Snake Hells Canyon Subbasin Assessment

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0 Introduction to Snake Hells Canyon Subbasin Assessment

This assessment is volume one of the *Snake Hells Canyon Subbasin Plan.* Volumes two and three—the inventory and management plan—are provided under separate cover. This assessment was produced as part of the Northwest Power and Conservation Council's (NPCC) subbasin planning process. The assessment, inventory and plan will help direct Bonneville Power Administration's (BPA) funding of projects that mitigate for damage to fish and wildlife caused by the development and operations of the Columbia River basin's hydropower system.

An adopted subbasin plan is intended to be a living document that increases analytical, predictive, and prescriptive ability to restore fish and wildlife. The *Hells Canyon Subbasin Plan* will be updated every three years to include new information to be integrated in a revision of the biological objectives, strategies, and implementation plan. The NPCC views plan development as an ongoing process of evaluation and refinement of the region's efforts through adaptive management, research, and evaluation. More information about subbasin planning can be found at www.nwcouncil.org.

The *Hells Canyon Subbasin Plan* includes three interrelated volumes that describe the characteristics, management, and vision for the future of the Hells Canyon subbasin:

Assessment (Volume 1)—The assessment is a technical analysis that examines the biological potential of the Hells Canyon subbasin to support key habitats and species, as well as factors limiting this potential. These limiting factors provide opportunity for restoration. The assessment describes existing and historic resources and conditions within the subbasin, focal species and habitats, environmental conditions, impacts outside the subbasin, ecological relationships, limiting factors, and a final synthesis and interpretation. A **technical team** was formed to guide development of the assessment and technical portions of the management plan. The technical team was comprised of scientific experts with the biological, physical, and management expertise to refine, validate, and analyze data used to inform the planning process.

Inventory (Volume 2)—The inventory summarizes fish and wildlife protection, restoration, and artificial production activities and programs within the Hells Canyon subbasin that have occurred over the last five years or are about to be implemented. The information includes programs and projects, as well as locally developed regulations and ordinances that protect fish, wildlife, and habitat.

Management plan (Volume 3)—This management plan defines a vision for the future of the subbasin, including biological goals and strategies for the next 10 to 15 years. The management plan includes a research, monitoring, and evaluation plan to ensure that implemented strategies succeed in addressing limiting factors and to reduce uncertainties and data gaps. The management plan also includes information about the relationship between proposed activities and the Endangered Species Act (ESA) and Clean Water Act (CWA).

Multiple agencies and entities are involved in managing and protecting fish and wildlife populations and their habitats in the Hells Canyon subbasin. Federal, state, and local regulations, plans, policies, initiatives, and guidelines are part of this effort. The Nez Perce Tribe, Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife

(WDFW), and IDFG share management authority over the fisheries resource. Federal involvement in this arena stems from ESA responsibilities and from management responsibilities for federal lands, most notably the Hells Canyon National Recreation Area. Numerous federal, state, and local land managers are responsible for multipurpose land and water use management, including the protection and restoration of fish and wildlife habitat. Major management entities involved in developing the *Hells Canyon Subbasin Plan* are outlined below.

Nez Perce Tribe

The Nez Perce Tribe served as lead entity for subbasin planning for the Hells Canyon subbasin. The tribe contracted with the NPCC to deliver the Hells Canyon Subbasin Plan while providing opportunities for participation in the process by fish and wildlife managers, local interests, and other key stakeholders, including tribal and local governments.

The Nez Perce Tribe is responsible for managing, protecting, and enhancing treaty fish and wildlife resources and habitats for present and future generations. Tribal government headquarters are located in the Clearwater River subbasin in Lapwai, Idaho, with offices in Kamiah and Orofino, Idaho. The NPT has treaty-reserved fishing, hunting, and gathering rights pursuant to the 1855 Treaty with the United States. Fish and wildlife activities relate to all aspects of management, including recovery, restoration, mitigation, enforcement, and resident fish programs.

Northwest Power and Conservation Council

The NPCC has the responsibility to develop and periodically revise the Fish and Wildlife Program for the Columbia Basin (NPCC 2000). In the 2000 revision, the NPCC proposed that 62 locally developed subbasin plans, as well as plans for the mainstem Columbia and Snake rivers, be adopted into its Fish and Wildlife Program. The NPCC will administer subbasin planning contracts pursuant to requirements in its Master Contract with BPA (NPCC 2003). The NPCC will be responsible for reviewing and adopting each subbasin plan, ensuring that it is consistent with the vision, biological objectives, and strategies adopted at the Columbia Basin and province levels.

Bonneville Power Administration

The BPA is a federal agency established to market power produced by the federal dams in the Columbia River basin. As a result of the Northwest Power Act of 1980, BPA is required to allocate a portion of power revenues to mitigate the damages caused to fish and wildlife populations and habitat from federal hydropower construction and operation. These funds are provided and administered through the Lower Snake River Compensation Plan (LSRCP). BPA provided the funds for subbasin planning contracts administered by the NPCC.

The Nez Perce Tribe subcontracted with Ecovista to facilitate the planning process and write plan documents. The Nez Perce Tribe subcontracted with the Idaho Council on Industry and the Environment (ICIE) to organize the public involvement and public relations tasks for the Hells Canyon subbasin. Staff at the NPT, Ecovista and ICIE comprised the **Project Team**. The Project Team coordinated the formation of the **Hells Canyon Planning Team** and **Technical Team**. The Planning Team was composed of representatives from government agencies with jurisdictional authority in the subbasin, fish and wildlife managers, county, industry, and user group representatives, and private landowners. The Planning Team guided the public involvement process, developed the vision statement, helped develop and review the biological objectives, and participated in prioritizing subbasin strategies. The technical team included scientific experts who guided the development of the subbasin assessment and plan. The technical team guided and participated in developing the biological objectives, strategies and research, and monitoring and evaluation sections of the plan, and the team reviewed all project documents. For more information about the Project Team, Planning Team and Technical Teams, including lists of participants, please see the introduction to Volume Three, *Snake Hells Canyon Subbasin Management Plan*.

For more information on subbasin planning and on subbasin planning in the Snake Hells Canyon Subbasin, please see the introduction to Volume Three, *Snake Hells Canyon Subbasin Management Plan*. This volume also contains information on public involvement and the review process.

1 Subbasin Overview

1.1 Subbasin Size and Location

The Snake Hells Canyon subbasin includes the mainstem of the Snake River and the small tributaries that flow into it as the Snake River flows from Hells Canyon Dam to the mouth of the Clearwater River at Lewiston, a length of 109 miles (river mile [RM] 247 to RM 138; Figure 1). The Snake River forms the border between Oregon and Idaho for the upper 71 miles of the subbasin and the border between Washington and Idaho for the lower 38 miles. The subbasin contains 862 square miles, or 551,792 acres. About 62% of this area falls in Idaho, 31% is in Oregon and the remaining 7% is in Washington. The subbasin contains part of five counties: Adams, Idaho, and Nez Perce in Idaho; Asotin in Washington; and Wallowa in Oregon. The lower portion of the subbasin contains the town of Asotin and portions of Clarkston and Lewiston. The remainder of the subbasin is either rural or undeveloped. The Salmon, Imnaha, Grande Ronde, and Clearwater rivers, as well as Asotin Creek, are major tributaries that join the Snake River in the Snake Hells Canyon subbasin. These rivers drain a combined area of 19,280 square miles (12,339,200 acres) and dramatically influence the water quality and hydrologic conditions in the Snake River.

Archaeological evidence suggests that the Snake Hells Canyon subbasin has been inhabited by Native Americans for the last 7,100 to 10,000 years. The subbasin's relatively mild winters, lush forage, and plentiful wildlife made it a particularly attractive home. It was consistently inhabited by the Nez Perce and frequently visited by the Shoshone-Bannock, Northern Paiute, and Cayuse Indians. The canyon's rock walls were an ideal canvas for ancient pictographs, and the inaccessibility of the subbasin has aided in their preservation. The unique geology and inaccessibility of the subbasin have made it a place of extreme cultural significance (USFS 1999). The entire subbasin is within the lands ceded by the Nez Perce Tribe to the federal government under the Treaty of 1855, and the tribe maintains treaty rights to fish, roots and berries, hunting, and pasture for horses and livestock in this area (Figure 1).

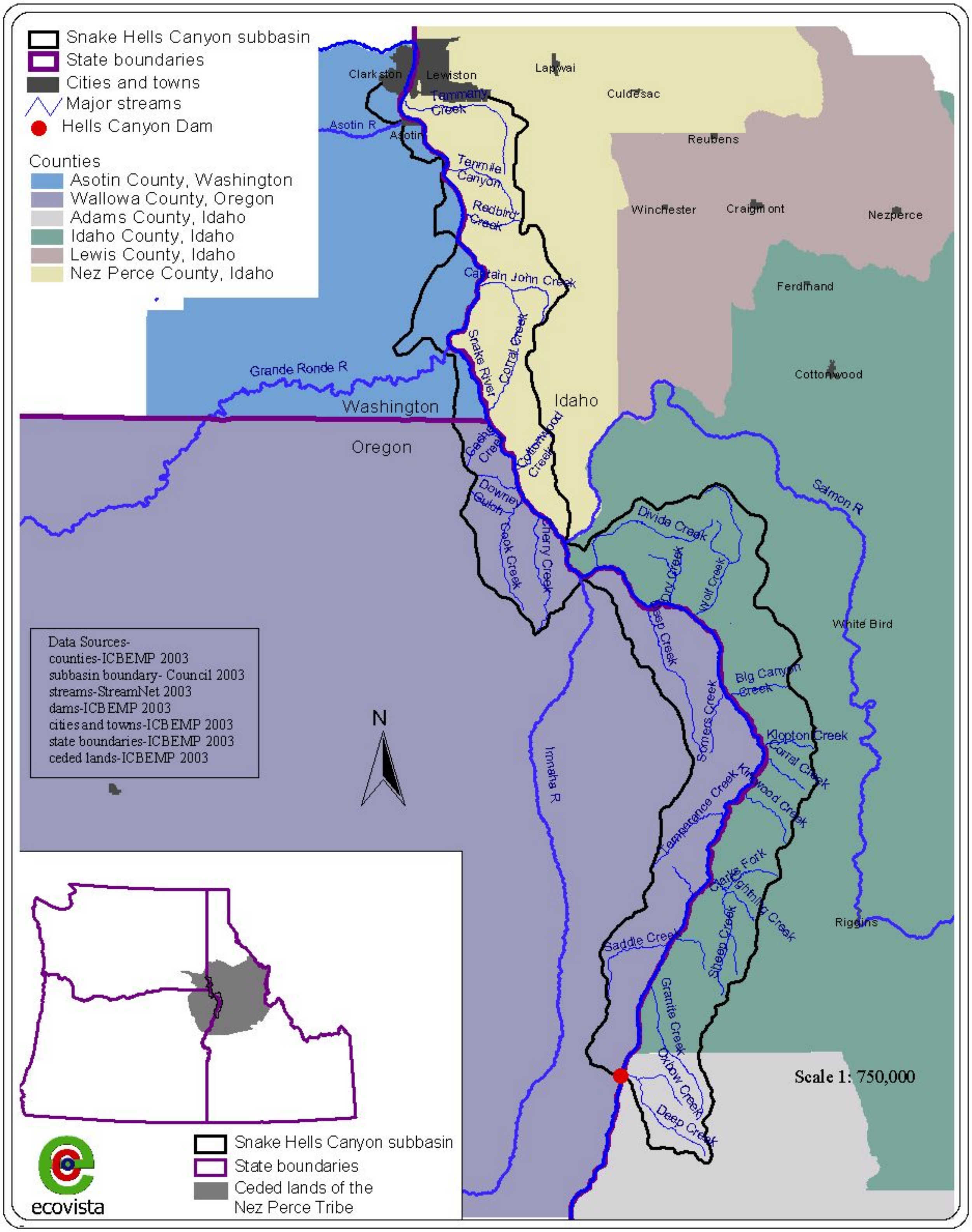

Figure 1. Location and major features of the Snake Hells Canyon subbasin.

1.2 Topography, Geology, and Soils

Elevations in the Snake Hells Canyon subbasin are highly variable, ranging from a low of 218 meters (715 feet) at its confluence with the Clearwater River (RM 139.3) to more than 2,860 meters (9,384 feet) in the peaks of the Seven Devils Mountains (Figure 2). He Devil Mountain, the tallest of the Seven Devils, towers almost 8,000 feet above the river below, creating the deepest gorge in the United States. The canyon averages 10 miles across. The upper part of the subbasin is characterized by an elevated mountainous mass cut by the deep canyons of the Snake and Salmon rivers; to the north is a gently undulating plateau 3,000 to 5000 feet in elevation (WDFW et al. 1990).

The most important events to shape Hells Canyon began about 13 million years ago when lava flows to the south dammed the Snake River, forming paleo-Lake Idaho, which was 150 miles long and 50 miles wide (Orr and Orr 1996). During this time, the Snake River was a tributary to the Salmon River north of Oxbow Dam. The mountain building of the Northern Rockies, which began sometime in the past 6 million years and still continues, uplifted the mountains to their current elevations, causing rivers and streams to rapidly incise the landscape and form the many canyons and gorges throughout the region (Orr and Orr 1996). Headward erosion of the Snake River in the southward direction cut through the lava dam, emptying Lake Idaho about 2 million years ago. The enormous amount of water spilling into the Snake River greatly increased the downcutting of the Hells Canyon, undercutting the Salmon River and making it a tributary to the Snake River at the same time (Vallier 1998).

The over-steepened side slopes of Hells Canyon caused many landslides to occur, forming many colluvial and alluvial fans near the base of the canyon. Wind-blown loess and volcanic ash have been deposited in the area and now mantle the ridges and summits on both sides of the canyon (USFS 1981a). During the late Pleistocene epoch (14,500 years ago), the Bonneville flood swept down through the Snake River, further steepening canyon slopes, creating terraces, and depositing gravels (Vallier 1998).

The formation of Hells Canyon is one of the most interesting geologic stories in North America. Major events begin in the Pennsylvanian period, about 300 million years ago when a volcanic island arc was accreted to the North American continent (Vallier 1998). The resulting formations containing volcanic, sedimentary, and metamorphic rocks are part of the Seven Devils Group (Orr and Orr 1996). The lithology of the Seven Devils Group includes argillite/slate, sandstone, mud/siltstone, interlayered meta-sedimentary, mafic meta-volcanic, and granitic gneiss. This group of rocks forms much of the bedrock through which the river currently cuts at the bottom of Hells Canyon and is an important influence on channel morphology and habitat (Hubbard 1956).

Jurassic and Cretaceous (160–120 million years ago) calc-alkaline intrusive granite associated with the Idaho batholith forms the high peaks of the Seven Devils Mountains and outcrops in various locations around Sheep Creek and the Triangle, Cactus, and Craig mountains (Vallier and Brooks 1986). The granite tends to weather into coarse granular sediment forming grussic, noncohesive soils prone to slope failure and mass wasting at higher elevations (McClelland et al. 1997).

The most dominate rock type in the Hells Canyon is the mafic volcanic flows from the early Miocene epoch (17.5–15 million years ago) Columbia River Basalt Group (Hooper and Swanson 1990). Many layers of lava form bench topography with cliff-faced rock outcrops intermixed with soils on the steep mid to upper slopes of the canyon (Figure 3). Basalt is prone to rockslides, forms many colluvium and alluvium deposits throughout the canyon, and is a major contributor of gravel and cobbles into the Snake River.

Soils within Hells Canyon influence erosion and sedimentation into the Snake River and its tributaries, affecting water quality and habitat. The primary factor governing soil development is the deep canyon itself, with steep continuous slopes that often continue well over a mile from the river to the crest of the mountain ridges on either side, ascending through several soil climatic regimes. Vegetation and soil development within the canyon are heavily influenced by the east/west-facing canyon sides that receive different precipitation and the north/south-slope aspects caused by many ephemeral streams receiving sunlight differently.

Soils in the canyon commonly contain varying amounts of coarse angular gravels, cobbles, silt, and ash (USFS 1981a). Many rock outcrops interrupt the soil landscape on the midslopes of the west-facing Idaho side and along the upper slopes of the east-facing Oregon side of the canyon. The intermittent outcrops and coarse material can inhibit erosion from surface runoff and reduce sediment transport.

Grassland soils called Mollisols are the dominant soil type in Hells Canyon (Figure 4). Many variations of this soil occur because it forms over the wide variety of conditions that exist throughout the canyon. The most common subtype forms in a semiarid environment and contains a clay-rich subsurface horizon. Near Lewiston, Idaho, the grassland soils at lower elevations with less precipitation are noted for having lime hardpans with some soils having natric or sodic horizons. In the higher elevations along the ridges of the Craig Mountains on the Idaho side of the canyon, clay-rich grassland soils grade into Alfisols. These soils often have an organic litter layer that protects them from surface erosion when left undisturbed.

In the area of the Seven Devils Mountains above 7,000 feet elevation, cold temperatures and recently exposed bedrock have severely restricted soil development and submature, coarse-grained, grussic soils called Inceptisols formed from granite and on the glacial till found in the area (USFS 1981b). These soils are noncohesive and prone to slope failure. Volcanic ash deposited over the whole region accumulated deep enough in the upper elevations on the Oregon side to form ashy soils called Andisols. These soils have a wide variety of properties, and erodibility is difficult to assess.

Few studies of soils and soil erosion have taken place in Hells Canyon, so information on the erosion characteristics and processes of soils is limited. Soils identified in the canyon are highly erodible (high K-factors) because of high silt/fine sand texture along with high concentrations of volcanic ash. However, surface erosion processes, such as rill and sheet erosion, are not as common in the canyon as in other nearby watersheds due to the undisturbed protective cover of grassland and shrub-steppe vegetation as well as forest canopies on many north-facing side slopes (Art Kreger, soil scientist, U.S. Forest Service [USFS], personal communication, May 2, 2001). Within the side slopes of the many draws on the Oregon side of the canyon in the bench topography, evidently some soil creep has taken place because deep current soils overlie horizons of rich, dark organic topsoil from past grassland soils (Art Kreger, soil scientist, USFS, personal communication, May 2, 2001).

Unlike soil erosion, the many hazards associated with geology in the Hells Canyon National Recreation Area (HCNRA) have long been studied (Vallier 1994, 1998). Erosion processes taking place in the canyon consist mainly of various forms of mass wasting, with rock and debris flows being the most prevalent. Sustained rainfalls and shaking from the many earthquakes that take place in and around Hells Canyon increase the likelihood of landslides occurring (Vallier 1994).

Because of the continuous steep slopes on either side of the canyon, landslides and debris flows can travel great distances downslope, often reaching the bottom. The colluvium at the bottom of many steep slopes, which is often unstable and subject to movement at any time, is also a source for sedimentation into streams. Undercutting by stream erosion or road construction has increased instability and movement on these deposits (Vallier 1994).

Rockslides in Hells Canyon and large falling rocks are an imminent danger to travelers in the HCNRA. Rock falls occur without warning on almost a daily basis. Rocks falling onto powerline roads have been known to leave indentations in these roads (Vallier 1994).

Although the many gravel bars, alluvial fans, river terraces, and landslides have occupied the Hells Canyon area for many thousands of years, sedimentation from fine material from more recent modern influences is still a large concern.

1.3 Climate and Weather

Climatic conditions in the Snake Hells Canyon subbasin are driven by summertime marine air moving up the Columbia River from the Pacific Ocean and Arctic air masses that spill over the Rockies during the winter. The 300-mile distance from the coast and the barrier provided by the Cascade Mountains moderates Pacific air masses and introduces many continental characteristics (Moseley and Bernatas 1991), such as hot summer temperatures (mean temperatures of 80–90 °F, with maximums often exceeding l00 °F) that are mediated by short and intense thunderstorms derived from thick, moist layers (Chapman 2001). In lower-elevation areas, occasional thunderstorms occurring from late spring through summer may result in flash floods that produce annual peak flows in localized areas. However, thunderstorms are generally brief and limited in size, resulting in highly localized impacts where they occur.

Arctic air masses may dominate the area during winter months, although Pacific air normally flushes these systems out, producing relatively mild winters (mean temperatures > 30 °F). At mid-elevations and on the upper plateau, temperatures are cooler with moderately severe winters and warm summers (Cassirer 1995). Precipitation comes in the form of short intense summer storms and longer, milder winter storms (IDEQ and ODEQ 2001). Timing, duration, and volume of peak flows are driven by snowmelt and/or seasonal rainstorms at lower elevations (< 5,000 feet) in the Snake Hells Canyon subbasin. Therefore, interannual variability in both the timing and volume of peak flows can be expected to be much greater than that at higher elevations. Rainstorms having the greatest impacts to hydrology at lower elevations are those occurring during winter or spring, with precipitation falling on frozen or snow-covered ground. Such rain-on-snow events can occur from November through March (Thomas et al. 1963) and may result in hydrograph peaks throughout this period.

Between 1961 and 1990, the average annual precipitation measured near Lewiston was 12.4 inches. The maximum annual precipitation recorded at this location during the same time period was 15.4 inches. Precipitation patterns do not change dramatically upstream: measurements taken at Weiser, a small town 225 miles upstream of Lewiston and 109 miles upstream of Hells Canyon Dam, indicate little change in precipitation patterns from those measured at Lewiston. Between 1961 and 1990, the average annual precipitation measured at Weiser was 11.3 inches. The maximum annual precipitation recorded at Weiser during this period was 16.3 inches (IDEQ and ODEQ 2001). Precipitation patterns do change dramatically with elevational increases in the subbasin. Data generated by the PRISM project indicate that the highest average annual precipitation of 51 inches per year occurs in the Seven Devils Mountains, the highest elevational area of the subbasin (Figure 5; Daly et al. 1997). Above 5,000 feet, more than 70% of the annual precipitation is in the form of snow (IDEQ 1998).

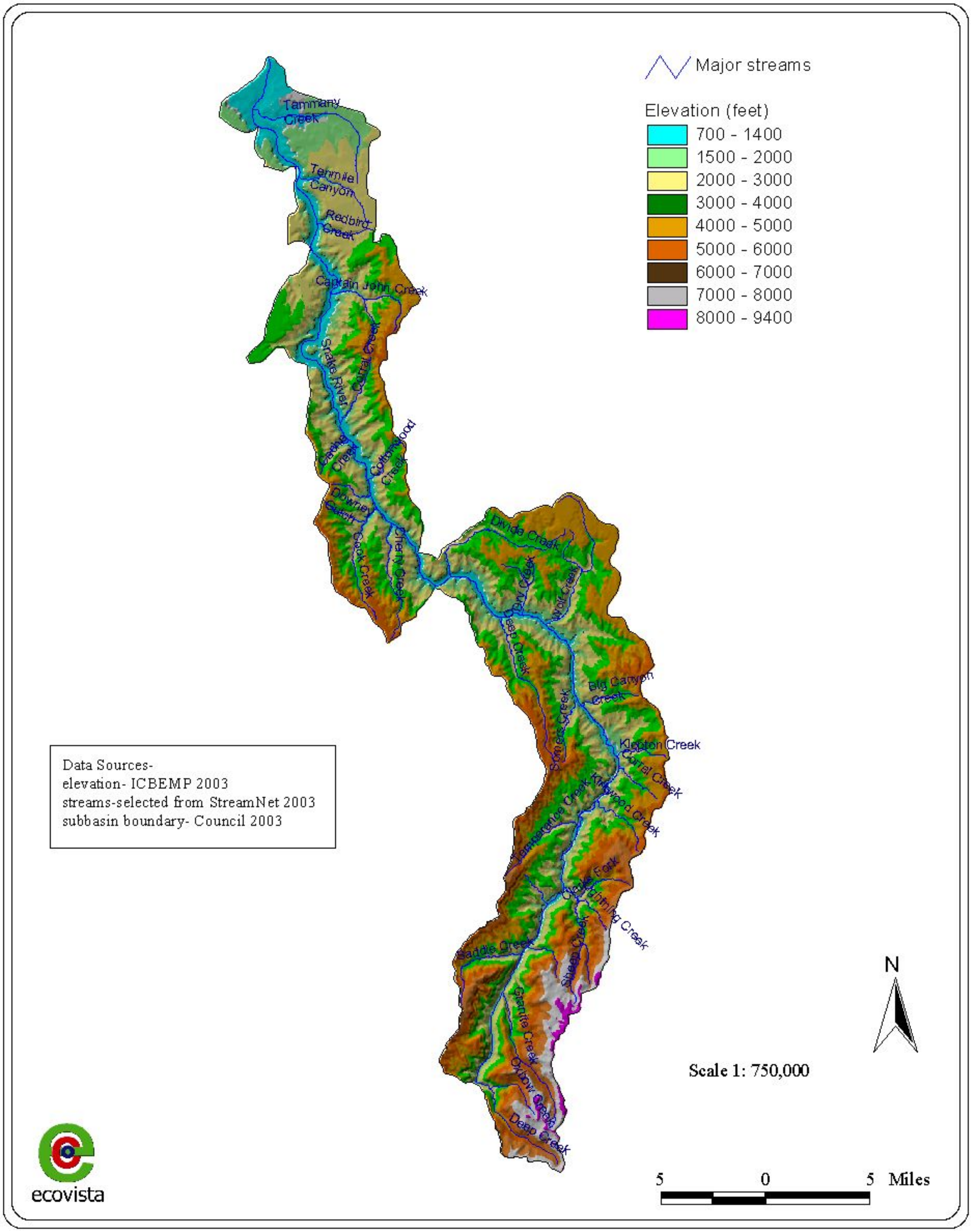

Figure 2. Topography and elevation in the Snake Hells Canyon subbasin.

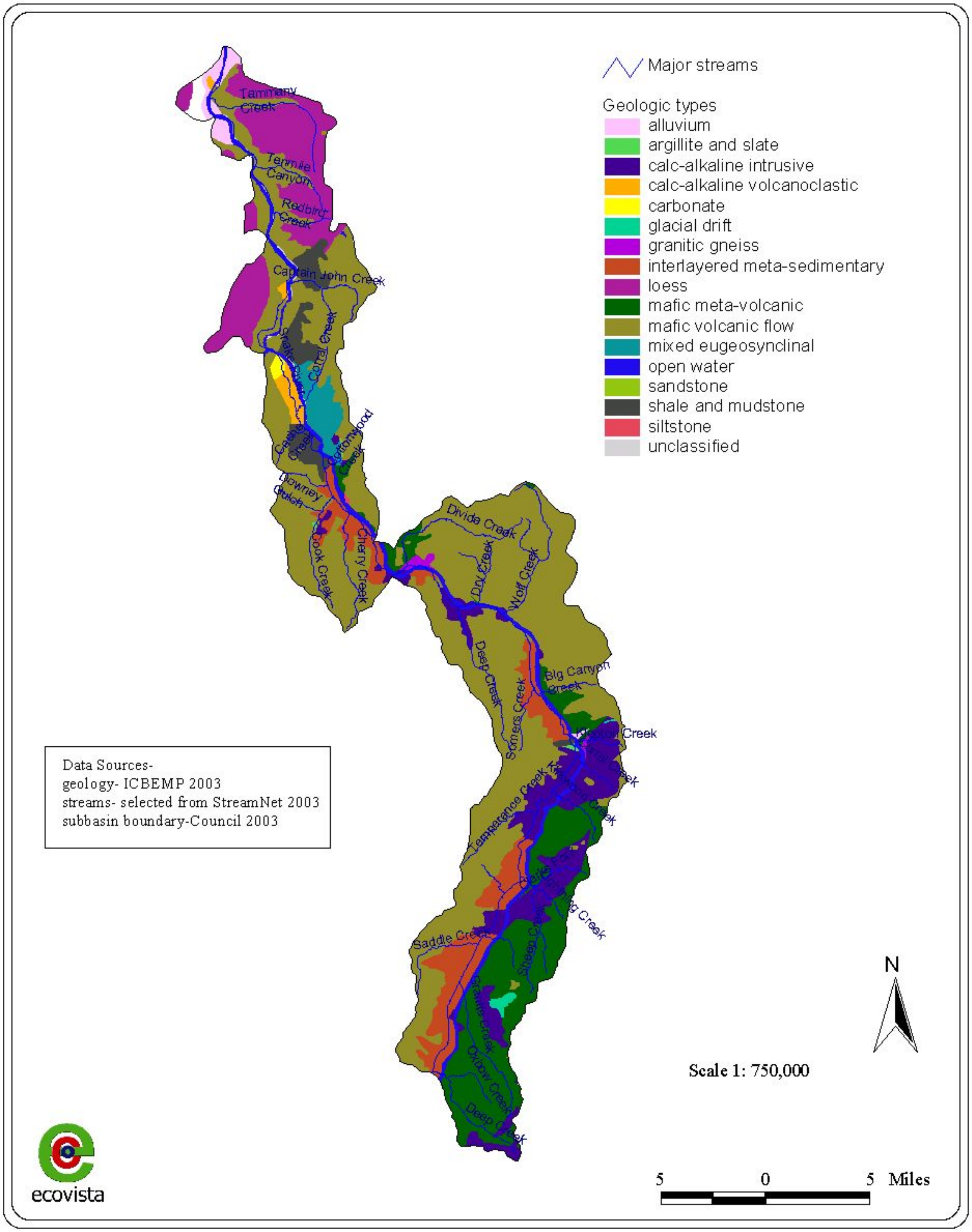

Figure 3. Geology of the Snake Hells Canyon subbasin.

