occur). We set to 0 the value of any cells that fell outside of the predicted habitat for that species *and* had a normalized distance value less than 75. This latter condition preserved in the output observations of a species that were outside of the WA-GAP predicted habitat. Values for each species grid surface ranged from 0 to 100.

To create a ranking of Heritage database species, we summed all of the output grid surfaces for each species and divided it into five categories (from 1 to 5) so that there were approximately and equal number of cells in each category. Areas with no Heritage species predictions were given a 0 value (Figure 26).

Because of their sensitive nature, Washington DNR maintains northern spotted owl (*Strix occidentalis*) locations in a separate database. Only generalized locations of breeding sites and non-breeding individuals was available at this time to PBI. Each breeding site and location of a non-breeding individual was randomly located within a 3mi radius circle. For the purposes of prioritization, we converted the circles to grid surfaces with 100m cells and merged the breeding site circles with those of non-breeding individuals. We assigned a value of 100 to the breeding site circles and 50 to the non-breeding circles. We then restricted this grid surface to the WA-GAP habitat models for the northern spotted owl as described above.

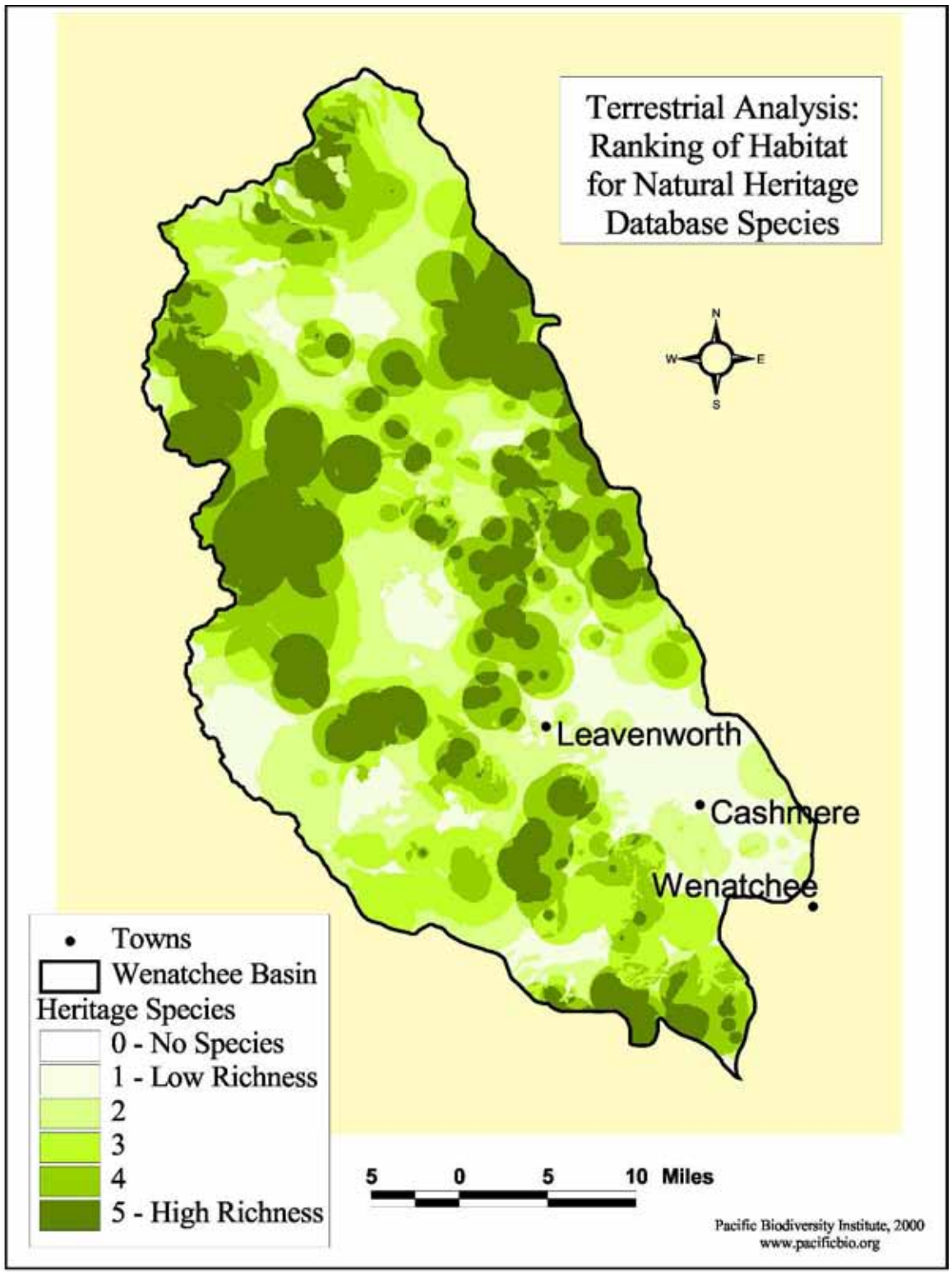


Figure 26. Ranking of habitats for WDFW Heritage database species for the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate areas with more observations of threatened, endangered, or special concern species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

Table 12. Species recorded in the WDFW Heritage Database for the Wenatchee River Basin.

Common Name	Scientific Name	Observations	Maximum Distance
Birds			
Northern Goshawk	*Accipiter gentilis*	197	2.5
Golden Eagle	*Aquila chrysaetos*	20	5
Great-blue Heron	*Adrea herodias*	4	5
Vaux's Swift	*Chaetura vauxi*	2	5
Spruce Grouse	*Dendragapus Canadensis*	1	2.5
Pileated Woodpecker	*Dryocopus pileatus*	3	5
Merlin	*Falco columbarius*	1	5
Peregrine Falcon	*Falco peregrinus*	2	5
Common Loon	*Gavia immer*	1	5
Bald Eagle	*Haliaeetus leucocephalus*	6	5
Harlequin Duck	*Histrionicus histrionicus*	1	5
White-tailed Ptarmagin	*Lagopus leucurus*	1	2.5
Loggerhead Shrike	*Lanius ludovicianus*	1	2.5
Lewis' Woodpecker	*Melerpes lewisi*	4	5
Mountain Quail	*Oreortyx pictus*	1	2.5
Osprey	*Pandion hailaetus*	46	5
White-headed Woodpecker	*Piciodes albolarvatus*	2	5
Black-backed Woodpecker	*Picoides arctus*	2	5
Three-toed Woodpecker	*Piciodes tridactylus*	5	5
Western Bluebird	*Salia mexicana*	3	1
Great gray Owl	*Strix nebulosa*	2	10
Northern Spotted Owl[1]	*Strix occidentalis*		10
Mammals			
Moose	*Alces alces*	1	5
Gray Wolf	*Canis lupus*	15	10
Wolverine	*Gulo gulo*	6	10
Lynx	*Lynx canadensis*	5	10
Marten	*Martes americana*	23	10
Fisher	*Martes pennati*	5	10
Fringed Myotis	*Myotis thysanodes*	1	2.5
Pacific Big-eared Bat	*Corhyorhinus townsendii townsendii*	1	2.5
Grizzly Bear	*Ursus arctos*	16	10
Reptiles & Amphibians			
Tailed Frog	*Ascaphus trueii*	11	1
Columbia Spotted Frog	*Rana luteventris*	10	1
Sharp-tailed Snake	*Contine tenuis*	1	1
Nightsnake	*Hypsiglena torquata*	1	1

[1.] Due to their sensitive nature, northern spotted owl locations are maintained in a separate database. Only generalized owl locations were released to PBI. See text for description of how northern spotted owl locations were processed.

Priority Habitats and Species

The WDFW also maintains a database of priority habitats and species observations (PHS) for the state. This database includes areas such as migration and calving areas for big game, areas where large concentrations of waterfowl are regularly found, or regular nesting sites for raptors. Because these features have areas associated with them (e.g.,

they are not single points like the Heritage database) complex modeling like that done for the Heritage observations is not necessary. The PHS database tracks 15 species or species group priority habitats in the Wenatchee River Basin (Table 13). The PHS database also records an attribute describing how an area is used by a species or species group (Table 14). Based on these attributes, we assigned weights to each area in the PHS database.

Table 13. Priority Habitats and Species for the Wenatchee River Basin

Common Name	Scientific Name	Types of Habitat
Golden eagle	*Aquila chrysaetos*	B
Ruffed grouse	*Bonassa umbellus*	B, RC
Elk	*Cervus elaphus*	B, M, RC, PA
Trumpeter Swan	*Cygnus buccinator*	RLC
Blue grouse	*Dendrogapus obscurus*	B, IO, RC, RLC
Bald eagle	*Haliaetus leucocephalus*	B, RC, RI
Harlequin duck	*Histrionicus histrionicus*	B
Lynx	*Lynx canadensis*	RNG
Marten	*Martes americana*	IO, RC
Pika	*Ochotona princeps*	RC
Mule deer	*Odocoileus hemionus*	B, M, RC, RLC, PA
Mountain goat	*Oreamnos americanus*	RC, RLC, M
Flammulated owl	*Otus flammeolus*	IO
Bighorn sheep	*Ovis canadensis*	RC
Waterfowl		B, RC, RLC

Table 14. Definitions of habitat type codes in the Priority Habitats and Species database

Code	Definition
B	Breeding
IO	Individual occurrence
M	Migration
PA	Parturition
RC	Regular concentration
RLC	Regular large concentration
RI	Regular individual
RNG	Range

We selected each priority habitat individually and converted it to a grid surface with 100m cells. Values were assigned to the habitat based on its attributed use (Table 14). It is important to note that there could be several different types of habitat for a single species or species group. For example, the PHS database contains polygons for breeding, migration, parturition, and regular concentrations of elk (*Cervus elaphus*). In this case, each habitat type would be given its corresponding value in the single grid surface for elk. All of the grid surfaces were summed and divided into five classes (1 to 5). Grid cells with no PHS habitats were given a code of 0 (Figure 27).

Large Carnivores

Large carnivores, because they range over large areas, are high-level trophic species and sensitive to human disturbance, have been suggested as an indicator of intact, functional native ecosystems (Estes 1996). As such, they are a valuable way of prioritizing the conservation value of a landscape. To assess the conservation value of land in the Wenatchee River Basin for large carnivores (Table 15), we relied on the predicted habitat

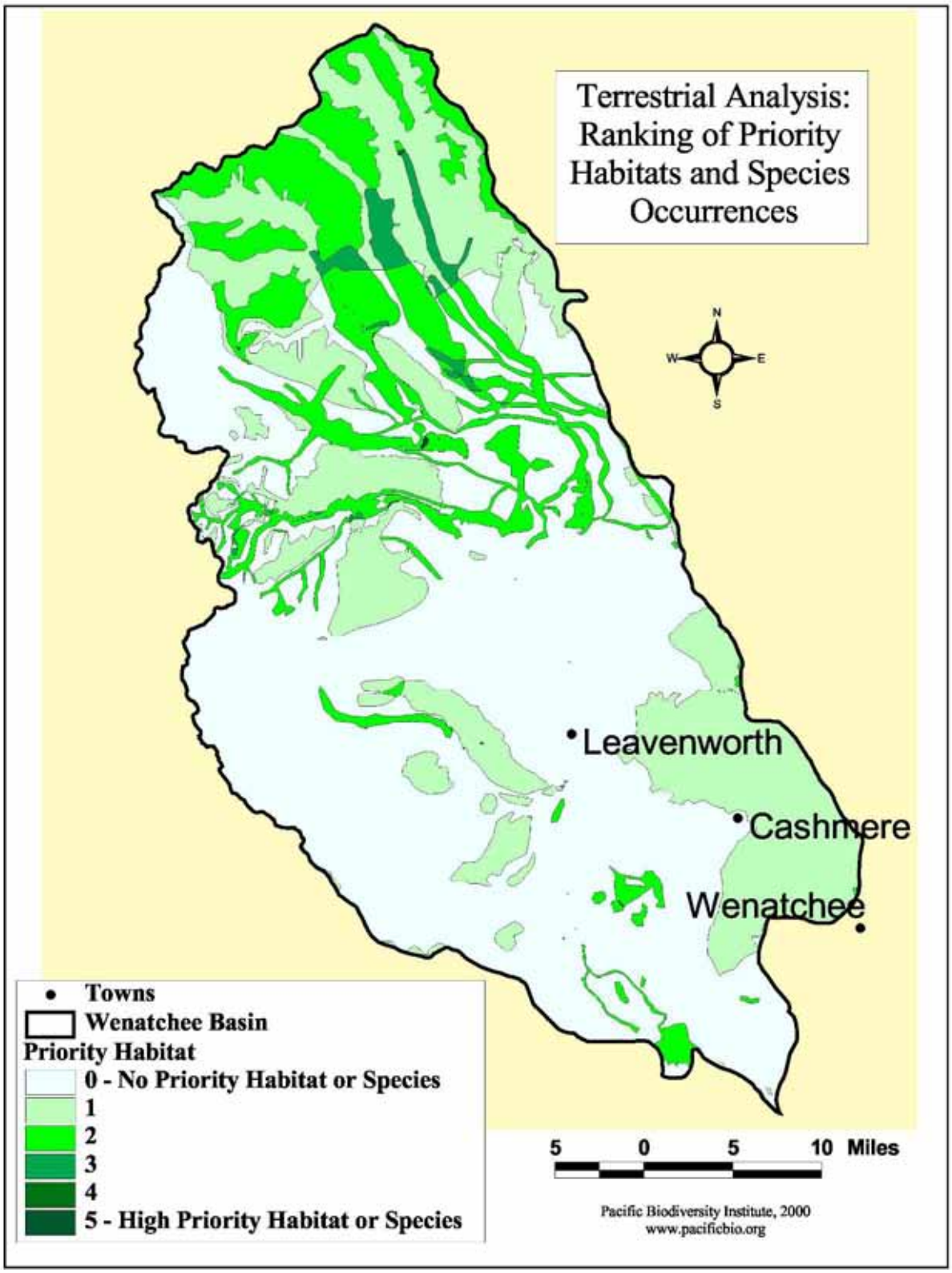


Figure 27. Ranking of habitats for the Washington Department of Fish and Wildlife's Priority Species and Habitats used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate overlap of habitats for many priority species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

models for these species from WA-GAP. Each species habitat model was clipped out for the Wenatchee River Basin and converted to a grid surface with 100m cells. The grid surface was coded as a 1 for predicted habitat and 0 for other areas. We then summed all of the species grid surfaces and ranked the output from 1 to 5 (Figure 28). Areas with no predicted large carnivore habitat for any species were coded as 0.

Table 15. Large carnivore species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name
River otter	*Lutra Canadensis*
Mink	*Mustella vison*
Black bear	*Ursus americanus*
Grizzly bear	*Ursus arctos*
Lynx	*Lynx canadensis*
Marten	*Martes americana*
Fisher	*Martes pennati*
Gray wolf	*Canis lupus*
Wolverine	*Gulo gulo*

Late-successional and Old-growth Species

Estimates of the amount of remaining late-successional and old-growth forest in the Pacific Northwest range from 10-17% (Noss et al. 1995). The species that inhabit these forests are experiencing habitat loss due to logging activities, and habitat degradation from fragmentation and isolation of their remaining habitat patches. Because the Wenatchee River Basin contains significant amounts of late-successional and old-growth forests, examination of the overlap of habitats for species associated with these forests is a valuable method of prioritizing the Wenatchee River Basin. We used the list of species generated by Federal Ecosystem Management and Assessment Team (FEMAT) (1993) to assess the conservation value of land in the Wenatchee River Basin for late-successional and old-growth associated species (Table 16). PBI relied on the predicted habitat models for these species from WA-GAP (Cassidy et al. 1997). Each species habitat model was clipped out for the Wenatchee River Basin and converted to a grid surface with 100m cells. The grid surface was coded as a 1 for predicted habitat and 0 for other areas. We then summed all of the species grid surfaces and ranked the output from 1 to 5 (Figure 29). Areas with no predicted habitat for any late-successional or old-growth associated species were coded as 0.

Northern Spotted Owl in Douglas-fir Forest. Photo by Peter Morrison.

