LAKE CHELAN

Subbasin Plan

Prepared for the Northwest Power & Conservation Council

Draft

Lake Chelan Subbasin Plan

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1 Introduction

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1.2 Subbasin Plan Approach and Public Involvement

1.2.1 Description of Board or Planning Unit

The Upper Columbia Salmon Recovery Board (UCSRB) is made up of representatives from Chelan, Douglas and Okanogan counties, the Yakama Nation and the Colville Tribes that are working on regional fish and wildlife recovery efforts. The UCSRB has been involved with both subbasin summaries and subbasin plans and has provided oversight for these planning efforts. The UCSRB has a board of directors that meets monthly and a regional recovery staff that also meets monthly. The staff has been working directly on planning efforts with the board providing oversight of work products as they are developed. The board is relaying on staff from the Chelan County PUD for detailed review of draft work products for the Lake Chelan subbasin.

1.2.2 Public Involvement

Chelan County and the Washington State Department of Fish and Wildlife are relying heavily on the extensive public outreach efforts conducted by the Chelan County PUD during the Lake Chelan FERC alternative relicensing process for FERC No. 637. As the subbasin plan is based on information and studies from the relicensing process, the public is already familiar with this information. The alternative relicensing process engaged the public early on and included participation by property owners, private businesses, agriculture, tourism and recreation industries, resource agencies, environmental groups, government officials, Indian tribes and citizens of Chelan County. Public outreach conducted by the Chelan County PUD included newsletters, presentations, meetings and many working groups. The relicensing process began in 1998 in order to submit the final license application to FERC by June 2004.

Chelan County has been providing draft products to the Chelan County PUD relicensing team in order to assure thorough review of subbasin planning products as they are developed. The final subbasin plan will be reviewed by the relicensing team and will be distributed to the stakeholder list used for the relicensing efforts. In addition, the Northwest Power and Conservation Council will be conducting a six-week public review period which will be advertised locally by Chelan County.

1.2.3 Mission Statement

The Lake Chelan subbasin plan is a model through which human and natural economies can begin to co-exist in more mutually inclusive ways than they have over the past 150 years. The plan acknowledges that as environmental integrity has been compromised, so have populations of salmon and other fish and wildlife species. In order to redress current situations, the plan focuses on understanding how human activities interact with the natural world, particularly the processes that sustain fish and wildlife.

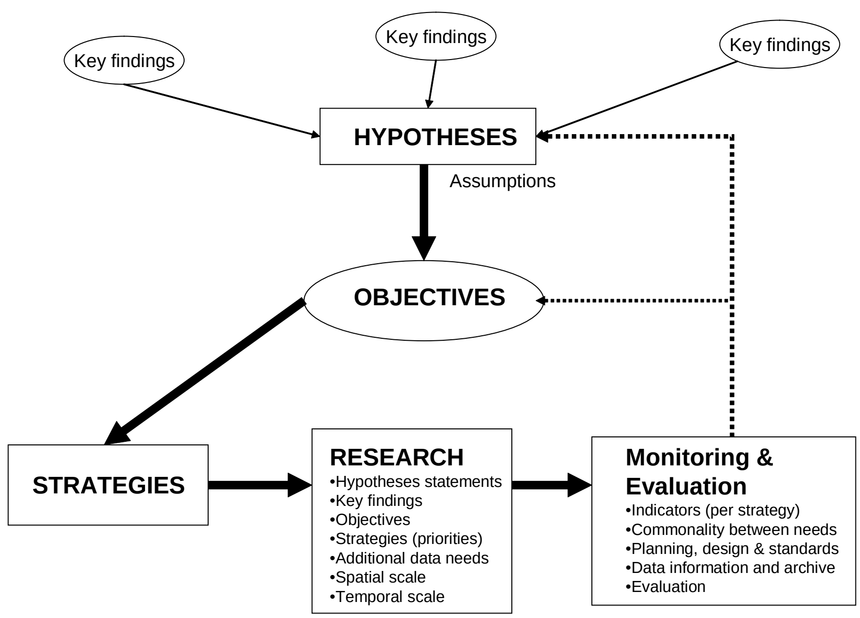
A major goal of the subbasin plan is to restore conditions to a more natural state. Thus, the plan emphasizes ecosystem-based perspectives that consider multiple species, their life histories, and their inter-relationships. Finally, the plan considers the subbasin's position within the larger context of the Columbia River basin, particularly with regard to anadromous fish populations.

The Lake Chelan subbasin plan is focused on restoring and maintaining indigenous fish and wildlife populations and their ecosystems to support sustainable harvest, cultural values, and non-consumptive benefits through a local, state, tribal, and federal partnership. Management decisions related to conclusions arrived at in the subbasin plan will be made in an open and cooperative coordinated process that respect different points of view and adhere to varied rights and statutory responsibilities.

1.2.4 Approach

Of primary interest to the Lake Chelan Subbasin Plan is the logic, or rational that supports the recommendations of the Management Plan. The fundamental premise in the development of this Plan is to identify 1) what habitat conditions have been most effected by developments in the last 200 years, 2) how have important species responded to these changes, and 3) what can local resource managers and citizens can do to maintain and enhance these and other important terrestrial and aquatic populations and ecosystems (Figure 1).

Figure 1. Logic diagram



Chelan Subbasin Plan

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2 Executive Summary

2.1.1 Purpose and Scope

The Lake Chelan Subbasin management plan – along with the supporting assessment and inventory -- is one of nearly 60 management plans currently being developed throughout the Columbia River Basin for the Northwest Power and Conservation Council (NPCC). This subbasin plan was crafted by the same team that is currently working on the Upper Middle Mainstem and Entiat subbasins, and thus shares many elements in common with those plans. The plans will be reviewed and adopted as part of the NPCC's Columbia River Basin Fish and Wildlife Program. Conclusions reached in the subbasin plans will help prioritize the spending of Bonneville Power Administration (BPA) funding for projects that protect, mitigate and enhance fish and wildlife that have been adversely impacted by the development and operation of the Columbia River hydropower system.

The primary goal of subbasin planning in the Columbia Basin is to respond to the Independent Scientific Group's Return to the River report to the NPCC. Notable conclusions from that report were:

"Our review constitutes the first independent scientific review of the Fish and Wildlife Program…"

"The Program's…lack of a process for prioritization provides little guidance for annual implementation…"

"We recommend incorporation of an integrated approach based on an overall, scientifically credible conceptual foundation…"

The NPCC responded to the ISG by creating the subbasin planning process, within the context of the 2000 Fish and Wildlife program. Subbasin plans provide the first basin-wide approach to developing locally informed fish and wildlife protection and restoration priorities.

Another important goal of the subbasin planning process is to bring people together in a collaborative setting to improve communication, reduce conflicts, address problems, and where ever possible, reach consensus on biological objectives and strategies that will improve coordinated natural resource management on private and public lands.

The plan could potentially have a significant effect on fish and wildlife resources in the subbasins and economic impact on the communities within the subbasins. For these reasons, public involvement is considered a critical component in the development of the subbasin plans.

An important objective of this subbasin plan is to identify management actions that promote compliance of the federal Endangered Species and the Clean Water acts. None of the recommended management strategies are intended nor envisioned to compromise or violate any federal, state or local laws or regulations. The intent of these management strategies is to provide local solutions that will enhance the intent and benefit of these laws and regulations. The NPCC, BPA, NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) intend to use adopted subbasin plans to help meet requirements of the 2000 Federal Columbia River Power System Biological Opinion. NOAA Fisheries and the USFWS have stated their intent to use subbasin plans as a foundation for recovery planning for threatened and endangered species.

The Lake Chelan management plan's purposes include providing benefits to fish and wildlife where that help is most needed. The broad purposes of the plan and of the NPCC program mesh regarding fish and wildlife species.

From the Columbia River Basin Fish and Wildlife Program (NPPC 1994):

The development of the hydropower system in the Columbia River Basin has affected many species of wildlife as well as fish. Some floodplain and riparian habitats important to wildlife were inundated when reservoirs were filled. In some cases, fluctuating water levels caused by dam operations have created barren vegetation zones, which expose wildlife to increased predation. In addition to these reservoir-related effects, a number of other activities associated with hydroelectric development have altered land and stream areas in ways that affect wildlife. These activities include construction of roads and facilities, draining and filling of wetlands, stream channelization and shoreline riprapping (using large rocks or boulders to reduce erosion along streambanks). In some cases, the construction and maintenance of power transmission corridors altered vegetation, increased access to and harassment of wildlife, and increased erosion and sedimentation in the Columbia River and its tributaries.

The habitat that was lost because of the hydropower system was not just land, it was home to many different, interdependent species. In responding to the system's impacts, we should respect the importance of natural ecosystems and species diversity."

Some species, such as some waterfowl species, have seemed to benefit from reservoirs and other hydropower development effects, but for many species, these initial population increases have not been sustained.

2.1.2 Subbasin Vision Statement

The Vision Statement for the Lake Chelan Subbasin is largely based on the Chelan County Watershed Planning Association Goal Statements for water resources. These goals are based on a sustainable future for the landscape, the economy, and the people in the subbasin.

The vision for the landscape is to balance habitat conservation with human uses to ensure the long-term health of plant, fish, wildlife and human communities.

The vision for the economy is based on efficient management and use of natural resources including reliable water supplies, fish and wildlife populations, and aquatic and terrestrial habitats.

The vision for the people is to manage natural resources to promote social and economic well-being and to improve or maintain our quality of life. Stake holders and interest groups will work together to foster increased understanding of the importance of natural resource conservation.

2.1.3 Goals and Biological Objectives

Biological objectives describe physical and biological changes within the subbasin needed to achieve the vision and address factors affecting focal habitats. Biological objectives for all ecoregion subbasins are habitat based and describe priority areas and environmental conditions needed to achieve functional focal habitat types. Where possible, biological objectives are empirically measurable and based on an explicit scientific rationale (the working hypothesis). Biological objectives are: consistent with subbasin-level visions and strategies, developed from a group of potential objectives based on the subbasin assessment and resulting working hypotheses, realistic and attainable within the subbasin, consistent with legal rights and obligations of fish and wildlife agencies and tribes with jurisdiction over fish and wildlife in the subbasin. The biological objectives are agreed upon by co-managers in the subbasin and are complementary to programs of tribal, state and federal land or water quality management agencies in the subbasin. Finally, the subbasin plans have quantitative and have measurable outcomes where practical.

Shrubsteppe

Goal: Provide sufficient quantity and quality shrubsteppe habitat to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing sagebrush-dominated shrub-steppe toward conditions 1, 2 and 3 identified in 3.1.7.2.3 (Inventory and Assessment).

- Determine the necessary amount, quality, and juxtaposition of shrubsteppe by the year 2008
- Identify and provide biological and social conservation measures to sustain focal species populations and habitats by 2010
- Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving agricultural practices, fire management, weed control, livestock grazing practices, and road management on existing shrubsteppe
- Determine population status of Brewer's sparrow by 2008
- Within the framework of the Brewer's sparrow population status determination, inventory other shrub-steppe obligate populations to test assumption of the umbrella species concept for conservation of other shrub-steppe obligates
- Maintain and enhance mule deer populations consistent with state/tribal herd management objectives

Ponderosa Pine

Goal: Provide sufficient quantity and quality ponderosa pine habitats to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing ponderosa pine toward conditions 1a, 1b, 2 and 3 identified in 3.1.7.1.3 (Inventory and Assessment).

- Determine the necessary amount, quality, and juxtaposition of ponderosa pine habitats by the year 2008
- Provide biological and social conservation measures to sustain focal species populations and habitats by 2010
- Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silvicultural practices, fire management, weed control, livestock grazing practices, and road management in existing and restored ponderosa pine habitat
- Determine population status of white-headed woodpecker, flammulated owl, and pygmy nuthatch by 2008

- Within the framework of the focal species population status determinations, inventory other ponderosa pine obligate populations to test assumption of the umbrella species concept for conservation of other ponderosa pine obligates

Riparian Wetlands

Goal: Provide sufficient quantity and quality riparian wetlands to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing riparian wetland habitats toward conditions 1a, 1b, and 2 identified in 3.1.7.3.3 (Inventory and Assessment).

- Determine the necessary amount, quality, and connectivity of riparian wetlands by the year 2008.
- Provide biological and social conservation measures to sustain focal species populations and habitats by 2010.
- Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silviculture, agricultural practices, fire management, weed control, livestock grazing practices, and road construction and maintenance on and adjacent to existing riparian wetlands.
- Determine population status of beaver and red-eyed vireo chat by 2008.
- Within the framework of the focal species population status determinations, inventory other riparian wetlands obligate populations to test assumption of the umbrella species concept for conservation of other riparian wetlands obligates.
- Maintain and enhance beaver populations where appropriate and consistent with state/tribal management objectives.

Westslope Cutthroat Trout

- Make historic spawning grounds available to westslope cutthroat trout (WSCT) earlier by removal of tributary barriers or lake level management by 2008 (assuming new license is issued to Chelan PUD)
- Eliminate the introductions of non-native species that have negative impacts on WSCT by 2010
- Decrease the abundance or remove key exogenous species by 2015
- Reduce direct harvest impacts on naturally produced WSCT by 2010

Bull Trout

- Determine if bull trout exist in the basin by 2008
- If bull trout are found, attain self sustaining non-migratory populations of bull trout (if feasible) by 2025
- Reduce abundance of exogenous stocks that may hinder reintroduction by 2010

- Ensure historic habitat remains in tact by 2008

Kokanee

- Reduce negative interactions with mysids by 2015
- Increase juvenile survival and increase abundance of adults in lake by 2010
- Ensure self-sustaining populations by 2015

2.1.4 Synopsis of Major Findings and Conclusions

The assessment and management plan identify strategies that benefit focal wildlife species that inhabit the subbasin's terrain and focal fish species that utilize Lake Chelan and its tributaries. Seven wildlife species were chosen as focal species to represent three focal habitat types within the Lake Chelan Subbasin: Shrubsteppe- mule deer and Brewer’s sparrow; Ponderosa Pine – pygmy nuthatch, white-headed woodpecker and flammulated owl; and Riparian Wetlands - American beaver and red-eyed vireo. Focal species’ current viability was evaluated and biological objectives and strategies devised, based on the condition, availability, and potential for restoration of focal habitat types on which these species depend.

Terrestrial

Numerous strategies identified during the subbasin planning process and outlined in the management plan attempt to contribute beneficially to several limiting factors in the Lake Chelan Subbasin. A general theme identified across the subbasin is a reduction in the quantity and quality of all types of wildlife habitat that focal and other species need to flourish. Among the causes of the diminution and fragmentation of shrubsteppe habitat are grazing, invasion of exotic plant species, fire management regimes and wildfires, and human disturbance. The invasion of crested wheatgrass and other introduced plant species and the loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities, has reduced shrubsteppe habitat quality and/or availability.

Ponderosa pine habitat has been degraded or lost due to timber harvest, fire reduction (and subsequent intensive wildfires), mixed forest encroachment, overgrazing, invasion of exotic plants, fragmentation, and development. Timber harvesting has reduced the amount of old growth forest and associated large diameter trees and snags, while invasion by exotic plants and fire reduction has altered understory conditions and increased fuel loads. Loss of habitat and habitat diversity/function has resulted in extirpation or reduction of ponderosa pine obligate species and these species are at increased risk of parasitism, competition with non-native species, predation by domestic animals (i.e. cats), and high levels of human disturbance.

Riparian wetland habitat has also been affected by livestock overgrazing and invasion of exotic vegetation. Grazing can widen channels, raise water temperature, and reduce understory cover. Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.

Aquatic

Westslope cutthroat trout currently appear to be reduced from historic abundance. Factors limiting the productivity of WSCT are related primarily to overharvest in the 19th century, historic and current hatchery practices, introduction of exogenous species, and barriers at the mouth of most of the spawning streams (excluding First, Twenty-five Mile Creek and the Stehekin River) to Lake Chelan. Spawning and rearing competition occurs with native bridgelip suckers and introduced rainbow trout and brook trout. Rainbow trout may also breed with WSCT, affecting genetic integrity. Predation by chinook salmon and lake trout may decrease spawner recruits.

Bull trout have not been documented within the Chelan Basin since the 1950s. It is not clear why they may be extinct, but potential reasons are: over harvest, loss of spawning grounds due to high floods in 1948 and 1949; or a catastrophic disease outbreak, or a combination of above factors.

Current spawning and rearing areas within the Stehekin, and other tributaries (except Railroad Creek) are functioning near pristine levels. However, re-introduction of bull trout may be inhibited by native kokanee and introduced rainbow trout, lake trout, and brook trout through competition during rearing, foraging, or spawning phases. Redd imposition by kokanee may decrease the viability of bull trout eggs and brook trout are also known to reduce genetic integrity of bull trout when they interbreed (and are sterile).

Kokanee were introduced in 1917 and have provided a large recreational fishery ever since. Kokanee populations have been volatile, which could be related to predator abundance, competition with native and exotic species for forage, and general lake productivity. Predation by lake trout and Chinook salmon significantly reduces the number of spawners in a given year, and competition with mysids, juvenile WSCT and Chinook salmon, and other native species may limit production of kokanee. Spawning habitat is not limiting.

2.1.5 Summary of Restoration and Conservation Measures

Terrestrial

Habitat quantity and quality can be improved by emphasizing conservation, protection, and connectivity of large blocks of high quality focal habitat. Strategies to achieve this goal include promoting local planning and zoning, utilizing governmental plans and programs, implementing habitat stewardship projects with private landowners, and protecting lands through acquisition, conservation easements, and cooperative agreements. The plan also promotes the development and implementation of fire management protocols (protection and prescribed burning), and weed control and road management plans.

Two strategies directed specifically at wildlife focal species pertain to all wildlife focal species within the subbasin, while other strategies are directed at individual focal species. Survey protocol will be selected and abundance, diversity, and richness of focal species will be measured. In addition, methodology, alternative to IBIS or GAP, will be selected and implemented to accurately characterize focal habitats in the Lake Chelan subbasin.

Both the fish and wildlife portions of this management plan provide strategies to protect and restore beaver habitat and, where possible, to prepare for reintroduction into suitable habitat where natural recolonization may not occur. The restored habitat would benefit beaver, whose activities would in turn benefit the salmon and steelhead that use the watershed for a portion of their life history. Natural and reintroduced beaver populations would be protected through state harvest restrictions. The plan also provides for the maintenance of mule deer populations and ensures their habitat needs are met.

Aquatic

Populations of WSCT can be increased by reducing direct harvest impacts and eliminating introductions of, and/or removing, non-native species. Subbasin planners encourage the production of a comprehensive fish stocking plan that considers all impacts to all species from introduced fish, and will determine the types of fish introduced, best release locations, and timing. Harvest limits on brook trout and rainbow trout should also be removed and harvest rates on Chinook salmon and lake trout increased to reduce competition and enhance spawning and productivity of WSCT. Further, fishing near tributary mouths should be delayed until after the spawning season to avoid taking WSCT that are either staging for spawning, or returning to Lake Chelan following spawning. Reducing direct harvest on vulnerable adults will increase the number of adult fish surviving, and since WSCT are iteroparous, more adults surviving after spawning means more adults will spawn again, thus increasing productivity.

All life histories of bull trout can be successfully reintroduced into the Chelan Basin, but because of established species assemblages, founding adfluvial forms of bull trout is not possible. First, it must be determined if bull trout exist in the basin by exploring likely places that may hold reserves of non-migratory bull trout. If bull trout are found, self sustaining non-migratory populations of bull trout need to be attained. If not found, a pilot reintroduction program for non-migratory populations should be developed.

Introduction of bull trout will depend on available broodstock, feasibility of using hatcheries, and whether there is a high likelihood that they can maintain a self-sustaining population. Restoration measures should also reduce abundance of exogenous stocks that may hinder reintroduction, ensure historic habitat remains in tact, determine predator-prey relationships in Lake Chelan and potential interactions with established populations, increase harvest on Chinook salmon and lake trout, remove harvest limit on brook trout, preserve (or restore) geo-fluvial processes in all tributaries, and reintroduce bull trout into historic habitat, if feasible.

A number of actions can be taken to increase the abundance and productivity of Kokanee: Increase harvest on Chinook salmon and lake trout, reduce the abundance of, and negative interactions with, mysids; develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate. Implementing these actions with help increase juvenile survival and abundance of adults and ensure self-sustaining populations.

2.1.6 Summary of Monitoring and Evaluation Needs

There is significant need for ongoing monitoring and evaluation within the Lake Chelan watershed. Although there is a high level of certainty with several key findings and strategies, without concerted monitoring and evaluation there is a margin of uncertainty that the best strategies will achieve the most benefit possible. Therefore, along with the actions suggested in the management plan, an extensive monitoring and evaluation effort within Lake Chelan is considered a high priority.

3 Subbasin Overview

3.1.1 Introduction

The Subbasin Overview has two main sections. The first, Subbasin in Regional Context, describes the Lake Chelan subbasin and its place within the Columbia Cascade Province or eco-region as defined by the Northwest Power and Conservation Council (NPCC). The second, the Subbasin Description, summarizes the Lake Chelan subbasin's geological, climatic, biological, and hydrological characteristics; gives an overview of its fish and wildlife resources; and describes the human population and activities that occur in the subbasin.

3.2 Subbasin in Regional Context

For planning purposes, the Northwest Power and Conservation Council divided the Columbia River Basin south of the Canadian border and its more than 50 subbasins into 11 eco-regions. NPCC is responsible for implementing the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) and the Fish and Wildlife Program mandated by the Act.

The 11 provinces, beginning at the mouth of the Columbia River and moving inland, are: Columbia Estuary; Lower Columbia; Columbia Gorge; Columbia Plateau; Columbia Cascade; Inter-Mountain; Mountain Columbia; Blue Mountain; Mountain Snake; Middle Snake; Upper Snake. These 11 eco-regions include the entire Columbia River basin in the United States, and together cover approximately 25,000 sq. mi. in Washington, Oregon, Idaho and Montana.