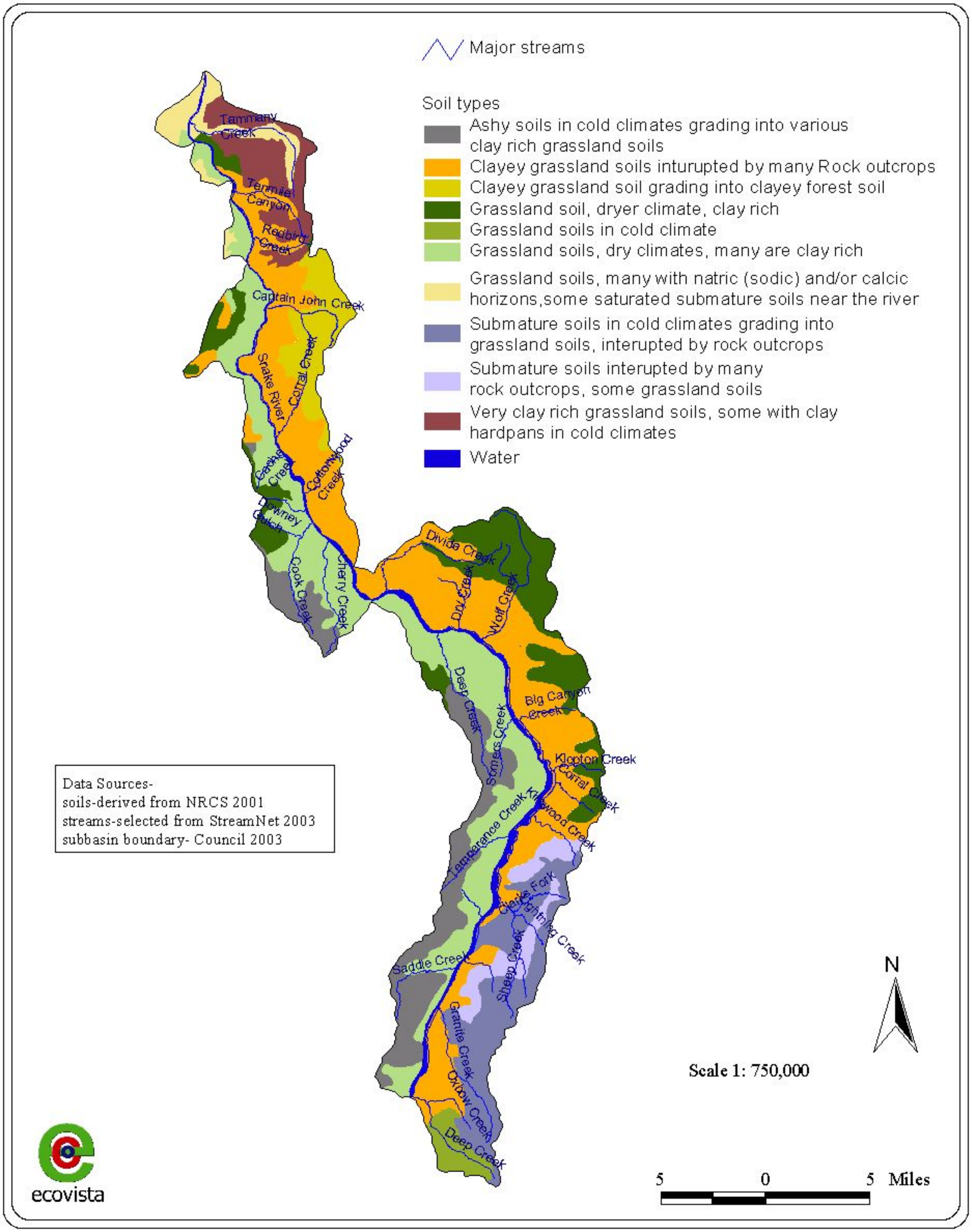

Figure 4. Soils of the Snake Hells Canyon subbasin.

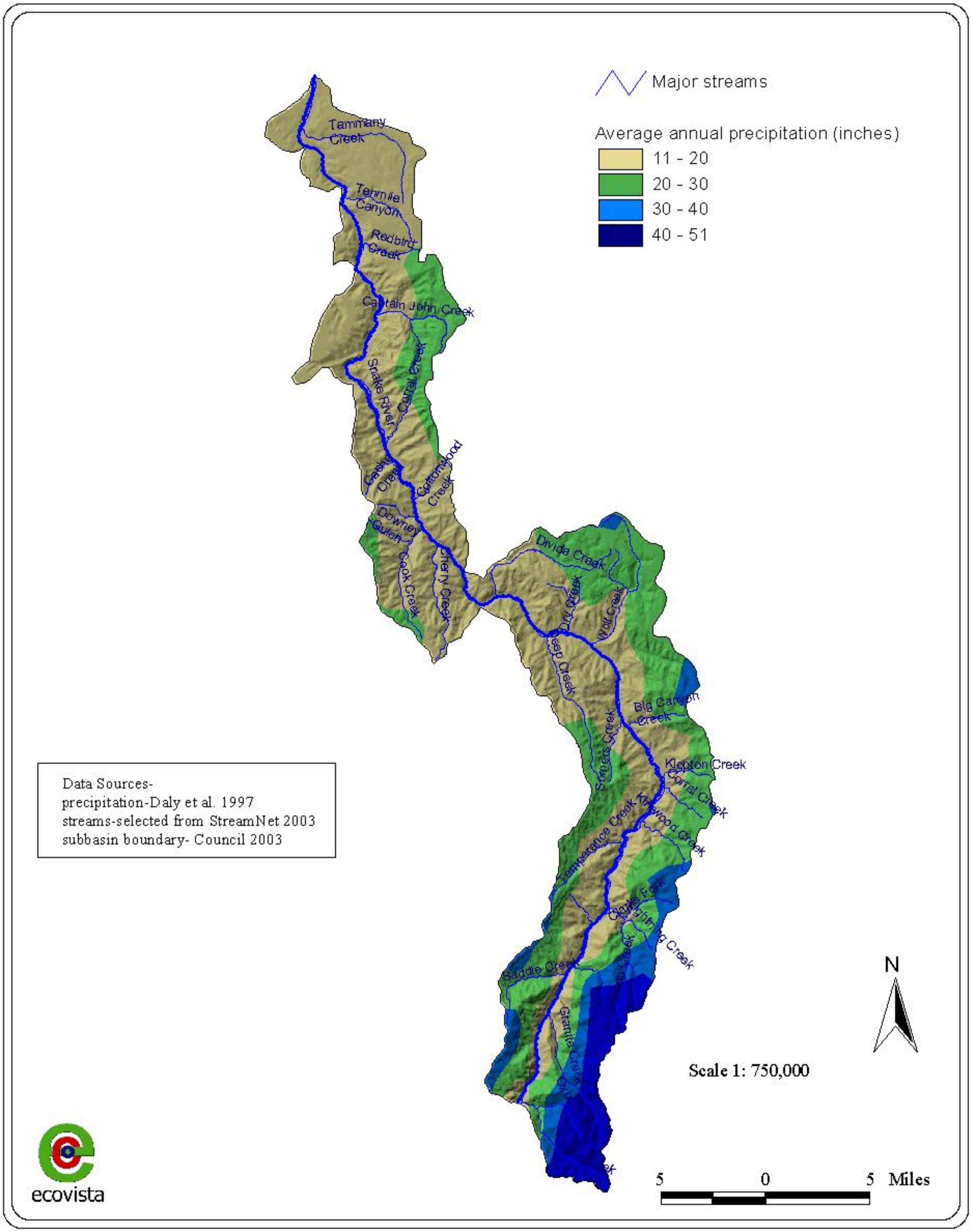

Figure 5. Precipitation patterns in the Snake Hells Canyon subbasin.

1.4 Land Cover and Wildlife Habitat Types

The flora of the Snake Hells Canyon subbasin is exceptionally diverse. This diversity reflects the complex topography, varied soil conditions, and dispersal corridors provided by the Snake and Salmon rivers. The area is home to many rare and endemic species of plants (Mancuso and Moseley 1994). This rich flora is known to include at least 650 vascular plant species, of which approximately 77% are native. Asteraceae (aster family) is the largest contributor to the flora, with a documented 98 species, followed by Poaceae (grass family) with 70 species (BLM 2002).

Wildlife habitat types (WHTs) are groupings of vegetative cover types, based on similarity of wildlife use, that have been delineated across the Columbia Basin by the Northwest Habitat Institute (2003). Descriptions in this assessment of the subbasin's vegetation were organized according to these WHTs to facilitate the assessment of wildlife conditions at the scale of the subbasin and allow for interpretation of this subbasin-scale assessment in the context of the Blue Mountain province and Columbia Basin as a whole.

Johnson and O'Neil define a wildlife habitat as "an area with the combination of the necessary resources (e.g., food, cover, water) and environmental conditions (temperature, precipitation, presence or absence of predators and competitors) that promotes occupancy by individuals of a given species (or population) and allows those individuals to survive and reproduce" (2001). Wildlife habitats are viewed as hierarchical in nature with vegetative type being the coarsest element selected for by a species, vegetative structure the next, and unique habitat elements (e.g., snags) the finest (Johnson and O'Neil 2001).

The current distributions and abundance of WHTs in the subbasin are shown in Figure 6, listed in Table 1, and described below. The Northwest Habitat Institute has also developed estimates of the historical distribution of WHTs in the Columbia Basin. Comparisons of these data with current WHT distributions are presented in section 3.5.10 and Appendix A. Areas designated as shrub-steppe in the original WHT classifications made by the Northwest Habitat Institute for the subbasin were reclassified as interior grasslands for this assessment. Local knowledge and subbasin-specific literature (BLM 2002, USFS 2003a) indicate that areas with either of these WHT designations in the subbasin have very similar characteristics, and both are dominated by similar canyon grassland communities. Therefore, they are more appropriately designated as interior grasslands.

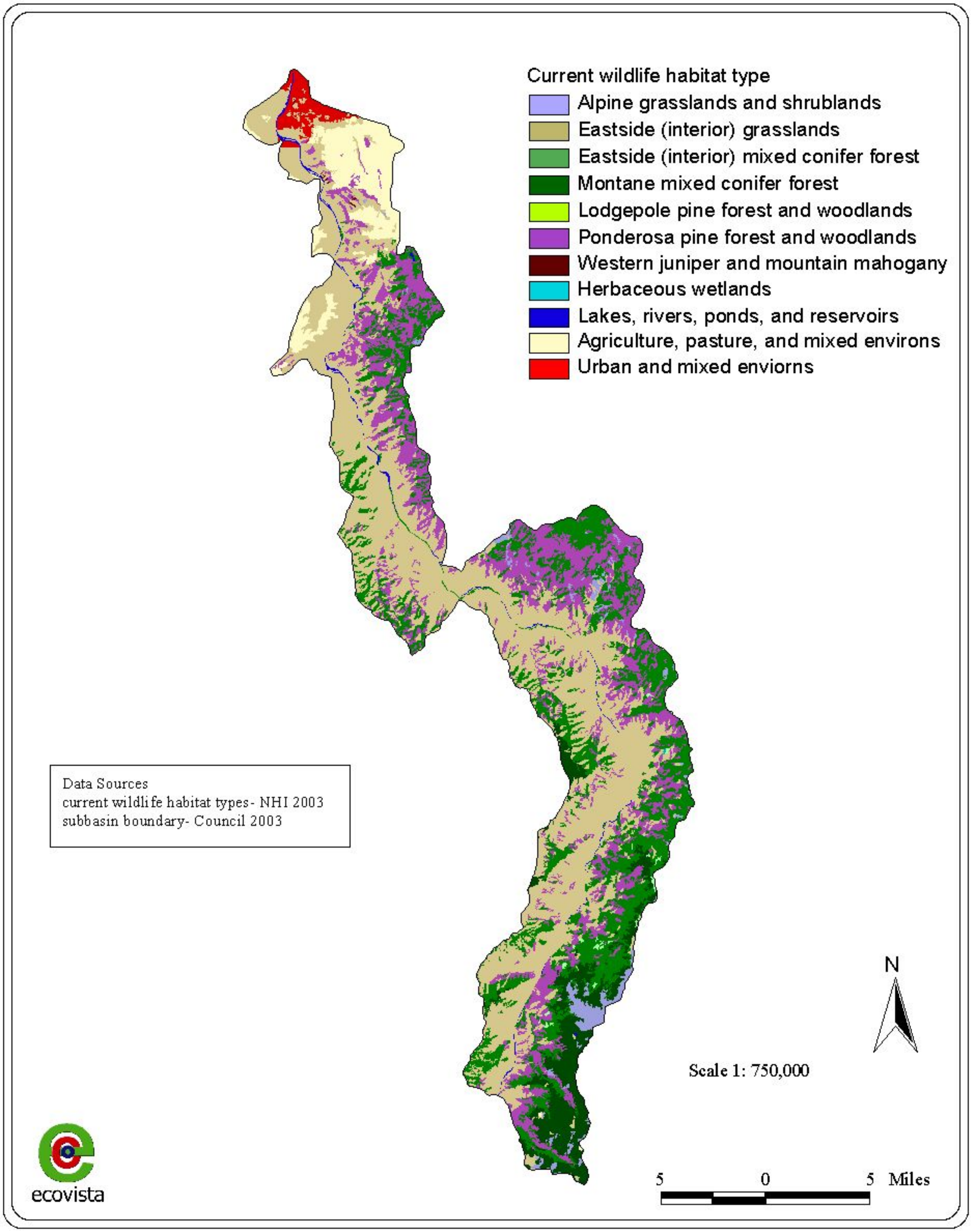

Figure 6. Current wildlife habitat types in the Snake Hells Canyon subbasin.

Table 1. Current acreages covered by the wildlife habitat types of the Snake Hells Canyon subbasin.

Habitat Type	Current Acreage
Interior grasslands (includes shrub-steppe designation)	239,834
Interior mixed conifer forest	115,175
Ponderosa pine and woodlands	110,806
Montane mixed conifer forest	33,483
Agriculture, pasture, and mixed environs	29,956
Alpine grasslands and shrublands	10,309
Urban and mixed environs	7,743
Lakes, rivers, ponds, and reservoirs	3,468
Lodgepole pine forest and woodlands	1,154
Western juniper and mountain mahogany woodlands	270
Herbaceous wetlands	58

1.4.1 Alpine Grassland and Shrublands

Alpine grasslands and shrublands occur in high mountains throughout the Pacific Northwest, including the Cascades, Olympic Mountains, Okanogan Highlands, Wallowa Mountains, and Blue Mountains, as well as on the Steens Mountain in southeastern Oregon. It is most extensive in the Cascades from Mount Rainier north and in the Wallowa Mountains. In the Snake Hells Canyon subbasin, it occupies 10,309 acres and occurs mainly in the Seven Devils area (Figure 6).

The climate is the coldest of any habitat in the region. Winters are characterized by moderate to deep snow accumulations, very cold temperatures, and high winds. Summers are relatively cool. Growing seasons are short because of persistent snowpack or frost. Elevation ranges from a minimum of 5,000 feet to 10,000 feet and always occurs above upper treeline in the mountains or a short distance below it. Small areas of open water, herbaceous wetlands, and subalpine parkland habitats sometimes occur within a matrix of this habitat. Cliffs, talus, and other barren areas are common features within or adjacent to this habitat (Johnson and O’Neil 2001).

This habitat type is dominated by grassland, dwarf-shrubland, or forbs and is extremely variable. Patches of krummholz are a common component of this habitat, especially just above upper treeline. In subalpine grasslands, which are considered part of this habitat, widely scattered coniferous trees sometimes occur. Five major structural types can be distinguished: subalpine and alpine bunchgrass grasslands, alpine sedge turf, alpine heath or dwarf-shrubland, fellfield and boulderfield, and snowbed forb community. Most subalpine or alpine bunchgrass grasslands are dominated by Idaho fescue (*Festuca ovina* var. *ingrata*), alpine fescue (*F. brachyphylla*), green fescue (*F. viridula*), Rocky Mountain fescue (*F. saximontana*), or timber oatgrass (*Danthonia intermedia*) and, to a lesser degree, by purple reedgrass (*Calamagrostis purpurascens*), downy oat-grass (*Trisetum spicatum*), or muttongrass (*Poa fendleriana*). Forbs are diverse and sometimes abundant in the grasslands. Alpine sedge turfs may be moist or dry and are dominated by showy sedge (*Carex spectabilis*), black alpine sedge (*C. nigricans*), Brewer's sedge (*C. breweri*), capitate sedge (*C. capitata*), nard sedge (*C. nardina*), dunhead sedge (*C. phaeocephala*), or western single-spike sedge (*C. pseudoscirpoidea*) (Johnson and O'Neil 2001).

One or more of the following species dominates alpine heaths: pink mountain-heather (*Phyllodoce empetriformis*), green mountain-heather (*P. glanduliflora*), white mountain-heather (*Cassiope mertensiana*), or black crowberry (*Empetrum nigrum*). Other less extensive dwarf-shrublands may be dominated by the evergreen coniferous common juniper (*Juniperus communis*), the evergreen broadleaf kinnikinnick (*Arctostaphylos uva-ursi*), the deciduous shrubby cinquefoil (*Pentaphylloides floribunda*), or willows (*Salix cascadensis* and *S. reticulata* ssp. *nivalis*). Tree species occurring as shrubby krummholz in the alpine are subalpine fir (*Abies lasiocarpa*), whitebark pine (*Pinus albicaulis*), and Engelmann spruce (*Picea engelmannii*) (Johnson and O'Neil 2001).

Most natural disturbances seem to be very infrequent and small scale in their effects. Herbivory and associated trampling disturbance by elk, mountain goats, and occasionally bighorn sheep seem to be important disturbances in some areas, creating patches of open ground. Small mammals can also have significant effects on vegetation. Frost heaving is a climatically related small-scale disturbance that is extremely important in structuring the vegetation. Extreme variation from the norm in snowpack depth and duration can act as a disturbance, exposing plants to winter desiccation, shortening the growing season, or facilitating summer drought. Slow recovery from disturbances is critically important in the maintenance of alpine grassland communities. Where fires have cleared sites previously inhabited by alpine forests, grasslands will form. It may take as much as 500 years for these forests to recover from fire and regenerate (Johnson and O'Neil 2001).

Because of the high elevation and moisture content in this environment, fire usually is not a significant factor in any successional processes. Most of the native grasses in this habitat type can establish themselves eventually on burned sites by wind-dispersed seeds. After low-severity fires, most can also sprout from on-site surviving rhizomes. Whitebark pine *(Pinus albicaulis*) and mixed conifer communities with a whitebark component experience fire frequently, although fire is usually unable to spread due to openings in the canopies and lack of fuel from any understory (Johnson and O'Neil 2001).

Vegetation changes in these communities are relatively slow. Tree invasion rates into subalpine grasslands are minimal compared with those for other subalpine communities. Seedling establishment for many plant species in the alpine zone is poor. Heath communities take about 200 years to mature after initial establishment and may occupy the same site for thousands of years. Most of this habitat is still in good condition and dominated by native species (Johnson and O'Neil 2001).

1.4.2 Interior Grasslands

Interior grasslands are found primarily in the Columbia Basin of Idaho, Oregon, and Washington, at mid- to low elevations and on plateaus in the Blue Mountains, usually within the ponderosa pine zone. In the Snake Hells Canyon subbasin, there is an estimated 239,834 acres of interior grasslands (Figure 6). The grasslands of the subbasin are particularly distinctive. Canyon grasslands are rare within the Columbia Basin, and despite years of disturbance, the Hells Canyon grasslands are among the most intact in terms of the native grassland species component (USFS 1999).

Perennial bunchgrasses dominate the interior canyon grasslands (Mancuso and Moseley 1994). Bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca ovina* var. *ingrata*) are the characteristic native bunchgrasses of this habitat and alternate dominance. Idaho fescue is common in moister, higher elevation areas, and bluebunch wheatgrass is more abundant in drier sites. Sand dropseed (*Sporobolus cryptandrus*) or threeawn (*Aristida longiseta*) are native dominant grasses on hot dry sites in deep canyons. Sandberg bluegrass (*Poa sandbergii*) is usually present and occasionally codominant in drier areas. Annual grasses are usually present on more disturbed sites. Medusahead (*Taeniatherum caput-medusae*), Kentucky bluegrass (*Poa pratensis*), and several brome grasses (*Bromus* spp.) can be widespread and codominant (Mancuso and Moseley 1994).

A dense and diverse forb layer can be present or entirely absent. More than 40 species of native forbs can grow in this habitat, including balsamroots (*Balsamorhiza* spp.), desert parsleys (*Lomatium* spp.), buckwheat (*Eriogonum* spp.), fleabane (*Erigeron* spp.), lupines (*Lupinus* spp.), and milkvetches (*Astragalus* spp.). Weedy invasive forbs that can grow in this habitat are knapweeds (*Centaurea solstitialis*, *C. diffusa*, *C. maculosa*), tall tumblemustard (*Sisymbrium altissimum*), hoary cress (*Cardaria draba*), and Russian thistle (*Salsola kali*) (Johnson and O'Neil 2001).

Smooth sumac (*Rhus glabra*) is a deciduous shrub locally found in combination with these grassland species. Rabbitbrushes (*Chrysothamnus nauseosus*, *C. viscidiflorus*) can occur in this habitat in small amounts, especially where grazed by livestock. In moist Palouse regions, common snowberry (*Symphoricarpos albus*) or Nootka rose (*Rosa nutkana*) may be present, but they are shorter than the bunchgrasses. Dry sites contain low succulent pricklypear (*Opuntia polyacantha*). Big sagebrush (*Artemisia tridentata*) is occasional and may be increasing in grasslands on former shrub-steppe sites. Black hawthorn (*Crataegus douglasii*) and other tall shrubs can form dense thickets near Idaho fescue grasslands. Ponderosa pine (*Pinus ponderosa*) may occur within the interior grasslands but mainly on northern aspects (Mancuso and Moseley 1994). Western juniper (*Juniperus occidentalis*) rarely occurs but in isolated patches (Johnson and O'Neil 2001).

A number of factors may be responsible for the loss of native grassland habitat. Disturbances resulting from overgrazing practices and fire have severely degraded bunchgrass community composition (Tisdale 1986). These disturbances favor annuals over perennials because annuals are better competitors overall for soil moisture (Barbour and Billings 2000). Overgrazing by livestock has introduced nonnative, invasive species such as starthistle and knapweed *(Centaurea* spp.), which may dominate most grassland habitats. Many species of invasive annual grasses—including cheatgrass (*Bromus tectorum*), red brome (*Bromus rubens*), and medusahead (*Taeniatherum caput-medusae*)—increase in dominance after fire and establish grass/fire cycles (Barbour and Billings 2000). Only in steeper, more remote areas where livestock grazing was limited are there healthy, native grassland communities (Mancuso and Mosely 1994).

Fire effects vary with ecological conditions, season, and severity of fire. Intense fires that occur in summer can cause considerable damage to native perennial grasses, resulting in the emergence of annual forbs. Bunchgrasses can usually survive light-severity fires and may reestablish from seed after fire if temperatures are low enough to allow for survival of seed (Wright and Bailey 1982).

Fire suppression can alter the composition of interior grasslands and, subsequently, their natural fire regimes. The result is often a heavy cover of shrubs or woody species. Without fire, black hawthorn patches expand on slopes, along with common snowberry and rose. Fires covering large areas can eliminate shrubs and their seed sources and create interior grassland habitat (Johnson and O'Neil 2001).

When lightning is the fire source, the severity of the fire is determined on whether it is a dry or wet storm (USFS 2003a). The Maloney Creek fire started during a dry lightning storm near the confluence of Maloney Creek and the Salmon River inside the Snake Hells Canyon subbasin; it covered over 74,000 acres. The majority of the burn was on the Idaho Department of Fish and Game's Craig Mountain Wildlife Management Area. The burn was mostly in the steep grasslands and exposed basalt rock cliffs that characterize this area. The Maloney Creek fire burned in an area that has a very active fire history, with natural fire intervals between 10 to 15 years. Since grass is the primary fuel for fires in this habitat, regeneration is rapid, and visible effects from a fire are masked in as short as one year (USFS 2003a).

1.4.3 Interior Mixed Conifer Forest

The interior mixed conifer forest habitat appears primarily in the Blue Mountains, East Cascades, and Okanogan Highland ecoregions of Oregon, Washington, adjacent Idaho, and western Montana. This habitat is located between the subalpine portions of the montane mixed conifer forest habitat and lower treeline ponderosa pine (*Pinus ponderosa*) forests. This habitat type inside the Snake Hells Canyon subbasin consists of an estimated 115,175 acres (Figure 6), with an elevation range between 3,000 and 5,500 feet. These forests consist of Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine forests at the lower, more xeric elevations, and grand fir–Douglas-fir forests and western larch (*Larix occidentalis*) forests at the upper, more mesic elevations (Johnson and O'Neil 2001).

This habitat contains a wide array of tree species and stand dominance patterns. Stand canopy structure is generally diverse, although single-layer forest canopies are currently more common than multilayered forests with snags and large woody debris. The tree layer varies from closed forests to more open-canopy forests or woodlands. This habitat may include very open stands. Undergrowth such as shrubs and forbs may dominate stands (Johnson and O'Neil 2001).

Douglas-fir is the most common tree species in this habitat. Lower elevations or drier sites may have ponderosa pine as a codominant with Douglas-fir in the overstory and often have other shade-tolerant tree species growing in the undergrowth. On moist sites, grand fir (*Abies grandis*), western redcedar (*Thuja plicata*), and/or western hemlock (*Tsuga heterophylla*) are dominant or codominant with Douglas-fir. Other conifers include western larch and western white pine (*Pinus monticola*) on mesic sites, Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*), and subalpine fir (*Abies lasiocarpa*) on colder sites (Johnson and O'Neil 2001).

Undergrowth vegetation varies from open to nearly closed shrub thickets with one to many layers. Throughout the interior conifer habitat, tall deciduous shrubs include Rocky Mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*), oceanspray (*Holodiscus discolor*), mallowleaf ninebark (*Physocarpus malvaceus*), and Scouler's willow (*Salix scouleriana*) at mid- to lower elevations. Medium-tall deciduous shrubs at higher elevations include fools huckleberry (*Menziesia ferruginea*), Cascade azalea (*Rhododendron albiflorum*), and big huckleberry (*Vaccinium membranaceum*). At generally drier sites, widely distributed mid-height to short deciduous shrubs include baldhip rose (*Rosa gymnocarpa*), shiny-leaf spirea (*Spiraea betulifolia*), and snowberry (*Symphoricarpos albus*, *S. mollis*, and *S. oreophilus*). Low shrubs of higher elevations include low huckleberries (*Vaccinium cespitosum* and *V. scoparium*) and five-leaved bramble (*Rubus pedatus*) (Johnson and O'Neil 2001).

Herbaceous broadleaf plants are important indicators of site productivity and disturbance. Species generally indicating productive sites include western oakfern (*Gymnocarpium dryopteris*), vanillaleaf (*Achlys triphylla*), wild sarsparilla (*Aralia nudicaulis*), wild ginger (*Asarum caudatum*), queen's cup (*Clintonia uniflora*), goldthread (*Coptis occidentalis*), false bugbane (*Trautvetteria caroliniensis*), windflower (*Anemone oregana*, *A. piperi*, *A. lyallii*), fairybells (*Disporum hookeri*), Sitka valerian (*Valeriana sitchensis*), and pioneer violet (*Viola glabella*). Other indicator forbs are dogbane (*Apocynum androsaemifolium*), false solomonseal (*Maianthemum stellata*), heartleaf arnica (*Arnica cordifolia*), several lupines (*Lupinus caudatus*, *L. latifolius, L. argenteus* ssp. *argenteus* var. *laxiflorus*), western meadowrue (*Thalictrum occidentale*), rattlesnake plantain (*Goodyera oblongifolia*), skunkleaf polemonium (*Polemonium pulcherrimum*), trailplant (*Adenocaulon bicolor*), twinflower (*Linnaea borealis*), western starflower (*Trientalis latifolia*), and several wintergreens (*Pyrola asarifolia*, *P. picta*, *Orthilia secunda*) (Johnson and O'Neil 2001).

Graminoids are common in this forest habitat. Columbia brome (*Bromus vulgaris*), oniongrass (*Melica bulbosa*), northwestern sedge (*Carex concinnoides*), and western fescue (*Festuca occidentalis*) are found mostly in mesic forests with shrubs or mixed with forb species. Bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca ovina* var. *ingrata*), and junegrass (*Koeleria macrantha*) are found in drier, more open forests or woodlands. Pinegrass (*Calamagrostis rubescens*) and Geyer's sedge (*C. geyeri*) can form a dense layer under Douglas-fir or grand fir trees (Johnson and O'Neil 2001).

Fires in interior mixed conifer forests were probably of moderate frequency, averaging 30 to 100 years before the twentieth century. Currently, fire intervals are averaging between 15 to 20 years. Shorter interval, less severe fires serve to maintain grassland and keep an open forest structure by removing seedlings and understory and enhancing tree regeneration, especially of ponderosa pine (Smith and Fischer 1997).

Most interior mixed forests have Douglas-fir as the most abundant species where fire has been suppressed. Where fire occurs in this habitat type, other tree species are better adapted and can dominate stands (Franklin and Dyrness 1973). Generally, wetter sites burn less frequently and stands are older with more western hemlock and western redcedar than drier sites. Many sites dominated by Douglas-fir and ponderosa pine, which were formerly maintained by wildfire, may now be dominated by grand fir, which is a fire-sensitive, shade-tolerant species (Johnson and O'Neil 2001).

1.4.4 Montane Mixed Conifer Forest

The geographic distribution of these forests is in mountains throughout Washington, Oregon, and Idaho. Within the Snake Hells Canyon subbasin, the habitat type occupies 33,483 acres (IBIS 2003). Montane mixed conifer stands are located in the Wallowa Mountains in Oregon, which are adjacent to the Grande Ronde subbasin, and in the Seven Devils Mountains in Idaho, next to the Salmon subbasin (Figure 6).

This habitat is typified by a moderate to deep winter snowpack that persists for three to nine months. Mean annual precipitation ranges from about 40 inches to greater than 200 inches. Elevation is mid- to upper montane, from as low as 2,000 feet (610 m) in northern Washington to as high as 7,500 feet (2,287 m) in southern Oregon and in the Seven Devils in Idaho. Soils are typically not well developed but varied in their parent material (IBIS 2003).

These forests vary from range to range in overstory, understory, and groundcover composition. They include a mixture of conifers such as Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*), western redcedar (*Thuja plicata*), white fir (*Abies concolor*), and mountain hemlock (*Tsuga mertensiana*). Some shrubs that commonly dominate or codominate the understory are ninebark (*Physocarpus malvaceus*), Scouler's willow (*Salix scouleri*), snowberry species (*Symphoricarpos albus* and *S. mollis*), oval-leaf huckleberry (*Vaccinium ovalifolium*), big huckleberry (*V. membranaceum*), grouseberry (*V. scoparium*), dwarf huckleberry (*V. cespitosum*), fools huckleberry (*Menziesia ferruginea*), devil's-club (*Oplopanax horridum*), and currants (*Ribes* spp.). Important evergreen shrubs include bearberry (*Arctostaphylos uva-ursi*), and Oregon boxwood (*Pachistima myrsinites*). A very diverse selection of graminoids and forbs exists throughout the subbasin (IBIS 2003).

Large areas of this habitat within the Snake Hells Canyon subbasin, specifically the Seven Devils wilderness area, are relatively undisturbed by human impacts and include significant old-growth stands. Fire is the major natural disturbance in this habitat. Other montane mixed conifer sites on private lands within the subbasin have been affected by logging and grazing practices. Windstorms are a common small-scale disturbance and occasionally result in stand replacement. Insects and fungi are often important small-scale disturbances, although they sometimes affect larger areas also (Johnson and O'Neil 2001).

Mean fire-return intervals vary greatly, from around 70 years for lower elevation forests to 400 years for higher elevation forests (FEIS 2004). Long periods of fire suppression may result in crowded to open mixed conifer stands with dense understories, resulting in severe stand-replacing burns. Fire is an important factor in providing wildlife habitat. A fire may thin dense stands of mixed conifer by clearing overstory, reduce competition by removing understory, and rejuvenate sprouting plants, thereby increasing the availability of browse and forage (Crane and Fischer 1986). Some post-fire invaders in this habitat type are lodgepole pine and quaking aspen. Trees of both species mature rapidly following fire and can form extensive even-aged stands (Barbour and Billings 2000).

1.4.5 Lodgepole Pine Forest and Woodlands

This habitat type is found along the interior of the Cascade Rang, as well as in the Blue Mountains and Okanogan Highlands. It ranges north into British Columbia and south to Colorado and California and is located mostly at mid- to higher elevations (3,000–9,000 feet). These environments can be cold and relatively dry, usually with a persistent winter snowpack. In the Snake Hells Canyon subbasin, it intermixes in small populations with montane mixed conifer forests on the east side of the Snake River and also appears occasionally in the Blue Mountains with ponderosa pine habitats (Figure 6). Lodgepole communities occupy only 1,154 acres of the subbasin area.

