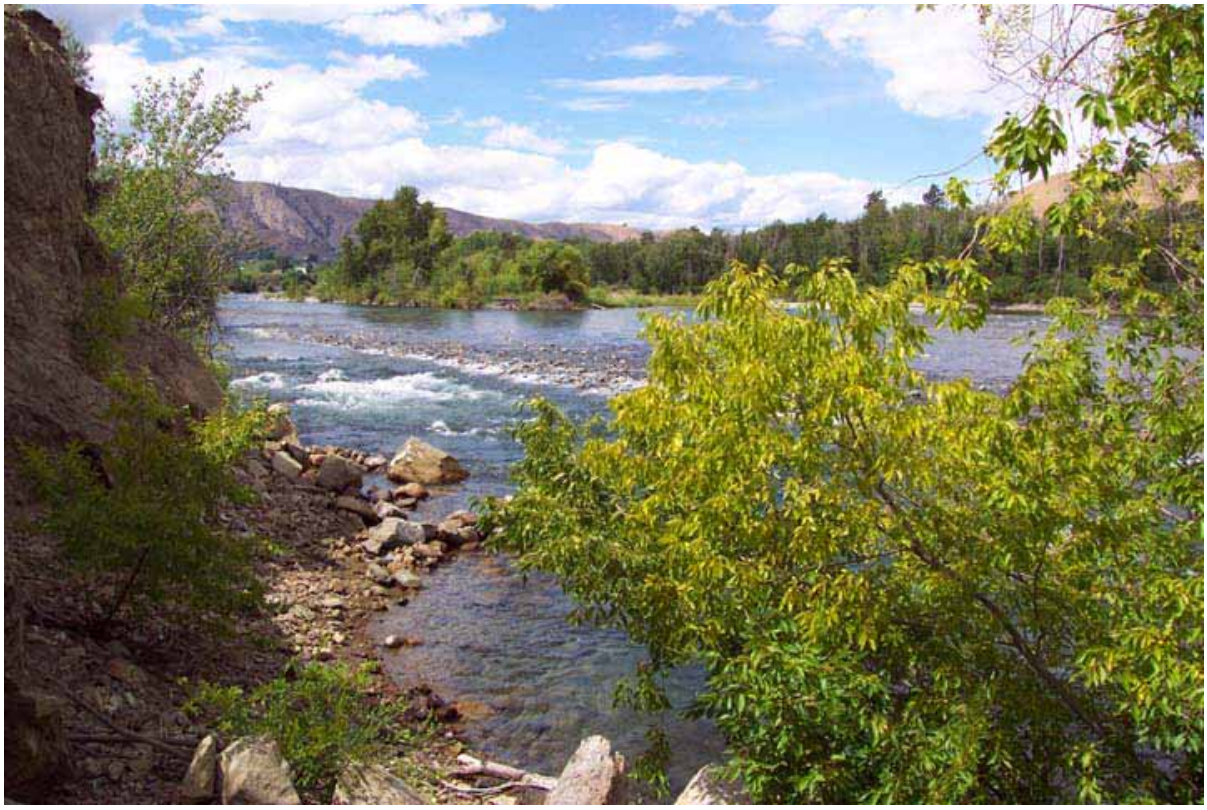

Natural Resource Information and Conservation Decision Support for the Wenatchee River Basin

Pacific Biodiversity Institute

CREDITS

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

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On the Cover:. Photo of the Wenatchee River by Peter Morrison.

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INTRODUCTION

The Icicle Fund has undertaken a multiyear effort to protect and restore some of the most significant natural systems and sites within the Wenatchee River Basin. As part of that effort, Pacific Biodiversity Institute undertook a project to provide information on the natural resources of the Basin. We have also developed a conservation decision support system that can aid in the exploration of conservation priorities that are based on the best available science. One of the goals of the Icicle Fund and this project is to inform the local community about the important biological systems along with recreational and scenic resources of special value within the watershed. Our hope is that the work undertaken in this project will help inform and inspire conservation actions that individuals, organizations and public agencies can take to identify, protect and restore these natural resources and to ensure that future development occurs in appropriate areas.

This work has been divided into two phases. During the first phase, Pacific Biodiversity Institute (PBI) gathered all readily available spatial information regarding natural resources in the basin and activities that might affect these resources. We also identified data gaps where important information was not available or where existing information could be substantially improved. In the second phase of this project we undertook filling some of these data gaps and updating other data sets have changed or been improved during the last year. In the second phase we also substantially revised and improved our aquatic and terrestrial analysis methods and developed a robust conservation decision support system.

This report and the conservation decision support system are intended to inform and guide people in conservation efforts so that they can efficiently identify and target the areas of highest value. The conservation decision support system is designed to be flexible so that it can address many conservation issues and meet the needs of many parties. Likewise, this report does not offer one approach or solution to the conservation of natural resources or the maintenance of ecological integrity in the basin. We provide information and a powerful tool to address these issues. Without this information and the conservation decision support system, conservation efforts will continue to be haphazard and reactive, and some of the most critical natural resources may slip away unnoticed.

This report describes the work undertaken in both phases of this project, it provides:

- Information on the spatial data that has been developed and acquired for the project
- Information on the aquatic and terrestrial analyses that have been undertaken
- Information on recreational and scenic resources
- Information on land ownership, management and conservation status
- Information on disturbances and threats to ecosystem integrity
- A synthesis of the above information

- A description of the conservation decision support system
- Documentation on how to use the conservation decision support system
- Recommendations and conclusions

GEOGRAPHY of the WENATCHEE RIVER BASIN

The Wenatchee River Basin consists of all land that drains into the Wenatchee River, a tributary of the Columbia River in central Washington (Figure 1). It is part of the 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 vegetation types and land uses (Figure 2). Alpine peaks, glaciers and snowfields characterize the highest elevations, while agricultural land, shrub-steppe communities, and riparian deciduous forests dominate the lowlands. Most of mid elevation terrain is covered by coniferous forest. The majority of the Basin is in federal ownership (81.2%) (Figure 3). Privately owned land (16.9%) is concentrated along the valley bottoms and in the eastern half of the basin (Figure 3). There are also small percentages of Washington State (1.2%) and Bureau of Land Management (BLM) (0.4%) lands in the Basin.

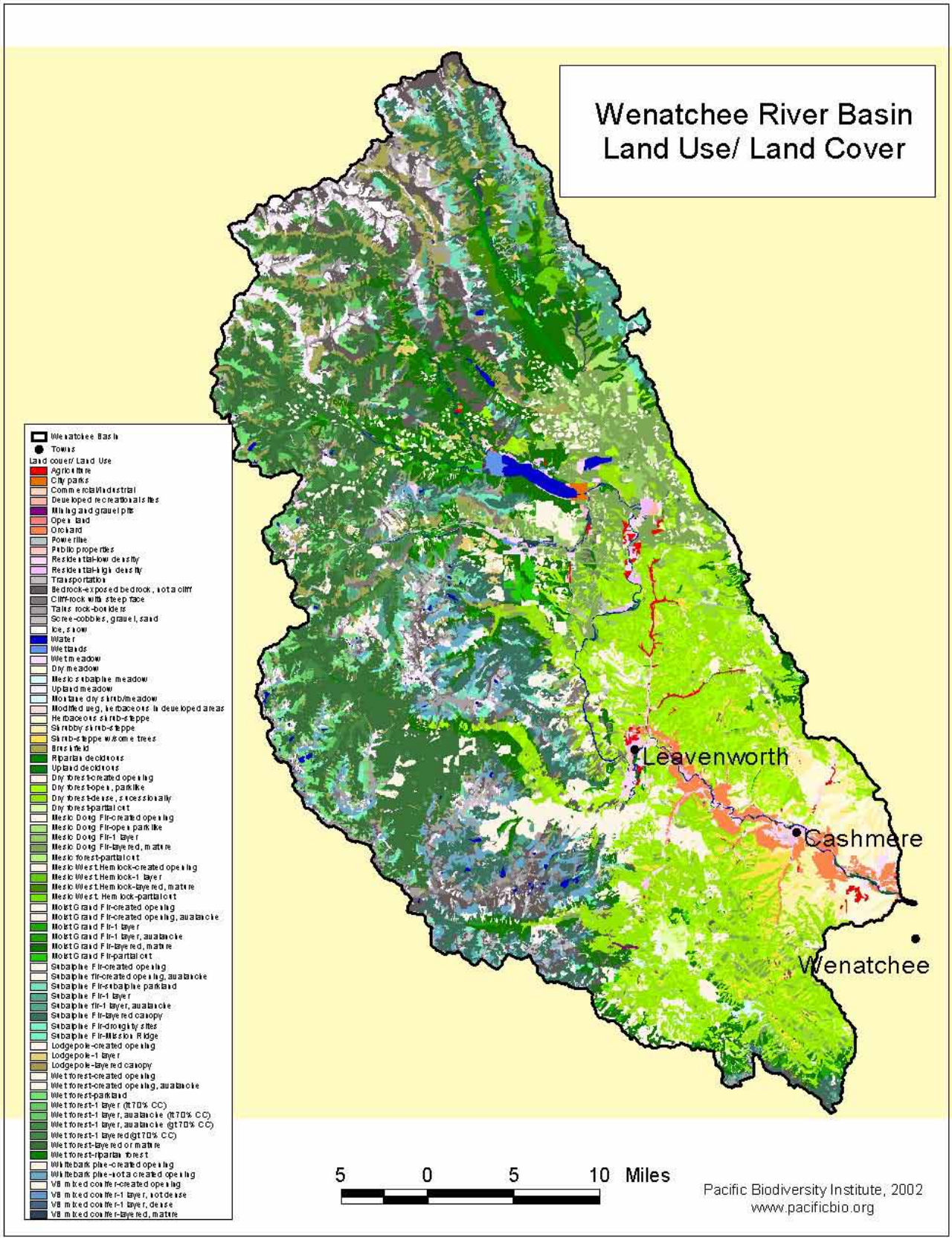


Figure 2. Vegetation and Land Use in The Wenatchee River Basin.
The Basin is characterized by a variety of land cover types from alpine peaks and glaciers to lowland forests and shrub-steppe. The majority of the basin is coniferous forest with some significant stands of late-successional forest.

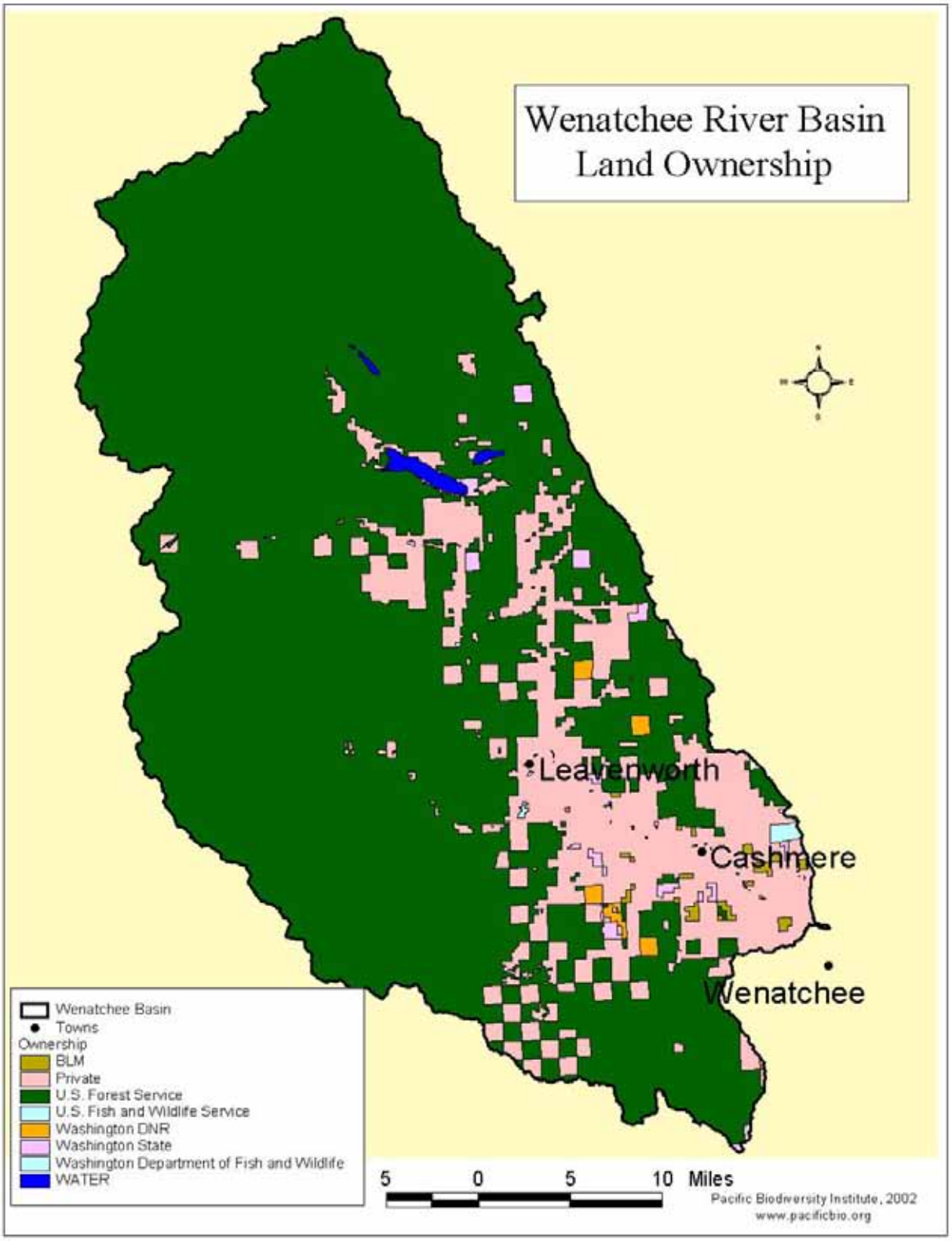


Figure 3. Ownership of the Wenatchee River Basin.
The majority of the Basin is US Forest Service ownership (81.2%). Private ownership (16.9%) is concentrated along the lower portion of the Wenatchee River.

SPATIAL DATA INVENTORY AND DESCRIPTION

Over the past two years we have conducted an extensive search of the spatial (GIS) and database data available to adequately describe and assess the natural resources of the Wenatchee River Basin. We have also developed many new and improved datasets specifically for this project. All the data were then clipped to the Wenatchee River Basin boundary and organized into directories in preparation for their use in a conservation decision support system that we created for the Icicle Fund. All data were projected into a standard map projection (UTM Zone 10 NAD27) and converted to several standard formats: Arc/Info coverages for vector GIS data, Arc/Info grids for raster-based GIS data, and TIFF images or ERDAS Imagine files for imagery.

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

Theme	Examples of Data Sets
Aquatic Analysis Data	Subwatershed and stream segment level analysis data on aquatic ecosystem characteristics
Demography	US Census blocks and population data, population change
Disturbances	Forest fires, floodplains, logging
Fish	Distribution of fish species and habitats
Geology	Geologic maps, mineral deposits and mines
Hydrography	Streams and rivers, lakes, watershed boundaries
Imagery	Aerial photography and satellite imagery
Management	USFS management designations, county zoning
Other	Town locations, USGS 7.5' quadrangle boundaries
Ownership	Land ownership, parcel boundaries and data
Pollution	Washington Department of Ecology point source pollution data
Recreation	Trails, climbing areas
Terrestrial Analysis Data	30 meter pixel level analysis data on terrestrial ecosystem characteristics
Topography	Digital elevation models (DEMs), slope steepness
Transportation	Roads, railroads
Vegetation	Vegetation cover types, late-successional forests, rare vegetation types, rare plants
Wildlife	Distribution of wildlife species and their habitats

Over the last two years, Pacific Biodiversity Institute has assembled or developed many GIS data layers or georeference images that represent most of the significant natural resources and environmental factors that should be considered in conservation planning. In doing this, we have reviewed nearly all the existing GIS data layers that have been previously developed for the area and determined if the data is of sufficient accuracy to be useful in planning and conservation efforts. We have also assembled some of the best GIS data that describes land ownership, land management, demographics, imagery, and a host of other types of data.

While most of the data we have assembled is from public sources, we have also done substantial improvement and modification of some data sets and developed other GIS data from scratch where publicly available data was not available.

What follows is a brief description of much of the data we have assembled.

Base Data

Disturbances

BLM-grazing: Information on grazing allotment parcels on BLM and DNR land. This layer is attributed with rudimentary data on number of cattle and condition of the range. This information is the most current available, but still may be outdated since the grazing permit applications on both BLM and DNR land were made in mid-1990s and have not been updated since.

Planned-Developments: This data layer gives information on some areas of planned development within the Wenatchee River basin. Owners have worked with the county to redefine the zoning restrictions in these areas for the purpose of future development. Therefore, the area will be developed according to the zoning restriction present in that area. Specific information about the planned development for each "file" (the file number is found in the attribute table) can only be obtained by contacting the Chelan County Long-Range Planning office.

Fire spot locations 1986 – 1992. Data accuracy varies with some observations being off by as much as one minute. This database in not adequate for project or small watershed (6th code HUCs) level analysis, but would be more appropriate for regional or larger watershed level analysis.

Historic fire occurrence data (1761-1938): Based on fire scar studies performed in selected plots throughout the Wenatchee River Basin. Data locations were rounded to the nearest minute (approx 2 km).

Floodplains: 100-year and 500-year floodplains in the Wenatchee River Basin. Data from the Federal Emergency Management Agency, September 1998. The zone code "A" stands for 100-year floodplains, or a 1% chance each year of having a flood in that area, and the zone code "x500" stands for 500-year floodplains, or a 0.2% chance each year of having a flood in that area.

Icicle Fire Intensity: This data layer contains information on the effect of the 2001 Icicle Creek fires on soil and vegetation. The polygons are coarsely defined and include the categories "low" "medium" and "unburned." This information is coarse and not ground-verified.

Logging History: This logging history layer is based on new information from the Wenatchee National Forest ranger districts, DNR and aerial photo interpretation.
Wenatchee National Forest grazing: Cattle, horse, sheep and goat grazing allotments managed by the Wenatchee National Forest. This data layer shows the areas where grazing is permitted and is attributed with information on livestock type and number, and season of use.

Fish

Native and Introduced Resident Fish: The resident native and alien fish data comes from two different data sources, and there is overlapping information between the two. For the analysis, we eliminated the overlap, but did not create a single data layer. The base data can be viewed by looking at these four datasets. Nativefish-wen and Alienfish-wen come from Wenatchee National Forest resident fish data and have been updated in 2002, but most of the sightings are older. The nativefish-streamnet and alienfish-streamnet come from the Department of Fish and Wildlife's STREAMNET database and contains more information, but many of the sightings are over 10-years old and have limited accuracy.
Anadromous Fish: Anadromous fish distribution data from the Limiting Factors Analysis and expert review. Data is current as of 2002.
Barriers: This coverage represents all barrier information from three different data sources. It represents a "first-cut" of this information and additional barriers may be missing. Culverts determined "impassable to fish" were extracted from the Chelan County, USFS, and WDFW data, and dams determined "impassable to fish" were extracted from Chelan County, StreamNet, and WDFW dam coverages. Impassability is based on each agency's own criteria.
Culverts: Culvert location data selected from the Chelan County, WDFW, and USFS culverts databases and merged.
Dams: Dams data selected from StreamNet and the Chelan County dams databases and merged.
Listed Fish: ESA Threatened and Endangered species fish distribution data from the Limiting Factors Analysis and expert review. Data is current as of 2002.

Geology

Landform: Geomorphology - land surface characteristics. The division of geomorphic units is based on two factors: 1) the primary process acting on the surface deposit or bedrock, and 2) the resultant shape and physical character of the terrain.
Lithology: Underlying substrate type for the Wenatchee River Basin.
Soils: Soils in the lowlands

Topography

DEMs: Digital Elevation Models (DEMs) are GIS layers representing the elevation of a given area. 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.
Slope: Based on digital elevation models, gives the steepness of the slopes (in degrees).
Aspect: Based on digital elevation models, gives the aspect
Shaded Relief: Based on digital elevation models, gives an idea of the topography in the Wenatchee Basin

DRGs: Digital Raster Graphics. These are digital versions of USGS 7.5 minute topographic maps.

Imagery
Digital Orthophotos: Georeferenced aerial photographs taken in 1990 and 1998 and enhanced for digital use.
Satellite Imagery: A chronosequence of Landsat MSS, TM5 and TM7 satellite image of the basin from 1972 through 1999.

Management
Land Use: Pacific Biodiversity Institute (PBI) developed a data layer of current developed land use in the Wenatchee River Basin. This land use coverage is primarily based on 1998 aerial photos, 1999 satellite imagery, and 2002 parcel data from the Chelan County Assessor's office. Land use was mapped with a 5-acre minimum mapping unit.
Zoning: The zoning layer was obtained from Chelan County and clipped to the Wenatchee River Basin. Each zoning category includes restrictions on use and number of buildings per acre. Future potential development can be inferred from this zoning information. Detailed descriptions of the land use restrictions in each zone can be found on Chelan County's website.

Land Ownership
Parcels: The Chelan County parcels layer was obtained from Chelan County on February 27, 2002 and clipped to the Wenatchee River Basin. The parcel layer contains information on current taxable parcels, current land value, building value, and owner name. The parcels reflect divisions for tax purposes. Some of the parcels may currently be subdivided into smaller lots. For example, a 40-acre tax parcel may have already been split into eight 5-acre lots by the owner but only show up in the parcel data as one 40-acre parcel. Information on the location of these subdivided parcels is not available in this GIS format.
Cost-per-acre: Private parcels were selected out of the Chelan County 2002 parcel data using a public lands layer developed by PBI. The assessor's information on the total monetary value of the parcel, divided by the parcel area (acres) was used to determine cost-per-acre.
Ownership: PBI developed a data layer of public land ownership in the Wenatchee River Basin. PBI's public land data is more complete and accurate than any other individual data source available for this region, combining parcel data from Chelan County, ownership information from the Wenatchee National Forest, and "Major Public Lands" data from the Department of Natural Resources. All source data layers are the most current available, with the

Wenatchee National Forest data updated in 2002, the Chelan County data updated in 2002, and the DNR data last updated in April 2000.

Transportation

Roads: Road 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.

Railroads: Railroads in the basin are from US Census Bureau Tiger Data.

Pollution

DOE Point Sources: Washington Department of Ecology listed point-source pollution sources. Includes information on whether the site is exceeding regulations or not. Database has not been updated since 2000. This data includes 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.

Demography

Demography data came from the 1990 and 2000 census data from the US Census Bureau. This data was modified and improved by restricting the census block data to areas of private land, where people actually live. We then calculated population change by subtracting the 1990 census population from the 2000 census population at a 30-meter grid cell resolution. The population change reflects population change at a block level, but this was calculated in a GIS grid format because there were changes in the block boundaries between the two censuses.

Recreation

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.

Other

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.

Vegetation and Land Use

Land Use: Pacific Biodiversity Institute developed a data layer of current land use in the Wenatchee River Basin. This land use coverage is primarily based on

1998 aerial photos, 1999 satellite imagery, and 2002 parcel data from the Chelan County Assessor's office.
Vegetation: This coverage is based on the most recent US Forest Service vegetation data. Improvements were made in grassland areas, meadow areas, deciduous areas, and agricultural/residential areas. The grassland areas were modified by replacing the old, all encompassing "grassland/shrubland" category with five new, more descriptive fields. Two new categories were added to increase the accuracy of different upland meadow types, and deciduous vegetation was divided into either "upland" or "riparian" deciduous forest. A combination of satellite imagery and digital orthophotos were used to update these areas. The agricultural/residential section of the original USFS vegetation map was largely replaced by corresponding areas in our Land Use map.

Data Layers used in Analysis (Prioritizations)

Aquatic Analysis

Subwatershed Level Data

Subwatersheds are based on the Forest Service's HUC6 hydrologic unit. PBI modified these to be more consistent in size and have a single drainage point. The subwatershed unit is used to account for all activities in the drainage areas that may contribute to the condition of the streams running through them. Details on the subwatershed-level assessment will be discussed below.

Alien Fish Species: Number of alien fish species in each subwatershed. Data from STREAMNET and Wenatchee National Forest. Data may be up to 10-years old.

Anadromous Fish Species: Number of anadromous fish species in each subwatershed. Data from the Limiting Factors Analysis and expert review. Data is current as of 2002.

Native/Resident Fish Species: Number of native, resident fish species in each subwatershed. Data from STREAMNET and Wenatchee National Forest. Data may be up to 10-years old.

Threatened/Endangered Fish Species: Number of Threatened or Endangered fish species in each subwatershed. Data from the Limiting Factors Analysis and expert review. Data is current as of 2001.

Wetland Area: Area of wetlands in subwatershed. Data from the National Wetlands Inventory. Units in square kilometers.

Roadless Areas (acres in subwatershed): Roadless Areas greater than 1000 acres as derived by PBI. Calculated as acres of roadless area in subwatershed.

Roadless Areas (percent of subwatershed): Another way to look at Roadless Areas.

Road Density: Density of roads in km/ km2.

Percent Developed: Percent of the subwatershed that has been developed. Based on PBI's land use mapping. All categories that have had major landscape alteration including low-density residential – extensively modified vegetation, high-density-residential, agriculture, city parks, etc. are considered developed.

Percent Logged: Percent of subwatershed that has been logged at some time between 1940 and the present. Data from the Wenatchee National Forest districts.

Stream Segment Level Data

The stream segment is a "segment unit" around all anadromous fish-bearing streams whose length is a segment of the stream with a uniform gradient and whose width is a 300-ft buffer around the stream. The segment data allows the user to analyze the most important part of the landscape to anadromous fish at a much finer scale than the subwatershed. Details on the subwatershed-level assessment will be discussed below.

Anadromous Fish Species: Number of anadromous fish species in each stream segment. Data from the Limiting Factors Analysis and expert review. Data is current as of 2002.

Hatchery Influence: Cumulative effect of nearby (within 10-km) hatcheries.

Percent Developed: Percent of the stream segment (300-ft buffered area on each side of stream) that has been developed. Based on PBI's land use mapping. All categories that have had major landscape alteration, including low-density residential, high-density-residential, agriculture, city parks, etc. are considered developed.

Percent in Floodplain: Percent of the stream segment (300-ft buffered area on each side of stream) that is in the floodplain. Based on Federal Emergency Management Act (FEMA) floodplain maps. Note that FEMA only mapped private lands, so this factor should only be included if you are prioritizing land within private lands.

Percent Logged: Percent of stream segment (300-ft buffered area on each side of stream) that has been logged at some time between 1940 and the present. Data from the Wenatchee National Forest districts.

Percent Wetland: Percent of stream-segment (300-ft buffered area on each side of stream) that is wetland. Data from the National Wetlands Inventory.

Road Density: Density of roads in stream segment (300-ft buffered area on each side of stream). Unit in km/ km2.

Stream Channel Confinement: Slope steepness in the 300-ft buffer around the stream segment. Steepness information based on 10-meter digital elevation models (DEM). Gives an indication of whether the stream segment is confined by steep slopes, or is in a flatter area with the potential to meander.

Stream Gradient: Slope of each stream segment, expressed in percent. Based on 1:24,000-scale hydrography lines and polygons and 10-meter digital elevation models (DEM). Data provided by Washington Department of Natural Resources (WADNR) and processed by SSHIAP.

Threatened/Endangered Fish Species: Number of Threatened or Endangered fish species in each stream segment. Data from the Limiting Factors Analysis and expert review. Data is current as of 2001.

Terrestrial Analysis Data

Most of the wildlife data layers were developed using a wildlife-habitat relationship model that was initially developed by Bill Gaines and Peter Singleton of the US Forest Service. We worked with the original authors of this model to improve it to better reflect the conditions within the Wenatchee Basin. The model then was applied to vegetation data that was based on the most recent US Forest Service vegetation data, but improvements were made by PBI in grassland areas, meadow areas, shrub-steppe areas, deciduous forests, and agricultural/residential areas. Vegetation was rated according to its suitability for different wildlife species. We grouped wildlife species and allowed the user to prioritize vegetation suitability for all species in a group or only for rare or endangered (of concern) species in a group. Wildlife sighting data comes from the Washington Department of Fish and Wildlife Heritage Database.

All Species in Group:

Amphibians: Number of amphibian species for which the vegetation is suitable.
Bats: Number of bat species for which the vegetation is suitable.
Gallinaceous Birds: Number of gallinaceous (chicken-like) species for which the vegetation is suitable.
Herons: Number of heron species for which the vegetation is suitable.
Passerines: Number of passerine (songbird) species for which the vegetation is suitable.
Nonpasserine Birds: Number of nonpasserine species for which the vegetation is suitable.
Raptors: Number of nonpasserine species for which the vegetation is suitable.
Shorebirds: Number of shorebird species for which the vegetation is suitable.
Waterfowl: Number of waterfowl species for which the vegetation is suitable.
Large Carnivores: Number of large carnivore species for which the vegetation is suitable.
Small Carnivores: Number of small carnivore species for which the vegetation is suitable.
Large Ungulates: Number of ungulate species for which the vegetation is suitable.
Wild Sheep and Goats: Number of wild sheep and goat species for which the vegetation is suitable.

Reptiles: Number of reptilian species for which the vegetation is suitable.
Rodents: Number of rodent-like (small mammals) species for which the vegetation is suitable.
Exotic Species: Number of exotic (introduced, invasive) species for which the vegetation is suitable.

Only Rare, Threatened, or Other species of concern:
Same definitions as above, except only the rare, threatened and other species of concern groups are included.

Other Terrestrial Influences:
Relative Forest Age: This data was developed from extensive analysis and modification of vegetation mapping conducted by Pacific Meridian Resources for the US Forest service in the early 1990's. The original data was fairly inaccurate, but some improvement was made for the purposes for which this data layer is currently used. Maximum influence occurs in the oldest part of the forest. This is a data layer that needs to be updated and improved.
Development: Based on PBI's land use map. All categories that have had major landscape alteration, including low-density residential, high-density-residential, agriculture, city parks, etc. are considered developed.
Natural Heritage Plants: Number of Natural Heritage Plants in a general area.
Population, 1990: Human population density for the year 1990. Based on block-level 1990 census.
Population, 2000: Human population density for the year 2000. Based on block-level 2000 census. .

Population Change: Population difference between 1990 and 2000 censuses. When set as a Negative influence, gives high priority where population has decreased the most, low priority where population increased the most.
Priority Habitats: Number of rare habitats or species identified by WDFW in their PHS database.
Size of Roadless Areas: Roadless areas on all ownerships are ranked by size. Larger roadless areas may provide refuge for human disturbance sensitive species.
Road Density: Density of roads, km/km2. This is usually a negative factor in determining conservation priorities.
Vegetation Rarity: This data was derived from vegetation mapping of vegetation types throughout the North Cascade ecosystem and reflects the overall rarity of vegetation types across the entire ecosystem and their degree of representation in existing protected areas.
Distribution of Rare Wildlife (WDFW Heritage Database): Chance of observing a rare/Endangered wildlife species based on previous sightings. The distribution is averaged across species and restricted to suitable habitat.

Statewide Sightings: Probability of observing a species based on statewide sightings.
Wenatchee Basin Sightings: Probability of observing a species based on sighting only in the Wenatchee Basin

LAND OWNERSHIP AND PROTECTION STATUS

Ownership

Accurate knowledge of ownership is critical to management and conservation of different parcels of land. However, while attempting to map public versus private lands in the Wenatchee River Basin, we discovered discrepancies among different maps of land ownership. We examined maps from the Chelan County Assessor's Office, U.S. Forest Service (USFS), and Washington Department of Natural Resources (DNR). The maps disagreed about ownership of 3,106 map polygons, or over 33,000 acres (135 km^2). This amounts to ownership disagreement on public lands covering of about 4% of the Wenatchee River Basin area (Figures 4 and 5). We believe that two problems are occurring.

First, agencies disagree about ownership of specific parcels. Although all three layers (County, US Forest Service, Washington State DNR) agree on ownership for most (96%) of the watershed, classification errors account for much (106 km^2, 79%) of the disputed land *area*. Classification problems could be resolved through parcel-by-parcel verification of ownership with original data sources. Although tedious, this could potentially increase map accuracy to >99% (based on area).

The second problem is disagreement over parcel boundaries. Even when agencies agree on who owns each parcel, discrepancies among the exact location of parcel boundaries create "slivers" of disagreement (Figure 4). The many black lines and checkerboard patterns show areas where two or more of the data sources disagree on parcel boundaries. Boundary errors in the GIS layers may occur from errors in the original (paper) maps, inaccurate digitizing, or errors due to use of different projection datums and reprojecting spatial data. Boundary errors account for 2,990 (96%) of the disputed map *polygons*, and would be difficult to resolve without knowing which map has the most accurate boundaries. The problem may be exacerbated if no single map source was the most accurate (e.g., boundaries of forested parcels may be mapped most accurately by USFS, whereas boundaries of private parcels are mapped most accurately by the County Assessor's Office). Ideally, a single (and presumably accurate) map of parcel boundaries should be used by all agencies. Although the total map area affected by disagreement over boundary locations is less than the area affected by disagreement over ownership of specific parcels, the former problem may be more serious because these "slivers" of disagreement are carried into subsequent GIS layers when spatial analyses are conducted.

The task of reconciling the differences between ownership maps of the various agencies was beyond the scope of this project. We decided that for the purpose of our current work, we would use the Chelan County parcel layer, supplemented with ownership data from the Wenatchee National Forest where the parcel layer was insufficient. We created a new public ownership layer which we now believe is a more accurate reflection of public land ownership than the ownership layers used in the first phase of this project. Considerable work is still needed in reconciling ownership differences in the Basin. Our thoughts on this matter are included in the Recommendations section of this document.

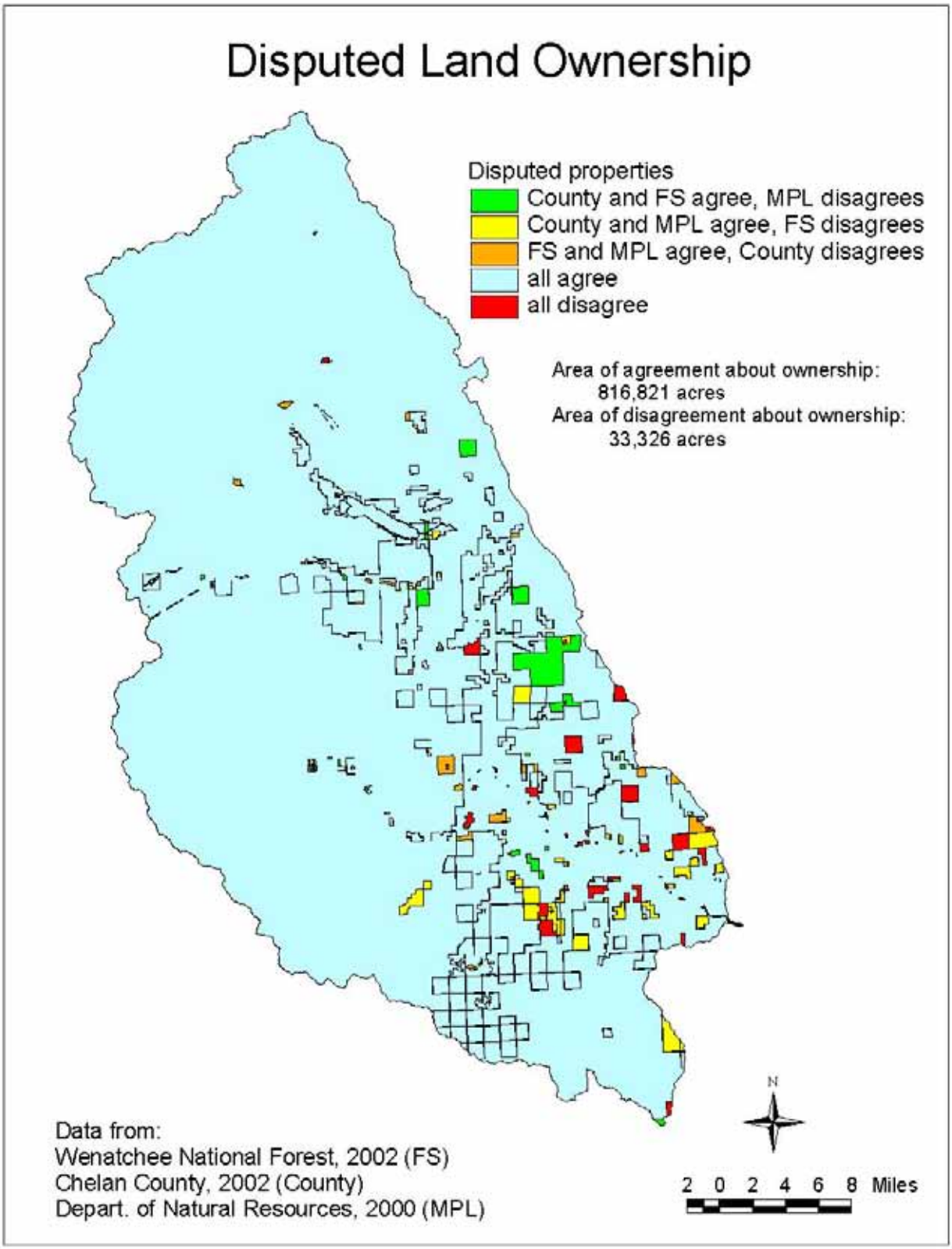


Figure 4. Areas of disputed ownership information involving three agency ownership maps (WA DNR, Wenatchee National Forest and Chelan County).

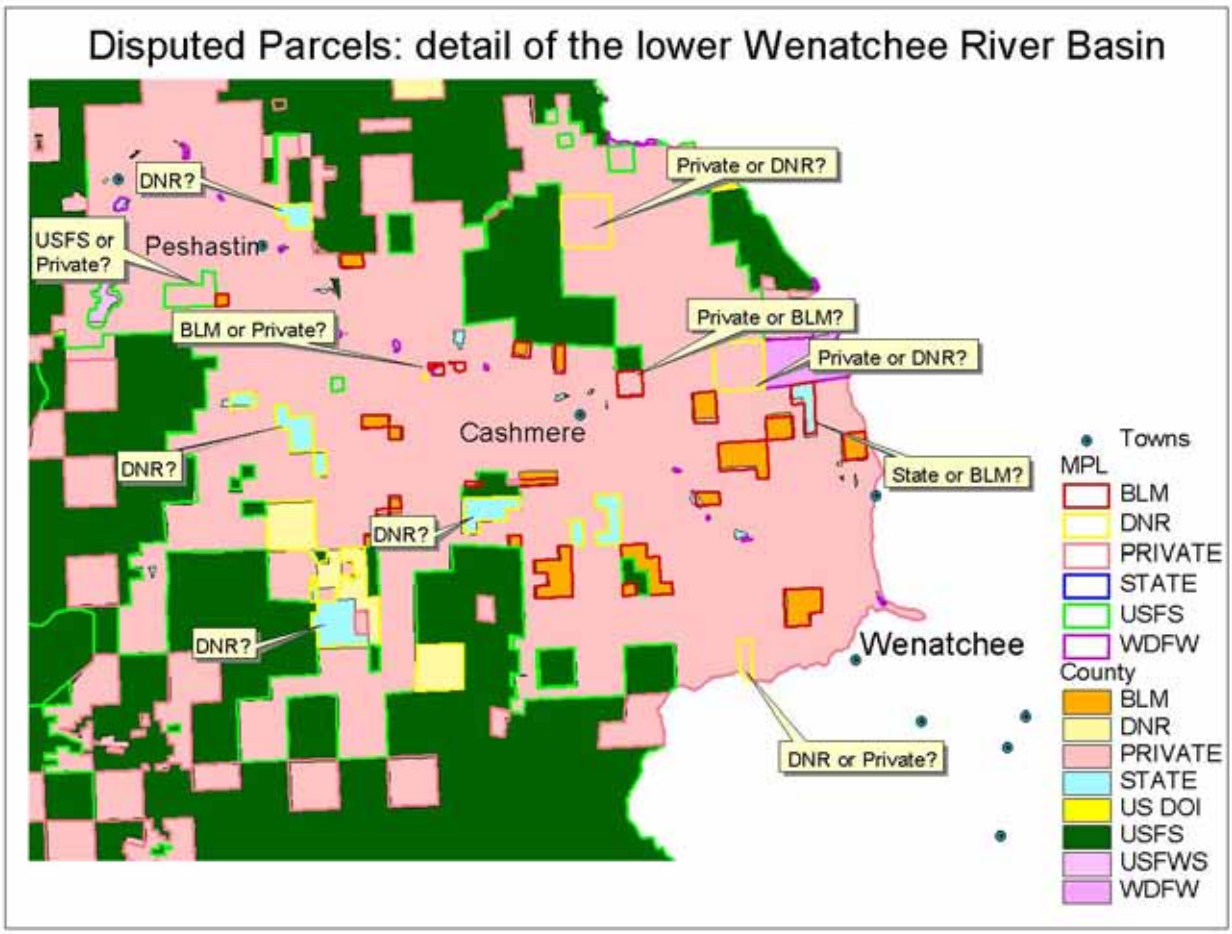


Figure 5. View of eastern portion of Wenatchee Basin showing some of the details of ownership discrepancies between agency ownership maps.

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.