Each of the 11 provinces will develop its own vision, biological objectives, and strategies consistent with those adopted at the subbasin level. NPCC's intent is to adopt these elements into the 2000 Fish and Wildlife Program during later rulemaking. The biological objectives at the province scale will then guide development of the program at the subbasin scale.

The provinces are made up of adjoining groups of ecologically related subbasins, each province distinguished by similar geology, hydrology, and climate. Because physical patterns relate to biological population patterns, fish and wildlife populations within a province are also likely to share life history and other characteristics (NPCC 2000). The Lake Chelan basin or subbasin is in the Columbia Cascade Province.

3.2.1 Columbia Cascade Province

The Columbia Cascade Province is the fourth smallest of the ecological provinces and covers an area of approximately 9,407 sq. mi. It is defined as the Columbia River and all tributaries downstream from, but not including, Chief Joseph Dam to Wanapum Dam. This area includes much of north-central Washington. The province is divided into six subbasins: Chelan, Okanogan, Methow, Lake Entiat, Wenatchee, and Columbia Upper Middle Mainstem (CBFWA 2004).

The Cascade Mountains form the western border of the province, and the U.S./Canada border forms the northern edge. The northeastern corner of the province passes through the Okanogan National Forest and the Colville Indian Reservation, while the southeastern boundary is bordered by Banks Lake, Lake Lenore State Wildlife Recreation area, and the towns of Ephrata and Quincy. Wanapum Dam lies at the southern tip of the province.

The province overlies two significantly different physiographic regions and topography varies widely (10,000 ft. at Glacier Peak to 600 ft. at the Columbia River). The Cascade Mountains, to the north and west, consists primarily of metamorphosed sedimentary, volcanic and granitic rock, while the Columbia Plateau, to the east and south, features vast thick layers of basaltic bedrock. Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas in the western and northern sections of the Province, and arid to semi-arid climates in the eastern and southern portions of the Province. The uppermost elevations along the Columbia Crest support subalpine fir communities, which in turn give way at the highest elevations to subalpine and alpine meadow grasses and forb species. Increased moisture in the basin's mid-elevations support a transition from the dominant ponderosa pine forests along the subbasin's lower slopes and valleys to Douglas-fir communities, while lower elevations are characterized by a more arid continental climate and shrubsteppe and steppe plant communities (shrubs, perennial bunch grasses, lichens, and mosses). High water table or seasonal flooding conditions found near/along lakes, streams and rivers support development of deciduous riparian communities.

The Confederated Tribes of the Colville Reservation, a federally recognized tribe, is located on 1.4 million acres in north central Washington in the Columbia Cascade Province. Many of the names of Colville's 12 aboriginal tribes indicate the geographic range and interest of today's Colville confederation. They include the Nespelem, the San Poil, the Lake, the Palus, the Wenatchi (Wenatchee), the Chelan, the Entiat, the Methow, the southern Okanogan, the Moses Columbia, and others.

Federal lands, including the Okanogan and Wenatchee National Forests make up most of the Western section and small portions of the northeastern section of the province (**Table 3**). The western one-third (341,051 acres) of the Colville Indian Reservation is also located within the Province (southeast portion of the Okanagan subbasin) and much of remaining Province lands are in private ownership. The western portion of the Province is predominately coniferous forest, while the eastern portion is comprised primarily of agricultural lands and Shrubsteppe / Steppe habitat (**Table 5**).

The Columbia Cascade is an important agricultural and grazing area and also encompasses several urban areas. Orchards and small areas of irrigated cropland are found along the Columbia River corridor between Chief Joseph and Rock Island dams. Most of the south-eastern portion of the Province (Columbia Upper Middle subbasin) is a sandy plateau where dryland farming and rangelands are the dominant agricultural practices. The area within much of Grant County is part of the Columbia Reclamation Irrigation Project and has extensive irrigated agriculture. Significant urban centers within the Province include Wenatchee, East Wenatchee, Entiat, Chelan, Pateros, Brewster, Winthrop, Leavenworth, Cashmere, Waterville, Bridgeport, and Okanogan/Omak, Washington. The western one-third (341,051 acres) of the Colville Indian Reservation is also located within the Province (southeast portion of the Okanagan subbasin).

The Columbia Cascade is also a significant source of hydroelectric power. Three major Columbia River dams are located within the Province: Rock Island Dam downstream and Rocky Reach Dam upstream of the Wenatchee-Columbia confluence, and Wells Dam downstream of the Methow-Columbia confluence. The Chief Joseph dam lies on the Columbia River, just outside the Province, east of Bridgeport, WA. Six more dams lie downstream of the Province on the mainstem Columbia which must be traversed by anadromous fish migrating to and from the province's subbasins: Wanapum, Priest Rapids, McNary, John Day, The Dalles, and Bonneville dams.

3.2.2 Terrestrial / Wildlife Relationships

The mule deer Chelan PMU (Population Management Unit) is located within this subbasin.

3.2.3 Aquatic / Fish Relationships

No hatcheries or rearing ponds are located in the Lake Chelan subbasin. Hatcheries are located, however, in all of the other subbasins within the Columbia Cascade Ecoprovince to address natural production of salmon and steelhead and to mitigate for fish and wildlife lost due to hydroelectric and irrigation development throughout the Columbia River Basin (CBFWA 2004).

Three federally listed threatened and endangered fish species are known to occur in the Project area. These are the upper Columbia River bull trout (listed as threatened by the USFWS), and the upper Columbia River summer steelhead and spring chinook (listed as endangered by the NMFS).

Spring Chinook within the ESU

The Upper Columbia River Spring Chinook were listed as an endangered species on March 24, 1999 and critical habitat for the ESU was designated on February 16, 2000. The listed ESU includes all naturally spawned populations of spring Chinook in accessible reaches of Columbia River tributaries between Rock Island and Chief Joseph dams, excluding the Okanogan River. Critical habitat covers this same geographic area. Several hatchery populations from the Methow and Wenatchee rivers where included in the listed ESU (Fisher and Talayco 2002).

Adult spring chinook salmon are not currently known to use the Okanogan River. The temperature regime, at the time spring chinook salmon spawn in the mainstem Okanogan River, is too high for successful spawning and rearing due to irrigation water withdrawals (K. Williams and J. Spotts, personal communication). In addition, spring chinook adults are collected as they migrate upstream at Wells Dam on the Columbia River, approximately 20 miles downstream of the confluence of the Okanogan River, and are transported to the Winthrop National Hatchery in Winthrop, Washington (U.S. Federal Register 1999)

Steelhead within the ESU

Upper Columbia River Steelhead was listed as an endangered species on August 18, 1977, and critical habitat for the ESU was designated on February 16, 2000. The ESU includes all naturally-spawned populations of steelhead in tributaries of the Columbia River between the Yakima River and Chief Joseph Dam. The Wells Hatchery stock steelhead were included in the listed ESU because they are considered essential for the recovery of the natural population. Critical habitat includes the same geographic area (Fisher and Talayco 2002).

This ESU has been greatly homogenized by the widespread planting of the Wells hatchery stock and concurrent poor survival of natural-origin fish. Each year approximately 100,000 Wells stock steelhead yearlings are outplanted into the Okanogan River and its tributaries, Omak and Salmon creeks, and the Similkameen River. This is an integrated recovery program designed to help recover endangered Upper Columbia River Steelhead (Fisher and Talayco 2002).

Bull Trout within the DPS

The ‘distinct population segment’ (DPS) for bull trout, incorporating the entire Columbia (i.e., upper and lower), was listed as threatened on June 20, 1999. An assessment of bull trout stock status on a watershed basis is currently under preparation, however, no such a

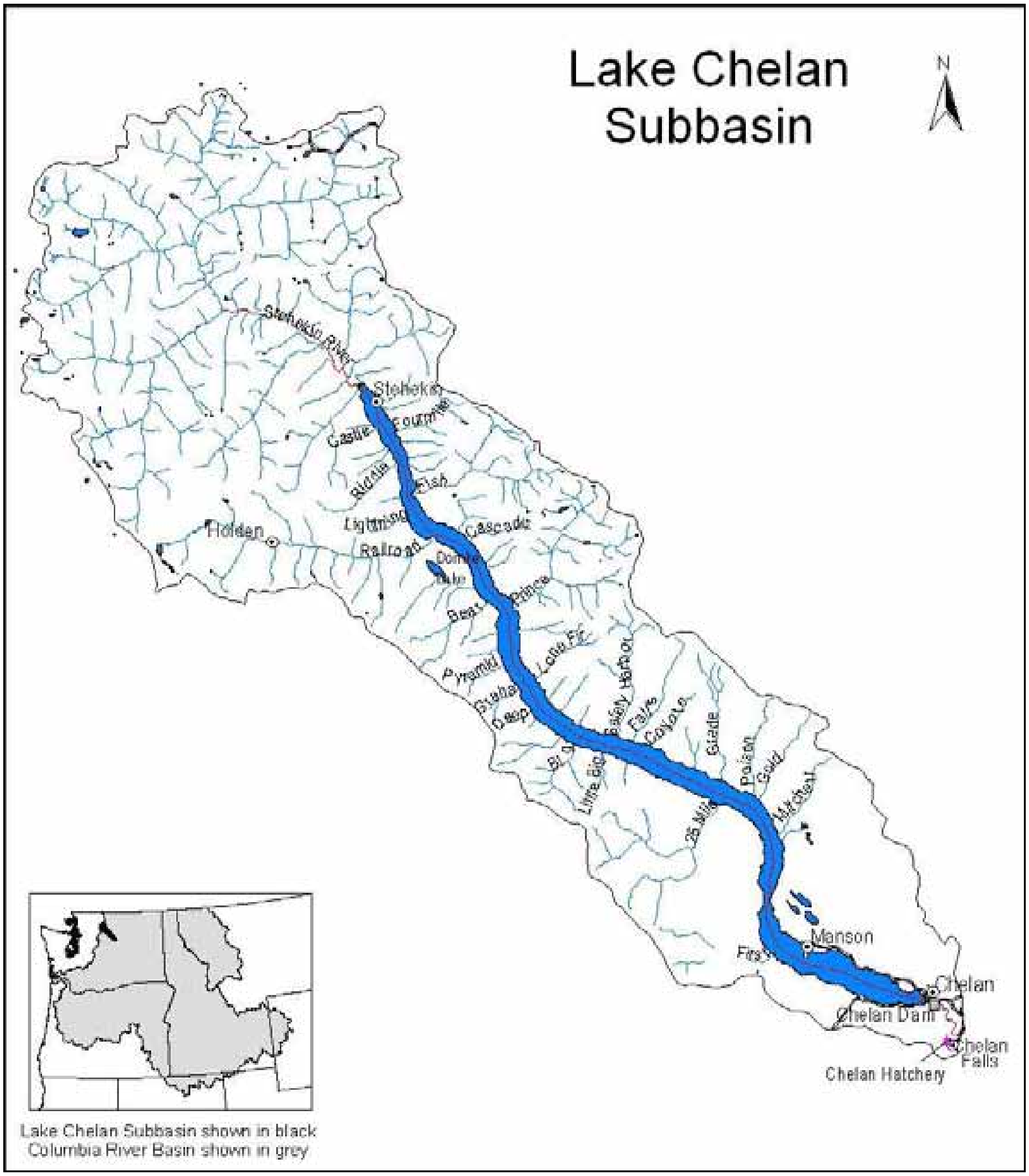
3.3 Subbasin Description

Introduction

The Lake Chelan subbasin is located in north central Washington and lies entirely within Chelan County. The subbasin comprises 6.5% of the Columbia Cascade Province and consists of 599,905 acres (937 sq. mi.).

The upper portion of the Chelan subbasin is within the North Cascades National Park and the Lake Chelan National Recreation Area. The middle part of the basin is in the Wenatchee National Forest. Most of the lower basin, which contains the majority of the development, is privately owned (Beck 1991). Lake Chelan, which comprises approximately 50.4 miles of the 75-mile-long basin, is the third deepest freshwater lake in the nation (FERC 2002) and the largest and deepest natural lake in Washington. The subbasin lies within an elongated, steeply sloped fjord basin formed by two glaciers. The Lake has an average width of 1.5 miles, a maximum depth of 1,486 feet, and it drains 2,393 sq. km (Beck 1991). It is bordered on the north by the Sawtooth Mountains and on the south by the Entiat and Chelan Mountains and the Glacier Peak Complex. Water from Lake Chelan flows from its southern end into the shortest river in Washington, the 4.1-mile-long Chelan River. This river falls 400 feet in its descent through a steep, rocky gorge to the Columbia River (FERC 2002).

Figure 2. Lake Chelan subbasin



Source: NPPC 2002b

3.3.1 Topographic/Physio-geographic Environment

Geology/Topography

The Lake Chelan basin is located between two significantly different physiographic provinces in north-central Washington. The Cascade Mountains, to the west, consist primarily of metamorphosed sedimentary, volcanic and granitic rock, and the Columbia Plateau, to the east, features vast thick layers of basaltic bedrock. Topographic elevations in the project vicinity range from over 9,000 feet above sea level at the crest of the Cascade Mountains to 700 feet on the Columbia River (FERC 2001). From Twentyfive Mile Creek uplake, the terrain is mountainous and rugged with glacial features such as cirques, truncated spurs, moraines, horns, and U-shaped valleys. In many cases, the steep slopes run directly into Lake Chelan with no flat beaches or shoreline. The terrain of the lower end of the lake is much less severe, mainly arid or semi-arid, and soils consist of alluvial deposits and glacial drift (Beck 1991, FERC 2002).

Lake Chelan and its immediate surroundings are the result of the complex interaction between two glacial masses. The lake was formed approximately 18,000 years ago during the Wisconsin glacial period. During this time, the Chelan Glacier moved down the valley from the north and the Okanogan-Columbia Valley lobe of the Cordilleran ice sheet extended upward from the south. The two glaciers approached each other and nearly met at Wapato Point and at a constriction known as "The Narrows" (a shallow sill 135 feet below the surface of the lake at its narrowest part). The approach and recession of these two glaciers caused erosion in the mid and upper portion of the lake, and geologic moraine deposits at the lower end of the lake. Together these effects created Lake Chelan (Kendra and Singleton 1987, and Hillman and Giorgi 1999 in Viola and Foster 2000). The lake now consists of two basins: the Lucerne basin, which is deep and fjord-like and extends north from The Narrows for 38 miles; and the Wapato basin, which is relatively wide and shallow in comparison (max. depth of 400 feet) and extends for 12 miles south of The Narrows (Hillman and Giorgi 1999 in Viola and Foster 2000).

Climate

The climate of the area is semi-arid and is characterized by hot, dry summers and mild to severe winters. The average summer maximum temperature for July is 86.4^{o}F, and the average winter maximum is 19.8^{o} F (Beck 1991). Precipitation and temperature vary widely depending on the elevation and proximity to the Cascade Crest. Winds typically are funneled down the lake valley in an easterly direction towards the Columbia River basin, where warm air masses are rising. This pattern causes increased wind speeds in the evenings, especially on the north shore of Lake Chelan (USFS 1998).

Average annual precipitation in the area ranges from a high of 150 inches near the crest of the Cascade Mountains to a low of 11 inches in the City of Chelan, near the Columbia River (Beck 1991). Total annual precipitation at Stehekin at the head of the lake averages 35 inches, the majority of which is snowfall from November through March (FERC, 2001).

Vegetation

The Lake Chelan Basin includes a diversity of life zones and plant and animal species. The upper two-thirds of the basin is mixed coniferous forest. The lower third is characterized by ponderosa pine, shrubsteppe (sage/bitter brush), and grassland plant communities. Within the lower basin, species typical of the Northern Cascades tend to prevail along tributaries on north-facing slopes, whereas Columbia Basin species generally dominate the south-facing slopes. The relatively mesic and sheltered conditions within riparian habitats obscure these vegetative differences (FERC 2002).

The basin is characterized by six primary vegetation zones: Ponderosa Pine (*Pinus ponderosa),* Douglas Fir *Pseudotsuga menziesii,* Grand Fir *Abies grandis,* Lodgepole Pine *Pinus contorta,* Subalpine Fir *Abies lasiocarpa,* and big sagebrush/bluebunch wheatgrass *Artemisia tridentata/Agropyron spicatum* (Franklin and Dyrness, 1973). The Douglas fir zone dominates most of the project area, extending from lakeshore to about the 4,000 foot elevation, where it blends into the grand fir and subalpine forest zones. The Douglas fir zone occurs along the upper 3/4 of the lake and along the Stehekin Valley. The major tree species in the zone are Douglas fir, ponderosa pine, lodgepole pine, and larch. Any of these four tree species may dominate forest stands in the Douglas fir zone. Snowberry, spirea, and rose are dominant shrubs in the Douglas fir zone understory, and bluebunch wheatgrass and fescue are dominant grasses.

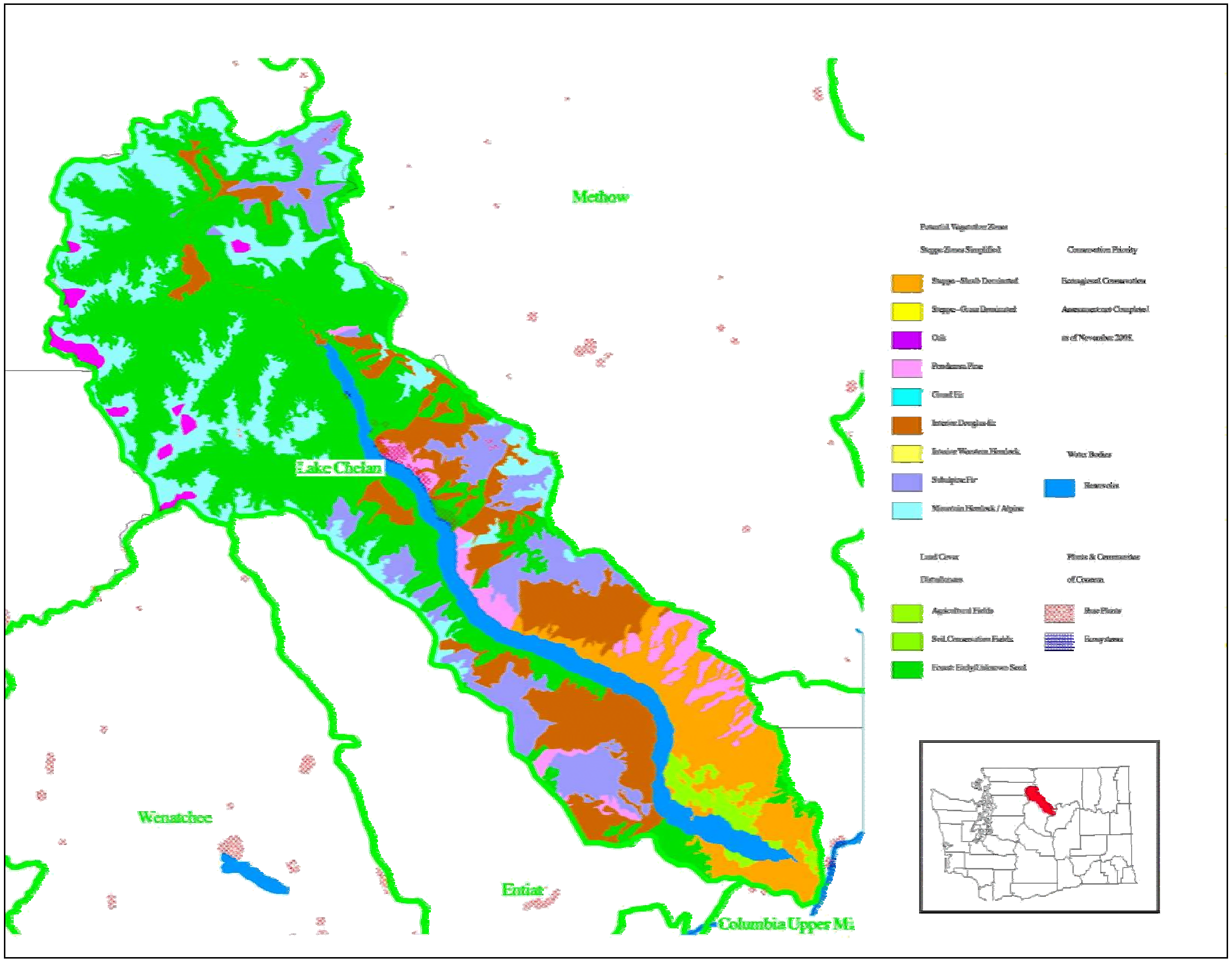
The southeastern portion of Lake Chelan is bordered by a mixture of ponderosa pine and steppe zones with agricultural crops intermingled. The ponderosa pine zone typically lies between the higher Douglas fir zone and the lower steppe zone. The ponderosa pine zone has a short growing season, minimal summer precipitation, summers with hot days and cool nights, and low winter temperatures, resulting in heavy snow accumulations. Within the Lake Chelan area, this zone is vegetated by ponderosa pine, Douglas fir, and in riparian bottoms, aspen and cottonwood. Common shrubs include bitterbrush, sagebrush, rose, ceanothus, and serviceberry. Dominant forbs and grasses are arrowleaf balsamroot, eriogonum, bluebunch wheatgrass, needle and thread, and recently, cheatgrass (Chelan PUD 1998).

The steppe zone, at the foot of Lake Chelan to the Columbia River, is occupied by the *Artemisia tridentata/Agropyron spicatum* (big sagebrush/bluebunch wheatgrass) association. This association is generally composed of four vegetation layers: 1) shrub layer of principally big sagebrush, bitterbrush, and rabbitbrush, 2) a layer of perennial grasses dominated by bluebunch wheatgrass, 3) a layer of low growing grasses such as Sandberg bluegrass and cheatgrass, and 4) a surface crust of crustose lichens and mosses (Chelan PUD 1998).