Rocky Mountain lodgepole pine grows with nearly all of the other mountain conifers in its range and often forms dense, nearly pure even-aged stands (Anderson et al. 1995). Mixed stands of Rocky Mountain lodgepole pine and other species are also common, especially stands of Rocky Mountain lodgepole pine, Engelmann spruce (*Picea engelmannii*), and subalpine fir (*Abies lasiocarpa*) at higher elevations and stands of Rocky Mountain lodgepole pine and Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) at lower elevations (Achuff 1989). Reproduction of other more shade-tolerant conifers can be abundant in the undergrowth.

Dominant lodgepole pine forests are usually associated with other montane conifers such as Grand fir (*Abies grandis*), western larch (*Larix occidentalis*), white pine (*Pinus monticola*), ponderosa pine (*P. ponderosa*), Douglas-fir, subalpine fir, mountain hemlock (*Tsuga mertensiana*), Engelmann spruce, and whitebark pine (*Pinus albicaulis*). Quaking aspen (*Populus tremuloides*) sometimes occur in small numbers.

Several distinct undergrowth types develop under the tree layer, such as evergreen or deciduous medium-tall shrubs, evergreen low shrub, or graminoids with few shrubs.. Tall deciduous shrubs include Rocky Mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*), oceanspray (*Holodiscus discolor*), or Scouler's willow (*Salix scouleriana*). These tall shrubs often occur over a layer of mid-height deciduous shrubs such as baldhip rose (*Rosa gymnocarpa*), russet buffaloberry (*Shepherdia canadensis*), shiny-leaf spirea (*Spiraea betulifolia*), and snowberry (*Symphoricarpos albus* and/or *S. mollis*). At higher elevations, big huckleberry (*Vaccinium membranaceum*) can be locally important, particularly following fire. Mid-tall evergreen shrubs can be abundant in some stands. These include creeping Oregon grape (*Mahonia repens*), tobacco brush (*Ceanothus velutinus*), and Oregon boxwood (*Paxistima myrsinites*). Colder and drier sites support low-growing evergreen shrubs, such as kinnikinnick (*Arctostaphylos uva-ursi*) or pinemat manzanita (*A. nevadensis*). Grouseberry (*V. scoparium*) are consistent evergreen low-shrub dominants in the subalpine part of this habitat.

Some undergrowth is dominated by graminoids with few shrubs. Pinegrass (*Calamagrostis rubescens*) and/or Geyer's sedge (*Carex geyeri*) can appear with grouseberry in the subalpine zone. Pumice soils support a grassy undergrowth of long-stolon sedge (*C. inops*), Idaho fescue (*Festuca ovina* var. *ingrata*), or western needlegrass (*Stipa occidentalis*). Other graminoids frequently encountered in this habitat are California oatgrass (*Danthonia californica*), blue wildrye (*Elymus glaucus*), Columbia brome (*Bromus vulgaris*), and oniongrass (*Melica bulbosa*). Kentucky bluegrass (*Poa pratensis*) and bottlebrush squirreltail (*Elymus elymoides*) can be locally abundant where livestock grazing has persisted.

The forb component of this habitat is diverse and varies with environmental conditions. A partial forb list includes goldthread (*Coptis occidentalis*), false solomonseal (*Maianthemum stellata*), heartleaf arnica (*Arnica cordifolia*), several lupines (*Lupinus caudatus*, *L. latifolius*, *L. argenteus* ssp. *argenteus* var. *laxiflorus*), meadowrue (*Thalictrum occidentale*), queen's cup (*Clintonia uniflora*), rattlesnake plantain (*Goodyera oblongifolia*), skunkleaf polemonium (*Polemonium pulcherrimum*), trailplant (*Adenocaulon bicolor*), twinflower (*Linnaea borealis*), Sitka valerian (*Valeriana sitchensis*), western starflower (*Trientalis latifolia*), beargrass (*Xerophyllum tenax*), and several wintergreens (*Pyrola asarifolia, P. picta, Orthilia secunda)*.

The successional status of lodgepole pine forests depends on environmental conditions, disturbance history, and competition from associated species. Fire, insects, pathogens, and certain wildlife have an important role in perpetuating or renewing lodgepole pine stands. Where lodgepole pine is seral, shade-tolerant trees will replace lodgepole without fire or other disturbance because of its shade intolerance and mineral seedbed preference. Absence of stand disturbance favors regeneration and eventual dominance of shade-tolerant species. Generally, the effect of fire in mature lodgepole stands is essentially the same as in immature stands. Severe fires recycle the stand by clearing competition and releasing seeds. Less severe burns thin the stand and prepare a seedbed for lodgepole regeneration (Crane and Fischer 1986).

Most stands of lodgepole pine forests have multiple age classes. This condition may be caused by disturbance patterns such as fire, insect infestation, fungal pathogens and parasitic plants (Agee 1993). These forests thrive under the influence of fire, and on many sites, fire is essential to lodgepole pine dominance (Achuff 1989). High-severity crown fires are likely in young stands, when the tree crowns are near deadwood on the ground. After the stand opens up, shade-tolerant trees increase in number. Lodgepole pine forests have a mean fire interval between 68 and 80 years. Summer drought areas generally have low- to medium-intensity ground fires occurring at intervals of 25 to 50 years, whereas areas with more moisture have sparse undergrowth and slow fuel buildup that result in less frequent, more intense fire (Agee 1993). With time, lodgepole pine stands increase in fuel loads. Woody fuels accumulate on the forest floor from insect and disease outbreaks and residual wood from past fires, windthrow, and snow breakage (Crane and Fischer 1986).

Lodgepole pine may be a host for parasitic plants such as dwarf mistletoe, which can infect stands and increase flammability. This increases risks to severe wildfire and subsequent stand replacement (Crane and Fischer 1986). Dwarf mistletoes kill by slowly robbing the tree of food and water. Diseased trees decline and die from the top down as lower infected branches take more food and water. Mortality occurs slowly in most cases and depends on the severity of infection and the stature of the tree. Dwarf mistletoes have a relatively long life cycle between infection and seed production (six to eight years). Fire affects dwarf mistletoe distribution. Less severe fires can leave an open, infested overstory, creating an ideal situation for rapid infection of the regenerated stand. But large, complete burns can eliminate or greatly reduce the parasite. After a severe burn, dwarf mistletoe slowly invades the new stand from infected trees along the edges of the burn. When trees are heavily infested by mistletoe, they are commonly attacked by bark beetles that kill branches or whole trees (Crane and Fischer 1986).

Mountain pine beetles can seriously deplete mature stands of lodgepole forests. Infestations of beetles attack, in epidemic proportions, large low-productivity stands capable of sustaining brood populations (Agee 1993). After an infestation by the beetles, stands of lodgepole are succeeded by more shade-tolerant species such as Douglas-fir, subalpine fir, or Engelmann spruce, depending on elevation. Mountain pine beetle outbreaks thin stands that add fuel and create a drier environment for fire or open canopies and create gaps for other conifer regeneration (Crane and Fischer 1986).

1.4.6 Ponderosa Pine Forest and Woodlands

In the Pacific Northwest, ponderosa pine–Douglas-fir (*Pseudotsuga menziesii*) woodland habitats occur along the eastern slope of the Cascades, in the Okanogan Highlands, and in the Blue Mountains. This habitat generally occurs on the driest sites supporting conifers. It is widespread and variable, appearing on moderate to steep slopes in canyons and foothills and on plateaus or plains near mountains. It can be found at elevations of 100 feet (30 m) to over 6,000 feet (1,829 m) (IBIS 2003). The Snake Hells Canyon subbasin has ponderosa pine forests and woodlands throughout its range, occupying 110,806 acres (Figure 6).

Ponderosa pine and Douglas-fir are the most common evergreen trees in this habitat. The deciduous conifer, western larch (*Larix occidentalis*), can be a codominant with the evergreen conifers in the Blue Mountains of Oregon, but it is seldom a canopy dominant. Grand fir may be frequent in the undergrowth on more productive sites, giving stands a multilayer structure.

Undergrowth can include dense stands of shrubs or, more often, be dominated by grasses, sedges, and/or forbs. Some Douglas-fir and ponderosa pine stands have a tall to medium-tall deciduous shrub layer of mallowleaf ninebark (*Physocarpus malvaceus*) or common snowberry (*Symphoricarpos albus*) and/or a short shrub layer including kinnikinnick (*Arctostaphylos uva-ursi*) and *Vaccinium* species. Antelope bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), black sagebrush (*A. nova*), and green rabbitbrush (*Chrysothamnus viscidiflorus*) often grow with ponderosa pine–Douglas-fir habitats.

Undergrowth is generally dominated by herbaceous species, especially graminoids. Within a forest matrix, these woodland habitats have an open to closed sodgrass undergrowth dominated by pinegrass (*Calamagrostis rubescens*), Geyer's sedge (*Carex geyeri*), Ross' sedge (*C. rossii*), long-stolon sedge (*C. inops*), or blue wildrye (*Elymus glaucus*). Drier savanna and woodland undergrowth typically contains bunchgrass steppe species such as Idaho fescue (*Festuca ovina* var. *ingrata*), rough fescue (*F. campestris*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Indian ricegrass (*Oryzopsis hymenoides*), or needlegrasses (*Stipa comata, S. occidentalis*). Common exotic grasses that may appear in abundance are cheatgrass (*Bromus tectorum*) and bulbous bluegrass (*Poa bulbosa*). Forbs, which are common associates in this habitat, are too numerous to be listed.

Windfall, insect infestations, and fire together have a role in the natural succession of a ponderosa pine forest (Wright 1978). Historically, natural fires burned ponderosa pine stands between 8 to 18 years on the average (USDAFS 1978). Most were ground fires consuming downed trees and branches from windfall and insect attacks, some understory components, and young tree seedlings (Franklin and Dyrness 1973). This process allowed seeds to become established on the bare mineral soil surface (Wright 1978). Ponderosa pine seeds will germinate rapidly when a fire has cleared the grass and the forest floor of litter, leaving only mineral-rich soil. (Fischer and Bradley 1987). Although some seedlings may be killed, pole-sized and mature ponderosa pine are resistant to fire because of thick bark and high canopy structure. No other conifer within its range is better adapted to survive surface fires. Ponderosa pine is more vulnerable to fire at more mesic sites where other conifers such as Douglas-fir and grand fir form dense understories that can carry fire upward to the canopy (Franklin and Dyrness 1973).

Wildlife, several diseases, rusts, and insects play important roles at various stages in the ponderosa pine's life cycle. Rabbits and hares injure or kill many seedlings, and in areas where pocket gopher populations are high, all seedlings and many saplings may be destroyed. Squirrels and porcupines attack sapling and pole-sized trees, deforming stems and trunks. Squirrels, chipmunks, and birds eat many seeds from cones, but in some reported cases, as much as 15% of ponderosa pine seedlings develop from unrecovered caches from squirrels. In years of low cone production, the potential seed crop may be severely reduced (Franklin and Dyrness 1973).

In eastern Washington, Idaho, and western Montana, over 50 species of insects have been identified as causing damage to or mortality of ponderosa pine. The most damaging of the tree-killing insects are the beetle species of *Dendroctonus* and *Ips*. The western pine beetle (*D. brevicomis*) and the mountain pine beetle (*D. ponderosae*) are major contributors to mortality in overmature, decadent trees. Trees die from the combined effects of a blue stain fungus transmitted by the beetle and extensive larval consumption of the phloem (Oliver and Ryker 1990).

Dwarf mistletoe *(Arceuthobium campylopodium*) is ponderosa pine's most widespread disease. On trees not killed, the parasite is responsible for a significant loss in growth, primarily in height, and is reported to reduce seed viability as much as 20%. In the Northwest, dwarf mistletoe has little effect on vigorous, young trees because height growth will usually exceed its upward spread, relegating the parasite to the lower crown branches (Oliver and Ryker 1990).

1.4.7 Western Juniper and Mountain Mahogany Woodlands

Western juniper and mountain mahogany (*Cercocarpus ledifolius*) woodlands are distributed from the Pacific Northwest south into southern California and east to western Montana and Utah, where it often occurs with pinyon–juniper habitat. In Oregon and Washington, this dry woodland habitat appears primarily in the Owyhee Uplands, High Lava Plains, and northern Basin and Range ecoregions. Secondarily, it develops in the foothills of the Blue Mountain and East Cascade ecoregions and seems to be expanding into the southern Columbia Basin, where it was naturally found in outlying stands. Isolated mountain mahogany communities occur throughout canyons and mountains of eastern Oregon. In the Snake Hells Canyon subbasin, small populations of juniper–mountain mahogany communities may be found on benches and foothills of the Blue Mountains and Craig Mountain and occupy around 270 acres.

Western juniper and/or mountain mahogany woodlands are often found on shallow soils on flats at mid- to high elevations, usually on basalts. Other sites range from deep, loess soils and sandy slopes to very stony canyon slopes. At lower elevations or in areas outside shrub-steppe, this habitat occurs on slopes and in areas with shallow soils. Mountain mahogany can occur on steep rimrock slopes, usually in areas of shallow soils or protected slopes. This habitat can be found at elevations of 1,500 to 8,000 feet, mostly between 4,000 and 6,000 feet.

This habitat reflects a transition between ponderosa pine forests and shrub-steppe. Western juniper generally occurs on higher topography, whereas the shrub communities are more common in depressions or steep slopes with bunchgrass undergrowth. In the Great Basin, mountain mahogany may form a distinct belt on mountain slopes and ridgetops above pinyon–juniper woodland. Mountain mahogany can occur in isolated, pure patches that are often very dense.

Western juniper and/or mountain mahogany dominate these woodlands either with bunchgrass or shrub-steppe undergrowth. Western juniper is the most common dominant tree in these woodlands. Part of this habitat will have curl-leaf mountain mahogany as the only dominant tall shrub or small tree. Mahogany may be codominant with western juniper. Ponderosa pine can grow in this habitat and, in some rare instances, may be an important part of the canopy. The most common shrubs in this habitat are basin, Wyoming, or mountain big sagebrush (*Artemisia tridentata* ssp. *tridentata,* ssp. *wyomingensis*, and ssp. *vaseyana*) and/or bitterbrush (*Purshia tridentata*). They usually provide significant cover in juniper stands. Low or stiff sagebrush (*Artemisia arbuscula* or *A. rigida*) are dominant dwarf shrubs in some juniper stands. Mountain big sagebrush appears most commonly with mountain mahogany and mountain mahogany mixed with juniper. Snowbank shrubland patches in mountain mahogany woodlands are composed of mountain big sagebrush with bitter cherry (*Prunus emarginata*), quaking aspen (*Populus tremuloides*), and serviceberry (*Amelanchier alnifolia*). Shorter shrubs such as mountain snowberry (*Symphoricarpos oreophilus*) or creeping Oregon grape (*Mahonia repens*) can be dominant in the undergrowth. Rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*) will increase with grazing.

Part of this woodland habitat lacks a shrub layer. Various native bunchgrasses dominate different aspects of this habitat. Sandberg bluegrass (*Poa sandbergii*), a short bunchgrass, is the dominant and most common grass throughout many juniper sites. Medium-tall bunchgrasses—Idaho fescue (*Festuca ovina* var. *ingrata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), needlegrasses (*Stipa occidentalis, S. thurberiana, S. lemmonii*), and bottlebrush squirreltail (*Elymus elymoides*)—can dominate undergrowth. Threadleaf sedge (*Carex filifolia*) and basin wildrye *(Leymus cinereus*) are found in lowlands and Geyer's and Ross' sedge (*Carex geyeri, C. rossii*), pinegrass (*Calamagrostis rubescens*), and blue wildrye (*E. glaucus*) appear on mountain foothills. Sandy sites typically have needle-and-thread (*Stipa comata*) and Indian ricegrass (*Oryzopsis hymenoides*). Cheatgrass (*Bromus tectorum*) or bulbous bluegrass (*Poa bulbosa*) often dominate overgrazed or disturbed sites. In good condition, this habitat may have mosses growing under the trees.

Both mountain mahogany and western juniper are fire intolerant. Under natural high-frequency fire regimes, both species formed savannas or occurred as isolated patches on fire-resistant sites in shrub-steppe or steppe habitat. Western juniper is considered a topoedaphic climax tree in a number of sagebrush-grassland, shrub-steppe, and drier conifer sites. It is an increaser in many earlier seral communities in these zones and invades without fires. Most trees over 13 feet (4 m) tall can survive low-intensity fires. The historical fire regime of mountain mahogany communities varied with community type and structure. The fire-return interval for mountain mahogany (along the Salmon River in Idaho) was 13 to 22 years until the early 1900s, after which time it has increased. Mountain mahogany can live to 1,350 years in western and central

Nevada. Some old-growth mountain mahogany stands avoid fire by growing on extremely rocky sites (Johnson and O'Neil 2001).

Juniper invades shrub-steppe and steppe and reduces undergrowth productivity. Although slow seed dispersal delays recovery time, western juniper can regain dominance in 30 to 50 years following fire. A fire-return interval of 30 to 50 years typically arrests juniper invasion. The successional role of curl-leaf mountain mahogany varies with community type. Mountain brush communities where curl-leaf mountain mahogany is either dominant or codominant are generally stable and successional rates are slow (Johnson and O'Neil 2001).

Over the past 150 years, with fire suppression, overgrazing, and changing climatic factors, western juniper has increased its range into adjacent shrub-steppe, grasslands, and savannas. Increased density of juniper and reduced fine fuels from an interaction of grazing and shading result in high-severity fires that eliminate woody plants and promote herbaceous cover, primarily of annual grasses. Diverse mosses and lichens occur on the ground in this type if it has not been too disturbed by grazing. Excessive grazing will decrease bunchgrasses and increase exotic annual grasses plus various native and exotic forbs. Animals seeking shade under trees decrease or eliminate bunchgrasses and contribute to increasing cheatgrass cover (Johnson and O'Neil 2001).

This habitat is dominated by fire-sensitive species. Therefore, the range of western juniper and mountain mahogany has expanded because of an interaction of livestock grazing and fire suppression. Quigley and Arbelbide (1997) concluded that in the inland Pacific Northwest, juniper/sagebrush, juniper woodlands, and mountain mahogany cover types are now significantly greater in extent than they were before 1900. Although it covers more area, this habitat is generally in degraded condition because of increased exotic plants and decreased native bunchgrasses. One-third of Pacific Northwest juniper and mountain mahogany community types listed in the National Vegetation Classification are considered imperiled or critically imperiled (Johnson and O'Neil 2001).

1.4.8 Herbaceous Wetlands

Herbaceous wetlands are found throughout the Pacific Northwest, usually in isolated sites, and represented in Oregon and Washington wherever local hydrologic conditions promote their development. They are more widespread in valley bottoms and high rainfall areas. but they are present in montane and arid climates as well. Hardstem bulrush–cattail–burreed marshes occur in wet areas throughout Oregon and Washington. Sedge meadows and montane meadows are common in the Blue and Ochoco mountains of central and northeastern Oregon. In the Snake Hells Canyon subbasin, herbaceous wetlands are scarce because of the steep terrain escalating up both sides of the Snake River. This habitat type may be found in the Seven Devils range and occupies only around 55 acres.

Seasonally to semipermanently flooded wetlands are found where standing fresh water is present through part of the growing season and the soils stay saturated throughout the season. Some sites are temporarily to seasonally flooded meadows, which generally occur on clay, pluvial, or alluvial deposits within montane meadows or along stream channels in shrubland or woodland riparian vegetation. In general, this habitat is flat, usually with stream or river channels or open water present. Elevation varies between sea level to 10,000 feet, although this habitat is infrequently above 6,000 feet (1,830 m).

Various grasses or grass-like plants dominate or codominate these habitats. Cattails (*Typha latifolia*) occur widely, sometimes adjacent to open water with aquatic bed plants. Several bulrush species (*Scirpus acutus, S. tabernaemontani, S. maritimus, S. americanus, S. nevadensis*) occur in nearly pure stands or in mosaics with cattails or sedges (*Carex* spp.). Burreeds (*Sparganium angustifolium, S. eurycarpum*) are the most important graminoids in areas with up to 3.3 feet (1 m) of deep standing water. A variety of sedges characterize this habitat. Some sedges (*Carex aquatilis, C. lasiocarpa, C. scopulorum, C. simulata, C. utriculata, C. vesicaria*) tend to occur in cold to cool environments. Other sedges (*C. aquatilis* var. *dives, C. angustata, C. interior, C. microptera, C. nebrascensis*) tend to be at lower elevations in milder or warmer environments. Slough sedge (*C. obnupta*) and several rush species (*Juncus falcatus, J. effusus, J. balticus*) are characteristic of coastal dune wetlands that are included in this habitat. Several spikerush species (*Eleocharis* spp.) and rush species can be important. Common grasses that can be local dominants and indicators of this habitat are American sloughgrass (*Beckmannia syzigachne*), bluejoint reedgrass (*Calamagrostis canadensis*), mannagrass (*Glyceria* spp.), and tufeeted hairgrass (*Deschampsia caespitosa*). Important introduced grasses that increase and can dominate with disturbance in this wetland habitat include reed canarygrass *(Phalaris arundinacea*), tall fescue (*Festuca arundinacea*), and Kentucky bluegrass (*Poa pratensis*).

Montane meadows are occasionally forb dominated with plants such as arrowleaf groundsel (*Senecio triangularis*) or ladyfern (*Athyrium filix-femina*). Climbing nightshade (*Solanum dulcamara)*, purple loosestrife (*Lythrum salicaria*), and poison hemlock (*Conium maculatum*) are common nonnative forbs in wetland habitats.

Shrubs or trees are not a common part of this herbaceous habitat although willow (*Salix* spp.) or other woody plants occasionally occur along margins, in patches, or along streams running through these meadows.

This habitat type is maintained through a variety of hydrologic regimes that limit or exclude invasion by large woody plants. Habitats are permanently flooded, semipermanently flooded, or flooded seasonally and may remain saturated through most of the growing season. Most wetlands are resistant to fire and those that are dry enough to burn usually burn in the fall. Most plants are sprouting species and recover quickly. Beavers play an important role in creating ponds and other impoundments in this habitat. Trampling and grazing by large native mammals is a natural process that creates habitat patches and influences tree invasion and success.

Herbaceous wetlands are often in a mosaic with shrub- or tree-dominated wetland habitats. Woody species can successfully invade emergent wetlands when this herbaceous habitat dries. Emergent wetland plants invade open water habitat as soil substrate is exposed. As habitats flood, woody species decrease to patches on higher substrate (soil, organic matter, large woody debris), and emergent plants increase unless the flooding is permanent. Fire suppression can lead to invasion of woody species in drier herbaceous wetland habitats (Johnson and O'Neil 2001).

Nationally, herbaceous wetlands have declined. These wetlands receive regulatory protection at the national, state, and county level. Montane wetland habitats are less altered than lowland habitats have been, even though they have undergone modification as well. A keystone species, the beaver, has been trapped to near extirpation in parts of the Pacific Northwest, while its population has been regulated in others. Herbaceous wetlands have decreased along with the diminished influence of beavers on the landscape (Johnson and O'Neil 2001).

1.4.9 Lakes, Rivers, Streams, Ponds, and Reservoirs

Lakes, streams, and rivers in Oregon and Washington occur statewide and are found from near sea level to about 10,200 feet, forming a continuous network connecting high mountain areas to lowlands and the Pacific coast. In the Snake Hells Canyon subbasin, open water habitats occupy around 3,468 acres, the bulk of the acreage coming from the Snake River, which dissects the subbasin for its entire length (Figure 6).

Lakes were historically formed through various natural and anthropogenic processes. Glaciers melted and left depressions where water accumulated. Craters created by extinct volcanoes also formed lakes. Human-built dams impound water, creating lakes behind them, and many lakes have formed in depressions and rocky coulees through the process of seepage from irrigation waters. Beavers have also created many ponds and marshes in Oregon and Washington.

Rivers and streams are fed from melting snowpacks during the spring and winter and by annual rainfall. Ponds, lakes, and reservoirs are typically adjacent to riparian and herbaceous wetlands.

Removal of gravel substrates result in reduction of spawning areas for anadromous fish. Overgrazing and loss of vegetation caused by logging produces increased water temperatures and excessive siltation, harming invertebrate communities. Incorrectly installed culverts may act as barriers to migrating fish and contribute to erosion and siltation downstream. Construction of dams is associated with changes in water quality, loss of fish passage, competition among species, loss of spawning areas because of flooding, and declines in native fish populations. Agricultural, industrial, and sewage runoff—salts, sediments, fertilizers, pesticides, and bacteria—harms aquatic species. Unregulated aerial spraying of pesticides over agricultural areas also poses a threat to aquatic and terrestrial life. Because clearcutting creates excessive intermittent runoff conditions, increases erosion and siltation of streams, and diminishes shade, it causes higher water temperatures, fewer terrestrial and aquatic food organisms, and increased predation. Landslides, which contributed to the widening of the channel, were a direct result of clearcutting. Clearcut logging can alter snow accumulation and increase the size of peak flows during times of snowmelt. Building of roads, especially those of poor quality, can be a major contributor to sedimentation in the streams (Johnson and O'Neil 2001).

1.4.10 Agriculture, Pasture, and Mixed Environs

Agricultural habitat, which is widely distributed at low to mid-elevations, is most abundant in broad river valleys throughout the basin and on gentle rolling terrain east of the Cascade Mountains. In the Snake Hells Canyon subbasin, it covers more than 29,956 acres, primarily in the northern extent of the subbasin (Figure 6).

Habitats of agricultural use and pasture occur within a matrix of other habitat types including interior grasslands, shrub-steppe, and various low to mid-elevation forest and woodland habitats. This habitat often dominates the landscape in flat or gently rolling terrain on well-developed soils. Unlike other habitat types, agricultural habitat is often characterized by regular landscape patterns and straight borders because of ownership boundaries and multiple crops within a region. This habitat type is structurally diverse because it includes several cover types ranging from low-stature annual grasses and row crops to mature orchards. Depending on management intensity or cultivation method, agricultural habitat may vary substantially in structure year to year. Cultivated cropland and modified grasslands are typified by periods of bare soil and harvest whereas pastures are mowed, hayed, or grazed once or more during the growing season (Johnson and O'Neil 2001). Within the Snake Hells Canyon subbasin, agricultural crops are primarily dryland wheat with some legumes such as lentils or peas.

Perennial herbaceous plants such as alfalfa, several species of fescue (*Festuca* spp.), bluegrass (*Poa* spp.), orchardgrass (*Dactylis glomerata*), and timothy (*Phleum pratensis*) are commonly seeded in improved pastures. Grass seed fields are single-species stands, whereas pastures maintained for haying are typically composed of at least two species. The improved pasture cover type is one of the most common agricultural uses in both states; it is produced with or without irrigation (Johnson and O'Neil 2001).

Unimproved pastures are predominately grassland sites that are often abandoned fields with little or no active management such as irrigation, fertilization, or herbicide applications. These sites may or may not be grazed by livestock. Unimproved pastures include rangelands planted to exotic grasses that are found on private land, state wildlife areas, federal wildlife refuges, and U.S. Department of Agriculture Conservation Reserve Program (CRP) sites. Grasses commonly planted on CRP sites are crested wheatgrass (*Agropyron cristatum*), tall fescue (*F. arundinacea*), perennial bromes (*Bromus* spp.), and wheatgrasses (*Elytrigia* spp.). Intensively grazed rangelands that have been seeded to intermediate wheatgrass (*Elytrigia intermedia*) or crested wheatgrass or that are dominated by increaser exotics such as Kentucky wheatgrass (*Poa pratensis*) or tall oatgrass (*Arrhenatherum elatius*) are unimproved pastures. Other unimproved pastures have been cleared and intensively farmed in the past, but they have been allowed to convert to other vegetation. These sites may be composed of uncut hay, litter from previous seasons, standing dead grass and herbaceous material, invasive exotic plants (Himalaya blackberry [*Rubus discolor*] and yellow starthistle [*Centaurea soltstitalis*]) with patches of native black hawthorn (*Crataegus douglasii*), snowberry (*Symphoricarpos* spp.), spirea (*Spirea* spp.), poison oak (*Toxicodendron diversilobum*), and encroachment of various tree species, depending on seed source and environment (Johnson and O'Neil 2001).

Modified grasslands are generally overgrazed habitats that were formerly native grasslands or shrub-steppe but are now dominated by annual plants, with only remnant individual plants of the native vegetation. Cheatgrass (*Bromus tectorum*), other annual bromes, medusahead (*Taeniatherum caput-medusae*), bulbous bluegrass (*Poa bulbosa*), and knapweeds (*Centaurea* spp.) are common increasers that form modified grasslands. Fire, following heavy grazing or repeated early-season fires, can create modified grassland monocultures of cheatgrass (Johnson and O'Neil 2001).

Management practices disrupt natural succession and stand dynamics in most of the agricultural habitats. Abandoned agricultural habitats may convert to other habitats, mostly grassland and shrub habitats from the surrounding native habitats. Natural fires are almost totally suppressed in this habitat, except in unimproved pastures and modified grasslands where fire-return intervals can resemble those of native grassland habitats. Fires are generally less frequent today than in the past, primarily because of fire suppression, construction of roads, and conversion of grass and forests to cropland (Johnson and O'Neil 2001).

Controlled burning is an important economical tool for managing agricultural areas and rangeland. Fire may be used to control undesirable plant species, restore natural grassland communities, improve the quality and quantity of forage for livestock and wildlife, improve grass cover for the protection of soil from erosion, eliminate crop residue, and improve water yield from seeps and springs. Fire is also used for pest and weed control and lowers the need for supplemental herbicide and pesticide treatments. Fires can stimulate the growth of perennial grasses in savannas and provide nutritious regrowth for livestock. Alternately, fires may have a destructive effect on different vegetation communities and animal species. Fire can reduce the organic matter in the soil and result in a decrease of soil fertility in future years (Johnson and O'Neil 2001). The use of controlled burning for improving croplands is a topic of debate in Pacific Northwest states because the practice is considered responsible for increases in carbon dioxide levels to our atmosphere, as well as a direct health risk for people who reside in urban and rural areas around controlled burns (Agricultural Air Quality Task Force 1999).

1.4.11 Urban and Mixed Environs

Urban habitat occurs throughout the Pacific Northwest. Most urban development in the Snake Hells Canyon subbasin is located in the northern region and closely associated with the agriculture and pasture habitat types (Figure 6). There are around 7,743 acres of urban development and mixed environs in the subbasin, primarily along the northern edge near Lewiston, Idaho.

Urban development often occurs in areas with little or no slope and frequently includes wetland habitats. Many of these wetlands have been filled in and eliminated. Urban development may occur within or adjacent to nearly every habitat type in Oregon and Washington; it often replaces habitats that are valuable for wildlife. The highest urban densities normally occur in lower elevations along natural or human-made transportation corridors, such as rivers, railroad lines, coastlines, or interstate highways. These areas often contain good soils with little or no slope and lush vegetation. Once level areas become crowded, growth continues along rivers or shores of lakes or oceans and eventually up elevated sites with steep slopes or rocky outcrops. Because early settlers often modified the original landscape for agricultural purposes, many of our urban areas are surrounded by agricultural and grazing lands.