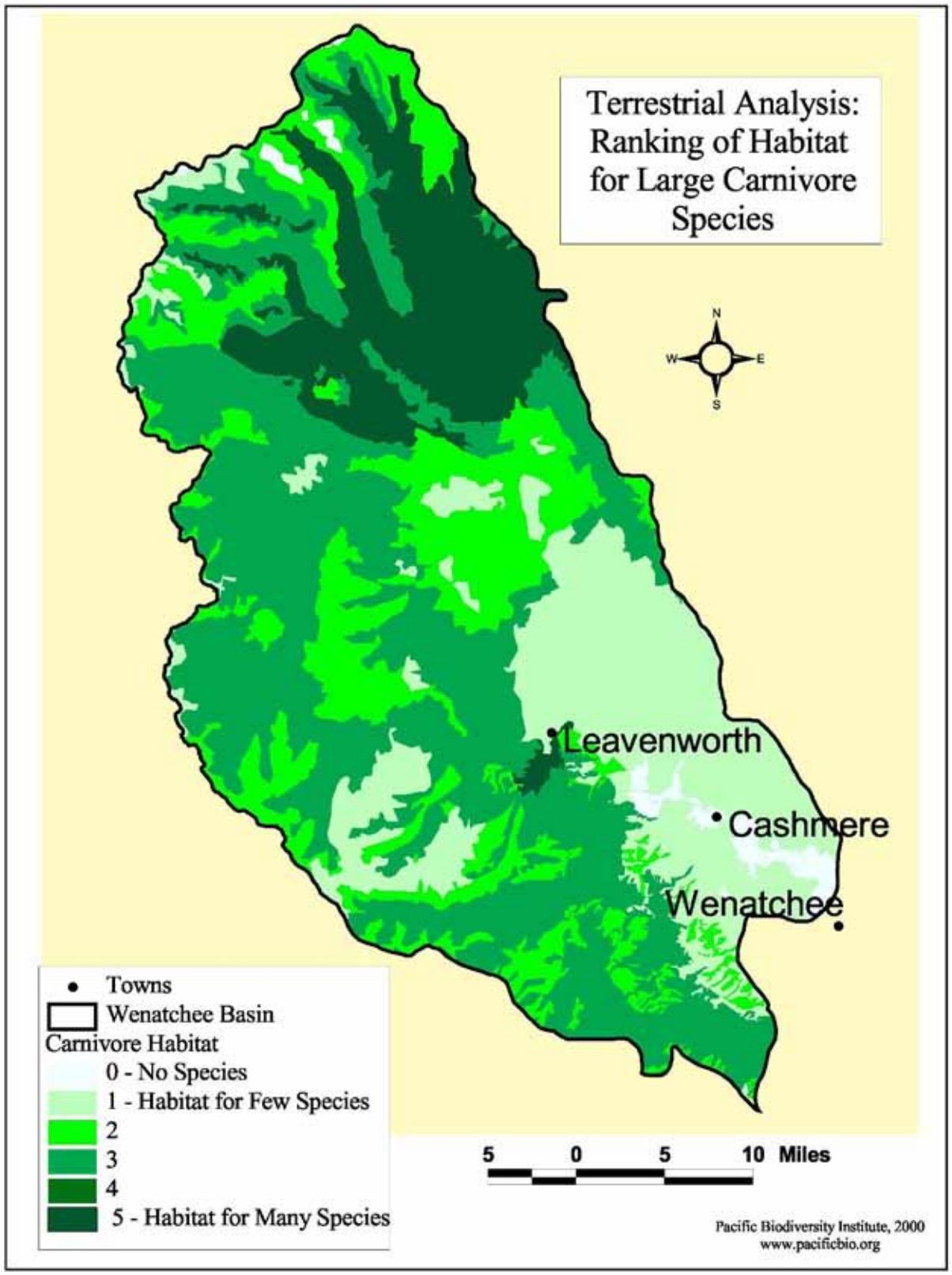


Figure 28. Large carnivore habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate habitat for many large carnivore species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

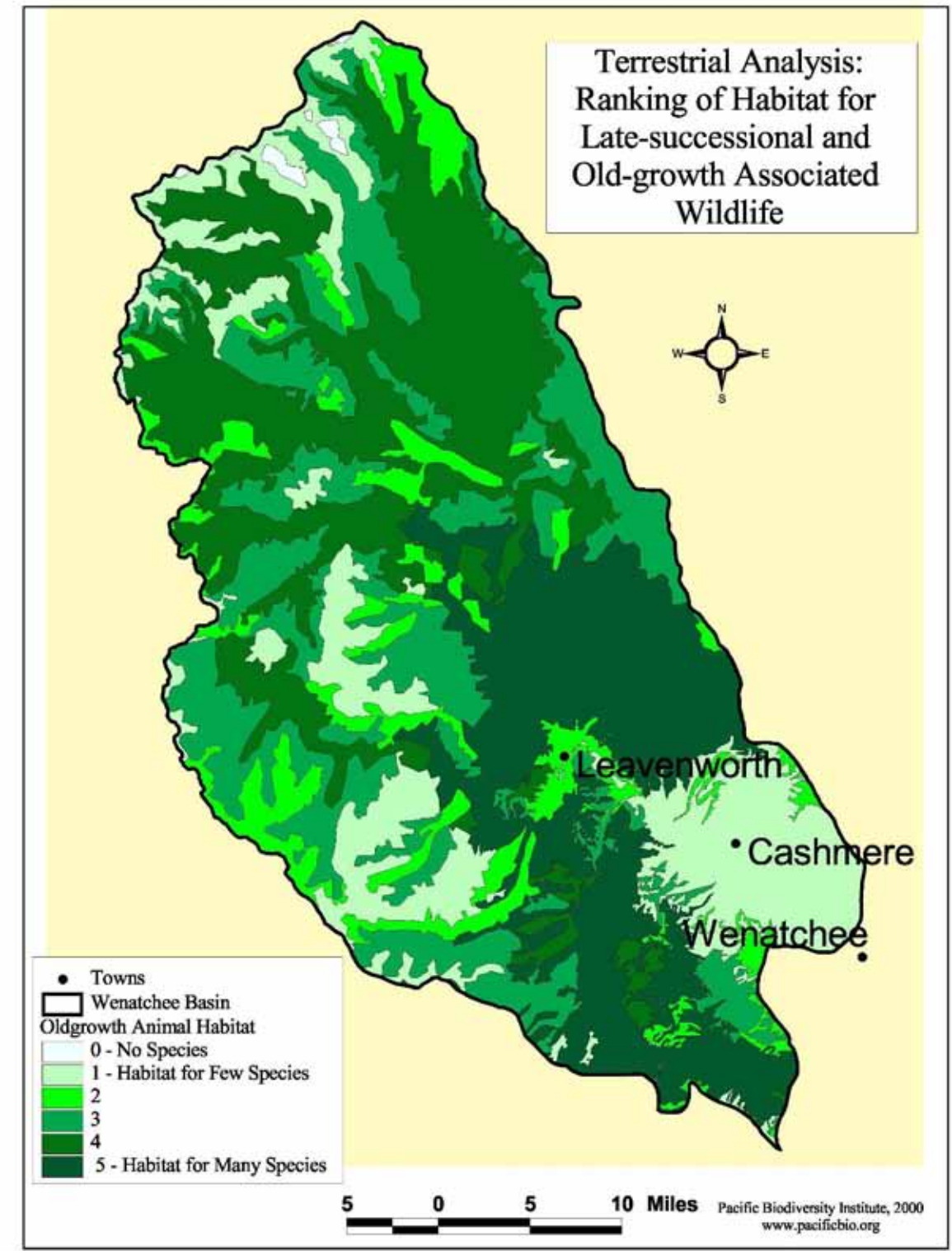


Figure 29. Late-successional and old-growth dependent species habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate areas of habitat for many late-successional/old-growth associated wildlife species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

Table 16. Late-successional and old-growth associated species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name
Amphibians	
Pacific giant salamander	*Dicamptodon tenebrosus*
Rough-skin newt	*Taricha granulosa*
Tailed frog	*Ascaphus trueii*
Birds	
Bald eagle	*Haliaeetus leucocephalus*
Barred owl	*Strix varia*
Barrow's goldeneye	*Bucephala islandica*
Black-backed woodpecker	*Picoides arcticus*
Brown creeper	*Certhia americana*
Chestnut-backed chickadee	*Parus rufescens*
Common merganser	*Mergus merganser*
Flammulated owl	*Otus flammeolus*
Golden-crowned kinglet	*Regulus satrapa*
Great gray owl	*Strix nebulosa*
Hairy woodpecker	*Picoides villosus*
Hammond's flycatcher	*Empidonax hammondii*
Harlequin duck	*Histrionicus histrionicus*
Hermit thrush	*Catharus guttatus*
Hooded merganser	*Lophodytes cucullatus*
Northern flicker	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Northern pygmy owl	*Glaucidium gnoma*
Northern spotted owl	*Strix occidentalis occidentalis*
Pileated woodpecker	*Dryocopus pileatus*
Pygmy nuthatch	*Sitta pygmaea*
Red crossbill	*Loxia curvirostra*
Red-breasted nuthatch	*Sitta Canadensis*
Red-breasted sapsucker	*Sphyrapicus rubber*
Three-toed woodpecker	*Picoides tridactyulus*
Varied thrush	*Ixoreus naevius*
Vaux's swift	*Chaetura vauxi*
Warbling vireo	*Vireo gilvus*
Western flycatcher	*Empidinax dificillis*
White-breasted nuthatch	*Sitta carolinensis*
White-headed woodpecker	*Picoides albolarvatus*
Williamson's sapsucker	*Syphyrapicus thyroideus*
Wilson's warbler	*Wilsonia pusilla*
Winter wren	*Troglodytes trogodytes*
Wood duck	*Aix sponsa*
Mammals	
Deer mouse	*Peromyscus maniculatus*
Douglas squirrel	*Tamiasciurus douglasii*
Elk	*Cervus elaphus*
Fisher	*Martes pennanti*
Forest deer mouse	*Peromyscus keeni*
Marten	*Martes Americana*
Shrew mole	*Neurotrichus gibbsii*
Southern red-backed vole	*Clethrinomys gapperii*
Townsend's chipmunk	*Tamias townsendii*
Big brown bat	*Eptesicus fuscus*
California myotis	*Myotis californicus*
Fringed myotis	*Myotix thysanodes*
Hoary bat	*Lasiurus cinereus*
Little brown myotis	*Myotis lucifugus*
Long-legged myotis	*Myotis volans*
Pallid bat	*Antrozous pallidus*
Silver-haired bat	*Lasionycteris noctivagans*
Yuma myotis	*Myotis yumanensis*

Amphibians

Amphibians have also been suggested as useful indicators of environmental quality and ecosystem integrity because of their complex life cycles (i.e., both aquatic and terrestrial) and their sensitivity to environmental contaminants (Landres et al. 1988). To assess the conservation value of land in the Wenatchee River Basin for amphibians (Table 17), we relied on the predicted habitat models for these species from WA-GAP. Each species habitat model was clipped out for the Basin and converted to a grid surface with 100m cells. The grid surface was coded as a 1 for predicted habitat and 0 for other areas. We then summed all of the species grid surfaces and ranked the output from 1 to 5 (Figure 30). Areas with no predicted amphibian habitat for any species were coded as 0.

Table 17. Amphibian species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name
Tiger salamander	*Ambystoma tigrinum*
Long-toed salamander	*Ambystoma macrodactyla*
Pacific giant salamander	*Dicamptondon tenebrosus*
Roughskin newt	*Taricha granulose*
Great-basin spadefoot	*Scaphiopus intermontanus*
Western toad	*Bufo bufo*
Pacific treefrog	*Hyla regalia*
Cascades frog	*Rana cascadae*
Columbia spotted frog	*Rana luteiventris*
Tailed frog	*Ascaphus trueii*

Reptiles

Reptiles are also useful indicators of environmental condition because of the sensitivity of many species to human disturbance. Additionally, many reptiles have historically been subject to extermination efforts by humans. To assess the conservation value of land in the Wenatchee River Basin for amphibians (Table 18), we relied on the predicted habitat models for these species from WA-GAP.

Table 18. Reptile species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name
Painted turtle	*Chrysemys picta*
Northern alligator lizard	*Elgaria coeurulea*
Short-horned lizard	*Phrynosoma douglassii*
Sagebrush lizard	*Sceloporus graciosus*
Western fence lizard	*Sceloporus occidentalis*
Western skink	*Eumeces skiltonianus*
Rubber boa	*Charina bottae*
Racer	*Coluber constrictor*
Gopher snake	*Pituophis catenifer*
Western terrestrial garter snake	*Thamnophis elegans*
Common garter snake	*Thamnophis sirtalis*
Nightsnake	*Hypsiglena torquata*
Sharp-tail snake	*Contia tenuis*
Western rattlesnake	*Crotalus viridis*

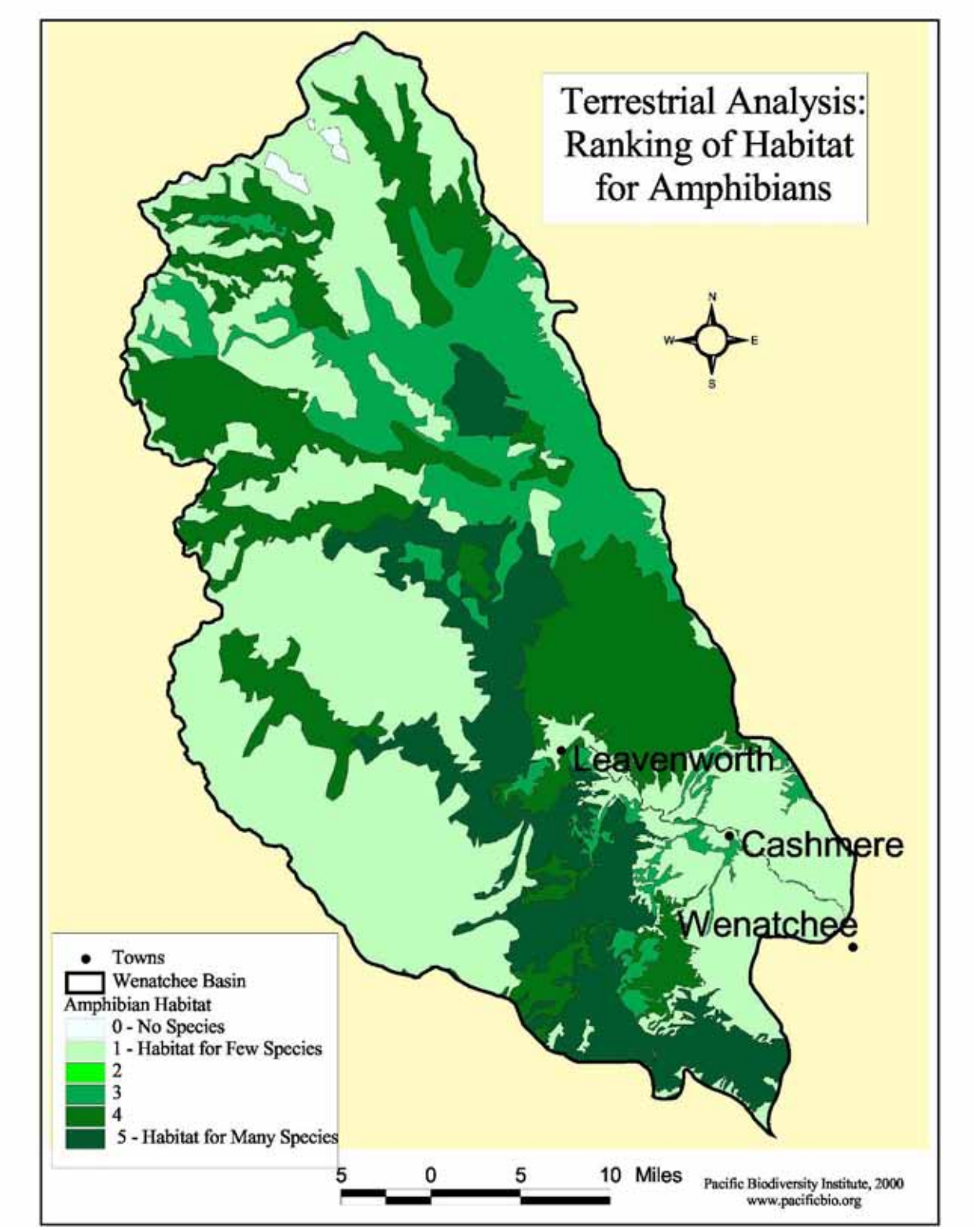


Figure 30. Amphibian habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate habitat for many amphibian species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

Each species habitat model was clipped out for the Wenatchee River Basin and converted to a grid surface with 100m cells. The grid surface was coded as a 1 for predicted habitat and 0 for other areas. We then summed all of the species grid surfaces and ranked the output from 1 to 5 (Figure 31). Areas with no predicted reptile habitat for any species were coded as 0.