The climate of the upper portion of Lake Chelan has a strong maritime influence, which has created a greater diversity of species, many of which are more characteristic of the western Cascades (Taylor, 1985).

Changes in biodiversity have been closely associated with changes in land use. Grazing, agriculture, and accidents have introduced a variety of exotic plants, many of which are vigorous enough to earn the title "noxious weed." Twenty-six species of noxious weeds occur in the Lake Chelan subbasin (**Table 1**). The Lake Chelan subbasin contains 22 rare plant communities. Table XX) Doc does not like Rare Plant Table; currently in separate file. [I’m assuming we’ve either got this some where or are not using it. Approximately 32% of the rare plant communities are associated with shrubsteppe habitat, and 68% with upland forest habitat. Rare/high-quality plant occurrences and communities are illustrated in **Figure 3**.

Figure 3. GAP Lake Chelan subbasin vegetation zones, including rare plants



Source: Cassidy 1997

Table 1. Noxious weeds in the Lake Chelan subbasin and their origin

Common Name	Scientific Name	Origin
Feld bindweed	*Convolvulus arvensis*	Eurasia
Scotchbroom	*Cytisus scoparius*	Europe
Buffalobur nightshade	*Solanum rostratum*	Native to the Great Plains of the U.S
Pepperweed whitetop	*Cardaria draba*	Europe
Common crupina	*Crupina vulgaris*	Eastern Mediterranean region
Jointed goatgrass	*Aegilops cylindrica*	Southern Europe and western Asia
Meadow hawkweed	*Hieracium caespitosum*	Europe
Orange hawkweed	*Hieracium aurantiacum*	Europe
Poison hemlock	*Conium maculatum*	Europe
Johnsongrass	*Sorghum halepense*	Mediterranean
White knapweed	*Centaurea diffusa*	Eurasia
Russian knapweed	*Acroptilon repens*	Southern Russia and Asia
Spotted knapweed	*Centaurea bibersteinii*	Europe
Purple loosestrife	*Lythrum salicaria*	Europe
Mat nardusgrass	*Nardus stricta*	Eastern Europe
Silverleaf nightshade	*Solanum elaeagnifolium*	Central United States
Puncturevine	*Tribulus terrestris*	Europe
Tansy ragwort	*Senecio jacobaea*	Eurasia
Rush skeletonweed	*Chondrilla juncea*	Eurasia
Wolf's milk	*Euphorbia esula*	Eurasia
Yellow star thistle	*Centaurea solstitialis*	Mediterranean and Asia
Canadian thistle	*Cirsium arvense*	Eurasia
Musk thistle	*Carduus nutans*	Eurasia
Scotch cottonthistle	*Onopordum acanthium*	Europe
Dalmatian toadflax	*Linaria dalmatica*	Mediterranean
Yellow toadflax	*Linaria vulgaris*	Europe

Source: Callihan and Miller 1994

A rare plant survey of the Lake Chelan Hydroelectric Project area (Chelan PUD, 2000c), based on 1998-1999 fieldwork (**Table 2**), showed no federally listed plant species, but identified 14 populations of five rare plant species within the Project area and a total of 452 plant taxa (Alverson and Arnett 1986, Taylor 1985, Chelan PUD, 2000c).

Table 2. Rare plant populations for Lake Chelan Hydroelectric Project

Common Name	Scientific Name	Status		Number of Populations
		WA	USFS	
Giant helleborine	*Epipactis gigantea*	S		1
Common bluecup	*Githopsis specularioides*	S		4
Sierra cliffbrake	*Pellaea brachyptera*	S	S	2
Seely's silene	*Silene seelyi*	T	S	1
Western ladies-tresses	*Spiranthes porrifolia*	S	S	6
Total number of populations within the Lake Chelan Hydroelectric Project Area				14
T = Threatened, S = Sensitive				

Source: Chelan PUD, 2000c

In addition to the Washington Natural Heritage Program (WNHP) state-listed rare plant species, two other species of interest were also found within the Lake Chelan Hydroelectric Project area and one species listed as threatened by the USFWS, Ute ladies-tresses (*Spiranthes diluvialis*), has been documented as potentially occurring in the Project area. *Pectocarya pusilla*, a small native annual in the borage family, was found in the Prince Creek area. This species is only known in Washington from a few collections in Klickitat County. The north shore also supports a population of unusually large shrubs in the manzanita genus. The USGS Biological Resources Division believes that these plants are *Arctostaphylos patula*, which is not widely distributed in Washington. Potential habitat for Ute ladies-tresses exists in the Lake Chelan Hydroelectric Project area; however, no populations were recorded during the rare plant survey (Chelan PUD, 2000c).

Soils

Throughout much of the subbasin, the soils consist of alluvial deposits and glacial drift. Volcanic pumice and ash from the Glacier Peak region are also present in many areas and deposits are relatively deep on north-facing slopes, whereas erosion has removed much of this material from south-facing slopes (Beck 1991, USFS 1998). The mountainous terrain consists mainly of large rock outcroppings and shallow soils (Beck 1991). Shoreline slopes are relatively steep and rocky, with most of the shoreline characterized by bedrock outcrops or glacial till. The glacial till materials are variable in texture and source but generally consist of gravel and cobbles in a matrix of silty sand (FERC 2002).

More recent colluvial and alluvial deposits are also common. Some colluvial deposits, derived from bedrock rather than till, are rockier with less silty sand. Alluvial deposits found at tributary mouths range from sand to cobbles and boulders; they are generally less dense and include more rounded particles than tills and colluvial soils. Outwash deposits found around the lower end of the lake and along the bypassed reach range from silty sands to sandy gravel and cobbles. These soils are often slightly cemented (FERC 2002).

Susceptibility of the various soils to erosion varies widely. Some of the tills are resistant to erosion, while the colluvial and alluvial deposits erode more easily. In many parts of the drawdown zone around the lake, colluvial deposits and the finer particles that form the matrix of the tills have been removed from the near-surface soils by wave action, leaving behind coarse gravels, cobbles, and boulders. Alternatively, where slopes are flatter and sandy soils more predominant, the drawdown zone is characterized by sand or sandy gravel (FERC 2002).

3.3.2 Jurisdictions and Land Ownership

The Lake Chelan subbasin is the historic lands of the Chelan tribe, now one of the 12 Confederated Tribes of the Colville Reservation. Their aboriginal territories were grouped primarily around waterways, including those in the Lake Chelan subbasin as well as many other Columbia Basin watersheds. These watersheds, including the Lake Chelan, contain traditional fishing, hunting and food gathering places still used today by tribal members for subsistence and ceremonial purposes. In 1879 the United States government by executive order created the Moses Columbia Reservation engulfing the Lake Chelan drainage. The forming of this reservation was for the purpose of relocating the Moses Columbia, Chelan, Entiat and Wenatchi tribes. The Moses Columbia Reservation is located east of the Okanogan and Columbia Rivers, north of the south shore of Lake Chelan, east of the Cascade Crest and south of the Canadian Border. Members of these tribes were later relocated onto the present Colville Reservation, but many families and allotments still exist along lake, river and stream corridors.

Over 90% of the Lake Chelan subbasin, primarily the upper portion, is in public ownership, with the WNF comprising approximately 70% and the North Cascades National Park (505,000 acres) accounting for another 23% . The upper nine miles of the lake and the Stehekin River are located within the Lake Chelan NRA (63,000 acres), a unit of the North Cascades NPS. The middle 27 miles of the lake are within the Chelan Ranger District (422,073 acres) of the WNF. Most of the lower basin, which contains the majority of the development, is privately owned. The BLM also manages parcels scattered throughout the basin. In 1988, 635,000 acres of North Cascades National Park, Lake Chelan NRA, and Ross Lake NRA (118,000) were designated by Congress as the Stephen Mather Wilderness Area (FERC 2002). The subbasin consists of 599,905 acres (937 mi^2) and is the second smallest in the Columbia Cascade Province, comprising just 6.5% of the land area. Lake Chelan lies within a 589,000 acre (924 mi^2) drainage basin (**Figure 2**) located along the eastern slopes of the Cascade Mountains in Chelan County in north-central Washington (FERC 2002). Approximately 87% of the Lake Chelan subbasin is in federal, state, and local government ownership. The remaining 13% of the lands in the Subbasin is in private ownership.

The WNF includes a net area of 2,164,180 acres, more than half of which is designated wilderness. The WNF is 140 miles long and 25 to 55 miles wide, stretching from Lake Chelan in the north through the rugged Goat Rocks Wilderness in the south. Included within the Chelan Ranger District are the 141,361-acre Glacier Peak Wilderness and the 54,802-acre Lake Chelan-Sawtooth Wilderness (FERC 2002).

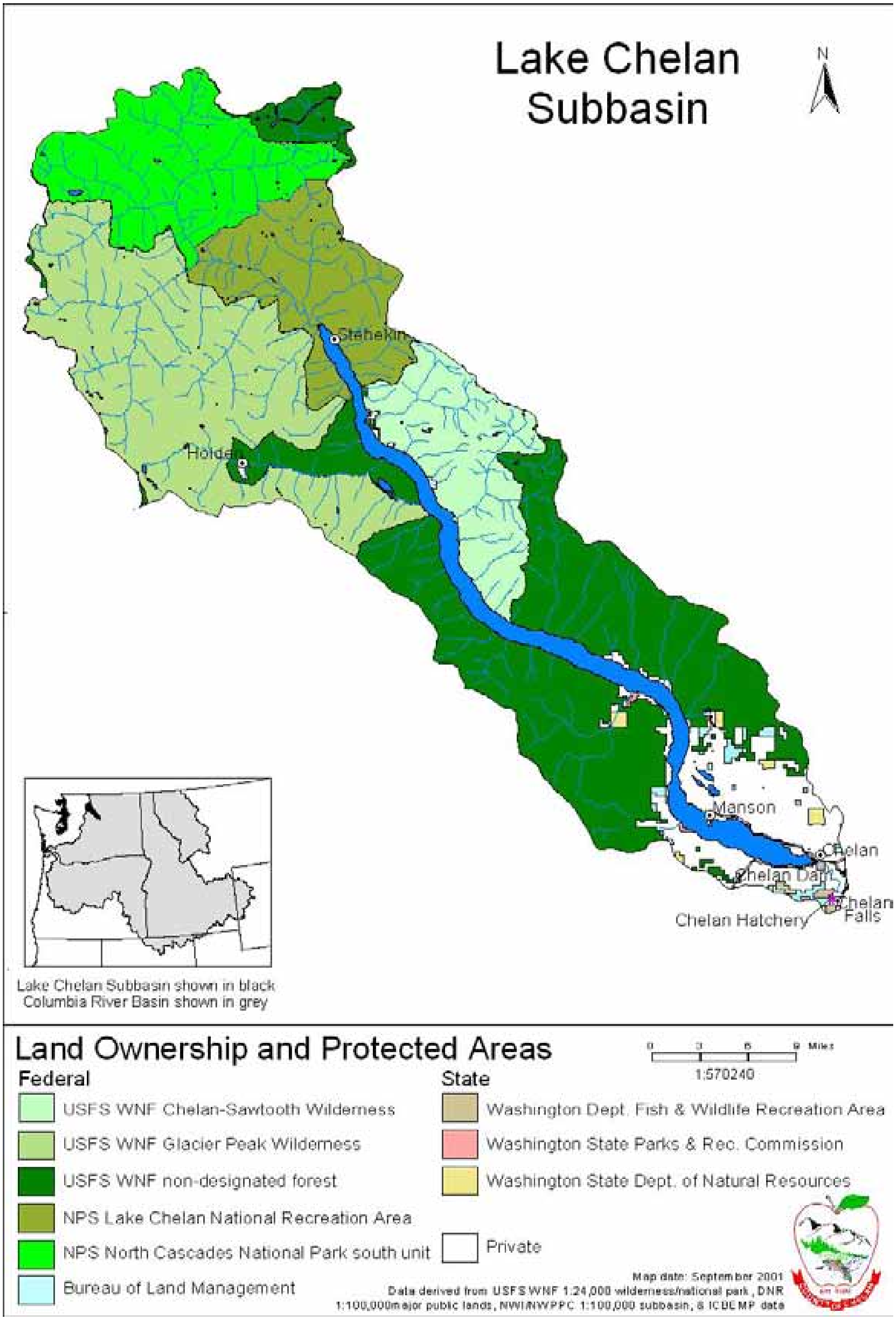
The Washington State Parks and Recreation Commission operates two state parks on the south shore of Lake Chelan. Lake Chelan State Park is located on the west side of the lake and occupies 126 acres. It features 6,454 feet of waterfront on Lake Chelan and 1,640 feet of stream frontage on First Creek. Twentyfive Mile Creek State Park occupies 235 acres on the south shore of the lake and has 1,500 feet of lakefront (FERC 2002).

Although Lake Chelan is a natural lake, its levels and outfall (the Chelan River—called the “bypassed reach” because its flow is diverted much of the year), are controlled as part of the Lake Chelan Hydroelectric Project, owned and operated by Chelan County Public Utility District No. 1. The PUD's license to operate the facility expires in 2006 (Kaputa and Woodward 2002).

Table 3. Land ownership in the Lake Chelan subbasin

Owner	Acres	Percent
Private	78,493	13%
Tribal	0	
Federal	517,883	86%
State	3,549	0.6%
Total	599,925	

Figure 4. Land ownership and protected status of lands in the subbasin



3.3.3 Land Use and Demographics

Land use within Lake Chelan subbasin is varied and includes conservation, recreation, primary and secondary (vacation and second homes) residential, resorts and agriculture (**Table 3**). Tourism is a significant part of the local economy. Consequently a substantial portion of the subbasin is protected for recreation and the enjoyment of the environment.

An estimated 277,480 acres (46%) are permanently protected in the Subbasin. These lands have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events of natural type are allowed to proceed without interference or are mimicked through management (high protection).

Approximately 10.5% (63,069 acres) of the Subbasin has permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state (medium protection status). Approximately 195,607 acres (33%) has permanent protection from conversion of natural land cover for the majority of the area, but is subjected to uses of either a broad, low intensity type or localized intense type (low protection status). Approximately 10.6% (63,769 acres) of the lands within the Subbasin lack irrevocable easements or mandates to prevent conversion of natural habitat types to anthropogenic habitat types (no protection).

The lake is also used for power production, irrigation, and commercial navigation. Recreation on land and water is an important part of the economy of the basin. While timber harvest occurred in the past, little timber is harvested now. Mineralized formations producing copper, gold, zinc and silver were mined at the Holden Mine on Railroad Creek from 1938 through 1957 (Beck 1991). Mining currently is a minor activity in the basin; however, in addition to the large claim at Holden, patented mining claims exist in private inholdings throughout the basin. Under current mining laws they could be proposed for development (Kaputa and Woodward 2002).

The upper two-thirds of the subbasin is quite remote and can be accessed only by water, foot, horseback or air (floatplane). The majority of land in this area is in public ownership and is managed for conservation objectives and/or recreation. With the exception of the Stehekin and Lucerne areas, there is very little development. Shoreline development in this portion of the lake is largely confined to small, primitive shoreline campgrounds administered by the USFS and the NPS. Several roads and trails in the upper basin provide access into the Lake Chelan National Recreation Area (NRA) and the Wenatchee National Forest (WNF) (FERC 2002).

The community of Stehekin is located at the head of the lake and has the most privately owned and developed land in the upper basin (primarily in the Stehekin Valley area). Land uses in Stehekin are primarily residential but also include a resort and several small commercial enterprises. Lucerne, located about eight miles down lake from Stehekin, has a number of private cabins adjacent to the lake, is served by commercial boat service, and is the primary access point to the small community of Holden (FERC 2002).

Because the lower one-third of the lake is primarily privately owned and the terrain is not as steep, it has received the most development. The City of Chelan (population 3,000 – 6,000) contains the most concentrated development in the subbasin. It is located at the lower end of Lake Chelan and is the only incorporated community on the lake. The Community of Manson (population 2,000 – 4,000) is located approximately eight miles up lake from Chelan on the north shore. Population decreases significantly in winter months (FERC 2002, Kaputa and Woodward 2002).

Table 4. Population of Chelan County 1990-2000

County	1990 Population	2000 Population	Area (sq. mi.)	People/sq. mi.
Chelan	52,250	66,616	2,291	22.8

Source: U.S. Census Bureau, 2000

Land uses in the lower basin include primary and secondary residences, agriculture, resorts and public recreation. Agriculture is the predominant land use, with nearly 9,500 acres of orchards (primarily apples). However, as the area becomes more popular as a recreation and second home destination, non-agricultural development has become a significant land use. Docks are common at lakeside residences, and resorts have features such as boat ramps, docks, marinas, beaches and swimming areas. These residential areas are located on both sides of the lake, within and outside of the boundaries of the Community of Manson and the City of Chelan (FERC 2002).

Between the dam at the end of the lake and the Columbia River is the 3.9-mile long bypassed reach. Most of the bypassed reach is owned by Chelan PUD and is undeveloped. Privately-owned parcels (primarily orchard) adjoin the north side of the Chelan River in Reaches 1 and 2 (FERC 2002).

Table 5. Existing land use within Lake Chelan subbasin

Land Use	Area (km2)	Percentage
Lake Chelan	135	5.6
Other Water Bodies	4	0.2
Forested Public Lands	2,000	83.6
Forested Private Lands	163	6.8
Agriculture - Orchard	47	2.3
Agriculture - Non-Orchard	31	1.3
Residential	6	0.2
Roadways	6	0.2
Commercial and Public Buildings	1	0.0
TOTAL	2,393	100.0

Source: Patmont et al. 1989

3.3.4 Chelan County Comprehensive Plan 2000

A comprehensive plan is required by the 1990 Growth Management Act (GMA). In response to increased pressures from unprecedented population growth in Washington State, the State Legislature passed the GMA. The GMA requires all cities and counties in the state to do planning. The fastest growing counties are required to adopt new comprehensive land use plans in compliance with the new law and to address the following 13 goals (City of Woodinville Comp Plan 2002):

Goal (1) Urban Growth – Encourage development in urban areas where adequate public facilities and services exist or can be provided in an efficient manner.

Goal (2) Reduce Sprawl – Reduce the inappropriate conversion of undeveloped land into sprawling, low-density development.

Goal (3) Transportation – Encourage efficient multimodal transportation systems that are based on regional priorities and coordinated with county and city comprehensive plans.

Goal (4) Housing - Encourage the availability of affordable housing to all economic segments of the population of the state, promote a variety of residential densities and housing types, and encourage preservation of existing housing.

Goal (5) Economic Development - Encourage economic development throughout the state that is consistent with adopted comprehensive plans; promote economic opportunity for all citizens of the state, especially for unemployed and disadvantaged persons; and encourage growth, all within the capacities of the state's natural resources, public services, and public facilities.

Goal (6) Property rights - Private property shall not be taken for public use without just compensation having been made. The property rights of landowners shall be protected from arbitrary and discriminatory actions.

Goal (7) Permits - Applications for both state and local government permits shall be processed in a timely and fair manner to ensure predictability.

Goal (8) Natural Resource Industries – Maintain and enhance natural resource-based industries, including productive timber, agricultural, and fisheries industries. Encourage the conservation of productive forest lands and productive agricultural lands, and discourage incompatible uses.

Goal (9) Open Space and Recreation – Encourage the retention of open space and development of recreational opportunities, conserve fish and wildlife habitat, increase access to natural resource lands, and discourage incompatible uses.

Goal (10) Environment – Protect the environment and enhance the state's high quality of life, including air and water quality, and the availability of water.

Goal (11) Citizen Participation and Coordination - Encourage the involvement of citizens in the planning process and ensure coordination between communities and jurisdictions to reconcile conflicts.

Goal (12) Public Facilities and Services – Ensure that those public facilities and services necessary to support development shall be adequate to serve the development at the time the development is available for occupancy and use without decreasing current service levels below locally established minimum standards.

Goal (13) Historic Preservation – Identify and encourage the preservation of lands, sites, and structures that have historical or archaeological significance.

The Chelan County Comprehensive Plan (Plan) (Hunter, Lynch and Stefaniw 2000) is a legal document adopted by local elected officials establishing policies that will guide the future development, growth, and land use within Chelan County through the year 2017. The plan strives to maintain and enhance the existing quality of life that includes: culture, customs, economy, agricultural economy, sense of community, water quality, and recreational opportunities. This is a plan to promote the development of a 12 month economy utilizing the abundant natural resources of the area. This plan should provide for expansion of these opportunities, while maintaining an adequate infrastructure to accommodate this growth. Continuous public participation is warranted, with decision making and implementation at the local level. This plan will ensure the protection of individual property rights, and provide for the right to farm according to historic and recommended practices.

The Chelan County Comprehensive Plan is divided into eight study areas of which the Chelan – Manson (Chelan subbasin) area is one. The plan is also broken down into elements: land use, transportation, capital facilities, economic development, utilities, and rural. The following is a summary of the plan's goals and policies for each of these elements.

Land Use Element

The majority of land in the County is in federal and state ownership. The County as a whole is not currently constrained on the availability of land to meet current and projected needs; however, it is constrained by funding resources for public utilities. Coordination between the Land Use Element and the Capital Facilities Element was essential in producing a plan with accurate projections for residential and economic development.

Natural Systems / Critical Areas

The Plan provides for the protection of critical areas, which include the following areas and ecosystems: (a) wetlands; (b) groundwater resources and aquifer recharge areas; (c) fish and wildlife habitat conservation areas; (d) frequently flooded areas known to be critical parts of the natural drainage system; and (e) geologically hazardous areas. The land use element is also required by the GMA to review; where applicable, drainage, flooding, and storm water run-off and to provide guidance for corrective actions to mitigate or cleanse those discharges that pollute waters of the state.