The original habitat is drastically altered in urban environments and replaced by buildings, impermeable surfaces, bridges, dams, and plantings of nonnative species. With the onset of urban development, total crown cover and tree density are reduced to make way for the construction of buildings and associated infrastructure. Understory vegetation may be completely absent, or if present, it is diminutive and single layered. Typically, three zones are characteristic of urban habitat. The high-density zone encompasses the heavy industrial and large commercial interests of the city, in addition to high-density housing areas. Vegetation is composed of a small amount of total tree canopy cover, low tree density, a high percentage of exotics, and a poor understory. The medium-density zone is composed of light industry mixed with high-density residential areas. Vegetation in this mid-zone is typically composed of nonnative plant species.

Characteristic vegetation in this zone consists of manicured lawns, trimmed hedges, and topped trees. The low-density zone is the outer zone of the urban–rural continuum. This zone normally contains only single-family homes. It has more natural groundcover than artificial surfaces. Vegetation is denser and more abundant than in the previous two zones and may include both native and nonnative plants.

1.5 Land Ownership and Protected Areas

1.5.1 Ownership

The majority of the Snake Hells Canyon subbasin is publicly owned, with more than half under USFS management (Table 2; Figure 7). The Wallowa-Whitman National Forest manages the majority of the USFS land, but portions on the Idaho side of the river are managed by the Payette and Nez Perce National Forests. Private land accounts for 32% of the subbasin. This private land is concentrated in the agricultural and urban areas of the lower subbasin and in the area surrounding Wolf and Dry creeks. The Craig Mountain area (Captain John, Corral, and Cottonwood Creeks) is cooperatively managed by the Bureau of Land Management (BLM), Idaho Department of Fish and Game (IDFG), Idaho Department of Lands, Nez Perce Tribe, and The Nature Conservancy.

Table 2. Land management agencies of the Snake Hells Canyon subbasin.

Land management agency	Acres	Percentage of Total Subbasin Area
Forest Service	287,006	52.4
Private	176,685	32.3
State of Idaho	45,006	8.2
Bureau of Land Management	31,369	5.7
State of Washington	3,068	0.6
Nez Perce Tribe	2,799	0.5
The Nature Conservancy	1,354	0.2
State of Oregon	112	> 0.1
Water	2,852	0.5

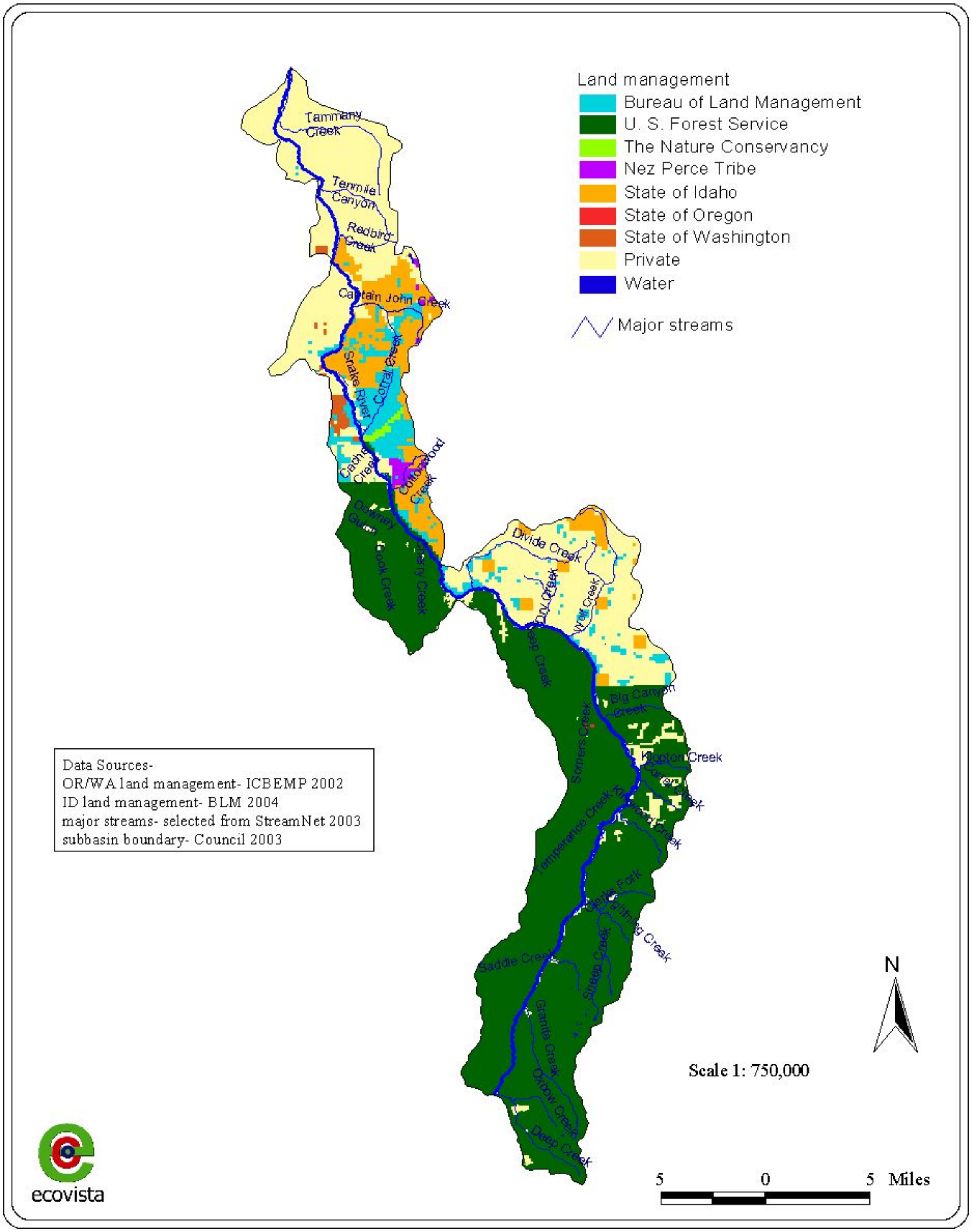

Figure 7. Land management in the Snake Hells Canyon subbasin.

1.5.2 Protected Areas

Much of the Snake Hells Canyon subbasin is protected and/or managed using a conservation-based strategy (Figure 8). The following areas in the Snake Hells Canyon subbasin are protected in this manner.

Hells Canyon National Recreation Area

Forty-six percent (298,270 acres) of the 652,488-acre HCNRA lies within the Snake Hells Canyon subbasin. The HCNRA was created by an act of Congress in 1975. Although the HCNRA includes portions of the Nez Perce, Payette, and Wallowa-Whitman National Forests, it is managed by the Wallowa-Whitman National Forest. The Hells Canyon Wilderness comprises nearly 215,000 acres within the HCNRA (USFS 2003a).
The act that created the HCNRA states that "to assure that the natural beauty, and historical and archaeological values of the Hells Canyon area and the seventy-one-mile segment of the Snake River between Hells Canyon Dam and the Oregon–Washington border, together with portions of certain of its tributaries and adjacent lands, are preserved for this and future generations, and that the recreational and ecologic values and public enjoyment of the area are thereby enhanced, there is hereby established the Hells Canyon Recreation Area" (USFS 2003a).

A comprehensive management plan was approved in 1982 and incorporated into the Wallowa-Whitman National Forest Land and Resource Management Plan (Forest Plan) in 1990. Adjustment of the existing (1982) comprehensive management plan was initiated in 1993, and the Draft Environmental Impact Statement was released in 1996. The Forest Supervisor re-initiated the process in 1998 with a revised draft environmental statement. The Record of Decision for the Hells Canyon National Recreation Area Comprehensive Management Plan was released July 22, 2003, and implemented August 29, 2003. The appeal period on the decision ended October 6, 2003. Six appeals were received and are currently under review by the Regional Forester. A decision on the appeals is anticipated some time in early spring 2004 (USFS 2003a). The Hells Canyon National Recreation Area Comprehensive Management Plan is a valuable reference on the area and contributed to the construction of this document.

Hells Canon National Wilderness Area

Almost 85% (182,370 acres) of the Hells Canyon Wilderness lies within the uppermost portion of the subbasin (Figure 8). The area is protected under the Wilderness Act of 1964.

Wild and Scenic Snake River

In 1975, approximately 67.5 miles of the Snake River in the HCNRA were designated as a component of the National Wild and Scenic Rivers System. In this reach, the river is managed to preserve its free-flowing character and unique environment while providing for continued public use (USFS 2001).

The 31.5-mile section of the river between Hells Canyon Dam and Upper Pittsburg Landing is designated as wild under the Wild and Scenic Rivers Act. This act defines wild as being "free of impoundments and generally accessible only by trail" and representing "vestiges of primitive America." The 36-mile section of river downstream of Upper Pittsburg Landing to RM 180.2 is designated as scenic, which is defined as "free of impoundments with shorelines and watershed still largely primitive, and shorelines largely undeveloped, but accessible in places by roads." An additional 4.2 miles of the river from RM 180.2 north to the HCNRA boundary at the Oregon–Washington line is recommended for scenic designation (USFS 2001).

The Wild and Scenic Snake River corridor extends approximately one-quarter mile back from the high-water mark on each shore. The river corridor itself is not wilderness, so wilderness regulations do not apply (USFS 2001).

Craig Mountain

The majority of the Craig Mountain Cooperative Management Area lies within the subbasin. The area has multiple managers including the Nez Perce Tribe, BLM, Idaho Department of Lands, The Nature Conservancy, and private landowners. The Craig Mountain Cooperative Management Area contains the 60,000-acre Craig Mountain Wildlife Mitigation Area purchased by the Bonneville Power Administration (BPA) in 1992 as partial mitigation for wildlife habitat losses resulting from construction of Dworshak Dam on the Clearwater River. The Nez Perce Tribe, IDFG, and BPA agreed to provide for the protection and enhancement of wildlife habitat through management of the area (Cassirer 1995). The pileated woodpecker, yellow warbler, black-capped chickadee, river otter, elk, and white-tailed deer are species that have been identified as having been negatively affected by construction of Dworshak Dam in the Clearwater subbasin, so they are given special management attention on the Craig Mountain Wildlife Mitigation Area (Cassirer 1995).

Chief Joseph Wildlife Area

The Chief Joseph Wildlife Area is 2,065 acres in size and located in Asotin County, Washington. Elevations range from 825 to 4,913 feet at Mt. Wilson, the highest point in the vicinity. The area is made up primarily of bluebunch wheatgrass grasslands with riparian woodlands surrounding streams and springs. The area provides important elk, mule deer, bighorn sheep, game bird, and nongame habitat (WDFW 2001a).

Research Natural Areas

Research natural areas (RNAs) are natural ecosystems that provide benchmarks for comparison with areas influenced by humans. They facilitate research for ecological studies and help preserve gene pools for threatened and endangered plants and animals.

Two established RNAs occur in the subbasin—the Lightning Creek and Wapshilla Ridge RNAs—and cover 8,555. Seven areas are proposed for designation as RNAs in the Snake Hells Canyon subbasin. These areas were selected to represent particular plant associations, geological formations, or other needs outlined in state natural heritage plans. According to the Wallowa-Whitman Forest Plan, proposed RNAs will be protected from uses that would reduce their suitability for RNA designation. Since their designation, no logging has occurred in the proposed RNAs. Once officially established, an RNA management plan will be written and integrated into the Forest Plan (USFS 1999).

Areas of Critical Environmental Concern

The designation, Areas of Critical Environmental Concern (ACECs), is authorized in section 202(c)(3) of the Federal Land Policy and Management Act of 1976 (FLPMA, P.L. 94-579). ACECs include public lands where special management attention and direction is needed to protect human life and safety from natural hazards or to protect and prevent irreparable damage to important historic, cultural, and scenic values; fish or wildlife resources; or other natural systems or processes (BLM 2003a). The Wapshilla Ridge RNA/ACEC, Captain John Creek RNA/ACEC, Lower Salmon ACEC, and Craig Mountain ACEC cover 4,394 acres in the Craig Mountain area of the subbasin (Figure 8) (BLM 2002).

Garden Creek Preserve

The Garden Creek Preserve is part of the Craig Mountain Wildlife Management Area, supporting Rocky Mountain bighorn sheep, elk, mountain lion, wolverine, black bear, ruffed grouse, partridge, and quail. To date, nine rare plant species have been identified in the vicinity, including Spalding's silene (also called Spalding's catchfly), western ladies tress, and stalk-leaved monkey flower (TNC 2004). Managers for the Craig Mountain Cooperative Management Area also manage the Garden Creek Preserve, which covers 8,023 acres in the subbasin (Figure 8).

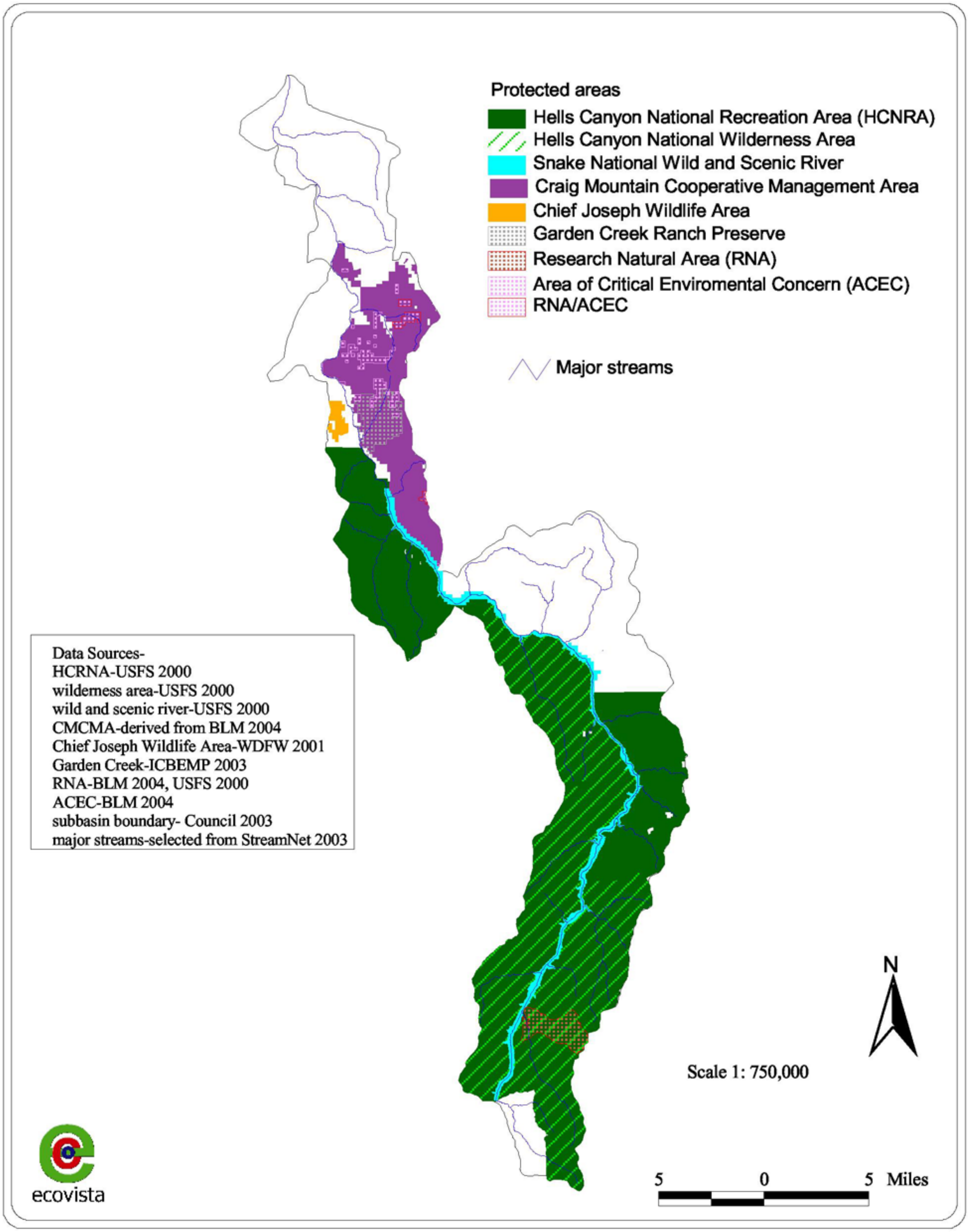

Figure 8. Areas in the Snake Hells Canyon subbasin that are managed and/or protected under a conservation-based strategy.

1.6 Socioeconomic Overview

1.6.1 Demographics and Economy

Comparison by State

Population—Idaho ranks 39th among the states in population and 11th in size. The projected population of Idaho in 2025 is approximately 1.7 million, compared with 4.2 million in Oregon and 7.8 million in Washington (Figure 9).

Income—For 1999, per capita income was below the U.S. average in both Idaho and Oregon and above the U.S. average in Washington (Figure 10).

Unemployment—On average, civilian labor-force unemployment declined from 1980 to 2000 in the United States, as well as in Idaho and Oregon (Figure 11) (U.S. Census 2002). In 1980, unemployment in Oregon, Washington, and Idaho was higher than the U.S. average, and the current unemployment rate in these three states remains higher than the U.S. average.

Poverty—The percentage of people below the poverty level in 1999 was higher in counties within the United States (12.4%) than in Idaho, Oregon, or Washington (Figure 12).

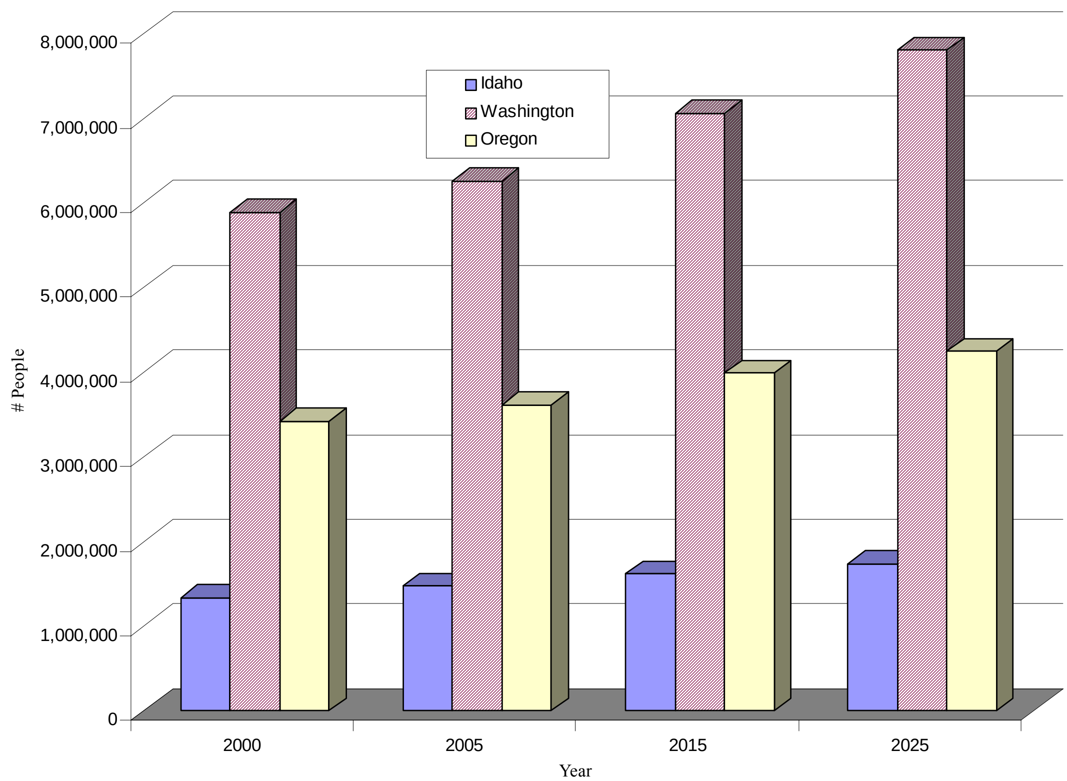

Figure 9. Projected populations of Idaho, Oregon, and Washington (U.S. Census Bureau 2000a).

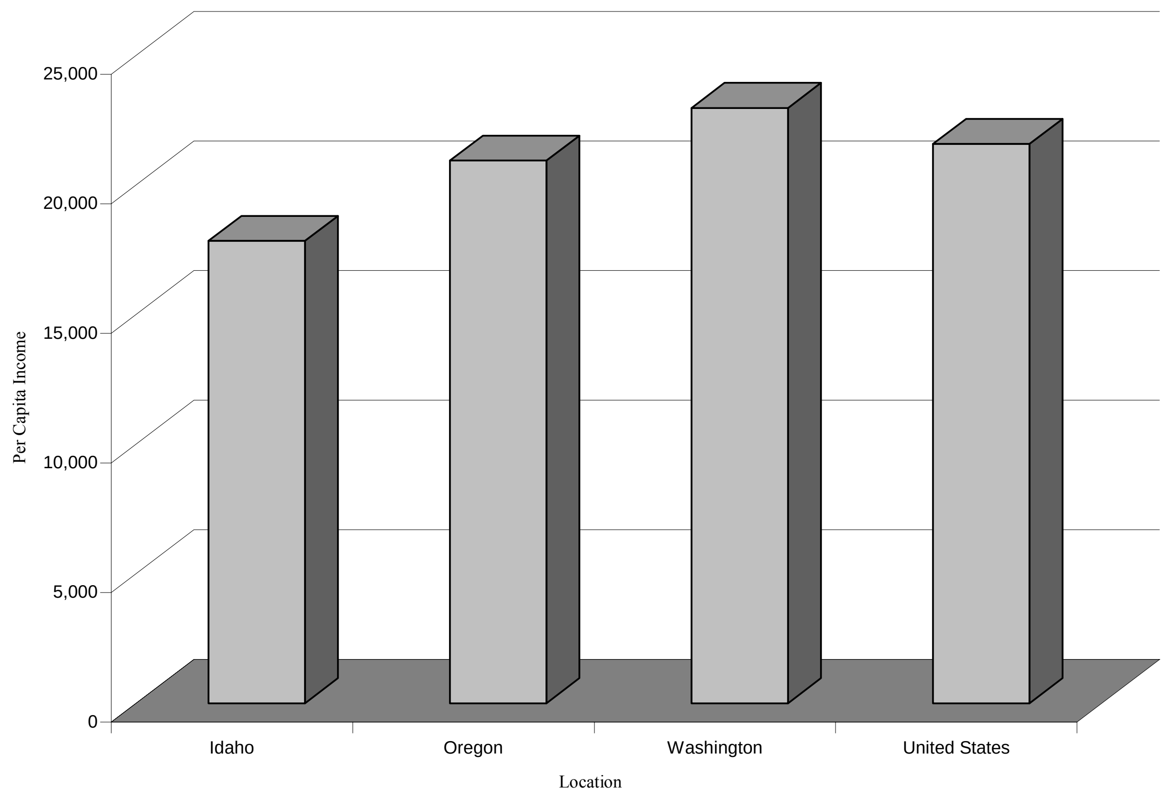

Figure 10. Per capita income in the United States and in Idaho, Oregon, and Washington in 1999 (U.S. Census Bureau 2000b).

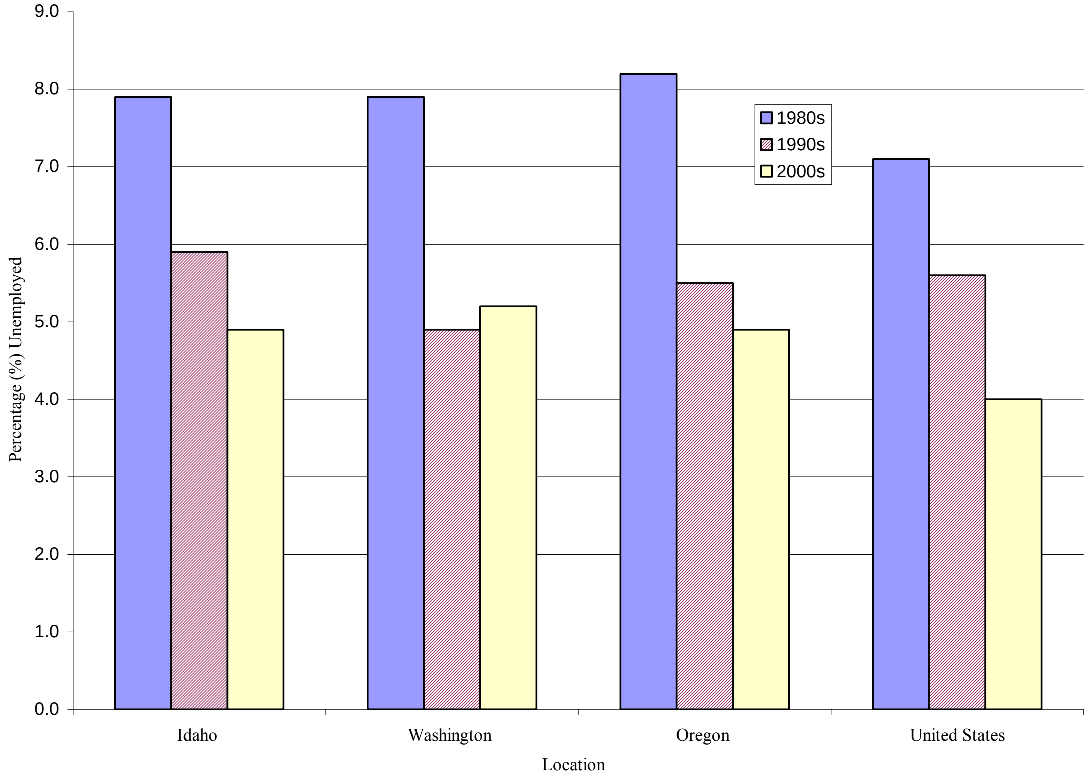

Figure 11. Trend in civilian labor-force percent unemployment as per decade averages in Idaho, Washington, Oregon, and the United States.

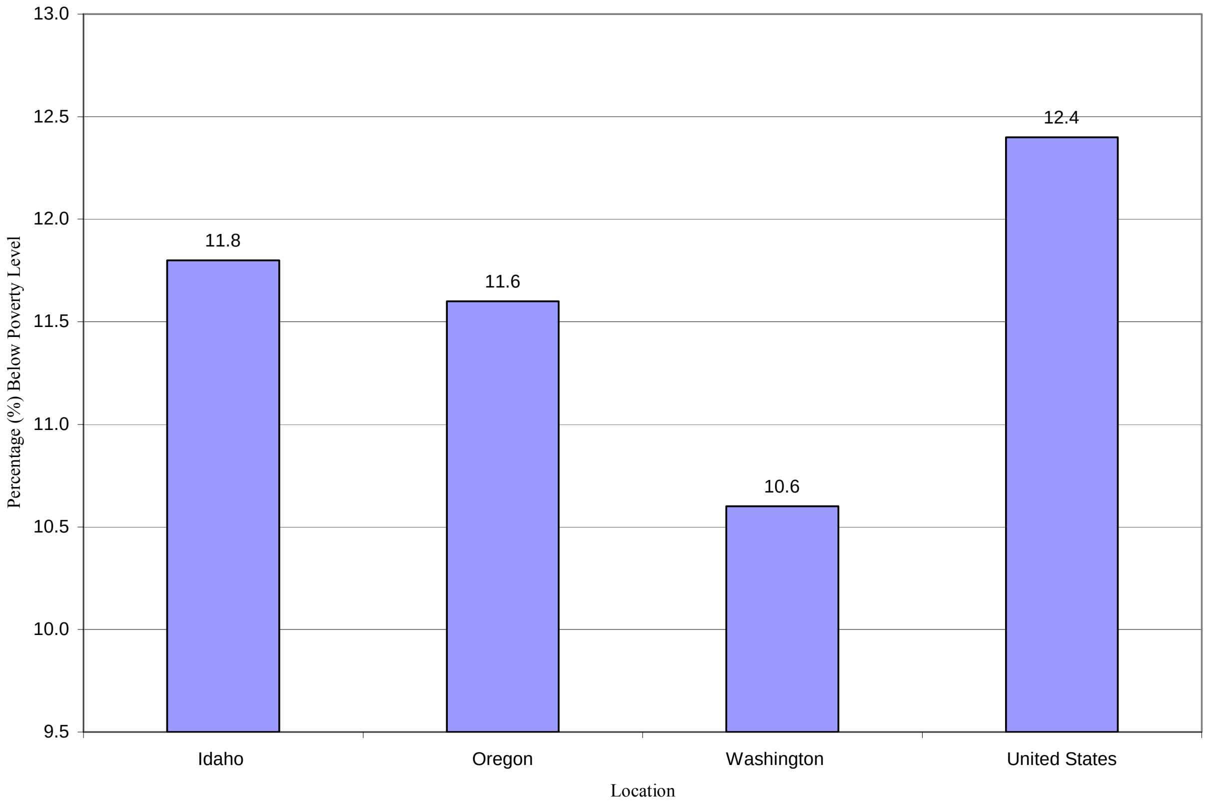

Figure 12. Percentage of persons below the poverty level (1999) in Idaho, Oregon, Washington, and the United States (U.S. Census Bureau 2000b).

Comparison by County

Asotin County in Washington; Wallowa County in Oregon; and Nez Perce, Lewis, and Idaho counties in Idaho all supply land base to the Snake Hells Canyon subbasin (Table 3).

Land Base and Population

The lower portion of the subbasin, which contains the town of Asotin and portions of Clarkston and Lewiston, is being developed at a much faster rate than the rest of the subbasin. Populations in all five counties partially contained in the Snake Hells Canyon subbasin increased between 1990 and 2000 (Table 3). This population increase is reflected both in more residents inhabiting the lower subbasin towns of Asotin, Lewiston, and Clarkston and in greater recreational pressure from residents of neighboring communities. In the upper half of the subbasin, some residential housing with septic systems exists, but the density is very low (IDEQ and ODEQ 2001). Communities within the boundaries of the subbasin are in the lower Hells Canyon portions of Idaho, Nez Perce, and Asotin counties (Figure 1).

Geographically, the largest counties in the subbasin are Idaho (8,500 sq. mi.), Wallowa (3,100 sq. mi.), and Adams (1,400 sq. mi.). However, each of these counties has fewer than 3 people per square mile, compared with 30 to 45 people per square mile found in the smaller Asotin and Nez Perce counties (Figure 13).

Table 3. Changes in population in counties partially contained within the Snake Hells Canyon subbasin, 1990–2000 (U.S. Census Bureau 2000b).