Protection status of lands in the Wenatchee River Basin can be divided into four categories (Figure 6). Please note that the acreage figures are approximate due to ownership discrepancies as described above. Approximately 319,575 acres receive permanent protection as Wilderness, Research Natural Area, or Natural Area Preserve (Table 2). We gave these lands the designation of Protection

Level 1. An additional 257,601 acres currently receive some degree of administrative protection from the US Forest Service. These areas include 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). We 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 2. 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	318,883
USFS Research Natural Area	189
USFS Natural Area Preserve	501

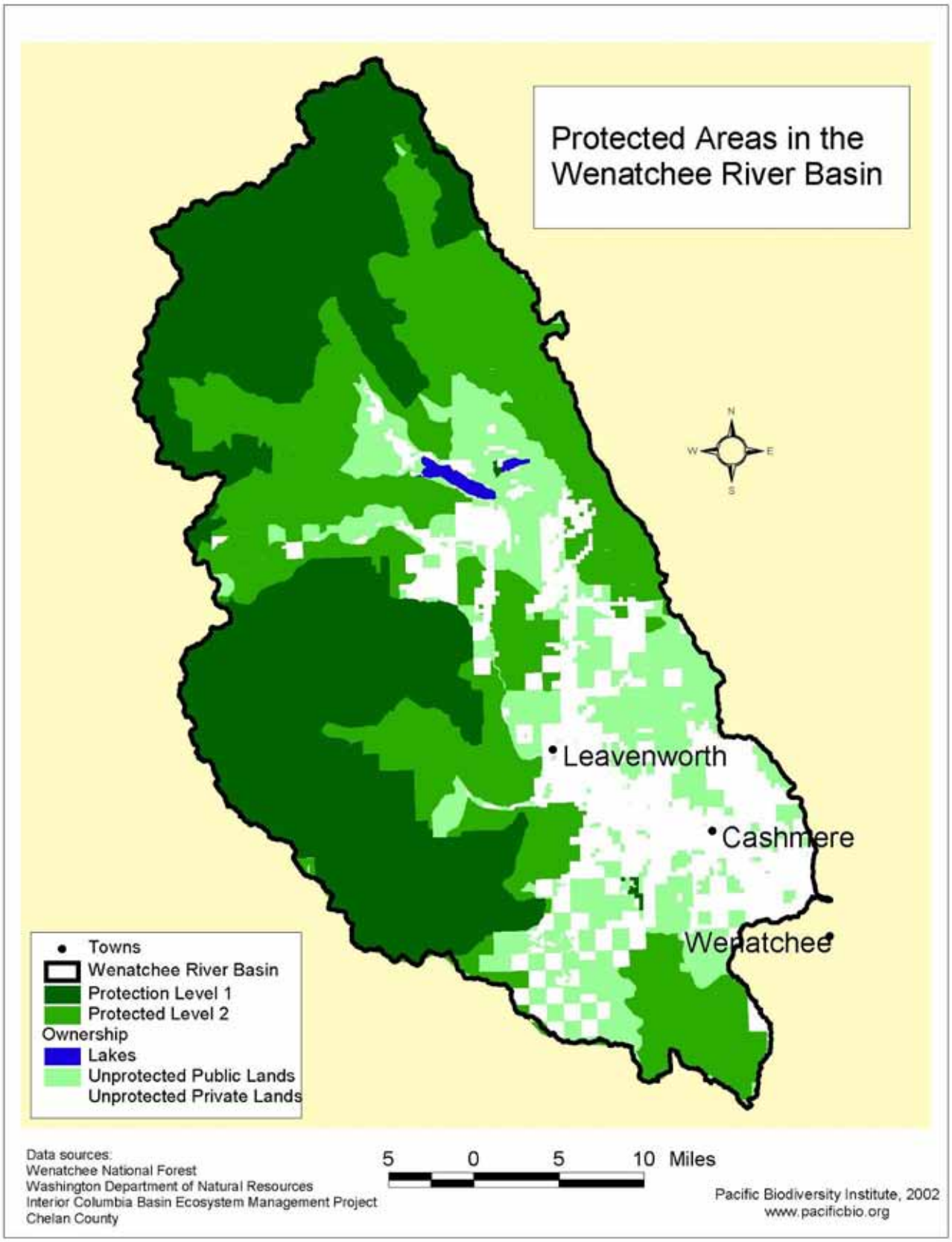


Figure 6. Protection status of lands within the Wenatchee Basin.

BIOLOGICAL RESOURCES

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 Ecosystem Assessment

Subwatershed Level Assessment

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 Forest Service for our prioritization unit. Since the Forest Service is still altering the final subwatersheds layer, PBI brought the layer to a point where it is useful for this project by modifying several of the subwatersheds so that they all drain at a single pour point and are similar in size. Each subwatershed was analyzed according to nine factors that serve as indicators of, or contributors to, the overall health, diversity, and productivity of aquatic ecosystems and the species inhabiting them (Table 3). 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 natural and human-made barriers that 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 following factors (Table 3) 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. For prioritization purposes, all values were scaled between 0 and 100 based on the minimum and maximum value possible for each factor.

Table 3. Factors used in the aquatic prioritization of the Wenatchee River Basin.
Positive factors contribute to the overall priority of an area, whereas negative factors detract from it. Each of these factors can be multiplied by any number to increase its weight relative to the other factors. One or all of these factors can be summed in prioritizing subwatersheds.

Factor	Suggested Influence	Values for use in ranking
Ecological Integrity		
Area of Natural Wetlands	Positive	0 – 100 based on area of natural wetlands. 100 represents 10.1 square kilometers of wetland present.
Percent Roadless Area	Positive	0 –100 based on amount Roadless in subwatershed. 100 means the watershed is 100% Roadless area
Road Density	Negative	0 – 100 based on total length of roads per subwatershed. 100 represents 3.4 kilometers of road / square kilometer (maximum possible)
Percent Developed	Negative	0 – 100 based on the percent of developed land per subwatershed 100 represents the highest percent of developed area (35%)
Proportion Logged	Negative	0 – 100 based on the percent of logged land per subwatershed. 100 represents the highest percent of a subwatershed that is logged (54%)
Fish		
Number of ESA-listed Fish Species	Positive	0 – 100 based on the number of ESA-listed fish species present per subwatershed. 100 represents all 4 species present
Number of Anadromous Fish Species	Positive	0 – 100 based on the number of anadromous fish species present per subwatershed. 100 represents all 4 species present
Number of Native, Resident Fish Species	Positive	0 to 100 based on the number of native, resident fish species present per subwatershed. 100 represents all 11 species present
Number of Non-native Fish Species	Negative	0 to 100 based the number of non-native fish species present per subwatershed. 100 represents all 4 species present

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. For prioritizing, the area of wetland was scaled between 0 and 100, where "0" is no wetland present, and "100" is 10.1 square kilometers present (the maximum amount in any subwatershed). These values were grouped into six categories for display purposes (Figure 7).

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). Roadless areas were mapped on all ownerships. The roadless area factor represents the subwatershed's undeveloped habitat condition based on the amount of undeveloped habitat. Roadless area can be viewed and analyzed as either total amount of roadless area in the subwatershed or by percent of total watershed that is roadless.

This roadless layer was intersected with the subwatershed layer and the amount and percentage of each subwatershed in roadless condition was calculated. The values were scaled between 0 and 100, where 0 means there is no roadless area in the subwatershed, and 100 means 100% of the subwatershed is roadless or the highest area of roadless area is present. For display purposes, the values for amount roadless were grouped into five categories, including <5000 acres roadless, 5000 to 7500, 7500 to 10,000, 10,000 to 15,000, and >15,000 acres of roadless area. The values for percent roadless were grouped into seven categories, including a category for less than 25% roadless, 25% - 50%, 50% - 75%, 75% - 90%, 90% - 95%, 95%- 99% and 99%-100% roadless (Figure 8).

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). Roads data was acquired from Wenatchee National Forest and the Washington Department of Natural Resources. These layers were merged together and overlaps removed to form a single road map. This road map 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 road density values were then scaled between 0 and 100, where 0 means there are no roads, and 100 means there are 3.4 kilometers of road per square kilometer (the maximum possible) in that subwatershed. The calculated road density for all subwatersheds in the Wenatchee River Basin was grouped into seven classes for display purposes (Figure 9). This final road density value can be used as a negative factor in the subsequent landscape-level subwatershed

prioritization.

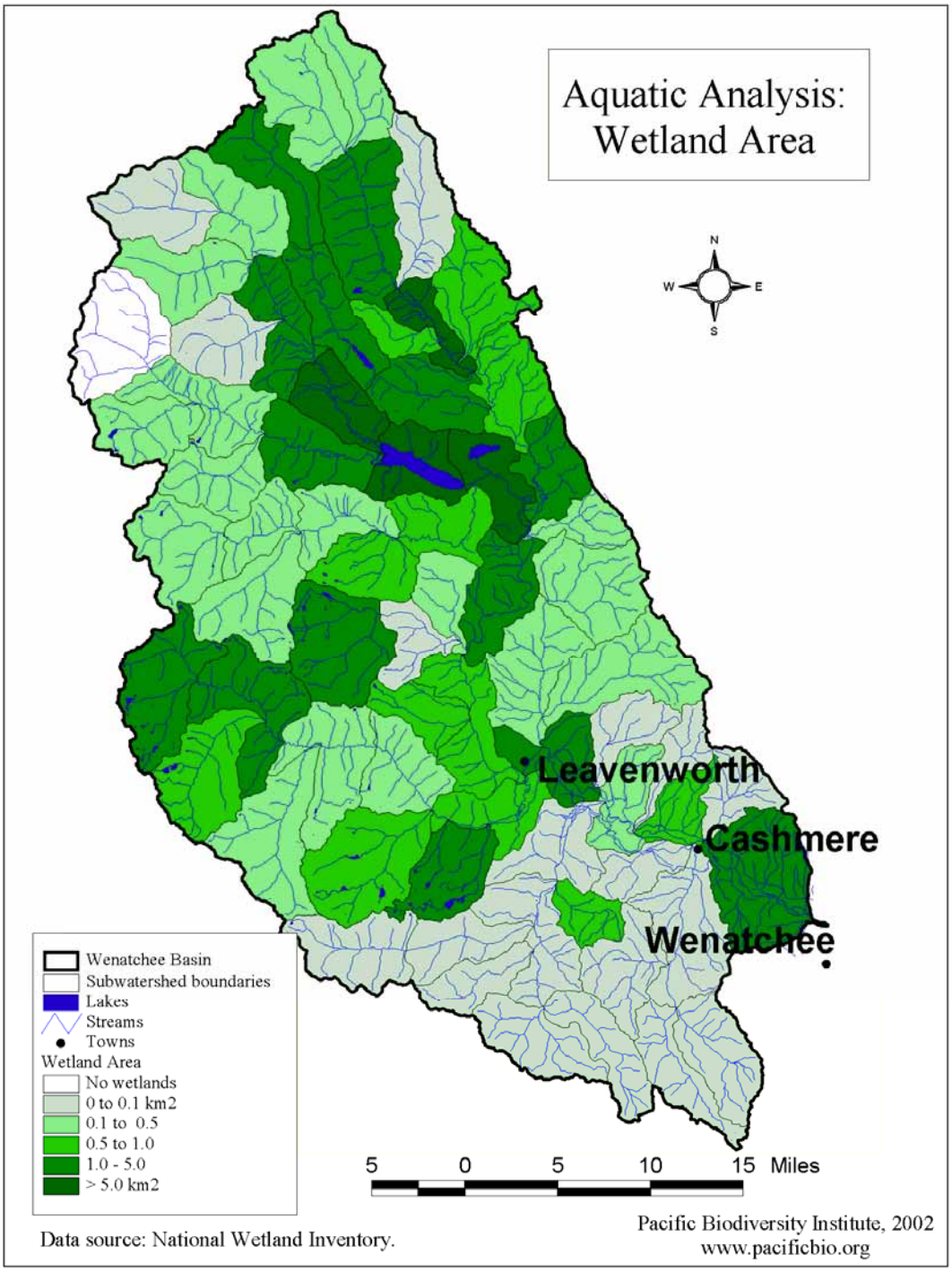


Figure 7. Total wetland area rankings for Wenatchee River Basin subwatersheds.
High values (dark green) indicate subwatersheds with a high percentage of natural wetlands, adding to aquatic priority. This was used as a positive factor in the aquatic analysis.

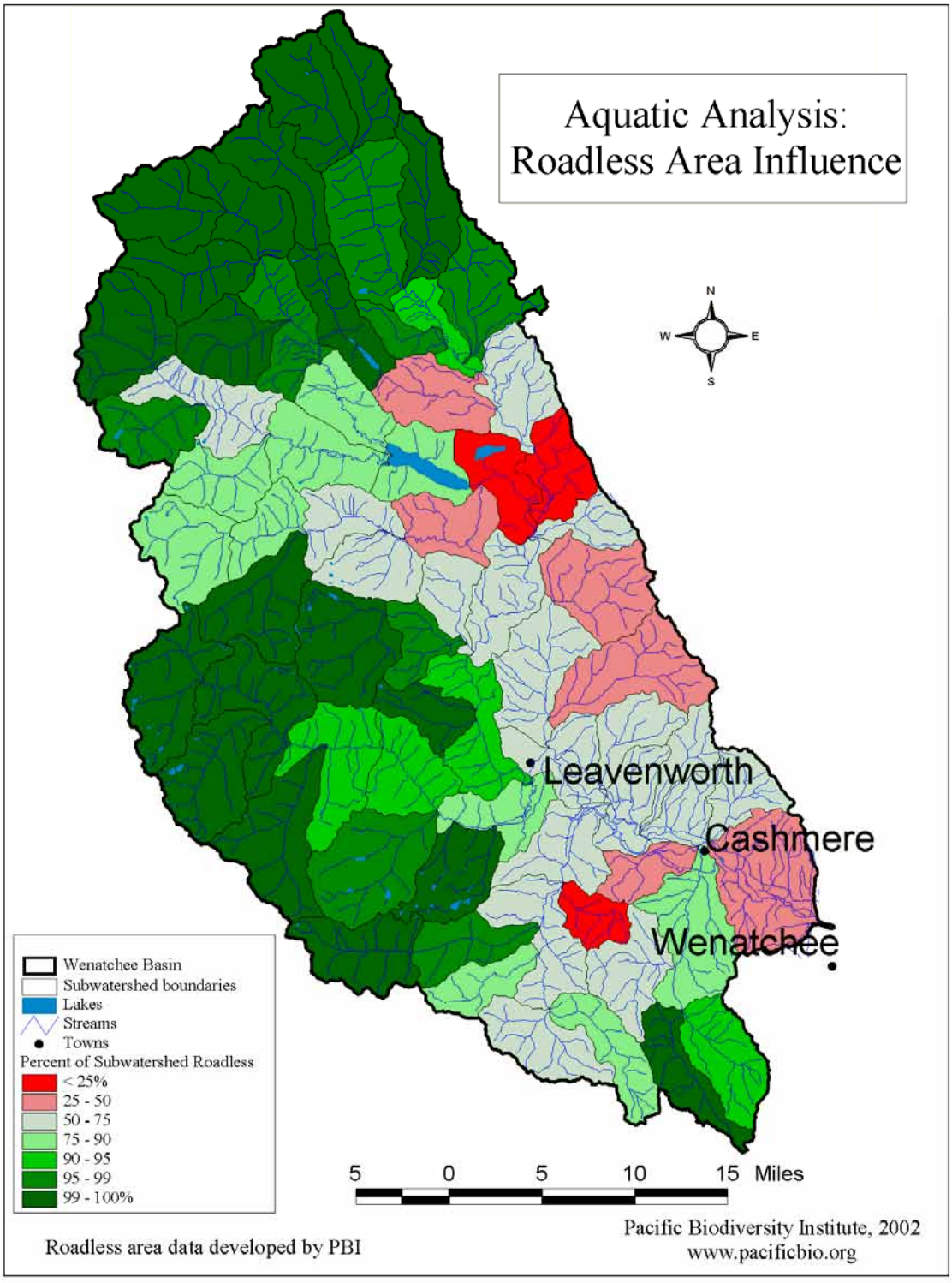


Figure 8. Roadless area influence for Wenatchee River Basin subwatersheds.
High values (dark green) indicate subwatersheds with a high percentage of roadless areas, adding to aquatic priority. This was used as a positive factor in the aquatic analysis.

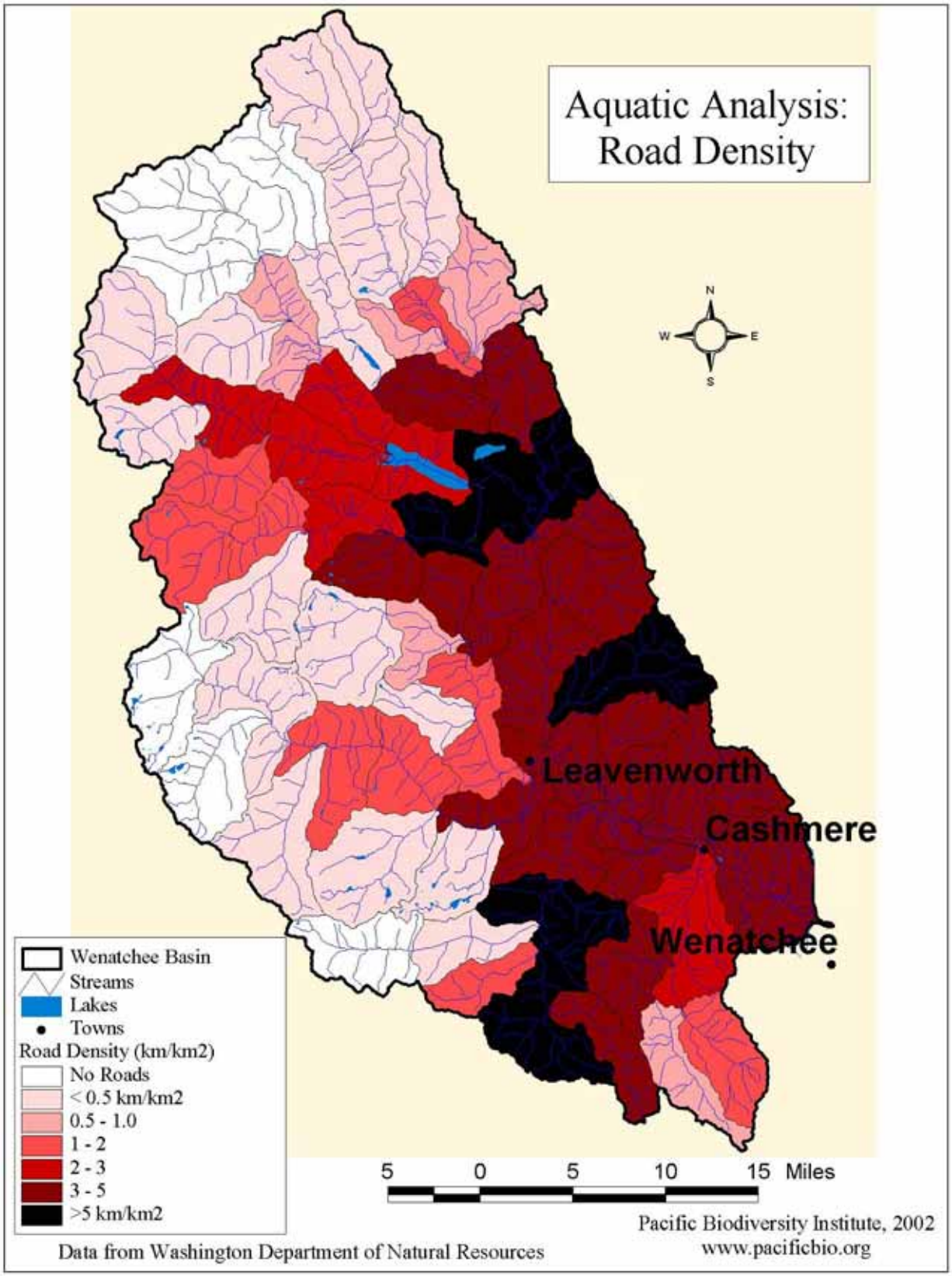


Figure 9. Road density rankings for Wenatchee River Basin subwatersheds.

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.

Developed Land Use

Pacific Biodiversity Institute developed a data layer of current land use in the Wenatchee River Basin. This land use coverage is primarily based on 1998 aerial photos, 1999 satellite imagery, and 2002 parcel data from the Chelan County Assessor's office. The land use map identifies eighteen different kinds of land use, but for analysis purposes, we identified areas as either developed or undeveloped. We calculated the percent of each subwatershed that was developed. The resulting values were scaled between 0 and 100, where 0 is no developed land use present in the subwatershed, and 100 is the maximum percent of developed land use present (35%). These values were split into five categories for display purposes. This factor can be used as a negative factor in the aquatic analysis.

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. Listed fish information compiled during the Washington State Conservation Commission's Limiting Factor Analysis, and then modified during an expert review process was used to map threatened, endangered and special concern fish distribution in the Wenatche River Basin (Table 4, Figure 10). The number of threatened, endangered, and special concern fish species occurring in each subwatershed can be used as a positive factor in our analysis.

The Limiting Factors Analysis listed fish data contains information on known, potential, and historic fish presence on a stream-reach level. Areas of known species presence were selected out and created into a separate layer. This layer was intersected with the subwatershed layer. It was then possible to sum the number of species present for each subwatershed. For prioritizing, the number of species was scaled between 0 and 100, where 0 is no species present, and 100 is four species present (the maximum possible). The final map layout shows total number of anadromous fish by subwatershed.

Table 4. Threatened or Endangered Fish Present in the Wenatchee River Basin.

Common Name	Scientific Name
Bull Trout	*Salvelinus confluentus*
Spring Run Chinook Salmon	*Oncorhynchus tschawytscha*
Summer Run Steelhead	*Oncorhynchus mykiss*
Sockeye Salmon	*Oncorhynchus nerka*

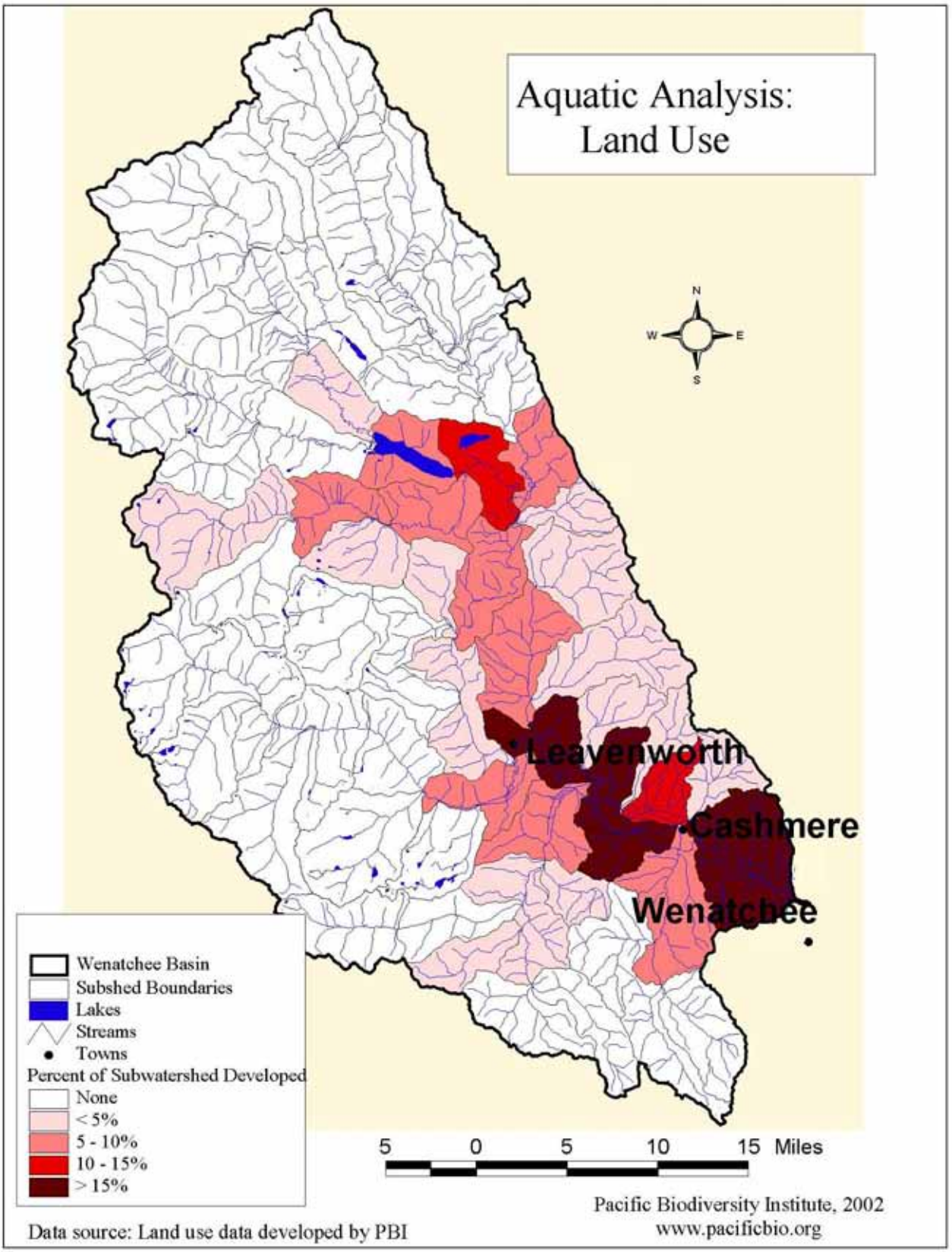


Figure 10. Land use rankings for Wenatchee River Basin subwatersheds.

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.

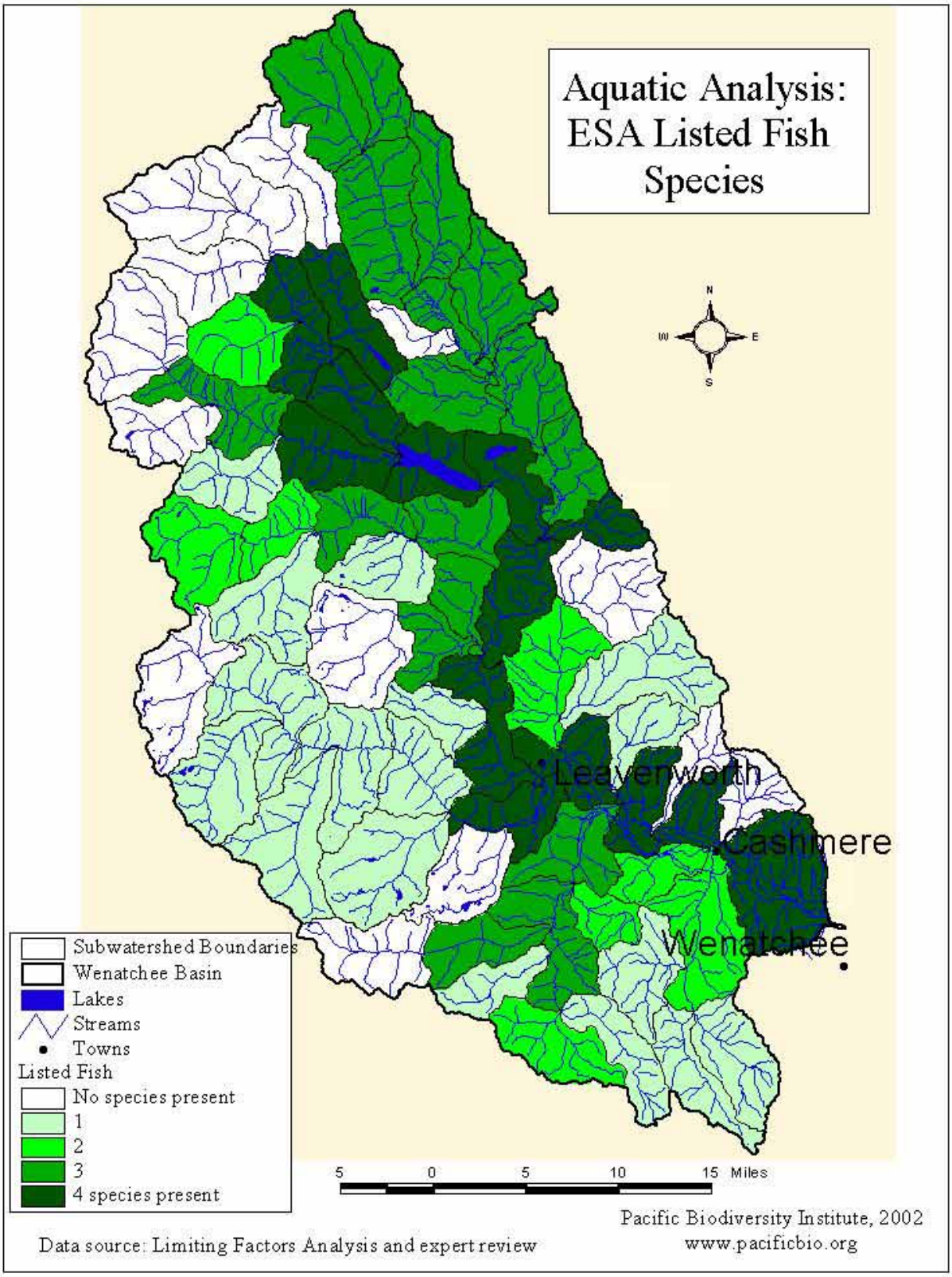


Figure 11. Presence of threatened, endangered, and special concern fish by subwatershed in the Wenatchee River Basin.

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. The same process as described for the threatened and endangered fish species was followed for anadromous fish species. Table 5 lists the anadromous fish species recorded in the Wenatchee River Basin. The final map layout shows total number of anadromous fish by subwatershed (Figure 12).

Table 5. 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*

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 13).

Data for native, resident fish was compiled from the Washington Department of Fish and Wildlife's STREAMNET, and the Wenatchee National Forest's resident fish data set. The data layers were combined and then intersected with the subwatershed layer. Overlap between the two data sets was eliminated and the number of species present per subwatershed summed. For prioritization, the number of resident fish was scaled between 0 and 100, where 0 is no species present, and 100 is eleven species present (the maximum possible). The final map layout shows total number of resident fish by subwatershed (Figure 13).

Table 6. Resident Fish Present in the Wenatchee River Basin

Common Name	Scientific Name
Bridgelip Sucker	*Catostomus columbianus*
Bull Trout	*Salvelinus confluentus*
Sucker, General	*Catostomus spp.*
Sculpin, General	*Cottus spp.*
Speckled Dace	*Rhinichthys osculus*
Kokanee Salmon	*Oncorhynchus nerka*
Largescale Sucker	*Catostomus macrocheilus*
Northern Pike minnow	*Ptychocheilus oregonensis*
Northern Squawfish	*Ptychocheilus oregonensis*
Rainbow Trout	*Oncorhynchus mykiss*
Redside Shiner	*Richardsonius balteatus*
Mountain Whitefish	*Prosopium williamsoni*
Pacific Lamprey	*Entosphenus tridentatus*
Westslope Cutthroat	*Oncorhynchus clarki*

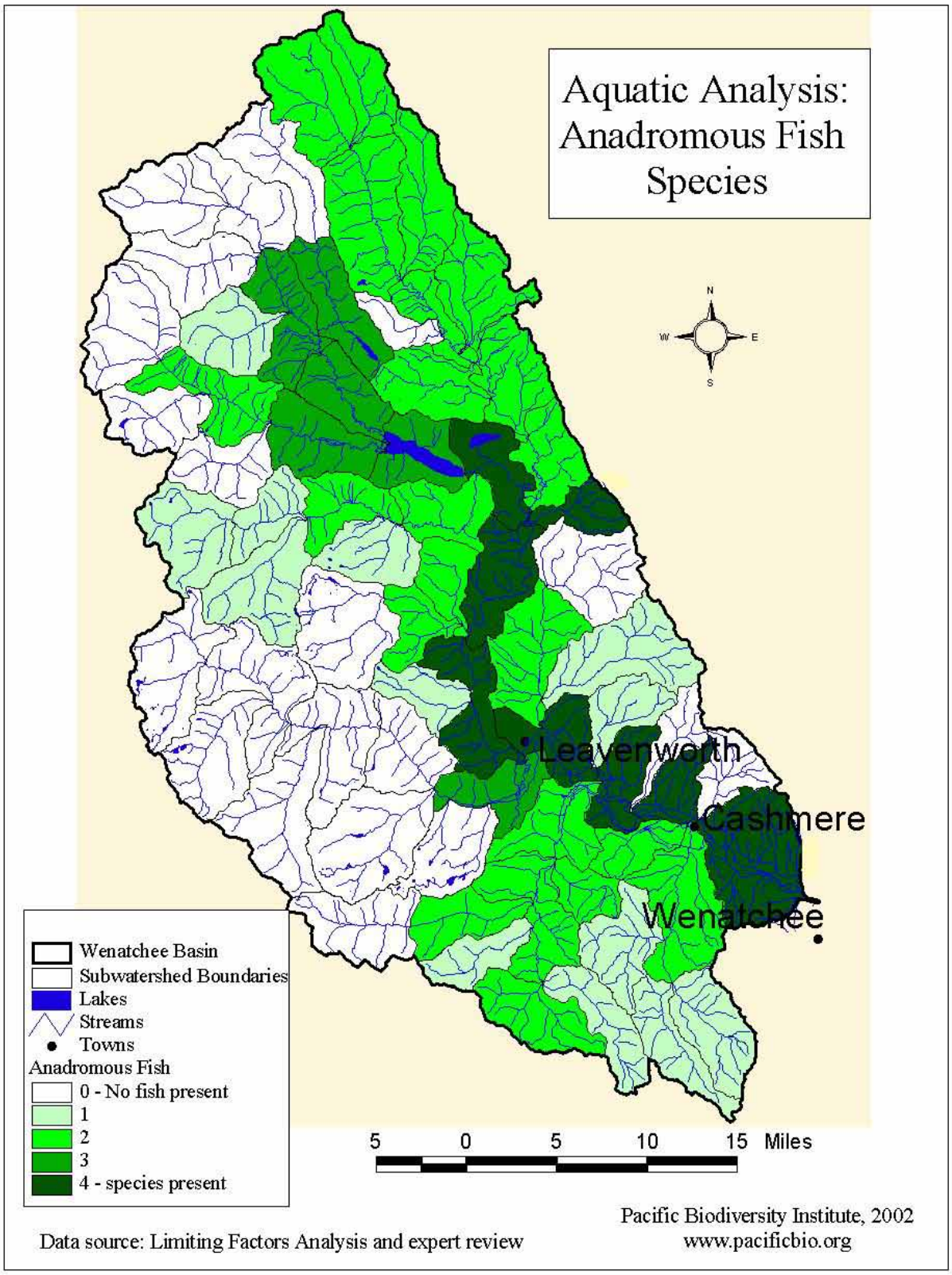


Figure 12. Presence of anadromous fish species by subwatershed in the Wenatchee River Basin.

High values (dark green) indicate subwatersheds with the most anadromous fish species, adding to aquatic priority. This can be used as a positive factor in subwatershed prioritization.

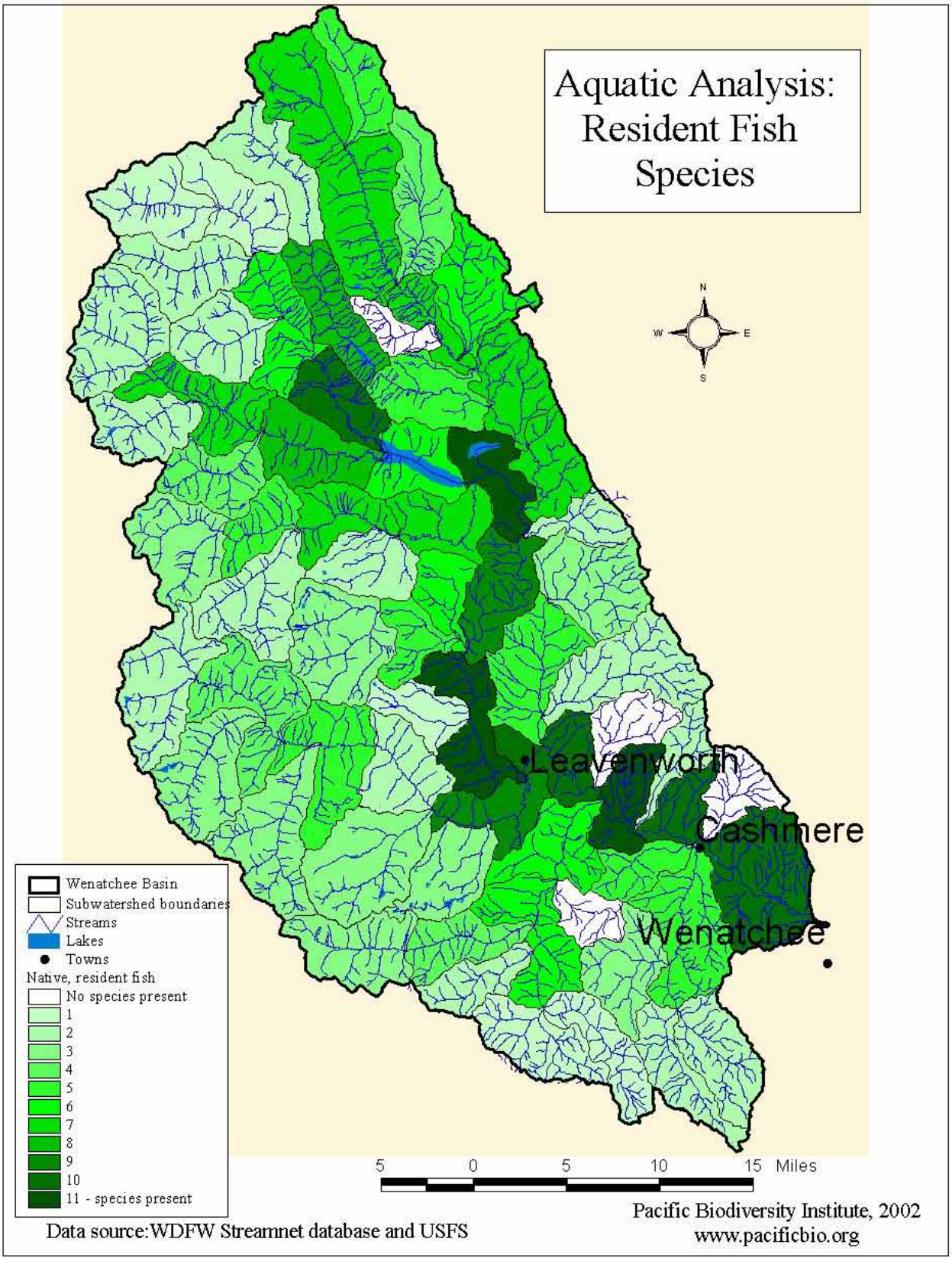


Figure 13. Presence of resident fish species by subwatershed in the Wenatchee River Basin.

High values (dark green) indicate subwatersheds with more resident fish species, adding to aquatic priority. This can be used as a positive factor in 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 7 lists the non-native fish reported by WDFW Streamnet and Wenatchee National Forest as occurring in the Basin. The same analysis methods used for resident, native fish were used in determining number of non-native fish per subwatershed. For prioritization, the number of non-native fish species were scaled between 0 and 100, where 0 is no species present, and 100 is four species present (the maximum possible). Number of non-native fish species can be used as a negative factor in the analysis (Figure 14).

Table 7. Non-native Fish Present in the Wenatchee River Basin.

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

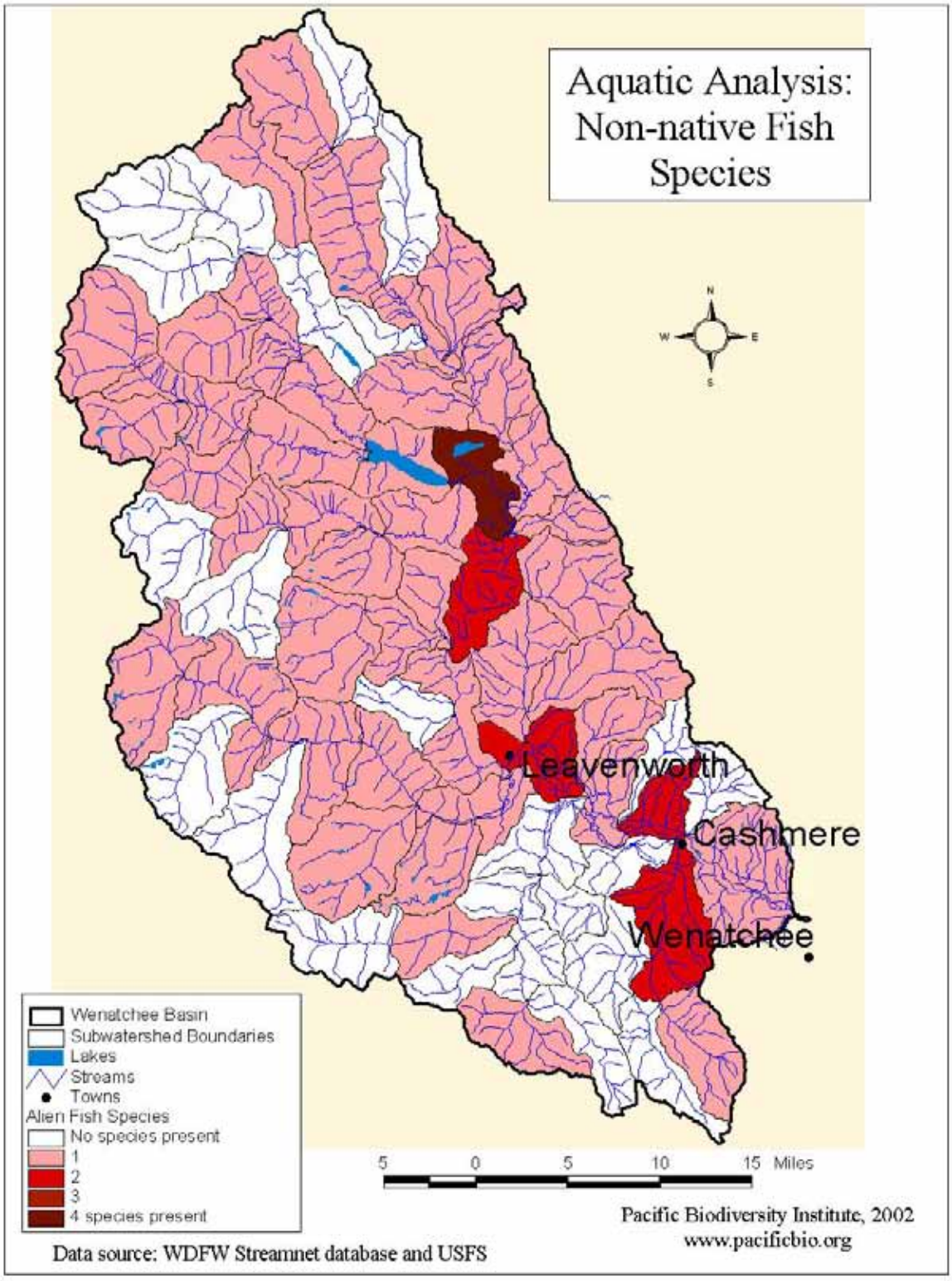


Figure 14. Presence of non-native fish species by subwatershed in the Wenatchee River Basin.
High values (dark red) indicate subwatersheds with more non-native fish species, detracting from aquatic priority. This can be used as a negative factor in subwatershed prioritization.