Bird Species of Concern

To assess the priority bird habitats in the Wenatchee River Basin we looked at the richness (total number of species in a given area) of bird species of conservation concern. We defined our list of bird species of conservation concern from the Audubon Society's WatchList for Washington (http://www.audubon.org/bird/watch/state2/wa.htm) as well as a list of federal and state threatened, endangered, and special concern species (Table 19). The WatchList is a prioritization of bird species designed to provide focus for education, research, and conservation initiatives, and is intended to complement, rather than replace, existing threatened, endangered, and special concern species listings.

Table 19. Audubon WatchList and state and federal threatened, endangered and special concern species in the Wenatchee River Basin.

Common Name	Scientific Name
Western grebe	*Aechmophorus occidentalis*
Barrow's goldeneye	*Bucephala islandica*
Blue grouse	*Dendragapus obscurus*
Sandhill crane	*Grus canadensis*
American avocet	*Recurvirostra americana*
Long-billed curlew	*Numenius americanus*
Wilson's phalarope	*Phalaropus tricolor*
Forster's tern	*Sterna forsteri*
Flammulated owl	*Otus flammeolus*
Black swift	*Cypseloides niger*
Calliope hummingbird	*Stellula calliope*
Rufous hummingbird	*Selasphorus rufus*
Williamson's sapsucker	*Sphyrapicus thyroideus*
Olive-sided flycatcher	*Contopus borealis*
Willow flycatcher	*Empidonax traillii*
Dusky flycatcher	*Empidonax oberholseri*
Black-throated gray warbler	*Dendroica nigrescens*
Sage sparrow	*Amphispiza belli*
Sage thrasher	*Orescoptes montanus*
Mountain quail	*Oreortyx pictus*
Vaux's swift	*Chaetura vauxi*
Lewis' woodpecker	*Melanerpes lewis*
Black-backed woodpecker	*Picoides arcticus*
White-headed woodpecker	*Picoides albolarvatus*
Harlequin duck	*Histrionicus histrionicus*
Bald eagle	*Haliaeetus leucocephalus*
Golden Eagle	*Aquila chrysaetos*
Peregrine falcon	*Falco peregrinus*
Northern goshawk	*Accipiter gentiles*
Common loon	*Gavia immer*
Northern spotted owl	*Strix occidentalis occidentalis*
Loggerhead shrike	*Lanius ludovicianus*
Upland sandpiper	*Bartramia longicauda*

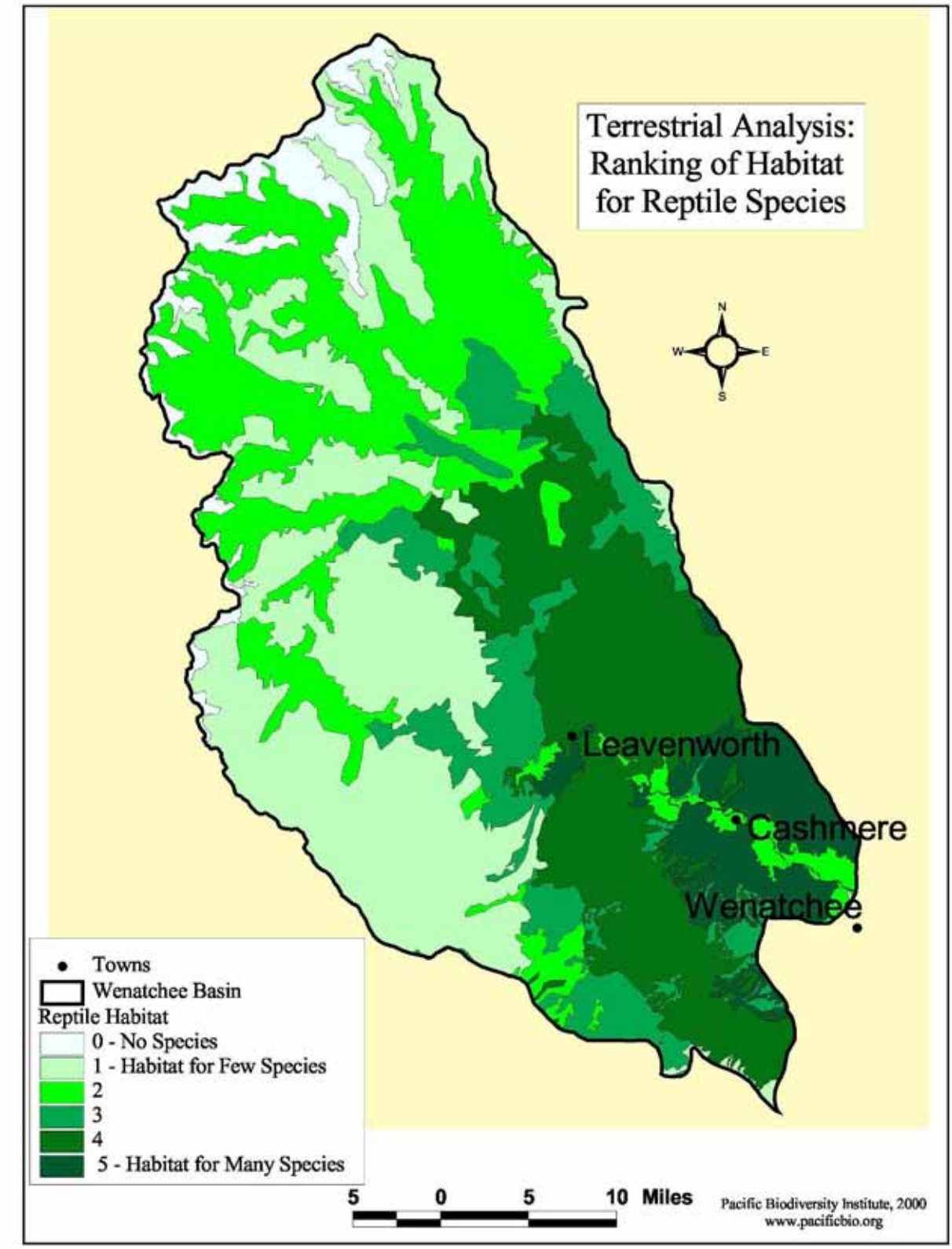


Figure 31. Reptile habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate habitat for many reptile species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

To assess the conservation priority of bird species of concern in the Wenatchee River Basin, we relied on the predicted habitat models for these species from WA-GAP (Cassidy et al. 1997). Each species habitat model was clipped out for the Basin and converted to a grid surface with 100m cells. The grid surface was coded as a 1 for predicted habitat and 0 for other areas. We then summed all of the species grid surfaces and ranked the output from 1 to 5 (Figure 32). Areas with no predicted habitat for any species were coded as 0.

Bats

The richness of bat species is a useful way of prioritizing an area since bats associate with unique habitat features (e.g., snags, large trees, caves or rock crevices) and are very sensitive to human disturbance. To assess the conservation value of land in the Wenatchee River Basin for bats (Table 20), we relied on the predicted habitat models for these species from WA-GAP. Each species habitat model was clipped out for the Basin and converted to a grid surface with 100m cells. The grid surface was coded as a 1 for predicted habitat and 0 for other areas. We then summed all of the species grid surfaces and ranked the output from 1 to 5 (Figure 33). Areas with no predicted bat habitat for any species were coded as 0.

Table 20. Bat species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name
Pallid bat	*Antrozous pallidus*
Big brown bat	*Eptesicus fuscus*
Spotted bat	*Euderma maculatum*
Hoary bat	*Lasiurus cinereus*
Silver-haired bat	*Lasionycteris noctivagans*
Small-footed myotis	*Myotis ciliolabrum*
Long-eared myotis	*Myotis evotis*
Little brown myotis	*Myotis lucifugus*
California myotis	*Myotis californicus*
Long-legged myotis	*Myotis volans*
Yuma myotis	*Myotis yumanensis*
Western pipistrelle	*Pipistrellus Hesperus*
Fringed myotis	*Myotis thysanodes*
Pacific big-eared bat	*Coryhorhinus townsendii*

Introduced and Invasive Animal Species

Human settlement and alteration of habitats introduces many exotic species into an ecosystem. Many of these species compete for resources with (e.g., starling [*Sturnus vulgaris*] use of nesting cavities) or prey upon (e.g., bullfrog [*Rana catesbiana*] predation of amphibian tadpoles, larve, and juveniles) native species, often with severe impacts. While the brown-headed cowbird (*Molothrus ater*) is a neo-tropical migrant native to the United States, extensive land clearing for agriculture has allowed this species to invade beyond it's historic range and into new areas. The brown-headed cowbird is a facultative brood parasite (meaning it only lays its eggs in the nests of other species), and it's young out-compete those of its host species. Since the brown-headed cowbird is a recent introduction to the avi-fauna of the western United States, the native species have not evolved appropriate defense mechanisms against cowbird predation. Thus, the brown-headed cowbird has contributed to significant declines in several host species (Erlich et al. 1988).

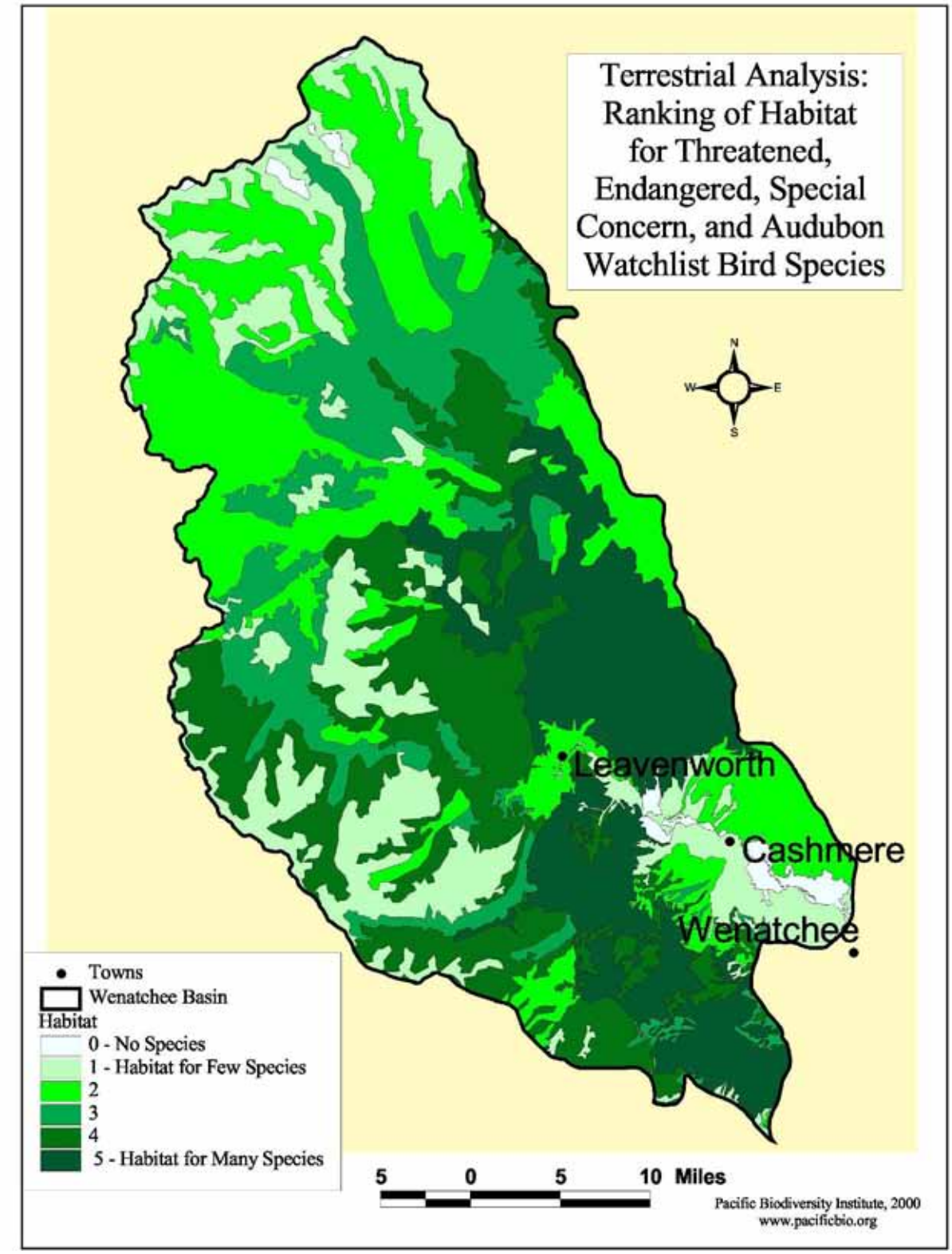


Figure 32. Audubon WatchList and state and federal threatened, endangered and special concern species habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate habitat for many threatened, endangered, special concern and Audubon WatchList bird species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

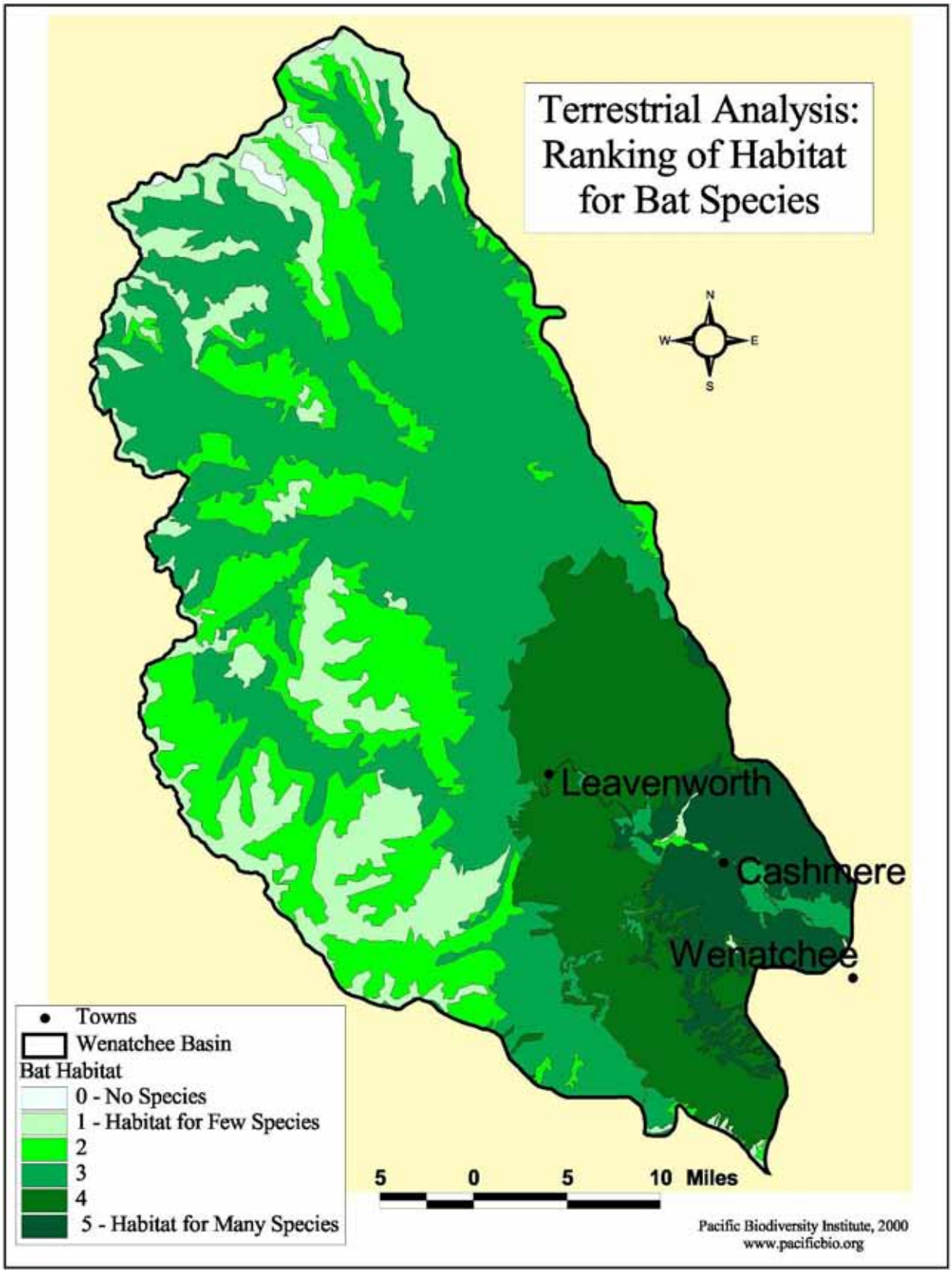


Figure 33. Bat habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate habitat for many bat species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

To assess the potential impact of introduced and invasive animal species in the Basin (Table 21), we relied on the predicted habitat models for these species from WA-GAP. Each species habitat model was clipped out for the Wenatchee River Basin and converted to a grid surface with 100m cells. The grid surface was coded as a 1 for predicted habitat and 0 for other areas. We then summed all of the species grid surfaces and ranked the output from 1 to 5 (Figure 34). Areas with no predicted introduced species habitat for any species were coded as 0.