County (State)	Population 1990 Census	Population 2000 Census	Change 1990–2000	
			Number	Percent
Asotin (WA)	17,605	20,551	2,946	16.7
Idaho (ID)	13,783	15,511	1,728	12.5
Nez Perce (ID)	33,754	37,410	3,656	10.8
Adams (ID)	3,254	3,476	222	6.8
Wallowa (OR)	6,911	7,226	315	4.6

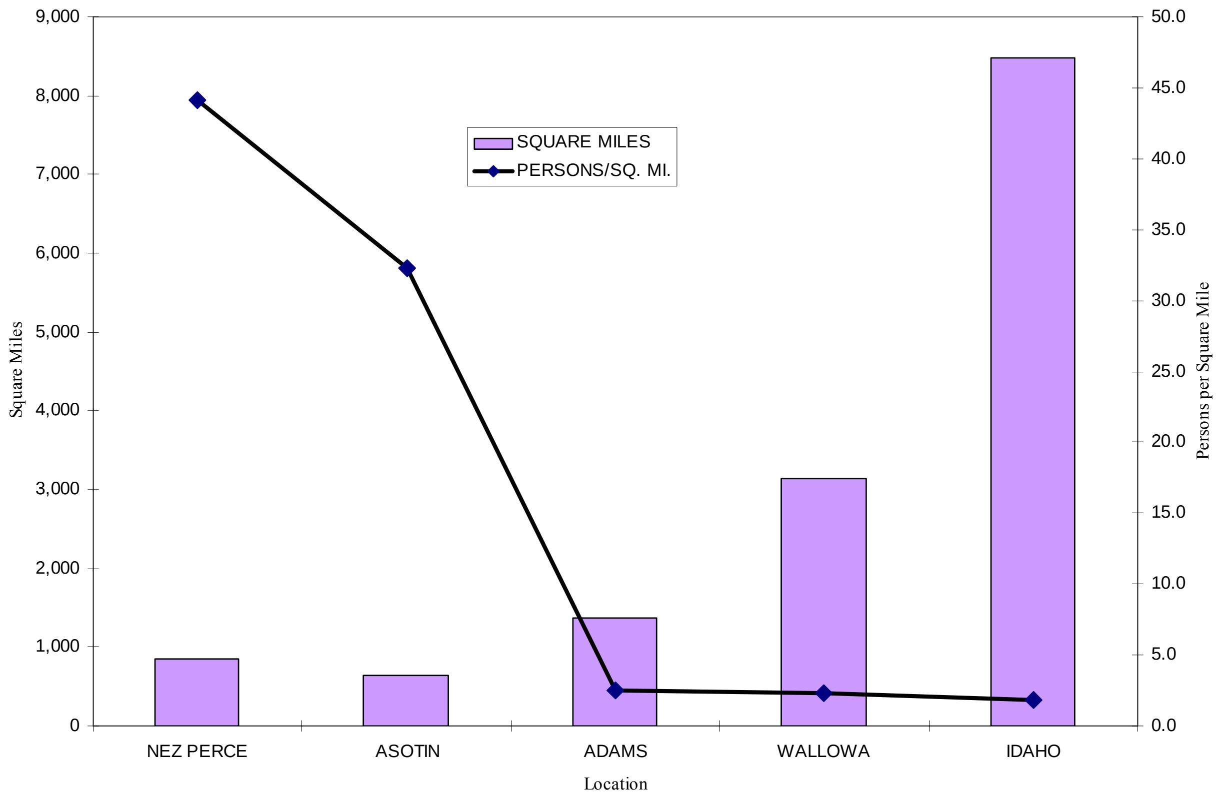

Figure 13. Land base in square miles compared with people per square mile in each of the counties within the Snake Hells Canyon subbasin.

Economics

Employment by Industry

Farming is not as important in the Snake Hells Canyon subbasin as in surrounding areas because geology and topography make the area less suitable for agriculture. The number of people employed in nonfarming industries has increased from the 1960s to the present in all of the counties within the subbasin (WSU 2003). The more populated counties have experienced more growth in the nonfarming sectors than the less populated counties have (Figure 14).

Currently, the service sector employs the highest percentage of employees in all of the counties within the subbasin (U.S. Census Bureau 2000b). Nez Perce and Asotin counties, the counties with the highest populations, have the highest percentage of workers in the service sector. Wallowa and Adams counties are the least populated but have the highest percentage of employees working in industries that utilize natural resources (Figure 15). Manufacturing and construction are most important in the lower subbasin counties, which are experiencing growth.

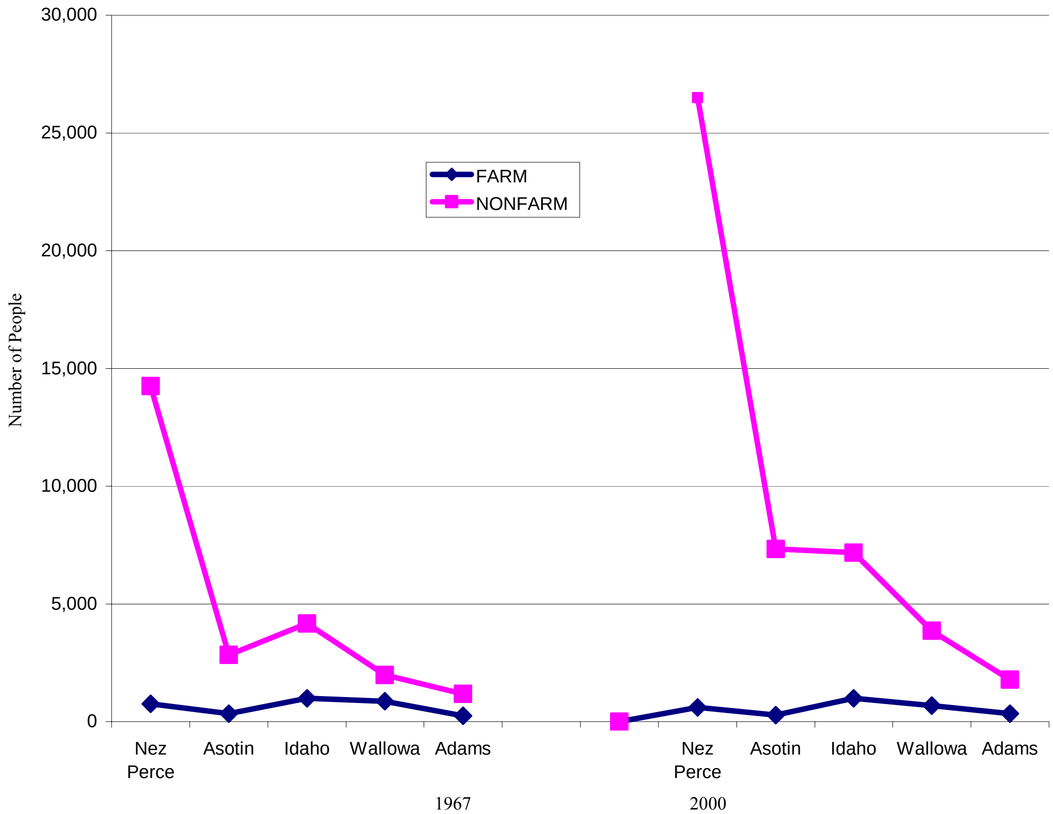

Figure 14. Number of people employed in the farm and nonfarm sectors in 1967 and 2000 by counties partially within the Snake Hells Canyon subbasin.

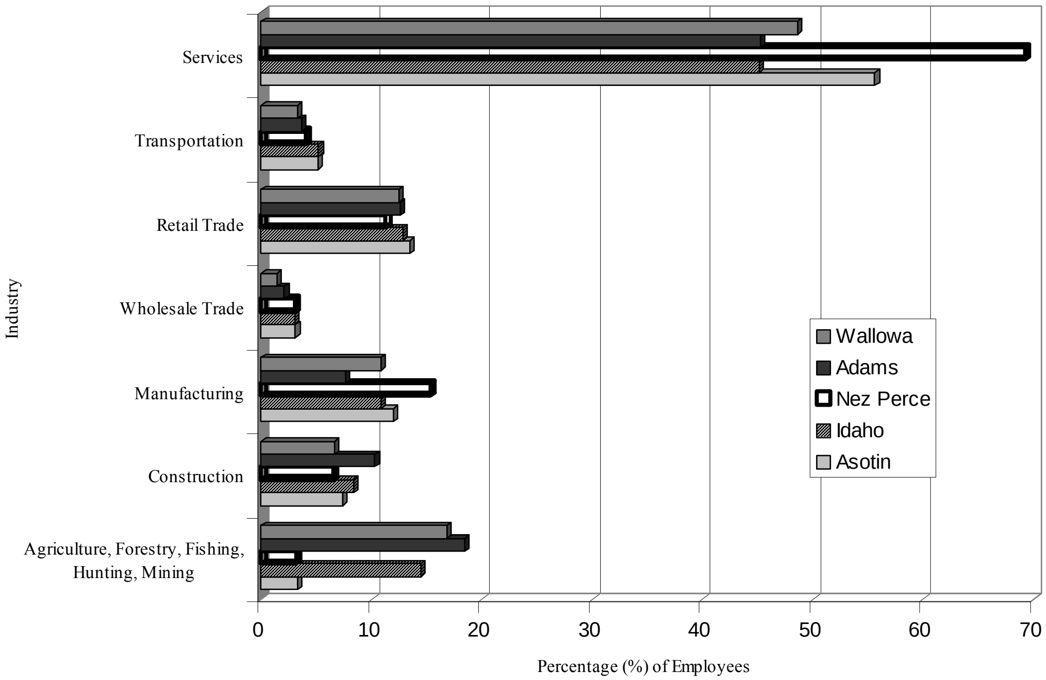

Figure 15. Percentage of employees that work in each industrial sector in 2000 by county within the Snake Hells Canyon subbasin (services include financial or professional services, education, arts, other services, and public administration). Agriculture is included with natural resource-based industries to provide a contrast between industries that utilize land resources and those that are service and skill oriented.

Major Employers

Table 4 lists major employers in counties with area in the Snake Hells Canyon subbasin (IDOC 2003, Palouse EDC 2003, Wallowa County 2003). Note the dual importance of the forestry and service-oriented sectors. Data are county based rather than subbasin based, and employers may or may not be active in the Snake Hells Canyon subbasin.

Table 4. Major employers and types of business, by counties partially within the Snake Hells Canyon subbasin.

Major Employer	Type of Business
Adams County, ID	
Adams County government	Government Services
U.S. Forest Service	Government Services
Evergreen Forest Products	Forest Products Manufacturing
S & S Drywall, Inc.	Construction
JI Morgans	?

Major Employer	Type of Business
Meadowcreek Properties	Real Estate
Council Community Hospital	Health Care Services
Seven Devils Mountains	Recreation/Tourism
Hells Canyon	Recreation/Tourism
Brundage Ski Area	Recreation/Tourism
Idaho County, ID	
Clearwater Forest Products, Inc.	Forest Products Manufacturing
School District #241	Education
U.S. Forest Service	Forestry
Pankey's Foods	Retail Sales
Grangeville School District	Education
Nez Perce National Forest	Forestry
Idaho County	Government Services
Nez Perce County, ID	
Potlatch	Forest Products
St. Joseph Regional Hospital	Health Care Services
Lewis Clark State College	Education
Alliant Techsystems	Manufacturing
Swift Transportation, Inc.	Transportation
City of Lewiston	Government Services
Deatly Company	Mineral Retail Sales
Lewiston Tribune	Publishing
Northwest Childrens Home, Inc.	Other Services
Nez Perce Tribe	Government Services
Wallowa County, OR	
School Districts	Education
U.S. Forest Service	Government Services
Wallowa County government	Government Services
Wallowa Health District	Health Care Services
Wallowa Forest Products	Forest Products Manufacturing
Safeway	Retail Food Sales
Moffit Brothers	?
Valley Bronze	?
Community Bank	Finances
Wallowa County Grain Growers	Agriculture
OR Fish and Wildlife Department	Government Services

Major Employer	Type of Business
Parks Bronze	?
Asotin County, WA	
Federal Government	Government Services
Garfield County	Government Services
Pomeroy Public Schools	Education
Garfield County Mem. Hospital	Health Services
Dye Seed Ranch Inc.	Retail Sales
Clarkston School District	Education
Tri-State Memorial Hospital	Health Services
Poe Asphalt	Construction
Costco	Retail Sales
Walla Walla Community College	Education

Employment by Recreation and Tourism

The recreation and tourism industry is difficult to measure on a county-by-county basis. In 2001, 486,000 Idaho residents and nonresidents (16 and older) spent nearly $755 million in Idaho for fishing and hunting and an additional $982 million for wildlife viewing and related activities (USFWS and USDC 2003). The International Association of Fish and Wildlife Agencies (Southwick Associates 2002) estimated that 6,197 jobs were created in Idaho from all hunting activities. The number of jobs created from all fishing activities was not included in this modeled estimate, but it may be higher than the number of hunting-related jobs, since fishing expenditures outweigh hunting expenditures in Idaho. Rural community economies are generally considered to benefit more from hunting and fishing activities than urban economies do, and some depend highly on these activities (Southwick Associates 2002).

A summary of 2002 sales of resident hunting and fishing licenses by county illustrates the areas where most hunters and anglers live in the subbasin (assuming that people buy licenses in their counties of residence). Nez Perce County had the highest number of license sales with 11,700 resident hunting and fishing licenses sold (Figure 16). The 1991 *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* found that 49% of all hunters and 52% of freshwater anglers traveled less than 25 miles to the sites they used most often (USFWS and USDC 2003).

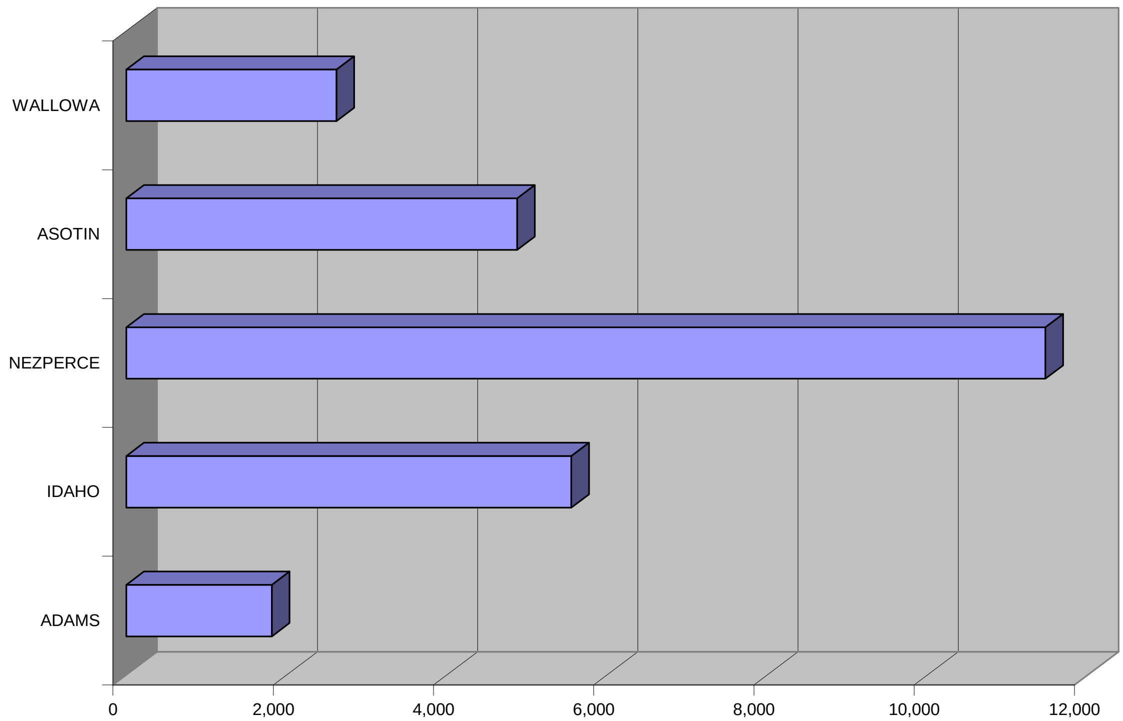

Figure 16. Resident hunting and fishing license sales in 2002 for counties in the Snake Hells Canyon subbasin (IDFG 2003a, ODFW 2003a, WDFW 2003a).

1.6.2 Social, Historical, and Cultural Values

The major social and cultural values of this area have been recently studied and discussed as part of the process to relicense Idaho Power Company's Hells Canyon Complex (Brownlee, Hells Canyon, and Oxbow dams). The following activities have significant social and cultural importance attached to them (BLM 2003; Gribskov 2002a,b; HCNRA 2003; Martin 2002; Melland 2002a,b; Orman 2002):

- Fishing
- Recreation
- Ecotourism (which includes viewing striking geological features)
- Traditional tribal uses
- Archaeology

1.7 Human Disturbances to Aquatic and Terrestrial Environments

Ranching and grazing, recreation, timber harvest, transportation, mining, urban development, and agriculture are primary land uses that potentially affect, or historically have affected, terrestrial and aquatic resources in the Snake Hells Canyon subbasin.

1.7.1 Ranching and Grazing

The horses of the Nez Perce Indians were the first domestic livestock grazed within the Snake Hells Canyon subbasin, probably as early as 1730. When the Nez Perce War ended around 1879, Euro-American settlers began grazing large livestock herds, primarily in the valley bottoms and lower slope areas. By 1900, more than 100 families were raising livestock along the Snake River between Battle Creek and the confluence with the Imnaha River. This period is considered the peak of livestock grazing by homesteaders in the area. The remoteness of the area made obtaining supplies and getting animals to market difficult, and when livestock prices declined, many of the 160-acre homesteads reverted to federal ownership or were purchased and consolidated into larger livestock operations.

Livestock grazing continues to be one of the main land uses at Craig Mountain and throughout privately owned lands in the subbasin. Sheep and cattle allotments on the Snake and Imnaha portions of the HCNRA peaked in 1920, with approximately 108,000 animal unit months (AUMs). The amount of grazing was reduced to 38,260 AUMS permitted on the same approximate area in 1998 (USFS 1999).

The preference for raising cows or sheep has changed a number of times. At first, cattle predominated, but large losses were incurred during the drought and bitterly cold years of 1884 through 1886, so many ranchers began to try sheep. Cattle-to-sheep ratios were 80 to 20% by 1915. During World Wars I and II, sheep grazing in the subbasin again increased due to government encouragement to increase the supply of wool for uniforms and meat for the troops. In 1940, cattle-to-sheep ratios on the HCNRA were 30 to 70%. Because domestic sheep could spread fatal bacterial pneumonia to bighorn sheep, domestic sheep grazing was eliminated on the Oregon portion of HCNRA on August 2, 1995 (USFS 1999). Grazing by domestic sheep continues on the Idaho portion of the HCNRA and on privately owned rangelands.

Overgrazing has negatively impacted both terrestrial and aquatic habitats in the subbasin. Livestock grazing has helped cheatgrass and other nonnative vegetation species establish, reduced the quantity and quality of riparian vegetation, and increased erosion and streambank failures. Most of this damage occurred in the late 1800s and early 1900s. Recently, strategies have been implemented to reduce negative impacts of grazing in the subbasin, including rotation of pastures, fencing of riparian areas, and overall reduction of livestock numbers. Since the mid-1900s, and especially in the past 20 years, the impacts of livestock grazing have been significantly reduced (USFS 1999).

1.7.2 Recreation

The Hells Canyon area is a world-renowned recreational destination, in large part because of unique whitewater rafting opportunities. Other recreational opportunities provided by the subbasin include hiking, horseback riding, camping, sightseeing, mountain biking, limited all-terrain vehicle riding, snowmobiling, swimming, power boating, photography, wildlife watching, hunting, and fishing (USFS 1999). The Snake River portion of the HCNRA received an average of 32,415 visitors per year between 1995 and 1997. Sightseeing was the primary reason for visits to the HCNRA (30%), followed by fishing (12%) (USFS 1999). Recreational activities peak in the summer season, with heavy usage observed between Memorial Day and Labor Day weekends. Recreational use of the subbasin is expected to increase, mirroring increases in nearby populations and the population of the country as a whole (USFS 1999, IDEQ and ODEQ 2001).

Snowmobiling is a substantial use within the HCNRA. The total area on the HCNRA dedicated to motorized oversnow use is approximately 40,786 acres, which is 6.25% of the total land base. There are approximately 132 miles of groomed trails.

1.7.3 Timber Harvest

Timber harvest on USFS-managed lands in the subbasin has been relatively limited. The designation of the HCNRA in 1975 legally prevented harvest of even-aged timber, including clearcutting or seed tree harvests. Regulations adopted in 1994 restricted the commercial harvest of timber on the HCNRA to harvests that enhance ecosystem health, wildlife habitat, or recreational and scenic uses; reduce the risk of harm posed by hazards; or respond to natural events such as fire, flood, earthquake, volcanic eruption, high winds, and disease or insect infestation. In addition to these restrictions, forest openings created by logging must be less than 2 acres in size. No timber harvest is permitted on the wilderness portion of the HCNRA (USFS 1999).

Timber harvest before the 1975 HCNRA designation impacted the ecosystem to some degree. Selective harvest has contributed to the loss of the ponderosa pine-dominated, open, parklike forest that probably historically characterized Craig Mountain and many of the forested lands in the subbasin (Mancuso and Moseley 1994). There has been a corresponding increase in mid-seral stands of Douglas-fir and grand/white fir; however, the changes in forest structure exhibited on the HCNRA are thought to be less severe than those in other parts of the subbasin and throughout the Columbia Basin (USFS 1999).

Many of the privately owned forested lands in the subbasin have been harvested. The extent and impact of this harvest on the Craig Mountain area have been studied by Narolski (1996). Prior to its purchase by the BPA in 1992, the Peter T. Johnson Wildlife Mitigation Unit was owned by the Pene Land Company and heavily logged in around 1986. According to Narolski (1996),

> …most of the valuable and larger trees were removed, leaving predominantly smaller, submerchantible, diseased, lower-value, and shade-tolerant species such as grand fir. Because of these past logging activities, poletimber stands comprised mainly of lodgepole pine can be found over much of the upland plateau within the WMU. The mid-1980s entry also affected the understory plant community, encouraging shade-tolerant grand fir regeneration along with assorted brush species, native grasses, and some noxious weeds.

Forest management activities taking place after the establishment of the Idaho Forest Practices Act (FPA) have had a lesser impact on fish habitat. The principal concerns with current and past forest management activities are increased sediment from roads, loss of riparian shade, and loss of riparian trees that enhance recruitment of large woody debris to stream channels. The FPA contains a number of rules on roads and stream shading related to these concerns. Carefully designed, constructed, and maintained roads minimize sediment input to streams. In addition, locating roads outside riparian areas helps maintain stream shade.

1.7.4 Transportation

The only state highway within the Snake Hells Canyon subbasin is Highway 129, located in Asotin County and connecting Clarkston, Washington, and Enterprise, Oregon. In 1999, traffic volume between Asotin and Clarkston was 5,600 vehicles per day at Critchville Road. However, the traffic volume quickly drops to 640 vehicles per day at Fairgrounds Road on the south end of the Asotin city limits (WSDOT 2000).

No rail service has ever been available in the subbasin (K. Frederickson, Washington State Department of Transportation, Rail Office, personal communication, May 2001; T. Long, Idaho Department of Transportation, Lewiston Office, personal communication, May 2001), although the Camas Prairie Line follows the north shore of the Snake River in Washington into Clarkston and Lewiston where it continues along the south shore of the Clearwater River. Even though the Camas Prairie Line is neither located within the subbasin nor heavily used, it does transport goods, especially dryland crops, from the area (K. Frederickson, Washington State Department of Transportation, Rail Office, personal communication, May 2001).

There are 735 miles of existing USFS roads on the HCNRA, of which 533 are currently open to travel. Fifty percent have natural surfaces, 4% have improved pit run, 12% have a crushed rock surface, 6% have been surface treated, and less than 1% have an asphalt concrete surface. The areas with the highest road density in the HCNRA fall outside the Snake Hells Canyon subbasin.

About 88% of the HCNRA is accessible by trail. An extensive trail system features 925 miles of trail, with approximately 361 miles occurring within the Hells Canyon Wilderness. Trail use in higher-elevation areas is limited to summer, while most lower-elevation trails are used year-round. Trails on the HCNRA evolved from Indian travel routes and big game migration routes; later, they were used for access for grazing, mining, and fire control. Because trails blazed by early users were not constructed for current patterns and levels of use, erosion affects some trails on steep grades.

Areas with low road density are associated with special management designation such as the Hells Canyon Wilderness, HCNRA, and areas without extensive historical logging activity. Road densities range from zero to over 5 miles of road per square mile for the various subwatersheds (IDEQ 1998).

Impacts of the transportation system to fish and wildlife populations are variable and potentially numerous, depending on the area and species present. Aquatic resources are most directly impacted by riparian degradation, altered hydrologic and sediment regimes, and passage issues related to roading. Terrestrial species are directly impacted by habitat fragmentation and disturbance/harassment, and habitat loss related to the transportation system. By providing access to areas, the transportation system may also be linked indirectly to impacts of various other land-use activities including recreation, timber harvest, mining, exotic species, and others.

1.7.5 Mining

In the 1860s, gold was discovered on the river bars of the Snake Hells Canyon subbasin. This discovery led to Euro-American settlement of the region. Placer mining for these deposits turned out to be relatively unsuccessful, but hundreds of rock piles still dot the river corridor as evidence of the attempt (USFS 1999). Later efforts focused on hard rock mining. Minerals excavated from the subbasin include gold, silver, copper, iron, and lead (Figure 17). Historical mining operations were widespread, but only sand, gravel and stone are currently excavated from the subbasin. These operations occur in the lower subbasin within 20 linear miles of Lewiston.

Impacts of mining activities are largely related to disturbance of spawning gravels (placer mining) and sediment production, and impacts may be long-lived. Tailings from historical placer mining activities still pose a sedimentation problem during peak flows (Mancuso and Moseley 1994). Mining activity may be detrimental to some wildlife species (e.g., stone mining may negatively impact amphibians and reptiles living in rocky habitats) while benefiting other species (e.g., hard rock mines create artificial caves that may benefit bats).

1.7.6 Agriculture

Cultivated land comprises 41,639 acres, or 7%, of the subbasin, with small grain crops in the lower 20 miles of the subbasin composing the vast majority of the region's agriculture (Figure 6). Small grains are grown on a three-year dryland crop rotation of wheat, barley, and a legume, oilseed, or fallow crop. Therefore, each crop in the rotation makes up about one-third of the acreage. Soft white, hard red spring, and hard red winter are the three classes of wheat. Both feed and malt barley are grown.

The legumes and oilseed crops are evenly divided into approximately one-sixth of the total rotation each. The variety of crops increases eastward as precipitation increases. The fallow rotation is found only on the western edge of the subbasin where a lack of adequate moisture prevents continuous cultivation. Legume crops include peas, lentils, and garbanzo beans, with the latter two the most common. Oilseed crops include mustard, flax, spring and winter rape, and spring and winter canola, the latter of which is the most prevalent. Traditionally, most of the legume–oilseed rotation was planted in legumes; however, poor prices for these crops have caused a shift toward more oilseed production, which is now equal to and will soon overtake production of legumes (S. O'Connell, Columbia Grain Growers, personal communication, May 2001).

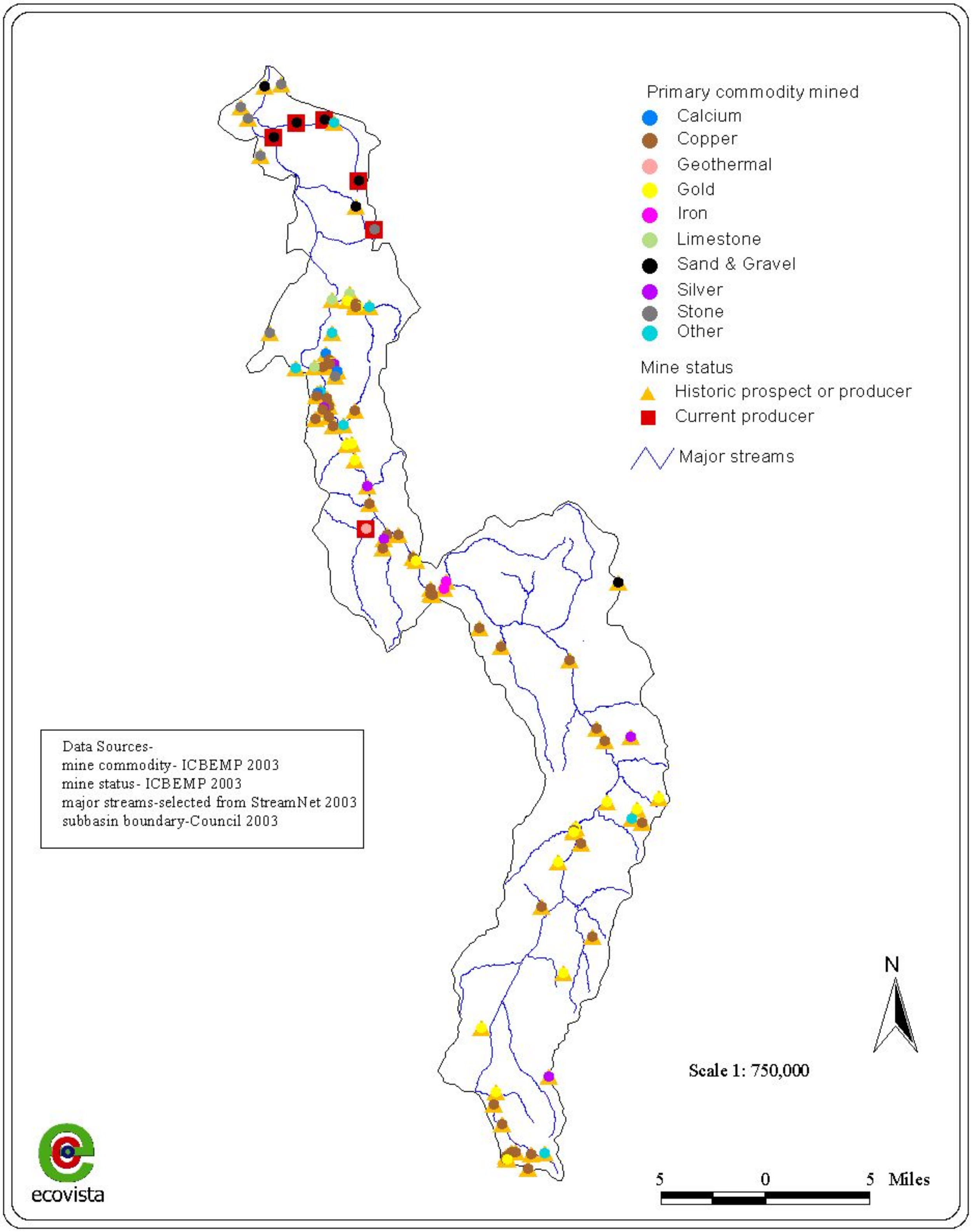

Figure 17. Current and historical mining activities in the Snake Hells Canyon subbasin.

As fertilizer costs increase, prompted by higher natural gas prices, farmers are applying commercial fertilizers with much more scrutiny. This situation has led to an increase in malt barley production because malt barley has a lower protein content and requires less nitrogen than feed barley. There is also a trend toward reduced tillage practices for the benefit of soil conservation as well as savings in labor, time, and wear on equipment (L. Smith, University of Idaho Cooperative Extension, Nez Perce County, personal communication, May 2001).