Barriers to Fish Passage

Dam and culvert data from Chelan County, Washington Department of Fish and Wildlife, and Wenatchee National Forest, and natural barrier data from StreamNet were used to create a layer of all barriers to fish passage in the Wenatchee River Basin. All data sources use slightly different terminology and different criteria for defining a structure as a barrier to fish passage, and no single data source includes all of the barriers in the basin. A rigorous review of all barriers data is needed, but was not within the scope of work for this project. The final barriers layer displayed here is a simple aggregate of all structures labeled as barriers by each agency (Figure 15). Overlaps between barrier locations were removed.

This data was not incorporated into the Decision Support System for analysis, but can be looked at as an overlay or “screen” in the final prioritization map.

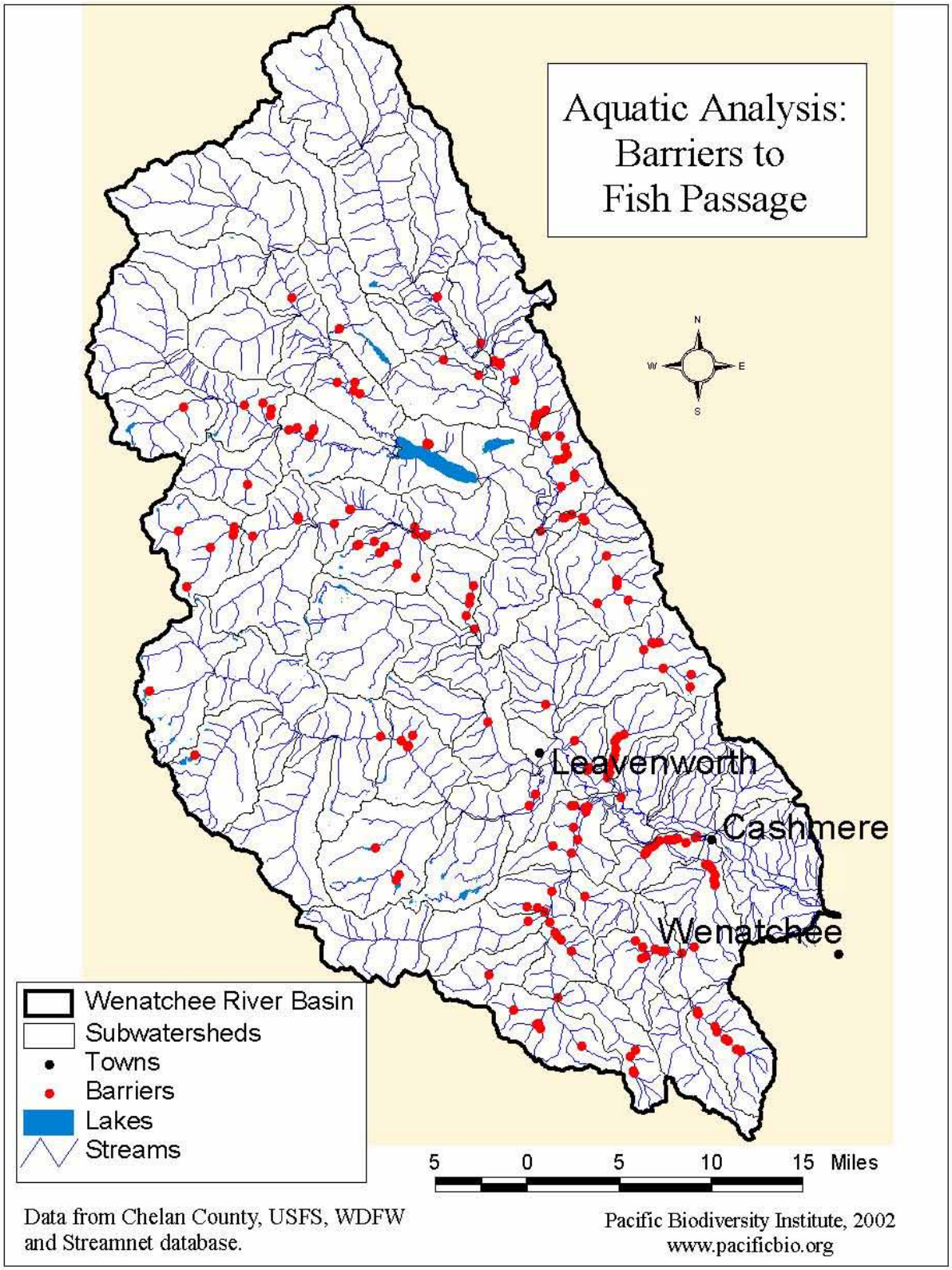


Figure 15. Barriers to anadromous fish species due to impassible culverts, dams and natural barriers in the Wenatchee River Basin.
Note that many of these barriers occur on tributary streams to the larger, fish-bearing streams.

Stream Segment Level Anadromous Fish Habitat Assessment

In-stream habitat and conditions in the surrounding riparian areas are the principle factor in affecting fish habitat. In this section of the analysis we looked at environmental factors affecting fish habitat on the stream-segment level. This portion of the analysis looked only at the streams bearing anadromous and/or listed fish species.

We broke the streams up into segments of uniform gradient using the SSHIAP segmented stream layer. We analyzed environmental conditions within a riparian buffer of 300-ft on each side of the streams, based on the Northwest Forest Plan's criteria for riparian reserves around fish-bearing streams (Forest Ecosystem Management: An Ecological, Economic, and Social Assessment and Social Assessment. Report of Forest Ecosystem Management Assessment Team. July 1993. p.III-22). These two processes created a unit of analysis based on both stream segment and riparian zone. This analysis based on stream-segment will allow for a prioritization that more closely reflects the conditions in and around the streams.

For each segment, we followed a process paralleling the subwatershed analysis. The number of anadromous fish (Figure 16) and listed fish (Figure 17)associated with each segment of the stream, as well as each stream segment's gradient were determined. We determined the conditions in the 300-ft buffer of land on each side of the stream. This included calculating the amount of wetland in the land around each stream segment (Figure18), the road density in the land around each stream segment (Figure 19), the percent of the land around each segment that has been logged (Figure20), and the percent of the land around each segment that is developed (Figure 21).

We also included the influence of fish hatcheries in this analysis. To determine fish hatchery 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 hatchery-influence areas were coded with the total number of zones to record influence from multiple facilities. The hatchery-influence layer was then intersected with the stream segment layer and hatchery influence was calculated for each stream segment.

Two other factors considered for the stream segment-based analysis are percent of the area around the stream segment in the floodplain (Figure 22) and channel confinement (Figure23). Channel confinement was calculated as average slope in the 300-m buffer on each side of the stream segment. We used a 10-meter digital elevation model for the slope data. Floodplain data was acquired from the Federal Emergency Management Agency, and is only available for private lands.

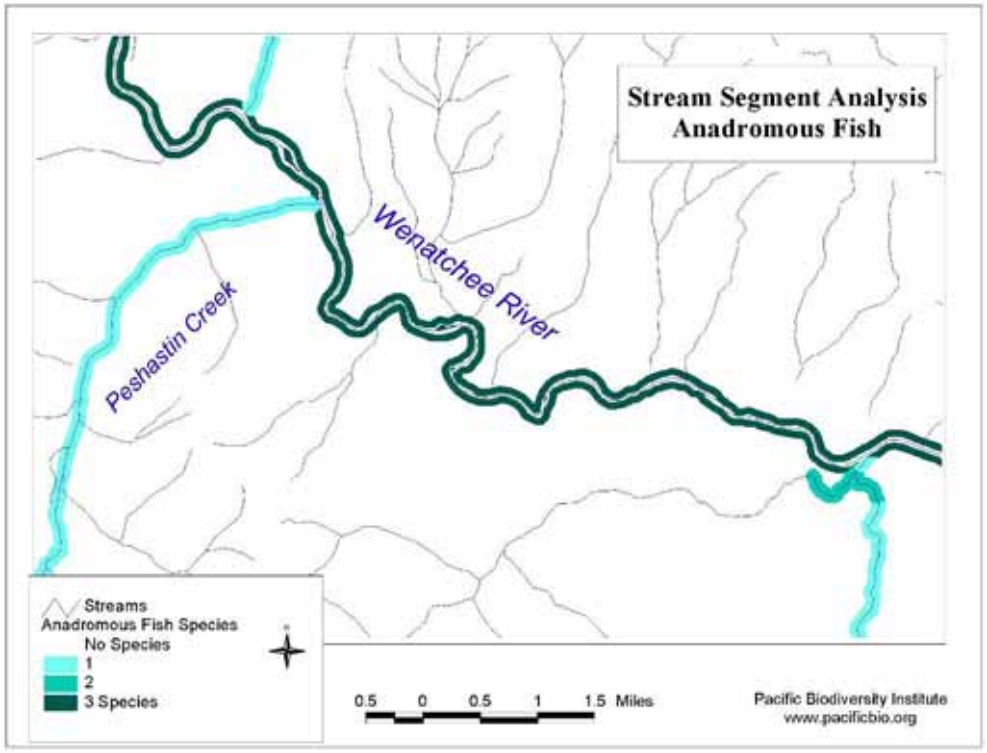


Figure 16: Presence of anadromous fish species by stream segment.

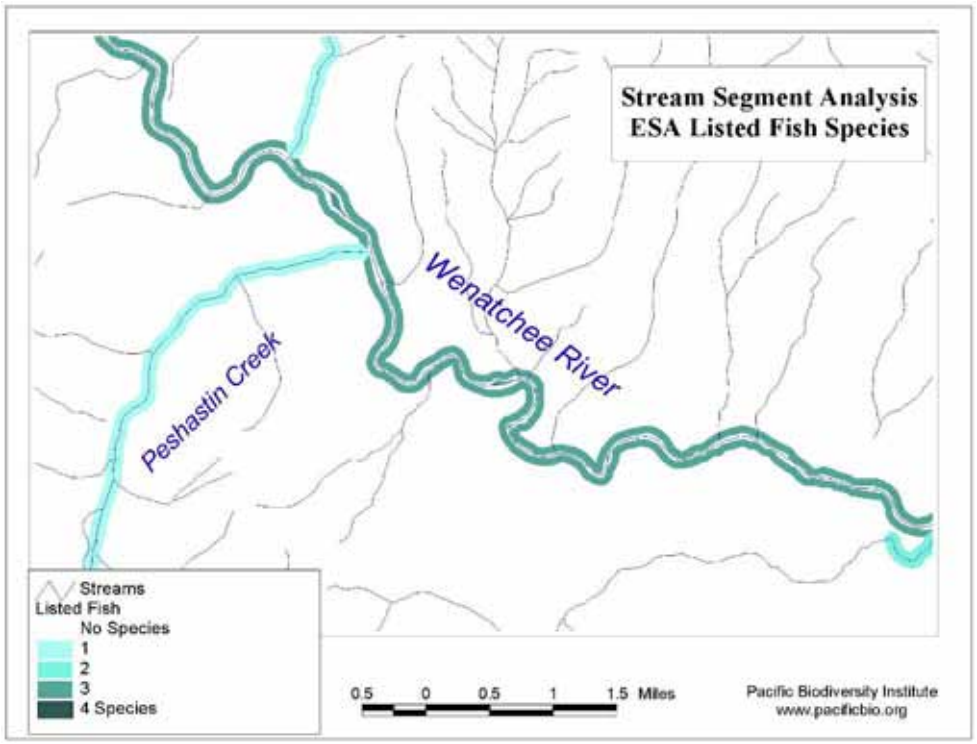


Figure 17: Presence of ESA Listed fish species by stream segment.

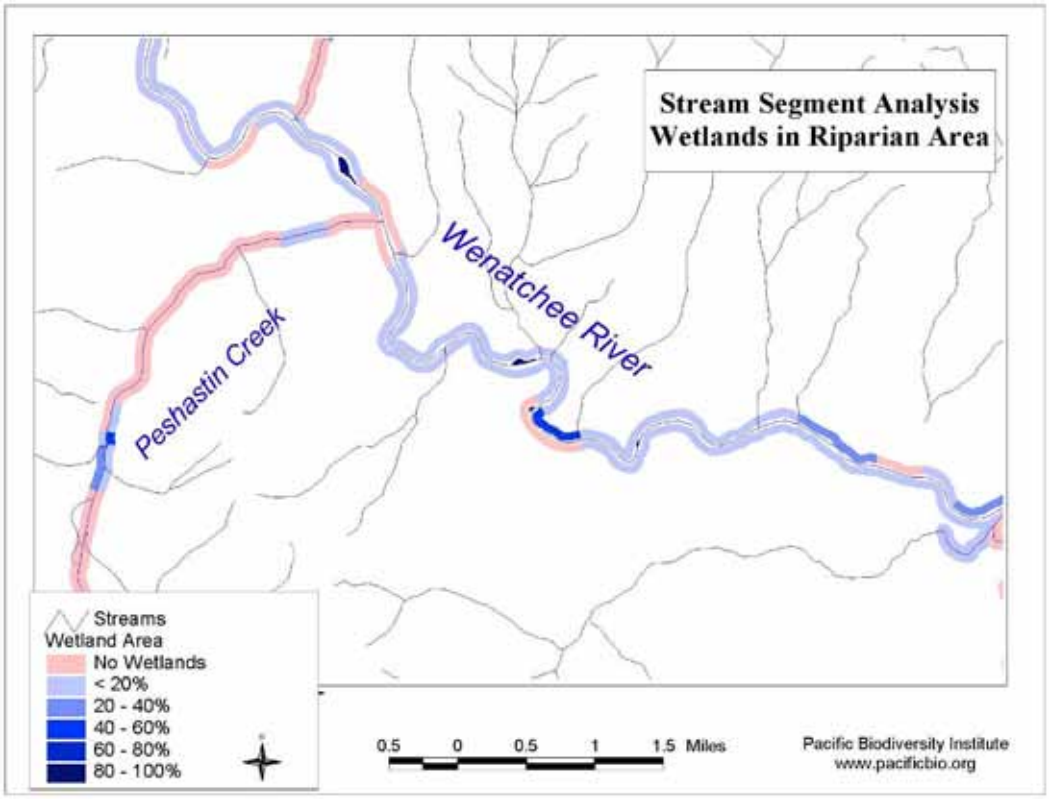


Figure 18: Amount of wetlands in the land around each stream segment.

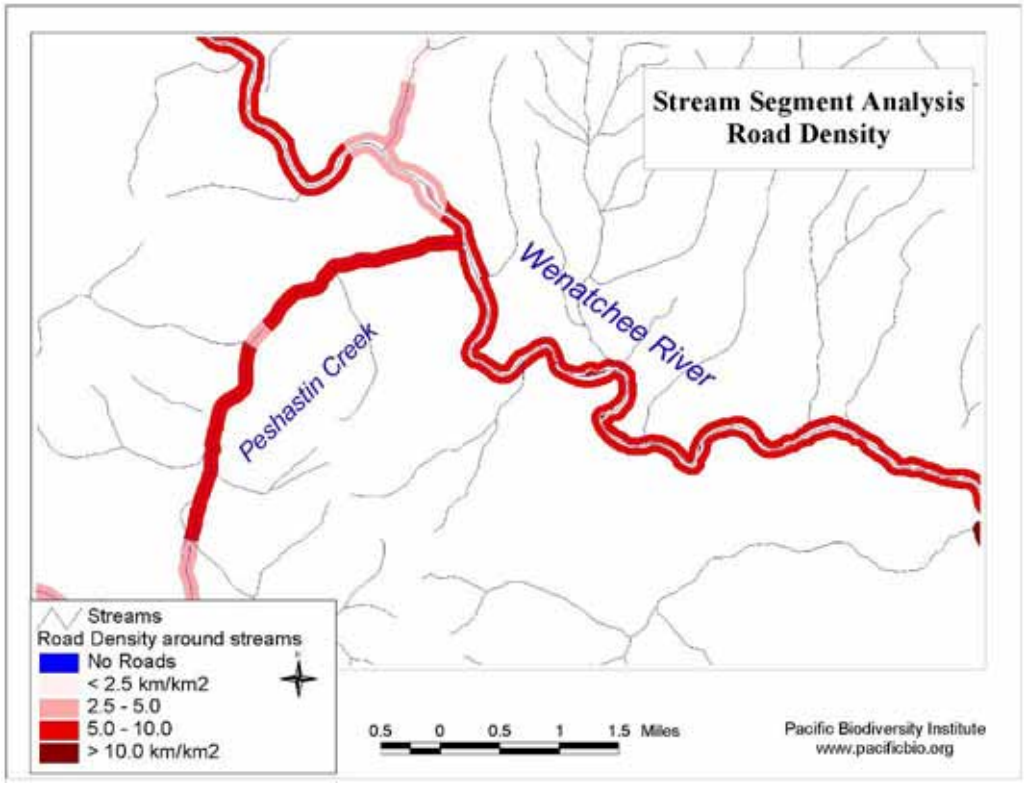


Figure 19: Road Density in the land around each stream segment (percent)

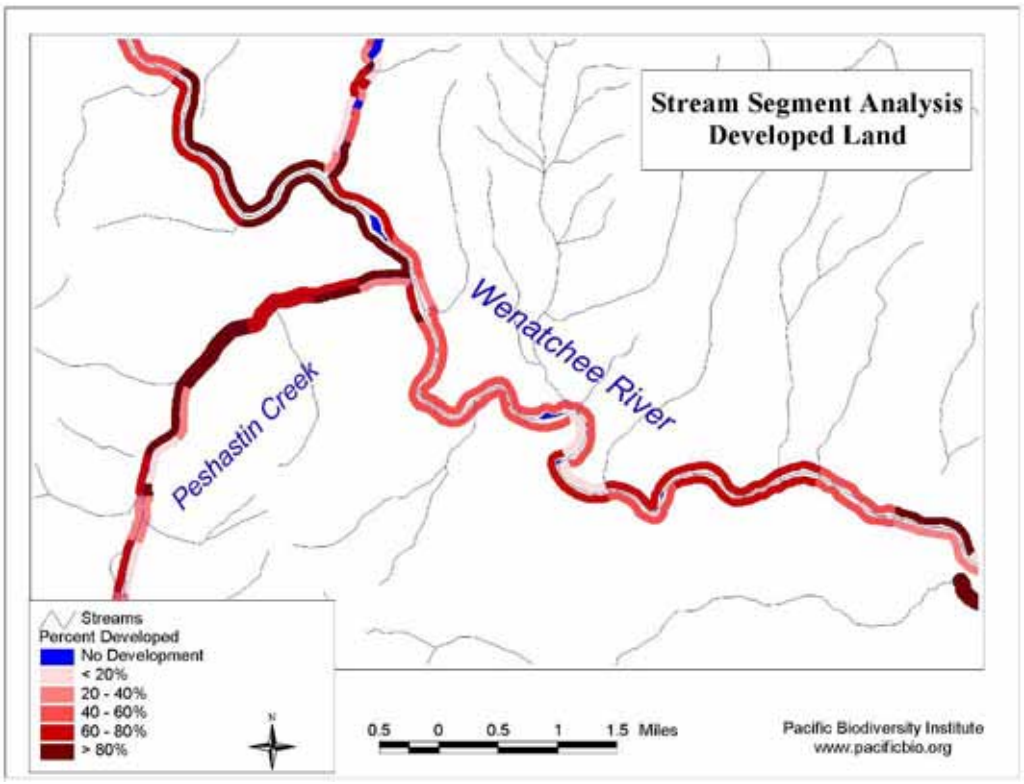


Figure 20: Amount of development in the land around each stream segment (percent)

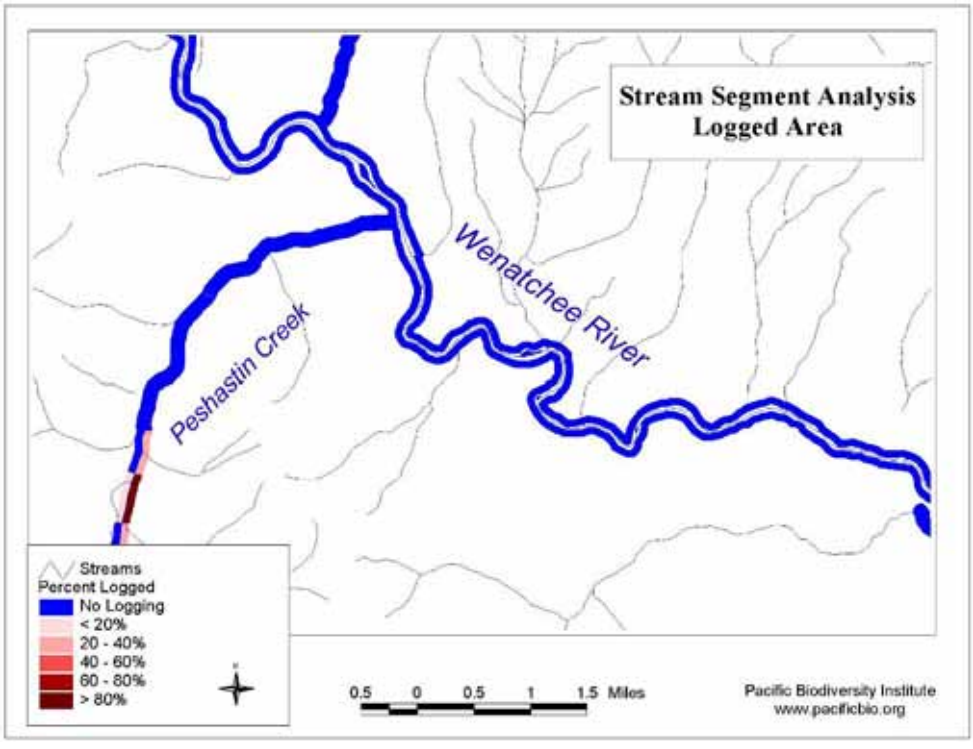


Figure 21: Logging activity in the land around each stream segment (percent)

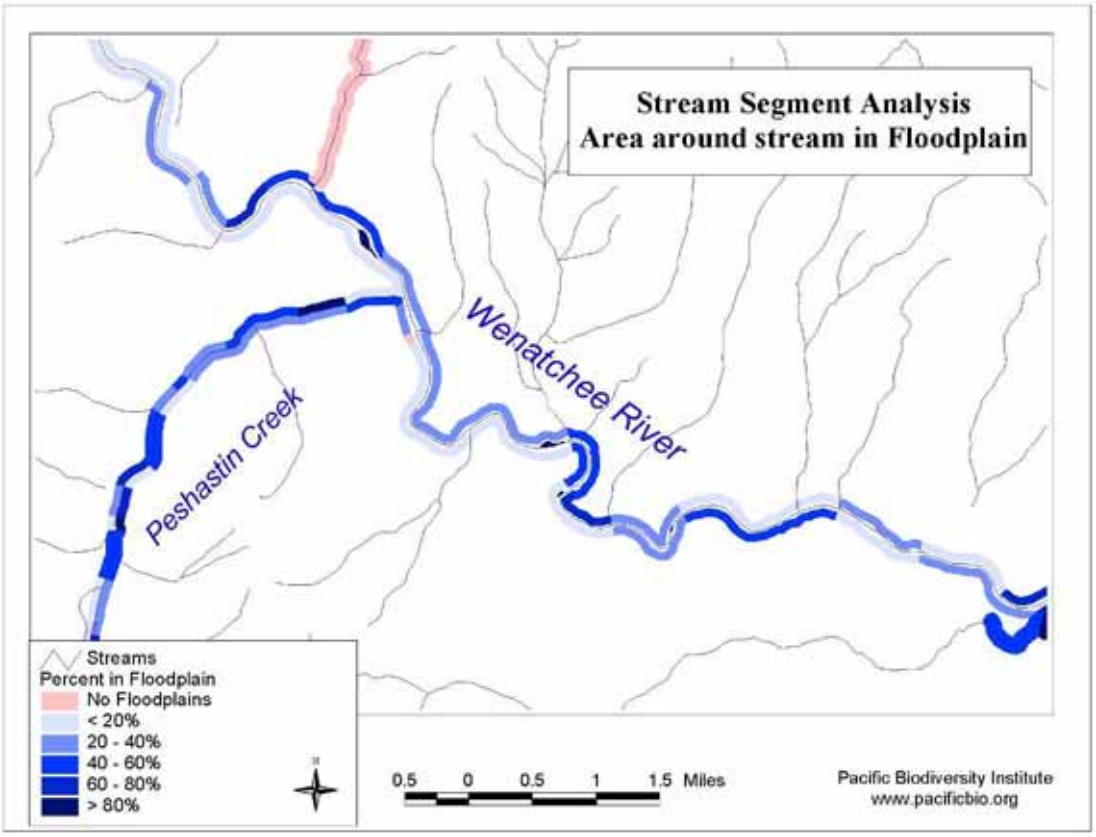


Figure 22: Amount of the area around stream that is in the 100- or 500- year floodplain

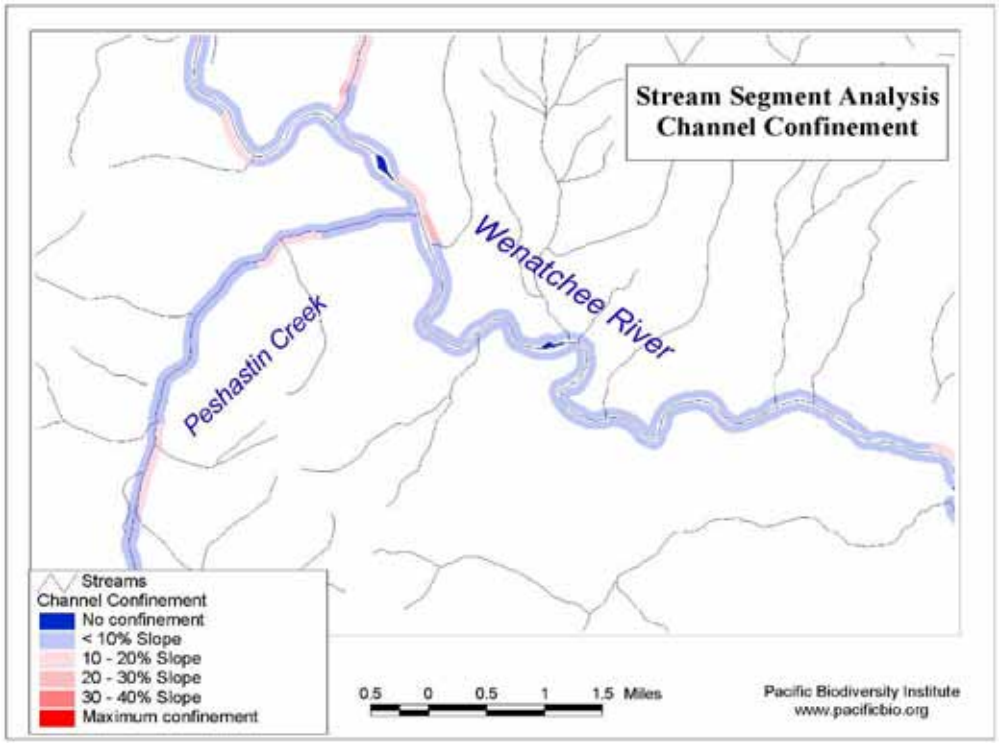


Figure 23: Average slope of 300-ft buffer around streams. Can be used as an indication of channel confinement.

Table 8. Land ownership for each subwatershed in the Wenatchee River Basin.

Subwatershed Name	Private	USFS	Washington State	BLM	DNR
BEAVER	11%	89%	0%		
BRENDER	93%	1%	1%	4%	2%
BUTCHER - KAHLER	54%	42%	4%		
CABIN - FALL	2%	98%			
CAMAS	31%	43%	10%	0%	16%
CHIKAMIN	1%	99%			
CHIWAUKUM 1		100%			
CHIWAUKUM 2	5%	94%	1%		
DERBY	9%	82%	1%		8%
DEVIL'S GULCH	1%	97%	2%		
EAGLE	29%	67%	0%		4%
EAST FORK MISSION	9%	90%	0%		1%
EIGHTMILE	0%	100%			
ENCHANTMENTS	2%	98%			
FRENCH		100%			
GILL - ROARING - COULTER	52%	48%			
HEADWATERS CHIWAWA 1		100%			
HEADWATERS CHIWAWA 2		100%			
HEADWATERS ICICLE		100%			
HEADWATERS LIT. WENATCHEE		100%			
HEADWATERS NASON	4%	96%	0%		
HEADWATERS PESHASTIN 1	4%	96%			
HEADWATERS PESHASTIN 2	44%	56%			
HEADWATERS WHITE 1		100%			
HEADWATERS WHITE 2		100%			
INDIAN		100%			
INGALLS 1		100%			
INGALLS 2	2%	98%			
JACK		100%			
LAKE		100%			
LAKE WENATCHEE	14%	61%	1%		
LOWER CHIWAWA 1	26%	74%			
LOWER CHIWAWA 2	1%	94%	5%		
LOWER CHUMSTICK	42%	57%	0%		0%
LOWER ICICLE 1	4%	96%			
LOWER ICICLE 2	47%	52%			
LOWER LITTLE WENATCHEE	2%	98%			
LOWER MISSION	46%	47%	4%	3%	
LOWER NASON	16%	84%	0%		
LOWER PESHASTIN	59%	35%	4%		2%
LOWER WENATCHEE 1	86%	1%	1%	7%	
LOWER WENATCHEE 2	55%	42%	1%	2%	
LOWER WHITE	18%	82%			
MEADOW - BRUSH	1%	99%			
MIDDLE CHIWAWA	7%	93%			
MIDDLE ICICLE	1%	99%			
MIDDLE WENATCHEE 1	78%	20%	1%		
MIDDLE WENATCHEE 2	75%	23%		2%	

NAHAHUM	74%	25%	1%		
NAPEEQUA 1		100%			
NAPEEQUA 2		100%			
NEGRO	19%	81%			
OLALLA	46%	53%			
PANTHER		100%			
RAGING		100%			
RAINY		100%			
ROCK		100%			
SAND	39%	56%			5%
SKINNEY	39%	59%	2%		
TUMWATER CANYON	15%	85%			
U. CHUMST. - LIT. CHUMST.	35%	58%	7%		
UPPER CHIWAWA		100%			
UPPER ICICLE		100%			
UPPER LITTLE WENATCHEE		100%			
UPPER NASON	9%	91%			
UPPER PESHASTIN	36%	64%			
UPPER WENATCHEE 1	27%	73%			
UPPER WENATCHEE 2	21%	71%	3%		
UPPER WHITE		100%			
WHITEPINE		100%			

Terrestrial Ecosystem Assessment

Terrestrial prioritization focused on native, undisturbed portions of the Basin; late-successional and old-growth forests; and rare, threatened, endangered, or special concern species. We prioritized the Wenatchee River Basin by 15 factors related to the ecological integrity or biodiversity of the landscape (Table 9). Together, these factors generally are believed to represent the full range of conditions for healthy, native ecosystems. However, each factor also provides a unique perspective for prioritizing the landscape. PBI 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.

The spatial distribution of each terrestrial factor across the Basin was modeled using a grid surface composed of 30 x 30 m cells. Habitats used by each species were determined from Cassidy et al. (1997), Wisdom et al. (2000), and Johnson and O'Neill (2001). The factors were divided into positive and negative influences (Table 9). Positive influences generally enhance the ecological integrity and/or biodiversity of an area, whereas negative influences detract from ecological integrity and/or biodiversity. The factors were summed to create the overall prioritization for the Wenatchee River Basin.

Table 9. 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	Suggested Influence	Value/ Rank
Ecological Integrity		
Roadless Areas	Positive	0 for roaded areas, 1 to 100 for roadless areas based on size of roadless area
Wetlands	Positive	100 for all wetland types
Road Density	Negative	0 for no roads/km^2 to 100 for highest roads/km^2
Population Density	Negative	0 for lowest population density to 100 for highest population density by census block group.
Change in population	Positive/Negative	
Terrestrial Vertebrates		
Heritage Species Sightings	Positive	0 to 100 based on the number of species observed at or near each cell.
Priority Habitats and Species	Positive	0 to 100 based on the number and type of WDFW priority habitat or species occurring in each cell
Large Carnivore Richness	Positive	0 to 100 based on the number of large carnivore species *predicted* to occur in each cell
Amphibian Richness	Positive	0 to 100 based on the number of amphibian species *predicted* to occur in each cell
Reptile Richness	Positive	0 to 100 based on the number of reptile species *predicted* to occur in each cell
Bat Richness	Positive	0 to 100 based on the number of bat species *predicted* to occur in each cell
Bird Species of Concern	Positive	0 to 100 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 100 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 100 based on the number of invasive, non-native species *predicted* to occur in each cell.
Plants and Vegetation		
Age of Forest	Positive	0 to 100 based on the age of forest in each cell
Size and Proximity of Late-successional and Old-growth Forest Patches	Positive	0 to 100 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 100 based on the rarity of vegetation types in the Greater North Cascades Ecosystem.
Natural Heritage Plants	Positive	0 to 100 based on the number of plant species in the WADNR Heritage Database
Logging Activity	Negative	100 for all areas with previous logging

Terrestrial Landscape Condition Factors

Roadless Areas

Roadless areas, because of their limited human disturbance, have more natural integrity than roaded portions of the landscape. PBI mapped roadless areas in 1998 (Morrison et al. 1998) and again in 2000 for the Wild Washington Campaign. We used road data from each USFS National Forest, Washington DNR Transportation Database, and other sources (e.g., roads digitized by PBI from aerial photography and satellite imagery). An area was considered roadless if it was >10 m from a road, >200 m wide, and >1,000 acres. Roadless areas were ranked from 1 to 5 based on their size and roaded areas were given a value of 0 (Figure 24).

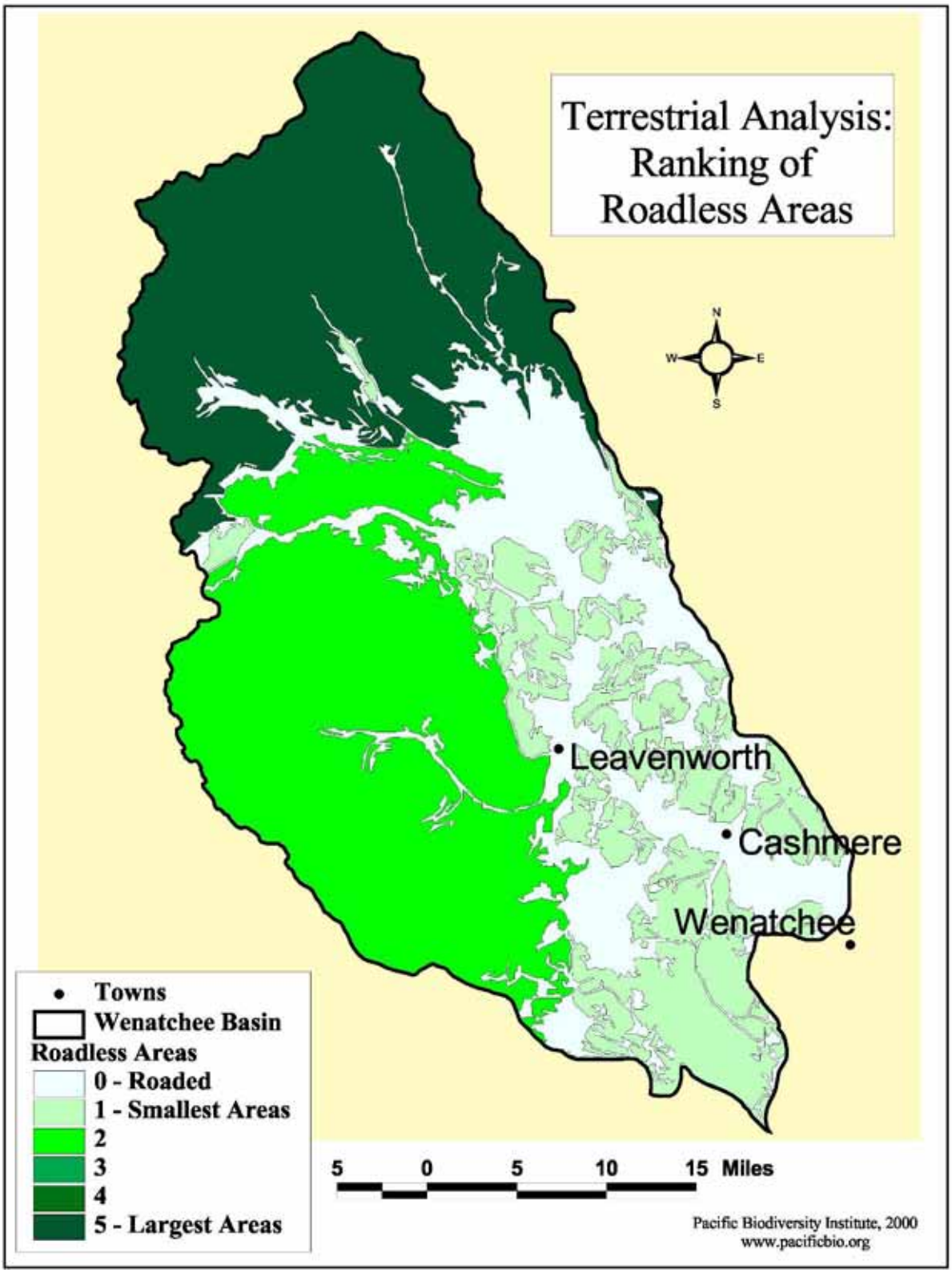


Figure 24. Roadless areas, by size, in the Wenatchee River Basin. Roadless areas were prioritized based on their size: large roadless areas (dark green) receiving higher priority than small ones (light green). This was used as a positive factor in the terrestrial analysis.

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 25).

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 26).

Population Density

Population density was used as an indicator of development pressure. We used population estimates from the year 2000 U.S. Census. We adjusted density (people/km^2) by the amount of private land in each census block (i.e., we assumed that people do not live on public lands). Density was scaled from 0 (lowest density) to 100 (highest) (Figure 27). We also mapped change in population density between 1990 and 2000, scaled from –100 (greatest decline) to zero (no change) to +100 (greatest increase) (Figure 28).

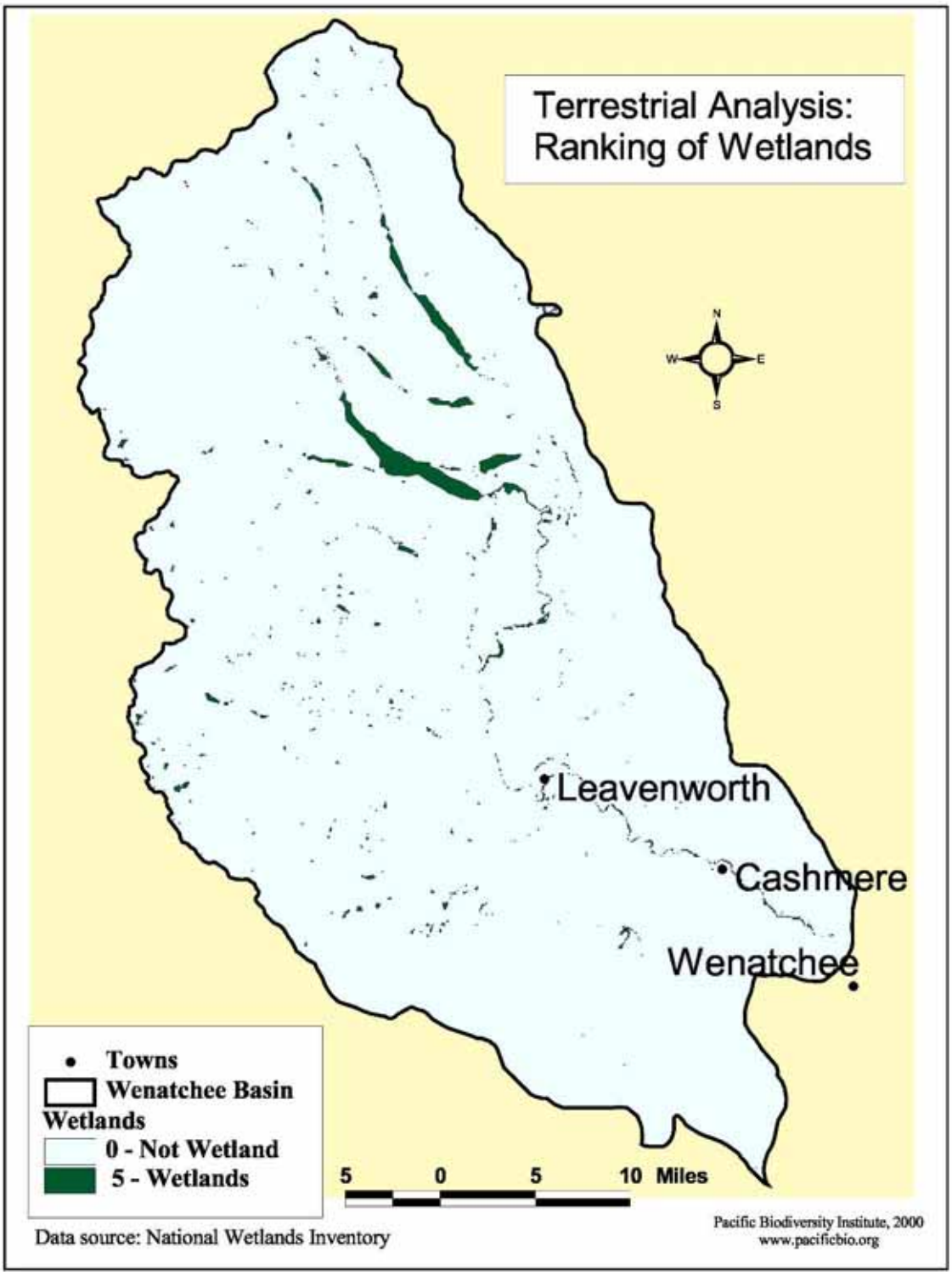


Figure 25. Wetlands rankings used in the terrestrial prioritization of the Wenatchee River Basin.
Because of their importance to terrestrial ecosystems, a rank of 5 was given to any natural wetland (dark green). This was used as a positive factor in the terrestrial analysis.