Plan goals help to identify and protect critical areas, and provide for reasonable use of private property while mitigating adverse environmental impacts. This includes protecting the quality and quantity of ground water used for public water supplies, protecting and maintaining air quality, preserving frequently flooded areas by limiting and controlling potential alterations and / or obstructions to those areas, and avoiding or mitigating significant risks that are posed by geologic hazard areas to property (public &private), health, and safety. They also ensure that development minimizes impacts upon significant natural, historic, and cultural features and preserves their integrity.

Resource Lands

County goals assure conservation and continued use of agricultural, forest, mineral, and rural resource lands that have long-term significance for commercial production. The Plan provides for reasonable, limited use of designated resource lands that are compatible with the long-term production of natural resource products. They also allow for short term mineral resource extraction opportunities in unincorporated areas (where appropriate), facilitate a healthy, diverse, and competitive agricultural industry, control encroachment of incompatible uses and ensure public health and safety. Chelan County calls for the mitigation of conflicts between resource and non-resource land uses in designated resource lands.

Residential Development

While recognizing that residential development is important and necessary to the sustainability of the communities, housing goals were developed to ensure that future development is compatible with surrounding land uses and can be efficiently and effectively served by public facilities and services. In addition, residential designations shall provide for an adequate supply of land to accommodate housing needs, and a variety of residential opportunities to serve a full range of income levels.

Urban Growth Areas (UGAs)

The GMA stipulates that UGAs are to include areas and densities sufficient to permit the urban growth that is projected to occur in the County over a twenty year planning period. Urban growth is encouraged within designated UGAs (areas already characterized by urban development where existing public facility and service capacity is available). Otherwise, in areas where public or private facilities or services are planned or could be provided and utilized in an efficient manner.

Commercial and Industrial Development

Similar goals apply to commercial and industrial development. Commercial and industrial development are limited to areas zoned for these activities within the UGAs (areas with the infrastructure and services to support such development) and in rural lands when consistent with the GMA. The existing commercial and industrial base is maintained and further diversification is promoted, while maintaining compatibility with surrounding land uses. The Plan also calls for the designation of adequate areas, which will allow for a range of opportunities and the diversification of area economies. Mitigation of impacts on other land uses and the community are required, were appropriate. Finally, the Plan retains docking facilities at the Stehekin Landing for both commercial and private use.

Open Space / Recreation

Plan goals encourage the retention of open space (underdeveloped land that helps define the rural character of the County), the development and maintenance of recreational facilities to meet the needs of residents and tourists, and the coordination of federal, state, local, and private planning. Park and recreation planning and development activities are required take into consideration impacts to surrounding land uses, critical areas, and significant natural, scenic, historic, and cultural features. The Plan also provides for public access to recreation sites and the reasonable, limited use of privately-owned land within the Open Space designation, provided that such development is reasonably compatible with open space recreation and fish and wildlife habitat conservation.

Master Planned Resorts

Another objective of the plan is to provide opportunities for Master Planned Resorts (MPRs: destination resort facilities that may be located outside of the UGA) consistent with the provisions of RCW 36.70A.360. These opportunities include encouraging and enhancing a diversity of recreational, lodging, and economic opportunities, and providing resorts (in existence as of July 1, 1990), which match the definition of an MPR, a means to be classified as such. The plan also requires that development regulations governing the review of MPRs shall incorporate appropriate environmental and design standards.

Transportation Element

Transportation goals provide for the efficient use of existing and future transit facilities for all citizens through a systematic approach of monitoring and maintaining the transport systems. The goals integrate many types of transportation systems and facilities (i.e. road, rail, air, bike, pedestrian, etc.) and establish levels of service, by coordinating transportation planning with other elements of the comprehensive plan (i.e. land use and rural areas), and coordination with other jurisdictions and transportation providers to meet shared needs. They also promote safe, efficient access to land, while maintaining the integrity and minimizing impacts of the transportation systems, and providing for the health and economic well-being of county citizens. Transportation improvements and development are provided through a fiscally sound approach that stays within the counties funding capacity. Further, the Plan provides for a systematic process for reviewing and updating the Transportation Improvement Program.

Capital Facilities Element

Plan goals ensure that adequate public facilities and services (i.e. fire, police, water, sanitary sewer, storm water, schools, hospitals, parks, etc.) are planned, located, designed and maintained in a timely, economical, efficient, and equitable manner, according to future development of the county and in coordination with other elements of the comprehensive plan (i.e. Land use and transportation) and other jurisdictions. This includes: establishing and achieving levels of service standards; encouraging compatible, multiple uses of public facilities; maximizing use, including rehabilitation, of existing facilities and replacing worn out or obsolete facilities, when and where feasible; ensuring funding for facilities and services that's within the counties capacity; and encouraging land use patterns that minimize (make reasonable) the cost of providing facilities and services. The Plan also encourages participation in, and the establishment of, a regional forum to address area wide public facility and service and utility needs as they arise.

With regards to environmental protections, the Plan ensures that public services and facilities are adequately planned and designed to prevent significant negative environmental impact, to assure access, and to protect public health, safety and welfare. Specifically, the county supports and encourages water conservation education and measures, energy conservation design strategies, and the design of facilities and services that are in keeping with the rural and scenic character of the county. Also, fire provisions provide for proper disposal of vegetative debris associated with capital development.

Economic Development Element

County goals are designed to increase efforts to support, retain, and expand the existing agricultural industry (includes expanding value-added agricultural products) and other local business, while diversifying the economy by promoting other opportunities for economic development throughout the County that provide diverse work opportunities, job security, and ensure a healthy, stable, growing economy. The plan seeks to attract businesses and industries that complement and build upon existing enterprises and those that conserve natural resources and open spaces, maintain environmental quality and rural character, and enhance the overall quality of life. Development of tourism and recreation is a key goal.

The Plan also encourages economic growth through other means. It proposes to involve citizens and other jurisdictions in the creation of decisions/direction for future growth in economic development including educational partnerships that provide the technically skilled labor force to attract and retain good paying industries. It also encourages economic growth through planning and development of the region’s public services and facilities’ capacity, and by pursuing legislative changes (including tax increment financing) and providing regulatory incentives to foster public/private partnerships and economic development.

Chelan County recognizes the need to be proactive in addressing ESA listings and entering into watershed planning efforts due to their potential impact on economic development efforts and the ability to pursue sustainable economic development. They will also work to retain and develop their site limited industrial sector and to diversify the local economy by strengthening manufacturing and promoting producer services and other basic industries.

Housing Element

Chelan County’s primary housing goal is to provide affordable housing to all economic segments of the population of the county. This includes promoting a variety of residential densities and housing types, providing an adequate supply of land zoned for residential use, and encouraging the appropriate preservation of existing housing stock.

Utilities Element

County utility goals promote increased efficiencies and quality service, multi-jurisdictional cooperation, coordination with other elements of the comprehensive plan (i.e. land use and transportation), and the provision of adequate, timely, safe, and cost effective utilities (power, water, sewer, telecommunications and, in some areas, irrigation) to support current and future development. This includes identifying the proper location of utilities, minimizing cost and disruption of normal activities, increasing effectiveness of the resource, and protecting the public and environment from negative impacts associated with the siting, development, and operation of utility services and facilities. The county will also promote the continued use, maintenance, development and revitalization of existing utilities whenever possible. Utility development regulations should be flexible, receptive to innovations, and based on specific situations.

To protect the environment and quality of life, the Plan calls for utilities to provided in such a way as to minimize negative visual and noise impacts. Where facilities may have negative impacts, regulations shall provide for adequate buffering and screening of facilities. Energy conservation, including new construction, and the use of cost effective alternative energy sources (i.e. solar and wind power) is also encouraged.

Chelan County has also set guidelines specific to the Stehekin area. These goals encourage the continued use and maintenance of hydroelectric facilities and the enhancement of hydroelectric power capabilities through system efficiency and the protection of facilities from erosion and flooding. Further, they seek to decrease future reliance upon diesel powered electricity by encouraging the use of alternative energy

Rural Element

Rural areas are those areas not designated for urban growth, agriculture, forest, or mineral resources. However, agriculture, farming/ranching, forestry, mineral, recreation and other similar activities are inherent within this designation. Plan goals take into consideration both human uses and the natural environment. They encourage rural development that maintains the rural character and visual integrity of the land and protects and restores the land and water environments required by natural resource-based economic activities, fish and wildlife habitats, rural lifestyles, outdoor recreation, and other open space. Other primary stipulations for rural development include developing at low levels of intensity, ensuring that the provision of public facilities and services are consistent with rural character and lifestyle, reducing the inappropriate conversion of rural lands to sprawling low-density development, and promoting coordination with other jurisdictions and sections of the plan.

The comprehensive plan provides for a variety of rural densities and designations, while striking a balance between maintaining the existing pattern of uses (i.e. residential, small-scale commercial, cottage and resource industries, tourism, recreation, agricultural, light industrial and limited natural resource processing, sales, and support services) and providing opportunities for future, compatible development. To accomplish this, the county promotes the continuation and enhancement of clustering (i.e. MPRs, designated rural service centers fully contained communities), density transfer, design guidelines, conservation easements, and other innovative techniques. Open space will be part of the development in order to protect rural values and buffer adjacent resource use/critical areas. Also, whenever feasible, rural developments will be encouraged to utilize community systems for domestic water and sewage disposal to increase efficiency, lower costs of providing these services, and to cause fewer impacts to the environment (i.e. aquifer recharge areas, water quality and quantity). Development and recreational opportunities in rural shoreline and other rural areas shall minimize potential adverse impacts to water quality, slope stability, vegetation, wildlife and aquatic life.

3.3.5 Hydrology

Lake Chelan is oriented generally in a northwest-to-southeast direction within a deeply glaciated valley and occupies approximately 50 miles of the 75-mile-long basin. The majority of inflow to Lake Chelan is from two major tributaries: the Stehekin River, which feeds into the lake from the west, provides 65%; Railroad Creek provides 10%. Approximately 50 small streams provide the remaining 25% of the inflow. Due to the shape of the valley, most tributaries are relatively steep and short (FERC 2001).

The lake consists of two distinct basins separated by a relatively shallow sill 135 feet below the surface of the lake at its narrowest part. The larger Lucerne Basin (upper 38.4 miles of the lake), has a maximum depth of 1,486 feet and contains over 92% of the total lake volume. The Wapato Basin is relatively broad and shallow, with a length of 12 miles and a maximum depth of 400 feet. Water entering the Lucerne Basin has an average residence time of approximately 10 years, however, the residence time of water within the smaller Wapato Basin is much shorter, ranging from approximately 0.2 to 1 year, depending on climatic factors (FERC 2001).

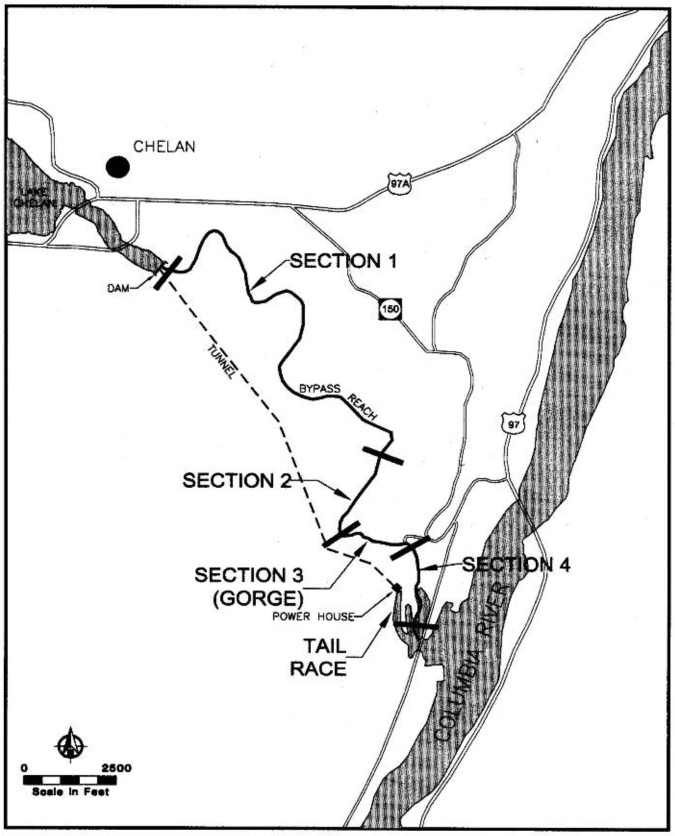
Nearly the entire Lake Chelan outflow, averaging approximately 2,000 cfs, is diverted through a 2.2-mile-long power tunnel (penstock; vertical drop of 401 feet), which passes the water through the powerhouse for hydroelectric generation and into the tailrace, which empties into the

Columbia River. The 3.9-mile bypassed reach (original Chelan River channel) is without flow during most of the year; normally, the only flow in the bypassed reach comes during the spring and early summer when snow melt raises the lake to levels requiring spill for flood control (Chelan PUD 1998, FERC 2001).

The powerhouse tailrace is a 1,700-foot-long channel adjacent to the lower end of the bypassed reach. The tailrace has a variable, near-zero gradient due to the backwater from the downstream Rocky Reach Project on the Columbia River. At the time of construction of the Lake Chelan Hydroelectric Project, the tailrace was excavated from the powerhouse to the Columbia River, and an earthen dike (now vegetated) was established between the tailrace and the bypassed reach (FERC 2002).

As shown in **Figure 5**, the bypassed reach is comprised of four distinct sections (Chelan PUD, 1999). The upper two sections, Sections 1 and 2, are relatively low gradient areas (approximately 55 ft/mi) extending a length of 3.0 miles. Section 3, referred to as the gorge, is 0.4-mile long with steep and narrow canyon walls. The gradient in this part of the channel is very steep, approximately 480 ft/mi. Waterfalls, from 5 to 20 feet high, numerous cascades, bedrock chutes, and large, deep pools characterize the stream channel in the gorge reach. Finally, Section 4 is 0.5-mile long and characterized by a wide floodplain. This section of the bypassed reach has a relatively low gradient (22 ft/mi) and a substrate comprised of gravel, cobble, and boulders. Section 4 extends from the bottom of the gorge section downstream to the confluence with the tailrace and Columbia River (Anchor, 2000).

Figure 5. Chelan River (bypassed reach) by section and Lake Chelan hydroelectric project



Impoundments and Irrigation Projects

Lake Chelan is a natural lake, but its levels are affected and controlled by the Lake Chelan Hydroelectric Project (Project), a dam and powerhouse owned and operated by Chelan County Public Utility District, which is located at the mouth of the lake on the Chelan River. The Project, constructed in 1927, is a 40-foot-high concrete gravity dam that raised the elevation of the lake by 21 feet above normal high water levels. The project reservoir, Lake Chelan, is operated between elevations of 1,079 feet and 1,100 feet to ensure optimum use of the reservoir for power generation, fish and wildlife conservation, recreation, water supply, and flood control. The annual drawdown of the lake begins in early October, with the lowest lake elevation normally occurring in April. The average annual drawdown is 15.8 feet, to elevation 1,084.2 feet. The lake refills during May and June and is maintained at or above elevation 1,098 feet from June 30 through September 30 each year, the peak recreation season. The upper 21 feet of the reservoir is allocated as storage (677,400 acre-feet), usable by the project for hydroelectric generation and other purposes. (FERC 2001, Anchor 2000).

Surface water is pumped from the lake to serve domestic water supplies for the towns of Chelan and Manson. In Chelan, the average winter use (February) is about 500,000 gallons per day; the average summer (August) use is 2,600,000 gallons per day (Bill Greenway, City of Chelan). The city of Manson consumes 325,000,000 gallons a year. Manson also has a large pumping station which supplies irrigation water through an underground system to 6,500 acres of farms (Paul Cross, Lake Chelan Reclamation District manager). Residents on private land at places like First

Creek, Twentyfive Mile Creek, Fish Creek and Canoe Creek withdraw minor amounts of water for domestic use as well.

The 76-year-old Lake Chelan Project is currently up for relicensing by FERC. As part of the relicensing process, Chelan PUD agreed to return water to a portion of the Chelan River that had been dry most of the year since the project's inception. Water temperatures in Lake Chelan, however, are potentially high enough to exceed Washington state's numeric standard for riverine water temperatures. Although Columbia River Inter-Tribal Fish Commission lost a court challenge to the agreement, to date Chelan PUD has not released a plan that indicates how it intends to address the possibility of exceedences in water temperatures.

3.3.6 Wildlife Resources

There are an estimated 341 wildlife species that occur in the Lake Chelan subbasin. Of these species, 105 (31%) are closely associated with riparian and wetland habitat and 75 (22%) consume salmonids during some portion of their life cycle. Seventeen wildlife species are non-native. Eight wildlife species that occur in the Subbasin are listed federally and 42 species are listed in Washington and Idaho as Threatened, Endangered, or Candidate species. A total of 98 bird species are listed as Washington or Idaho State Partners in Flight priority and focal species. A total of 57 wildlife species are managed as game species in Washington (Appendix A). The most abundant big game species present in the Lake Chelan vicinity include: mule deer, mountain goats, black bears and cougars. Lesser numbers of white-tailed deer, Rocky Mountain elk and moose are reported. The WDFW manages these species. Mountain goats, considered a Priority Species by WDFW, were observed near Bear Creek (FERC 2002).

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3.3.7 Fish Resources

Lake Chelan and its tributaries support a variety of fish species. Appendix B lists fish species historically and currently present in the Lake Chelan subbasin and whether they are native or introduced (FERC 2001). The predominant salmonid species native to the Lake Chelan subbasin are westslope cutthroat trout. Bulltrout are believed to have been extirpated (Cavender, 1978; Pratt, 1992). Lake Chelan does not contain anadromous fish species because of the steep gorge in the Chelan River at the mouth of the lake (Hillman and Giorgi, 2000). However, fish populations from the Columbia River, including migrating salmonids, have been found in the Lake Chelan Project tailrace and in the lower part of the Chelan River (FERC, 2001).

Lake Chelan supports an important sport fishery consisting of kokanee (landlocked sockeye salmon), landlocked chinook salmon, rainbow trout, cutthroat trout, lake trout and burbot. Other fish found in Lake Chelan include smallmouth bass, pygmy and mountain whitefish, a variety of panfish/sunfish, northern pikeminnow, suckers, minnows and sculpins (FERC 2002). Brown (1984) provides an overview of the Lake Chelan fishery resource, based on intensive creel, limnological and tributary surveys done in 1981 and 1982. Relicensing studies conducted on Lake Chelan in 1999 and 2000 provide comparative data to those collected by Brown (1984) (DES, 2000a). During summer, fish biomass in the lower basin is most likely greater than 90% coarse fish (Brown 1984).

4 Terrestrial Assessment

4.1.1 Introduction

The terrestrial assessment for the Lake Chelan subbasin focuses on three discrete habitats: shrubsteppe, eastside (interior) riparian wetland, and ponderosa pine. In order to determine the health of these several ecosystems, focal species for each habitat have been identified and will be assessed. The terrestrial assessment reflects the biological potential of the subbasin and the opportunities for restoration. Information on wildlife focal species is taken directly from the report Draft Columbia Cascade Ecoprovince Wildlife Assessment and Inventory by Paul Ashley and Stacey Stovall (See Appendix A).

General Terrestrial Habitat Conditions

In general, the lower elevations and downlake portions of the basin support species associated with shrubsteppe vegetation, such as mule deer. As precipitation increases, ponderosa pine and its dependent wildlife species increase in abundance. On north aspects and at higher elevations, Douglas fir and lodgepole pine increase, creating habitat conditions more favorable to species that require higher canopy closure and more complex forest structure. Ecosystem processes such as fire, wind, and avalanche all serve to create and maintain habitat conditions favorable to a wide variety of relatively rare species such as lynx, fisher, and wolverine, as well as other species of concern such as the white-headed woodpecker and black-backed woodpecker. The north shore supports large areas of unroaded wildlife habitat including winter range and spring emergence habitat for grizzly bears as well as comparatively large areas of fire-regenerated habitats favored by lynx and cavity-dependent species. On the other hand, these same processes have created limited habitats for species associated with interior habitats (USFS 1998).

Human activities have influenced the distribution and condition of wildlife habitats throughout the basin to a greater or lesser degree. Domestic sheep grazing at the turn of the century eliminated bighorn sheep from the area. Grazing has also affected riparian habitats and the condition of meadows and winter ranges. Critical mule deer winter ranges have been affected by residential and agricultural development, reservoir operation, timber harvest activities, and fire exclusion. Logging has resulted in the wide scale removal of large ponderosa pine trees and subsequently reduced populations of dependant species, as well as snag dependent species in some areas. Road building, irrigation, and reservoir construction and operation, as well as numerous other management activities have reduced the extent and quality of riparian habitats and populations of dependent species such as amphibians. Management attempts to influence ecosystem processes such as fire have had widespread and significant effects on the condition of wildlife habitat throughout the area, resulting in decreased habitat for some species and increased habitat for others. The numbers of large carnivores and large raptors have declined significantly due to predator control and other management activities (USFS 1998).

Vegetation Zones

Cassidy (1997) identified six historic (potential) vegetation zones that occur within the subbasin. The three-tip sage, central arid steppe, and ponderosa pine vegetation zones are described in detail in Ashley and Stovall (unpublished report, 2004). These vegetation zones constitute focal habitat types. Douglas-fir, subalpine fir, and alpine parkland are not focal habitat types, but these vegetation zones occur extensively throughout the Subbasin.