In the upper subbasin, agricultural activity ranges from small hay fields in the canyons located on bars and benches to larger hay fields located in the upland prairie, meadows, or plateau areas. Large dryland farming occurs north of the Salmon River (Camas Prairie) and in the lower portion of the Snake Hells Canyon subbasin on the upland plateau areas (Figure 6).

Agricultural impacts to aquatic systems are most commonly related to sediment production, introduction of excess nutrients or other contaminants to waterways, loss or degradation of riparian areas, and altered hydrologic regimes. Terrestrial impacts are most greatly related to loss of key habitat types (e.g., native grassland communities) through conversion to agriculture.

1.7.7 Urban Development

Urban development impacts the lower portion of the subbasin, which contains the town of Asotin and portions of Clarkston and Lewiston. The remainder of the subbasin is either rural or undeveloped. Populations in all five counties partially contained in the Snake Hells Canyon subbasin increased between 1990 and 2000 (Table 3). This population increase is reflected in both more residents inhabiting the lower subbasin towns of Asotin, Lewiston, and Clarkston and greater recreational pressure from the residents of neighboring communities. In the upper half of the subbasin, some residential housing with septic systems exists, but the density is very low (IDEQ and ODEQ 2001).

Direct impacts of urban development on aquatic ecosystems include alteration and degradation of aquatic habitat areas and alteration of hydrologic regimes. Habitat loss, degradation, and fragmentation are the primary direct impacts of urban development on wildlife species. Indirect impacts to both fish and wildlife species include introduction of pollutants, harassment, and increases in other land uses (transportation, recreation, etc.).

1.7.8 Diversions, Impoundments, and Irrigation Projects

Idaho Power Company (IPC) operates the Hells Canyon Complex (Hells Canyon, Oxbow, and Brownlee dams) at the upstream end of the Snake Hells Canyon subbasin. This three-dam complex has significantly altered hydrologic regimes downstream (see section 1.8). In addition, there are numerous small water rights (less than 0.02 cubic feet per second [cfs]) used for irrigation, livestock, and domestic use. The USFS and BLM are currently filing on many springs and creeks in accord with Snake River Adjudication protocols.

1.7.9 Barriers

Although the original Federal Energy Regulatory Commission (FERC) license for Hells Canyon Dam included fish passage, no fish passage was ever built. Access to spawning areas upstream of Hells Canyon Dam was blocked starting in 1955 by a three-dam complex. Although other anadromous species formerly used the area above Hells Canyon Dam, fall chinook may have been most impacted by impoundment. Snake River fall chinook were historically distributed from the mouth of the Snake River to a natural barrier at Shoshone Falls, Idaho, at RM 615 (Haas 1965). The upper reaches of the mainstem Snake River, particularly near the town of Marsing, Idaho (RM 390, 144 miles upstream of Hells Canyon Dam; Haas 1965), were the primary areas used by fall chinook salmon, with only limited spawning activity reported downstream of RM 272 (NMFS 2000a). After construction of the dams, the areas available for spawning included 104 miles of free-flowing Snake River downstream of Hells Canyon Dam and associated tributaries, including the Imnaha, Salmon, Grande Ronde, and Clearwater rivers (Rondorf and Tiffan 1997). An estimated 80% of the Snake River drainage formerly used by fall chinook salmon for spawning and rearing has been eliminated due to habitat changes or lack of access (USFS 1999).

No artificial barriers are known to occur on main tributaries to the Snake River in the subbasin. However, natural barriers to salmonid migration, such as low flows or high gradients, have been identified on many of the small tributaries that drain into the Snake River on the Idaho side. Specifically, in the lower portion of the subbasin, natural barriers (falls) occur on Captain John Creek (RM 5.8) and the South Fork of Captain John Creek (RM 1.7) (BLM 2000b). Low-flow barriers have been documented on Madden Creek, a tributary to Captain John Creek, and are suspected to occur at the mouth of Corral Creek when Snake River flows are low (BLM 2000b). In the upper portion of the subbasin (above the Salmon River confluence), natural barriers have been identified in Dry Creek, Wolf Creek (about 0.75 miles upstream of the confluence with the Snake River), Getta Creek (during periods of low flow), and Highrange Creek (because of steep gradient and low flows) (BLM 2000a).

1.7.10 Fire Suppression

Natural (lightning-caused) fires are a primary factor perpetuating natural forest ecosystems and landscape diversity in the Snake Hells Canyon subbasin (Cooper et al. 1991). Planned and unplanned burning by Native Americans had an extensive impact on maintaining stand composition and structure. The high frequencies in some of the fire-scar samples in certain studies may have resulted from Indian-caused fires (Barrett and Arno 1982 *in* Cooper et al. 1991). Prospectors and settlers also set fires to expose mineral outcrops (Space 1964 *in* Cooper et al. 1991) and improve range. In recent history, numerous wildfires have burned within the Snake Hells Canyon ecosystem (Figure 18).

Fire-free intervals can be inferred to some extent by climax tree series and habitat type. *Pinus ponderosa-Pseudotsuga menziesii*/bunchgrass types have a mean fire-free interval of six years, compared with *Abies lasiocarpa* habitat types that have an interval of over 40 years (Arno and Peterson 1983 *in* Cooper et al. 1991). Modern fire suppression has, however, resulted in plant communities that have greater biomass and less vigorous vegetative growth, with increased susceptibility to pathogens and wildfires of greater severity and size (Johnson 1998). These changes are illustrated by comparing historical and current severity ratings for plant communities within the subbasin (Figure 19 and Figure 20, respectively). There has been a significant reduction in the extent of the nonlethal and mixed fire regimes.

Years of fire suppression in the subbasin have resulted in dramatically altered fire-return intervals or frequencies (Figure 21 and Figure 22). These fire regimes maintained late seral single-layer types by thinning shade-tolerant tree species in early, mid-, and late seral multilayer types. Reductions in fire frequency have increased fuel loads and resulted in hotter burning, more intense fires and a shift from nonlethal to lethal fire regimes in many areas (Quigley and Arbelbide 1997).

Successional processes following wildfire and logging have been described for some northern Idaho habitat types (Lyon and Stickney 1976, Arno et al. 1985, Green and Jensen 1991). In general, the composition of post-disturbance plant communities is dependent on environmental site conditions, existing vegetation, severity of disturbance, life history characteristics of individual species, and (to some degree) chance (Morgan and Neuenschwander 1984). Research by Lyon and Stickney (1976) has shown that immediately following a fire, forest plant communities were composed largely of species present prior to the event. Even five years post-disturbance, species composition was 80% similar to the prefire community, and all species had established during the first year. These findings suggest that many local plant species are well adapted to surviving and propagating after fires.

The most abundant trees in the Snake Hells Canyon subbasin are seral species adapted to periodic fire disturbance (Table 5). Adaptations to fire include thick, corky, fire-resistant bark (*Larix occidentalis*, *Pinus ponderosa*, *Pseudotsuga menziesii*), light or winged seeds (*L. occidentalis*, *P. ponderosa*, *P. menziesii*, *Pinus monticola*), serotinous cones (*Pinus contorta*), and rapid initial growth in height (Cooper et al. 1991). As evidenced by even-aged stand structure, a considerable amount of viable seed survives even catastrophic fires.

Successional processes in riparian areas, shrub fields, and grasslands have been less well studied than coniferous forest types of the subbasin have been. Fire is a common occurrence within low-elevation grasslands and shrub fields. Within bluebunch wheatgrass communities, light to moderate fires can enhance cover of wheatgrass, but severe fires can be detrimental to bunchgrass survival (Johnson 1998). Cheatgrass and other annual grasses can increase following severe fires in the wheatgrass zone. The timing and intensity of livestock grazing can also influence the composition of successional plant communities following disturbance. Idaho fescue is more sensitive to damage from fire than some other native bunchgrasses are (Johnson 1998). Even moderate fires can result in significant decreases in Idaho fescue coverage for several years following the event.

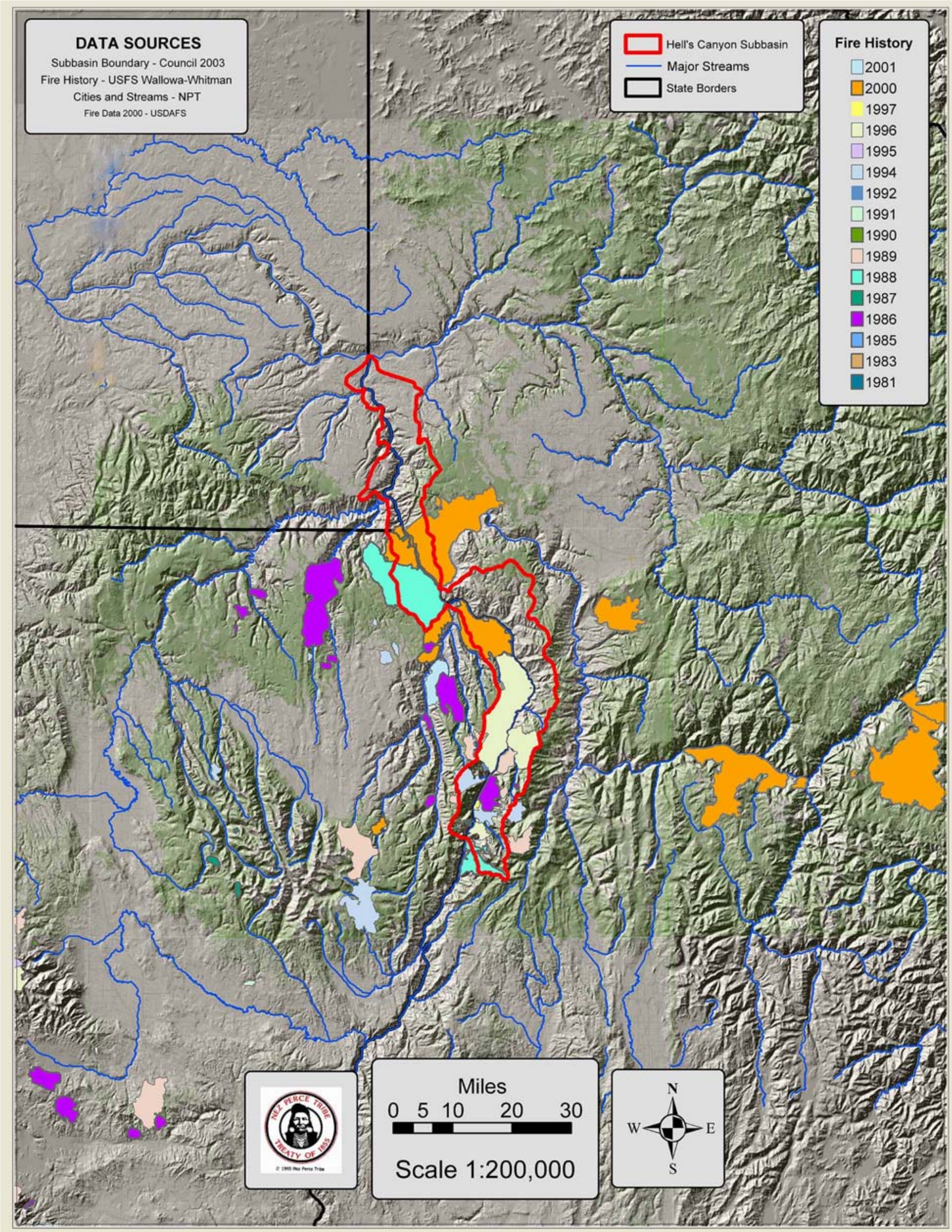

Figure 18. Recent fire activity within and adjacent to the Snake Hells Canyon subbasin.

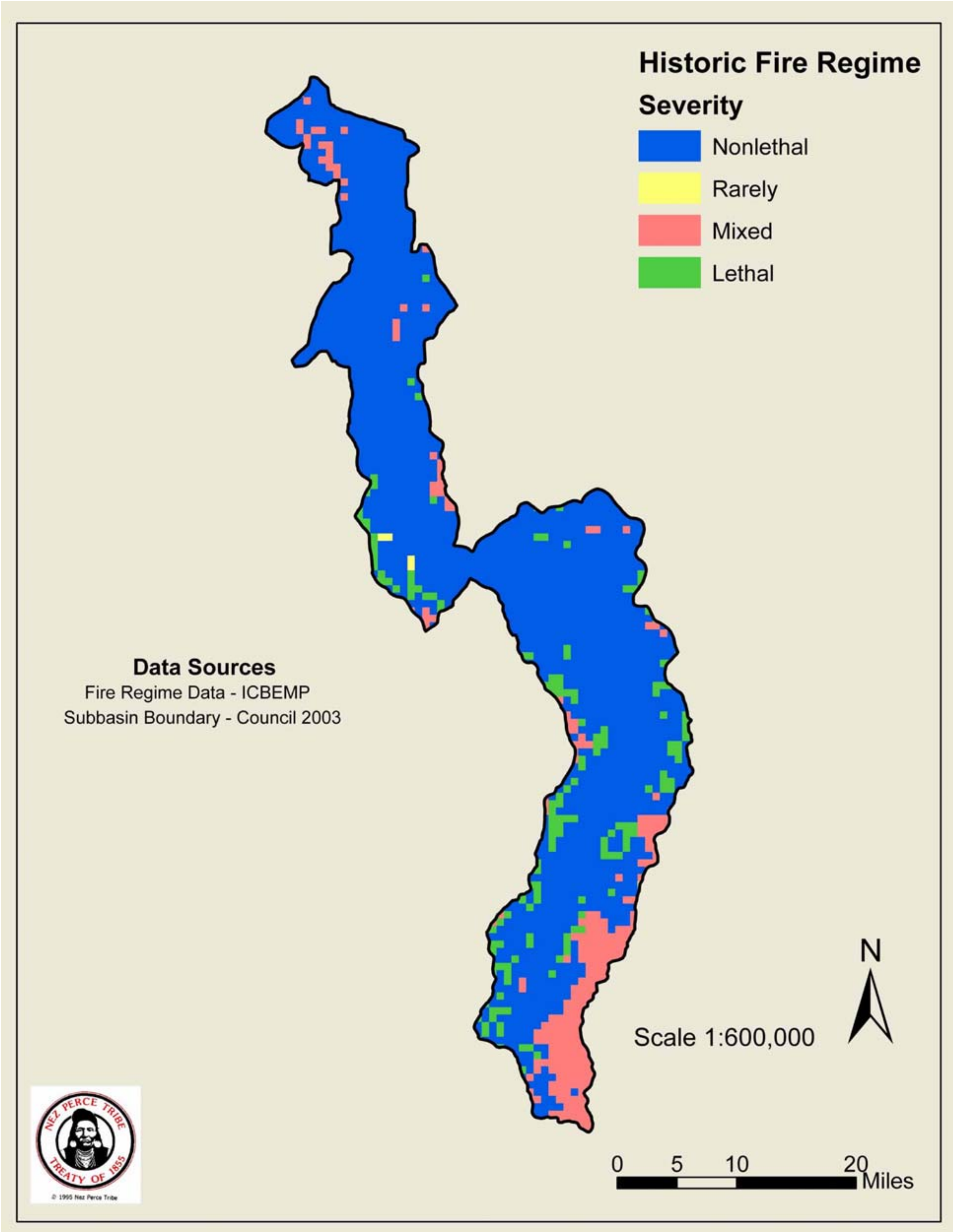

Figure 19. Historic fire regime severity ratings for the Snake Hells Canyon subbasin.

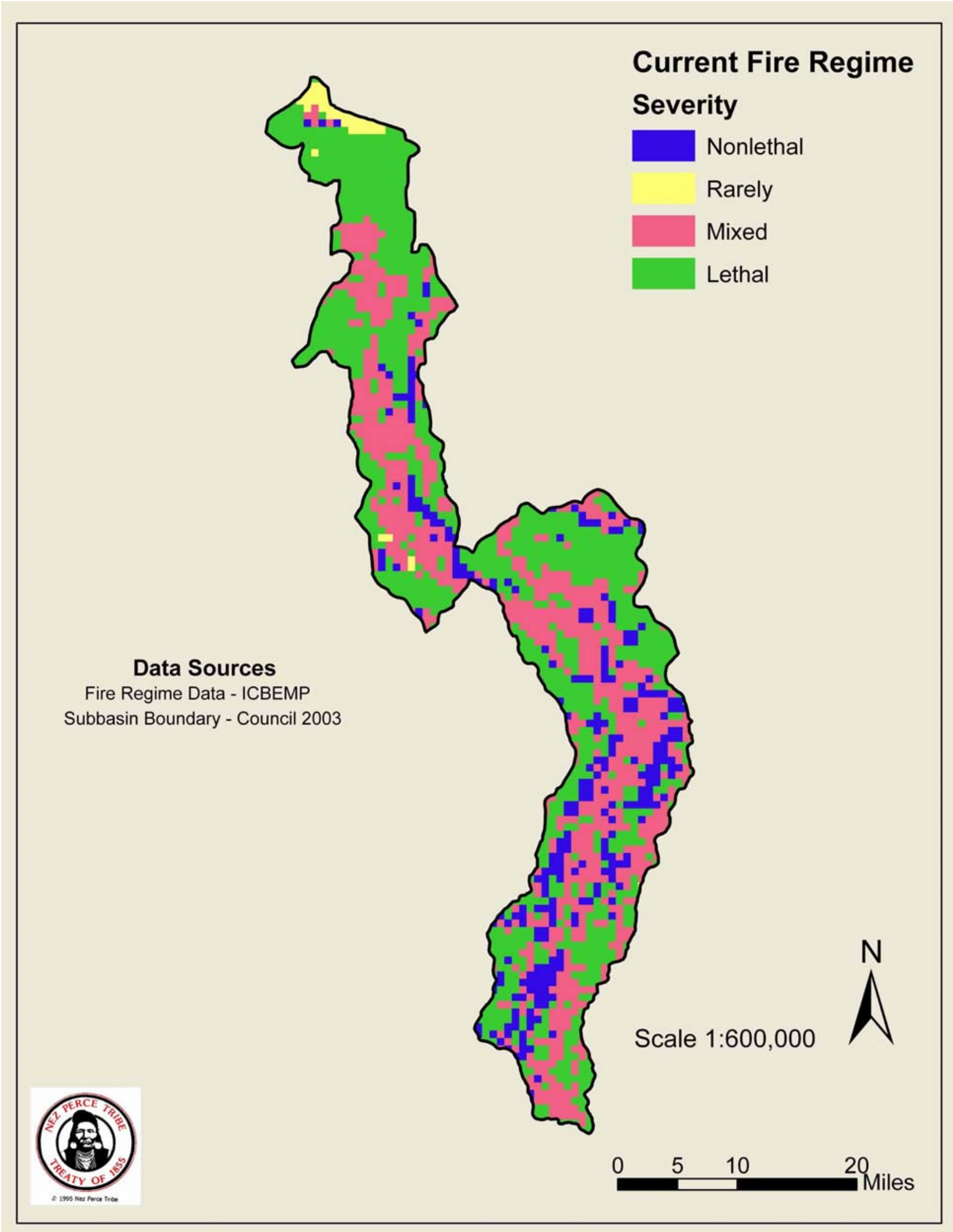

Figure 20. Current fire regime severity ratings for the Snake Hells Canyon subbasin.

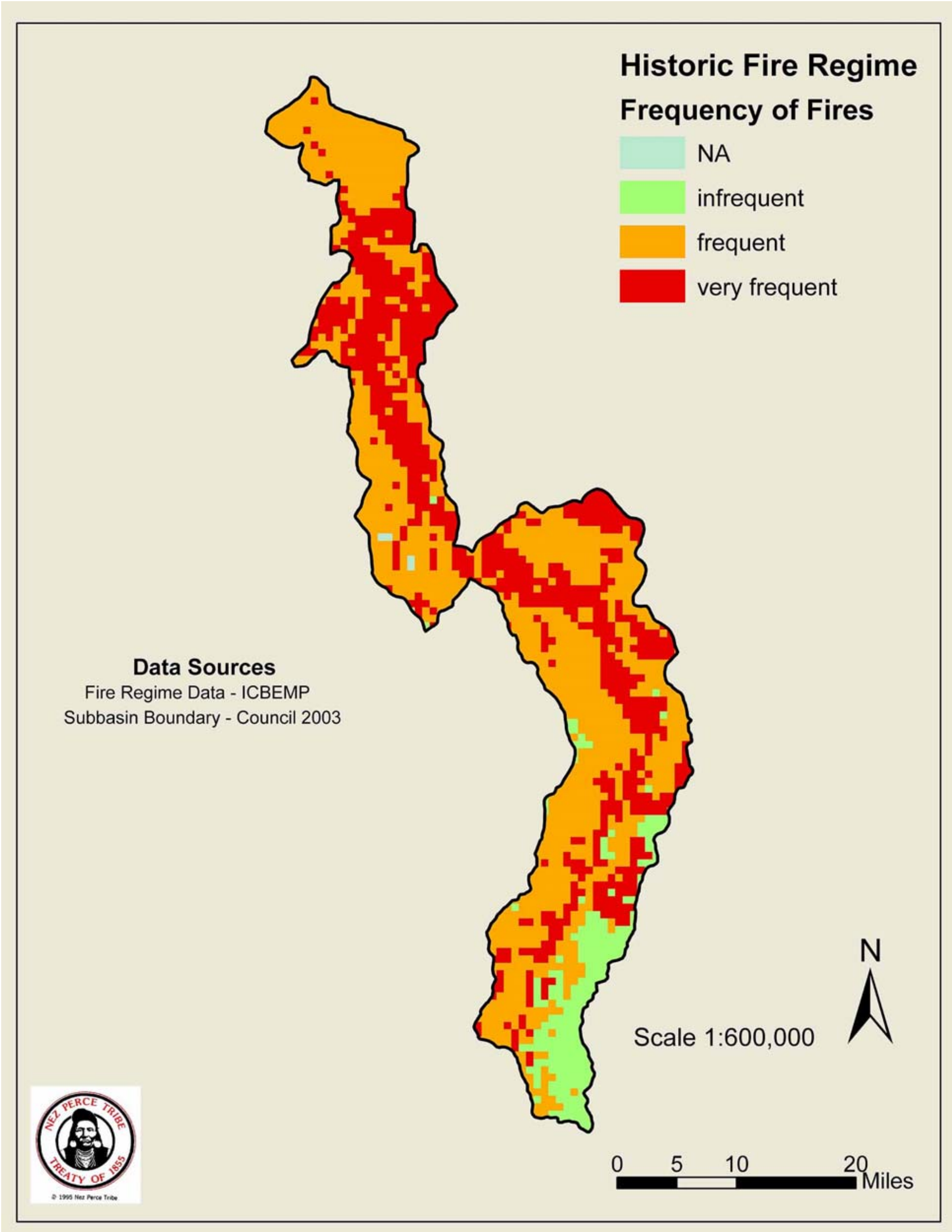

Figure 21. Historic fire frequency for the Snake Hells Canyon subbasin.

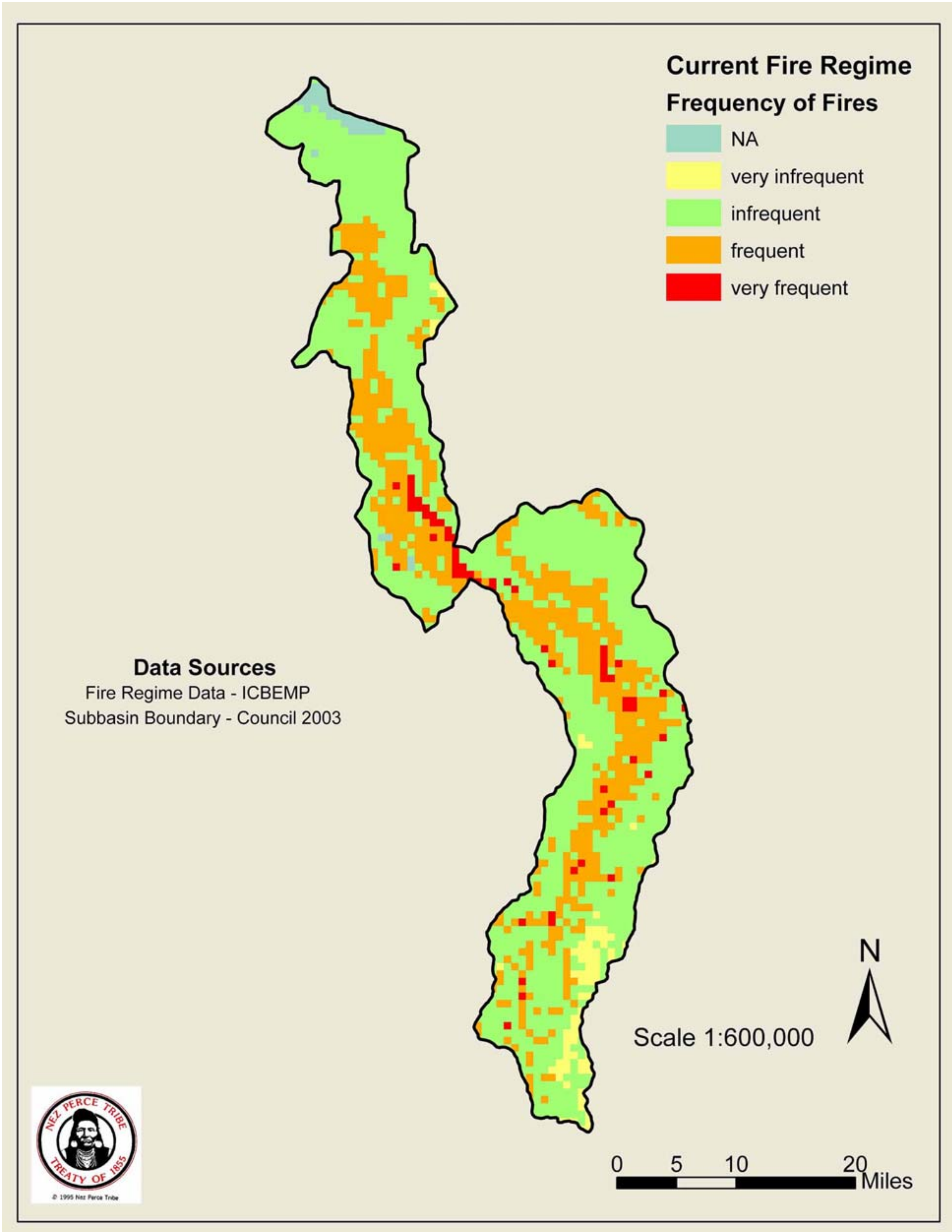

Figure 22. Current fire frequency for the Snake Hells Canyon subbasin.

Table 5. Tolerance of tree species to fire (Fischer and Bradley 1987).

Species	Tolerance							
	Bark Thickness of old trees	**Root Habit**	**Resin in old bark**	**Branch habit**	**Stand habit**	**Relative inflammability of foliage**	**Lichen growth**	**Degree of fire resistance**
Western Larch	Very thick	Deep	Very little	High and very open	Open	Low	Medium to heavy	Most resistant
Ponderosa Pine	Very thick	Deep	Abundant	Moderately high and open	Open	Medium	Medium to light	Very resistant
Douglas-fir	Very thick	Deep	Moderate	Moderately low and dense	Mod. - dense	High	Heavy medium	Very resistant
Grand Fir	Thick	Shallow	Very little	Low and dense	Dense	High	Heavy medium	Medium
Lodgepole Pine	Very thin	Deep	Abundant	Moderately high and open	Open	Medium	Light	Medium
Western White Pine and Whitebark Pine	Medium	Medium	Abundant	High and dense	Dense	Medium	Heavy	Medium
Western Red Cedar	Thin	Shallow	Very little	Moderately low and dense	Dense	High	Heavy	Medium
Engelmann Spruce	Thin	Shallow	Moderate	Low and dense	Dense	Medium	Heavy	Low
Mountain Hemlock	Medium	Medium	Very little	Low and dense	Dense	High	Medium to heavy	Low
Western Hemlock	Medium	Shallow	Very little	Low and dense	Dense	High	Heavy	Low
Supalpine Fir	Very thin	Shallow	Moderate	Very low and dense	Mod.- dense	High	Medium to heavy	Very low

Shrubland plant communities vary widely in their response to fire. Dryland shrub communities such as ninebark often respond favorably to moderate fires (Johnson 1998) due to their ability to resprout from root crowns (Lyon and Stickney 1976). Vigorous regrowth following fire can create highly palatable forage for elk, deer, rabbits, and other browsers. Idaho fescue associated with ninebark communities, however, often responds poorly following fire because the greater fuel loads in shrub fields result in hotter, longer-duration fires that can damage or kill the plants (Johnson 1998).

Shrub species that respond poorly to fire include big sagebrush and mountain mahogany. Both of these species are often killed by even moderate fires, although mountain mahogany seed germination increases following light fires (Johnson 1998).

1.7.11 Introduction of Exotic Species

Land-use activities in the subbasin have contributed to significant changes to the vegetative composition of communities in the subbasin; these changes are particularly notable in grassland habitats. Habitats in the lower subbasin have been the most impacted by noxious weeds and other invasive plant species. Yellow starthistle has altered the composition of large areas of the canyon grassland. In areas where disturbance has been severe, native perennial grasses have been eliminated and noxious weed such as whitetop, Scotch thistle, and yellow starthistle occupy the sites, along with other weedy species such as cheatgrass and St. Johnswort (USFS 2003a). In other areas of the subbasin, invasive plant species and noxious weeds are less pervasive, but preventing their spread is a management priority (see section 0 and the management plan for details).

1.8 Hydrography and Hydrology

The macroclimate patterns previously described (see section 1.3) have little functional impact on the hydrology of the mainstem Snake River within the Snake Hells Canyon subbasin. Mainstem hydrology is dictated primarily by dam operations through the Hells Canyon Complex and inflows from surrounding subbasins (such as the Salmon River).

Macroclimate has a more substantial impact on the hydrology of smaller tributaries within the subbasin. In lower-elevation areas, occasional thunderstorms occurring from late spring through summer may result in flash floods that produce annual peak flows in localized areas. However, because thunderstorms are generally brief and limited in size, their impacts are highly localized.

Timing, duration, and volume of peak flows are driven by snowmelt and/or seasonal rainstorms at lower elevations (less than 5,000 feet) in the Snake Hells Canyon subbasin. Therefore, interannual variability in both the timing and volume of peak flows is likely to be much greater than that at higher elevations. Rainstorms having the greatest impacts to hydrology at lower elevations occur during winter or spring, with precipitation falling on frozen or snow-covered ground. Such rain-on-snow events can occur from November through March (Thomas et al. 1963) and may result in hydrograph peaks throughout this period.

Hydrological features of the Snake Hells Canyon subbasin are best described by dividing the reach into two sections: the lower section, which extends below the confluence of the Salmon River to the Clearwater River, and the upper section, which extends from the confluence of the Salmon upriver to Hells Canyon Dam.