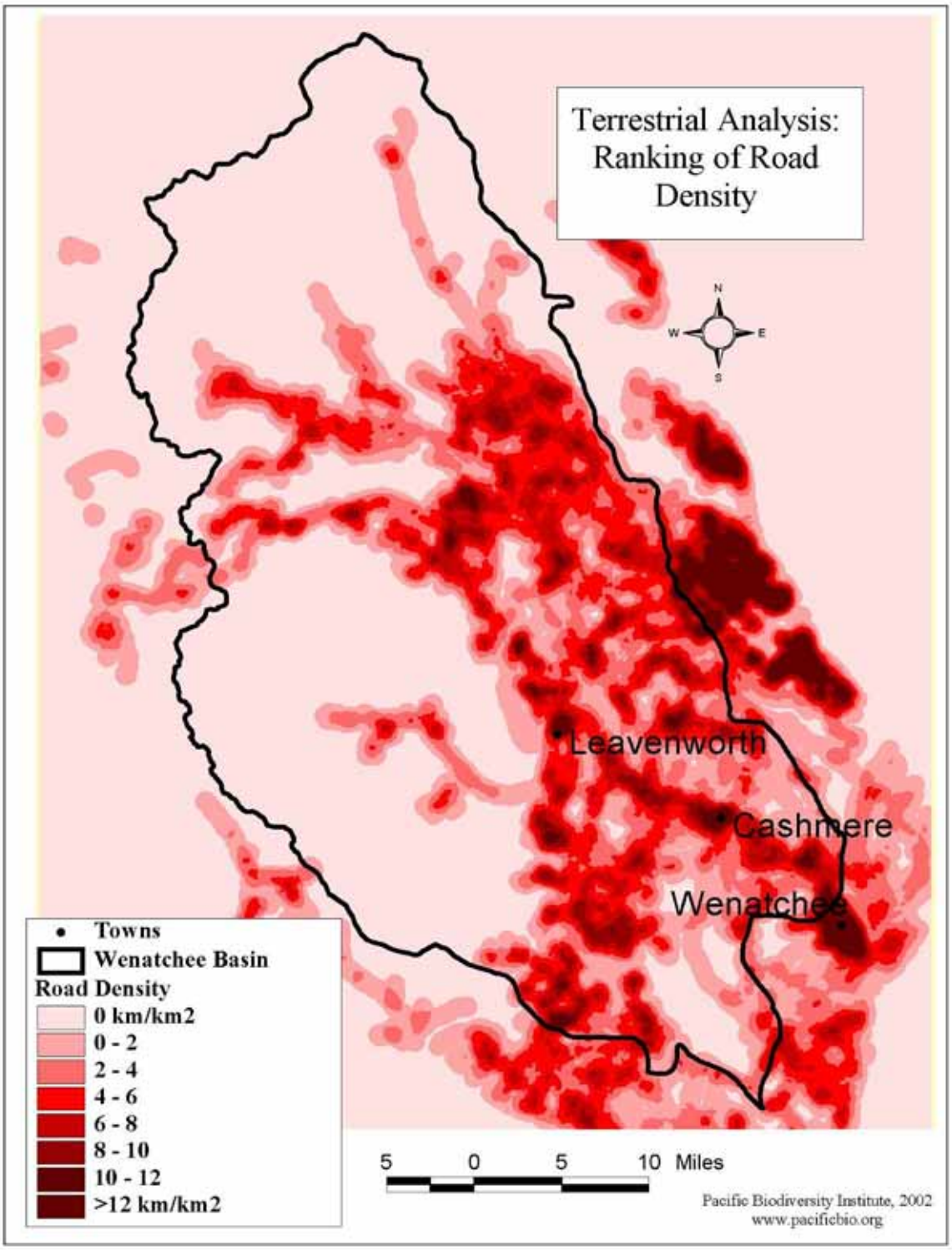


Figure 26. Road density rankings used in the terrestrial prioritization of the Wenatchee River Basin.
High values (dark red) indicate areas with high density of roads per km^2, detracting from terrestrial priority. This was used as a negative factor in the terrestrial analysis.

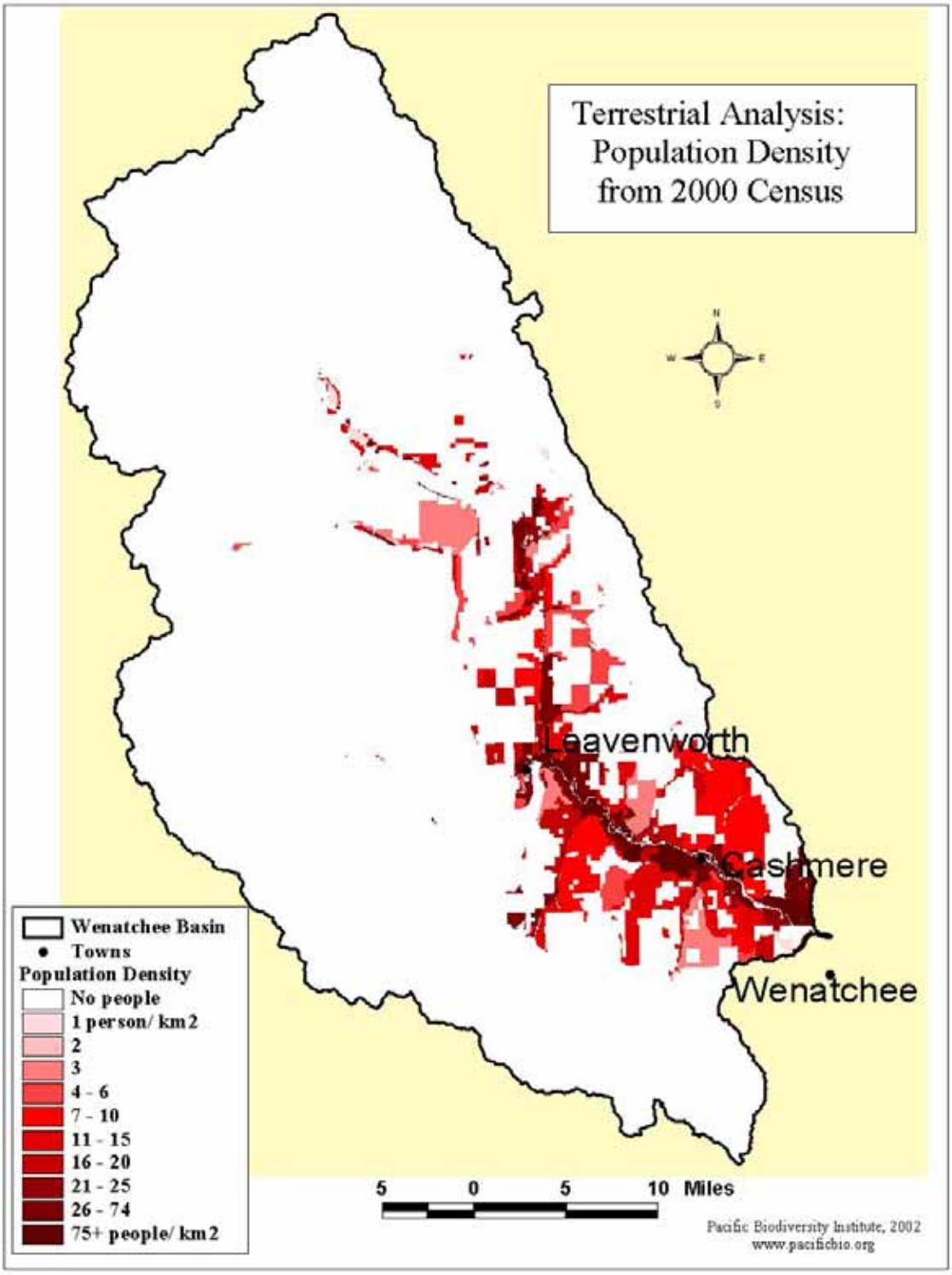


Figure 27. Population density rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark red) indicate areas with high human population density, detracting from terrestrial priority. This was used as a negative factor in the terrestrial analysis.

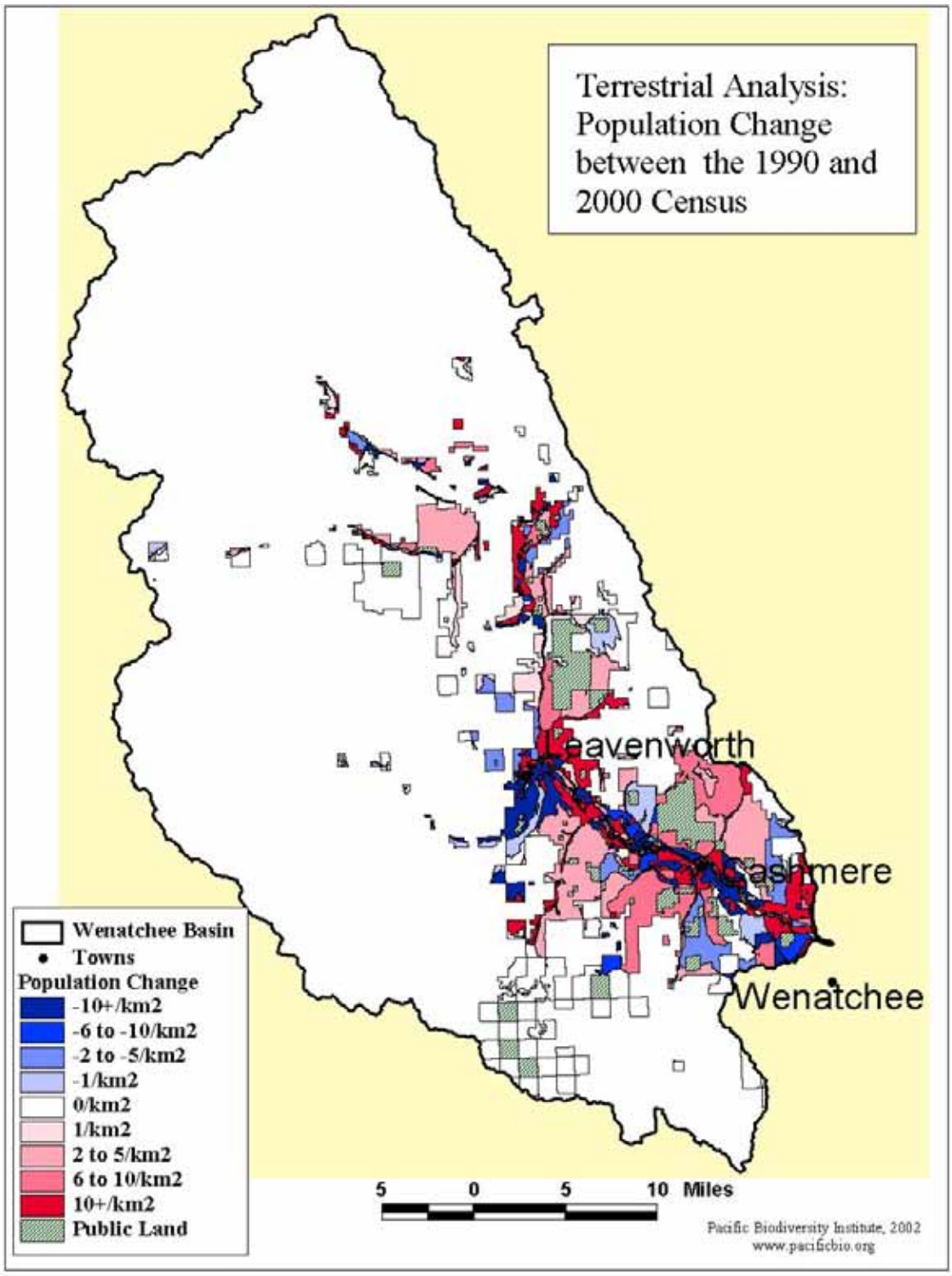


Figure 28. Population change from 1990 to 2000 used in the terrestrial prioritization of the Wenatchee River Basin.
Blue colors represent reduction in population and red colors represent increase in population. White indicates no population change, or areas where no people live.

Heritage Species Sightings

Known habitat locations for threatened, endangered, rare, or species of special concern deserve special attention and protection. The Washington Department of Fish and Wildlife (WDFW) and Washington Department of Natural Resources (DNR) maintain databases of sightings for imperiled species and species of conservation concern. Although not exhaustive, these databases contain important information on rare species. PBI obtained the most recent (2002) version of the Heritage databases, which contain 33 species that have been recorded since 1978 (Table 10). This list includes 2 amphibians, 2 reptiles, 20 birds, and 9 mammals. A few species (Vaux's swift, loggerhead shrike, western bluebird, moose, lynx, sharp-tailed snake, nightsnake) had too few observations in the Wenatchee River Basin for analysis.

We used the distribution of sightings for each species to generate a map showing the probability of observing the species in a given area. The sightings and probability maps were generated for the entire state of Washington. Within the Wenatchee River Basin, we then modified these maps based on the location of suitable habitat for each species. That is, we set the probability of observing a species to zero in habitats that were not suitable for it. Finally, we took the average probability of observing a species (adjusted for the location of suitable habitat) across all Heritage species (Figure 29). The interpretation of this map is: if you take a Heritage species at random, what would be the chances of observing it in a given area considering where it has been observed before and where suitable habitat exists for it in the Wenatchee River Basin? We created a second map that simply shows the number of Heritage species for which a given habitat would be suitable (Figure 30).

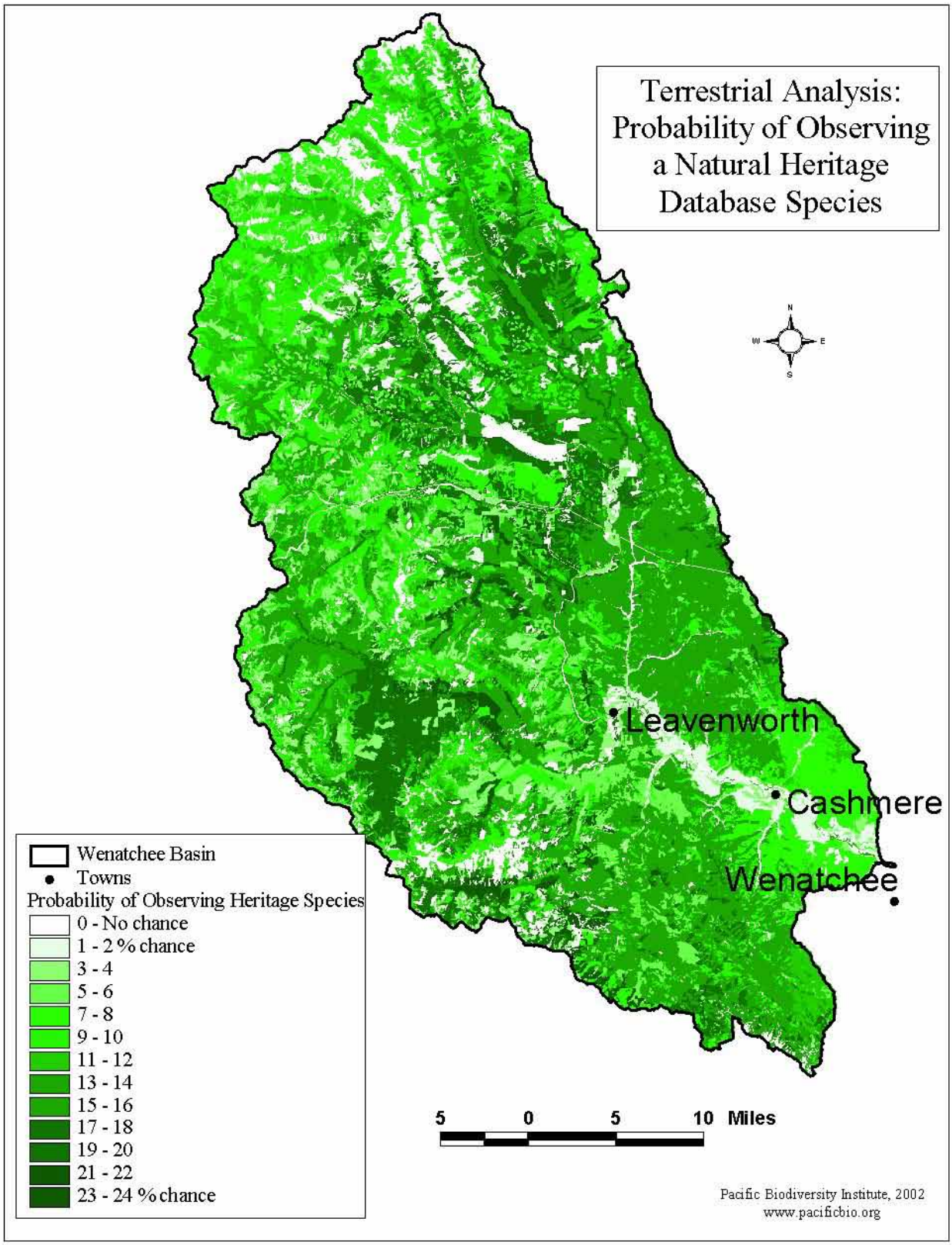


Figure 29. Probability of observing WDFW Heritage species in the Wenatchee River Basin.

High values (dark green) indicate areas where there a greater likelihood of observing threatened, endangered, or special concern species, adding to terrestrial priority. Probabilities based on sightings and habitat data.

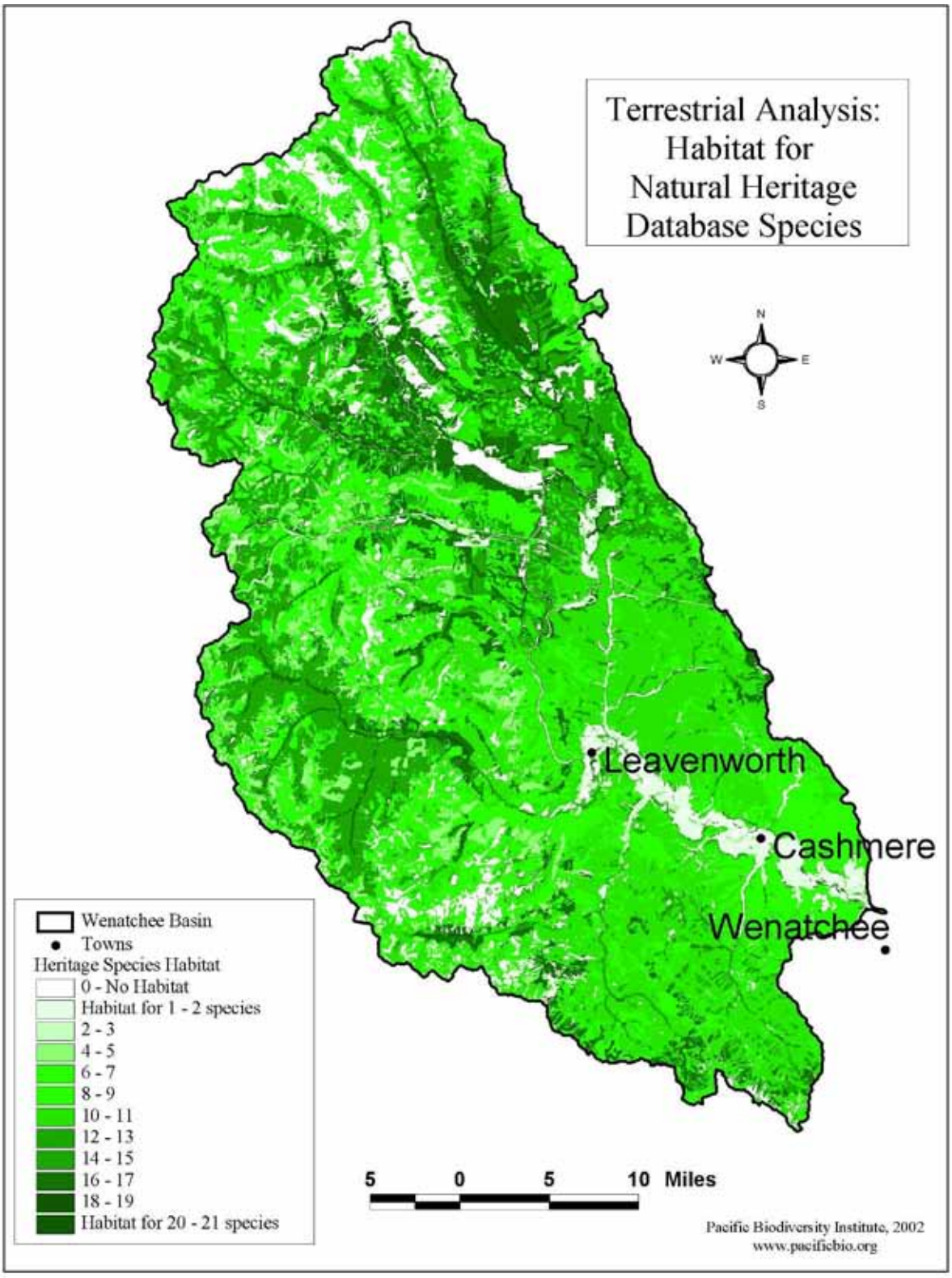


Figure 30. Habitats for WDFW Heritage species for the terrestrial prioritization of the Wenatchee River Basin.
High values (dark green) indicate areas where there is more habitat for threatened, endangered, or special concern species, adding to terrestrial priority. This can be used as a positive factor in the terrestrial analysis.

Table 10. Species recorded in the WDFW Heritage Database in 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[2]	*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[2]	*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[2]	*Salia mexicana*	3	1
Great gray Owl	*Strix nebulosa*	2	10
Northern Spotted Owl[1]	*Strix occidentalis*		10
Mammals			
Moose[2]	*Alces alces*	1	5
Gray Wolf	*Canis lupus*	15	10
Wolverine	*Gulo gulo*	6	10
Lynx[2]	*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[2]	*Contine tenuis*	1	1
Nightsnake[2]	*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.

[2.] Not enough sightings to estimate a probability distribution in the Wenatchee River Basin.

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. The PHS database tracks 15 species or species group priority habitats in the Wenatchee River Basin (Tables 11, 12).

Table 11. 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 12. 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

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*). Alternatively, one habitat could be a priority habitat for multiple species. For example, as breeding habitat for one species and habitat where large concentrations of individuals are found for another species. We added together the total number of priority habitat or species that overlapped in each area and mapped them across the Wenatchee River Basin (Figure 31).

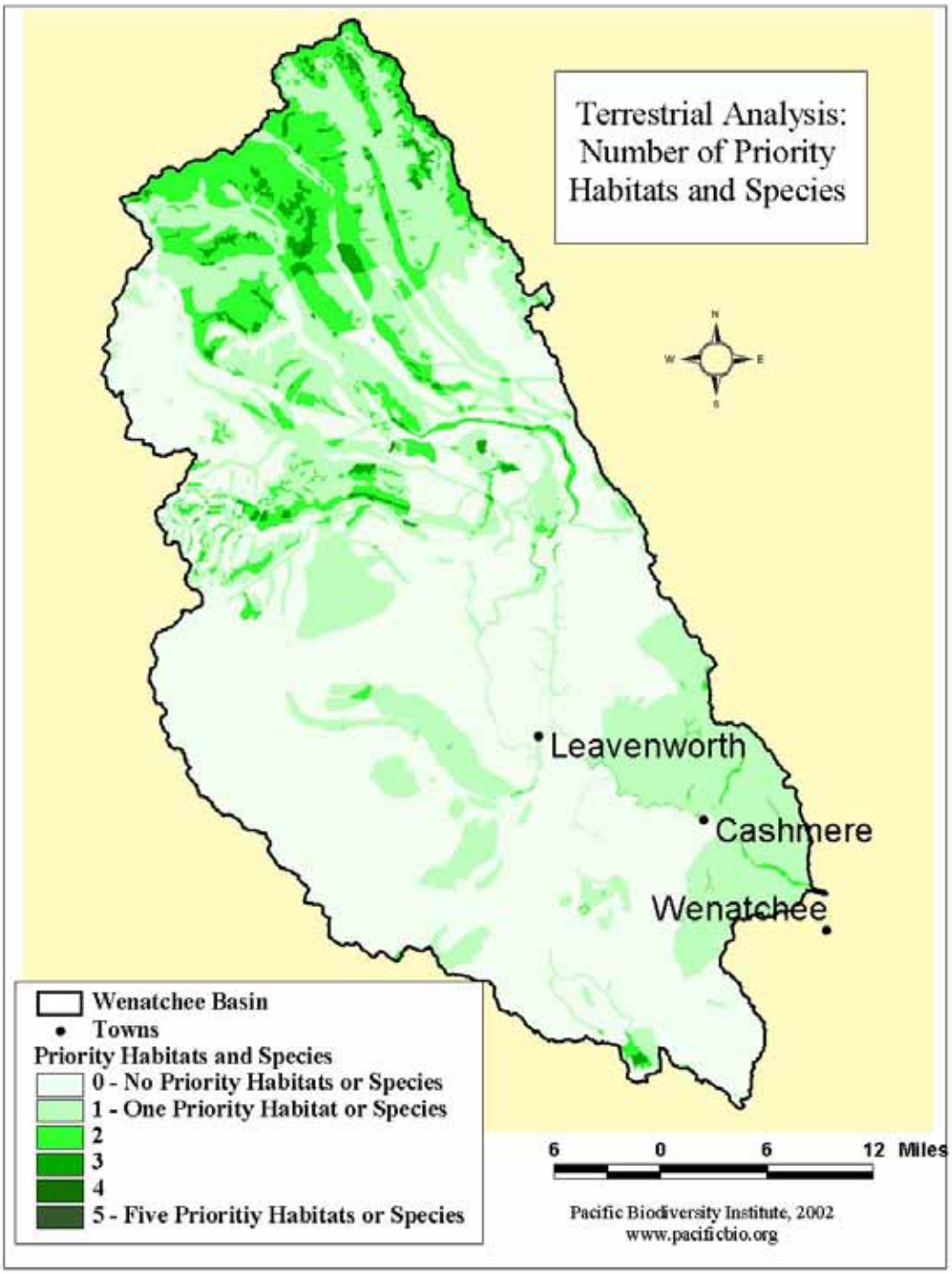


Figure 31. Ranking of habitats for the Washington Department of Fish and Wildlife's Priority Species and Habitats used in the terrestrial prioritization of the Wenatchee River Basin.

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.

Large Carnivores

Large carnivores may be used as an indicator of intact, functional, native ecosystems because they range over large areas, are high-level trophic species, and are sensitive to human disturbance (Estes 1996). Therefore, they are a valuable way to prioritize the conservation value of a landscape. We assessed the number of large carnivores (Table 13) for which each area (i.e., 30-m grid cell) in the Basin provided suitable habitat (Figure 32).

Table 13. Large carnivore species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name	Species of Concern
Black bear	*Ursus americanus*	*N*
Grizzly bear	*Ursus arctos*	*Y*
Mountain lion	*Puma Con*	*N*
Coyote	*Canis lat*	*N*
Gray wolf	*Canis lupus*	*Y*
Wolverine	*Gulo gulo*	*Y*

Medium and Small Carnivores

Mid-sized and small carnivores also are indicators of an intact ecosystem. We assessed the number of medium and small carnivores (Table 14) for which each area (i.e., 30-m grid cell) in the Basin provided suitable habitat (Figure 33).

Table 14. Medium and small carnivore species included in the Wenatchee River Basin terrestrial prioritization

Common Name	Scientific Name	Species of Concern
Marten	*Martes americana*	*Y*
Fisher	*Martes pennati*	*Y*
Mink	*Mustella vison*	*N*
River otter	*Lutra Canadensis*	*Y*
Lynx	*Lynx canadensis*	*Y*
Bobcat	*Lynx rufus*	*N*
Ermine (short-tail weasel)	*Mus erm*	*N*
Longtail weasel	*Mus fre*	*N*
Racoon	*Pro lot*	*N*
Western spotted skunk	*Spi gra*	*N*
Badger	*Tax tax*	*N*
Red Fox	*Vul vul*	*N*

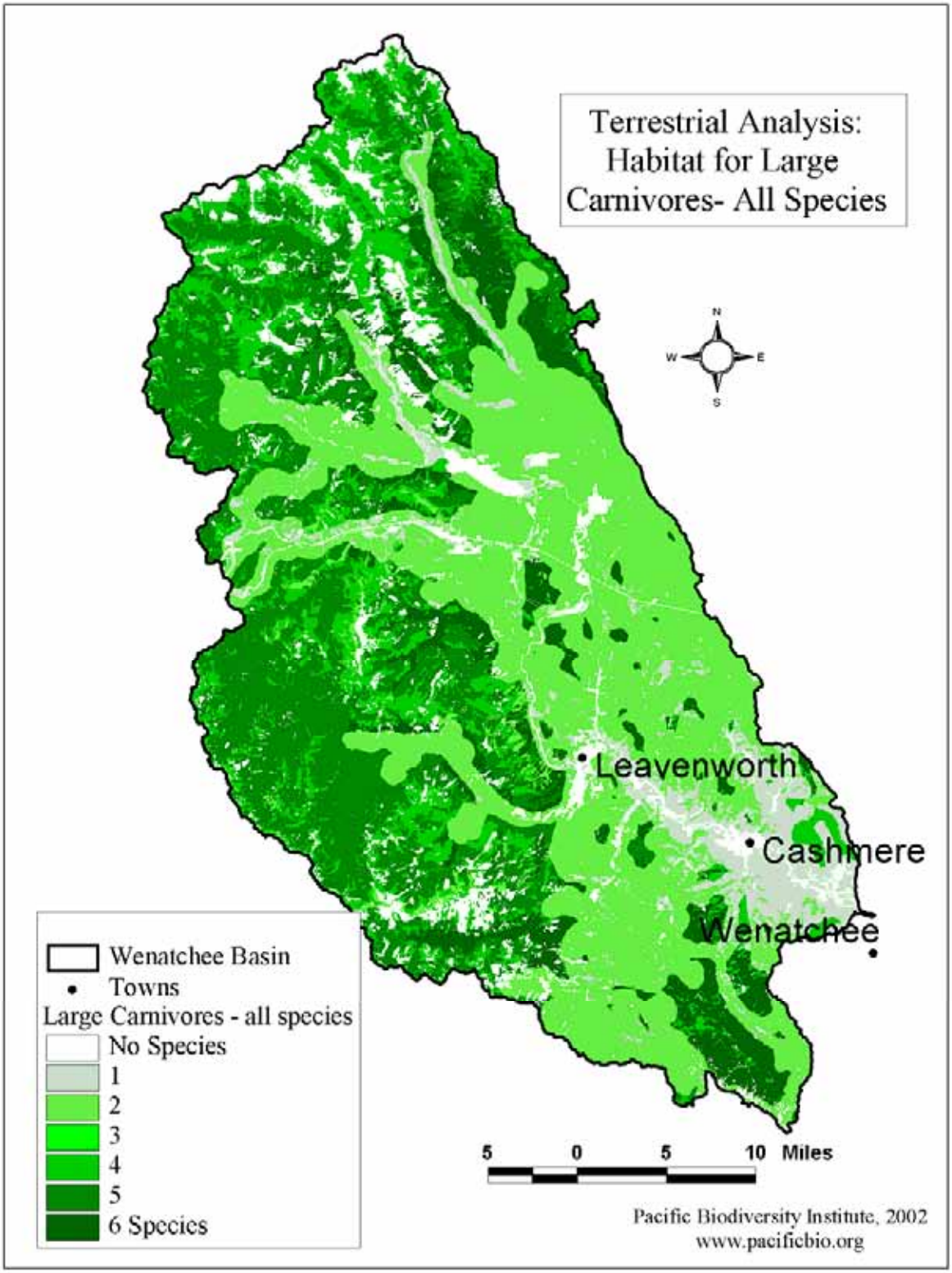


Figure 32. Large carnivore habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin.
High values (dark green) indicate habitat for many large carnivore species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

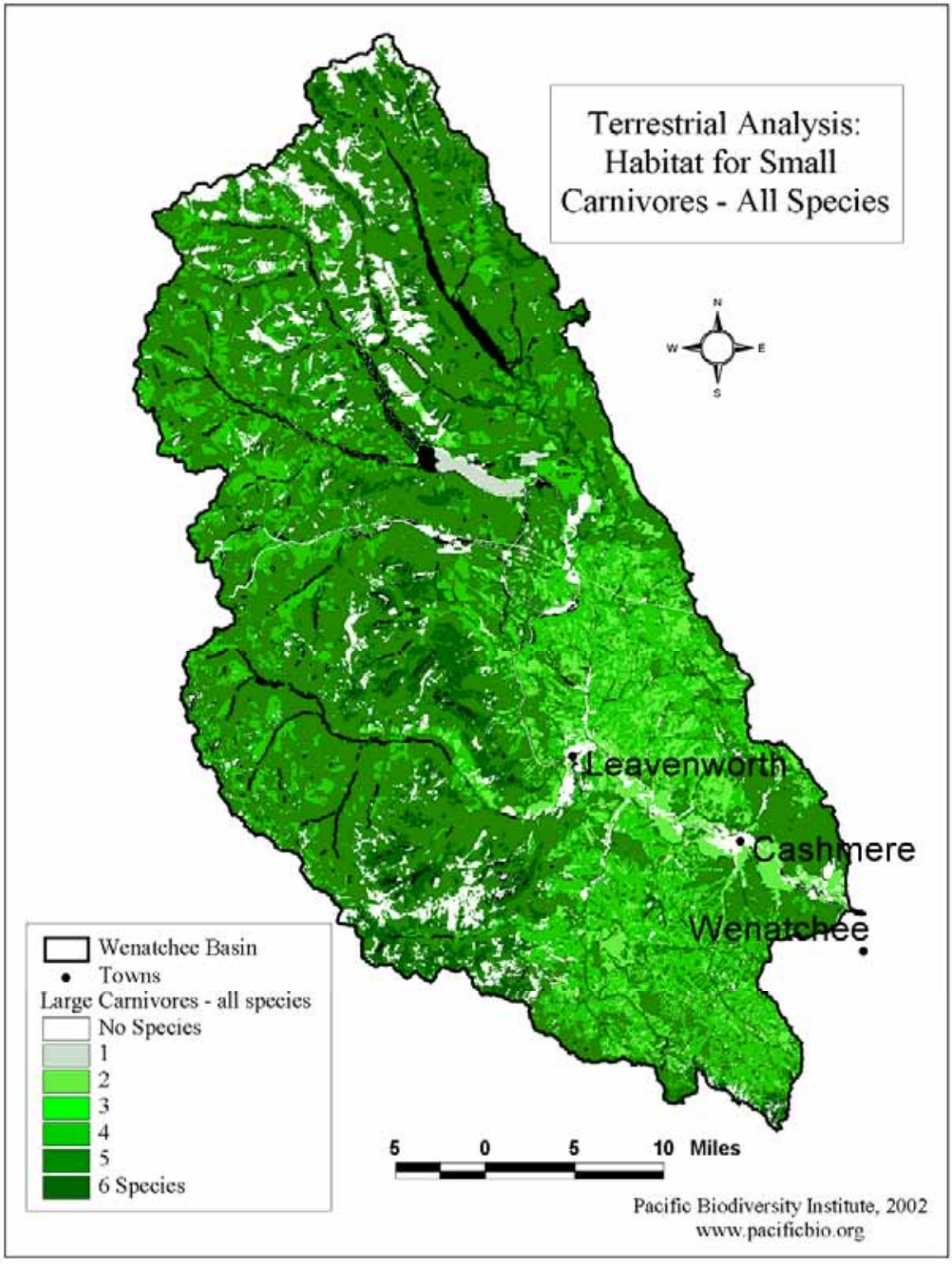


Figure 33. Small carnivore habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin.
High values (dark green) indicate habitat for many small carnivore species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

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 15), we relied on the predicted habitat models for these species from the wildlife-habitat relationship model. Each species habitat model was clipped out for the Basin and converted to a grid surface with 30m 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 100 (Figure 34). Areas with no predicted amphibian habitat for any species were coded as 0. This process was repeated for the amphibian species of concern.

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

Common Name	Scientific Name	Species of Concern
Long-toed salamander	*Ambystoma macrodactyla*	*Y*
Pacific giant salamander	*Dicamptondon tenebrosus*	*Y*
Northwest salamander	*Amb gra*	*Y*
Roughskin newt	*Taricha granulose*	*Y*
Western toad	*Bufo bufus*	*Y*
Pacific treefrog	*Hyla regalia*	*N*
Cascades frog	*Rana cascadae*	*Y*
Columbia spotted frog	*Rana luteiventris*	*Y*
Tailed frog	*Ascaphus trueii*	*Y*

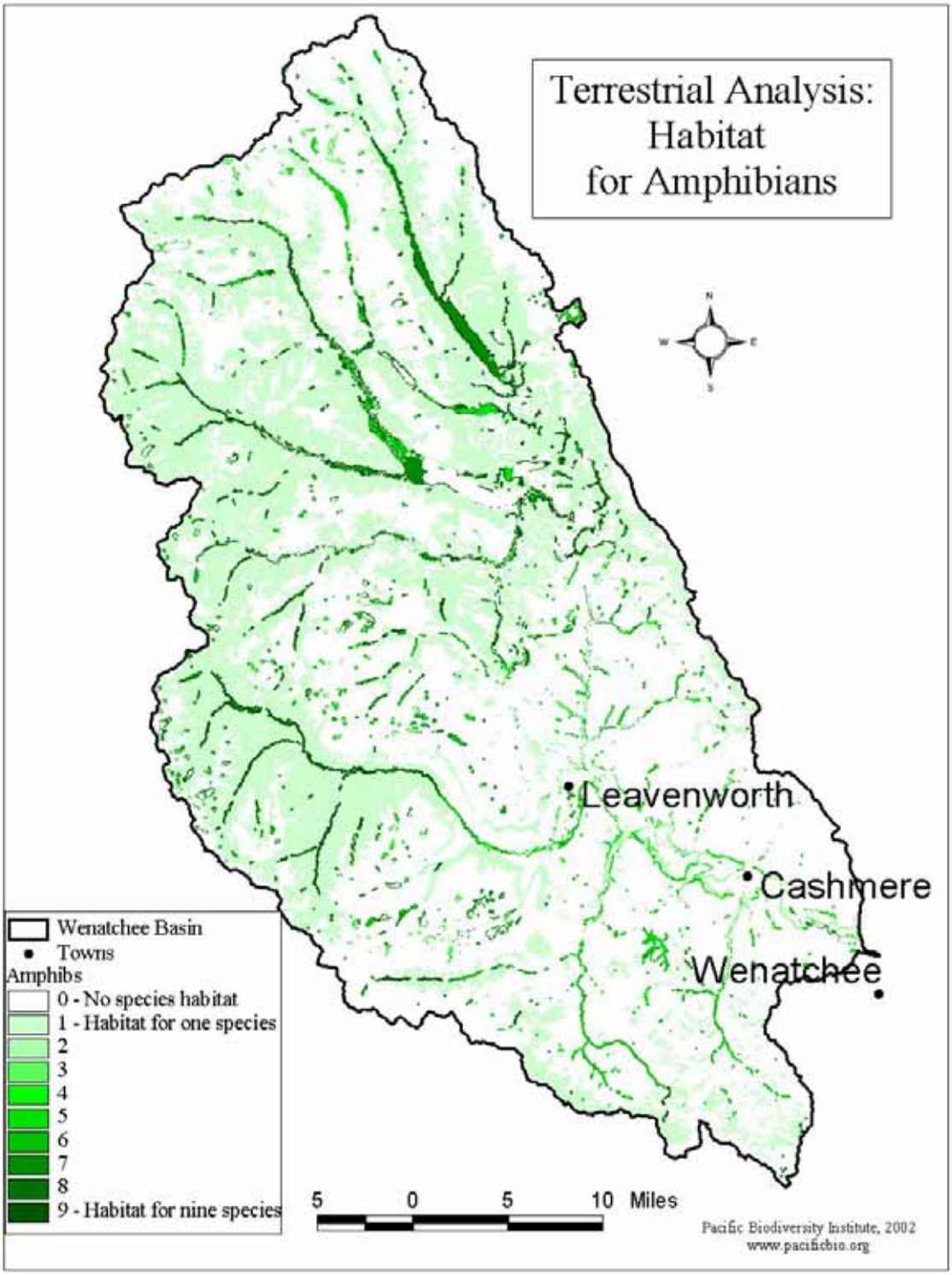


Figure 34. Amphibian habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin.
High values (dark green) indicate habitat for many amphibian species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

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 reptiles (Table 16), we relied on the predicted habitat models for these species from the wildlife-habitat relationship model.

Table 16. Reptile species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name	Species of Concern
Northern alligator lizard	*Elgaria coeurulea*	*N*
Western fence lizard	*Sceloporus occidentalis*	*N*
Western skink	*Eumeces skiltonianus*	*N*
Rubber boa	*Charina bottae*	*N*
Racer	*Coluber constrictor*	*N*
Gopher snake	*Pituophis catenifer*	*N*
Western terrestrial garter snake	*Thamnophis elegans*	*N*
Common garter snake	*Thamnophis sirtalis*	*N*
Nightsnake	*Hypsiglena torquata*	*Y*
Sharp-tail snake	*Contia tenuis*	*Y*
Western rattlesnake	*Crotalus viridis*	*N*

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 100 (Figure 35). Areas with no predicted reptile habitat for any species were coded as 0. This process was repeated for the reptile species of concern.