Subbasin Habitat Types

The Lake Chelan Subbasin consists of 15 wildlife habitat types, which are briefly described in (**Table 6**). Detailed descriptions of these habitat types can be found in Ashley and Stovall (unpublished report, 2004).

Dramatic changes in wildlife habitat have occurred throughout the Subbasin since pre-European settlement (circa 1850). IBIS data limitations for describing historic and current habitat conditions at the subbasin level are described in section 1.1 (Ashley and Stovall, unpublished report, 2004). Due to the limitations and inaccuracies associated with the IBIS mapping, the IBIS historic and current characterizations of habitats were not used for subbasin-level analyses.

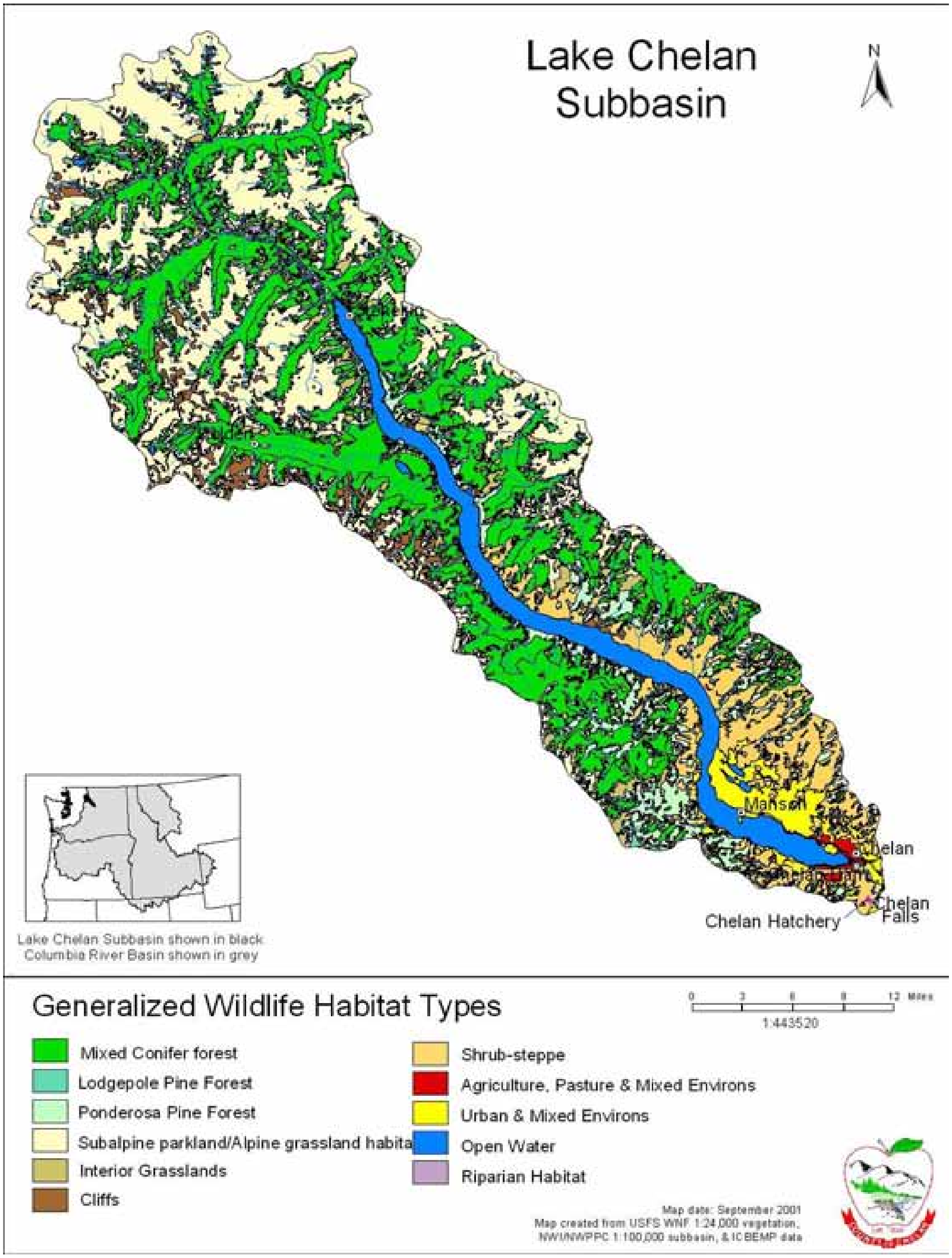
Table 6. Wildlife habitat types within Lake Chelan subbasin

Habitat Type	Brief Description
Montane Mixed Conifer Forest	Coniferous forest of mid-to upper montane sites with persistent snowpack; several species of conifer; understory typically shrub-dominated.
Eastside (Interior) Mixed Conifer Forest	Coniferous forests and woodlands; Douglas-fir commonly present, up to 8 other conifer species present; understory shrub and grass/forb layers typical; mid-montane.
Lodgepole Pine Forest and Woodlands	Lodgepole pine dominated woodlands and forests; understory various; mid-to high elevations.
Ponderosa Pine and Interior White Oak Forest and Woodland	Ponderosa pine dominated woodland or savannah, often with Douglas-fir; shrub, forb, or grass understory; lower elevation forest above steppe, shrubsteppe. (Oak is not known to exist in the subbasin.)
Upland Aspen Forest	Quaking aspen (*Populus tremuloides*) is the characteristic and dominant tree in this habitat.
Subalpine Parkland	Coniferous forest of subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and lodgepole pine (*Pinus contorta*).
Alpine Grasslands and Shrublands	This habitat is dominated by grassland, dwarf-shrubland (mostly evergreen microphyllous), or forbs.
Eastside (Interior) Grasslands	Dominated by short to medium height native bunchgrass with forbs, cryptogam crust.
Shrubsteppe	Sagebrush and/or bitterbrush dominated; bunchgrass understory with forbs, cryptogam crust.
Agriculture, Pasture, and Mixed Environs	Cropland, orchards, vineyards, nurseries, pastures, and grasslands modified by heavy grazing; associated structures.
Urban and Mixed Environs	High, medium, and low (10-29% impervious ground) density development.

Habitat Type	Brief Description
Open Water – Lakes, Rivers, and Streams	Lakes, are typically adjacent to Herbaceous Wetlands, while rivers and streams typically adjoin Eastside Riparian Wetlands and Herbaceous Wetlands
Herbaceous Wetlands	Emergent herbaceous wetlands with grasses, sedges, bulrushes, or forbs; aquatic beds with pondweeds, pond lily, other aquatic plant species; sea level to upper montane.
Montane Coniferous Wetlands	Forest or woodland dominated by evergreen conifers; deciduous trees may be co-dominant; understory dominated by shrubs, forbs, or graminoids; mid- to upper montane.
Eastside (Interior) Riparian Wetlands	Shrublands, woodlands and forest, less commonly grasslands; often multi-layered canopy with shrubs, graminoids, forbs below.

Source: IBIS 2003

Figure 6. Wildlife habitat types in Lake Chelan subbasin



4.1.2 Focal Habitat Selection and Rationale

The focal habitat selection and justification process is described in (Ashley and Stovall, unpublished report, 2004). Focal habitats selected for the Lake Chelan Subbasin include shrubsteppe, riparian wetlands, and Ponderosa Pine Forest. Agriculture is a habitat of concern. Neither the IBIS nor the Washington GAP Analysis data recognize the historic presence of herbaceous wetlands or riparian wetlands. Additionally, the current extent of these habitat types as reflected in these databases is suspect at best; however, NWI (FWS 1999-0518), hydric soils data (NRCS) and WDFW Priority Habitat and Species data were used to represent current riparian wetland and herbaceous wetland habitats. The amount of extant acres for each focal habitat type is illustrated by subbasin in **Table 7**.

Table 7. Current comparison of focal habitat acreage in Columbia Cascade Province subbasins

Subbasin	Focal Habitat			
	Ponderosa Pine (acres)	Shrub steppe (acres)	Riparian Wetlands (acres)	Herb aceous Wetlands (acres)
Entiat	55,807	32,986	94	
Lake Chelan	**45,480**	**45,018**	**5,079**	
Wenatchee	51,912	24,248	141	
Methow	139,853	107,655	4,232	
Okanogan	140,738	562,763	9,920	
Upper Middle Mainstem Columbia River	50,843	753,073	3,898	6,032
Crab	4,660	991,397	12,227	

Source: IBIS 2003, FWS 1999

Focal Habitat Changes

In many cases, quantification of changes in focal wildlife habitats at the subbasin level either does not exist or is considered unreliable. Ponderosa pine, shrubsteppe, and wetland habitats within the Subbasin have decreased significantly since 1850.

IBIS riparian wetland historic habitat data are incomplete and not suitable for use in subbasin level analyses. As a result, riparian wetland analysis is incomplete. Accurate habitat type quantification, especially those detailing riparian wetland habitat, are needed to improve assessment quality and support management strategies. In spite of the lack of quantifiable historic habitat conditions, subbasin wildlife managers believe that significant physical and functional losses have occurred to riparian wetland habitats.

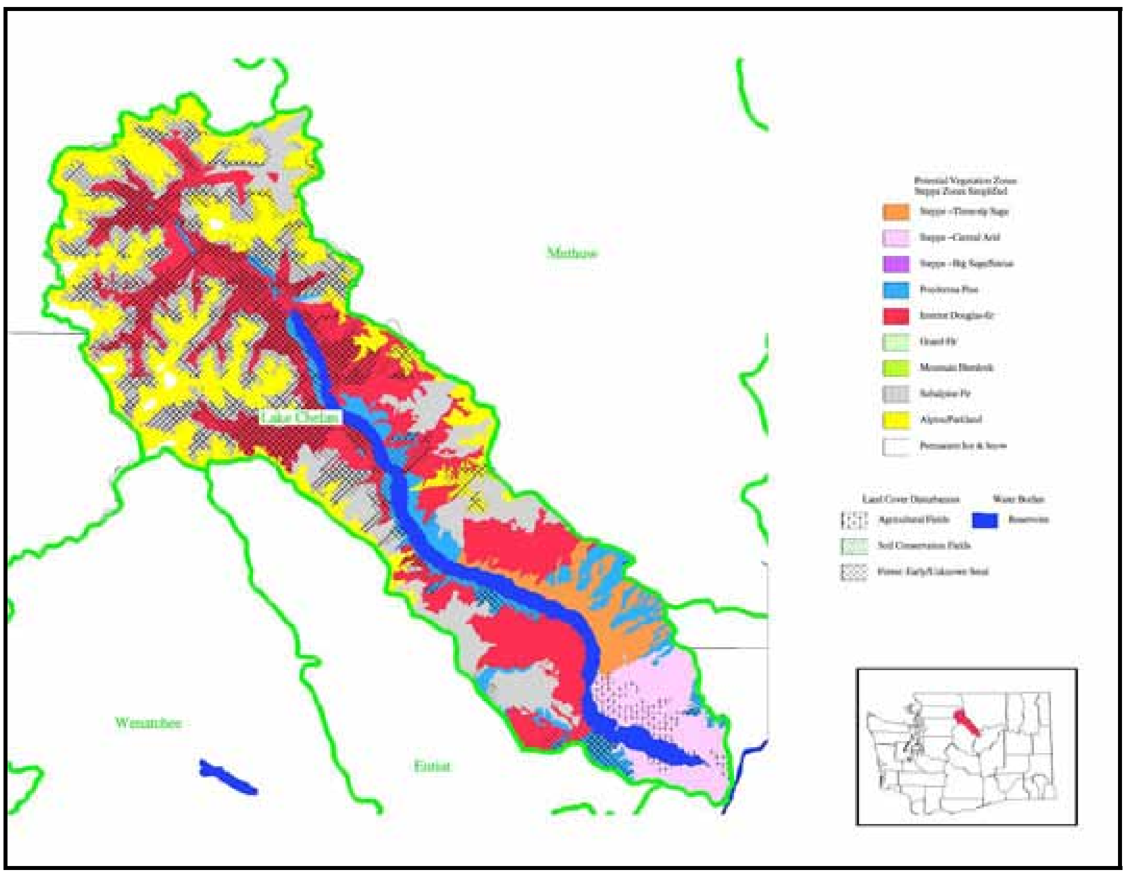
Agriculture is Habitat of Concern

Agriculture has replaced much of the native habitats historically existing in the subbasin. Because of the extensive presence of agriculture, it is considered a habitat type today. In the

Lake Chelan subbasin, the dominant agricultural cropland habitat is fruit orchards. Some native species still exist in this habitat type, but the diversity of wildlife and plant species is decreased compared to historical habitat that have been replaced by agriculture. Also, agriculture has resulted in introduced plants and animals in the subbasin, many spreading beyond the borders of the agricultural habitat, reducing the quality of native habitats still existing today. Agricultural extent in the Lake Chelan subbasin is illustrated in **Figure 7**.

Because of the extent, and likely permanence and economic importance of this habitat, it should be considered in the management of wildlife in the subbasin. There is, however, limited opportunity to effect change in agricultural land use at the landscape scale, subbasin planners did not conduct a full-scale analysis of agricultural conditions. The Conservation Reserve Program (CRP) has had some success encouraging farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover (native grasses, wildlife plantings, trees, filter strips, or riparian buffers) that help establish wildlife habitat, improve water quality (by reducing soil erosion and sedimentation), and generally enhance shrubsteppe and wetland resources.

Figure 7. Agricultural lands in Lake Chelan subbasin



Source: Cassidy 1997

Protection Status

The GAP protection status of agricultural habitat in the Lake Chelan subbasin is illustrated in **Table 8**. Small amounts of agricultural lands, however, are given low and medium protection status. Low and medium protection is limited to lands enrolled in conservation easements, or those that are under other development restrictions such as county planning ordinances.

Table 8. Agriculture GAP protection status in Lake Chelan subbasin

GAP Protection Status	Acres
High protection	277,480
Medium protection	63,069
Low protection	195,607
No protection	63,769

Source: NHI 2003

4.1.3 Focal Wildlife Species Selection and Rationale

An estimated 341 wildlife species are likely to inhabit the Lake Chelan Subbasin. Eight wildlife species were chosen as focal species to represent three focal habitats within the Lake Chelan Subbasin. Habitat attributes required by the focal species represent conditions and features of a properly functioning ecosystem and desired future conditions for focal habitats that will direct planners in developing and implementing habitat management goals and activities for the Lake Chelan Subbasin.

Table 9. Species richness and associations for Lake Chelan subbasin

Class	Lake Chelan	Percentage of Total	Total for Province
Amphibians	11	65	17
Birds	221	94	234
Mammals	93	96	97
Reptiles	16	84	19
Total	341	93	367
Association			
Riparian wetlands	73	94	78
Other wetlands (herbaceous and montane coniferous)	32	86	38
All wetlands	105	91	116
Salmonids	75	90	82

Source: IBIS 2003

Lambeck (1997) defined focal species as a suite of species whose requirements for persistence define the habitat attributes that must be present if a landscape is to meet the requirements for all species that occur there. The key characteristic of a focal species is that its status and trend provide insights to the integrity of the larger ecological system to which it belongs (USFS 2000).

Subbasin planners refer to these species as "focal species" because they are the focus for describing desired habitat conditions and attributes and needed management strategies and/or actions. The rationale for using focal species is to draw immediate attention to habitat features and conditions most in need of conservation or most important in a functioning ecosystem. The corollary is that factors that affect habitat quality and integrity within the province also impact wildlife species, hence, the decision by subbasin planners to focus on focal habitats with focal species in a supporting role (Ashley and Stovall, unpublished report, 2004).

Province planners consider focal species' life requirements representative of habitat conditions or features that are important within a properly functioning focal habitat type. In some instances, extirpated or nearly extirpated species (e.g., sharp-tailed grouse) were included as focal species if subbasin planners believed they could potentially be reestablished and/or are highly indicative of some desirable habitat condition (Ashley and Stovall, unpublished report, 2004).

For wildlife and terrestrial habitat resources, Province/Subbasin planners identified a focal species assemblage, (species that inhabit the same habitat type and require similar habitat attributes) for each focal habitat type. Six bird species and two mammalian species were selected to represent three focal habitats (Shrubsteppe, Eastside [Interior] Riparian Wetland, and Ponderosa Pine Forest) in the Lake Chelan Subbasin: Brewer's sparrow (*Spizella breweri*), mule deer (*Odocoileus hemionus*), red-eyed vireo (*Vireo olivaceus*), American beaver (*Castor canadensis*), pygmy nuthatch (*Sitta pygmaea*), white-headed woodpecker (*Picoides albolarvatus*), and (*Spizella breweri*) flammulated owl (*Otus flammeolus*).

Table 10. Wildlife focal species selection matrix for Lake Chelan subbasin

Common Name	Focal Habitat[1]	Status[2]		Native Specie s	PHS[3]	Partners in Flight	Game Specie s
		Federal	State				
Wildlife							
Brewer's sparrow	Shrub steppe	n/a	n/a	Yes	No	Yes	No
Mule deer		n/a	n/a	Yes	Yes	No	Yes
Red-eyed vireo	Riparian wetland	n/a	n/a	Yes	No	No	No
American beaver		n/a	n/a	Yes	No	No	Yes
Pygmy nuthatch	Ponderosa pine forest	n/a	n/a	Yes	No	No	No
White-headed woodpecker		n/a	C	Yes	Yes	Yes	No
Flammulated owl		n/a	C	Yes	Yes	Yes	No

1 SS = Shrubsteppe; RW = Riparian Wetlands; PP = Ponderosa pine
2 C = Candidate; SC = Species of Concern; T = Threatened; E = Endangered; FS = WDFW & Chelan PUD Focus Species, SS = Regional Forester's Sensitive Species
3 PHS = WDFW Priority Habitats and Species

4.2 Shrubsteppe

Rationale for Selection

Shrubsteppe was selected as a focal habitat because changes in land use over the past century have resulted in the loss of over half of Washington's shrubsteppe habitat (Dobler *et al.* 1996). Shrubsteppe communities support a wide diversity of wildlife. The loss of once extensive shrubsteppe communities has substantially reduced the habitat available to a wide range of shrubsteppe-associated wildlife, including several birds found only in this community type (Quigley and Arbelbide 1997; Saab and Rich 1997). More than 100 bird species forage and nest in sagebrush communities, and at least four of them (sage grouse, sage thrasher, sage sparrow, and Brewer's sparrow) are obligates, or almost entirely dependent upon sagebrush (Braun *et al.* 1976). In a recent analysis of birds at risk within the interior Columbia Basin, the majority of species identified as of high management concern were shrubsteppe species (Vander Haegen *et al*. 1999). Moreover, over half these species have experienced long-term population declines according to the Breeding Bird Survey (Saab and Rich 1997).

Historic

Historically, sage and bitterbrush-dominated steppe vegetation occurred throughout the majority of the lower elevations in the Lake Chelan subbasin as variations of shrubsteppe habitat once occupied most of the non-forested land in eastern Washington. The moister draws and permanent stream courses imbedded in the shrubsteppe landscape supported strands of riparian vegetation dominated by moisture loving shrubs and small trees, including thick stands of water birch.

Deer winter range once covered about 100,000 to 200,000 acres in the lowlands and extended across the Columbia River. Prior to construction of the Rocky Reach Dam, water was lower and the channel was narrower in winter. Small wetlands, meadows and riparian areas along streams, springs, and adjacent forests provided deer and other wildlife with good thermal cover essential to cold, severe winters (USFS 1996 in NPPC 2002).\

According to Chelan PUD 1998 Initial Consultation Document, the historical botanical resources of the Lake Chelan Project area (the boundaries are similar to those defined for the Lake Chelan Subbasin Plan) would have been closely correlated with existing botanical resources. The forested and non-forested plant communities which are present today would have been present historically, though perhaps occupying more or less spatial area historically. Frequent wildfires maintained and shaped the forested and shrubsteppe portions throughout the Lake Chelan project area, particularly before widespread fire suppression.

Current

The greatest changes in shrubsteppe habitat from historic conditions are habitat losses due to conversion, loss of function due to fragmentation, reduction of bunchgrass cover in the understory, and an increase in sagebrush cover. Soil compaction is also a significant factor in heavily grazed lands, affecting water percolation, runoff, and soil nutrient content. A long history of grazing, fire, and invasion by exotic vegetation has altered the composition of the plant community within much of the extant shrubsteppe in this region (Quigley and Arbelbide 1997; Knick 1999), and it is difficult to find stands which are still in relatively natural condition.

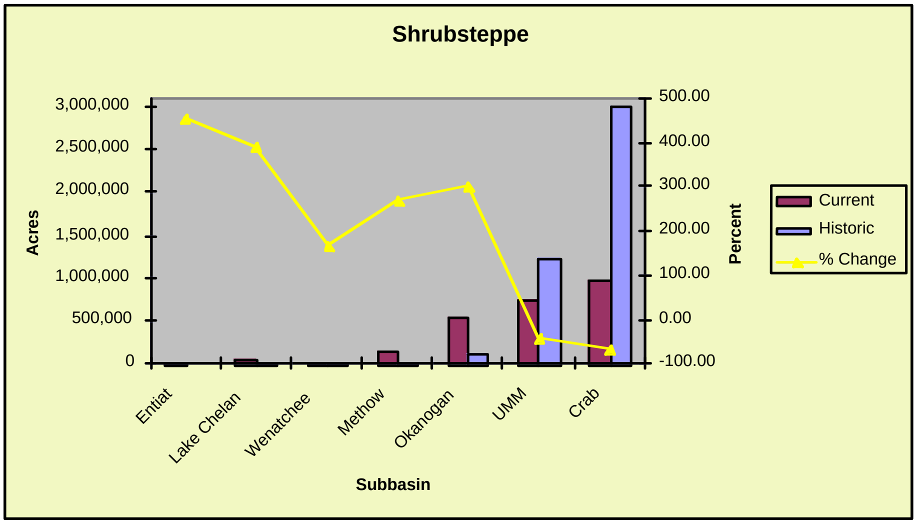
Fire has relatively little effect on native vegetation in the three-tip sagebrush zone, since three-tip sagebrush and the dominant graminoids resprout after burning. Three-tip sagebrush does not appear to be much affected by grazing, but the perennial graminoids decrease and are eventually replaced by cheatgrass (*Bromus tectorum*), plantain *(Plantago* spp.), big bluegrass (*Poa secunda),* and/or gray rabbitbrush (*Chrysothamnus nauseosus).* In recent years, diffuse knapweed (*Centaurea diffusa)* has spread through this zone and threatens to replace other exotics as the chief increaser after grazing (Roche and Roche 1998).