Table 21. Introduced and invasive animal species included in the terrestrial prioritization of the Wenatchee River Basin.

Common Name	Scientific Name
Amphibians	
Bullfrog	*Rana catesbeiana*
Birds	
European starling	*Sturnus vulgaris*
Brown-headed cowbird	*Molothrus ater*
House finch	*Carpodacus mexicanus*
House sparrow	*Passer domesticus*
Mammals	
Virginia Opossum	*Didelphis virginiana*
House mouse	*Mus musculus*
Norway rat	*Rattus norvegicus*
Black rat	*Rattus rattus*

Late-successional and Old-growth Forests

We relied on evaluation of the late-successional and old-growth (LSOG) forests developed by Morrison et al. (1995) to determine the distribution and relative importance of late-successional and old-growth forests in the Wenatchee River Basin. This work relied on GIS data obtained from the US Forest Service developed under contract with Pacific Meridian Resources. While this data is perhaps the best available data, experience of both the authors and the US Forest Service has shown that this data has a relatively low accuracy in depicting the location of old-growth forests. Morrison et al. (1995) developed two generalized data sets from the original data. The first data set depicts the relative age and successional development of the forests on a pixel-by-pixel basis. The second data set depicts the relative value that a stand of LSOG may have based on its size and proximity to other LSOG stands. Both of these data sets were use in our assessment of the Wenatchee River Basin. The GIS grid representing the age of the forest was compressed into five equal area classes, with class 5 representing the oldest forest class (Figure 35). The GIS grid surface that depicts the size of LSOG stands and their proximity to each other was also ranked from 1 to 5 with class 5 representing the largest stands (Figure 36). While the greatest concentrations of older forest occur in the western part of the Basin, there are significant areas of old forest and scattered patches throughout the Basin.

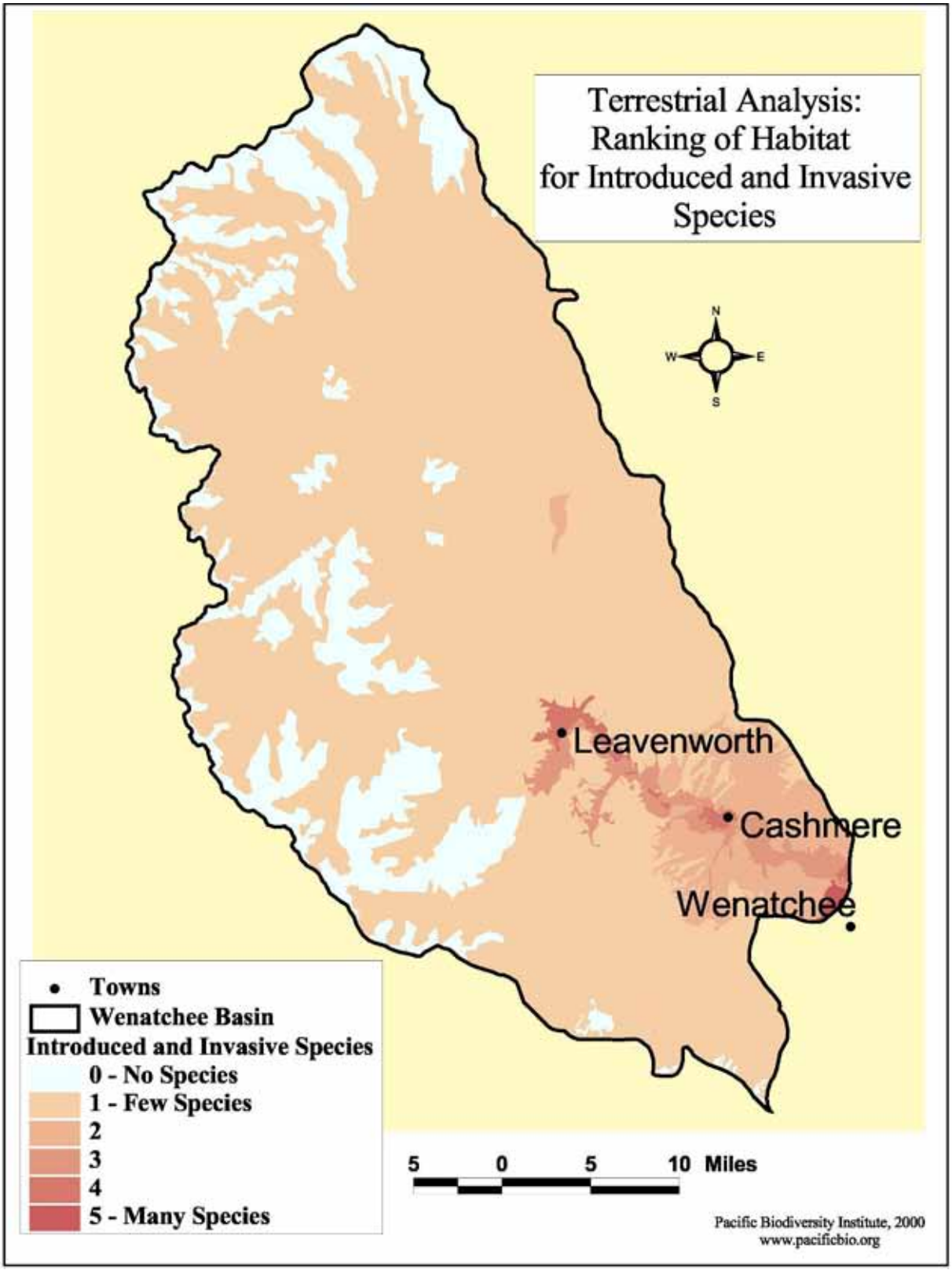


Figure 34. Introduced and invasive species habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High vales (dark red) indicate habitat for many invasive and introduced wildlife species, detracting from terrestrial priority. This was used as a negative factor in the terrestrial prioritization.

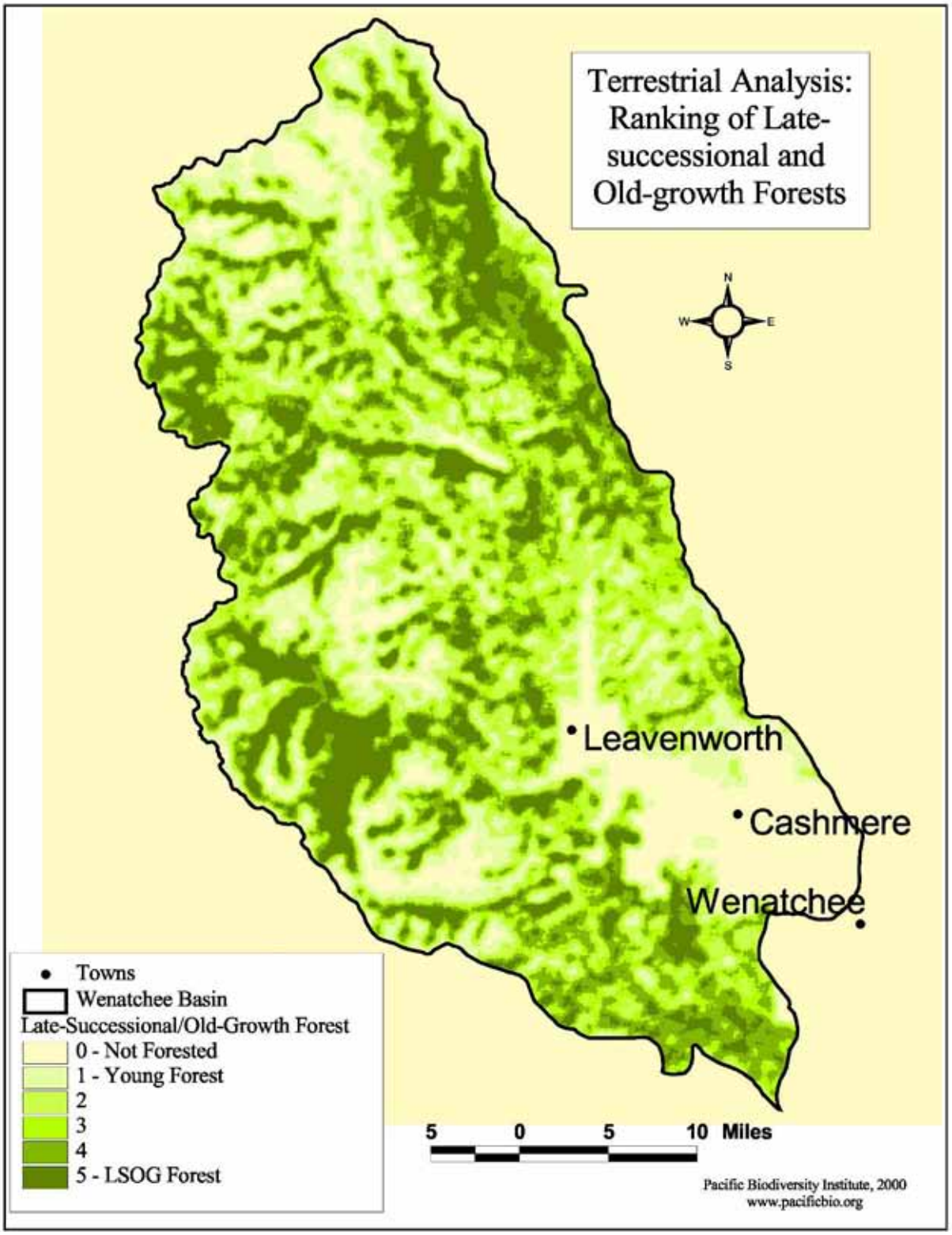


Figure 35. Late-successional and old-growth forest rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate the presence of late-successional/old-growth forests, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

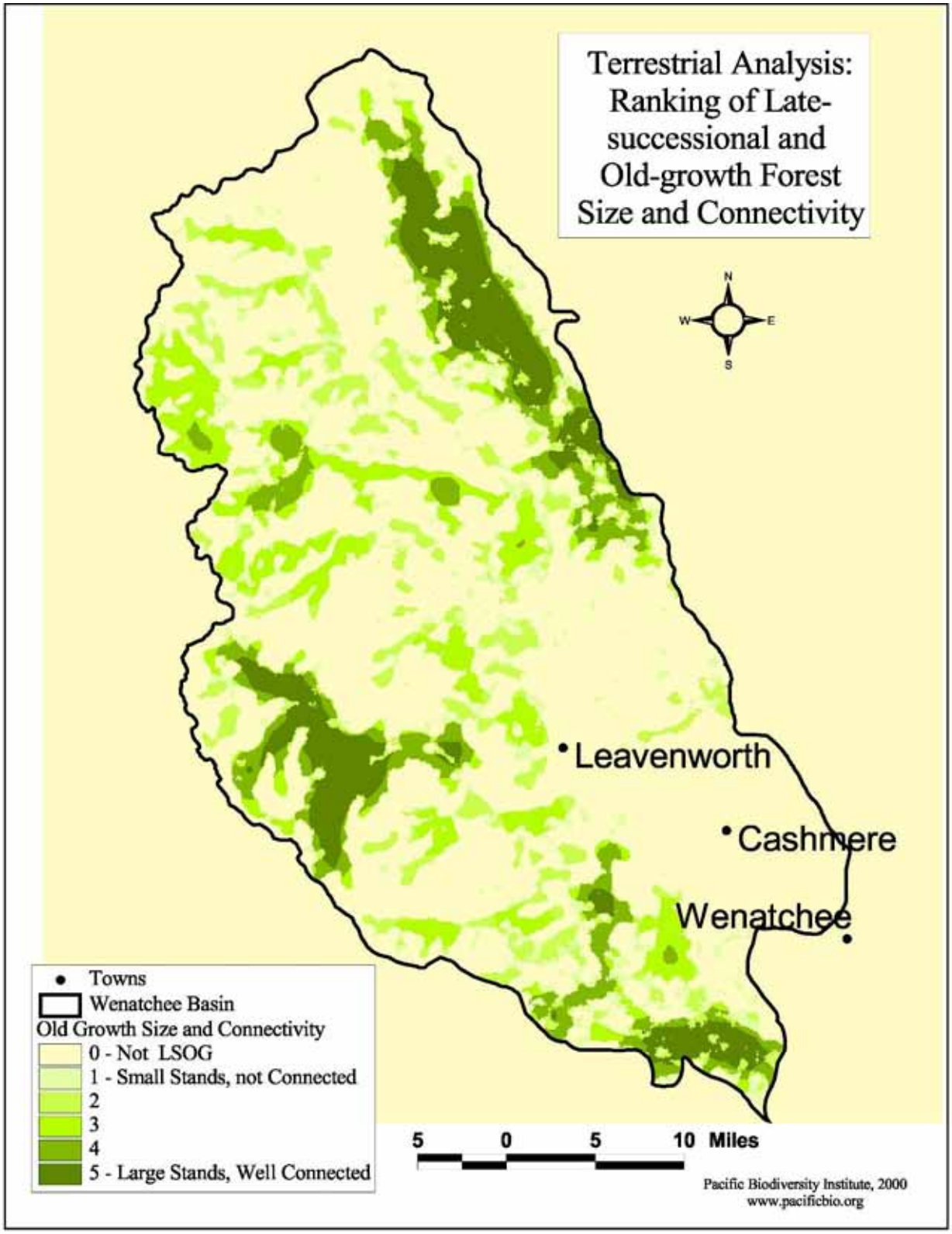


Figure 36. Late-successional/old-growth forest connectivity and size rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate large late-successional/old-growth stands that are well connected to other old stands. This adds to terrestrial priority and was used as a positive factor in the terrestrial analysis.

Vegetation Rarity

Assessment of rare vegetation types is a useful method for insuring that unrepresented parts of an ecosystem are conserved (Pressy in press). Morrison et al. (1995) rated the rarity of all vegetation types in the Greater North Cascades Ecosystem in relationship to their overall abundance in the ecosystem and their degree of representation in protected areas. PBI used their vegetation rarity index to create a vegetation rarity ranking for the Wenatchee River Basin.

Common vegetation types received a low value while rare types were coded higher. The resulting grid surface (100m cells) ranged in value from 0 to 5 (Figure 37). It should be noted that a vegetation rarity analysis confined to the Wenatchee River Basin would result in somewhat different results. However, we feel that an ecosystem scale analysis of vegetation rarity is more meaningful to an assessment of conservation priorities than one restricted to the Basin. The rarest vegetation types are found in the shrub-steppe and riparian areas in the lower parts of the Basin.

Rare Plant Occurrences – The Natural Heritage Plant Database Factor

Washington DNR maintains a Natural Heritage database of rare, threatened, or endangered plant observations. In the Wenatchee River Basin there were 316 records between the 38 species known to occur in the Basin (Table 22).

These data are maintained as polygons representing the distribution of a known population of plant species. We converted these polygons for each species to grid surfaces with 100m cells. Areas where the species occurred were given a value of 1. We summed all of the species surface grids to create a grid of richness of Natural Heritage plant species (Figure 38). Since the values of the richness grid varied from 0 to 4, we did not divide this factor into new categories.

Logging Activity

PBI obtained logging activity layers from the Wenatchee NF Lake Wenatchee and Leavenworth Ranger Districts. These data sets cover all logging operations for the ranger district including pruning and pre-commercial thinning. PBI evaluated these data against time-series satellite imagery for the Basin and recent aerial photography to assess their accuracy and completeness. We digitized additional logging activities and other permanent disturbances, such as powerline corridors and ski runs, when they were not included in the Wenatchee NF data. We deleted polygons from the Wenatchee NF data for which it was easily apparent that no activity had taken place. The final logging activity layer was converted to a grid surface with 100m cells. Areas with logging activity were given a value of 5 (Figure 39). All non-logged areas were given a value of 0.

Table 22. Plant species in the Washington DNR Natural Heritage Database for the Wenatchee River Basin.