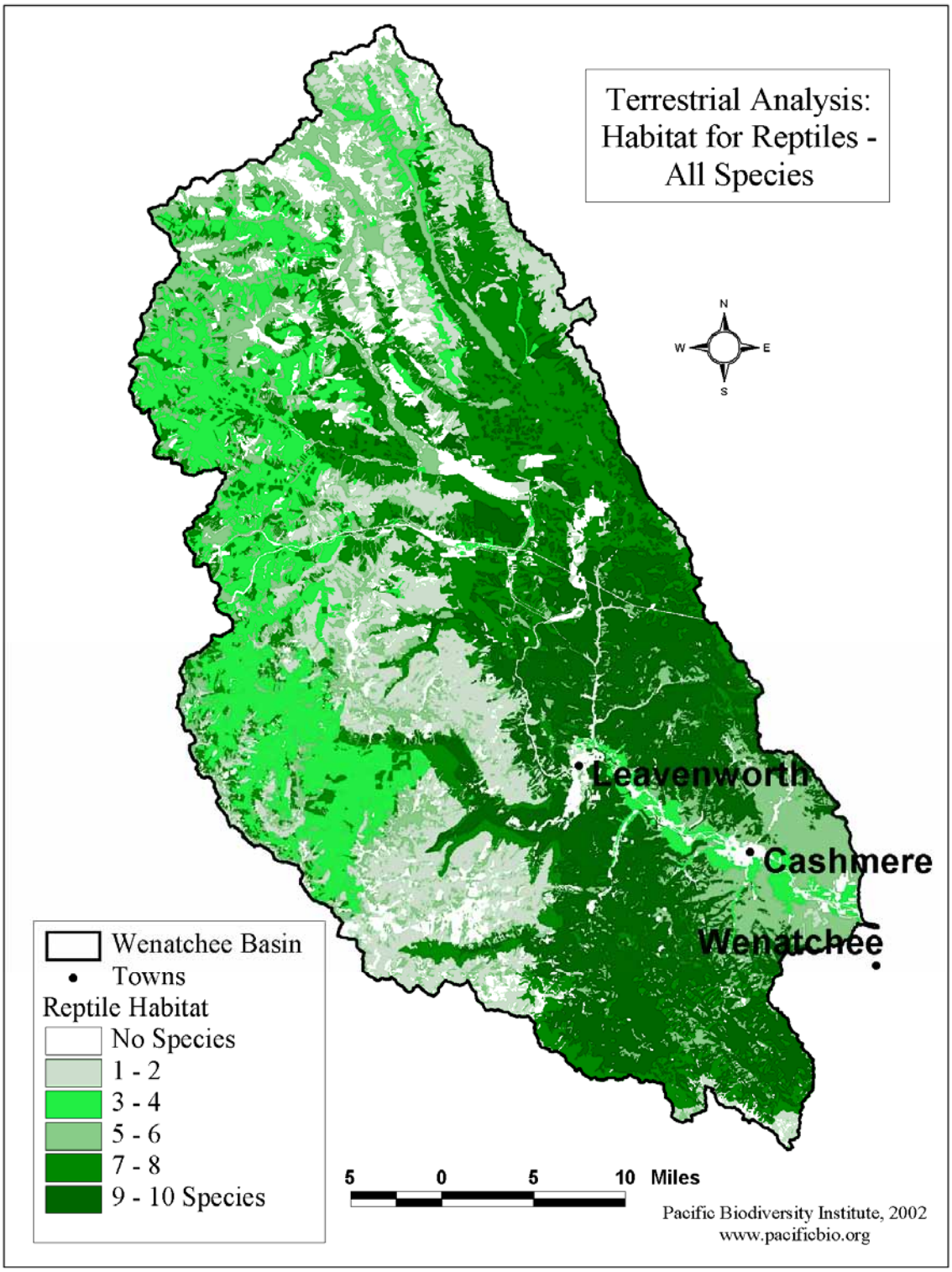


Figure 32: Reptile habitat used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate habitat for many amphibian species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

Bird Species

We divided bird species into species groups: gallinaceous (chicken-like), herons, passerines (songbird), nonpasserines, raptors, shorebirds and waterfowl. To assess the areas where vegetation is suitable in the Wenatchee River Basin for the different groups of birds, we relied on the predicted habitat models for these species from the wildlife-habitat relationship model. Lists of bird species of concern comes 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. 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 17 . Gallinaceous bird species in the Wenatchee River Basin.

Common Name	Scientific Name/Code	Species of Concern
BLUE GROUSE	*Dendragapus obscurus*	*Y*
CALIFORNIA QUAIL	*Cal cal*	*N*
CHUKAR	*Ale chu*	*N*
GRAY PARTRIDGE	*Per per*	*N*
MOUNTAIN QUAIL	*Oreortyx pictus*	*Y*
NORTHERN BOBWHITE	*Col vir*	*N*
RING-NECKED PHEASENT	*Pha col*	*N*
RUFFED GROUSE	*Bon umb*	*N*
SAGE GROUSE	*Sen uro*	*N*
SHARP-TAILED GROUSE	*TYMPHA*	*N*
SPRUCE GROUSE	*DENCAN*	*N*
WHITE-TAILED PTARMIGAN	*LAGLEU*	*N*
WILD TURKEY	*MELGAL*	*N*

Table 18. Heron species in the Wenatchee River Basin.

Common Name	Scientific Name	Species of Concern
AMERICAN BITTERN	BOTLEN	*N*
BLACK-CROWNED NIGHT HERON	NYCNYC	*N*
GREAT BLUE HERON	ARDHER	*N*
GREAT EGRET	ARDALB	*N*

Table 19. Passerine species in the Wenatchee River Basin.

Common Name	Scientific Name	Species of Concern
AMERICAN CROW	CORBRA	N
AMERICAN DIPPER	CINMEX	N
AMERICAN GOLDFINCH	CARTRI	N
AMERICAN PIPIT	ANTRUB	N
AMERICAN REDSTART	SETRUT	N
AMERICAN ROBIN	TURMIG	N
ASH-THROATED FLYCATCHER	MYICIN	N
BANK SWALLOW	RIPRIP	N
BARN SWALLOW	HIRRUS	N
BEWICK'S WREN	THRBEW	N
BLACK SWIFT	CYPNIG	Y
BLACK-BILLED MAGPIE	PICPIC	N
BLACK-CAPPED CHICKADEE	PARATR	N
BLACK-HEADED GROSBEAK	PHEMEL	N

BLACK-THROATED GRAY WARBLER	DENNIG	Y
BOBOLINK	DOLORY	N
BOHEMIAN WAXWING	BOMGAR	N
BREWER'S BLACKBIRD	EUPCYA	N
BREWER'S SPARROW	SPIBRE	N
BROWN CREEPER	CERAME	N
BUSHTIT	PSAMIN	N
CANYON WREN	CATMEX	N
CASSIN'S FINCH	CARCAS	N
CEDAR WAXWING	BOMCED	N
CHESTNUT-BACKED CHICKADEE	PARRUF	N
CHIPPING SPARROW	SPIPAS	N
CLARK'S NUTCRACKER	NUCCOL	N
CLIFF SWALLOW	HIRPYR	N
COMMON RAVEN	CORCOR	N
COMMON YELLOWTHROAT	GEOTRI	N
DARK-EYED JUNCO	JUNHYE	N
DUSKY FLYCATCHER	EMPOBE	Y
EASTERN KINGBIRD	TYRTYR	N
EVENING GROSBEAK	COCVES	N
FOX SPARROW	PASILI	N
GOLDEN-CROWNED KINGLET	REGSAT	N
GOLDEN-CROWNED SPARROW	ZONATR	N
GRASSHOPPER SPARROW	AMMSAV	N
GRAY CATBIRD	DUMCAR	N
GRAY FLYCATCHER	EMPWRI	N
GRAY JAY	PERCAN	N
HAMMOND'S FLYCATCHER	EMPHAM	N
HERMIT THRUSH	CATGUT	N
HERMIT WARBLER	DENOCC	N
HORNED LARK	EREALP	N
HOUSE FINCH	CARMEX	N
HOUSE WREN	TROAED	N
LARK SPARROW	CHOGRA	N
LAZULI BUNTING	PASAMO	N
LEAST FLYCATCHER	EMPMIN	N
LINCOLN'S SPARROW	MELLIN	N
LOGGERHEAD SHRIKE	LANLUD	Y
MACGILLIVRAY'S WARBLER	OPOTOL	N
MARSH WREN	CISPAL	N
MOUNTAIN BLUEBIRD	SIACUR	N
MOUNTAIN CHICKADEE	PARGAM	N
NASHVILLE WARBLER	VERRUF	N
NORTHERN MOCKINGBIRD	MIMPOL	N
NORTHERN ORIOLE (BULLOCK'S)	ICTBUL	N
NORTHERN ROUGH-WINGED SWALLOW	STESER	N
NORTHERN WATERTHRUSH	SEINOV	N
OLIVE-SIDED FLYCATCHER	CONBOR	Y
ORANGE-CROWNED WARBLER	VERCEL	N
PINE GROSBEAK	PINENU	N
PINE SISKEN	CARPIN	N
PURPLE FINCH	CARPUR	N
PYGMY NUTHATCH	SITPYG	N

RED CROSSBILL	LOXCUR	N
RED-BREASTED NUTHATCH	SITCAN	N
RED-EYED VIREO	VIROLI	N
RED-WINGED BLACKBIRD	AGEPHO	N
ROCK WREN	SALOBS	N
ROSY FINCH	LEUTEP	N
RUBY-CROWNED KINGLET	REGCAL	N
SAGE SPARROW	AMPBEL	Y
SAGE THRASHER	OREMON	Y
SAVANNAH SPARROW	PASSAN	N
SAY'S PHOEBE	SAYSAY	N
SCRUB JAY	APHCAL	N
SOLITARY VIREO	VIRSOL	N
SONG SPARROW	MELMEL	N
SPOTTED TOWHEE	PIPMAC	N
STELLAR'S JAY	CYASTE	N
SWAINSON'S THRUSH	CATUST	N
TOWNDSEND'S SOLITAIRE	MYATOW	N
TOWNSEND'S WARBLER	DENTOW	N
TREE SWALLOW	TACBIC	N
VARIED THRUSH	IXONAE	N
VAUX'S SWIFT	CHAVAU	Y
VEERY	CATFUS	N
VESPER SPARROW	POOGRA	N
VIOLET-GREEN SWALLOW	TACTHA	N
WARBLING VIREO	VIRGIL	N
WESTERN BLUEBIRD	SIAMEX	N
WESTERN FLYCATCHER	EMPOCC	N
WESTERN KINGBIRD	TYRVER	N
WESTERN MEADOWLARK	STUNEG	N
WESTERN TANAGER	PIRLUD	N
WESTERN WOOD-PEWEE	CONSOR	N
WHITE-BREASTED NUTHATCH	SITCAR	N
WHITE-CROWNED SPARROW	ZONLEU	N
WHITE-WINGED CROSSBILL	LOXLEU	N
WILLOW FLYCATCHER	EMPTRA	Y
WILSON'S WARBLER	WILPUS	N
WINTER WREN	TROTRO	N
YELLOW WARBLER	DENPET	N
YELLOW-BREASTED CHAT	ICTVIR	N
YELLOW-HEADED BLACKBIRD	XANXAN	N
YELLOW-RUMPED WARBLER	DENCOR	N

Table 20. Nonpasserine bird species in the Wenatchee River Basin

Common Name	Species Code	Species of Conern
AMERICAN WHITE PELICAN	PELERY	N
ANNA'S HUMMINGBIRD	CALANN	N
BAND-TAILED PIGEON	COLFAS	N
BELTED KINGFISHER	CERALC	N
BLACK-BACKED WOODPECKER	PICARC	Y
BLACK-CHINNED HUMMINGBIRD	ARCALE	N

CALLIOPE HUMMINGBIRD	STECAL	Y
COMMON NIGHTHAWK	CHOMIN	N
COMMON POORWILL	PHANUT	N
DOUBLE-CRESTED CORMORANT	PHAAUR	N
DOWNY WOODPECKER	PICPUB	N
HAIRY WOODPECKER	PICVIL	N
LEWIS'S WOODPECKER	MELLEW	Y
MOURNING DOVE	ZENMAC	N
NORTHERN FLICKER	COLAUR	N
PILEATED WOODPECKER	DRYPIL	N
RED-BREASTED SAPSUCKER	SPHRUB	N
ROCK DOVE	COLLIV	N
RUFOUS HUMMINGBIRD	SELRUF	Y
SANDHILL CRANE	GRUCAN	Y
SORA	PORCAR	N
THREE-TOED WOODPECKER	PICTRI	N
VIRGINIA RAIL	RALLIM	N
WHITE-HEADED WOODPECKER	PICALB	Y
WHITE-THROATED SWIFT	AERSAX	N
WILLIAMSON'S SAPSUCKER	SPHTHY	Y
YELLOW-BILLED CUCKOO	COCAME	N

Table 21: Raptor species in the Wenachee River Basin

Common Name	Scientific Name	Species of Concern
BALD EAGLE	HALLEU	Y
BARN OWL	TYTALB	N
BARRED OWL	STRVAR	N
BOREAL OWL	AEGFUN	N
BURROWING OWL	SPECUN	N
COOPER'S HAWK	ACCCOO	N
FERRUGINOUS HAWK	BUTREG	N
FLAMMULATED OWL	OTUFLA	Y
GOLDEN EAGLE	*Aquila chrysaetos*	Y
GREAT GRAY OWL	STRNEB	N
GREAT HORNED OWL	BUBVIR	N
LONG-EARED OWL	ASIOTU	N
MERLIN	FALCOL	N
NORTHERN GOSHAWK	*Accipiter gentiles*	Y
NORTHERN HARRIER	CIRCYA	N
NORTHERN PYGMY-OWL	GLAGNO	N
NORTHERN SAW-WHET OWL	AEGACA	N
NORTHERN SPOTTED OWL	*Strix occidentalis occidentalis*	Y
OSPREY	PANHAL	N
PEREGRINE FALCON	*Falco peregrinus*	Y
PRAIRIE FALCON	FALMEX	N
RED-TAILED HAWK	BUTJAM	N
SHARP-SHINNED HAWK	ACCSTR	N
SHORT-EARED OWL	ASIFLA	N
SWAINSON'S HAWK	BUTSWA	N
TURKEY VULTURE	CATAUR	N
WESTERN SCREECH-OWL	OTUKEN	N

Table 22: Shorebird species in the Wenatchee River Basin

Common Name	Scientific Code	Species of Concern
American Avocet	*Recurvirostra americana*	Y
BLACK TERN	CHLNIG	N
BLACK-NECKED STILT	HIMMEX	N
CALIFORNIA GULL	LARCAL	N
CASPIAN TERN	STECAS	N
COMMON SNIPE	GALGAL	N
FORSTER'S TERN	*Sterna forsteri*	Y
GLAUCOUS-WINGED GULL	LARGLA	N
KILLDEER	CHAVOC	N
LONG-BILLED CURLEW	*Numenius americanus*	Y
RING-BILLED GULL	LARDEL	N
SEMI-PALMATED PLOVER	CHASEM	N
SPOTTED SANDPIPER	ACTMAC	N
UPLAND SANDPIPER	*Bartramia longicauda*	Y
WILSON'S PHALAROPE	*Phalaropus tricolor*	Y

Table 23: Waterfowl species in the Wenatchee River Basin

Common Name	Species Code	Species of Ccncern
AMERICAN COOT	FULAME	N
AMERICAN WIGEON	ANAAME	N
BARROW'S GOLDENEYE	*Bucephala islandica*	Y
BLUE-WINGED TEAL	ANADIS	N
BUFFLEHEAD	BUCALB	N
CANADA GOOSE	BRACAN	N
CANVASBACK	AYTVAL	N
CINNAMON TEAL	ANACYA	N
COMMON GOLDENEYE	BUCCLA	N
COMMON LOON	*Gavia immer*	Y
COMMON MERGANSER	MERMER	N
EARED GREBE	PODNIG	N
GADWALL	ANASTR	N
GREEN-WINGED TEAL	ANACRE	N
HARLEQUIN DUCK	*Histrionicus histrionicus*	Y
HOODED MERGANSER	LOPCUC	N
HORNED GREBE	PODAUR	N
LESSER SCAUP	AYTAFF	N
MALLARD	ANAPLA	N
NORTHERN PINTAIL	ANAACU	N
NORTHERN SHOVELER	ANACLY	N
PIED-BILLED GREBE	PODPOD	N
REDHEAD	AYTAME	N
RED-NECKED GREBE	PODGRI	N
RING-NECKED DUCK	AYTCOL	N
RUDDY DUCK	OXYJAM	N
TRUMPETER SWAN	CYGBUC	N
WESTERN GREBE	*Aechmophorus occidentalis*	Y
WOOD DUCK	AIXSPO	N

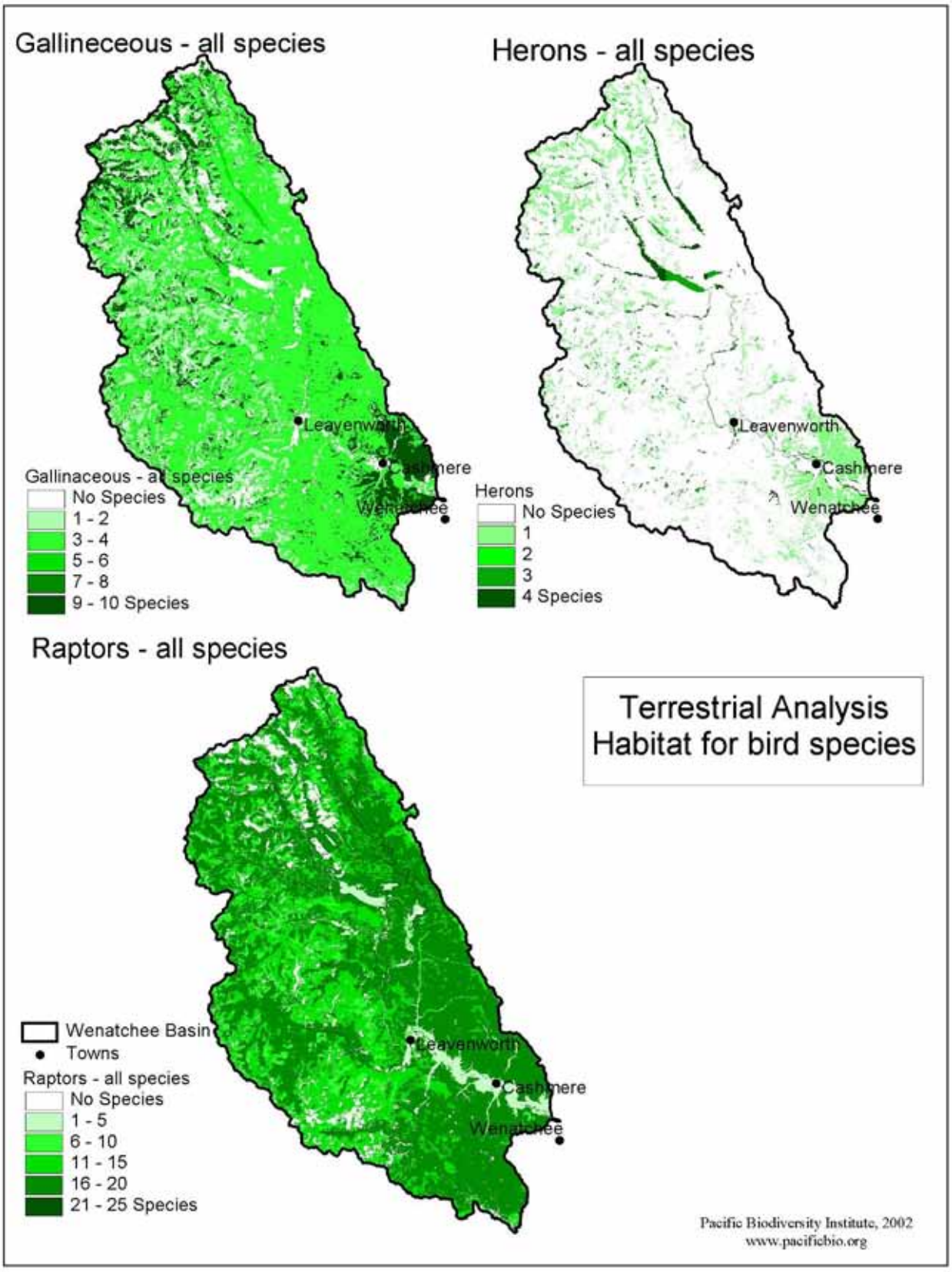


Figure 36: Bird habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. Gallinaceous, Heron and Raptors. High values (dark green) indicate habitat for many bat species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

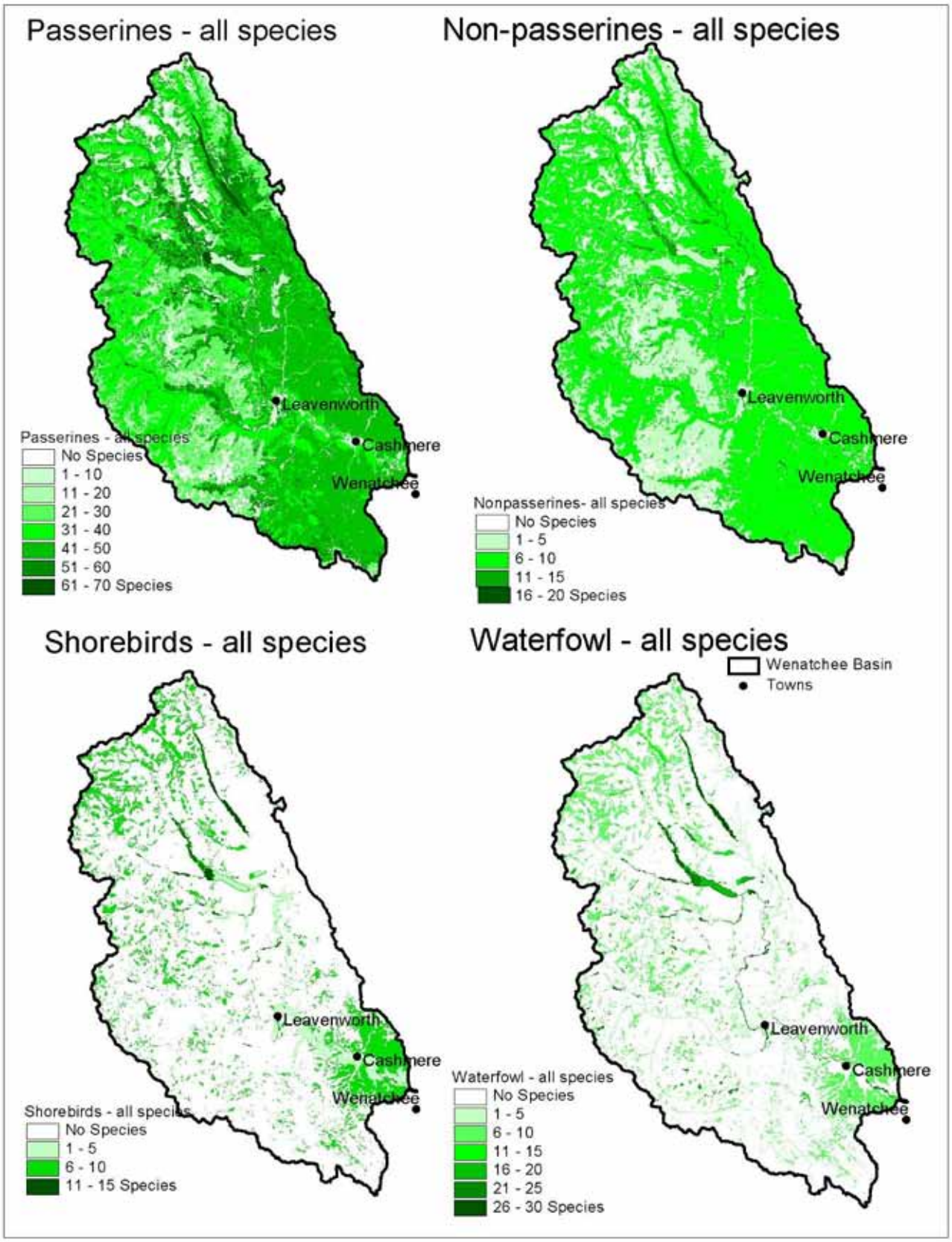


Figure 37: Bird habitat ranking used in the terrestrial prioritization of the Wenatchee River Basin. Passerines, non-passerines, shorebirds and waterfowl. High values (dark green) indicate habitat for many bat species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

To assess the conservation priority of bird species in the Wenatchee River Basin, we relied on the predicted habitat models for these species from the wildlife-habitat relationship model. Each species habitat model was clipped out for the Basin and converted to a grid surface with 30m 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 100. Areas with no predicted habitat for any species were coded as 0. This process was repeated for species of concern.

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 24), we relied on the predicted habitat models for these species from the wildlife-habitat relationship model. Each species habitat model was clipped out for the Basin and converted to a grid surface with 30m 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 100 (Figure 38). Areas with no predicted bat habitat for any species were coded as 0. This process was repeated for species of concern.

Table 24. Bat species included in the Wenatchee River Basin terrestrial prioritization.

Common Name	Scientific Name	Species of Concern
Big brown bat	*Eptesicus fuscus*	*N*
Hoary bat	*Lasiurus cinereus*	*Y*
Silver-haired bat	*Lasionycteris noctivagans*	*Y*
Pallid bat		*N*
Long-eared myotis	*Myotis evotis*	*Y*
Little brown myotis	*Myotis lucifugus*	*N*
California myotis	*Myotis californicus*	*N*
Long-legged myotis	*Myotis volans*	*N*
Yuma myotis	*Myotis yumanensis*	*N*
Fringed myotis	*Myotis thysanodes*	*Y*
Keen myotis	*Myotis keen*	*N*
Townsend's big-eared bat	*Ple townsendii*	*Y*

Ungulates

Ungulates are herbivorous animals including elk, mule deer and white-tailed deer. They are critical as prey to large carnivores. Habitat location data for ungulates was based on the wildlife-habitat relationship model. Each species habitat model was clipped out for the Basin and converted to a grid surface with 30m 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 100 (Figure 38). Areas with no predicted ungulate habitat for any species were coded as 0.

Table 25: Ungulates in the Wenatchee River Basin

Common Name	Scientific Name	Species of Concern
MULE DEER	ODOHEM	N
ROCKY MOUNTAIN ELK	CERELA	*N*
WHITETAIL DEER	ODOVIR	*N*

Sheep

Big-horned sheep and mountain goats are species of concern in the Wenatchee River Basin. Habitat location data for these sheep was based on the wildlife-habitat relationship model. Each species habitat model was clipped out for the Basin and converted to a grid surface with 30m 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 100 (Figure 38). Areas with no predicted sheep habitat for any species were coded as 0.

Table 26: Sheep of concern in the Wenatchee River Basin

Common Name	Scientific Name	Species of Concern
BIGHORN SHEEP	OVICAN	Y
MOUNTAIN GOAT	OREAME	Y

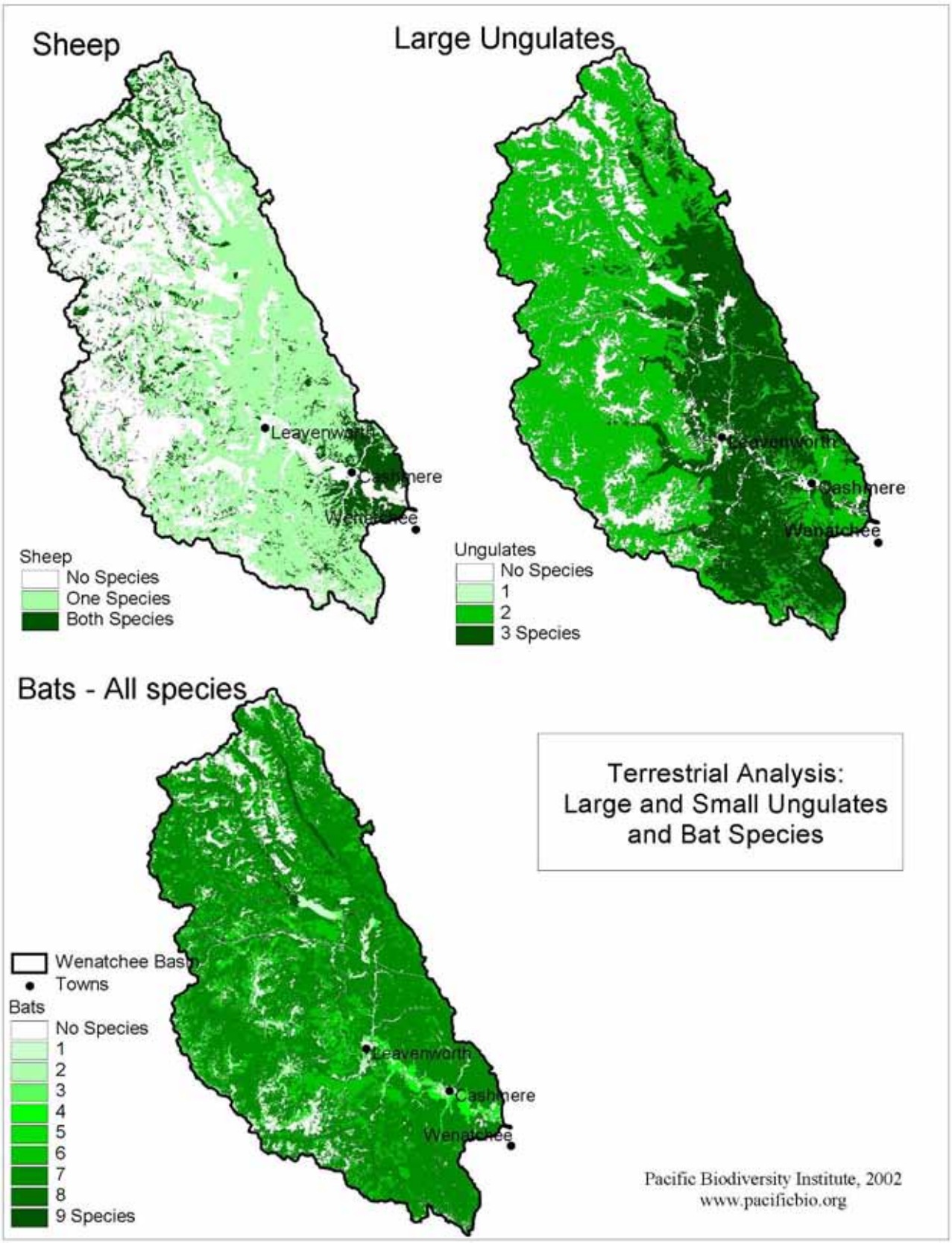


Figure 38. Large ungulates, sheep and bat habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin. High values (dark green) indicate habitat for many bat species, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

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).

To assess the potential impact of introduced and invasive animal species in the Basin (Table 21), we relied on the predicted habitat data for these species from the wildlife-habitat relationship model. Each species habitat model was clipped out for the Wenatchee River Basin and converted to a grid surface with 30m 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 100 (Figure 39). 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
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*

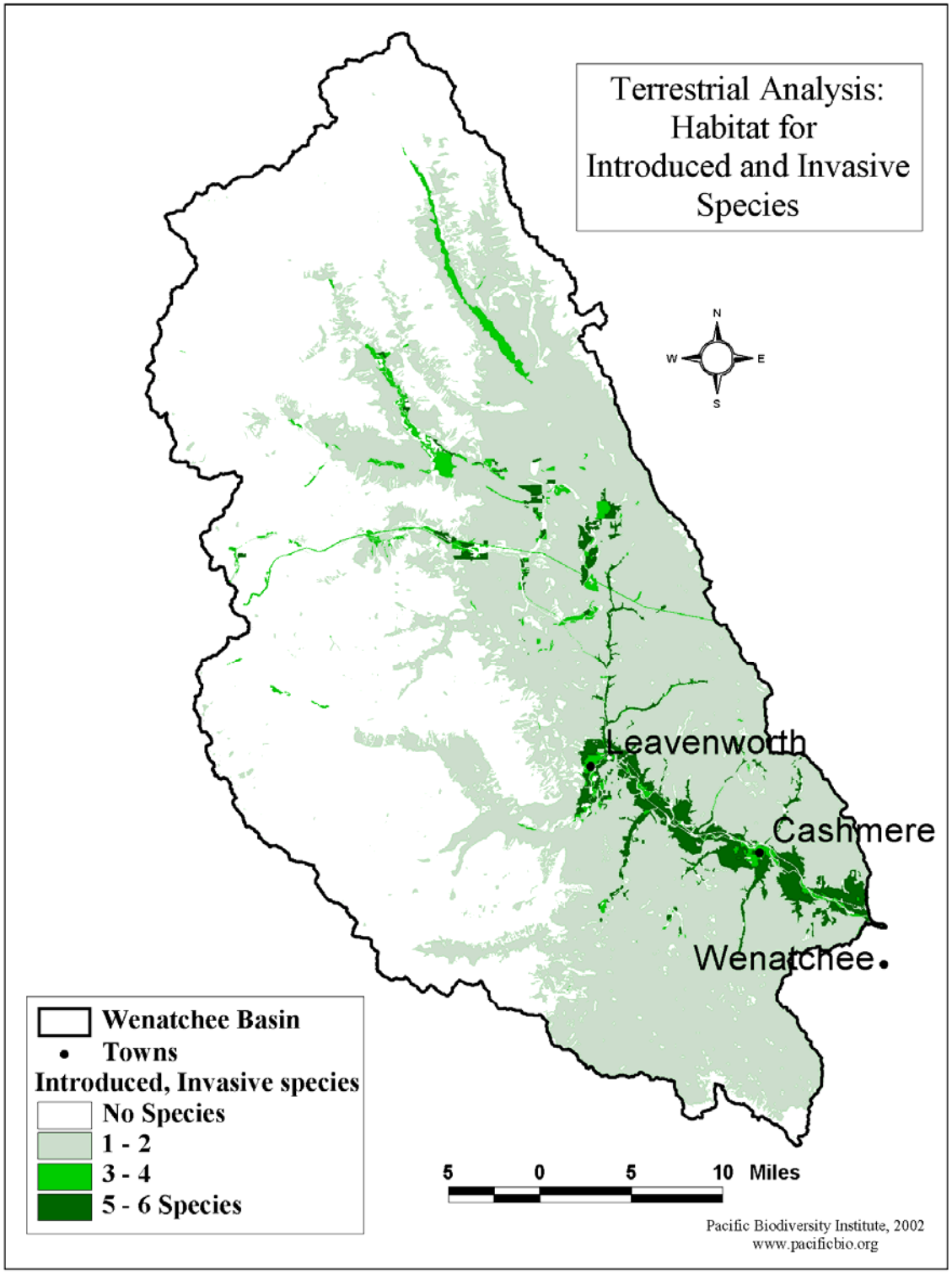


Figure 39. Introduced and invasive species habitat rankings used in the terrestrial prioritization of the Wenatchee River Basin.
High vales (dark green) indicate habitat for many invasive and introduced wildlife species, detracting from terrestrial priority. This was used as a negative factor in the terrestrial prioritization.

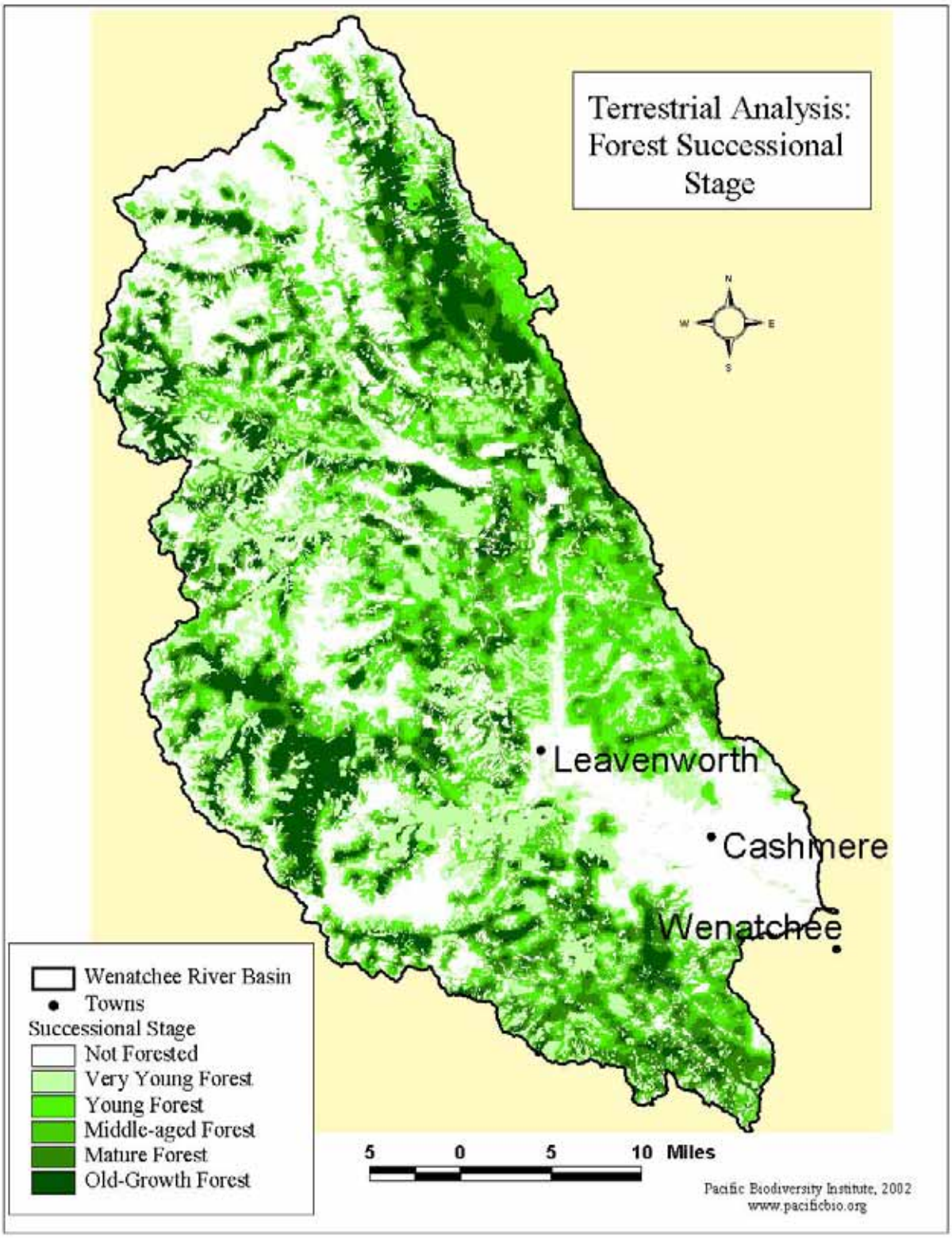


Figure 40. Successional stage and old-growth forests in the terrestrial prioritization of the Wenatchee River Basin.
High values (dark green) indicate the presence of late-successional/old-growth forests, adding to terrestrial priority. This was used as a positive factor in the terrestrial analysis.

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. 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 (Figure 41).

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 42). 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 transmission line 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 100 (Figure 43). 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
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

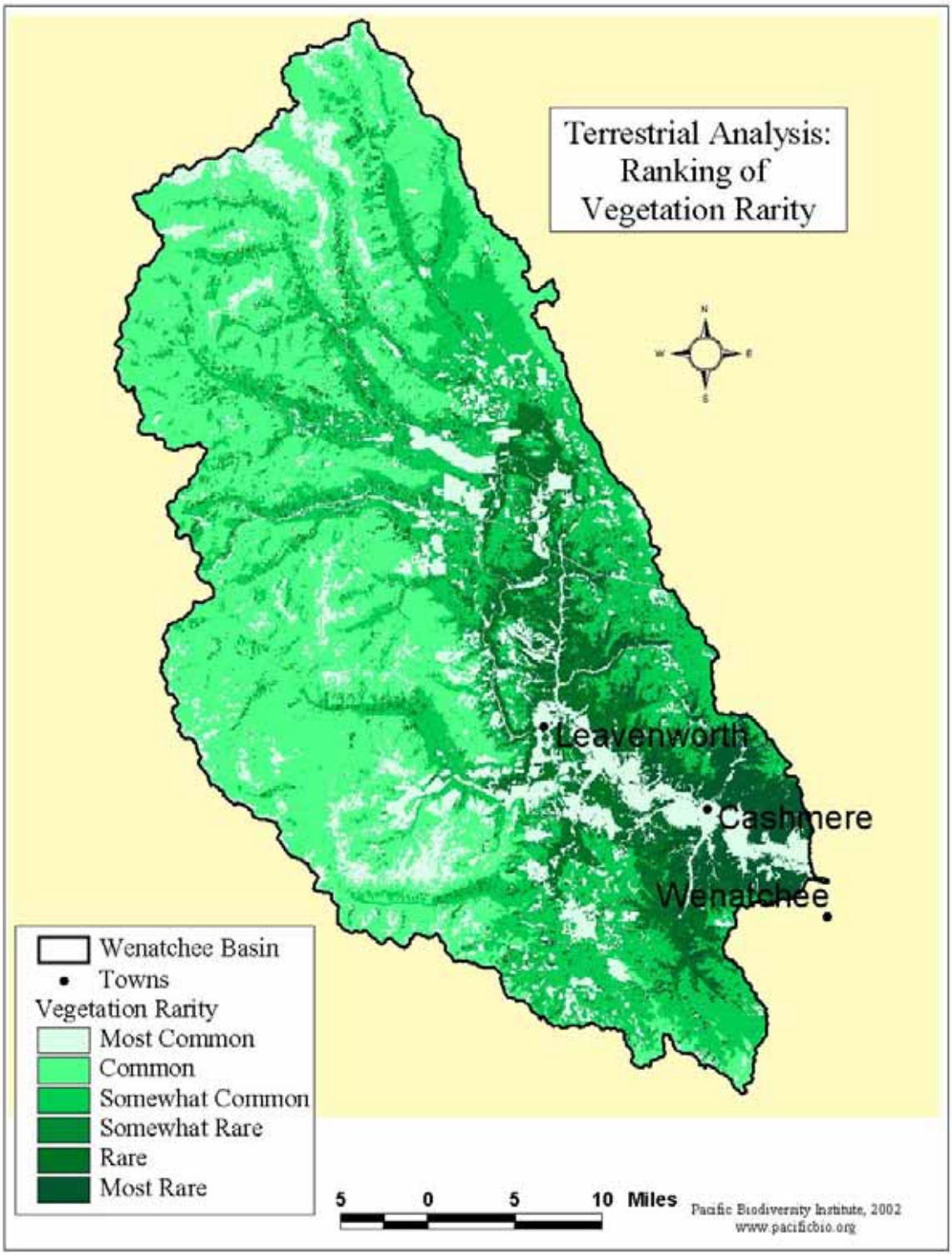


Figure 41. Vegetation rarity rankings used in the terrestrial prioritization of the Wenatchee River Basin.
High values (dark green) indicate vegetation types that are rare in the Greater North Cascades Ecosystem. This increases conservation priority and was used as a positive factor in the terrestrial prioritization.