In areas of central arid steppe with a history of heavy grazing and fire suppression, true shrublands are common and may even be the predominant cover on non-agricultural land. Most of the native grasses and forbs are poorly adapted to heavy grazing and trampling by livestock. Grazing eventually leads to replacement of the bunchgrasses with cheatgrass, Nuttall's fescue (*Festuca microstachys*), eight flowered fescue (*F. octofiora),* and Indian wheat (*Plantago patagonica*) (Harris and Chaney 1984). In recent years, several knapweeds (*Centaurea spp*.), have become increasingly widespread. Russian star thistle (*Centaurea repens)* is particularly widespread, especially along and near major watercourses (Roche and Roche 1988 in Cassidy 1997).

Although shrubsteppe and open forest habitat are preferred by deer in winter and by other species throughout the year, today only 56,000 acres of winter range still exist. Reduced winter range size is attributed to a number of factors: 1) the Rocky Reach Dam /Rock Island hydroelectric facility commenced operation in 1961, flooding much of the low elevation winter habitat and preventing access to available habitat across the river; 2) the 1994 Tyee fire eliminated about 70% of the cover and forage provided in the winter range; 3) grazing and development (agricultural and residential) favor invasion by noxious weeds, diminishing the deer's native forage base of grasses and forbs; 4) roads constructed to accommodate timber harvest, development, and winter recreation (cross country skiing, hunting, and snowmobiling) have fragmented habitat and increased the number of deer killed by motorists (USFS 1996 in NPPC 2002).

Protection Status

Figure 8. Comparison of shrubsteppe habitat in province subbasins



Source: IBIS 2003

The protection status of shrubsteppe habitat for Ecoprovince subbasins is compared in **Figure 8**. In Lake Chelan the protection status of remaining shrubsteppe habitats subbasin falls primarily within the "low" to "no protection" status categories (**Table 11**). As a result, this habitat type will likely suffer further degradation, disturbance, and/or loss in the subbasin. Protection status of shrubsteppe habitat within the Lake Chelan subbasin is illustrated

Table 11. Shrubsteppe habitat GAP protection status in Lake Chelan subbasin

GAP Protection Status	Acres
High Protection	2,451
Medium Protection	1,034
Low Protection	22,013
No Protection	19,540

Source: IBIS 2003

Limiting Factors

Factors affecting shrubsteppe habitat are explained in detail in section 4.2.10.2 (Ashley and Stovall (unpublished report 2004) and are summarized below:

Lake Chelan shrubsteppe/grassland ecosystems have been degraded, fragmented and lost because of the encroachment of urban and residential development and conversion to agriculture (e.g., approximately 60% of shrubsteppe in Washington [Dobler *et al.* 1996]). The best sites for healthy sagebrush communities (deep soils, relatively mesic conditions) are also best for agricultural productivity; thus, past losses and potential future losses are great. Most of the remaining shrubsteppe in Washington is in private ownership with little long-term protection (57%). Shrubsteppe habitat is also limited by the conversion of CRP lands back to cropland.

A long history of fire management, intensive grazing, and invasion of exotic plant species has altered the composition of the plant community, degraded and destroyed wildlife habitat, and reduced habitat viability for wildlife, especially obligate and semi-obligate species. Big sagebrush communities are killed by fire and lost to brush control (may not be detrimental relative to interior grassland habitats), leaving the relatively unaffected grasses as dominants (Daubenmire 1975). Grazing compacts soils, and eventually leads to the replacement of native grasses (e.g. bunchgrasses) and forbs with exotic species (e.g. cheatgrass, diffuse knapweed, Russian thistle). Grazing, in particular, has caused the loss and reduction of cryptogamic crusts (lichens and mosses that grow between the dominant bunchgrass and shrubs), which help maintain the ecological integrity of shrubsteppe/grassland communities. Nest parasites (brown-headed cowbird) and domestic predators (cats) may also be present in high numbers in these altered landscapes, particularly those in proximity to agricultural and residential areas subject to high levels of human disturbance.

4.2.1 Brewer's Sparrow (*Spizella Breweri*)

Brewer's sparrows are representative of shrubsteppe habitat. Although not currently listed, Brewer's sparrows have significantly declined across their breeding range in the last 25 years, a cause for concern because this species is one of the most widespread and ubiquitous birds in shrubsteppe ecosystems (Saab et al. 1995). Brewer's sparrow is a sagebrush obligate where sagebrush cover is abundant (Altman and Holmes 2000). However, in recent decades many of the shrubsteppe habitats in Washington have changed as a result of invasion by exotic annuals, especially cheatgrass. Cheatgrass-dominated areas have an accelerated fire regime that effectively eliminates the sagebrush shrub component of the habitat, a necessary feature for Brewer's sparrows (Vander Haegen et al. 2000).

Conservation practices that retain deep-soil shrubsteppe communities, reduce further fragmentation of native shrubsteppe, and restore annual grasslands and low-productivity agricultural lands are all important (Vander Haegen et al. 2000). A patchy distribution of sagebrush clumps is more desirable than dense uniform stands. Removal of sagebrush cover to <10% has a negative impact on populations (Altman and Holmes 2000). Recommended habitat objectives include the following: patches of sagebrush cover 10-30%, mean sagebrush height > 64cm (24 in), high foliage density of sagebrush, average cover of native herbaceous plants > 10%, bare ground >20% (Altman and Holmes 2000).

Brewer's Sparrow Life History, Key Environmental Correlates, and Habitat Requirements

Life History

Diet

Brewer's sparrows forage by gleaning a wide variety of small insects from the foliage and bark of shrubs. Occasionally, seeds are taken from the ground. They will drink free-standing water when available but are physiologically able to derive adequate water from food and oxidative metabolism (Rotenberry *et al.* 1999). Lepidopterans (butterflies and moths, 90% larvae), araneans (spiders), hemipterans (bugs), and homopterans (hoppers, aphids, etc.) make up 70% of the nestling diet (Petersen and Best 1986).

Reproduction

Breeding begins in mid-April in the south to May or early June in the north. Clutch size is usually three to four. Nestlings are altricial. Brewer's sparrow reproductive success is correlated with climatic variation and with clutch size; success increasing in wetter years (Rotenberry and Wiens 1989, 1991).

Brewer's sparrows are able to breed the first year following hatch and may produce two broods a year. In southeastern Idaho, the probability of nest success was estimated at 9% (n = 7; Reynolds 1981). In eastern Washington 31 of 59 (53%) pairs were unsuccessful, 25 (42%) fledged one brood, 3 (5%) fledged two broods (Mahony *et al.* 2001). The probability of nest success was an estimated 39% for 495 nests monitored in eastern Washington; reproductive success was lower in fragmented landscapes (M. Vander Haegen unpubl. data in Altman and Holmes 2000). The number of fledglings produced/nest varies geographically and temporally. The average number of fledglings/nest range from 0.5-3.4 but may be zero in years with high nest predation (Rotenberry *et al*. 1999).

Nesting

Brewer's sparrow pair bonds are established soon after females arrive on breeding areas, usually in late March but pair formation may be delayed by colder than average spring weather. Not all males successfully acquire mates. In Washington, 51% of 55 males monitored in the breeding season were observed incubating eggs, especially during inclement weather (Mahony *et al*. 2001). Pairs may start a second clutch within 10 days after fledging the young from their first brood (Rotenberry *et al.* 1999).

Brown-headed cowbirds (*Molothrus ater*) are known to lay eggs in Brewer's sparrow nests; parasitized nests are usually abandoned (Rich 1978, Biermann *et al.* 1987, Rotenberry *et al.* 1999). Parasitism of Brewer's sparrows nest by cowbirds is only about 5% in eastern Washington (Altman and Holmes 2000).

Both parents feed the nestlings, 90% of foraging trips are < 50 m (164 ft) from the nest site. Fledglings are unable to fly for several days after leaving the nest and continue to be dependent upon the parents. During this period they remain perched in the center of a shrub often < 10 m (33 ft) from the nest and quietly wait to be fed (Rotenberry *et al.* 1999).

Migration

Brewer's sparrow is a neotropical migrant. Birds breed primarily in the Great Basin region and winter in the southwestern U.S., Baja, and central Mexico. North-south oriented migration routes are through the Intermountain West. Brewer's sparrows are an early spring migrant. Birds arrive in southeastern Oregon by mid-late March. The timing of spring arrival may vary among years due to weather conditions. Birds generally depart breeding areas for winter range in mid-August through October (Rotenberry *et al.* 1999).

Mortality

Nest predators include gopher snake (*Pituophis catenifer*), western rattlesnake (*Crotalus viridis*), common raven (*Corvus corax*), black-billed magpie (*Pica pica*), loggerhead shrike (*Lanius ludovicianus*), long-tailed weasel (*Mustela frenata*), Townsend's ground squirrel (*Spermophilus townsendii*), and least chipmunk (*Tamias minimus*). Predators of juvenile and adult birds include loggerhead shrike, American kestrel (*Falco sparverius*), sharp-shinned (*Accipiter striatus*) and Cooper's (*A. cooperi*) hawks (Rotenberry 1999).

Habitat Requirements

In eastern Washington, abundance of Brewer's sparrows (based on transect surveys) was negatively associated with increasing annual grass cover; higher densities occurred in areas where annual grass cover was <20% (Dobler 1994). Vander Haegen *et al.* (2000) determined that Brewer's sparrows were more abundant in areas of loamy soil than areas of sandy or shallow soil, and on rangelands in good or fair condition than those in poor condition. Additionally, abundance of Brewer's sparrows was positively associated with increasing shrub cover. In southwestern Idaho, the probability of habitat occupancy by Brewer's sparrows increased with increasing% shrub cover and shrub patch size; shrub cover was the most important determinant of occupancy (Knick and Rotenberry 1995).

Nesting

Brewer's sparrows construct an open cup shaped nest generally in a live big sagebrush shrub (Petersen and Best 1985, Rotenberry *et al.* 1999). In southeastern Idaho, mean sagebrush height (54 cm, 21 in) and density (29% cover) were significantly higher near Brewer's sparrow nest sites than the habitat in general while herbaceous cover (8%) and bare ground (46%) were significantly lower (Petersen and Best 1985). The average height of nest shrubs in southeastern Idaho was 69 cm (27 in). Ninety% (n = 58) of Brewer's sparrows nests were constructed at a height of 20-50 cm (8-20 in) above the ground (Petersen and Best 1985).

Breeding

Brewer's sparrow is strongly associated with sagebrush over most of its range, in areas with scattered shrubs and short grass. They can also be found to a lesser extent in mountain mahogany, rabbit brush, bunchgrass grasslands with shrubs, bitterbrush, ceonothus, manzanita and large openings in pinyon-juniper (Knopf *et al.* 1990; Rising 1996; Sedgwick 1987; USDA Forest Service 1994). In Canada, the subspecies *taverneri* is found in balsam-willow habitat and mountain meadows.

The average canopy height is usually < 1.5 meter (Rotenberry *et al.* 1999). Brewer's sparrow is positively correlated with shrub cover, above-average vegetation height, bare ground, and horizontal habitat heterogeneity (patchiness). They are negatively correlated with grass cover, spiny hopsage, and budsage (Larson and Bock 1984; Rotenberry and Wiens 1980; Wiens 1985; Wiens and Rotenberry 1981). Brewer's sparrows prefer areas dominated by shrubs rather than grass. They prefer sites with high shrub cover and large patch size, but thresholds for these values are not quantified (Knick and Rotenberry 1995). In Montana, preferred sagebrush sites average 13% sagebrush cover (Bock and Bock 1987). In eastern Washington, Brewer's sparrow abundance significantly increased on sites as sagebrush cover approached historic 10% level (Dobler *et al.* 1996). Brewer's sparrows are strongly associated throughout their range with high sagebrush vigor (Knopf *et al.* 1990).

Adults are territorial during the breeding season. Territory size is highly variable among sites and years. In central Oregon and northern Nevada, territory size was not correlated with 17 habitat variables but was negatively associated with increasing Brewer's sparrow density. The average size of territories ranges from 0.5-2.4 ha (1.2-5.9 ac, n = 183) in central Oregon. The reported territory size in central Washington is much lower, 0.1 ha (0.2 ac) (Rotenberry *et al.* 1999).

Non-breeding

In migration and winter, Brewer's sparrows use low, arid vegetation, desert scrub, sagebrush, creosote bush (Rotenberry *et al.* 1999).

Brewer's Sparrow Population and Distribution

Population

Historic

No data are available.

Current

Brewer's sparrows can be abundant in sagebrush habitat and will breed in high densities (Great Basin and Pacific slopes), but densities may vary greatly from year to year (Rotenberry *et al.* 1999). Dobler *et al.* (1996) reported densities of 50-80 individuals/km^2 in eastern Washington. In the Great Basin, density usually ranged from 150-300/km^2, sometimes exceeding 500/km^2 (Rotenberry and Wiens 1989). Brewer's sparrow breeding density ranges from 0.08 to 0.10 individuals/ha in shadscale habitat in eastern Nevada (Medin 1990). Breeding territory usually averages between 0.6-1.25 hectares and will contract as densities of breeding birds increase (Wiens *et al.* 1985).

In southeastern Oregon, densities have ranged from 150-300 birds/km^2 (390-780/mi^2), but can exceed 500/km^2 (1,295/mi^2) (Weins and Rotenberry 1981, Rotenberry and Weins 1989).

Distribution

Historic

Jewett *et al.* (1953) described the distribution of the Brewer's sparrow as a fairly common migrant and summer resident at least from March 29 to August 20, chiefly in the sagebrush of the Upper Sonoran Zone in eastern Washington. They describe its summer range as north to Brewster and Concully; east to Spokane and Pullman; south to Walla Walla, Kiona, and Lyle; and west to Wenatchee and Yakima. Jewett *et al.* (1953) also noted that Snodgrass (1904: 230) pointed out its rarity in Franklin and Yakima counties. Snodgrass also reported that where the vesper sparrow was common, as in Lincoln and Douglas counties, the Brewer's sparrow was also common (Jewett *et al.* 1953). Hudson and Yocom (1954) described the Brewer's sparrow as an uncommon summer resident and migrant in open grassland and sagebrush. They also reported occupied nests near Pullman.

Undoubtedly, the Brewer's sparrow was widely distributed throughout the lowlands of southeast Washington when it consisted of vast expanses of shrubsteppe habitat. Large scale conversion of shrubsteppe habitat to agriculture has resulted in populations becoming localized in the last vestiges of available habitat (Smith *et al.* 1997). A localized population existed in small patches of habitat in northeast Asotin County. Brewer's sparrow may also occur in western Walla Walla County, where limited sagebrush habitat still exists.

Current

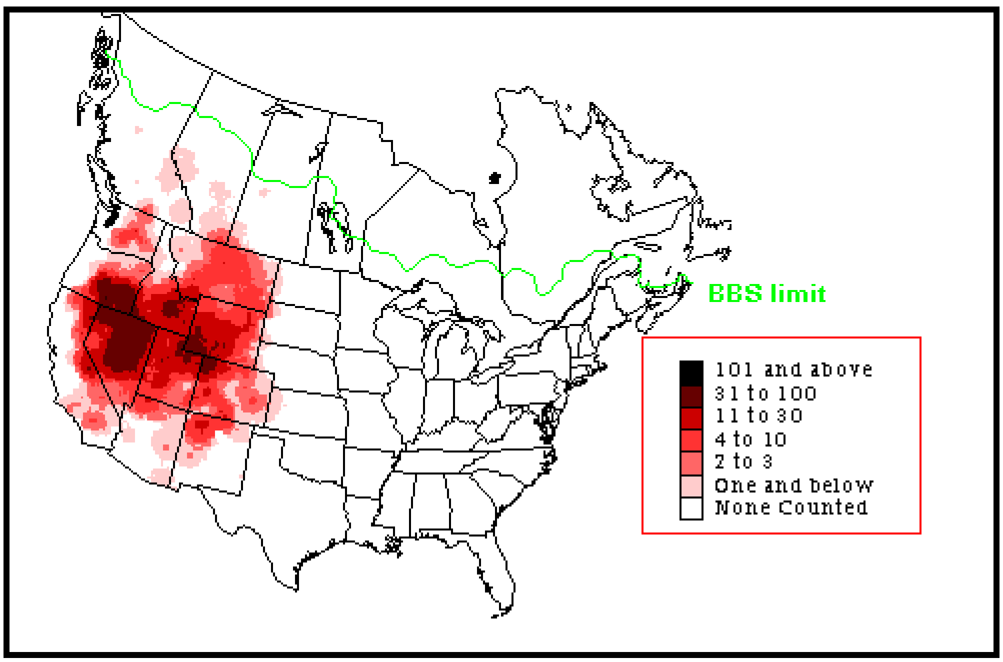
Washington is near the northwestern limit of breeding range for Brewer's sparrows. Birds occur primarily in Okanogan, Douglas, Grant, Lincoln, Kittitas, and Adams counties (Smith *et al.* 1997).

There is high annual variation in breeding season density estimates. A site may be unoccupied one year and have densities of up to 150 birds/km^2 the next. Because of this variation, short-term and/or small scale studies of Brewer's sparrow habitat associations must be viewed with caution (Rotenberry *et al.* 1999).

Breeding

The subspecies *breweri* is found in southeast Alberta, southwestern Saskatchewan, Montana, and southwestern North Dakota, south to southern California (northern Mojave Desert), southern Nevada, central Arizona, northwestern New Mexico, central Colorado, southwestern Kansas, northwestern Nebraska, and southwestern South Dakota (AOU 1983, Rotenberry *et al.* 1999; **Figure 9**). The subspecies *taverneri* is found in southwest Alberta, northwest British Columbia, southwest Yukon, and southeast Alaska (Rotenberry *et al.* 1999).

Figure 9. Brewer's sparrow breeding season abundance



Source: BBS data in Sauer et al. 2003

Non-breeding

During the non-breeding season, Brewer's sparrows are found in southern California, southern Nevada, central Arizona, southern New Mexico, and west Texas, south to southern Baja California, Sonora, and in highlands from Chihuahua, Coahuila, and Nuevo Leon south to northern Jalisco and Guanajuato (Terres 1980, AOU 1983, Rotenberry *et al.* 1999).

Brewer’s Sparrow Status and Abundance Trends

Status

Brewer’s sparrow is often the most abundant bird species in appropriate sagebrush habitats. However, widespread long-term declines and threats to shrubsteppe breeding habitats have placed it on the Partners in Flight Watch List of conservation priority species (Muehter 1998). Saab and Rich (1997) categorize it as a species of high management concern in the Columbia River Basin.

Considered a shrubsteppe obligate, the Brewer’s sparrow is one of several species closely associated with landscapes dominated by big sagebrush (*Artemisia tridentate*) (Rotenberry 1999, Paige and Ritter 1999). Historically, the Brewer’s sparrow may have been the most abundant bird in the Intermountain West (Paige and Ritter 1999) but Breeding Bird Survey trend estimates indicate a range-wide population decline during the last 25 years (Peterjohn *et al.* 1995). Brewer’s sparrows are not currently listed as threatened or endangered on any state or federal list. Oregon-Washington Partners in Flight consider the Brewer’s sparrow a focal species for conservation strategies for the Columbia Plateau (Altman and Holmes 2000).

Trends

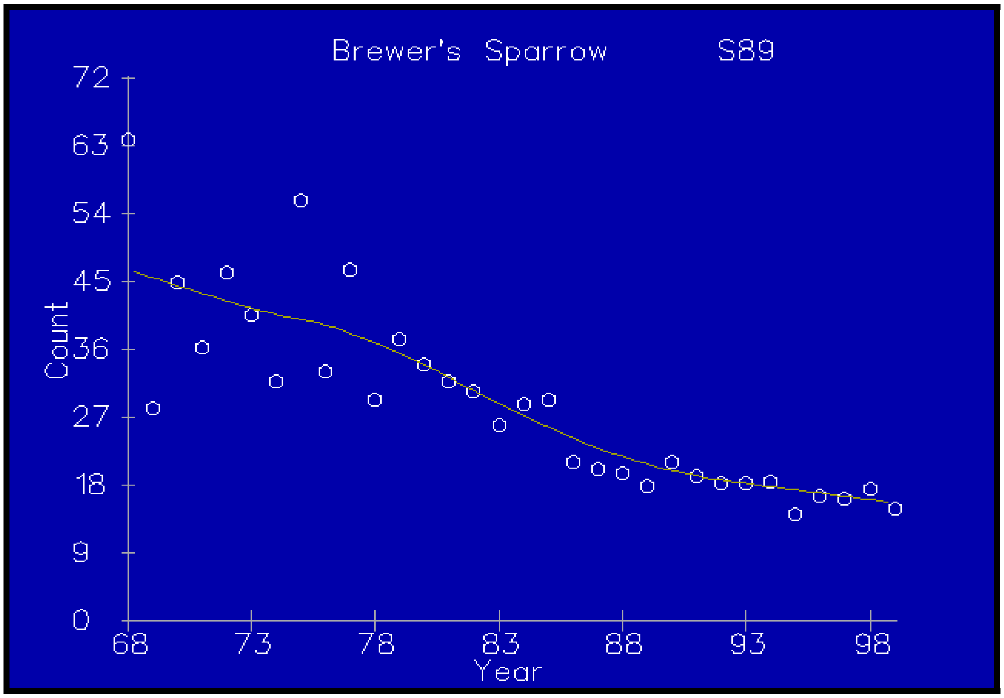
Breeding Bird Survey (BBS) data for 1966-1996 show significant and strong survey-wide declines averaging -3.7 % per year (n = 397 survey routes). The BBS data (1966-1996) for the Columbia Plateau are illustrated below. Significant declines in Brewer’s sparrow are evident in California, Colorado, Montana, Nevada, Oregon, and Wyoming, with the steepest significant decline evident in Idaho (-6.0 % average per year; n = 39). These negative trends appear to be consistent throughout the 30-year survey period. Only Utah shows an apparently stable population. Sample sizes for Washington are too small for an accurate estimate. Mapped BBS data show centers of summer abundance in the Great Basin and Wyoming Basin (Sauer *et al.* 1997).