Common name	Scientific name	# of observations
Tall agoseris	*Agoseris elata*	3
	Ahtiana pallidula	1
	Ahtiana sphaerosporella	1
Pasqueflower	*Anemone nuttalliana*	3
Palouse milk-vetch	*Astragalus arrectus*	1
Lance-leaved grape-fern	*Botrychium lanceolatum*	23
Moonwort	*Botrychium lunaria*	2
Victorin's grape-fern	*Botrychium minganense*	40
Two-spiked moonwort	*Botrychium paradoxum*	2
Stalked moonwort	*Botrychium pedunculosum*	1
St. John's moonwort	*Botrychium pinnatum*	14
Buxbaum's sedge	*Carex buxbaumii*	3
Bristly sedge	*Carex comosa*	1
Smoky mountain sedge	*Carex proposita*	7
Russet sedge	*Carex saxatilis var major*	3
Long-styled sedge	*Carex stylosa*	1
Thompson's chaenactis	*Chaenactis thompsonii*	28
Bulb-bearing water-hemlock	*Cicuta bulbifera*	1
Clustered lady's-slipper	*Cypripedium fasciculatum*	39
Wenatchee larkspur	*Delphinium viridescens*	21
Salish fleabane	*Erigeron salishii*	1
Boreal bedstraw	*Galium kamtschaticum*	6
Ross' avens	*Geum rossii var depressum*	2
Showy stickseed	*Hackelia venusta*	4
Longsepal globemallow	*Iliamna longisepala*	48
Western pearlshell	*Margaritifera falcata*	2
Brewer's cliff-brake	*Pellaea breweri*	4
Chelan rockmat	*Petrophyton cinerascens*	2
Sticky phacelia	*Phacelia lenta*	2
Least phacelia	*Phacelia minutissima*	1
Small northern bog-orchid	*Platanthera obtusata*	1
Gray's bluegrass	*Poa arctica ssp arctica*	1
Pygmy saxifrage	*Saxifraga rivularis*	2
Strawberry saxifrage	*Saxifragopsis fragarioides*	2
Oregon checker-mallow	*Sidalcea oregana var calva*	8
Seely's silene	*Silene seelyi*	18
Swertia	*Swertia perennis*	1
Thompson's clover	*Trifolium thompsonii*	7

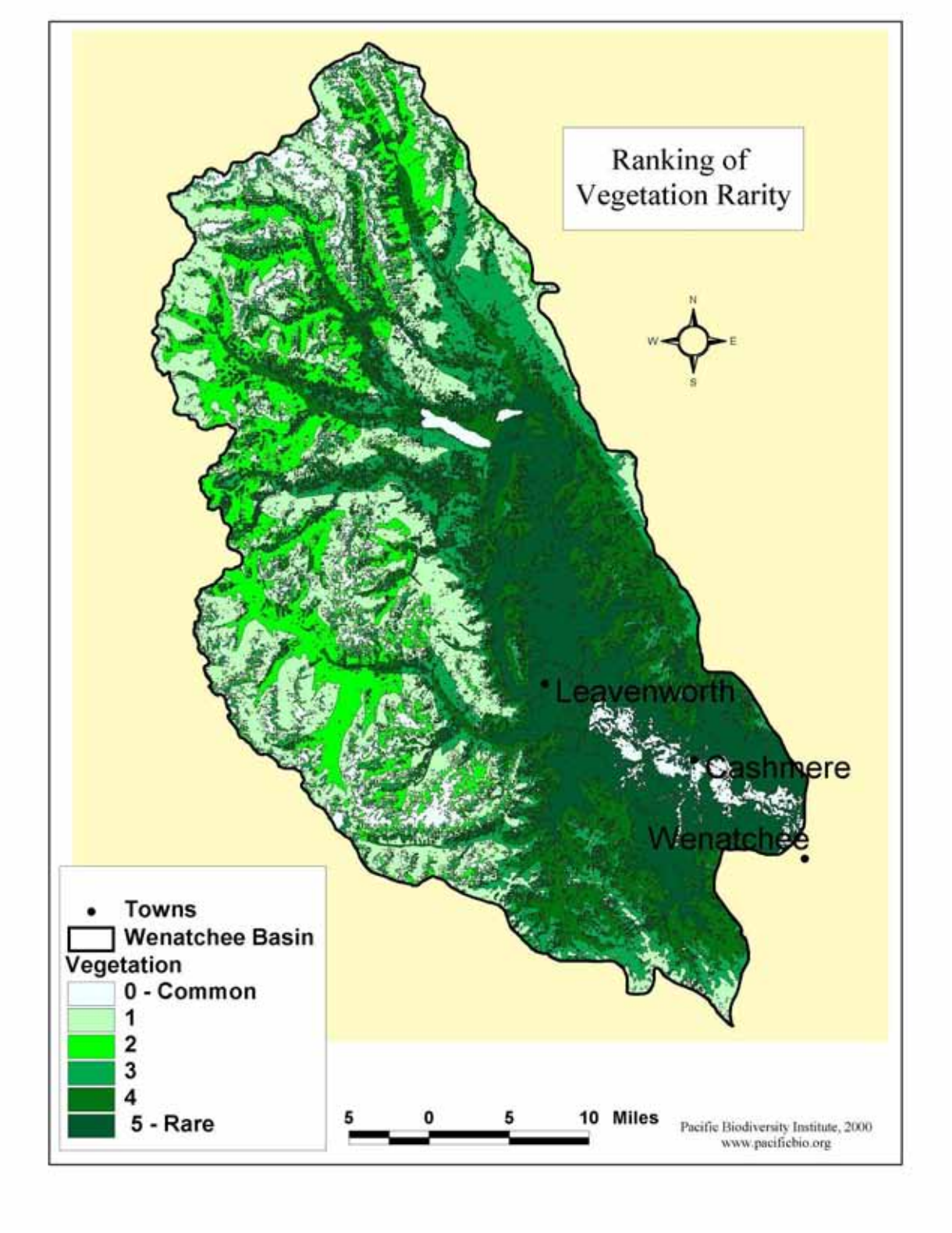


Figure 37. Vegetation rarity rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate vegetation types that are rare in the Greater North Cascades Ecosystem. This increases conservation priority and was used as a positive factor in the terrestrial prioritization.

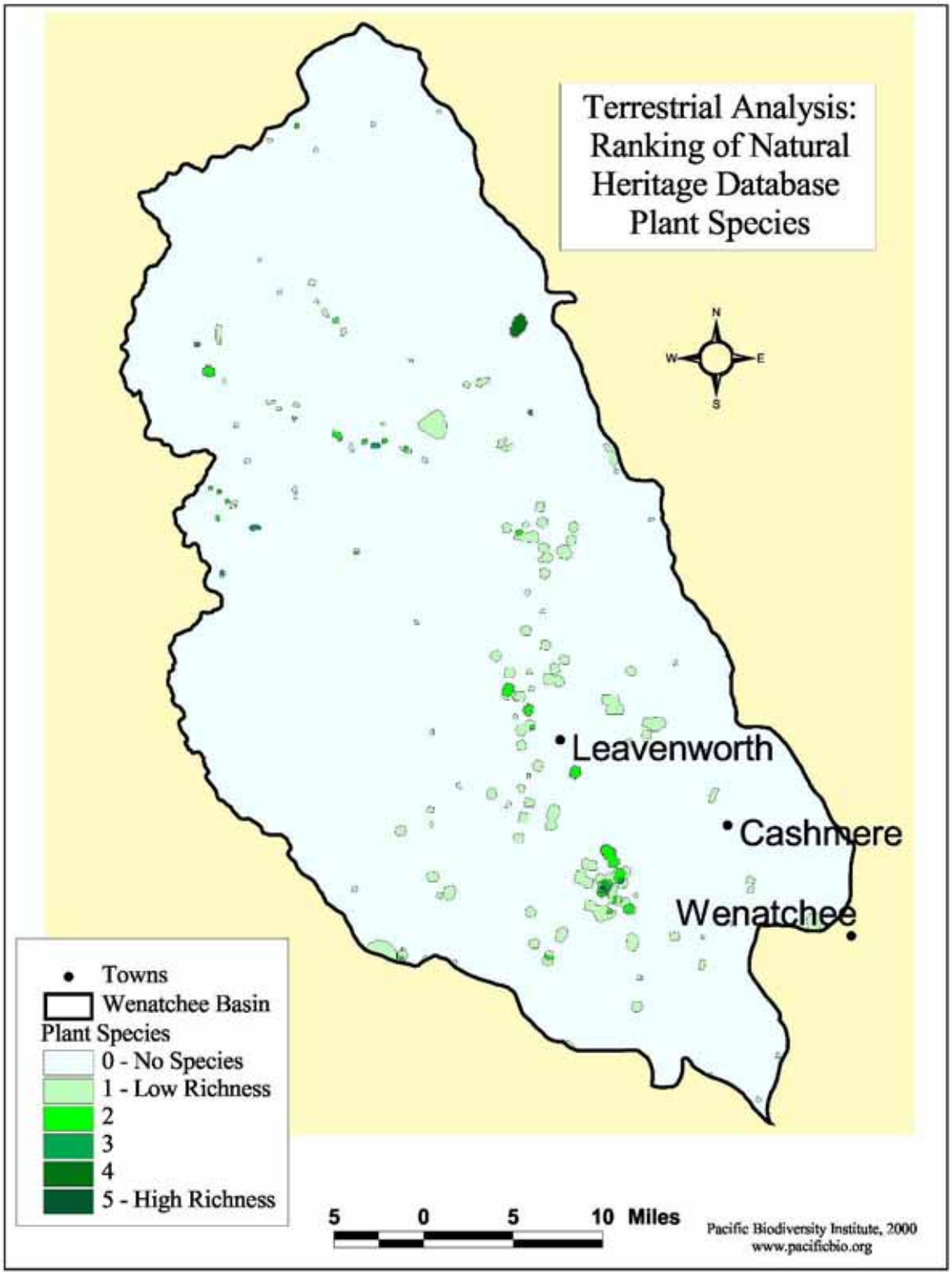


Figure 38. Ranking of Washington Natural Heritage Plant database records for the Wenatchee River Basin terrestrial prioritization. High values (dark green) indicate the presence of many threatened, endangered, or special concern plant species. This increases conservation priority and was used as a positive factor in the terrestrial prioritization.

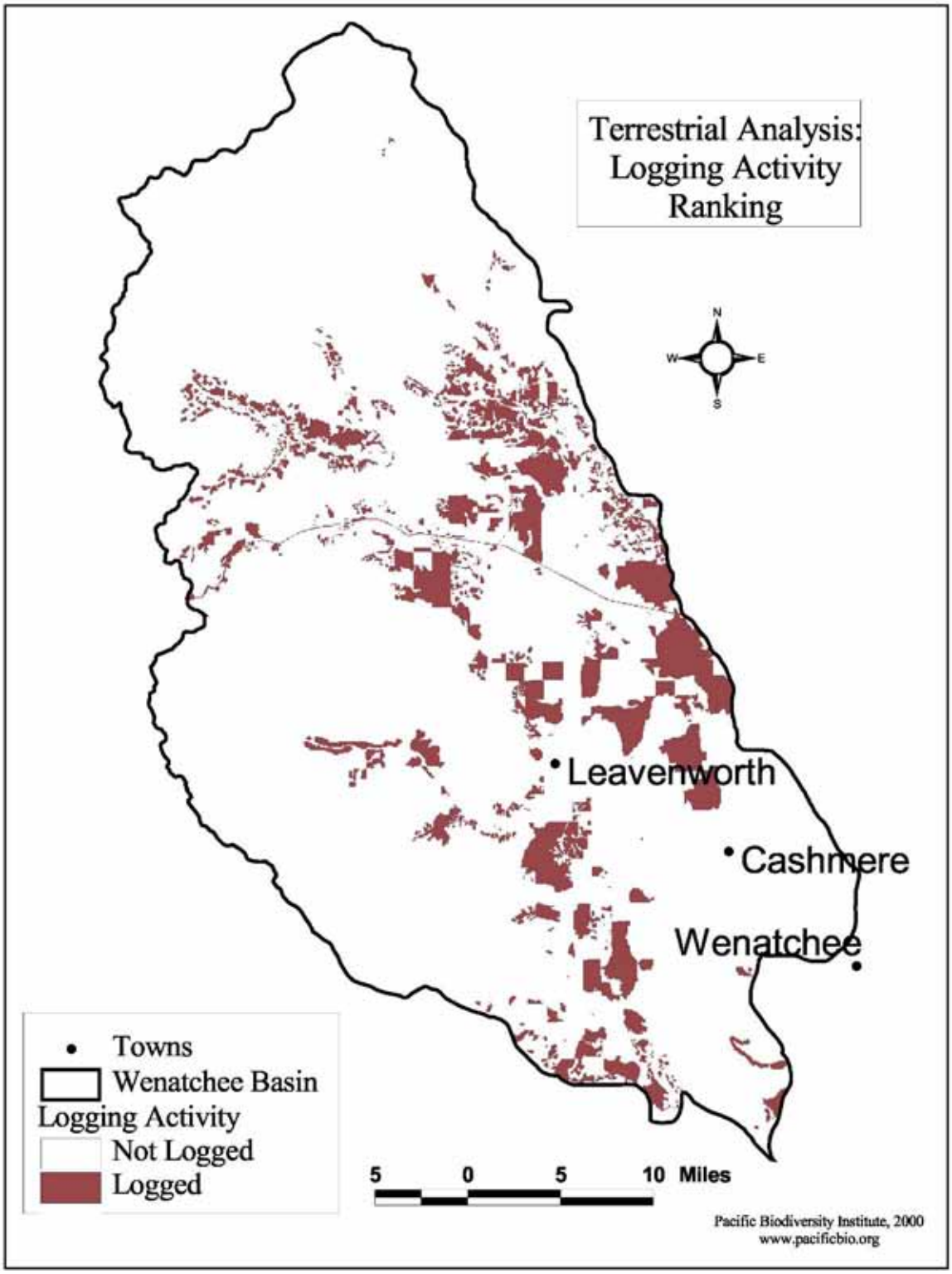


Figure 39. Logging activity ranking for the Wenatchee River Basin terrestrial prioritization. Because of the impacts of logging on natural environments, areas that have been logged were given a value of 5. This was used as a negative factor in the terrestrial prioritization.

Evaluation of Terrestrial Habitat Condition

The overall priority values for the terrestrial prioritization of the Wenatchee River Basin ranged from –4 to 44 before standardization. After standardization (adding 4 to each score), values ranged from 0 to 48 (Figure 40). The mean conservation priority value across the entire Basin was 24.3.

Areas of highest priority were mostly along the Chiwawa River and in the vicinity of State Route 97 to Blewett Pass. Other high-ranking areas were well dispersed throughout the Basin. Areas of the lowest priority fell along the Wenatchee River downstream from Leavenworth and in high, alpine areas.

While the majority of the highest-priority areas were in public ownership, there was a considerable amount of high-ranking land in private ownership in the Basin (Figure 41). The most significant areas on private lands occur upstream of Lake Wenatchee, in the Chickawum Creek area, along the Wenatchee River above Leavenworth, Icicle Creek drainage, and the land adjacent to State Route 97 to Blewett Pass (See Appendix C for a list of the highest-ranking Chelan County parcels).

Climbing in the Enchantments. Photo by Peter Morrison.

RECREATIONAL RESOURCES

Recreational activities are widely varied in the Wenatchee River Basin. The Basin is known for it's first-rate hiking and backpacking, camping, skiing, rock climbing, whitewater rafting and kayaking, mountain biking, wildlife viewing, hunting and fishing. Data on recreational use of the Basin, however, is limited and of varying quality. To assess recreational and scenic potential in the Basin, we gathered GIS data on trail systems, parks, wilderness areas, campgrounds, rock climbing areas, whitewater rafting rivers, and fishing areas. PBI requested data from Washington Department of Fish and Wildlife on public access points and motorized boat launches, but this information was not available at the time that this report was written. Currently, watchable-wildlife sites do not exist in a GIS data format. PBI is currently working on digitizing these sites and other recreation data for the area.

Outside of wilderness areas, there are 33 US Forest Service campgrounds and three Washington State Parks in the Basin (Figure 42). Additionally, the Alpine Lakes, Glacier Peak, and Henry M. Jackson Wilderness areas account for 36.4% of the total Basin area. There are over 90 roadless areas in the Basin (exclusive of USFS Wilderness Areas) totaling over 146,000 acres (42.5% of the total basin, Figure 43). These roadless areas offer many dispersed recreation opportunities. Over 1,300 miles of trails penetrate the wilderness areas and other wild places in the Basin.