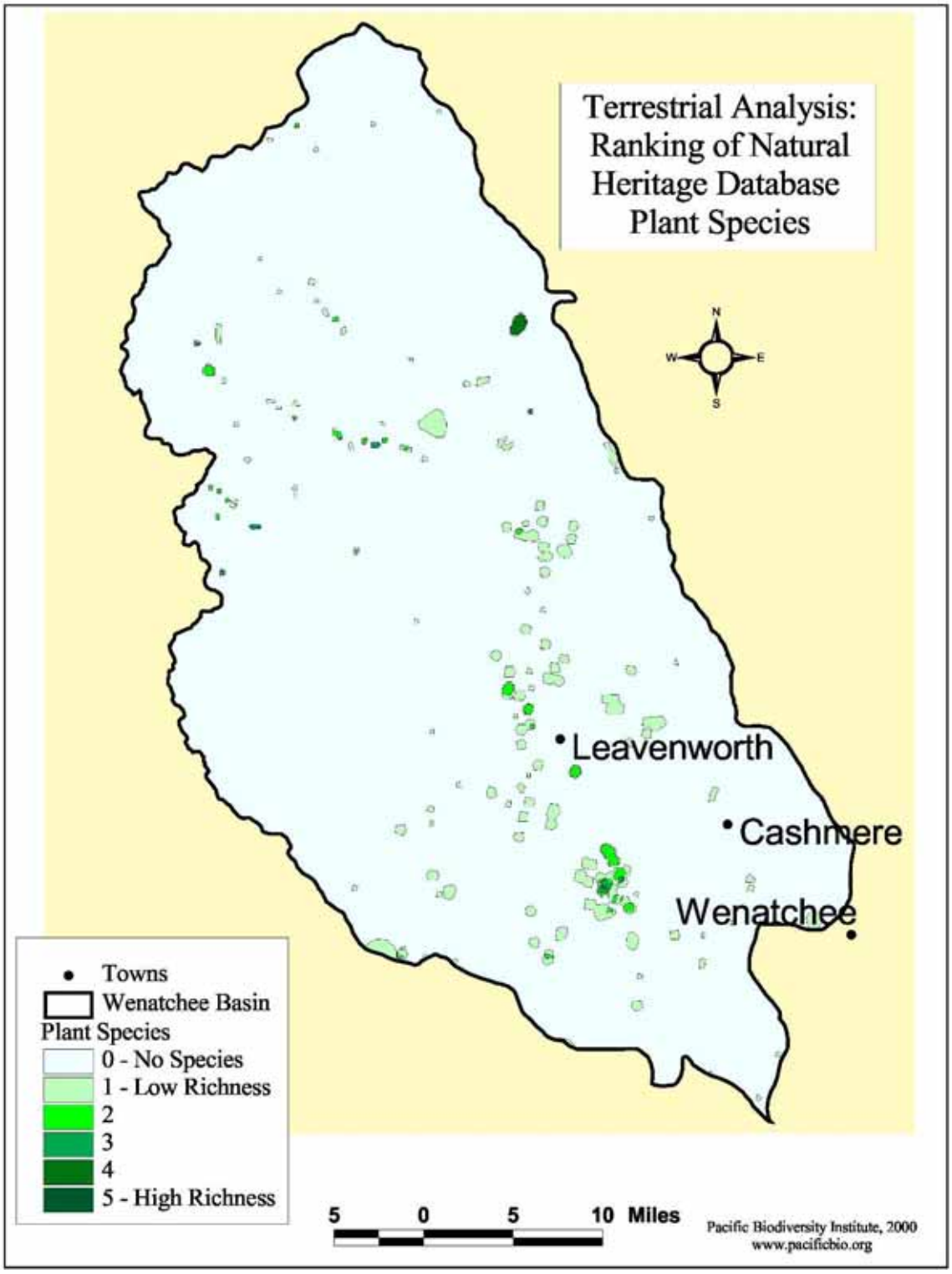


Figure 42. Ranking of Washington DNR Natural Heritage Plant database records for the Wenatchee River Basin terrestrial prioritization.
High values (dark green) indicate the presence of many threatened, endangered, or special concern plant species. This increases conservation priority and was used as a positive factor in the terrestrial prioritization.

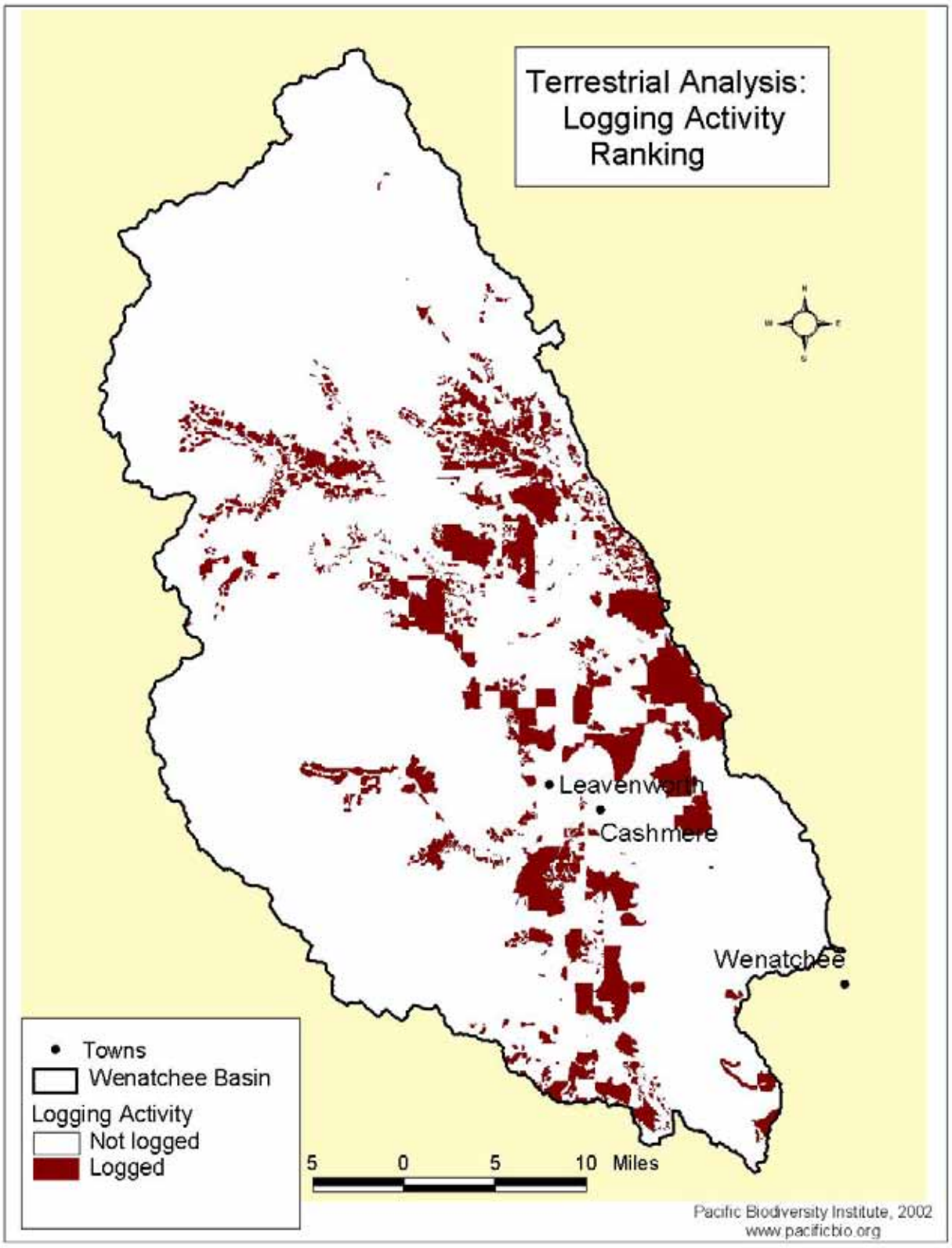


Figure 43. Logging activity ranking for the Wenatchee River Basin terrestrial prioritization.

Because of the impacts of logging on natural environments, areas that have been logged were given a value of 100. This was used as a negative factor in the terrestrial prioritization.

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 44). 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 45). 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.

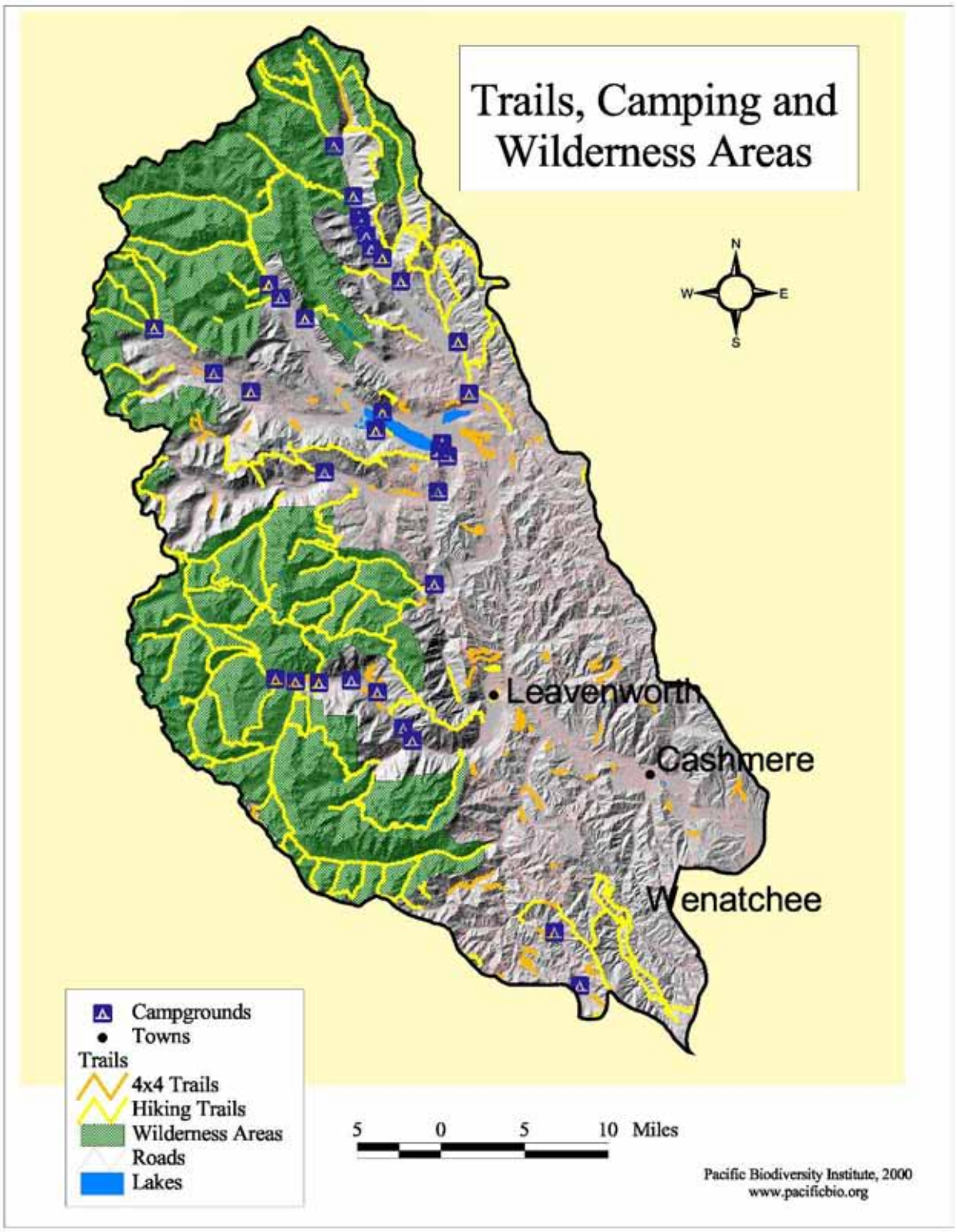


Figure 44. Trails and camping areas in the Wenatchee River Basin. Camping, hiking, and backpacking are among the most popular outdoor recreation activities in the Basin. Extensive trail networks penetrate the three wilderness areas in the Basin.

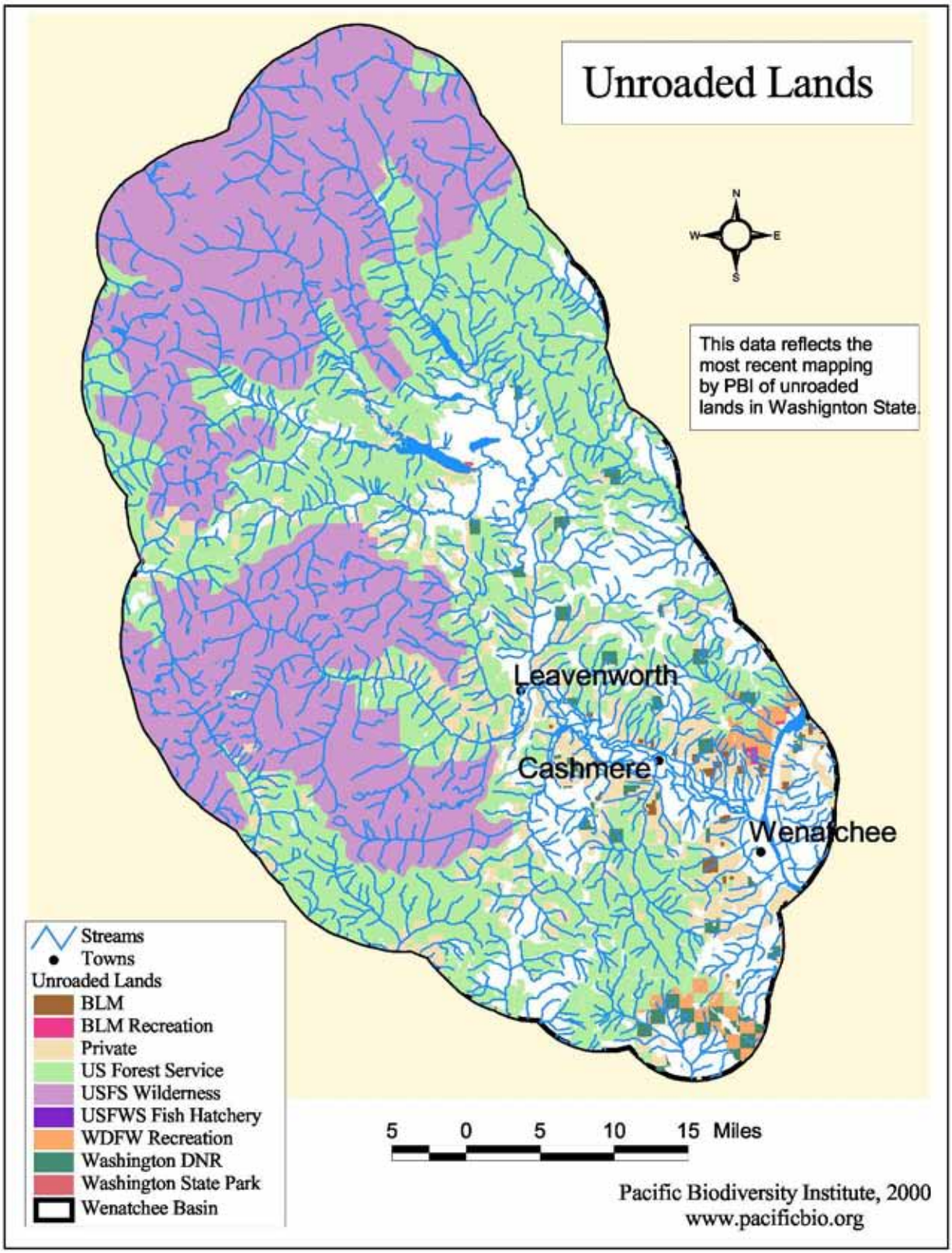


Figure 45. Roadless areas and wilderness in the Wenatchee River Basin. The majority of the roadless areas in the Basin are either Wilderness or US Forest Service land.

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 46). 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 47). 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.

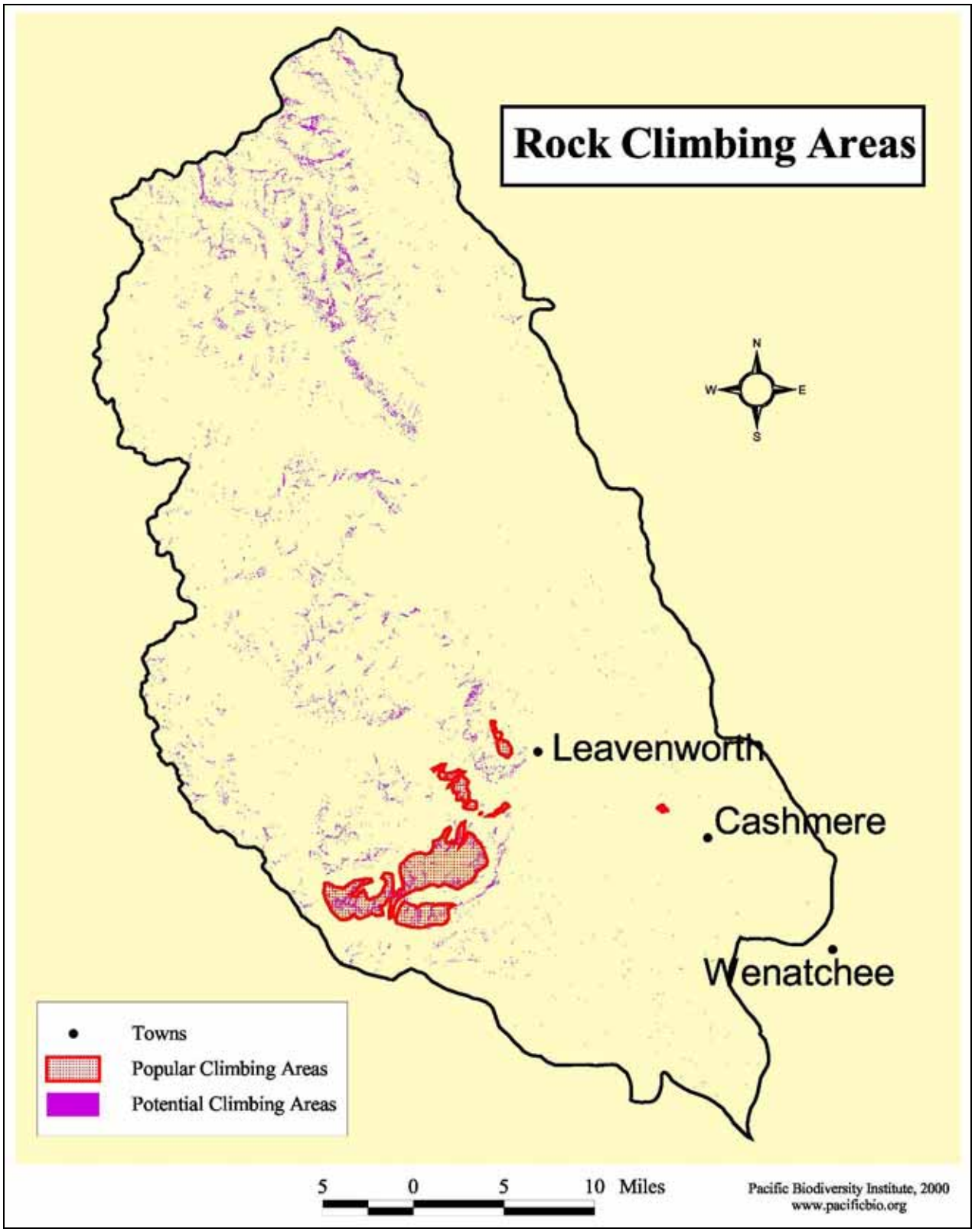


Figure 46. Popular climbing areas and potential climbing areas in the Wenatchee River Basin.
The Basin is renowned for its rock climbing sites. Many additional areas have rock climbing potential.

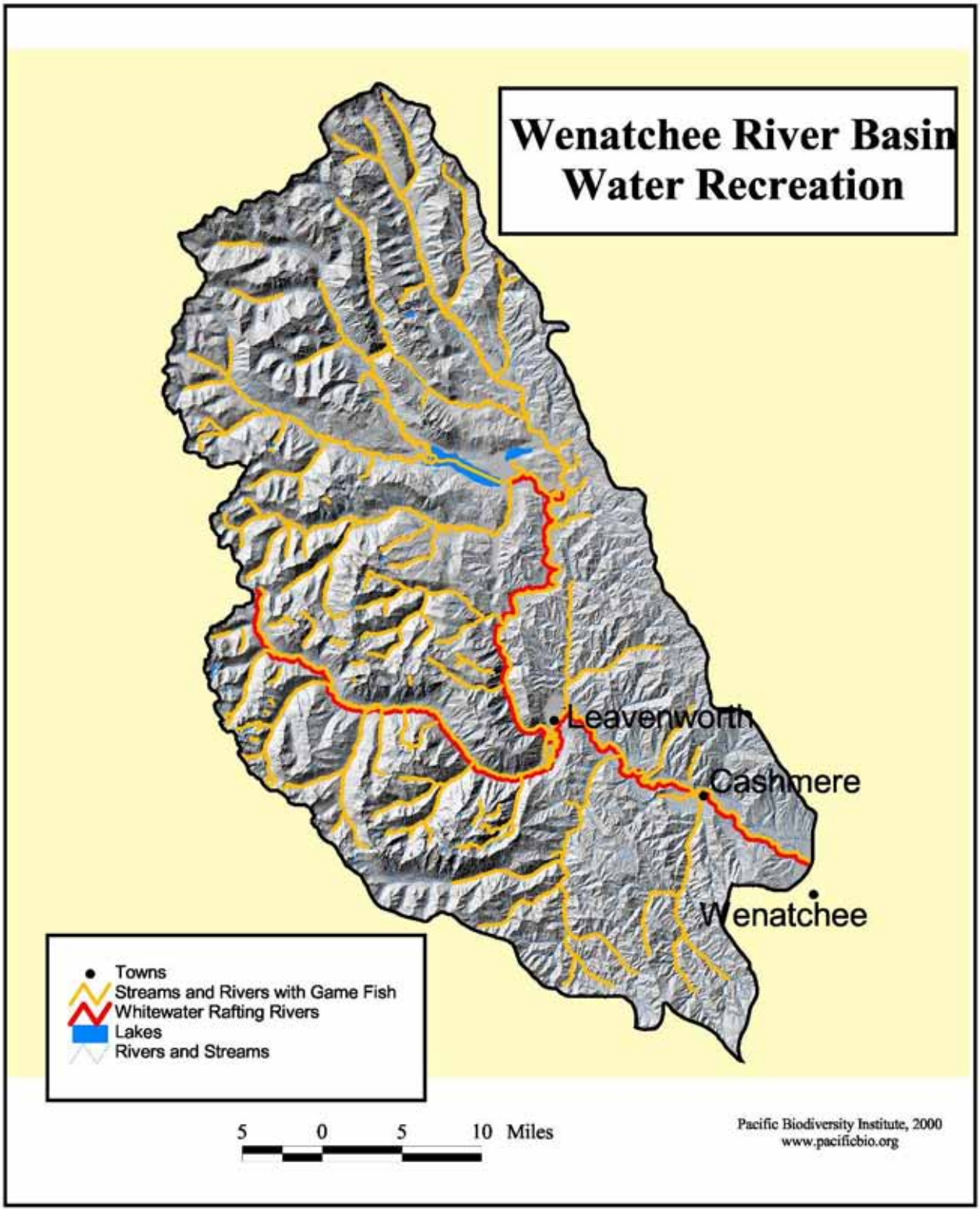


Figure 47. Recreation opportunities in the Wenatchee River Basin: Fishing and Whitewater Rafting.
The Wenatchee River and Icicle Creek are popular whitewater areas. Most of the rivers and larger streams contain game fish. Boating is popular on Lake Wenatchee and Fish Lake.

CURRENT and FUTURE THREATS

Current and future threats to ecological integrity and biodiversity in the Wenatchee River Basin were assessed using a variety of data sources. Six major categories of threats were identified (Table 23). Of these, logging and road building, mining, development, and alien plan invasions were assessed as either the most threatening currently, or with the highest potential for future threat. Of these, data on planned development information needs to be requested from Chelan County on a parcel-by-parcel basis. Currently, no adequate source of data on the distribution and spread of alien plants exists for use in this ecosystem assessment.

Current and future threats were assessed for mining, pollution, logging and road building. These are the only threat categories for which PBI had data or that the data was consistent and reliable for the Wenatchee River Basin. Aside from development, these are among the major threats to ecological integrity in the Basin.

Table 23. Categories and information sources for current and future threats to ecological integrity and biodiversity in the Wenatchee River Basin.

Threat Category	Current Threats	Current and Future Threat Indicators
Logging/Road Building	Proposed actions	Management designation
Mining	Active mine locations	Inactive mines, mineral deposits
Pollution	Washington DOE registered facilities licensed to discharge into waterways	Washington DOE and EPA registered hazardous waste facilities
Development	Proposed Planned Developments, timber harvests, subdivisions, etc.	Underlying County Zoning code, Permits, Proposed Actions
Grazing	Grazing	Number of stock, season of use, soil condition
Alien Plant Invasions	Not Available	Not Available
Motorized Recreation	Not Available	Not Available

There is currently one active mining site in the Wenatchee River Basin and two more immediately outside the basin (Figure 48). Additionally, an action has been proposed by the Wenatchee National Forest to permit surface mining of landscape and building rock north of Lake Wenatchee (Table 24). There are an additional 488 prospects, claims or inactive mining sites. These could be petitioned for development or reactivation.

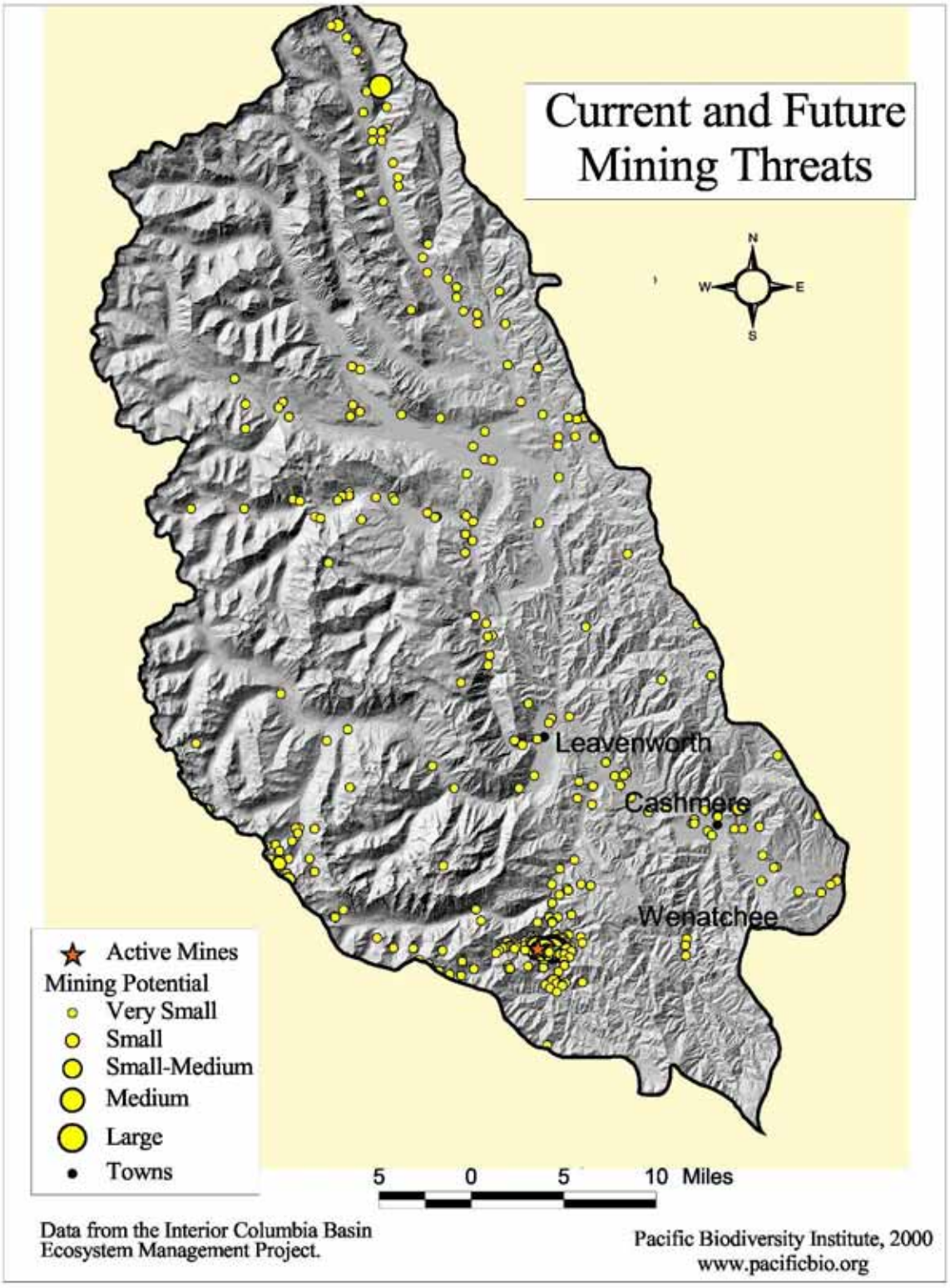


Figure 48. Current and future mining threats in the Wenatchee River Basin. There is one active mine in the Bain and several prospects with high potential for development.

Table 24. Proposed actions in the Wenatchee River Basin listed by the Wenatchee National Forest as of September, 2002.

Type of Action	Description	Area
Sewage Connection Project	Connect Camp Zanika to Chelan County's septic line. Bury 4 septic tanks and main sewage lines	T27N, R16E, Sec. 24
Septic Line	Location of septic system drain field (for single-family dwelling) on National Forest land	T27N, R18E, SW 1/4., NW ¼ of Sec. 32
ORV Tie Trail	Connection of ORV trail between Lower Chiwawa Trail #1548 and Mad River Trail #1409.	T27N, R18E, Sec 17, 19
Communications Tower	Construct tower north of alpine ski area on Skyline ridge. Two story building and propane generator	T26N, R13E, Sec. 11 and 14
Mineral Materials Sale	Mining for surface rock	T28N, R16E, Sec 30
Road obliteration and construction	Relocation of FS Road #6400 away from White River	T28N, R16E, SW ¼, Sec. 18
Water holding tanks	Land clearing, 400-ft road construction, 3 water holding tanks	T27N, R17E, SE1/4,NW1/4, Sec. 18
Fire Fuels Reduction	Fuels reduction in the area of 4th of July Fire (Icicle Fires) on 30 acres of land. Non-commercial thinning and pruning	Forth of July Fire area, Icicle Creek
Trail and Trailhead relocation	Relocation of Chatter Creek Trail and Trailhead due to disturbance by fire	T24N, R16E, Sec 6 and 32
Reservoir construction	Location of Reservoir on FS land	T21N, R19E, Sec 26
Culvert Replacements	Replace 4 culverts on Sand Creek to improve fish passage	T22N, R18E, Sec 1

There are 485 facilities licensed to produce or handle hazardous waste in the Wenatchee River Basin (Figure 49). Of these, 70 sites have waste disposal permits, 19 of which dispose of waste into a water source (either ground water, stream water, or public waste system). Twelve sites have permits to release pollutants into the atmosphere. There are 27 state-run clean-up sites in the Basin and an additional 13 voluntary cleanup sites. The 136 hazardous waste generators and 240 underground storage tanks pose potential future threats.

Logging and its associated activities pose probably the greatest threat to the ecological integrity of the Wenatchee River Basin. One logging-related action is currently being proposed in the Basin (Table 24). This does not take into account actions that have already been started, or actions planned by Washington DNR or on private lands, for which data was not available. 115,919 acres (46,931 ha) of the National Forest Land in the Basin is designated as Matrix management (Figure 50). Matrix is the area intended for extractive activities such as logging. Thus, the remaining natural areas (those that have not been logged) are at the highest risk of logging in the future. Additionally, there are 67 mi (110 km) of maintained power transmission line corridors in the Basin. These areas and areas adjacent to them receive a high level of recurring disturbance from clearing. The Public Utility District has proposed a re-routing of the Chumstick Transmission Line that would affect two townships in the Basin.

The Chelan County Planning Department registers planned developments on all private lands. Owners have worked with the county to redefine the zoning

restrictions in these areas for the purpose of future development. Therefore, the area will be developed according to the zoning restriction present in that area. Specific information about the planned development for each “file” (the file number is found in the attribute table) can only be obtained by contacting the Chelan County Long-Range Planning office.

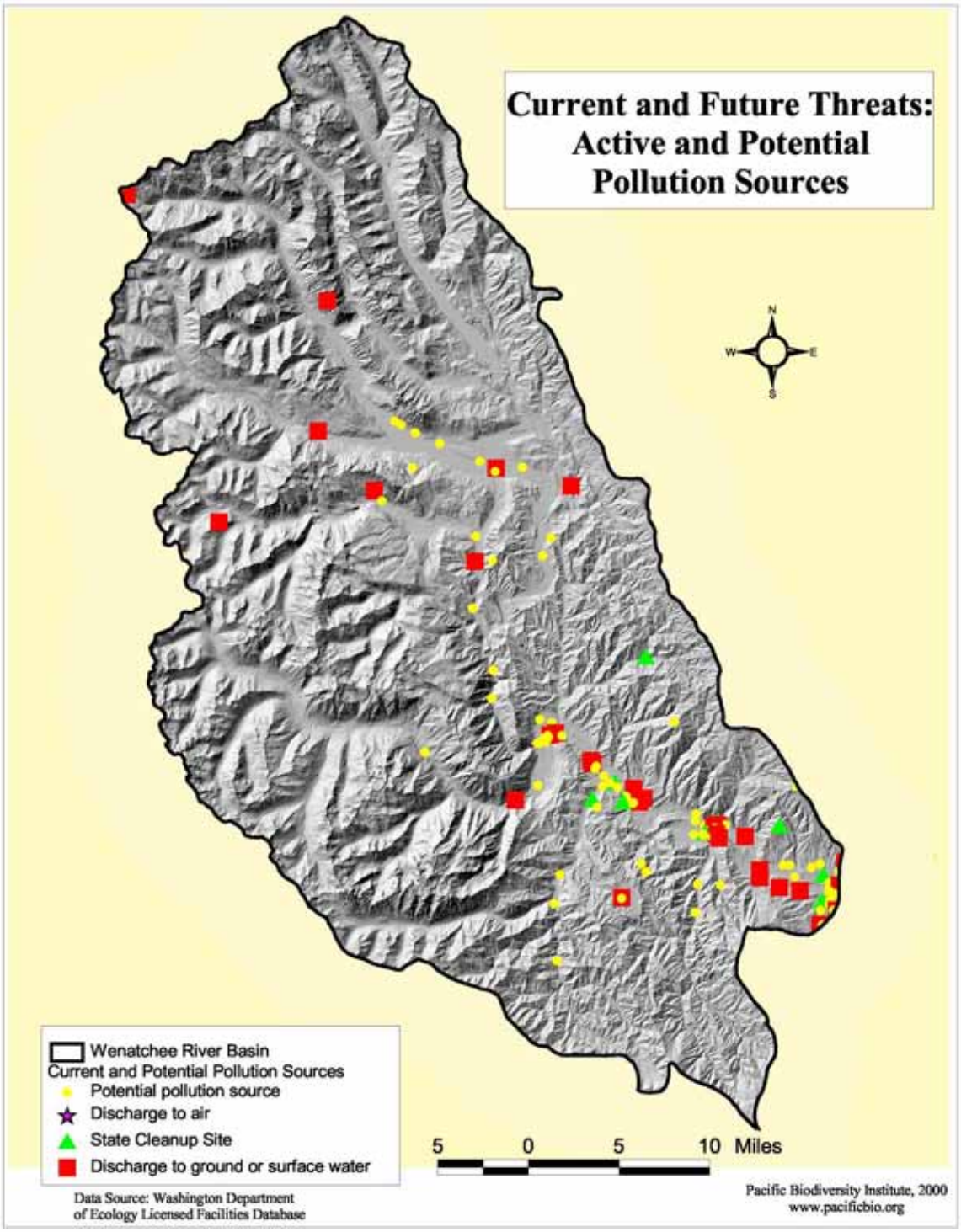


Figure 49. Current and future pollution threats in the Wenatchee River Basin.

There are 19 facilities licensed to dispose waste into waterways in the Basin. The 136 hazardous waste generators and 240 underground storage tanks pose future pollution threats.

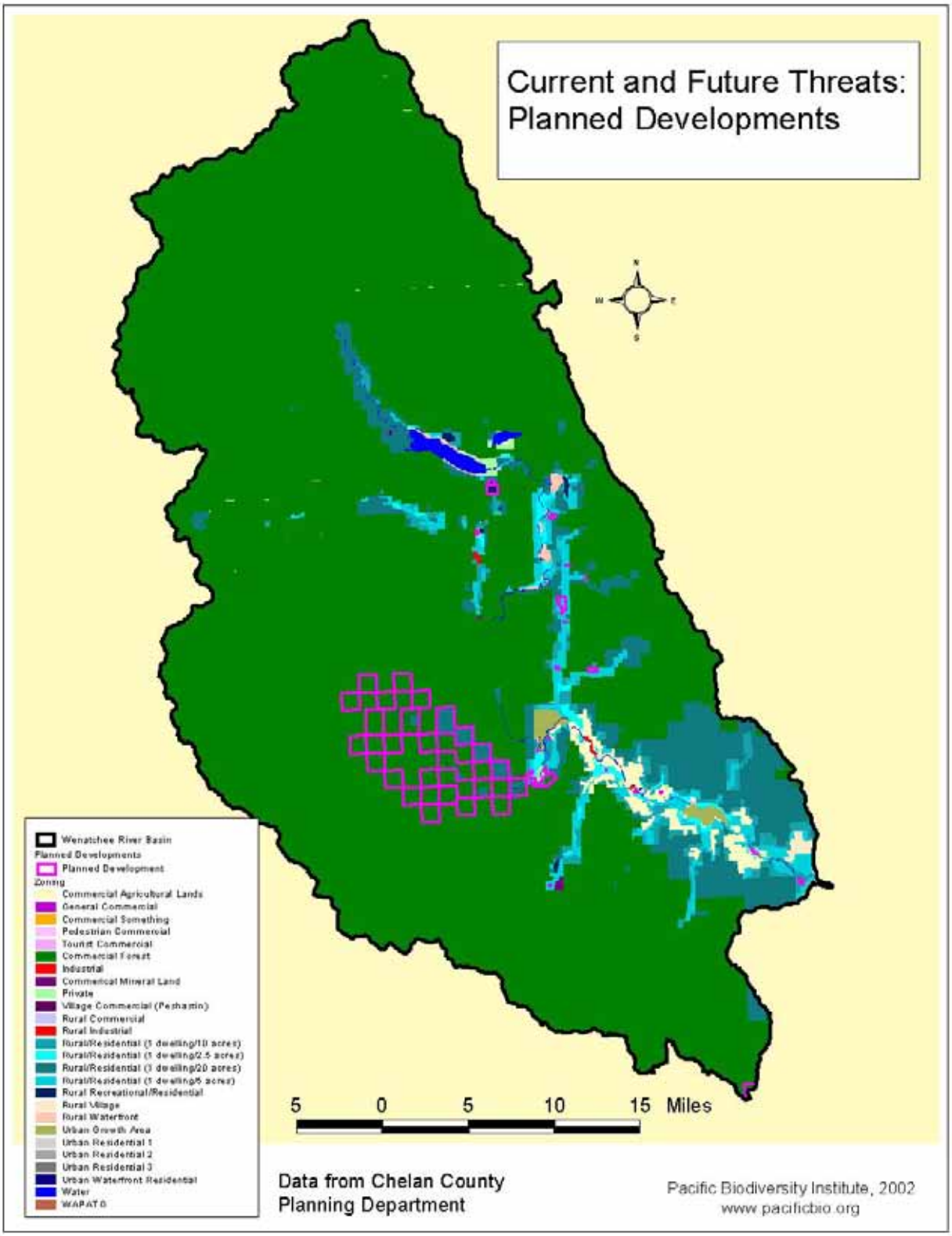


Figure 50. Planned Developments. The purple polygons represent some areas of planned development within the Wenatchee River basin. The proposed development will follow the area's zoning requirement.

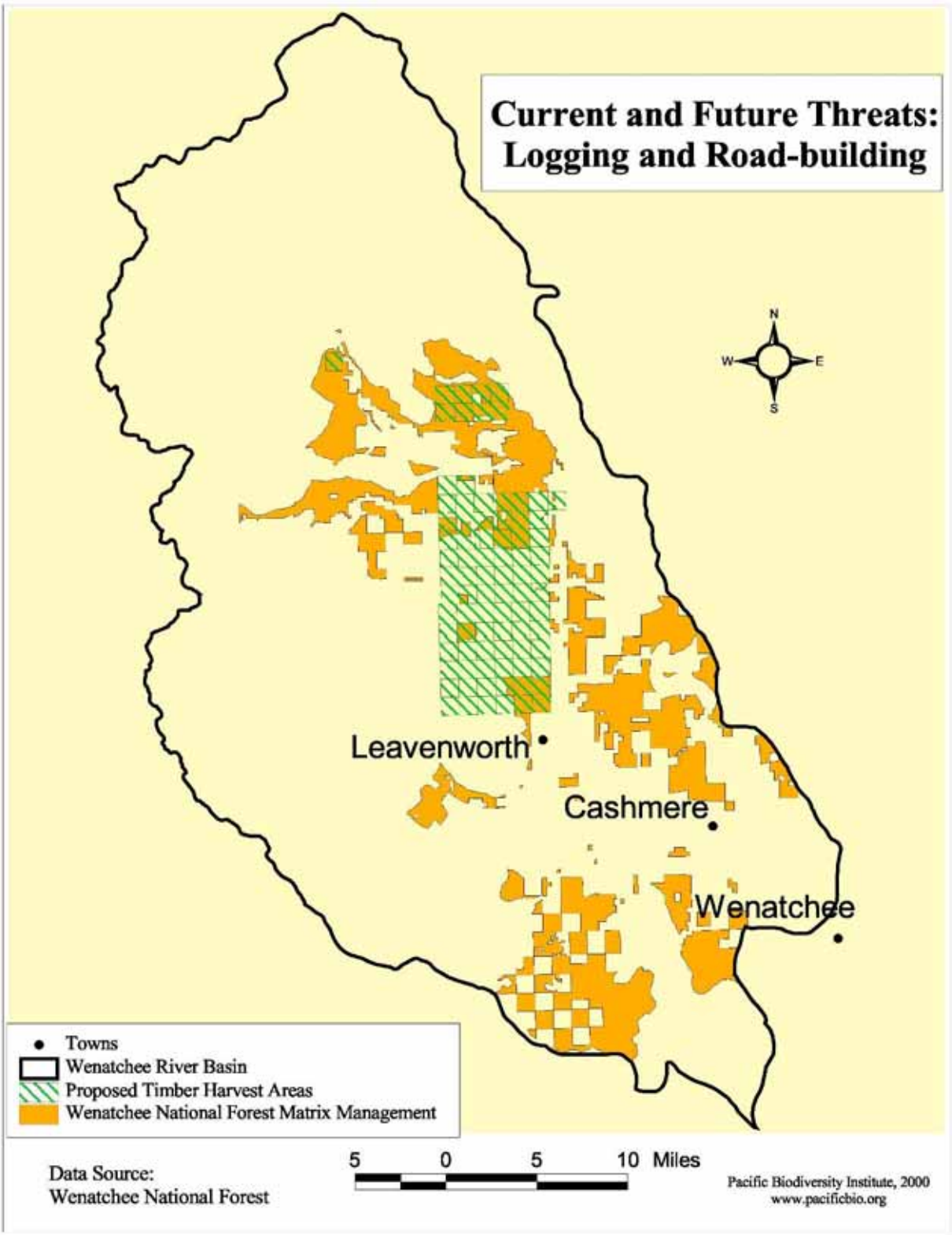


Figure 51. Current and future logging and road-building threats in the Wenatchee River Basin.
US Forest Service land designated as 'Matrix' is managed for the production of timber. These lands are most likely to be logged or have roads built on them in the future.