Christmas Bird Count (CBC) data for the U.S. for the period 1959-1988 indicate a stable survey-wide trend (0.2 % average annual increase; n = 116 survey circles), and a significantly positive trend in Texas (6.7 % average annual increase; n = 33). Arizona shows a non-significant decline (-1.4 % average annual decline; n = 34). Mapped CBC data show highest wintering abundances in the borderlands of southern Arizona, southern New Mexico, and west Texas (Sauer *et al.* 1996).

Note that although positively correlated with presence of sage thrashers (*Oreoscoptes montanus*), probably due to similarities in habitat relations (Wiens and Rotenberry 1981), thrashers are not exhibiting the same steep and widespread declines evident in BBS data (see Sauer *et al.* 1997).

According to the ICBEMP terrestrial vertebrate habitat analyses, historical source habitats for Brewer's sparrow occurred throughout most of the three ERUs within our planning unit (Wisdom et al. in press). Declines in source habitats were moderately high in the Columbia Plateau (39%), but relatively low in the Owyhee Uplands (14%) and Northern Great Basin (5%). However, declines in big sagebrush (e.g., 50% in Columbia Plateau ERU), which is likely higher quality habitat, are masked by an increase in juniper sagebrush (>50% in Columbia Plateau ERU), which is likely reduced quality habitat. Within the entire Interior Columbia Basin, over 48% of watersheds show moderately or strongly declining trends in source habitats for this species (Wisdom *et al.* in press) (from Altman and Holmes 2000).

Figure 10 Brewer's sparrow trend for Columbia Plateau



Source: BBS data in Sauer et al. 2003

Factors Affecting Brewer's Sparrow Population Status

Key Factors Inhibiting Populations and Ecological Processes

Habitat Loss and Fragmentation

Large scale reduction and fragmentation of sagebrush habitats occurring due to a number of activities, including land conversion to tilled agriculture, urban and suburban development, and road and power-line rights of way. Range improvement programs remove sagebrush by burning, herbicide application, and mechanical treatment, replacing sagebrush with annual grassland to promote forage for livestock.

Grazing

Rangeland in poor condition is less likely to support Brewer's sparrows than rangeland in good and fair condition. Grazing practices that prevent overgrazing, reduce or eliminate invasion of exotic annuals, and restore degraded range are encouraged (Vander Haegen *et al.* 2000). Brewer's sparrow response to various levels of grazing intensity is mixed. Brewer's sparrows respond negatively to heavy grazing of greasewood/great basin wild rye and low sage/Idaho fescue communities; they respond positively to heavy grazing of shadscale/Indian ricegrass, big sage/bluebunch wheatgrass, and Nevada bluegrass/sedge communities; they respond negatively to moderate grazing of big sage/bluebunch wheatgrass community; and they respond negatively to unspecified grazing intensity of big sage community (see review by Saab *et al.* 1995).

Grazing can trigger a cascade of ecological changes, the most dramatic of which is the invasion of non-native grasses escalating the fire cycle and converting sagebrush shrublands to annual grasslands. Historical heavy livestock grazing altered much of the sagebrush range, changing plant composition and densities. West (1988, 1996) estimates less than 1% of sagebrush steppe habitats remain untouched by livestock; 20% is lightly grazed, 30% moderately grazed with native understory remaining, and 30% heavily grazed with understory replaced by invasive annuals. The effects of grazing in sagebrush habitats are complex, depending on intensity, season, duration and extent of alteration to native vegetation.

Invasive Grasses

Cheatgrass readily invades disturbed sites, and has come to dominate the grass-forb community of more than half the sagebrush region in the West, replacing native bunchgrasses (Rich 1996). Crested wheatgrass and other non-native annuals have also fundamentally altered the grass-forb community in many areas of sagebrush shrubsteppe, altering shrubland habitats.

Fire

Cheatgrass has altered the natural fire regime in the western range, increasing the frequency, intensity, and size of range fires. Fire kills sagebrush and where non-native grasses dominate, the landscape can be converted to annual grassland as the fire cycle escalates, removing preferred habitat (Paige and Ritter 1998).

Brood Parasitism

Brewer's sparrow nests are an occasional host for brown-headed cowbird (*Molothrus ater*); nests usually abandoned, resulting in loss of clutch (Rotenberry *et al.* 1999). Prior to European-American settlement, Brewer's sparrows were probably largely isolated from cowbird parasitism, but are now vulnerable as cowbird populations increase throughout the West and where the presence of livestock and pastures, land conversion to agriculture, and fragmentation of shrublands creates a contact zone between the species (Rich 1978, Rothstein 1994).

Frequency of parasitism varies geographically; the extent of impact on productivity unknown (Rotenberry *et al.* 1999). In Alberta, in patchy sagebrush habitat interspersed with pastures and riparian habitats, a high rate of brood parasitism reported. Usually abandoned parasitized nests and cowbird productivity was lower than Brewer's (Biermann *et al.* 1987). Rich (1978) also observed cowbird parasitism on two nests in Idaho, both of which were abandoned.

Predators

Documented nest predators (of eggs and nestlings) include gopher snake (*Pituophis melanoleucus*), Townsend's ground squirrel (*Spermohpilus townsendii*); other suspected predators include loggerhead shrike (*Lanius ludovicianus*), common raven (*Corvus corax*), black-billed magpie (*Pica pica*), long-tailed weasel (*Mustela frenata*), least chipmunk (*Eutamias minimus*), western rattlesnake (*Crotalus viridis*), and other snake species. Nest predation significant cause of nest failure. American kestrel (*Falco sparverius*), prairie falcon (*Falco mexicanus*), coachwhip (*Masticophis flagellum*) reported preying on adults (Rotenberry *et al.* 1999). Wiens and Rotenberry (1981) observed significant negative correlation between loggerhead shrike and Brewer's sparrow density.

Pesticides/Herbicides

Aerial spraying of the herbicide 2,4-D did not affect nest success of Brewer’s sparrows during the year of application. However, bird densities were 67% lower one year, and 99% lower two years, after treatment. Birds observed on sprayed plots were near sagebrush plants that had survived the spray. No nests were located in sprayed areas one and two years post application (Schroeder and Sturges 1975).

Out-of-Subbasin Effects and Assumptions

No data could be found on the migration and wintering grounds of the Brewer’s sparrow. It is a short-distance migrant, wintering in the southwestern U.S. and northern Mexico, and as a result faces a complex set of potential effects during it annual cycle. Habitat loss or conversions is likely happening along its entire migration route (H. Ferguson, WDFW, pers. comm., 2003). Management requires the protection shrub, shrubsteppe, desert scrub habitats, and the elimination or control of noxious weeds. Wintering grounds need to be identified and protected just as its breeding areas. Migration routes and corridors need to be identified and protected.

4.2.2 Mule Deer (*Odocoileus hemionus*)

No data was provided in the Ashley/Stovall report for mule deer for the Lake Chelan Subbasin. The information below was taken from the Lake Chelan Subbasin Summary)

Population Delineation and Characterization

Mule deer require the juxtaposition of food, cover, and water. Areas without water available within 1 mile (1.6 km) show decreased use. Deer use cover both to hide and to regulate temperature. They feed primarily on shrubs such as bitter brush, except in spring, when they prefer herbaceous materials. Summer and winter ranges are most often geographically separate (WDFW 1991).

Population Status

The 1994 Tyee fire removed much of the deer winter browse in the Chelan PMU (Population Management Unit). Recovery from the fire has been slow. In addition, the winter of 1996-97 was severe. As a result of lost habitat and winter weather, the deer population within the Chelan PMU is low. Mild winters will allow this population to rebuild, but until shrub communities re-establish on winter range, this population will not reach pre-fire levels (WDFW 1999).

4.3 Eastside (Interior) Riparian Wetland

Rationale for selection

Riparian wetlands was selected as a focal habitat because its protection, compared to other habitat types, may yield the greatest gains for fish and wildlife while involving the least amount of area (Knutson and Naef 1997). (Neither the IBIS nor the Washington GAP Analysis data recognized the historic presence of riparian wetlands. The current extent of this habitat type as reflected in these databases are suspect at best; however, riparian wetland habitat is a high priority habitat wherever it is found in the Ecoprovince.) Riparian habitat: covers a relatively small area yet it supports a higher diversity and abundance of fish and wildlife than any other habitat; provides important fish and wildlife breeding habitat, seasonal ranges, and movement corridors; is highly vulnerable to alteration; and has important social values, including water purification, flood control, recreation, and aesthetics.

The eastside (interior) riparian wetlands habitat type refers only to riverine and adjacent wetland habitats in both the Ecoprovince and individual subbasins. Historic (circa 1850) and, to a lesser degree, current data concerning the extent and distribution of riparian wetland habitat are a significant data gap at both the Ecoprovince and subbasin level. The lack of data is a major challenge as Ecoprovince and subbasin planners attempt to quantify habitat changes from historic conditions and develop strategies that address limiting factors and management goals and objectives.

Due to the lack of historic riparian wetland data, the IBIS database cannot be relied upon for comparisons in the Ecoprovince and individual subbasins between the historic and current extent of riparian wetlands. According to the IBIS database (2003), there are an estimated 3,898 acres of riparian wetland habitat currently in the Subbasin. Although there are no historic data, the actual number of acres or absolute magnitude of the change is less important than recognizing the loss of riparian habitat and the lack of permanent protection continues to place this habitat type at further risk.

Historic

Historically, riparian habitat was limited except in the Stehekin Valley riparian and near the mouths of the tributaries. Riparian wetland habitat was characterized by a mosaic of plant communities occurring at irregular intervals along streams and dominated singularly or in some combination by grass-forbs, shrub thickets, and mature forests with tall deciduous trees. Beaver activity and natural flooding are two ecological processes that affected the quality and distribution of riparian wetlands.

Current

The USFWS National Wetlands Inventory (NWI) maps detailing the Lake Chelan area indicate small, localized wetlands along lake tributaries. Pockets of wetlands are identified on the Stehekin River delta entering the lake and within the bypassed reach exiting the lake. A detailed 1999 riparian zone investigation indicated that riparian habitats along eight Lake Chelan focus tributaries exhibited considerable variation (NPPC 2002) (**Table 12**).

Table 12. Environmental setting and conditions at eight focus tributaries and Chelan River

Study Area	Aspect	Regional Setting	Valley Configuration	Riparian Habitat
Chelan River	NW	Shrubsteppe, open coniferous forest, cliffs, and urban areas.	Steep-walled gorge descends to a broad floodplain.	Sparse, deciduous trees and shrubs, mostly restricted to upper and lower reaches.
Mitchell Creek	SW	Shrubsteppe with widely scattered conifers.	Narrow channel confined within a V-shaped valley with moderately steep slopes and some terraces.	Mostly narrow but typically dense deciduous tree and shrub habitats.
Grade Creek	SW	Shrubsteppe with widely scattered conifers.	Narrow channel confined within a deeply incised canyon.	Sparse and narrow, limited to creek bank; mostly small deciduous trees.
Box Canyon	NE	Predominantly open coniferous forest with some shrub steppe.	Narrow channel with broad terraces confined within a steep-walled canyon.	Narrow riparian zone alongside incised creek bed; in places dense shrub habitats; deciduous forest occurs on terraces outside of riparian influence.
Big Creek	NE	Predominantly open coniferous forest with some shrub steppe.	Narrow channel confined within a narrow gorge; steep side slopes.	Narrow riparian zone along creek consisting mostly of mature western red cedar forest (small grove of deciduous trees at mouth).

Study Area	Aspect	Regional Setting	Valley Configuration	Riparian Habitat
Bear Creek	NE	Predominantly coniferous and mixed forest.	Narrow channel confined within a U-shaped valley with moderately steep slopes and some terraces.	Narrow riparian zone along creek consisting of dense shrub and deciduous tree habitats; adjacent areas of mixed forest occur on higher ground that is probably outside of riparian influence.
Prince Creek	SW	Open coniferous forest.	Moderately wide channel; V-shaped valley terminates in a broad alluvial fan.	Narrow riparian zone alongside creek consisting mostly of shrub-sized cottonwoods and willows, and occasional larger trees.
Fish Creek	W	Coniferous forest.	Moderately wide channel; V-shaped valley terminates in a broad alluvial fan.	Narrow bands of mixed forest and shrub habitats along main channel and overflow channels.
Stehekin River	SE	Extensive coniferous and mixed forest, with scattered clearings; private residential developments and public recreation areas.	Wide alluvial channel within a broad U-shaped glacial trough with broad terraces.	Extensive riparian zone that includes stands of deciduous trees, scrub-shrub habitat, and emergent wetlands; riparian areas occur in bottomlands along the river channel, along a tributary stream (Devore Creek), and along a broad alluvial delta at the confluence with Lake Chelan.

Source: NPPC 2002

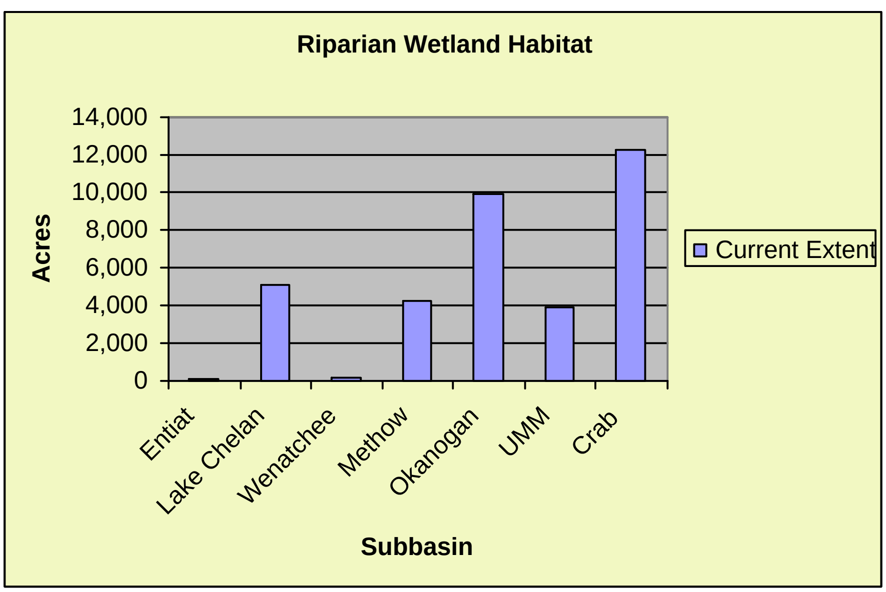
The riparian zone at Mitchell Creek was recently enhanced by planting shrubs. This has resulted in a dense but narrow band of riparian shrub habitat. The width of the riparian zone at Mitchell Creek is narrow because the creek channel is deeply incised in some areas, limiting the area suitable for riparian vegetation. Similarly, the riparian zones along Box Canyon, Big Creek, Bear Creek, Prince Creek and Fish Creek are relatively narrow due to incised creek beds and/or confining canyons. However, the Stehekin River has a wide alluvial channel within a broad U-shaped valley with abundant lowlands suitable for riparian vegetation.

The aspect of the tributaries has a significant influence on the local microclimate and thus the surrounding vegetation. Sites with a southwest aspect tend to have relatively drier microclimates resulting in arid habitats surrounding narrow riparian corridors. The dominant vegetation surrounding both Grade Creek and Mitchell Creek are arid shrubsteppe habitats. Further west, the vegetation surrounding sites with a west to southwest aspect, including Prince Creek and Fish Creek, consists predominantly of open conifer habitats. Sites with a northeast aspect, such as Box Canyon and Bear Creek, tend to have more dense vegetative cover within and adjacent to the riparian zone. The northeast aspect helps retain moisture, which promotes dense vegetative growth both within and adjacent to the riparian zone. This results in habitats characterized by heavy shade, cool temperatures and high humidity. Sites with a northeast aspect also tend to have soils with significant amounts of organic material, while the soils associated with sites having a southwest aspect tend to have a lower proportion of organic material. Due to the low organic content, these sites are relatively sandy, and they drain more quickly, resulting in less than ideal conditions for riparian vegetation. The importance of aspect is even illustrated at some sites by differences in side-slope vegetation patterns, where more arid conditions prevail on east-facing slopes.

While most recreation activity is concentrated in designated camping areas and trails, some trampling or cutting of riparian vegetation and disturbance of wildlife has been known to occur. Uncontrolled use of some areas is partly responsible for somewhat degraded riparian conditions. However, recreation activities are a relatively insignificant factor influencing riparian habitats compared to human development. There is considerable residential development near the mouth of the Stehekin River where native vegetation has been removed and low areas filled in. This development consists primarily of seasonal homes. Much of the development at the Stehekin River is adjacent to high-quality riparian habitats, and human disturbance to riparian habitats and wildlife probably occurs. Although no dwellings were located near the other tributaries studied, there is development occurring within the alluvial fans of other tributaries to Lake Chelan.

Protection Status

Figure 11. Current extent of riparian wetlands in province subbasins



Source: IBIS 2003

The protection status of riparian habitat is compared by subbasin above. The protection status of remaining riparian wetland habitats in the Lake Chelan subbasin falls primarily within the “medium” to “high” status categories (**Table 13**). As a result, further habitat degradation, disturbance, and loss in the subbasin can be prevented and/or minimized.

Table 13. Eastside (interior) riparian wetlands GAP protection status in Lake Chelan subbasin

GAP Protection Status	Acres
High Protection	1,488
Medium Protection	2,785
Low Protection	337
No Protection	473

Source: IBIS 2003

Limiting Factors

Factors affecting grassland habitat are described in Ashley and Stovall (unpublished report, 2004) and summarized below:

Riverine wetland habitats in the subbasin have been altered, degraded, fragmented and lost due to numerous factors. Recreational developments and disturbances (e.g., ORVs, cutting and spraying of riparian vegetation for eased access to water courses), particularly in high-use recreation areas, and during nesting season has destroyed riverine wetland habitat and reduced wildlife productivity. Livestock overgrazing has widened channels, raised water temperatures, and reduced understory cover. Hydrological diversions and control of natural flooding regimes (e.g., dams) results in reduced stream flows and reduction of overall area of riparian habitat, loss of vertical stratification in riparian vegetation, and lack of recruitment of young cottonwoods, ash, willows, etc. Hydro projects also destabilize stream banks, narrow stream channels, reduce the flood zone, and reduce the extent of riparian vegetation. As a result, large tracts necessary for area-sensitive species (e.g. yellow-billed cuckoo) have been fragmented and lost.

Anthropogenic activities also lead to the conversion of native vegetation to invasive exotics and the introduction of exotic wildlife that compete with native species for cover and food. Native riparian shrub and herbaceous vegetation have been replaced with exotic species such as reed canary grass, purple loosestrife, perennial pepperweed, salt cedar, indigo bush, and Russian olive. Reproductive success of cavity nesting species (e.g. Lewis' woodpecker, downy woodpecker, and tree swallow) may be reduced due to high energetic costs associated with high rates of competitive interactions with European starlings for cavities. Wildlife in hostile landscapes, particularly those in proximity to agricultural and residential areas, may also have a high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.

4.3.1 Red-eyed Vireo (*Vireo Olivaceus*)

There has been a major focus over the past several years on songbirds and the reasons for their declines. Many species of Neotropical migrant birds are experiencing population declines mainly because of the loss and fragmentation of breeding, wintering, and migratory stopover habitats.

These long distance migrants tend to be more vulnerable to habitat loss and fragmentation than birds that are resident or those that migrate only short distances within North America. Tropical deforestation, forest fragmentation on their breeding grounds and increases in brood parasites like the brown-headed cowbird (*Molothrus ater*) have all been blamed in part for these declines. At least 49 species are highly associated breeding species in riparian forest and shrub habitats. Many of these species are generalists that also occur as breeders in other habitat types [e.g., American robin (*Turdus migratorius*), Bewick's wren (*Thryomanes bewickii*), and Swainson's thrush (*Catharus ustulatus*)]. However, others such as red-eyed vireo, yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Iceteria virens*), warbling vireo (*Vireo gilvus*), and Bullock's oriole (*Icterus galbula*) are obligate or near obligate to riparian habitat.

Most species are primarily insectivores that take advantage of the high insect productivity that occurs in riparian habitats. In general, the greater the structural layering and complexity of the habitat, the greater the insect productivity and the greater the bird species diversity. Many studies have reported higher species richness, abundance, or diversity in riparian zones than adjacent habitats, particularly at lower elevations (Stauffer and Best 1980; Knopf 1985). Other riparian associated bird species are tied to unique features such as nesting cavities provided by snags [e.g., downy woodpecker (*Picoides pubescens*), black-capped chickadee (*Parus atricapillus*), tree swallow (*Tachycineta bicolor*)], nectar of flowering plants in the understory [e.g., rufous hummingbird (*Selasphorus rufus*)], fruit from berry producing plants in the understory and subcanopy [e.g., cedar waxwing (*Bombycilla cedrorum*)], or a dense, diverse shrub layer (e.g., Swainson's thrush). It is sometimes useful to choose an index species to represent a habitat used by many other species. The red-eyed vireo is a focus species for large canopy trees in riparian deciduous woodland.