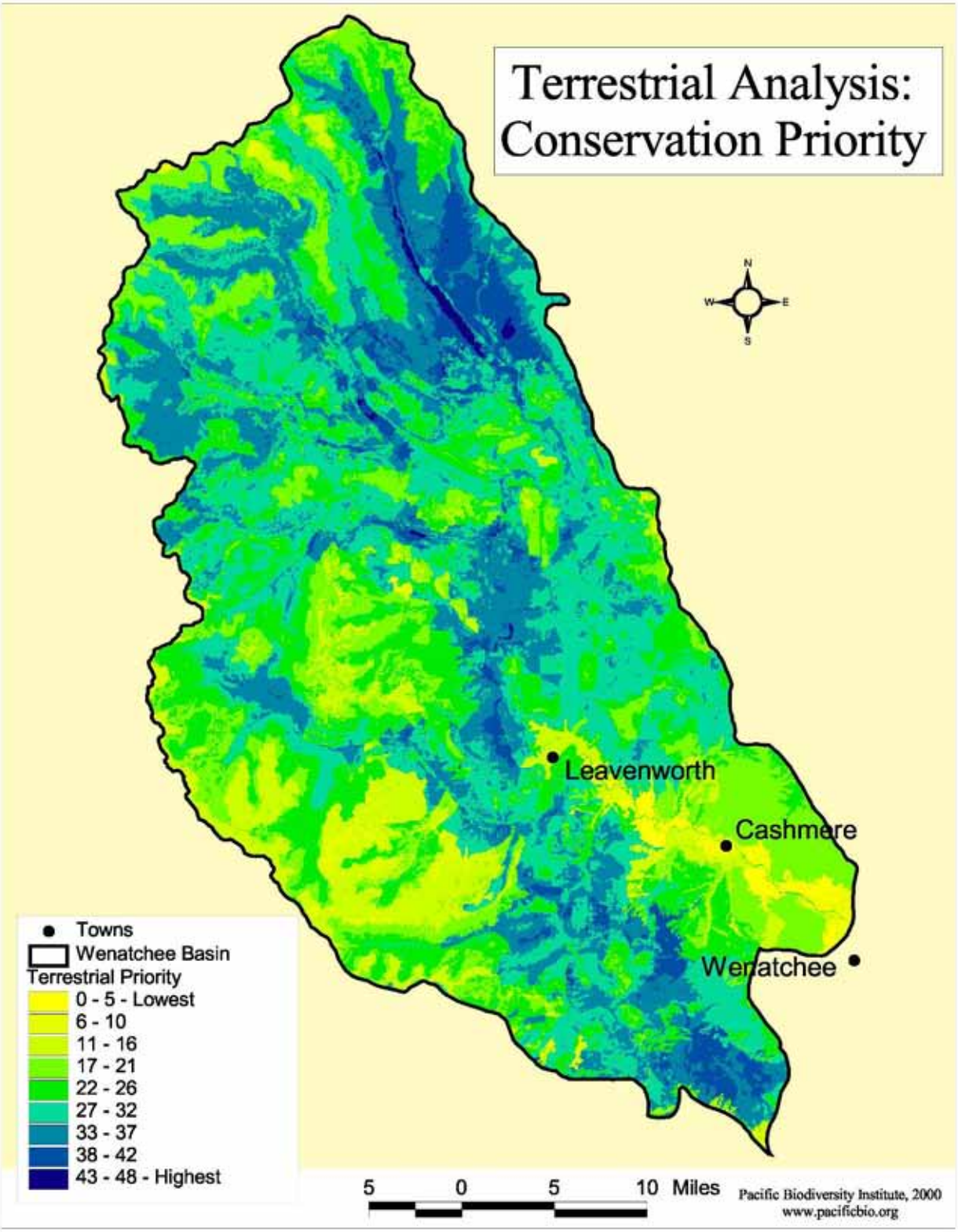


Figure 40. Terrestrial habitat conservation priorities for the Wenatchee River Basin. High values (dark blues) have the highest values for positive factors and the lowest values for negative factors. These are the highest priority areas in the Basin.

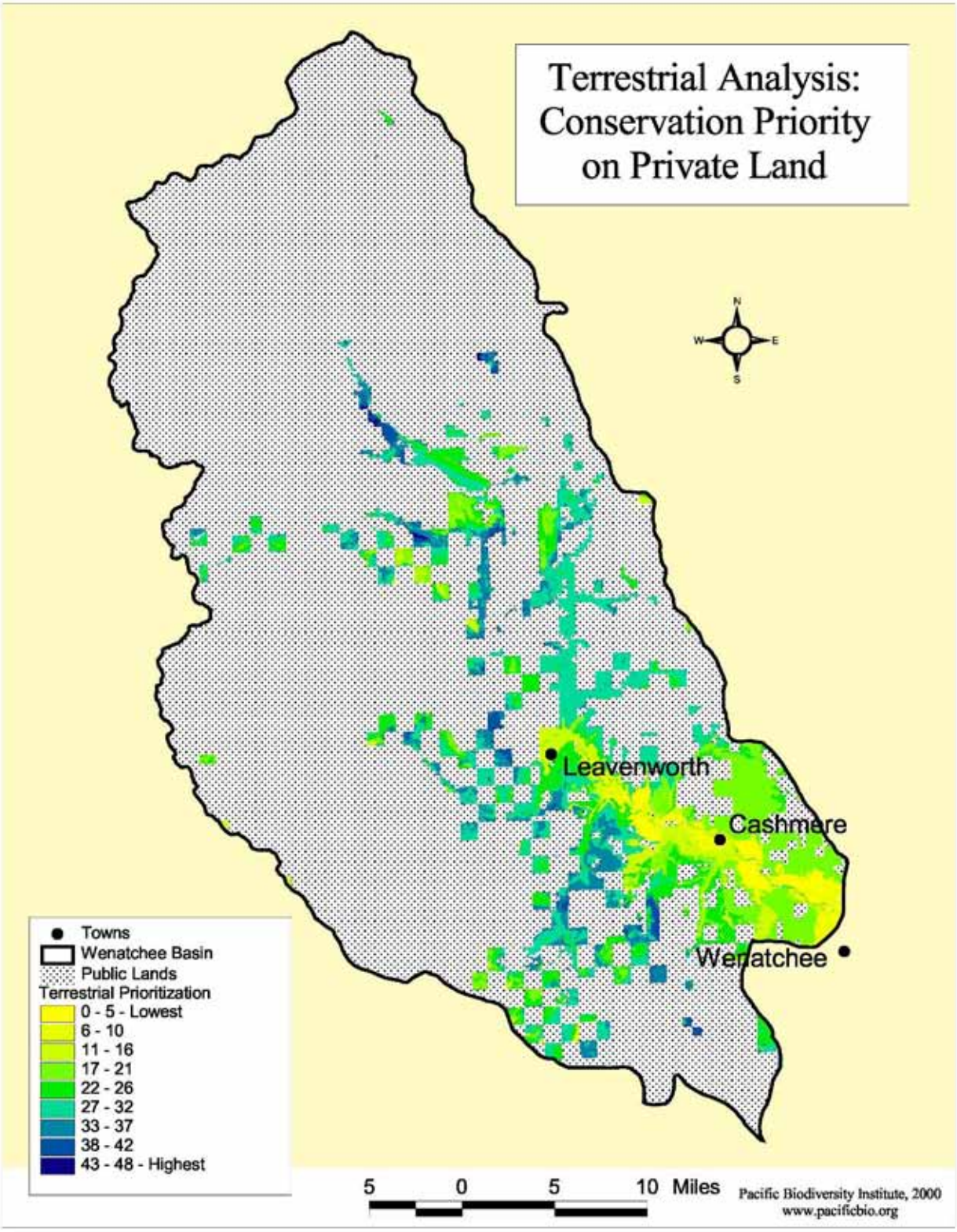


Figure 41. Terrestrial habitat conservation priorities for private lands in the Wenatchee River Basin. High priority areas are shown in dark blue. Significant portions of the private land in the Basin were rated as high priority by the terrestrial prioritization.

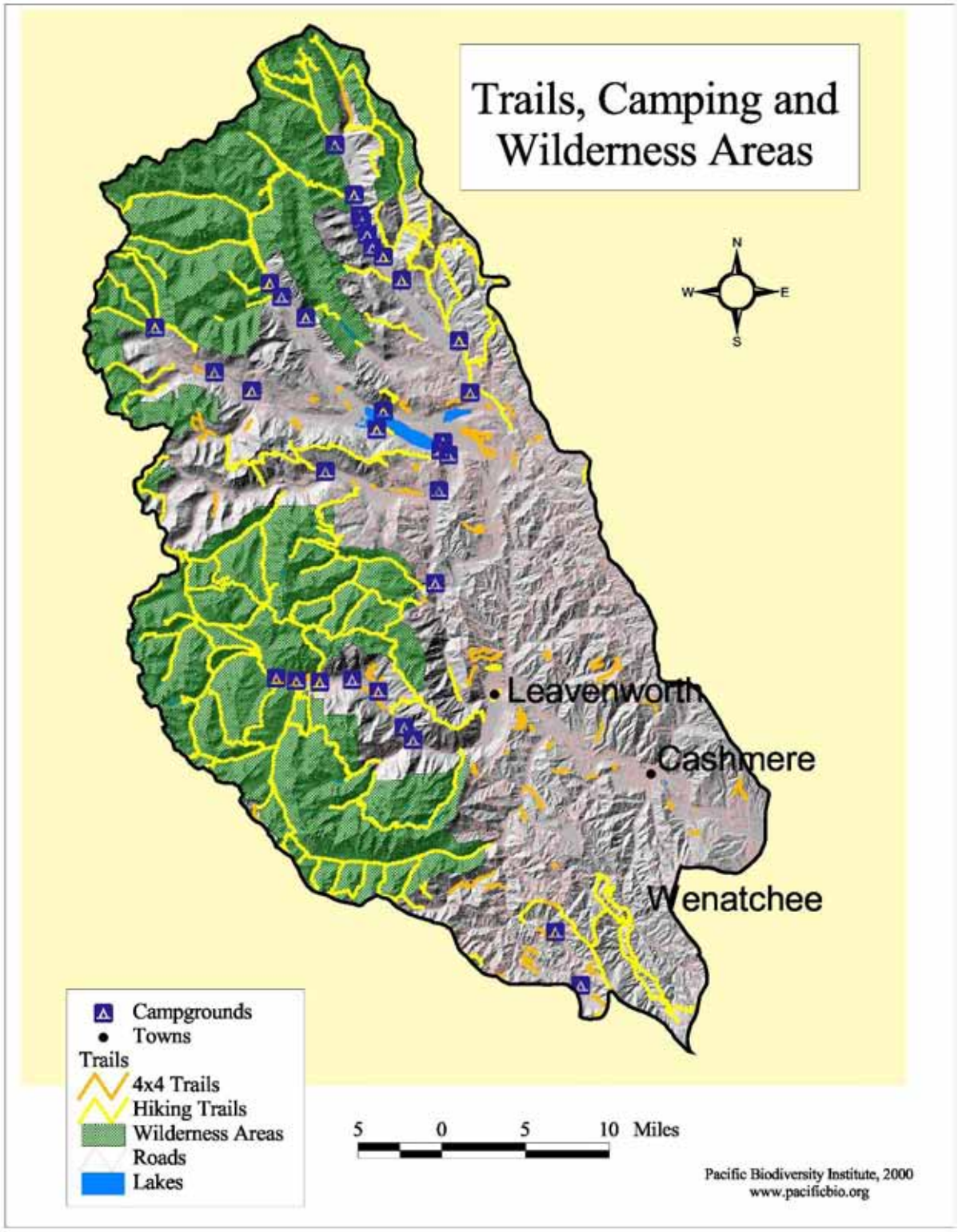


Figure 42. Trails and camping areas in the Wenatchee River Basin.
Camping, hiking, and backpacking are among the most popular outdoor recreation activities in the Basin. Extensive trail networks penetrate the three wilderness areas in the Basin.

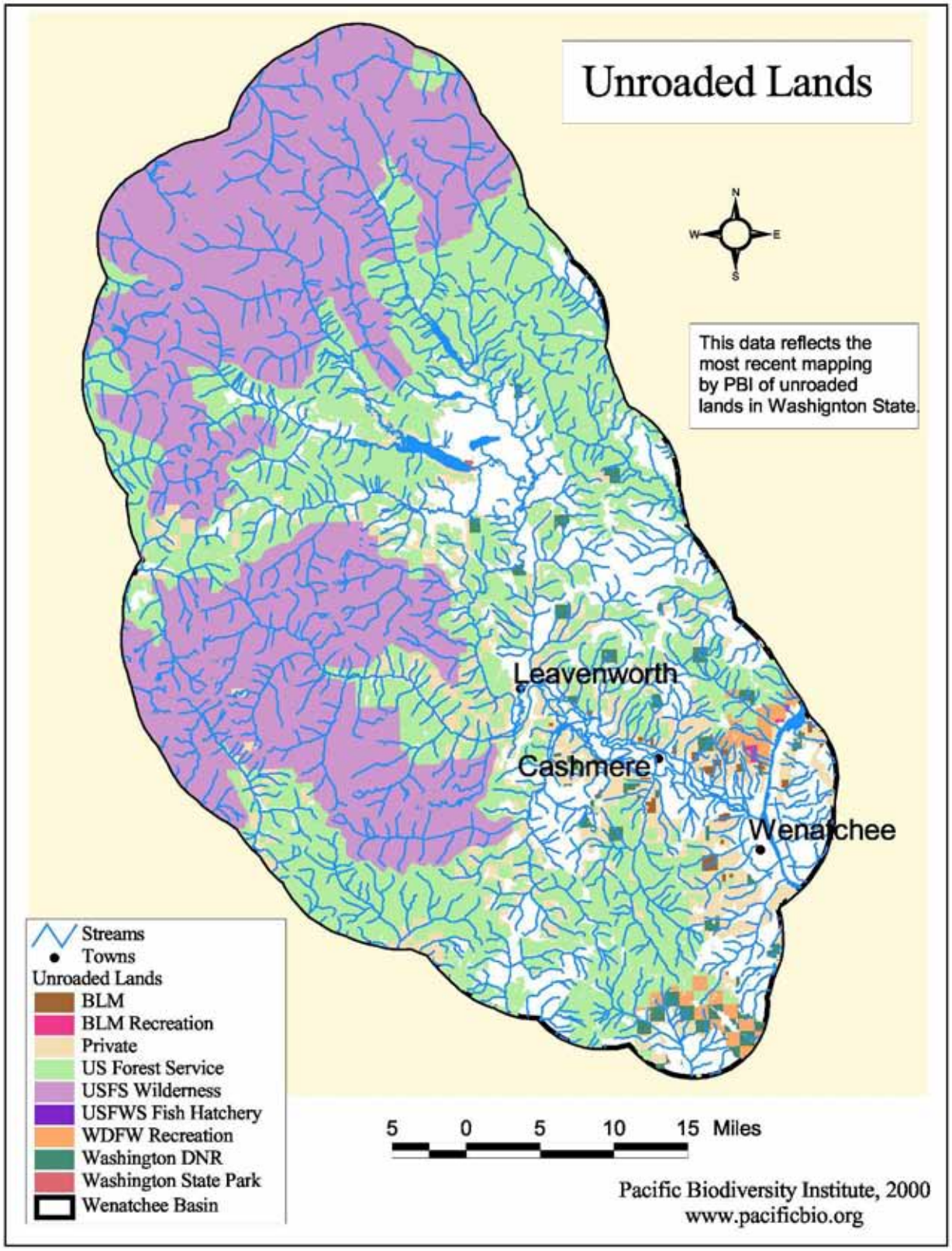


Figure 43. Roadless areas and wilderness in the Wenatchee River Basin. The majority of the roadless areas in the Basin are either Wilderness or US Forest Service land.

Rock and ice climbing are also popular activities in the Wenatchee River Basin. The most popular climbing areas are in the Peshastin Pinnacles, Tumwater Canyon, Icicle Canyon, and the Enchantment Mountains (Figure 44). GIS based mapping of cliffs indicates that there is significant additional potential for rock and ice climbing in the western half of the Wenatchee River Basin.

The lakes and waterways of the Wenatchee River Basin also provide considerable recreational opportunities (Figure 45). Whitewater rafting and kayaking are popular on the Wenatchee River below Lake Wenatchee and in the middle and lower parts of Icicle Creek. Game fish are present in the lakes, rivers and most of the larger streams in the Basin. Boating is popular activity on Lake Wenatchee and Fish Lake.

Unfortunately, quantitative data on many recreational activities are not readily available, especially in a spatially explicit format. PBI is currently working on obtaining and then digitizing some recreational features of the Basin such as watchable wildlife sites. Our current information on recreation and recreational potential for the Basin is limited by the lack of readily available information. As the recreational industry is continuing to grow, more effort should be invested in documenting use patterns of recreation in the basin.