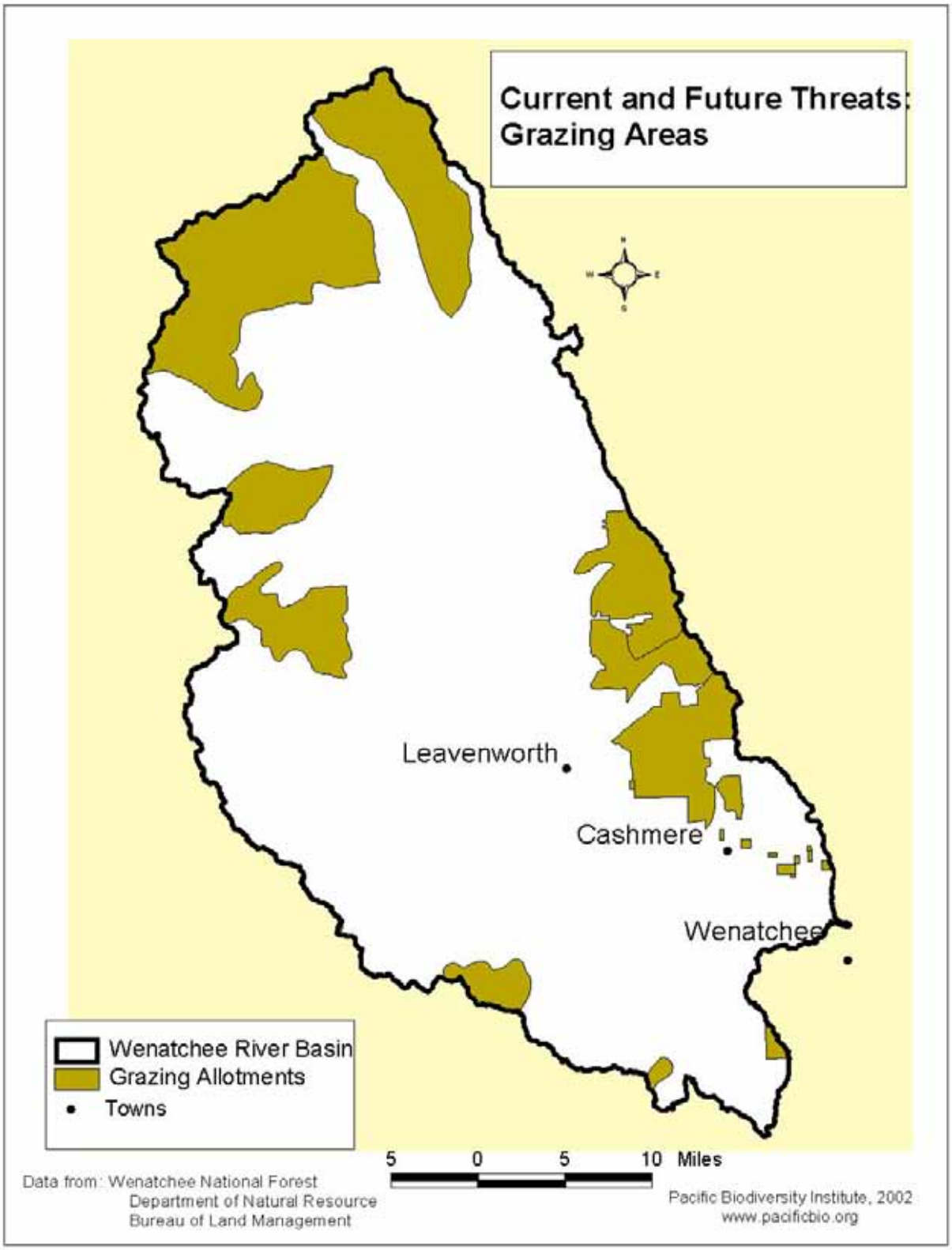


Figure 52. Past and Current grazing allocations on Federal and State land.
Data on grazing on private land is not available.

THE DECISION SUPPORT SYSTEM – A Tool For Conservation Planning In The Wenatchee River Basin

Pacific Biodiversity Institute designed a Decision Support System (DSS) to allow people to view and examine the data described above and to choose which factors are most important to include when making conservation decisions.

The system is designed to look at conditions across the entire watershed and identify areas that are the very best at meeting the criteria that you specify. For example, if you want to choose a piece of land that has the best habitat for blue herons and the least amount of development, you can input data on the areas of habitat for this species and on threats to this species, and the DSS will produce a map showing which pieces of land have conditions that are best for that species. The map will also show gradations between very good conditions and very poor conditions.

When using the DSS, remember that all maps and spatial data layers are just a representation of reality and have inherent error. While we have made our best effort to obtain, develop and use accurate information, some data layers in the DSS may have unacceptable accuracy for some applications. We recommend that all the data supplied with the DSS be periodically reviewed, updated and improved.

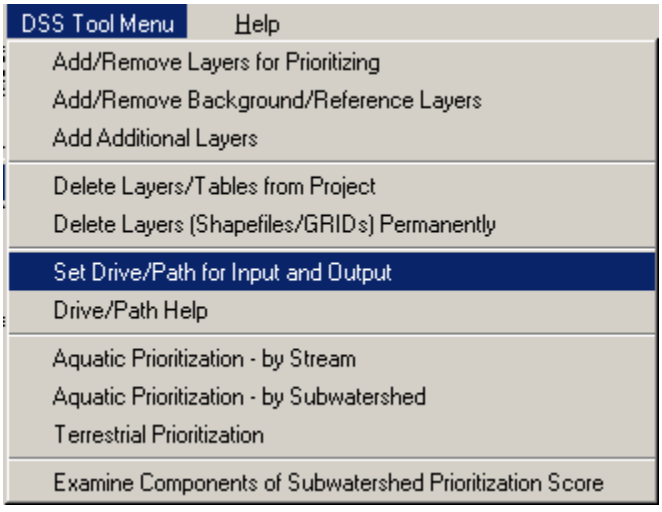
The Decision Support System is based on ESRI's ArcView software. This software allows a user to view and combine spatial environmental data for the Wenatchee River Watershed. The DSS was designed for users with no prior GIS experience. However, for more advanced users, the full functionality of ArcView GIS still is available.

Getting Started

Copy the entire DSS folder from the CD onto your local hard drive. The ArcView project is located in the DSS folder and is called "dss-v1.apr". Open "dss-v1.apr". Once the project is open you will see a list of menus at the top of the screen. All of the work you do in the DSS will begin with the DSS Tool Menu.

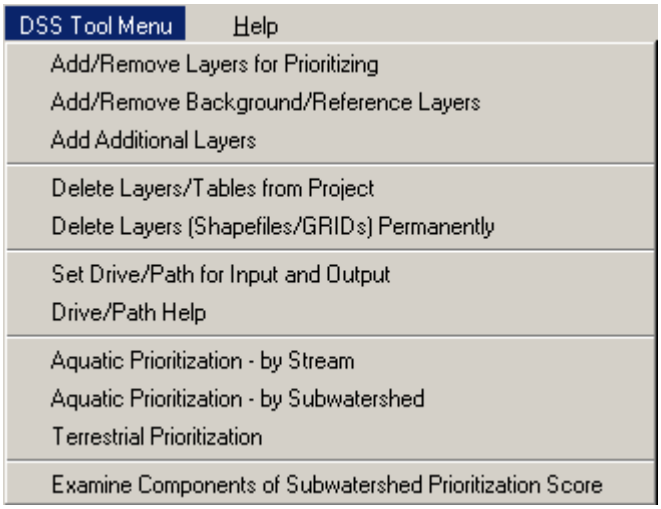
Before you do any operations in the DSS, the DSS must know where data files are located and where to save output. You will need to click on "Set Drive/Path for Input and Output". Next to "Drive location of DSS data" type the letter of your hard drive X:\ (where X = any hard drive).

Output can be saved to any drive and subdirectory.



DSS Tool Menu

A customized menu called “DSS Tool Menu” has been added to the standard ArcView menu bar. The DSS supports three basic functions:



1) adding/removing map layers from the view and project -menu sections 1 and 2,

2) Setting the drive and path for input/output files – menu section 3, and

3) combining and examining map layers for prioritizing areas – menu sections 4 and 5.

Add/Remove Map Layers

There are three options for adding data layers to your view window.

"Layers for Prioritizing" - are data layers with environmental values that can be meaningfully
scored and added together to prioritize areas for conservation. Select this option to
add or remove these layers to/from the Map View.
EXAMPLE: Number of fish in a stream, road density

“Background/Reference Layers" - are data layers that cannot be scored or added together for
prioritizing but still provide useful reference information. Select this option to add
or remove these layers to/from the Map View.
EXAMPLE: aerial photos, political boundaries

"Additional Layers" - allows the user to add any data layer to the Map View (same as
selecting *View - Add Theme*).

Remove / Delete Map Layers

"Delete Layers/Tables From Project" - allows the user to select any layers currently displayed in the Map View (or any active view) for removal. Select this option to remove layers not included as Prioritizing or Background/Reference Layers, as another way to remove layers included as Prioritizing or Background/Reference layers, to remove layers created by Prioritizations, or to delete tables.

"Delete Layers (Shapefiles/Grids) Permanently" - Select this option to permanently delete
layers from your hard drive. Most useful for deleting shapefiles and grids created by prioritizations. Does the same thing as selecting *File - Manage Data Sources in ArcView*.

Set Drive/Path For Input And Output

The directory structure under which data layers are stored for input must all be within X:\DSS\DATA (where X = any hard drive). Simply set the X to your hard drive letter and the system will look for the structure DSS\DATA. Output can be saved to any drive/ subdirectory. Use this option to set or change these paths

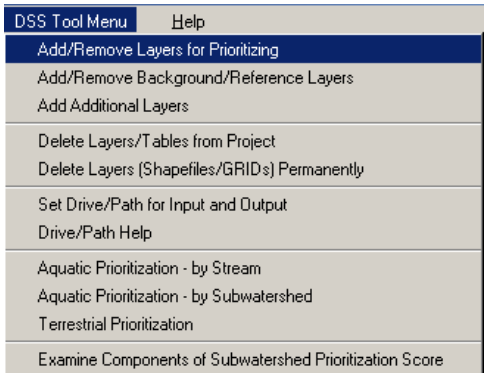
Examining and Reviewing Data Layers

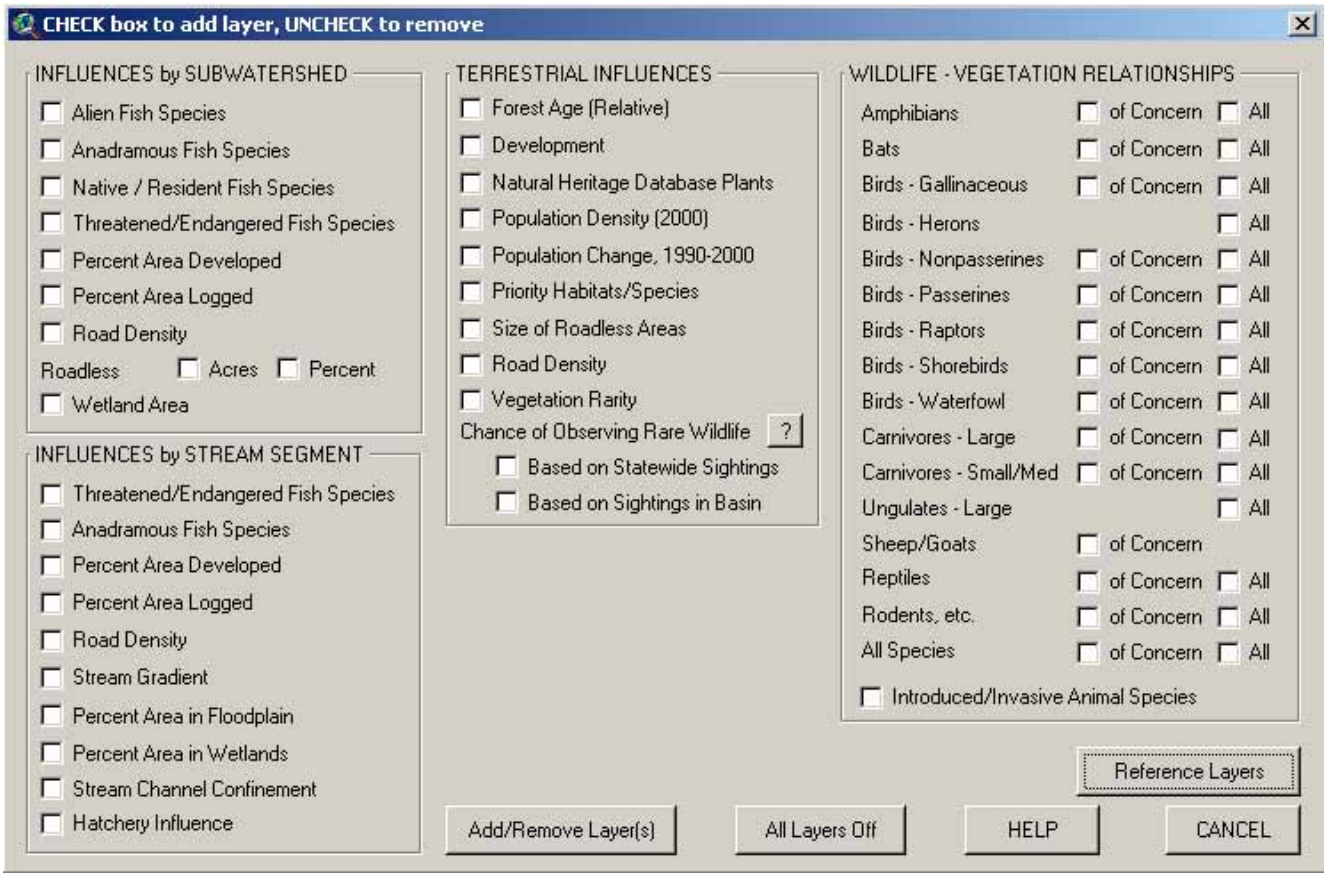
In the Decision Support System, data is grouped into two categories: Data layers that you can view and combine for prioritizing (Layers for Prioritizing), and layers that you can just view (Background/Reference layers and Additional Layers). Data for this project was acquired from the USFS and other public agencies or was developed by Pacific Biodiversity Institute. Complete data descriptions are included in another document.

Layers for Prioritizing

Go to the **DSS Tool Menu** and select **Add/Remove Layers for Prioritizing**.

To add these layers onto your view screen, click the check boxes next to the layers you want to add, then choose **Add/Remove Layer(s).** The computer will add the layers you marked checked, and removed the layers that you unchecked. Once the layers are added, you can zoom in on sections, and compare many layers at the same time.

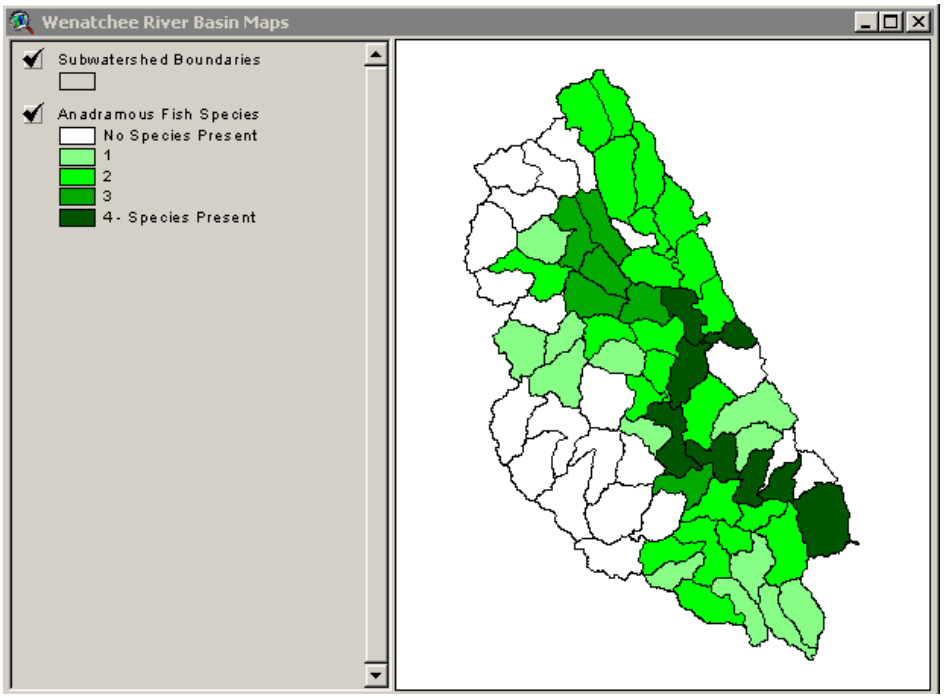




Note the different sections of data: Influences by Subwatershed, Influences by Stream Segment and Terrestrial Influences, and Wildlife-Vegetation Relationships. These different types of data are discussed below.

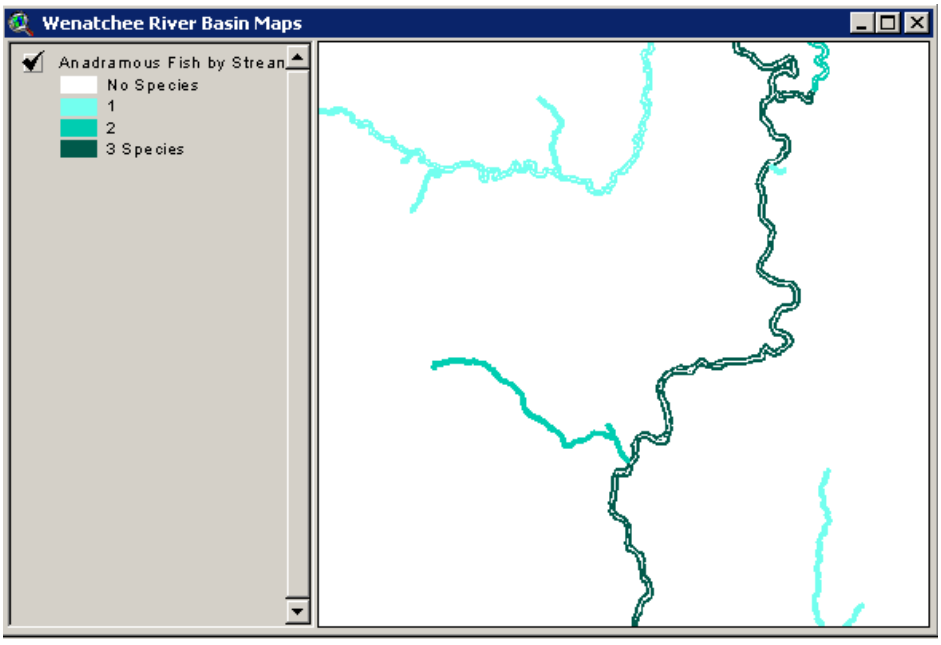
Influences by Subwatershed

The aquatic data was summarized on a subwatershed level and a "stream-segment" level. The data was summarized by subwatershed to help users prioritize land in a way that accounts for both in-stream characteristics and the upland characteristics that contribute to those in-stream conditions. The map below shows the number of anadromous fish species found in streams running through each subwatershed.



Influences by Stream Segment

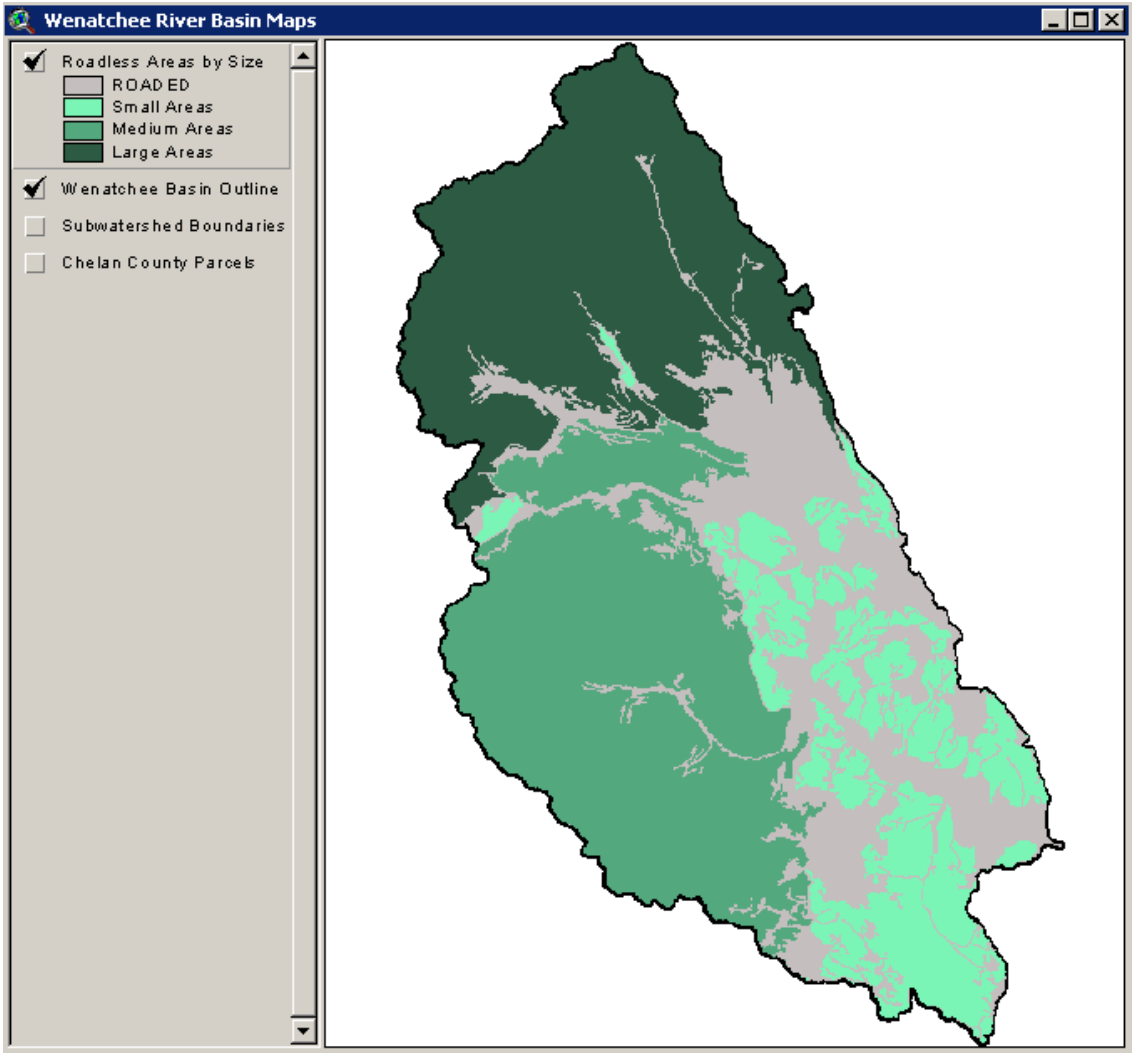
Aquatic data also was summarized on a "segment unit" level for all anadromous fish-bearing streams whose length is a segment of the stream with a uniform gradient and whose width is a 300-ft buffer on both sided of the stream. The segment data allows the user to analyze the most important. Each side of the stream in treated



independently, as conditions on one side may differ from conditions on the other side. The adjacent image shows the number of anadromous fish in a given segment.

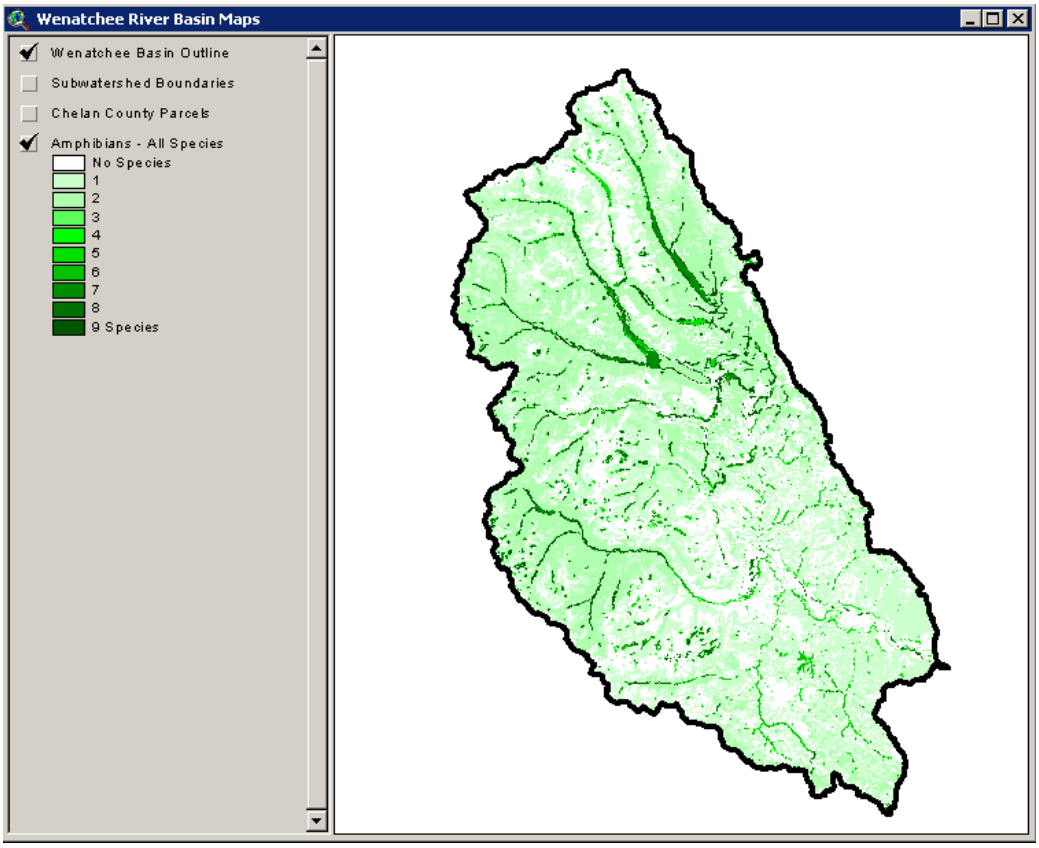
Terrestrial Influences

Terrestrial data includes both natural landscape conditions such as vegetation, and human influences such as land use. Data on potential habitat use of all vertebrate, non-fish species in the Basin is also supplied with the DSS. This data was derived from a wildlife-habitat relationship model developed by Bill Gaines (Wenatchee National Forest) and Peter Singleton (USFS Wenatchee Forest Sciences Lab) and then adapted and refined for this project by Don Katnik and Peter Morrison (Pacific Biodiversity Institute). Terrestrial data was mapped at 30-m resolution. The Basin was divided into 30x30 m cells or pixels and each cell coded with values related to terrestrial environmental variables. The map below shows Roadless areas in the Wenatchee River Basin.



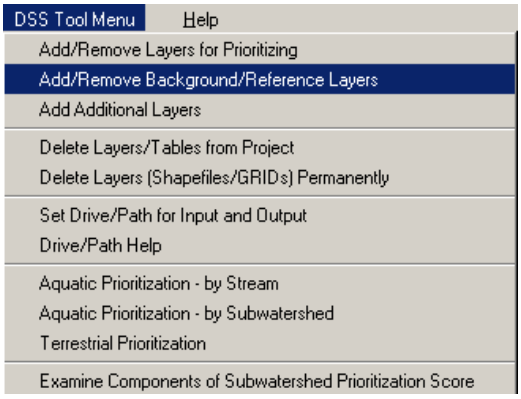
Wildlife – Vegetation Relationships

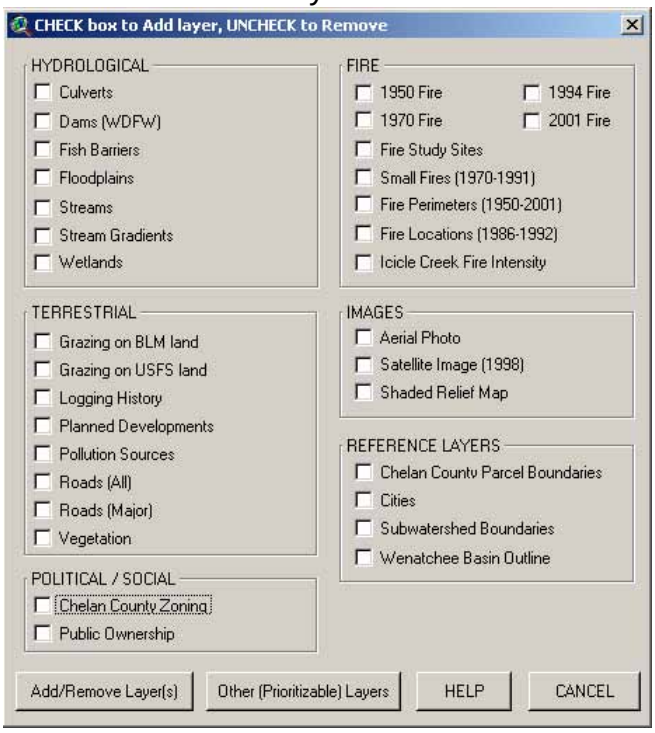
Vegetation was rated according to its suitability for different wildlife species. We grouped wildlife species and allowed the user to look at vegetation suitability for all species in a group or only for rare or endangered (of concern) species in a group.



Background/Reference Layers

Additional layers for viewing include Hydrological, Terrestrial, Political/Social, Fire History, Images, and Reference layers. These can be accessed through the **DSS Tool Menu** under the heading **Add/Remove Background/Reference Layers.**





Additional Layers can be added using the "add theme" function in ArcView. These layers are found in the DSS\Data folder.

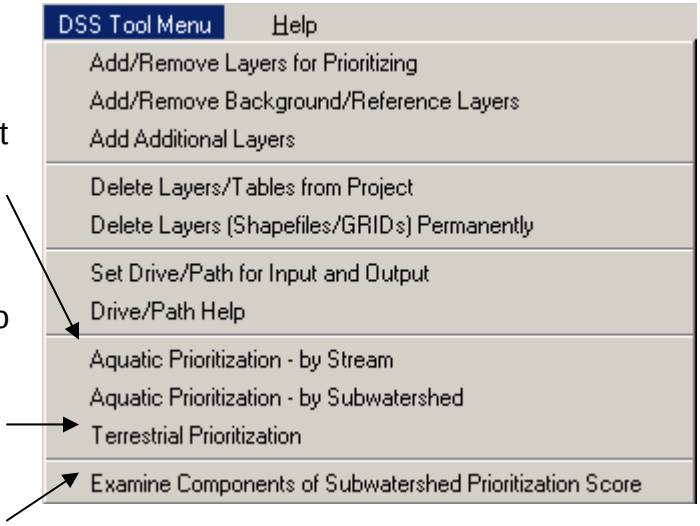
Prioritizations

The prioritization functionality of the DSS allows the user to determine how different areas within the Wenatchee River Basin compare to one another based on criteria specified by the user. We refer to this combination of data layers and relative comparison between areas as "prioritization". A map produced through a prioritization will show gradations between areas with low priority and areas with high priority. The high priority areas are those that have the most positive factors and the least negative factors. Which factors are included in the prioritization, and whether those factors have a positive or negative influence, are determined by the user.

The following items in the **DSS tool menu** allow you to conduct prioritizations:

"Aquatic, By Stream" - Stream segments can be prioritized by 10 variables including fish numbers; gradient; channel confinement; percent area around the stream that has been logged, developed, or is covered by wetlands or floodplains, etc.

"Aquatic, By Subwatershed" - similar to By Stream except prioritization is done at the subwatershed level. This prioritization uses some of the same data sources as the stream-level prioritization, and some additional ones.



"Terrestrial" - Prioritize terrestrial areas by 40 variables including the suitability of vegetation for a variety of wildlife species, relative forest age, population density, road density, etc.

Each map layer depicts the range of influence of the factor scaled from zero (no influence) to 100 (maximum influence). When several layers are combined in a prioritization, the values from the different layers are averaged (for each subwatershed, stream segment, or cell--depending on the type of prioritization being done).

Conducting a Prioritization

Choose the type of prioritization to be done (by subwatershed, by stream segment, or by cells for terrestrial factors) by selecting a choice from the fourth section of the "DSS Tool menu."

In conducting a prioritization, first choose which data layers you think are appropriate to use for addressing the question that you have chosen.

- Click on the check-box next to the data layers that you want to add.

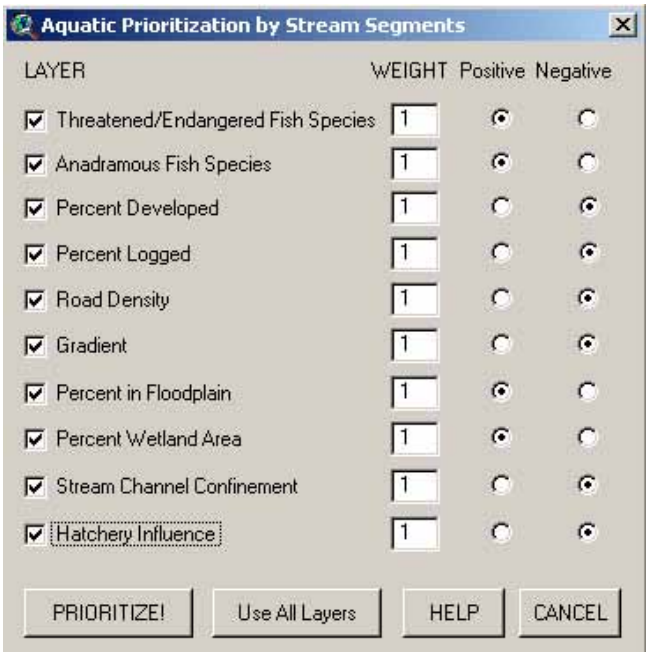
You will next have to decide how important you want each factor to be in relation to the other factors used in your prioritization. The “weight” choice allows you to decide how important the given factor is based on your conservation goals. The “Influence” choice (positive or negative) allows you to decide how the factor affects the condition of the natural environment based on your conservation goals.

- Type in the “weight” you want to give to each factor.
- Choose the “influence” (positive or negative) you want to give to each factor.
- To combine the selected layers, click the “PRIORITIZE!” button.
- Specify a name for your prioritization and where you want it saved. There is a Prioritizations folder in the DSS directory: **DSS\ds_system\Prioritizations**
- You will also be prompted to save a table of your prioritization. Give it the same name as your prioritization. This way, you will be able to go back and see which factors, weights, and influences you used in creating each prioritization. The file will be saved as a text file (.txt). You can look at this file later by clicking on **Tables**…**Add** in ArcView.

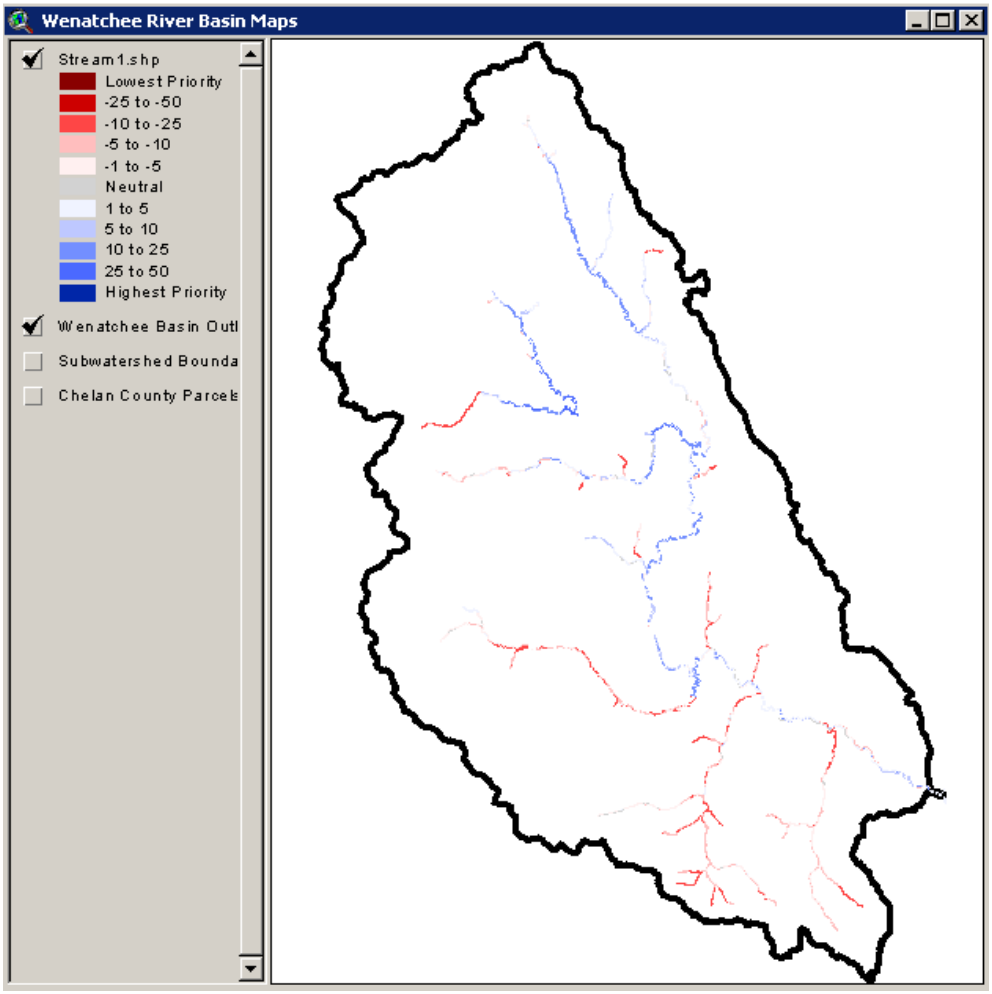
The system will now create a map showing how the different areas compare to one another based on the criteria you chose!