The lower section flows 50 miles from the mouth of the Salmon River (RM 188) to the mouth of the Clearwater River (RM 138). This segment of river is regulated by Hells Canyon Dam (RM 247) and large contributing tributary rivers, which include the Clearwater and Grande Ronde rivers. Lower order tributaries joining the Snake River in this reach include Asotin Creek, Tammany Creek, Redbird Creek, and several other streams, many of which flow only during periods of runoff. The Clearwater River contributes approximately 30% of the total flow of the Snake River at that point. Water discharge records are from a U.S. Geological Service (USGS) discharge station located 1.2 miles downstream of the Grande Ronde River (period of record 1958–1997). The average annual discharge is 35,900 cfs, highest daily mean is 191,000 cfs (maximum of 195,000 cfs on June 18, 1974), and lowest daily mean is 6,630 cfs (minimum of 6,010 cfs on September 2, 1958). High flows average 80,000 to 140,000 cfs, and mean low flows generally range from 8,000 to 15,000 cfs. Stream flows follow a pattern of low flows during the late summer and fall months and high flows in the spring and early summer months. The lowest portion of the subbasin includes several miles of Lower Granite Reservoir, which extends upstream to Asotin at RM 146.8. With three major dams upstream—Brownlee, Oxbow and Hells Canyon—water levels fluctuate daily and weekly for power generation and are seasonally impacted to moderate flooding and provide water for irrigation.

The upper section of the Snake River through Hells Canyon flows 58.8 miles from Hells Canyon Dam (RM 247) to the mouth of the Salmon River (RM 188). This segment of river is regulated by Hells Canyon Dam. The largest tributary in this river segment is the Imnaha River (RM 192). Water discharge records are from a USGS discharge station located 0.6 mile downstream of Hells Canyon Dam (period of record 1966–1997). The average annual discharge is 20,650 cfs, highest daily mean is 98,100 cfs (maximum of 103,000 cfs on January 2, 1997), and lowest daily mean is 4,360 cfs (minimum of 4,360 cfs on May 8, 1977; Figure 23).

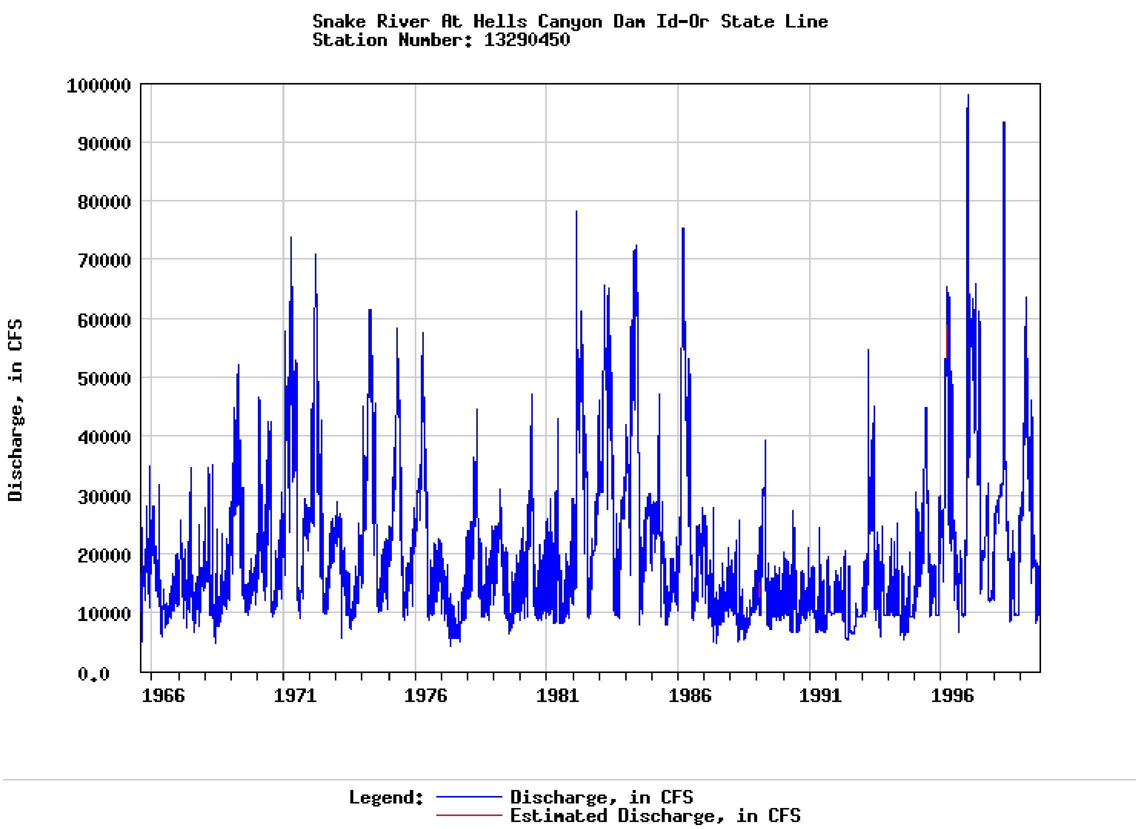

Figure 23. Average daily flows measured at Hells Canyon Dam gage 13290450 (1966–1997).

Mean high flows generally range from 60,000 to 80,000 cfs, and mean low flows generally range from 7,000 to 10,000 cfs. Currently, a minimum discharge at Hells Canyon Dam is maintained at 10,000 cfs during fall chinook salmon spawning and incubation periods. Again, stream flows are low during the late summer and fall and high during the spring and early summer.

More than 95% of total inflow into the subbasin down to the Salmon River is contributed from upstream flows through Hells Canyon Dam (Figure 24 and Figure 25) (IDEQ and ODEQ 2001). These flows are heavily influenced by upriver water uses. The Hells Canyon Complex provides irrigation storage for more than 3.5 million acres of land upstream of Brownlee Dam, for a total estimated annual consumptive use of 6 to 8 million acre-feet (IDEQ and ODEQ 2001). Currently, high flows are not usually as high as those recorded in the early 1900s, and in most areas, average low flows are not generally as low. Although the volume of water that passes through the subbasin annually has not changed substantially, the timing of flows has been altered by the Hells Canyon Complex.

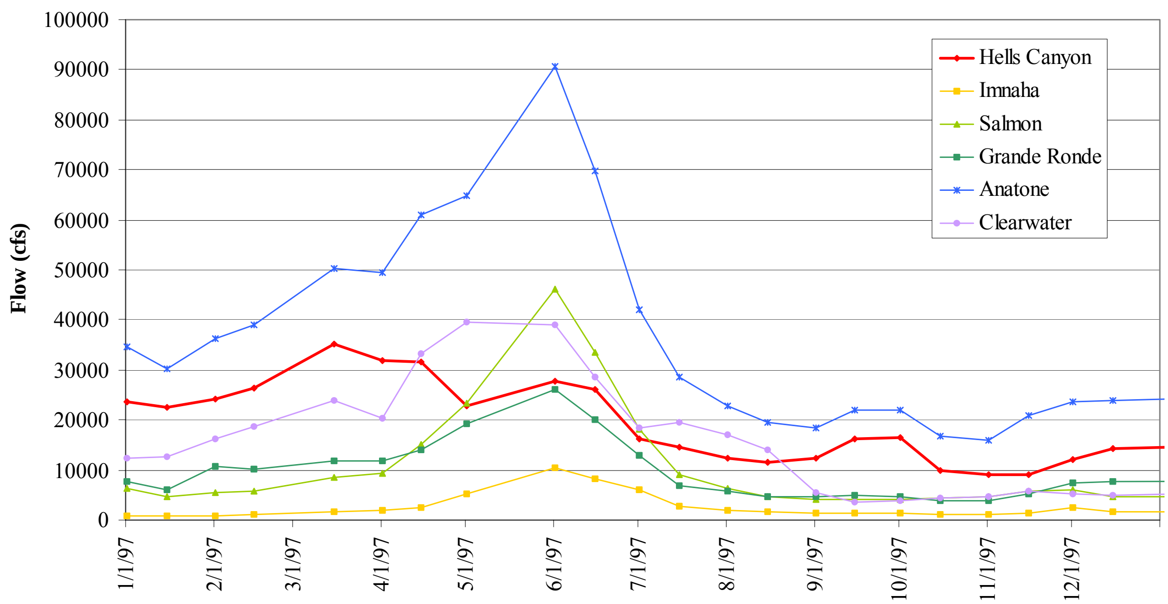

Figure 24. Flow in the Snake River (at the Hells Canyon and Anatone gages) and contributing flows from four main tributaries during 1997.

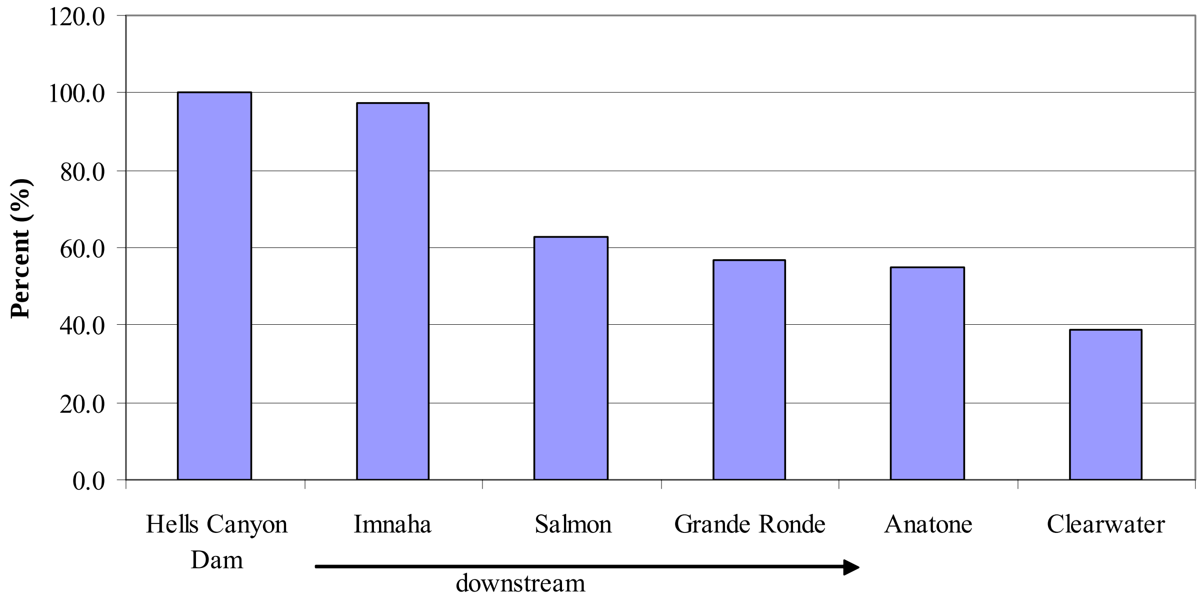

Figure 25. Percentage of the contribution of flow from Hells Canyon Dam at various points in the Snake Hells Canyon subbasin during 1997.

Water releases through Hells Canyon Dam cause the Snake River to fluctuate dramatically each day due to the effects of power peaking (Figure 26) (USGS 2001). These effects are most pronounced above the confluence with the Salmon River (Kern 1976). Above the Salmon River, these fluctuations cause severe enough disturbances to vegetation to prevent the establishment of anything more than early successional plants within the fluctuation zone. The flow of the Salmon River moderates the impacts of the flow enough to allow more complex vegetative communities below the confluence (Kern 1976).

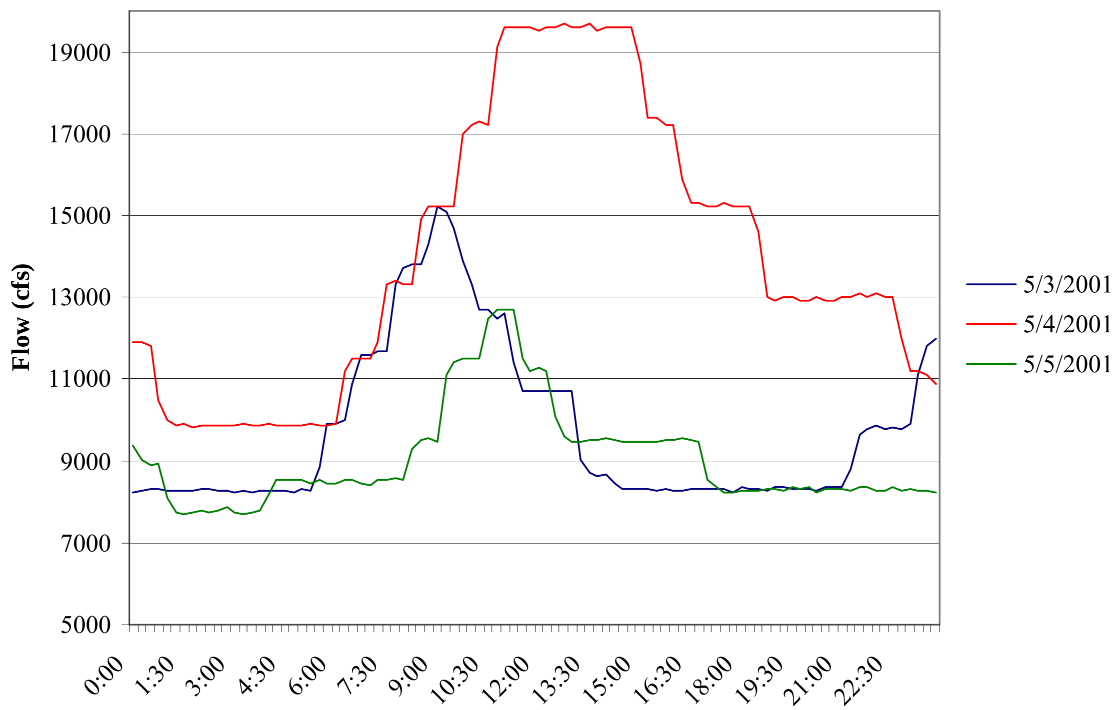

Figure 26. Daily flow fluctuations at Hells Canyon Dam for three days in March 2001.

As mentioned earlier, the FERC relicensing process for the Hells Canyon Complex is currently underway. IPC filed the draft license application in November 2002 and the final license application in July 2003. In addition, section 401 of the Clean Water Act (CWA) requires IPC to file for certification with the states of Idaho, Oregon, and Washington (IDEQ and ODEQ 2001).

1.9 Water Quality

Little water quality information exists for the Snake Hells Canyon subbasin. Water quality data—including temperature, flow, conductivity, oxygen, oxygen saturation, pH, suspended solids, total persulfate nitrogen, ammonia nitrogen, total phosphorus, dissolved soluble phosphorus, turbidity, fecal coliform, and nitrate-nitrite—is collected by the Washington Department of Ecology at the Snake River station (gage 35A150) just above the confluence of the Clearwater River.

In the mainstem, above and below the confluence with the Salmon River, water quality is generally excellent (IDEQ 1998). It fully supports all beneficial uses identified for the river (recreation, primary and secondary contact recreation, salmonid spawning, domestic water supply, agricultural water supply, and cold water biota). However, elevated summer water temperatures are not optimum for salmonid rearing conditions, and high sediment concentration occurs during high-flow events (WDFW et al. 1990, IDEQ 1998).

1.9.1 303(d) Listed Segments

Water quality limited segments are streams or lakes listed under section (§) 303(d) of the CWA for either failing to meet their designated beneficial uses or exceeding state or tribal water quality criteria. States assume a responsibility to develop a 303(d) list and establish a total maximum daily load (TMDL) for the impaired parameter(s). Streams listed under §303(d) within the Snake Hells Canyon subbasin are summarized in Table 6.

Water quality in the Snake Hells Canyon subbasin is subject to different criteria of three states. Idaho, Washington and Oregon each use different methodologies to determine what constitutes a water quality violation. In the reach between Oregon and Idaho, the river must meet the criteria of both states due to the water mixing at the state line in the middle of the river (IDEQ and ODEQ 2001).

Temperature and sediment are the two factors listed under §303(d) of the CWA that have limiting effects on fish populations within the subbasin. Total dissolved gas, although not included under 303(d) listings, had been recommended for listing and was addressed in the recent TMDL developed for the Snake River (IDEQ and ODEQ 2001).

1.9.2 Temperature

According to the U.S. Environmental Protection Agency (USEPA, cited in IDEQ and ODEQ 2001),

> Data collected roughly monthly from 1975 to 1991 by the USEPA in the Downstream Snake River segment at RM 247 (below Hells Canyon Dam) show temperatures ranging from 1 °C in January, 1979 and 1985 (air temperature at –4.5 °C and 2 °C respectively) to 24 °C in July, 1975 and September, 1987 (air temperature at 35 °C and 30 °C respectively). When compared to the 13 °C absolute maximum temperature target identified by the SR-HC TMDL for salmonid spawning in interstate waters (because these are instantaneous data, there is no way to determine an average) the data show that the target was routinely not met during September (82%) and October (47%). Targets were not met in November only 7% of the time. Roughly 22% of all available data show temperatures above 17.8 °C (all occurring during late July, August or September). Roughly 1% of all available data show temperatures above 22 °C (all occurring in July or September). This set contained 148 data points. These data were collected over a variety of seasonal variations, but do not represent continuous monitoring.

During the winter, the average temperature of inflowing water from Hells Canyon Dam is approximately 6 °C (43 °F), and the average summer temperature for inflowing water is 20 °C (68 °F) (IDEQ and ODEQ 2001). Water temperatures at RM 192 (just above the confluence with the Imnaha River) are warmer in the summer and cooler in the fall than those measured just below Hells Canyon Dam (Anderson 2000). Daily maximum and minimum temperatures have a wider range and greater variance as distance from Hells Canyon Dam increases. IDEQ and ODEQ (2001) found that water temperatures in the Snake River generally decrease by an average of 3 °C during the summer between Hells Canyon Dam and the Salmon River. However, Anderson (2000) found that water temperatures changed by approximately 10% of the difference between air and water temperatures between Hells Canyon Dam and the Salmon River, warming about 1 °C as the water flowed through the canyon during summer. Anderson also found that, during the summer, the outflow from Hells Canyon Dam may be either warmer or cooler than water temperatures measured in primary Snake River tributaries. This finding means that the tributaries can either warm or cool the Snake River (Anderson 2000). Downstream temperatures in the Snake River, recorded just above the confluence of the Clearwater River at the Washington Department of Ecology station 35A150, regularly fail state water quality criteria during summer months (July–September; Figure 27). Although flow datasets for 1999–2000 are incomplete, flow and temperature do not appear to be correlated ($\rho_{x1,x2} = -0.09$).

Table 6. Stream segments in the Snake Hells Canyon subbasin listed as impaired or with beneficial uses under §303(d) of the CWA.

Listing State	Segment	303(d) Listed Parameters	Designated Beneficial Uses
Idaho	Snake River—Hells Canyon Dam downstream to confluence with Clearwater River	not listed	cold water biota salmonid spawning primary contact recreation domestic water supply
Idaho	Divide Creek	sediment	
Idaho	Wolf Creek	sediment	
Idaho	Getta Creek	sediment	
Idaho	Cottonwood Creek	sediment	
Idaho	Deep Creek	metals sediment pH	
Idaho	Tammany Creek	sediment	
Oregon	Snake River—Hells Canyon Dam downstream to Washington Border	mercury, temperature	public/private domestic water supply industrial water supply irrigational water livestock watering salmonid rearing and spawning resident fish and aquatic life water contact recreation wildlife hunting, fishing, boating aesthetics anadromous fish passage commercial navigation and transport
Washington	Snake River—confluence with Clearwater River to 1 mile upstream	temperature	water supply (domestic, industrial, agricultural) stock watering fish and shellfish wildlife habitat, recreation commerce and navigation

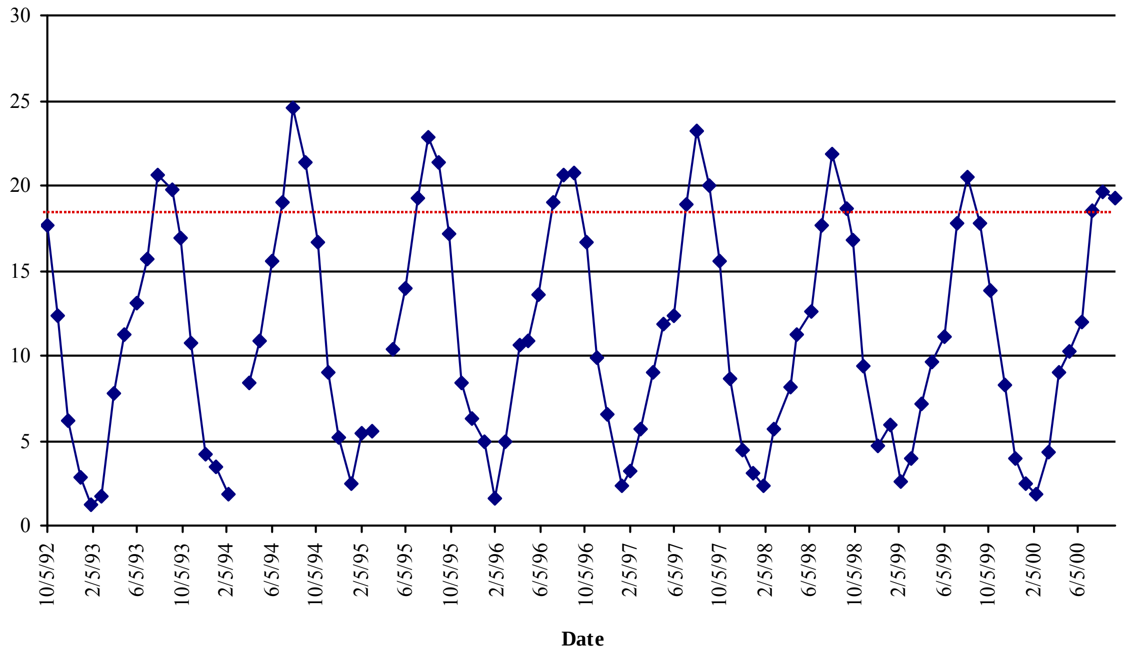

Figure 27. Stream temperatures recorded at Washington Department of Ecology station 35A150 on the mainstem Snake River above the confluence of the Clearwater River (1992–2000).

1.9.3 Sediment

Excessive fine sediment is the most common pollutant in impaired streams in Idaho (Rowe et al. 2003). Within the Snake Hells Canyon subbasin, six tributary streams in Idaho are listed under §303(d) for sediment concerns: Tammany, Divide, Wolf, Getta, Cottonwood, and Deep creeks (Table 6). The Tammany Creek sediment TMDL (IDEQ 2001) was completed in September 2001. TMDLs for the other five listed streams are planned but not yet complete.

Total maximum daily load (TMDL) plans prepared to address excessive fine sediment in these streams must comply with the existing Idaho narrative water quality standard for sediment, which states that “Sediment shall not exceed quantities...which impair beneficial uses” (IDAPA 58.01.02.200.08). Rowe et al. (2003) suggest appropriate water column and streambed measures for gaging attainment of the narrative sediment goal during TMDL development. Water column and instream measures that were determined to be the best indicators of sediment-related impairment of beneficial uses include light penetration, turbidity, total suspended solids and sediments, embeddedness, extent of streambed coverage by surface fines, percent subsurface fines in potential spawning gravels, riffle stability, and intergravel dissolved oxygen. Targets for each of these measures will be recommended in sediment TMDLs to allow attainment of the narrative Idaho sediment standards.

For clarification it is important to note that, although not listed under §303(d) for sediment concerns, the mainstem Snake River below Hells Canyon Dam is often referenced as having sediment limitations. Rather than excess fine sediments (which would be listable), the Snake River below Hells Canyon Dam is deficient in sediment due to operation of the Hells Canyon Complex and would benefit from added sediment (USFS 1999). The three upriver dams trap suspended sediment and bedload, while fluctuating water levels increase rates of streambank erosion downstream. The upstream entrapment of sediments has retarded recruitment and/or development of new sandbars and silt deposits. These deposits provide substrate for riparian growth (Kern 1976).

1.9.4 Total Dissolved Gas

The Snake River is not currently listed as limited by total dissolved gas (TDG) in Oregon or Idaho, although IDEQ and ODEQ (2001) recommend that TDG limitation be added to the 2002 303(d) list for each state. Both Oregon and Idaho have a TDG criterion of 110%; excess TDG in the water column has been shown to be detrimental to the survival of numerous fish species. IPC has been monitoring TDG below Hells Canyon Dam and found that, at all spill levels, the criterion was exceeded from below Hells Canyon Dam to at least RM 180 (IPC 1999). A declining trend in TDG occurred with distance from the dam, and a direct relationship exists between distance from compliance with the criterion and the amount of spill (IDEQ and ODEQ 2001).

1.9.5 Mercury

Oregon lists the upper half of the Snake River (above the confluence with the Salmon River) as water quality limited due to mercury contaminants, which may pose threats to humans through fish consumption (IDEQ and ODEQ 2001). Only one sample has been collected within the reach, and that sample included tissue from only two fish. All other samples used were from sites upstream of Hells Canyon Dam. The major source of mercury is assumed to be from Brownlee Reservoir and upstream tributary flows (IDEQ and ODEQ 2001). The one data point available shows the mercury level at 0.15 mg/kg dry weight fish tissue, which is below the level used by the Oregon Division of Health to establish a mercury fish tissue advisory (IDEQ and ODEQ 2001).

In rare cases, when concentrations are extremely high, mercury can result directly in the death of aquatic biota. More commonly, bioaccumulation and concentration affect designated beneficial uses (fishing and wildlife habitat) by building up concentrations within the food chain to levels where consumers (human or other predators) can be adversely affected (IDEQ and ODEQ 2001).

1.9.6 Point Sources of Water Pollution

Within the Snake Hells Canyon subbasin, no point sources of water pollution are known to exist above (IDEQ and ODEQ 2001) or below the Salmon River confluence.

2 Regional Context

2.1 Relation to the Columbia Basin and other Ecoprovinces and Subbasins

Due to its relatively centralized setting within the Snake River basin, the Snake Hells Canyon subbasin has strong ties with surrounding ecoprovinces and their component subbasins. The Snake Hells Canyon subbasin is one of four subbasins within the Blue Mountain Ecoprovince and one of the eleven ecoprovinces in the Columbia Basin
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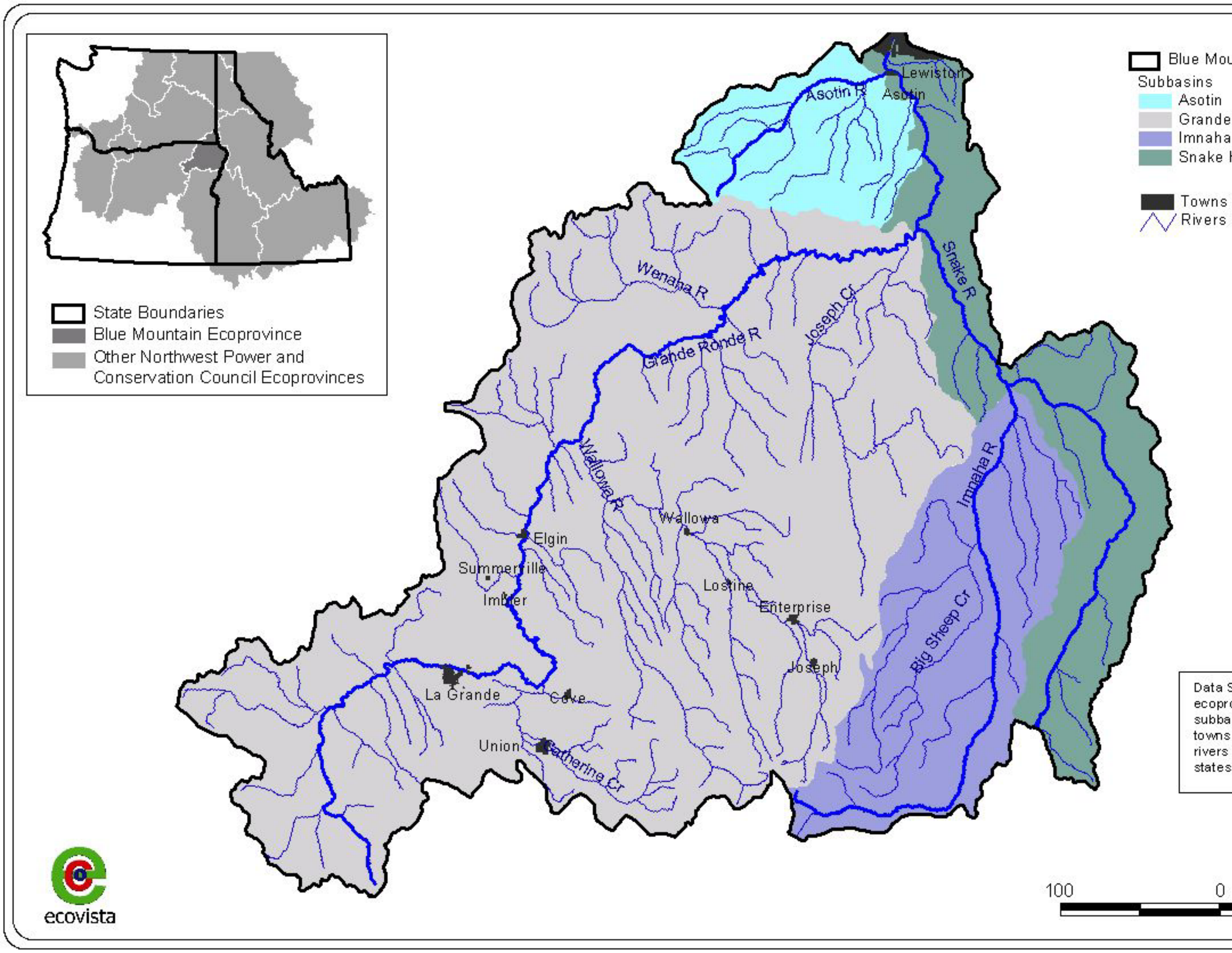

Figure 28). From within the Blue Mountain Ecoprovince, the Imnaha, Grande Ronde, and Asotin subbasins contribute substantial inflows to the Snake Hells Canyon subbasin

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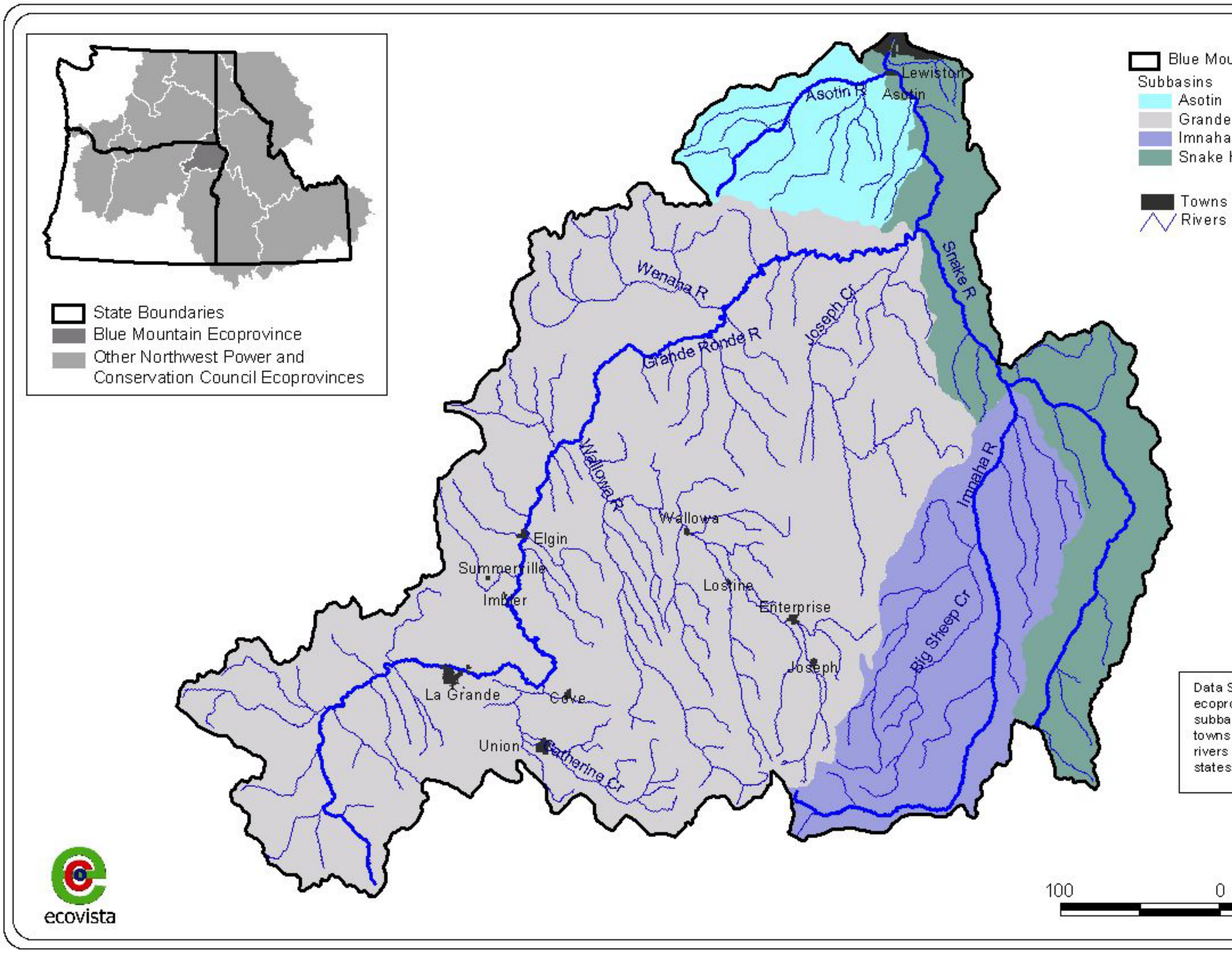

Figure 28). Additionally, the Salmon subbasin in the Mountain Snake Ecoprovince provides substantial inflow to the Snake Hells Canyon subbasin. Inflow from upstream into the Snake Hells Canyon subbasin is derived from the Middle Snake Ecoprovince, which includes flows generated from the Upper Snake Ecoprovince; outflow from the subbasin joins with that from the Clearwater subbasin (Mountain Snake Ecoprovince) to provide inflows to the Columbia Plateau Ecoprovince.