SCENIC RESOURCES

Spatially explicit information on scenic resources in the Wenatchee River Basin is not currently available. Much of the Basin is very scenic, but scenic resources are hard to quantify and valuation of the scenic quality of a landscape varies greatly between individual observers. More thought, discussion and exploration is needed to adequately try to quantify the scenic resources of the Basin in a spatially explicit fashion so that they can be used in a conservation prioritization effort.

There are many areas in the Wenatchee River Basin that are of outstanding scenic quality. The riparian corridors along most of the rivers and streams are still intact and offer great beauty to the viewer as they change with the seasons. Likewise the many mountains that form the backdrop for the inhabited portion of the valley are truly spectacular. The deep forests and open shrub steppe country both offer the viewer subtle beauty and more dramatic vistas.

While scenic resources are difficult to rate on a numeric scale, one way to get a spatial perspective on these resources is to build a spatially connected library of images that visually depict parts of the watershed. PBI has begun such an image library (and some of the photographs from this library illustrate this report). This image library can be added to by the Icicle Fund and by community members. Through the progressive addition of images to the library, the scenic resources of the Wenatchee River Basin can be made evident – so that individual viewers can evaluate these resources from their own aesthetic perspective. This spatially connected image library can then be an integral part of a conservation decision support system.

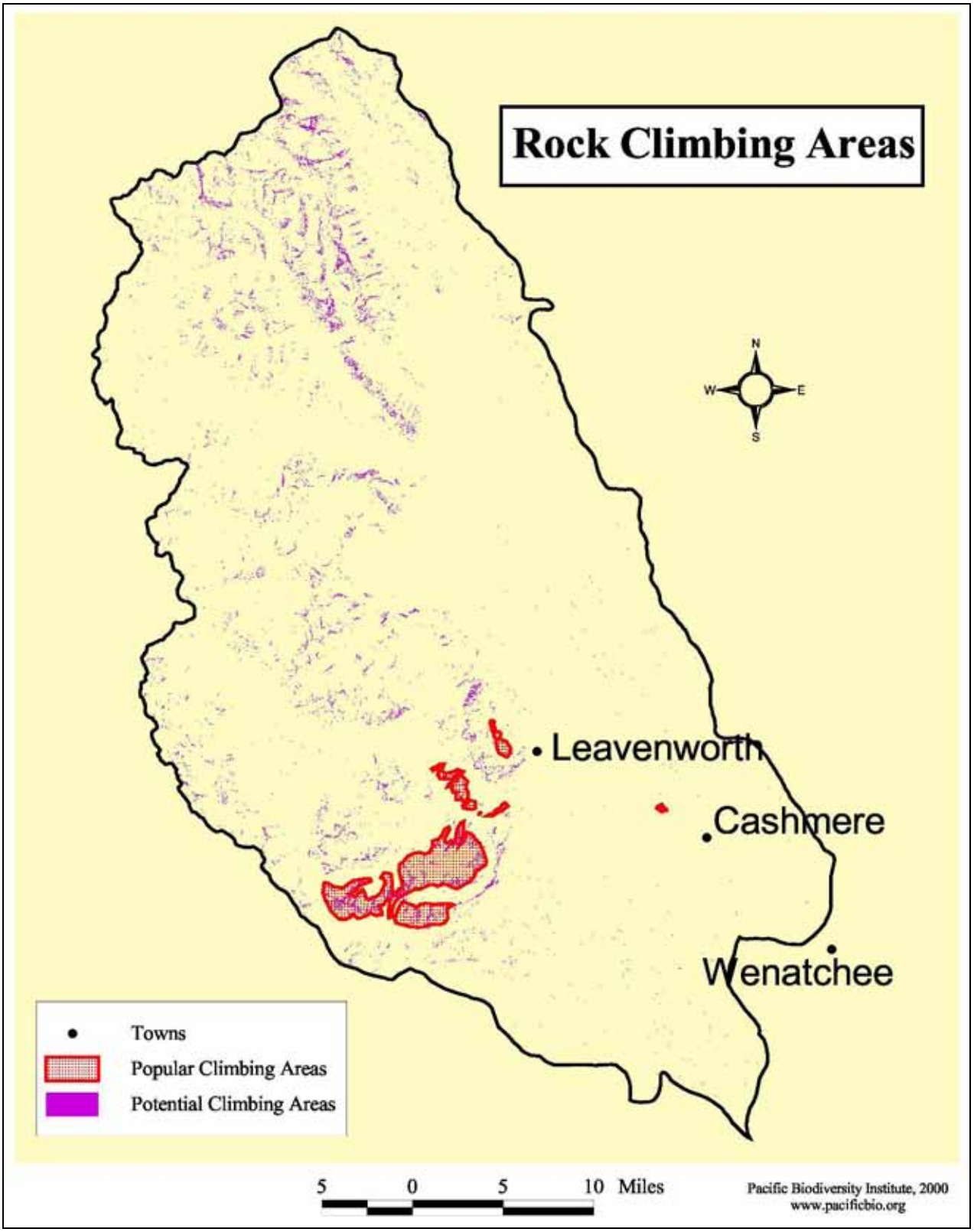


Figure 44. Popular climbing areas and potential climbing areas in the Wenatchee River Basin. **The Basin is renowned for its rock climbing sites. Many additional areas have rock climbing potential.**

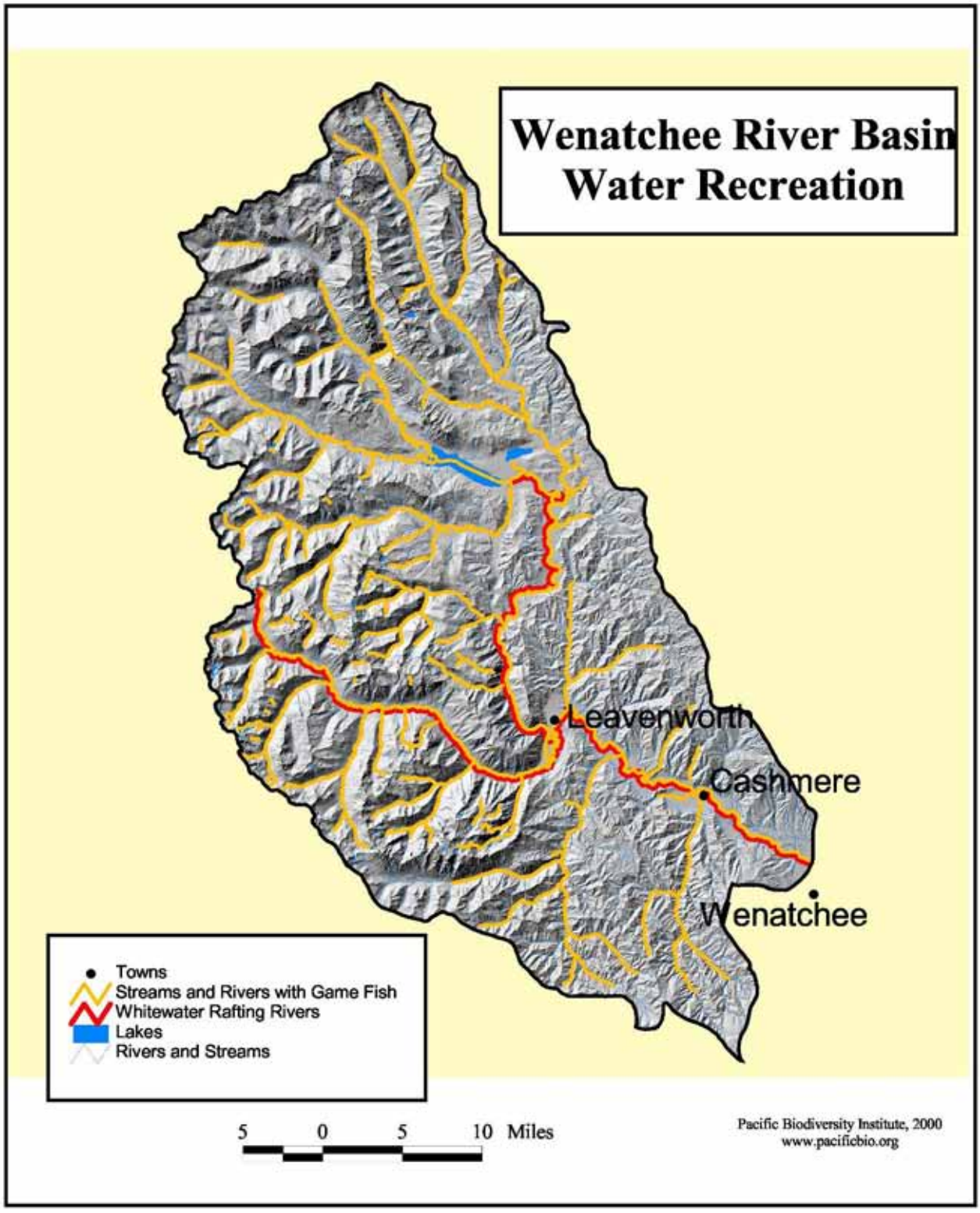


Figure 45. Recreation opportunities in the Wenatchee River Basin: Fishing and Whitewater Rafting. The Wenatchee River and Icicle Creek are popular whitewater areas. Most of the rivers and larger streams contain game fish. Boating is popular on Lake Wenatchee and Fish Lake.

SYNTHESIS

The Many Perspectives to Conservation Prioritization

The importance of a particular patch of habitat depends on the many factors we have attempted to assess in this report. But foremost, its importance depends on viewpoint. From the perspective of one particular species, a patch of habitat may be exciting and rewarding, uninteresting, or even dangerous. Another species may relate to that habitat patch in a similar or opposite fashion. It is possible to prioritize habitat from the perspective of each individual species. It is also possible to prioritize habitat from the perspective of assemblages of species, or even the entire biota of an area. It is also possible to prioritize habitat for the purpose of specific conservation agendas – such as the protection of wetlands, or the maintenance of animal movement corridors. Finally, it is also possible to prioritize the landscape for one particular human use or value (e.g. hiking, bird watching, nature photography). There is no one "right" way to prioritize a landscape for conservation action.

Shrub-steppe and flowers above Cashmere. Photo by Peter Morrison.

In this report we have attempted to present a variety of perspectives – largely based on species assemblages and an overview that synthesizes all the biota of conservation concern in the Wenatchee River Basin. We also present information on a variety of human uses. In Appendices D through G we present the reader with maps on a species by species basis that depict where each species is most likely to occur and find adequate habitat. These maps of habitat potentially occupied by each species of conservation concern can help focus conservation action directed toward an individual species.

Ideally, the goal is to maximize the impact of any conservation action so that as many species or human values benefit from this action. Our synthesis of individual species priorities into species assemblages and the combination of all factors into an overall conservation prioritization is an initial attempt to determine where conservation actions will have maximum impact on a diverse set of species and natural amenities.

Our ultimate goal in this project is to present the Icicle Fund with an information-rich decision support system that can be used to look at the landscape from many perspectives. In this report we present examples of some of these perspectives – but there are many perspectives we have not had time yet to explore. Ideally, conservation prioritization is best done in an interactive and iterative fashion where many viewpoints are explored and compared. This report should be viewed as only the beginning of a longer effort to establish sound conservation priorities in the Basin.

Protection Status and its Influence on Conservation Priorities within the Wenatchee River Basin.

Prior conservation actions have resulted in protection of significant portions of the Wenatchee River Basin. In our initial assessment of conservation priorities for terrestrial and aquatic species we do not consider the current protection status of lands (Figures 20 and 40). It is interesting to note that the areas with highest conservation priority largely fall outside of protected areas. It is a well known fact that most existing protected areas were designated to preserve areas of high scenic and recreational value - not the biologically rich portions of the landscape (Meffe and Carroll 1994). In the Washington Cascades and the Wenatchee River Basin, the reserves largely consist of three large Wilderness Areas, which are dominated by snowfields, glaciers and rocky peaks. The lower elevation, biologically rich forests and shrub-steppe country has received little lasting protection. This factor adds great importance to the work that the Icicle Fund is now undertaking. Significant conservation action is needed to protect these high priority habitats.

As a first step in determining which high priority areas should receive conservation focus, we focused on the unprotected portion of the landscape and then evaluated current and future threats in the Wenatchee River Basin. Our initial synthesis of terrestrial and aquatic conservation priorities for the unprotected portion of the landscape (masking out the protected portion) reveals the areas most appropriate for future conservation action (Figures 49 and 50). We also evaluated conservation priorities restricted to the privately owned portion of the Basin (Figures 21 and 41).

Comparison between aquatic and terrestrial prioritization.

In general, there was good correspondence between the prioritization ranking of the aquatic and terrestrial methods (Figure 51). Both methods predicted the Chiwawa River, White River, and portions of the Wenatchee River upstream of Lake Wenatchee as being among the highest priority areas. Both methods also prioritized the Wenatchee River corridor upstream from Leavenworth as high. The areas of discrepancy between the two prioritizations came in areas that did not contain high degrees of threatened or endangered fish, anadromous salmonids, or resident fish.

Combination of aquatic and terrestrial prioritization.

The aquatic and terrestrial prioritization methods can be combined into one overall prioritization that reflects both perspectives (Figure 52). While we urge the reader to look at each prioritization method independently when evaluating a particular area, the sum of both prioritization methods can be useful in determining the places to start looking for areas where conservation actions can have the maximum benefit to both aquatic and terrestrial species.

Conservation prioritization at an individual parcel level.

PBI also attributed each private parcel in the Wenatchee River Basin with its average conservation value from each prioritization. This allows ranking of the private lands for possible conservation action and identification of which factors contribute to the value of that parcel. An example of conservation priority values for private parcels in the

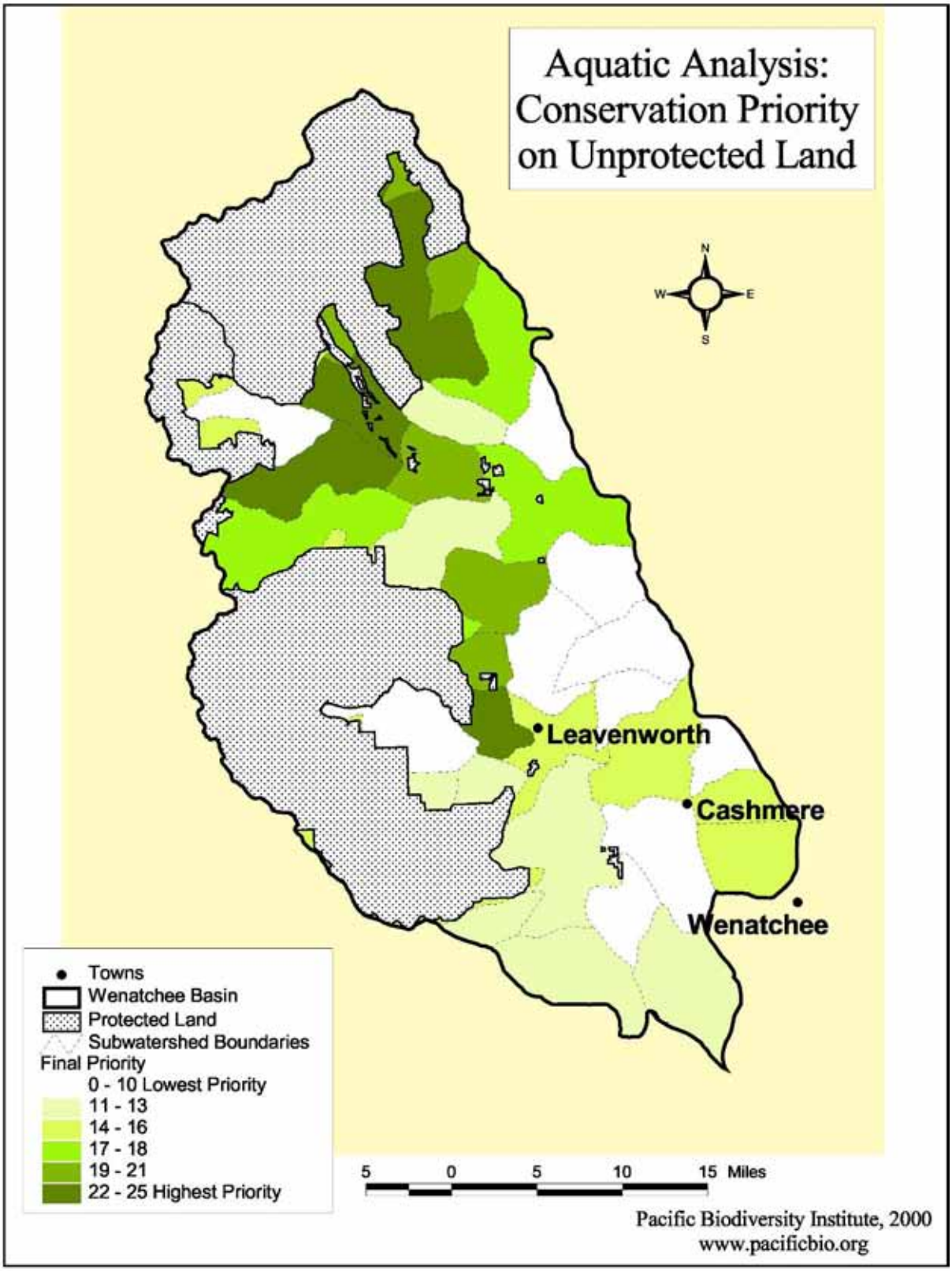


Figure 49. Aquatic Priorities in areas of the Wenatchee River Basin that do not have permanent protection status. Highest priority areas are shown in dark green.