Below are some examples of what those maps will look like:

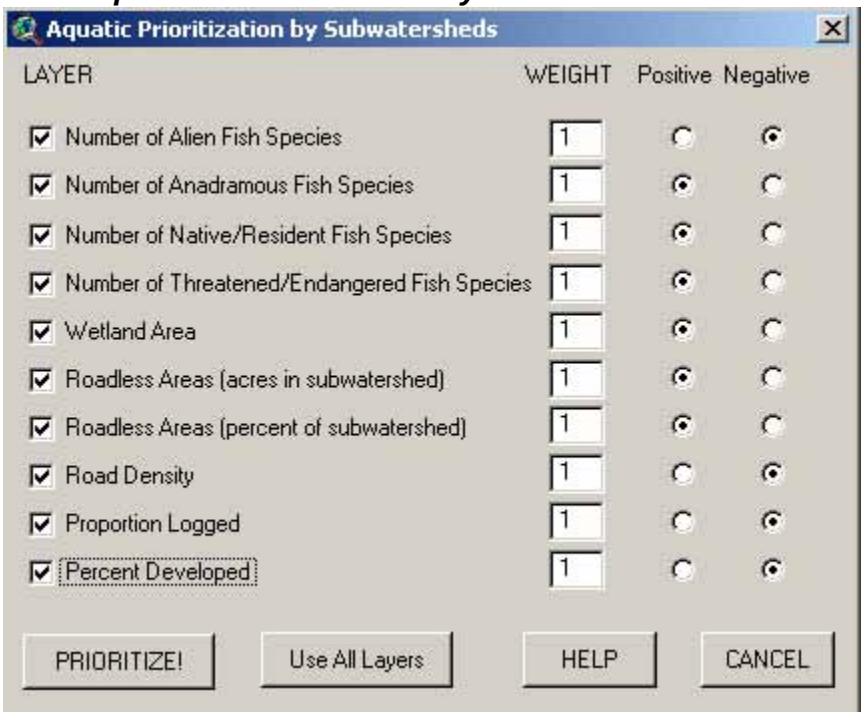
Example of an Aquatic Prioritization – By Stream



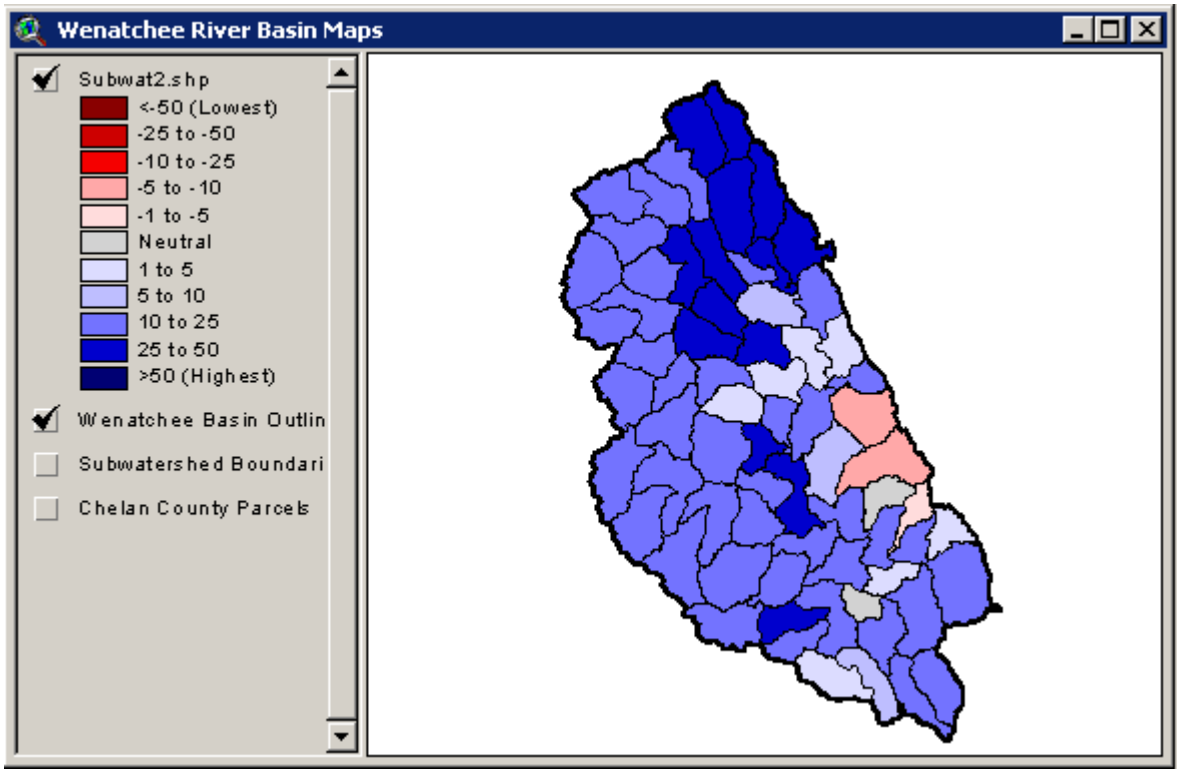
The map that resulted:



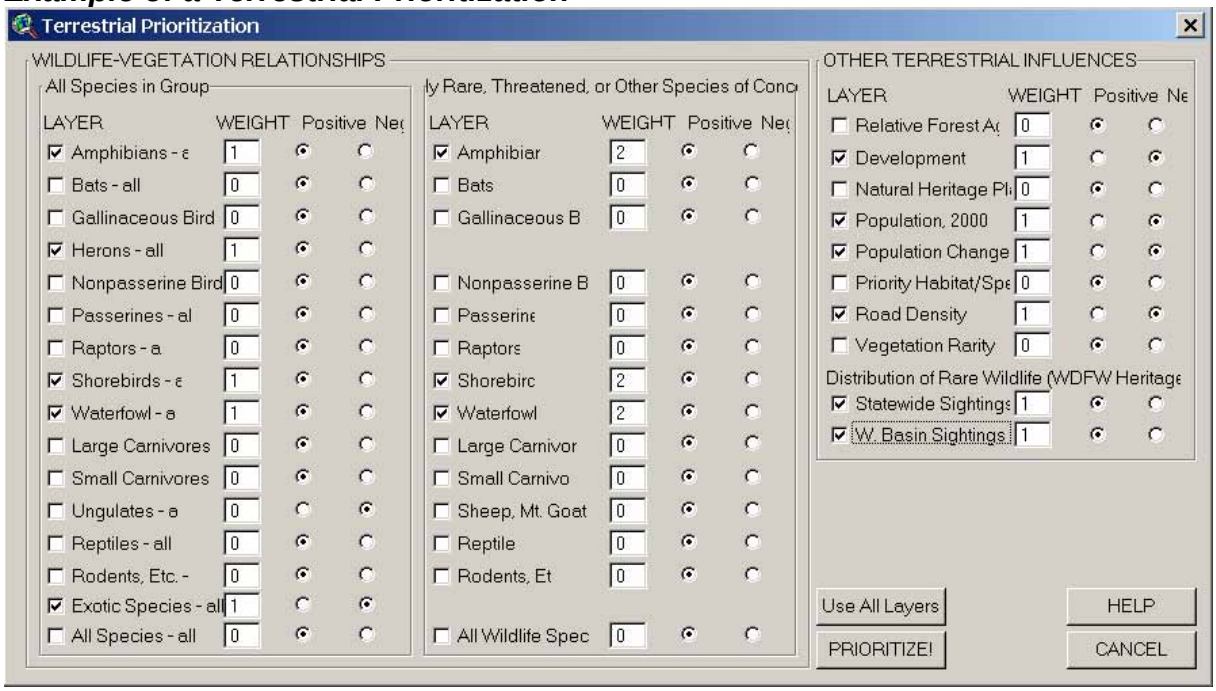
Example of an Aquatic Prioritization – By Subwatershed



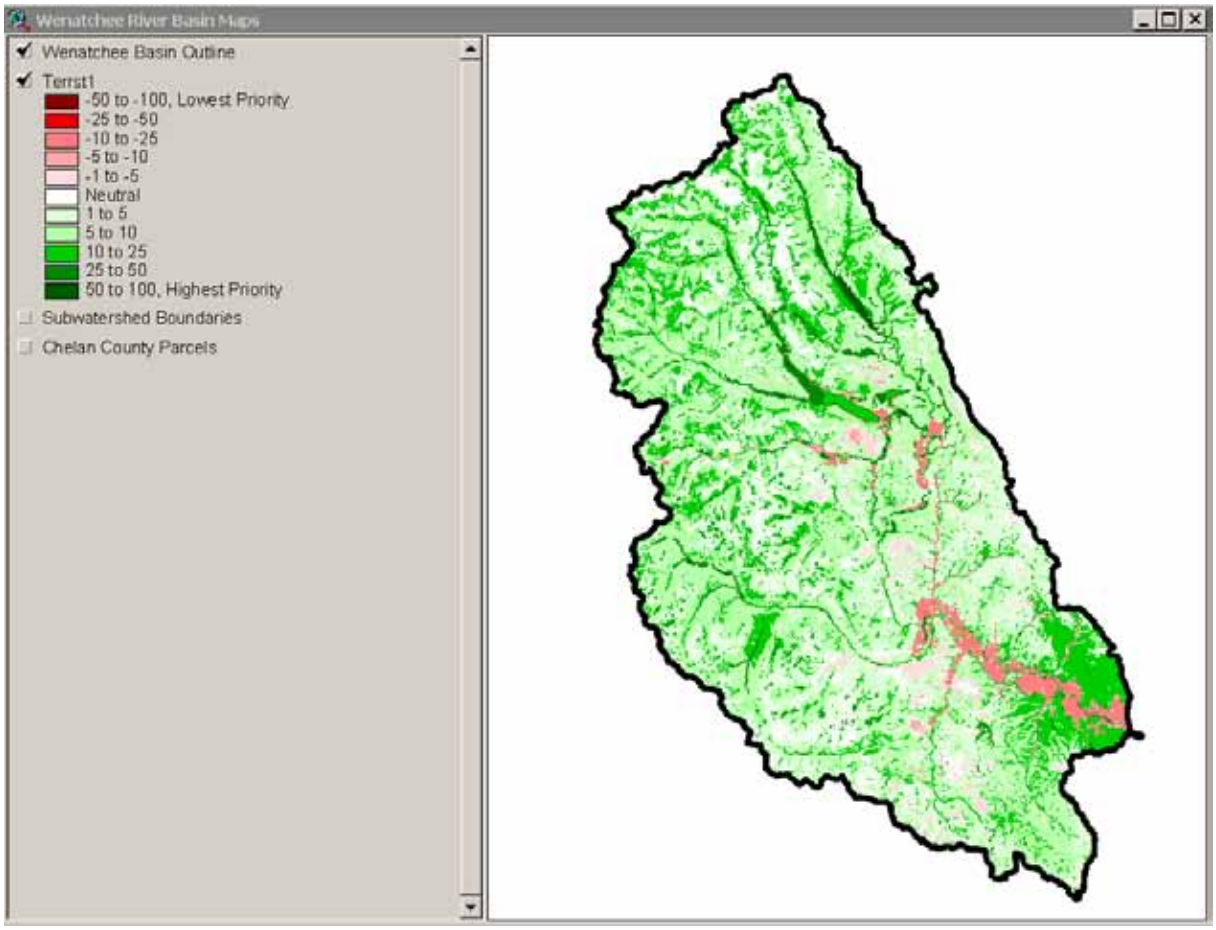
The map that resulted:



Example of a Terrestrial Prioritization

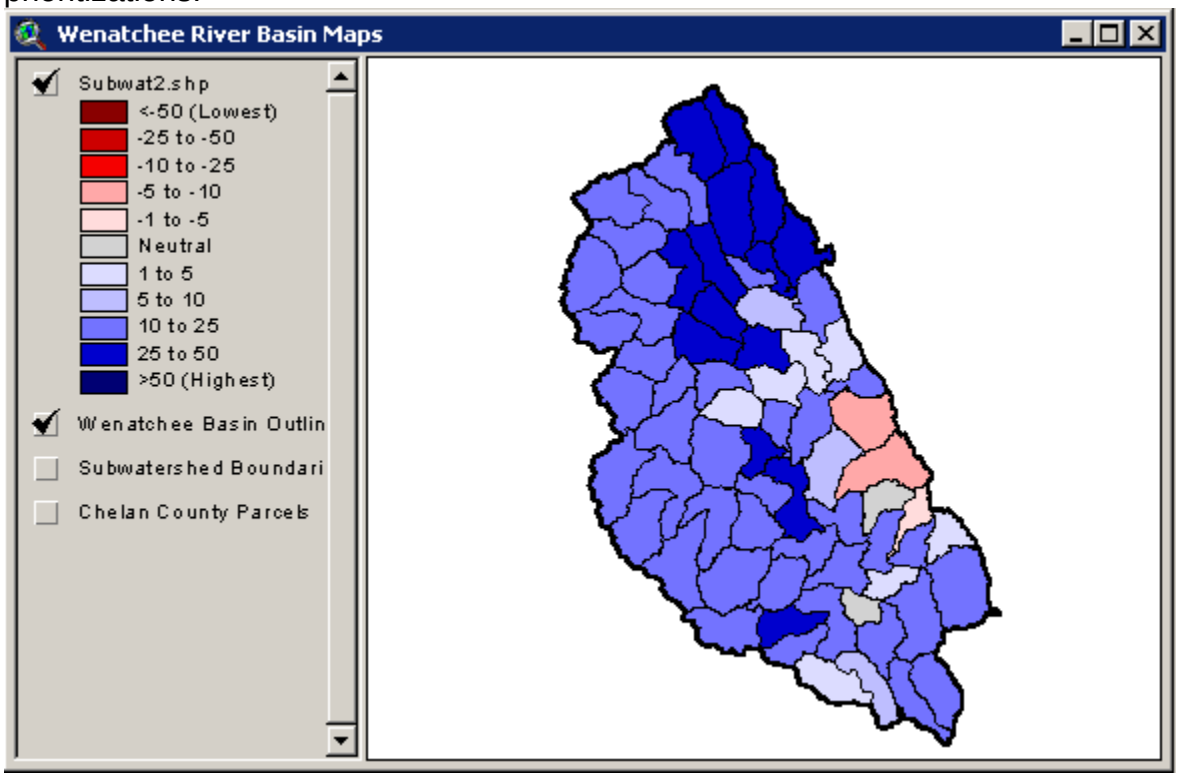


Note that once you click “PRIORITIZE!” the map may take a while to draw on. Here’s the map that resulted:



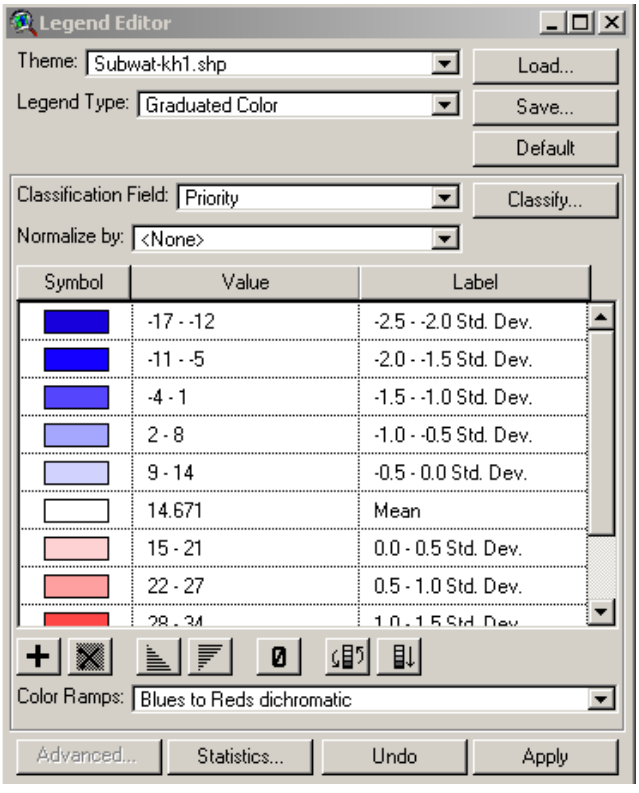
Interpreting Your Prioritization

Priority scores can range from –100 (maximum negative influence or least desirable for conservation – colored dark red), to zero (negative and positive influences offset or no influencing factors at the site – colored grey), to +100 (maximum positive influence or most desirable for conservation – colored blue [aquatic] or green [terrestrial]). You will view the results of your prioritization with the default scaling of <-50 to >50 points for subwatershed level prioritizations (since most values occur in the mid-ranges) and –100 to +100 for terrestrial prioritizations.



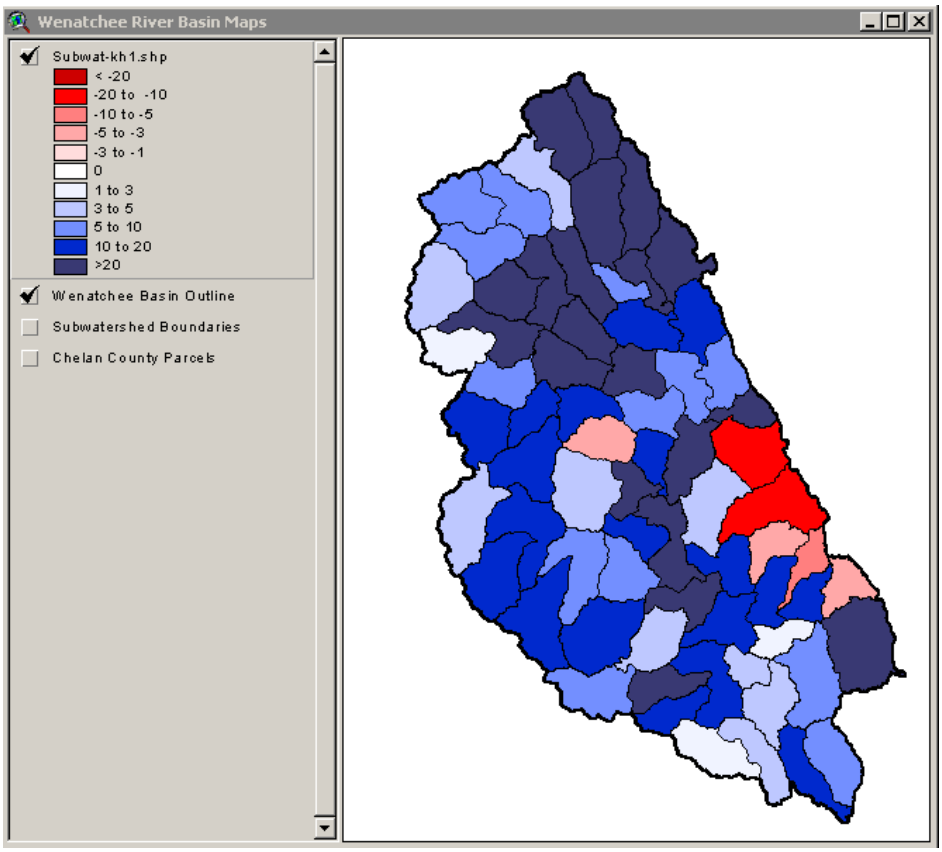
Differences may be difficult to detect, so you can re-scale the scores by double-clicking on the layer name to open the *Legend Editor* and adjusting the scale ranges. Adjusting the scores around the mean score, from highest to lowest value will show more variation between areas.

You can do this either manually, or by selecting "Classify…" "Type = Standard Deviation" "Number of Classes = ½ Std Dev."

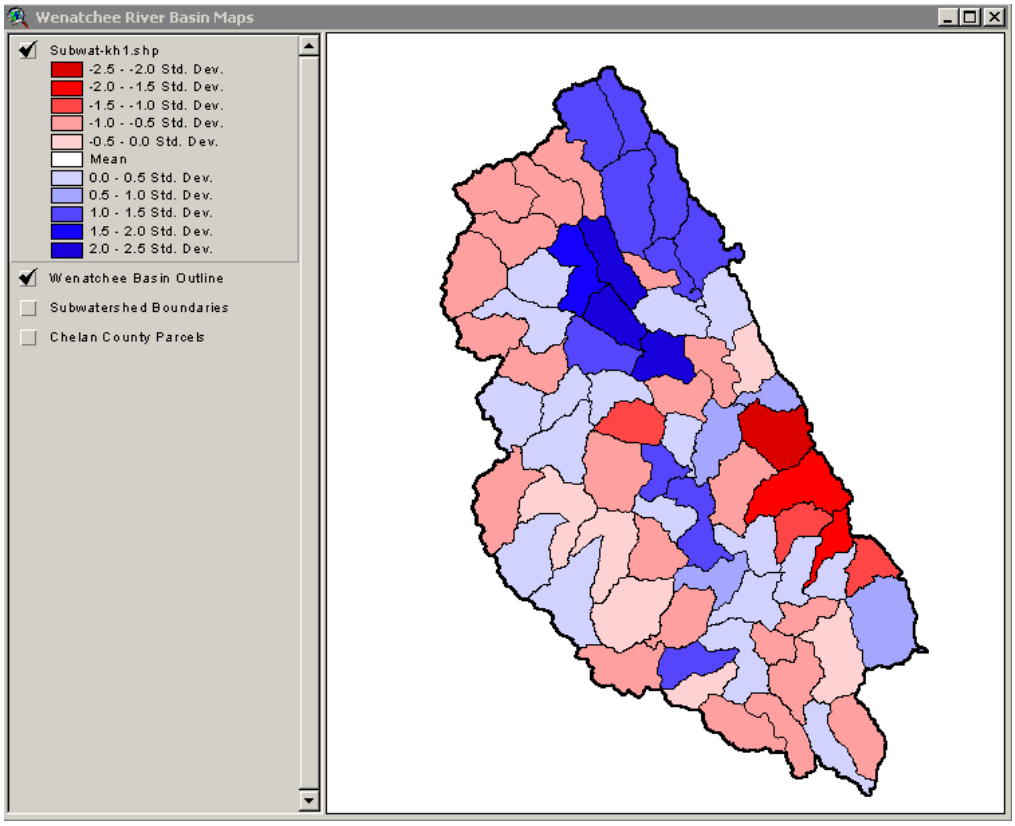


Below is a map that resulted from using the same data values as the map above, but adjusting the prioritized values from the lowest to the highest priority (in this case –20

and +20). Note that you can see greater variation between areas



Below is a map that resulted from adjusting the prioritized values around the mean value using the Standard Deviation function. Compare this map to the one above~ Similar watersheds are classified as high and low priority.



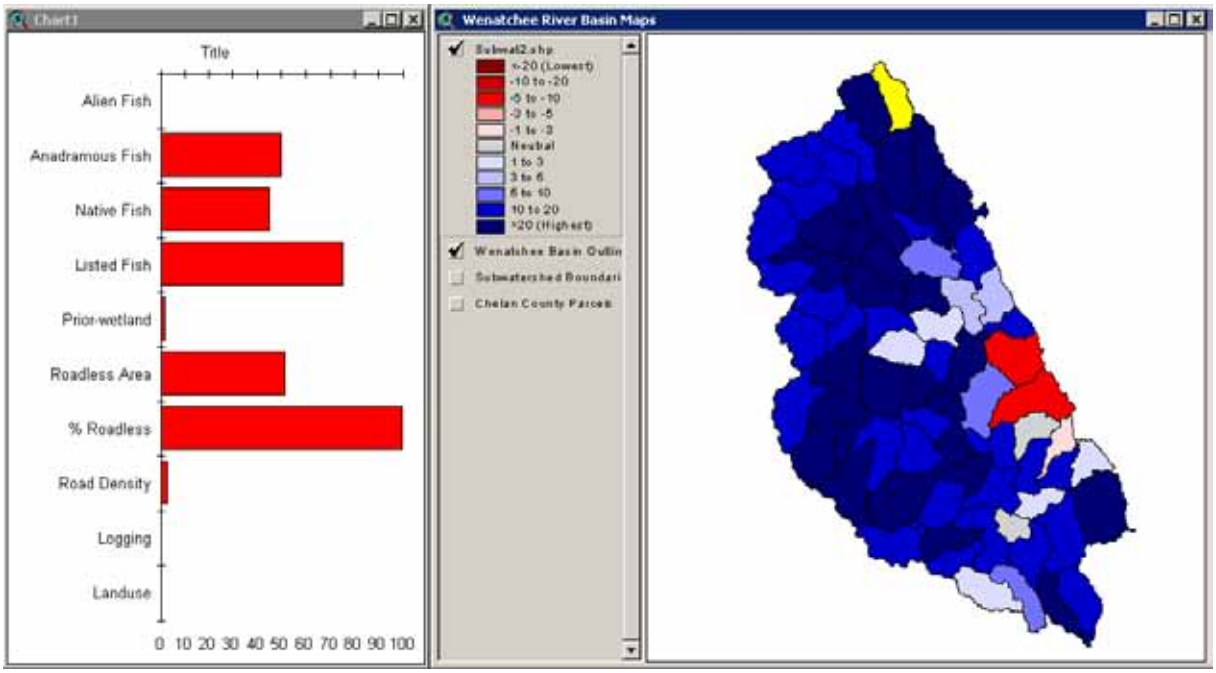
Note that you will want to adjust the scaling and the color scheme in a way that makes the most sense to you!

If you get confused, just remember that what the prioritization maps are showing are indications of the RELATIVE value of the different areas in terms of the biological and environmental criteria that you deemed as important. The areas that come out as neutral, or around 0, are those that have a pretty even number of positive and negative characteristics. If there is not much difference between the areas on your map, this could be because the environmental conditions that you are looking at do not vary much across the Basin.

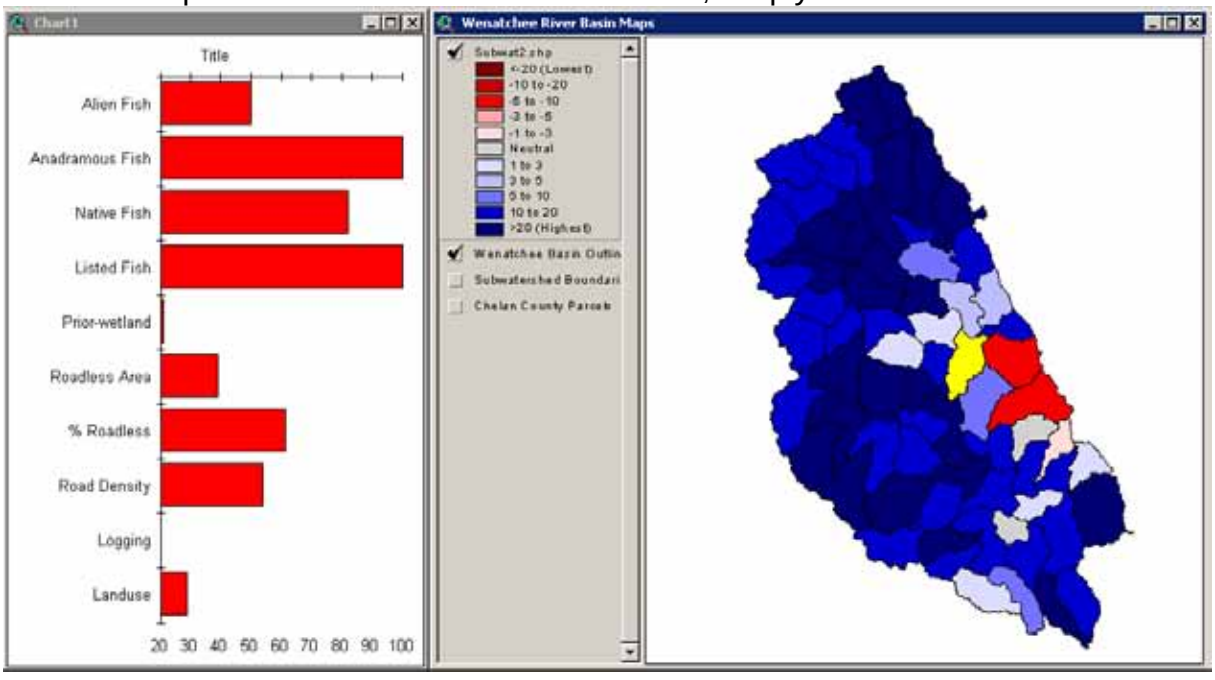
Prioritizations are meant to be indications of which areas might have high conservation value. You will have to do ground checks and gather other information before making a final conservation decision.

Examine Components of Subwatershed Prioritization Score

For Aquatic Prioritizations at the Subwatershed level, you can examine the relative values for all the layers to help determine why scores between different subwatersheds are different by selecting the **Examine Components of Subwatershed Prioritization Score** from the **DSS Tool Menu**. This will create a chart like the one below, showing the relative contributions of the layers for the highlighted subwatershed. Factors that contributed a negative influence will also be shown. In the sample prioritization below, the amount of Roadless area in the subwatershed contributed the most to the shed's biological value, followed by the number of listed and anadromous fish in streams fed by the subwatershed. Whether the factor has a positive or negative influence is not accounted for in the charts.



To view components for a different subwatershed, simply click on it.



SYNTHESIS

The Many Perspectives to Conservation Prioritization

The importance of a particular patch of habitat depends on the many factors. 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.

For this project we have assembled a vast array of information and constructed a conservation decision support system that is designed to allow the user to evaluate priorities from many perspectives. It is possible to use this information to look at one conservation issue (e.g. the protection of one endangered species) but it is also possible to use this information to maximize the impact of any conservation action so that as many species or human values benefit from a conservation action.

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. 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.

Integration Of Aquatic And Terrestrial Conservation Priorities

The decision support system and the data layers that it queries are divided into aquatic ecosystem and terrestrial ecosystem components. It is useful to assess each component separately, and then compare them through overlaying the priorities determined for both components. The terrestrial and aquatic ecosystems are inextricably linked and effective conservation actions will explore the effects of the proposed action in both realms.

Conservation Prioritization At An Individual Parcel Level

Parcel level data is supplied with the decision support system and it is possible to determine parcel level priorites by overlaying the parcel data on the prioritization results. In this fashion you can attributed each private parcel in the Wenatchee River Basin with its average conservation value from the prioritization. This allows ranking of the private lands for possible conservation action and identification of which factors contribute to the value of that parcel.

There area also many other factors to consider when selecting high priority parcels for conservation purchase or other actions. Parcel size is often an important factor to consider, as large parcels often offer greater conservation opportunities and less management headache. Private parcels with small sizes are more likely to have already been developed and thus have little conservation potential. Large parcels with high priority will produce the largest gains to Basin-wide conservation. Figure 53 illustrates the range of parcel sizes encountered in the Wenatchee River Basin. There are still many parcels that are over 100 acres in size that offer conservation opportunities.

Parcel adjacency to public land is an important factor to consider for many conservation actions. When a parcel can be purchased that is immediately adjacent to public land it can often be transferred to public ownership. It also often adds to an existing block of relatively undisturbed habitat. Figure 54 illustrates the private parcels that are immediately adjacent to public lands in the Basin. It also illustrates parcels that are separated from public land by only one, two, three, four, and five parcels. Parcels that are adjacent to public lands, or blocks of parcels that together have public land adjacency should often be considered higher priority than parcels that are removed from public land.

Parcel cost is always an important factor when contemplating a conservation purchase. Figure 55 illustrates the parcel cost-per-acre for the private parcels in the Basin. Parcels with high conservation priority but low cost-per-acre are to be considered conservation bargains. These parcels should rise to the top of the list of parcels considered for immediate conservation action.

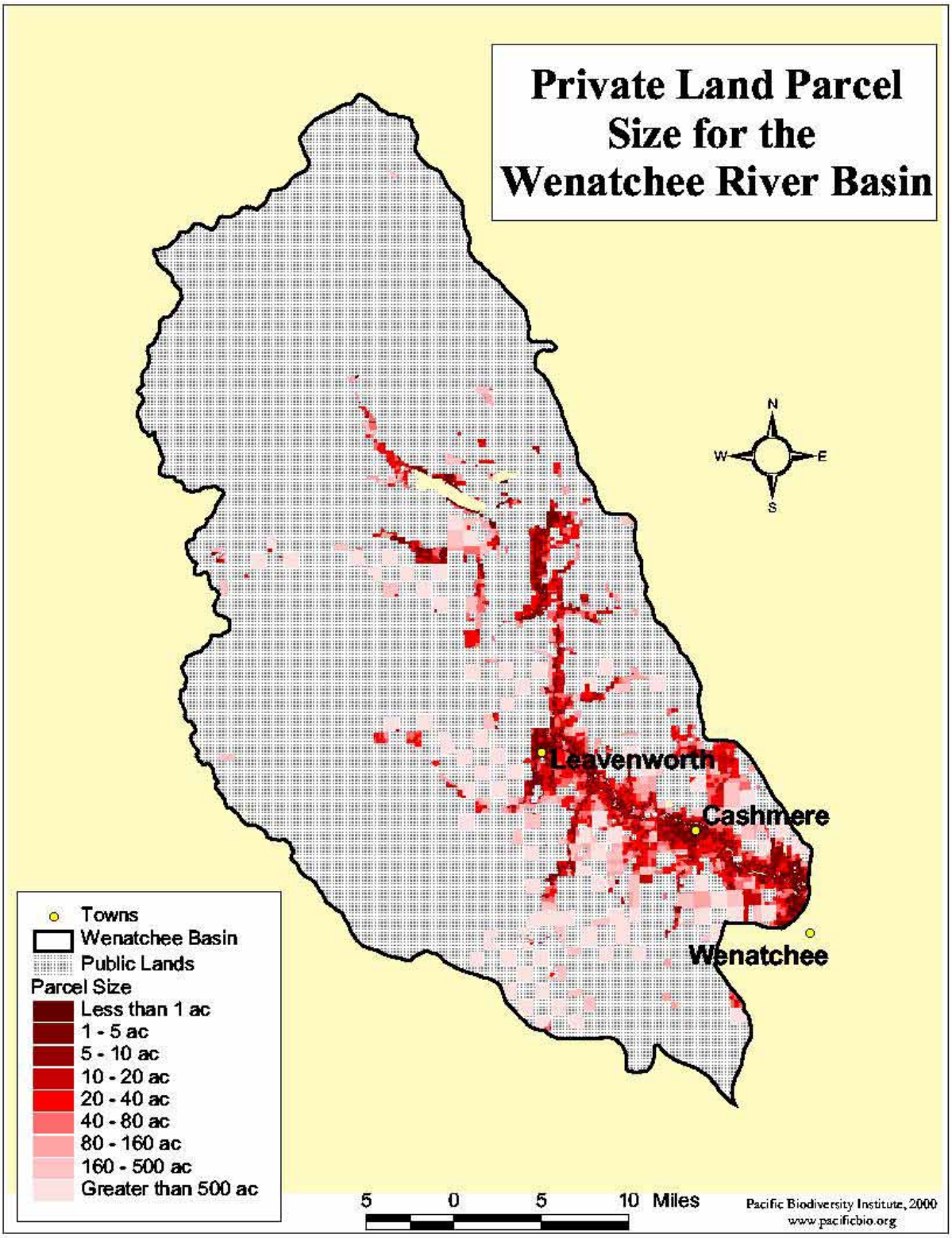


Figure 53. Parcel size for private land in the Wenatchee River Basin. Private parcels with small sizes are more likely to have already been developed and thus have little conservation potential. Large parcels with high priority will produce the largest gains to Basin-wide conservation.

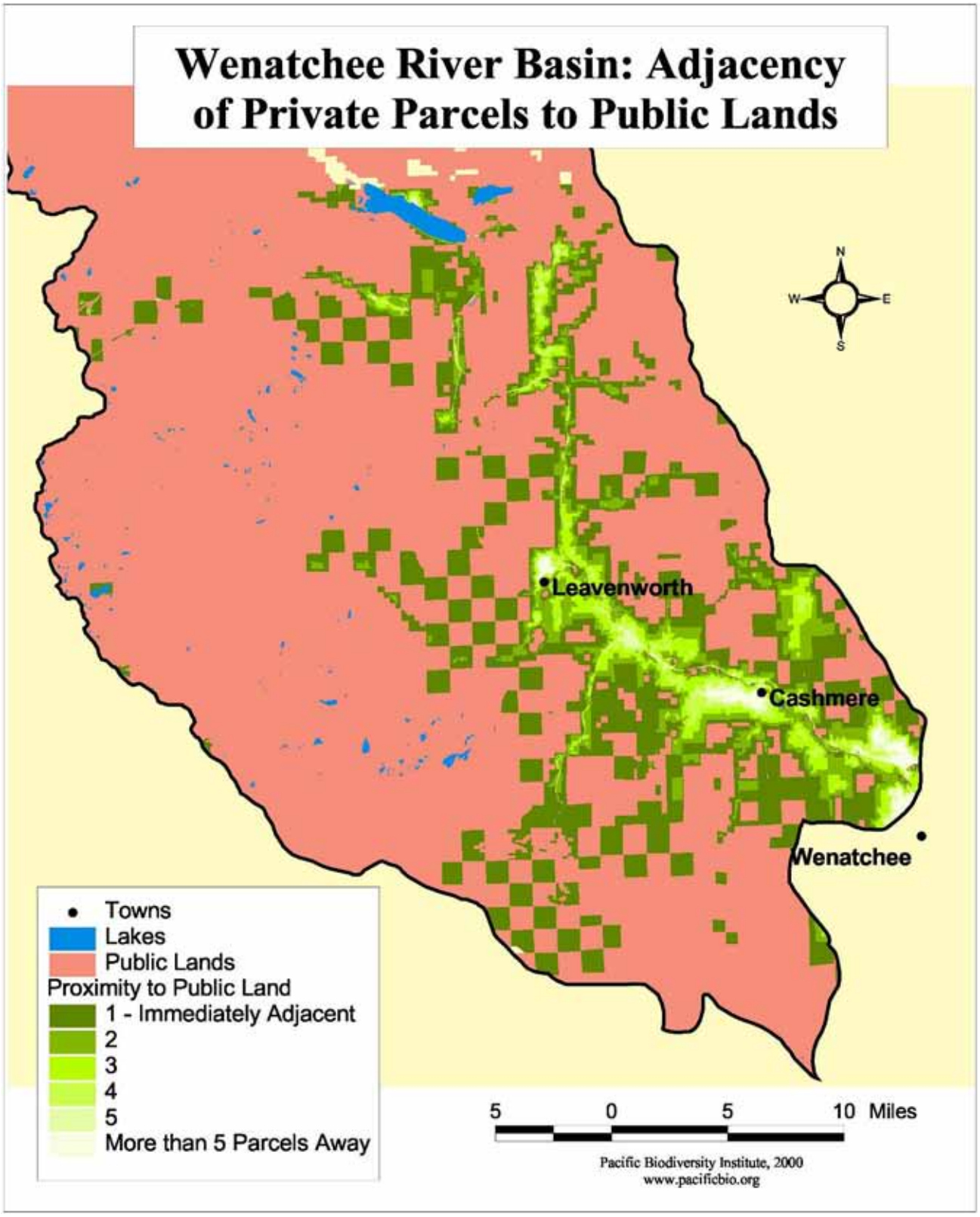


Figure 54. Adjacency of private parcels to public lands in the Wenatchee River Basin.

Parcels that are immediately adjacent to public lands are shown in dark green. Parcels in lighter shades of green are farther away from public lands.

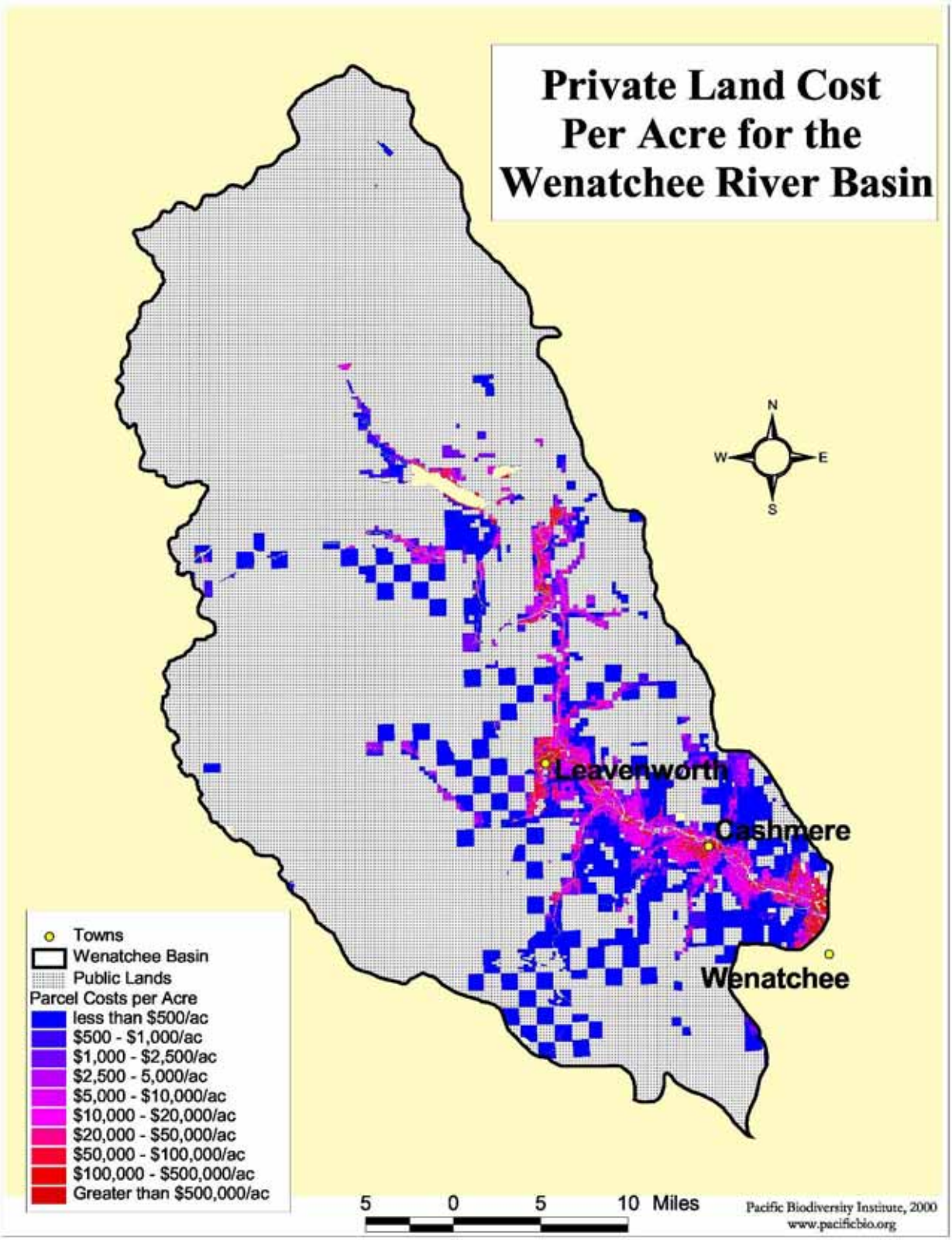


Figure 55. Cost per acre for private lands in the Wenatchee River Basin. The highest cost-per-acre parcels are shown in reds and purples. Low cost-per-acre parcels are shown in blue.

Examination of Conservation Priority Results

The conservation priority results from the decision support system and the information contained in the master environmental database we have created for the Icicle Fund can be examined to further explore the characteristics of a high priority area. First, we suggest you use the satellite imagery and digital aerial photography to inspect the area. Secondly, you can examine each underlying data layer to see the biological and environmental characteristics of the area.

RECOMMENDATIONS

Appropriate Uses for the Conservation Decision Support System

This report should be considered a description of many of the natural resources present in the Wenatchee River Basin. It also describes a tool – the Conservation Decision Support System that can access a wide variety of information on natural resources and aid in the exploration of conservation priorities.

Conservation prioritization is ideally an interactive and iterative process. The examples presented in this document are only one way of looking at things and there are many other valid ways. Several 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.

The results from the DSS designed for the Wenatchee River Basin are intended to identify areas with high conservation potential and high risk relative to other areas *within* the basin. The areas identified 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 and the DSS are only directly applicable to the Wenatchee River Basin.

Just because a piece of land does not receive a high priority rating does not mean that it is not of significant conservation value. The DSS looks for areas where many factors coincide – indicating high levels of ecological integrity and biodiversity. But, each of the component measures is important and any prospective piece of land should be evaluated against each component individually.

Next Steps

Future Enhancements To Spatial Data For Use In Conservation Planning Within The Wenatchee River Basin

The need remains to improve and add information that will be valuable in the conservation planning process. Some of the data the data that could stand additional improvement includes:

- **Greatly improved vegetation and forest stand condition data**. Although many efforts have been undertaken to map vegetation types and forest condition, there is still substantial room for improvement. Many experts that are familiar with the current vegetation data recognize this fact. Particular improvement is needed in the ability of the vegetation data to accurately map variation in forest age, structural characteristics and species composition. There is also great room for improvement in vegetation that accurately reflects the variation in non-forested plant communities. Since vegetation is the most important determinant of wildlife habitat, improved vegetation data would allow for much better wildlife management. It would also enable better land management and conservation planning.
- **Accurate historical landscape condition and vegetation data** from several time periods: late 1800's, 1950, and 1970's.
- **Data on other wildlife such as invertebrates, butterflies, mollusks**.
- **Data on where hatchery fish are released.**
- **A complete culvert inventory** that incorporates and reconciles all existing data.
- **Invasive weed data.** Including extent of existing weed populations and areas where potential invasions are likely.
- **Information on where grazing occurs** on private land and the level of grazing and its effect on vegetation composition and structure.
- **Digital data of where future logging activities are planned.**
- **Fish habitat use by life stage.**
- **Detailed aerial photo and field-based riparian zone vegetation mapping** for the anadromous fish-bearing streams.
- **Detailed mapping of channel and bank condition** along all anadromous fish-bearing streams.
- **More complete, up to date, historical logging activity data** (what are management types?)
- **Data on amount of use each road gets**, whether it's a dirt road or paved road or highway – and the traffic volumes on each road.

Many other data sets will need periodic updating and improvement. 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.

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.

Future analysis of ecological integrity and conservation priorities:

We have just scratched the surface of the use of this data to analyze ecological integrity within the Wenatchee Basin. There are many uses for this data and the

DSS that we have only begun to explore. Here are some examples of interesting future analyses:

- Investigate the way the different terrestrial ecosystem factors and disturbance factors influence individual wildlife species.
- Analyze the landscape changes that have occurred and project the future landscape condition given current trends.

A build-out analysis within Wenatchee Basin.

CONCLUSIONS

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. The presence of high priority lands in the unprotected part of the landscape calls for greater levels of stewardship and more attention to the protection of the ecological integrity of these lands. A collaborative approach that involves many interests is needed to insure that the Wenatchee Basin continues to be such a remarkable place.

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