The Snake Hells Canyon subbasin has a variety of characteristics that make it unique in the Blue Mountain Ecoprovince, most related to its being a mainstem subbasin. The Snake Hells Canyon subbasin is the only mainstem subbasin within the Blue Mountain Ecoprovince, and it consists primarily of a single large river and surrounding face drainages rather than a "classic watershed" where tributaries combine to form a mainstem prior to emptying into an even larger water body. Rather than being defined by headwaters and ridgetops, the upstream boundary of the Snake Hells Canyon subbasin is Hells Canyon Dam.

The prevalence of large mainstem river habitats within the Snake Hells Canyon subbasin in particular results in aquatic resources that are relatively unique within the Blue Mountain Ecoprovince. Although other areas within the ecoprovince are used by fall chinook salmon and white sturgeon, the mainstem habitats within the Snake Hells Canyon subbasin are disproportionately important to these two fishes. The mainstem Snake River below its confluence with the Salmon River also provides a critical component of the migration corridor for endangered Snake River sockeye salmon migrating back to Redfish Lake in Idaho. The mainstem Snake River also provides migration and rearing habitat for steelhead, spring chinook, and bull trout.

The mainstem nature of the subbasin makes a variety of management situations within this subbasin unique within the Blue Mountain Ecoprovince. Mainstem subbasins do not operate as independent units: a decision in one subbasin, such as the Lower Middle Snake subbasin, could have significant impacts on other mainstem subbasins both upstream and down. This relationship complicates the ability to address "out-of-subbasin effects," which differ for upstream and downstream directions. (Upstream examples include water use and reduced sediment transport through reservoir systems. Downstream examples include mainstem transportation and passage, flow, harvest, ocean conditions, and the systemwide effects of artificial production.) These out-of-subbasin effects are often major drivers in biological performance or habitat conditions within mainstem subbasins, and, because of their magnitude and complexity, are difficult to define and characterize from a subbasin perspective.

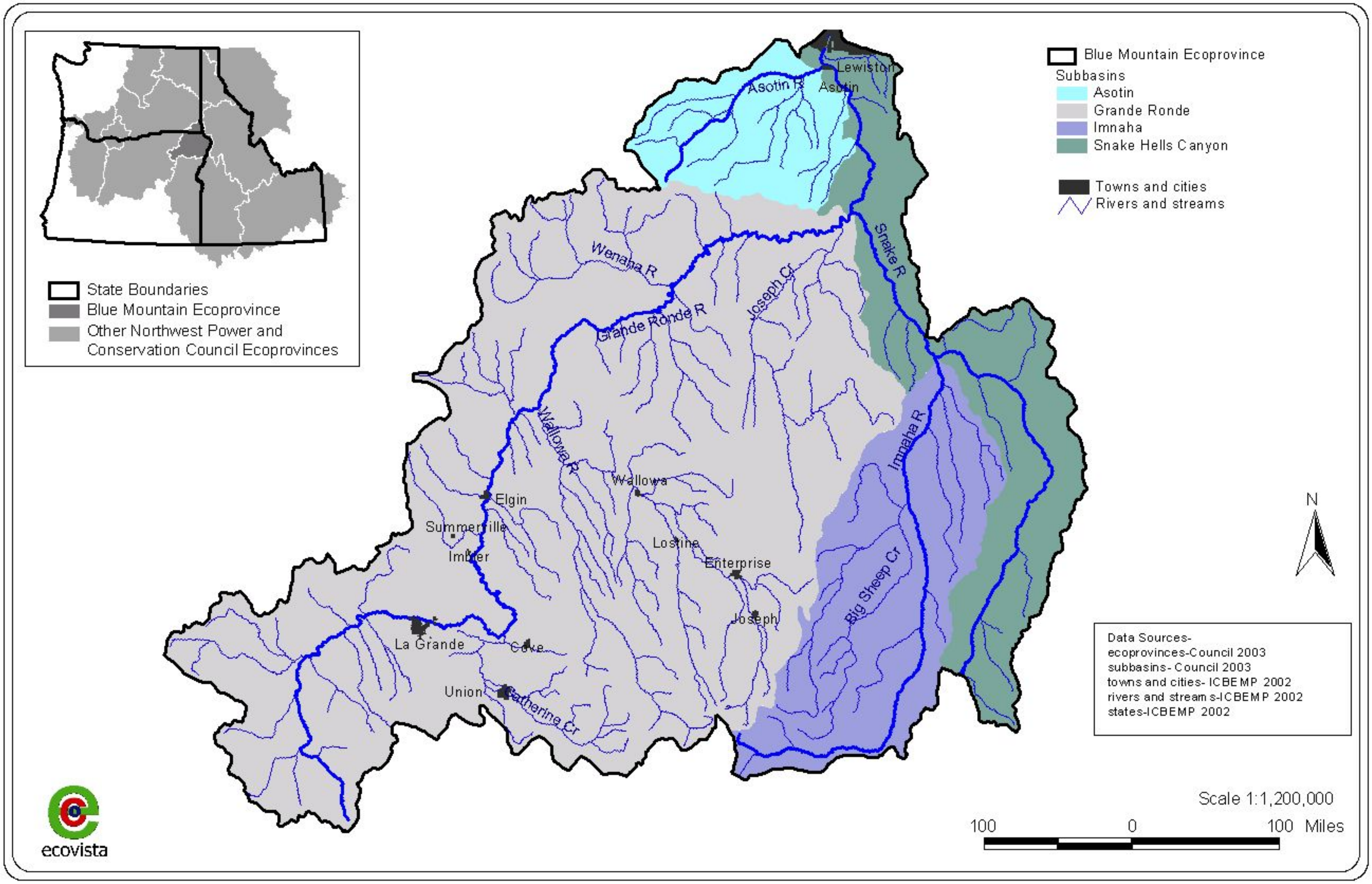

Figure 28. Location of the Snake Hells Canyon subbasin in the Blue Mountain Ecoprovince

Two recent regional assessment efforts have identified portions of the Snake Hells Canyon subbasin as being areas of regional conservation importance based on high biodiversity and/or the presence of rare or endemic organisms. The Interior Columbia Basin Ecosystem Management Project (ICBEMP) mapped centers of biodiversity and endemism/rarity, across the Interior Columbia Basin in 1994. In 2003, The Nature Conservancy used the SITES model to develop a conservation portfolio for the Middle Snake-Blue Mountain Ecoregion. These regional efforts, which help to establish the importance of the Snake Hells Canyon subbasin in efforts to protect and restore the fish and wildlife species of the region, are discussed below.

2.1.1 ICBEMP Centers of Biodiversity and Endemism

ICBEMP expert panels of agency and nonagency scientists were convened between October 1994 and May 1995 to identify areas of rare and endemic populations of plant, invertebrate, and vertebrate species (ICBEMP 1997). The panels of experts produced maps showing areas having unusually high biodiversity and areas containing high numbers of rare or locally or regionally endemic species (Figure 29 and Figure 30). The centers of concentration were developed at the coarse scale and in a short time frame and were mostly based on the panel's personal knowledge of areas and species locations. These developers suggested that they be considered a first approximation of identifying areas with particularly diverse collections of rare or endemic species or areas with high species richness. Centers of concentration might be candidates for RNAs or other natural area designations pending further local assessment and refinement (ICBEMP 1997). Forty-one percent of the subbasin was identified as a center of plant biodiversity (Table 7 and Figure 29). These areas occurred along the Snake River corridor of the mid- to upper subbasin. A small area on Craig Mountain was identified as an animal center of biodiversity. Seventy-seven percent of the Snake Hells Canyon subbasin was selected as a center of plant endemism and rarity (Table 7). This area runs the length of the Snake River corridor in the subbasin (Figure 30).

Table 7. Areas selected as centers of biodiversity or centers of endemism and rarity in the Snake Hells Canyon subbasin.

Interior Columbia Ecosystem Management Project Designation	Area of Snake Hells Canyon Subbasin Selected (acres)	% of Snake Hells Canyon Subbasin Selected
Centers of Biodiversity—Plants	229,072	41
Centers of Biodiversity—Animals	6,284	1
Centers of Endemism and Rarity—Animals	0	0
Centers of Endemism and Rarity—Plants	425,030	77

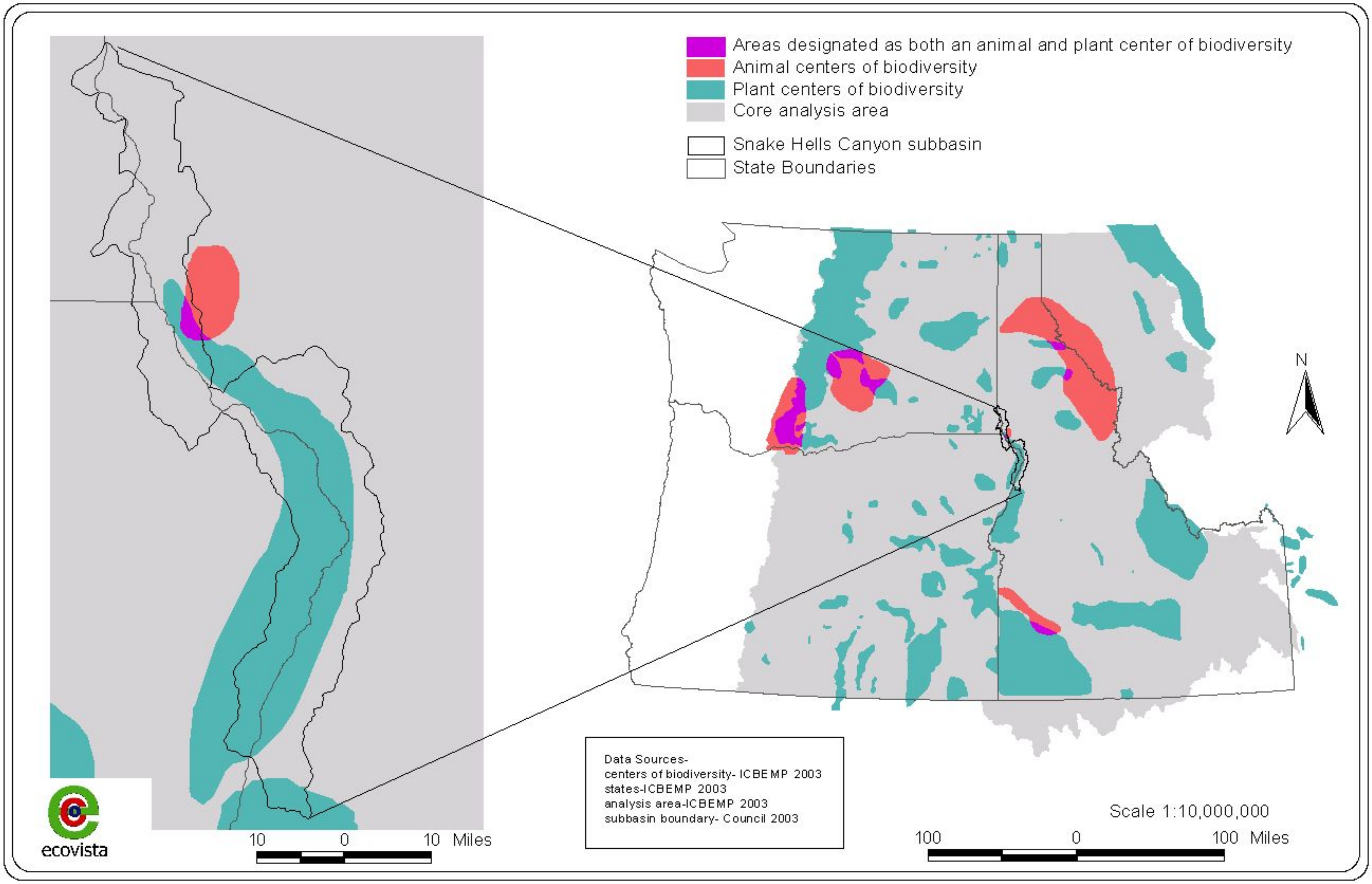

Figure 29. Centers of biodiversity in the ICBEMP analysis area and the Snake Hells Canyon subbasin.

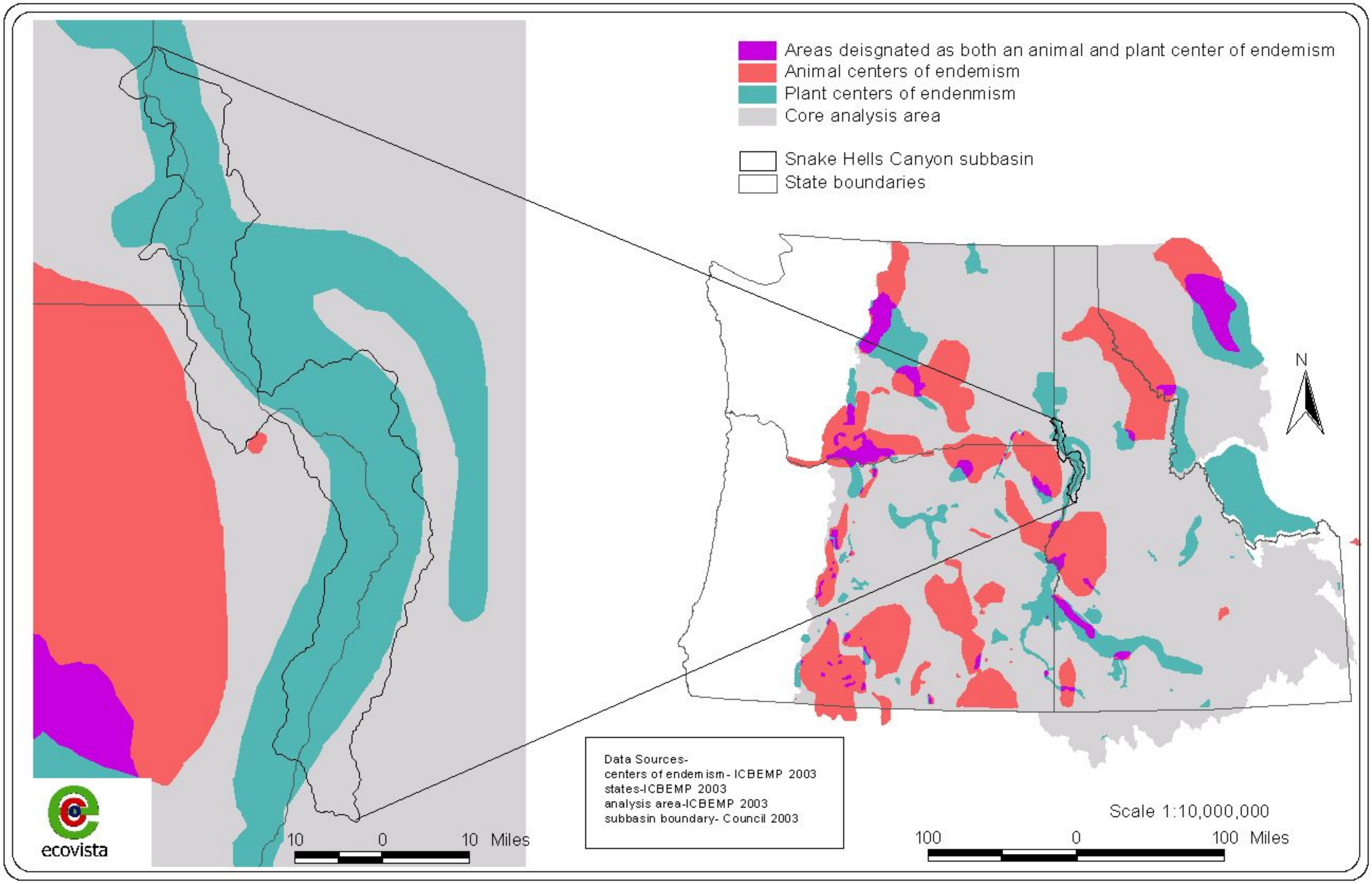

Figure 30. Centers of endemism and rarity in the ICBEMP analysis area and the Snake Hells Canyon subbasin.

2.1.2 The Nature Conservancy's Sites Model

The Nature Conservancy has recently completed an ecoregional conservation plan for the Middle Rockies-Blue Mountain Ecoregion, which covers 81,587 square miles (52,215,958 acres) in Oregon, Idaho, Montana, and a small part of Washington. Eighty-seven percent of the Snake Hells Canyon subbasin is contained within this ecoregion. The goal for the Middle Rockies-Blue Mountains Ecoregion conservation plan was to identify the suite of conservation sites and strategies that will ensure the long-term survival of all viable native plant and animal species and natural communities in the ecoregion. Due to the complexity of the Middle Rockies-Blue Mountain Ecoregion, a site-selection model was used to help design a portfolio that will achieve this goal in the most cost-effective manner possible. The site-selection model used in this project is an optimization model that applies a combination of simulated annealing and iterative improvement to the portfolio design problem (SITES). The simulated annealing used by SITES is a minimization method, where biodiversity is a constraint and the goal is to minimize the cost or size of the portfolio. The model was run at the 6th field hydrologic unit code (HUC) scale (TNC 2003).

Preparing to run the SITES model involves three main steps:

- Identifying the conservation targets that will help to maintain the biodiversity of the area
- Identifying the desired representation of the conservation targets in the ecoregion
- Identifying the costs and suitability of protection of different areas

Conservation Targets

The Nature Conservancy planning team utilized a coarse filter/fine filter approach to biodiversity conservation. The coarse filter is a community-level conservation strategy whereby natural community types are used as conservation targets to represent 85 to 90% of species and ecological processes in a community. However, given current knowledge, this ecosystem approach cannot be counted on to maintain and protect all biodiversity. Some species, especially the rarest, will fall through the pores of the coarse filter. Therefore, a fine filter of rare species conservation planning is needed as a complement (Noss and Cooperrider 1994, cited in TNC 2003).

The Nature Conservancy planning team selected 978 coarse and fine filter conservation targets for the Middle Rockies-Blue Mountain Ecoregion (Table 8). Most data, such as the distribution of all plant and animal species targets in the ecoregion, were obtained from the four state Natural Heritage Programs. Species are classified into five classes based on their global distribution: G1 = critically imperiled globally, G2 = imperiled globally, G3 = globally rare or uncommon, G4 = globally widespread and apparently secure, and G5 = globally widespread and secure. The following conservation ranks were considered in the selection of conservation targets from this database:

- All G1, G2, and federally listed species were included.
- G3 species were considered individually.
- G4 and G5 species were included if the species were declining over all or part of their range, the populations were disjunct from distant ecoregions, or they were endemic.

Data obtained from other sources included the predicted distribution maps for wide-ranging birds and mammals such as the greater sage-grouse, wolverine, gray wolf, and lynx and were obtained from the state Gap Analysis Programs (GAPs). Distribution data for wide-ranging fish were obtained from StreamNet. Aquatic community distribution data were developed by the planning team using a physically based classification model that was applied in a geographic information system (GIS) to represent aquatic communities in the ecoregion (TNC 2003).

Representation Goals

The Nature Conservancy planning team developed conservation goals for the representation of each target element or surrogate in the portfolio. Portfolio representation goals were developed based on three primary factors:

- Distribution of the targets across the ecoregion
- Number of occurrences or amount of area occupied
- Degree of endangerment for the conservation target

Table 8. Type, distribution sources, and representation goals for the 978 coarse and fine scale conservation targets selected for the Middle Rockies-Blue Mountain Ecoregion SITES run.

Conservation Targets	Number of Targets	Source of Distribution Data	Representation Goal for Portfolio
Fine Filter Targets	**Total = 269**		
Plant	127	EOR[a]	Dependent on conservation rank and degree of endemism
Terrestrial Animals	54	EOR[a]	Dependent on conservation rank and degree of endemism
		GAP models	20% of distribution per section for species of high conservation concern, 10% for others
Aquatic Animals	33	EOR[a]	Dependent on conservation rank and degree of endemism
		StreamNet	Dependent on rarity and degree of historical decline
Rare Plant Communities	55	EOR[a]	Dependent on conservation rank and degree of endemism
		HUC 6	Dependent on degree of rarity
Coarse Filter Targets	**Total = 709**		
Aquatic Macrohabitats	207	Modeled	Dependent on abundance of type in ecoregion
Riparian Plant Communities	209	Modeled	10% of distribution
Nonriparian Plant Communities	293	GAP cover types	Dependent on biodiversity and rangewide distribution and ecoregional abundance
TOTAL TARGETS	**978**		

[1] EOR = Element Occurrence Record database that is maintained by state Natural Heritage Programs/Conservation Data Centers

Cost and Suitability

The following are factors considered in determining the cost and suitability of conservation of terrestrial habitats for the Middle Rockies-Blue Mountain Ecoregion conservation plan:

- The conservation suitability of private land was considered to be somewhat lower than the same area of public land. Cost would rise faster as private land area increased in a 6th field HUCs than for a similar increase in public land area.
- The Nature Conservancy planning team wanted the model to choose areas of public land that were less roaded. So they chose a parameter that causes the first few roads in a 6th field HUC to dramatically increase the cost, but the rate of increase declines beyond a certain density threshold. In other words, it is the first roads that decrease the suitability the most and, after a point, the cumulative effect of additional roads becomes less.
- The opposite is true of private land. They did not want the model to automatically shy away from private land, so they chose a parameter where a low level of roads and converted land does not dramatically increase the cost (decrease suitability). The cost rises slowly at first for private land but more rapidly as the percentage of converted and roaded land increases in a 6th field HUC.

Several factors were considered when rating the cost and suitability of conservation in aquatic habitats:

- ICBEMP aquatic integrity scores
- Dams within the HUC
- Length of the 303(d)-listed segment within the HUC
- Number of point sources within the HUC

To account for the relatively low cost of continuing to protect areas with existing protection, 6th field HUC watersheds that were completely or partially contained by a protected area greater than 25 acres in size were locked into the portfolio selection (i.e., these areas were always selected in the development of the conservation strategy) (TNC 2003).

SITES Outputs

The model begins by generating a completely random portfolio. Next, it iteratively explores trial solutions by making sequential random changes to this portfolio. Either a randomly selected selection unit (6th field HUC watershed) that is not yet included in the portfolio is selected or a selection unit already in the system is deleted. At each step, the new solution is compared with the previous solution, and the best one is accepted.

The modeled solution constituted the first draft of the conservation portfolio. The Nature Conservancy planning team and an independent review team then reviewed the first draft and modified it based on personal experience in the ecoregion. The final recommended portfolio encompasses 37% of the ecoregion and meets the representation goal for over 90% of the terrestrial community targets, aquatic community targets, invertebrate species targets, and federally listed targets (TNC 2003).

Snake Hells Canyon Subbasin's Contribution to Selected Conservation Portfolio

Seventy-two percent of the Snake Hells Canyon subbasin was selected as part of the conservation portfolio for the Middle Rockies-Blue Mountain Ecoregion (Figure 31). This is a reflection of both the area's biological importance and the large amount of land in the subbasin that is protected. Because of the low cost of continuing to protect these areas, they were locked into the conservation portfolio. Areas selected for the Middle Rockies-Blue Mountain conservation portfolio within the Snake Hells Canyon subbasin contributed to meeting the representation goals for 26 fish and wildlife species target, 16 rare plant species targets, and 27 rare plant association or habitat type species targets (Appendix B).

2.2 NOAA Fisheries Evolutionarily Significant Units

The Snake Hells Canyon subbasin is an important area for a variety of endangered, threatened, and/or sensitive species and is included in the Snake River evolutionarily significant units (ESUs) designated by the National Oceanic and Atmospheric Agency (NOAA Fisheries [also known as the National Marine Fisheries Service or NMFS]) for steelhead trout, spring/summer chinook, and fall chinook, all listed as threatened under the Endangered Species Act (ESA). In addition, a portion of the Snake River within the Snake Hells Canyon subbasin provides a migration corridor for endangered sockeye salmon included in the Snake River ESU (NMFS 2002).

2.3 USFWS Designated Bull Trout Planning Units

The subbasin lies within the Columbia River Distinct Population Segment for bull trout listed as threatened under the ESA by the U.S. Fish and Wildlife Service (USFWS). The Snake Hells Canyon subbasin is part of two bull trout recovery units—the Imnaha-Snake River Basin Recovery Unit and Snake River Basin Recovery Unit. Within the Imnaha-Snake River Basin Recovery Unit, the Snake River Critical Habitat Subunit defined by the USFWS contains all of the proposed critical habitat designations for bull trout within the Snake Hells Canyon subbasin. Proposed critical habitat includes the Sheep and Granite creek drainages in Idaho (USFWS 2002a).

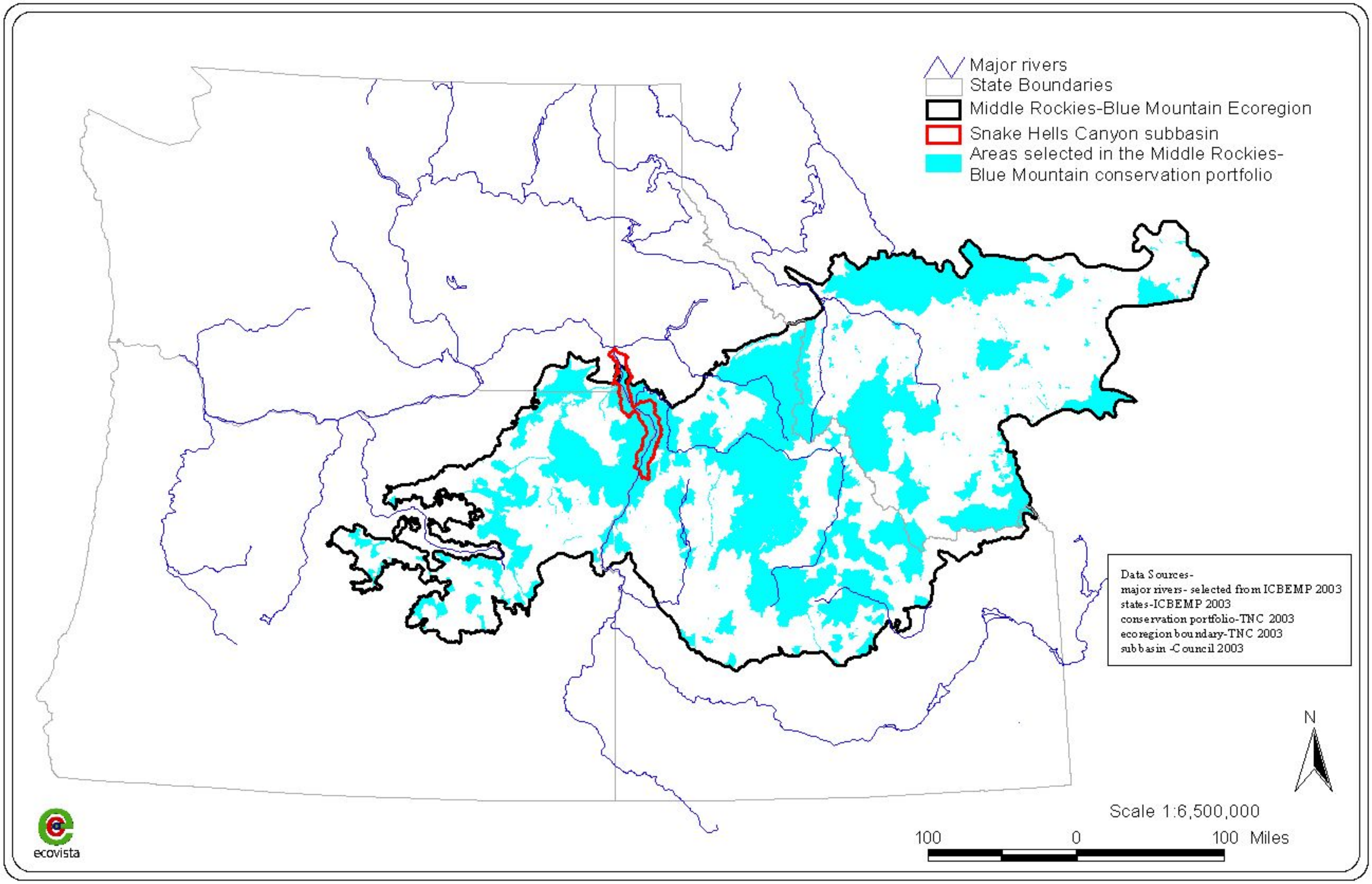

Figure 31. Areas selected by SITES for the Middle Rockies-Blue Mountain Ecoregion conservation portfolio (TNC 2003).