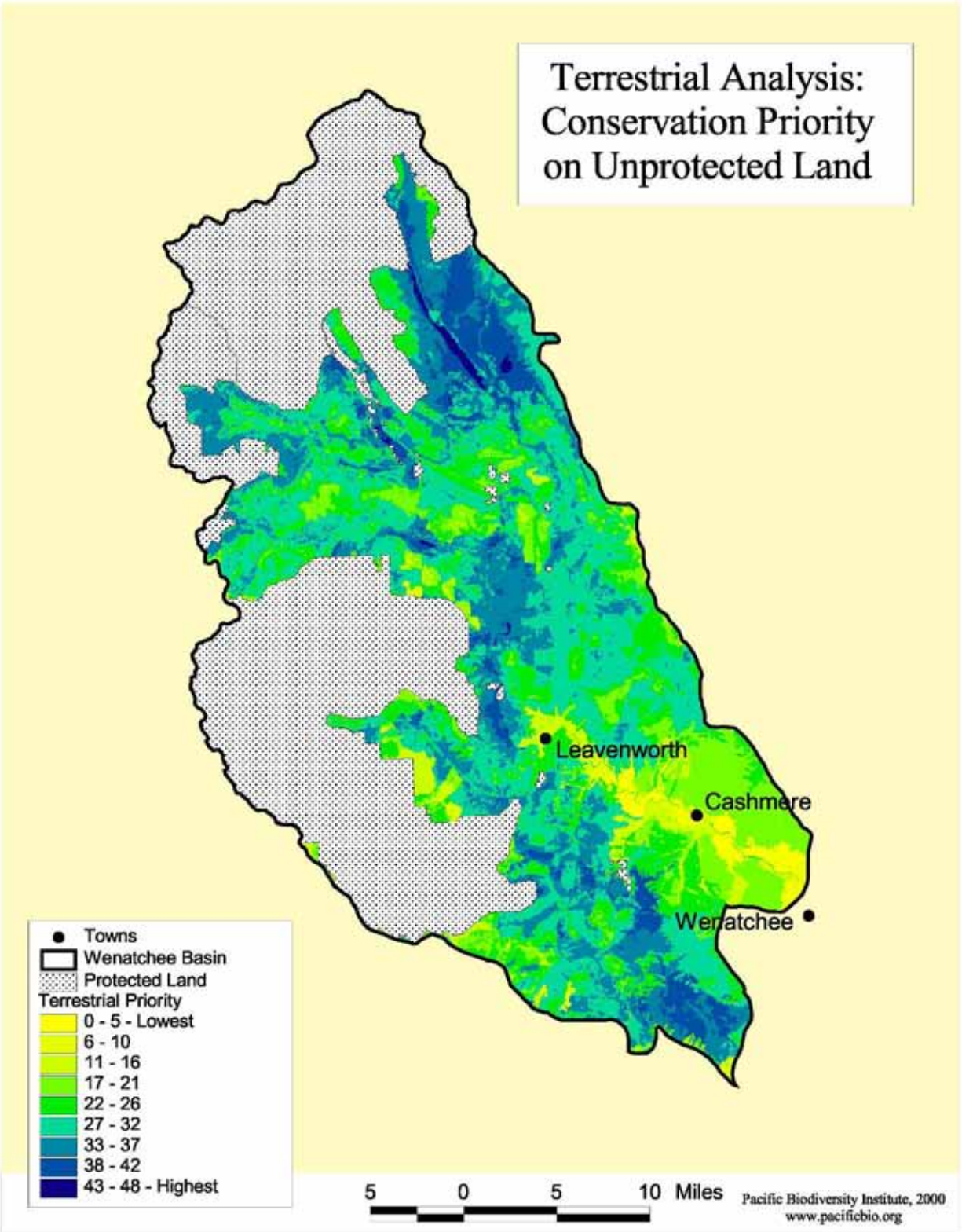


Figure 50. Terrestrial Priorities for areas of the Wenatchee River Basin that do not have permanent protection status. Highest priority areas are shown in dark blue.

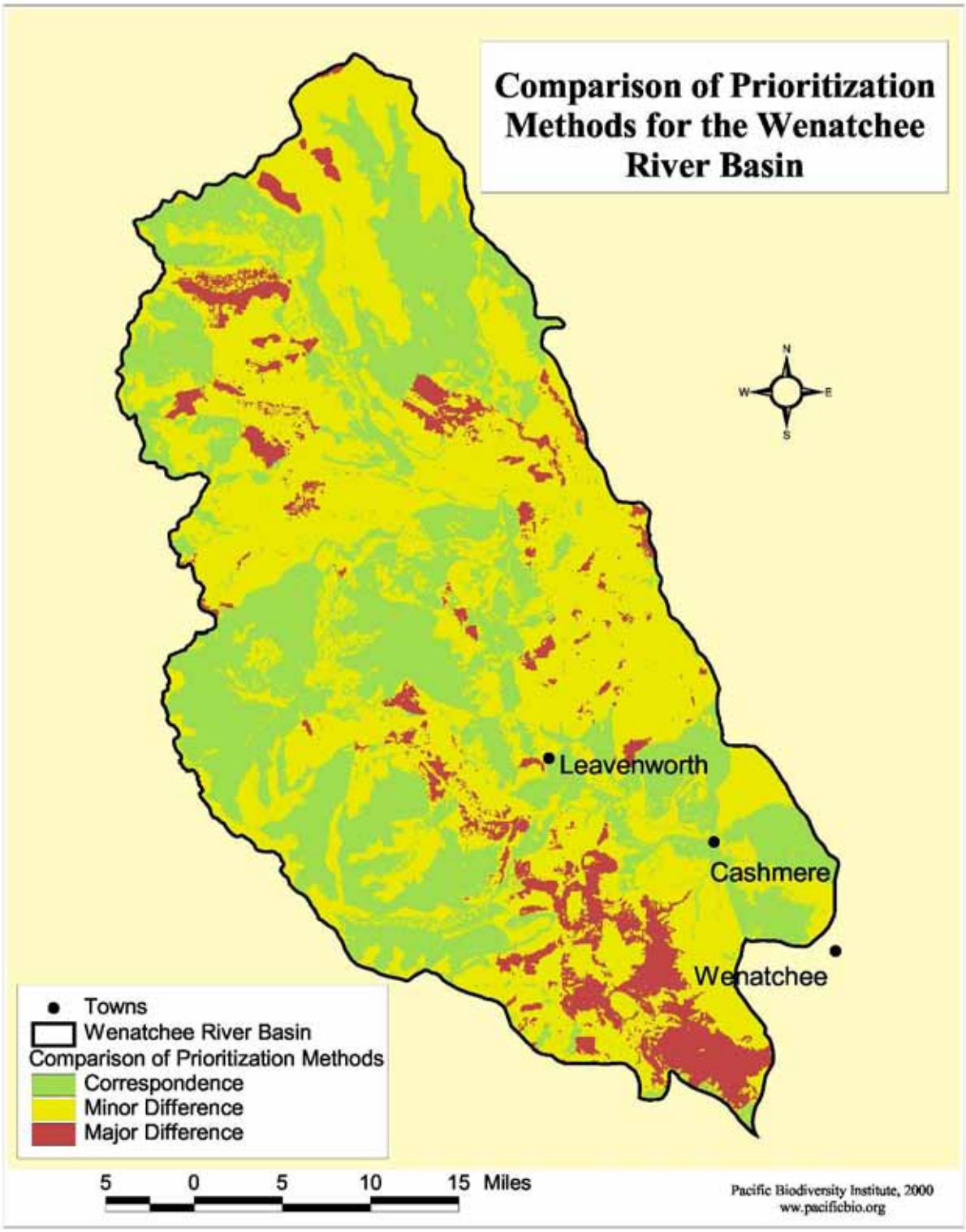


Figure 51. Comparison of the prioritization values of the aquatic and terrestrial prioritizations of the Wenatchee River Basin. Both prioritizations were divided into low, medium, and high priority areas and then compared. Areas of correspondence (both prioritizations ranked high or both ranked low) are shown in green. Red indicates areas where one prioritization ranked it as high and the other ranked it low.

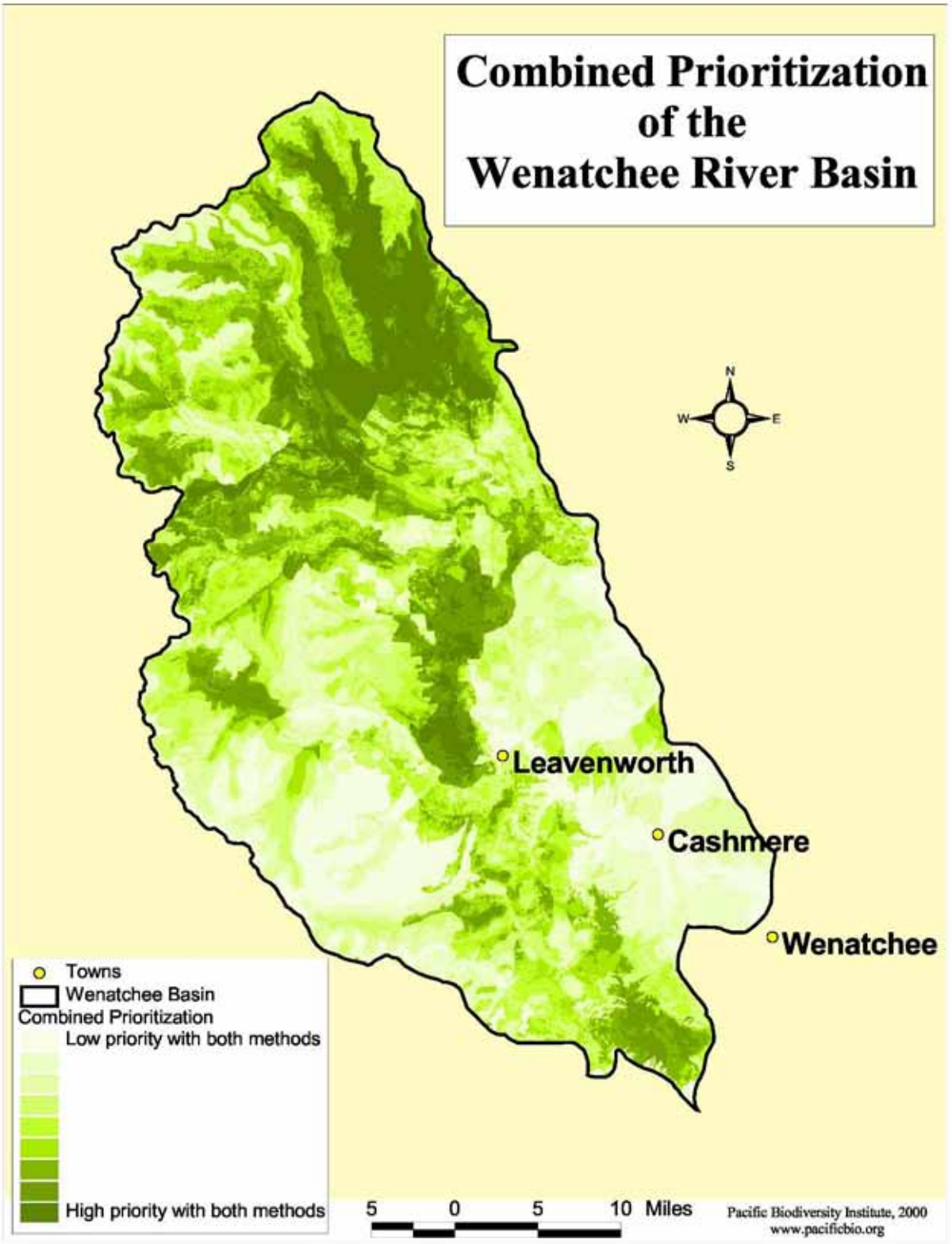


Figure 52. A combined aquatic and terrestrial prioritization for the Wenatchee River Basin. This prioritization was created by adding the priority values for the aquatic and terrestrial prioritizations. Low resulting values are areas that both prioritization methods have ranked as low. High resulting values are areas that both prioritization methods have ranked as high.

Wenatchee River Basin with an aquatic prioritization value greater than or equal to 22 and greater than 10 acres is presented in Appendix B. This is a list of the highest 10% of parcels greater than 10 acres ranked by the aquatic prioritization.

RECOMMENDATIONS

Appropriate Uses for this Prioritization

This report should be considered a description of an initial conservation prioritization of the Wenatchee River Basin. It should not be considered the final work on conservation priorities in the area. Only immediately available data layers were used in this study. Several significant data layers were not immediately available for this work. Several other data layers used in this study are somewhat out-of-date or need improvement in accuracy. The addition of new and improved data will improve the ability to reliably predict conservation priorities.

Conservation prioritization is ideally an interactive and iterative process. This prioritization should be considered one iteration and several more iterations may be needed before a reliable final prioritization is created. Subsequent prioritizations should explore a variety of weightings and combinations of the many factors assessed in this study.

This prioritization of the Wenatchee River Basin is intended to identify areas with high conservation potential and high risk relative to other areas *within* the basin. The areas identified here as high priority should be checked in the field to insure that they are indeed exemplary habitats for the basin. The results of this study are only directly applicable to the Wenatchee River Basin. While the methods can (and in some instances have) been applied elsewhere, the results of so doing may not be exactly equivalent to those for the Wenatchee River Basin.

Just because a piece of land did not receive a high priority rating does not mean that it is not of significant conservation value. Our rating systems tend to slightly favor forested environments and are based on the coincidence of many measures of ecological integrity and biodiversity. Each of the component measures is important and any prospective piece of land should be evaluated against each component individually.

Next Steps

This initial conservation prioritization is not intended to be a comprehensive and final assessment of the Wenatchee River Basin. This work is only one of a myriad of ways to prioritize conservation efforts in the basin. As described above, several more iterations of the prioritization process may be needed before a highly reliable final prioritization is complete.

Many potentially useful data sets were not available to PBI or had not been created. First, an accurate data layer which depicts the current level of development on private lands within the Basin is needed to accurately assess areas that are relatively pristine or in various stages of development. Second, an updated and more refined vegetation map is needed that can better predict habitat condition and distribution. Third, an updated and more accurate map of forest condition, structure and age is needed to assess the status of late-successional forests in the Basin. The development and application of more

sophisticated wildlife habitat relationship models would also greatly improve the predictive capability of the species level prioritizations.

Data should continue to be collected for the biological systems of and threats to the Wenatchee River Basin. Specifically, information on logging and road building threats on private and state lands should be acquired and incorporated into the prioritizations. Also, information on the threat categories of development, motorized recreation, and alien plant invasions should be acquired or generated.

Many other data sets could stand to be improved in accuracy and completeness. Observational databases (i.e., those recording the locations of plants, fish, or wildlife) can often be more a reflection of where people have looked for a species than the actual distribution of that species. These data sets should be updated as new information becomes available.

CONCLUSIONS

Dragontail Peak in the Enchantments.
Photo by Peter Morrison

The Wenatchee River Basin contains much land of high conservation priority. Although a relatively large percentage of the land in basin is protected, most of the highest priority lands (identified from both the aquatic and terrestrial methods) does not have permanent protection status. Additionally, a large proportion of the high-priority areas are on private land. Our work suggests that the greatest immediate threat to the ecological integrity and biodiversity of the Wenatchee River Basin comes from uncontrolled development and unsound land management activities in parts of the basin. In the long-term, conservation efforts should be focused on the highest priority lands.

This work provides an initial assessment of the conservation priorities in the Wenatchee River Basin. While not intended to be the final word, the results presented here will enable a focusing of conservation efforts in the basin and protection of its best remaining habitats.

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