The red-eyed vireo is a locally common species in riparian growth and strongly associated tall, somewhat extensive, closed canopy forests of cottonwood, maple, or alder in the Puget Lowlands (C. Chappell pers. comm.) and along the Columbia River in Clark and Skamania Counties.

This vireo has been one of the most abundant birds in North America, although its numbers seem to have declined recently, possibly as a result of the destruction of wintering habitat in the neotropics, fragmentation of northern breeding forests, or other causes. Its principal habitat, broad-leaved forests, often supports one pair per acre. The red-eyed vireo is a fierce fighter around its nest and can intimidate even the large pileated woodpecker (*Dryocopus pileatus*). Its horizontal posture and slow movement through the understory of broad-leaved woods make it an easy bird to study.

Focal Species Life History, Key Environmental Correlates, and Habitat Requirements

Life History

Diet

Vireos are primarily insectivorous, with 85% of its diet composed of insects and only 15% of its diet vegetable, mostly fruits and berries eaten in August to October. A third of the total food is composed of caterpillars and moths, mainly the former. Beetles, hymenoptera bugs and flies rank next to lepidoptera in importance as food items for the red-eyed vireo.

Reproduction

Courtship begins in May, with the peak of egg laying in the first half of June.

Nesting

The nest is a thin-walled pendant cup of bark strips and plant fibers, decorated with lichen and attached to a forked twig, usually containing 3 or 4 white eggs, sparsely marked with dark brown. It is usually found 5 to 10 feet above the ground, although nests as low a 2 feet and as high as 60 feet are reported (Bent 1965). Both sexes share in incubation and the young hatch in 12 to 14 days. Occasionally a pair may raise two broods in a season (Bent 1965).

Migration

The red-eyed vireo is known in Central America as a transient, journeying between its breeding range in North America and its winter home in South America. September is the month when these vireos pass southward through the Isthmus of Panama in the greatest numbers, but stragglers have been recorded in Costa Rica as late as October 28 and November 10 (Bent 1965). The northward passage begins in late March and is at its height in April, while an occasional straggler may be seen early in May (Bent 1965). As they pass through Central America they are met singly or in small flocks.

Mortality

The red-eyed vireo typically lays 3 to 4 eggs. However it is commonly parasitized by the brown-headed cowbird. The host bird incubates and cares for these interlopers, commonly to the detriment of its own young. Often the young cowbird will push the young of the host out of the nest causing failure of the host’s nesting. This parasitism may compromise productivity especially in areas where habitat modification creates openings close to the riparian zone.

Habitat Requirements

Partners in Flight have established biological objectives for this species in the lowlands of western Oregon and western Washington. These include providing habitats that meet the following definition: mean canopy tree height >15 m (50 ft), mean canopy closure >60%, young (recruitment) sapling trees >10% cover in the understory, riparian woodland >50 m (164 ft) wide (Altman 2001). Red-eyed vireos are closely associated with riparian woodlands and black cottonwood stands and may use mixed deciduous stands.

The patchy distribution in Washington for this species correlates with the distribution of large black cottonwood (*Populus tnchocarrpa*) groves, which are usually limited to riparian areas. The Red-eyed vireo is one of the most abundant species in northeastern United States, but is much less common in Washington due to limited habitat.

Focal Species Population and Distribution

Population

Historic

No data are available.

Current

Little is known about population size, although the red-eyed vireo is one of the most abundant species in northeastern United States; it is much less common in Washington due to limited habitat.

Distribution

Describe current and historic distribution. It is particularly important to identify areas that were accessible historically but have been rendered not accessible due to anthropogenic modifications.

For avian species, there generally is not enough information to break this down into "historic" and "current." For game species or ESA species or for other species for which historic and current population data are available, it should be identified.

Historic

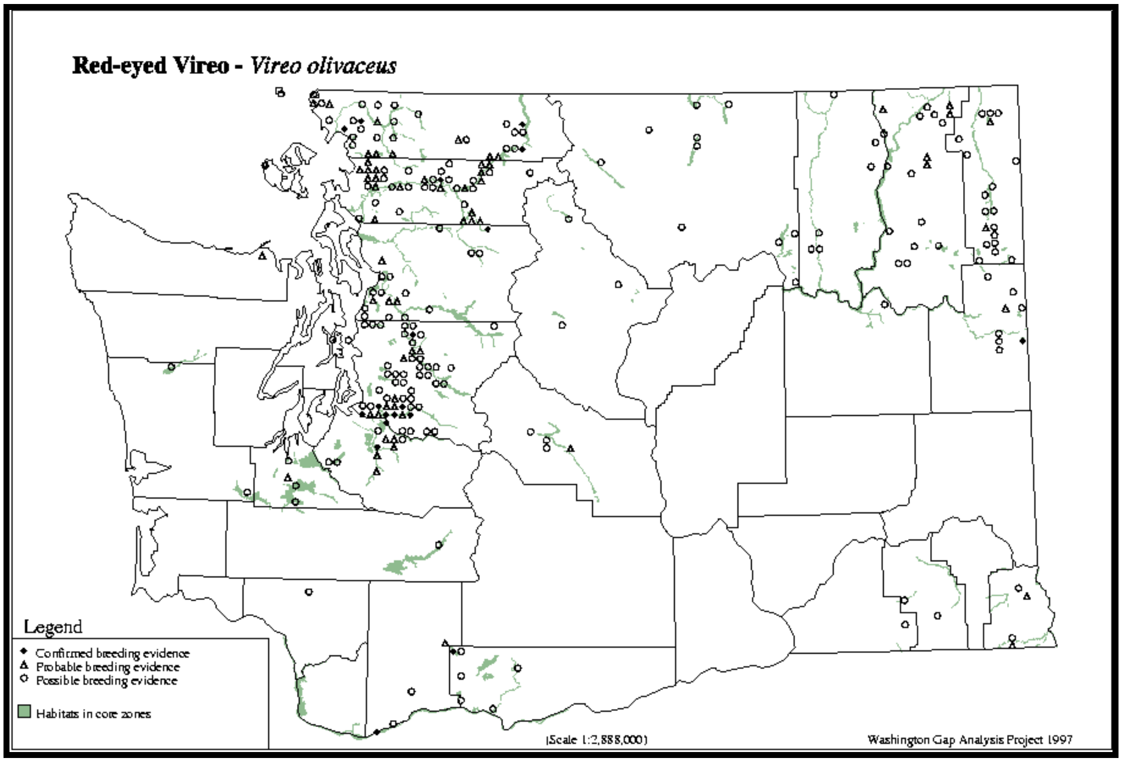
No data are available.

Current

The North American breeding range of the red-eyed vireo extends from British Columbia to Nova Scotia, north through parts of the Northwest Territories, and throughout most of the lower United States (see figure below). They migrate to the tropics for the winter.

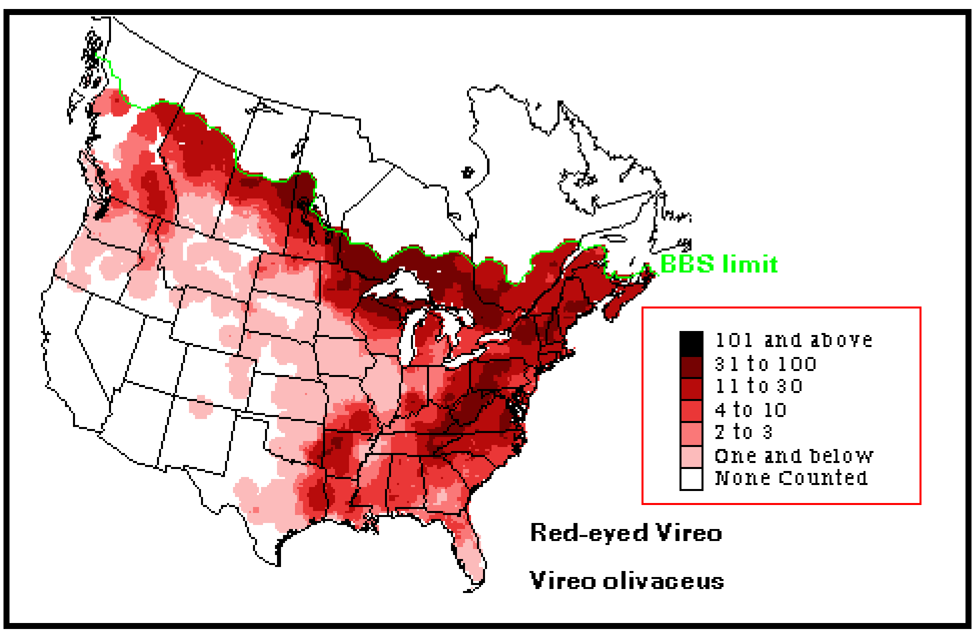
The patchy distribution in Washington for this species correlates with the distribution of large black cottonwood (*Populus trichocarpa*) groves, which are usually limited to riparian areas. The red-eyed vireo is one of the most abundant species in the northeastern United States, but is much less common in Washington due to limited habitat.

Figure 12. Red-eyed vireo distribution and breeding data, 1987-1995



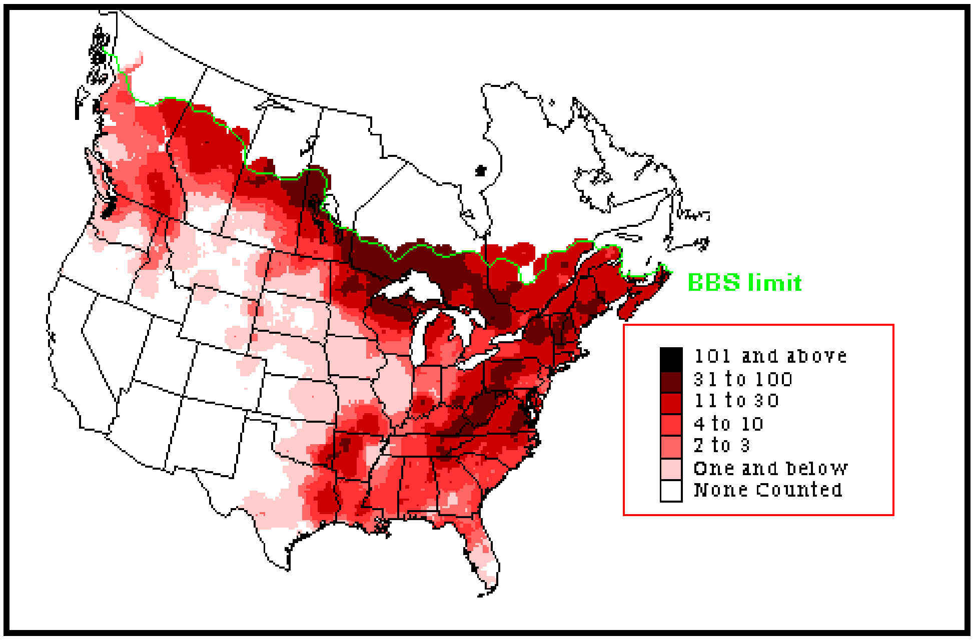
Source: Washington GAP Analysis Project 1997

Figure 13. Red-eyed vireo breeding distribution



Source: Sauer et al. 2003

Figure 14. Red-eyed vireo summer distribution



Source: Sauer et al. 2003

Focal Species Status and Abundance Trends

Status

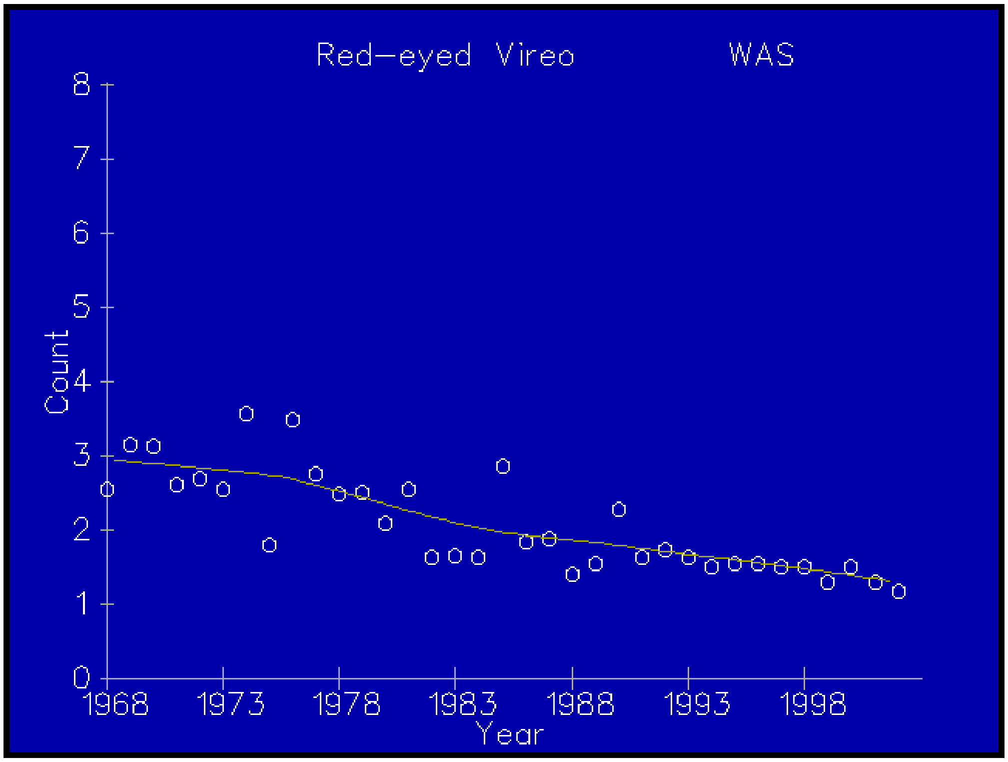
The red-eyed vireo is secure, particularly in the eastern United States. Within the state of Washington, the red-eyed vireo is locally common, more widespread in northeastern and southeastern Washington and not a conservation concern (Altman 1999).

Red-eyed vireos are currently protected throughout their breeding range by the Migratory Bird Treaty Act (1918) in the United States, the Migratory Bird Convention Act (1916) in Canada, and the Convention for the Protection of Migratory Birds and Game Mammals (1936) in Mexico.

Trends

In Washington, Breeding Bird Survey (BBS) data show a significant population increase of 4.9% per year from 1982 to 1991 (Peterjohn 1991) (see figure below). However, long-term, this has been a population decline in Washington of 2.6% per year, although the change is not statistically significant largely because of scanty data (Sauer *et al.* 2003). Because the BBS dates back only about 30 years, population declines in Washington resulting from habitat loss dating prior to the survey would not be accounted for by that effort.

Figure 15. Red-eyed vireo trend results



Source: BBS data in Sauer et al. 2003

Factors Affecting Red-eyed Vireo Population Status

Key Factors Inhibiting Populations and Ecological Processes

Habitat Loss

Habitat loss due to hydrological diversions and control of natural flooding regimes (e.g., dams) has resulted in an overall reduction of riparian habitat for red-eyed vireos through the conversion of riparian habitats and inundation from impoundments.

Habitat Degradation

Like other neotropical migratory birds, red-eyed vireos suffer from habitat degradation resulting from the loss of vertical stratification in riparian vegetation, lack of recruitment of young cottonwoods, ash (*Fraxinus latifolia*), willows (*Salix spp*.), and other subcanopy species.

Streambank stabilization (e.g., riprap), which narrows stream channel, reduces the flood zone and extent of riparian vegetation. The invasion of exotic species such as canarygrass (*Phalaris spp*.) and blackberry (*Rubus spp*.) also contributes to a reduction in available habitat for the red-eyed vireo. Habitat loss can also be attributed to overgrazing, which can reduce understory cover. Reductions in riparian corridor widths may decrease suitability of riparian habitat and may increase encroachment of nest predators and nest parasites to the interior of the stand.

Human Disturbance

Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites, such as brown-headed cowbirds and domestic predators (cats), and can be subject to high levels of human disturbance. Recreational disturbances, particularly during nesting season, and particularly in high-use recreation areas may have an impact on red-eyed vireos.

Pesticides/Herbicides

Increased use of pesticide and herbicides associated with agricultural practices may reduce the insect food base for red-eyed vireos.

4.3.2 American Beaver (*Castor Canadensis*)

The American beaver (*Castor canadensis*) is a large, highly specialized aquatic rodent found in the immediate vicinity of aquatic habitats (Hoffman and Pattie 1968). The species occurs in streams, ponds, and the margins of large lakes throughout North America, except for peninsular Florida, the Arctic tundra, and the southwestern deserts (Jenkins and Busher 1979). Beavers construct elaborate lodges and burrows and store food for winter use. The species is active throughout the year and is usually nocturnal in its activities. Adult beavers are nonmigratory.

American Beaver Life History, Key Environmental Correlates, and Habitat Requirements

Life History

Diet

Beavers are exclusively vegetarian in diet. A favorite food item is the cambial, or growing, layer of tissue just under the bark of shrubs and trees. Many of the trees that are cut are stripped of bark, or carried to the pond for storage under water as a winter food cache. Buds and roots are also consumed, and when they are needed, a variety of plant species are accepted. The animals may travel some distance from water to secure food. When a rich food source is exploited, canals may be dug from the pond to the pasture to facilitate the transportation of the items to the lodge.

Much of the food ingested by a beaver consists of cellulose, which is normally indigestible by mammals. However, these animals have colonies of microorganisms living in the cecum, a pouch between the large and small intestine, and these symbionts digest up to 30% of the cellulose that the beaver takes in. An additional recycling of plant food occurs when certain fecal pellets are eaten and run through the digestive process a second time (Findley 1987).

Woody and herbaceous vegetation comprise the diet of the beaver. Herbaceous vegetation is a highly preferred food source throughout the year, if it is available. Woody vegetation may be consumed during any season, although its highest utilization occurs from late fall through early spring. It is assumed that woody vegetation (trees and/or shrubs) is more limiting than herbaceous vegetation in providing an adequate food source.

Denney (1952) summarized the food preferences of beavers throughout North America and reported that, in order of preference, beavers selected aspen (*Populus tremuloides*), willow (*Salix spp.*), cottonwood (*P. balsamifera*), and alder (*Alnus spp.*). Although several tree species have often been reported to be highly preferred foods, beavers can inhabit, and often thrive in, areas where these tree species are uncommon or absent (Jenkins 1975). Aspen and willow are considered preferred beaver foods; however, these are generally riparian tree species that may be more available for beaver foraging but are not necessarily preferred over all other deciduous tree species (Jenkins 1981). Beavers have been reported to subsist in some areas by feeding on coniferous trees, generally considered a poor quality source of food (Brenner 1962; Williams 1965). Major winter foods in North Dakota consisted principally of red-osier dogwood (*Cornus stolonifera*), green ash (*Fraxinus pennsylvanica*), and willow (Hammond 1943). Rhizomes and roots of aquatic vegetation also may be an important source of winter food (Longley and Moyle 1963; Jenkins pers. comm.). The types of food species present may be less important in determining habitat quality for beavers than physiographic and hydrologic factors affecting the site (Jenkins 1981).

Aquatic vegetation, such as duck potato (*Sagittaria spp.)*, duckweed (*Lemna spp.)*, pondweed (*Potamogeton spp.)*, and water weed (Elodea spp.), are preferred foods when available (Collins 1976a). Water lilies (Nymphaea spp.), with thick, fleshy rhizomes, may be used as a food source throughout the year (Jenkins 1981). If present in adequate amounts, water lily rhizomes may provide an adequate winter food source, resulting in little or no tree cutting or food caching of woody materials. Jenkins (1981) compared the rate of tree cutting by beavers adjacent to two Massachusetts ponds that contained stands of water lilies. A pond dominated by yellow water lily (*y. variegatum*) and white water lily (*N. odorata*), which have thick rhizomes, had low and constant tree cutting activity throughout the fall. Conversely, the second pond, dominated by watershield (*Brasenia schreberi*), which lacks thick rhizomes, had increased fall tree cutting activity by beavers.

Reproduction

The basic composition of a beaver colony is the extended family, comprised of a monogamous pair of adults, subadults (young of the previous year), and young of the year (Svendsen 1980). Female beavers are sexually mature at 2.5 years old. Females normally produce litters of three to four young with most kits being born during May and June. Gestation is approximately 107 days (Linzey 1998). Kits are born with all of their fur, their eyes open, and their incisor teeth erupted.

Dispersal of subadults occurs during the late winter or early spring of their second year and coincides with the increased runoff from snowmelt or spring rains. Subadult beavers have been reported to disperse as far as 236 stream km (147 mi) (Hibbard 1958), although average emigration distances range from 8 to 16 stream km (5 to 10 mi) (Hodgdon and Hunt 1953; Townsend 1953; Hibbard 1958; Leege 1968). The daily movement patterns of the beaver centers around the lodge or burrow and pond (Rutherford 1964). The density of colonies in favorable habitat ranges from 0.4 to 0.8/km2 (1 to 2/mi2) (Lawrence 1954; Aleksiuk 1968; Voigt *et al.* 1976; Bergerud and Miller 1977 cited by Jenkins and Busher 1979).

Home Range

The mean distance between beaver colonies in an Alaskan riverine habitat was 1.59 km (1 mi) (Boyce 1981). The closest neighbor was 0.48 km (0.3 mi) away. The size of the colony's feeding range is a function of the interaction between the availability of food and water and the colony size (Brenner 1967). The average feeding range size in Pennsylvania, excluding water, was reported to be 0.56 ha (1.4 acre). The home range of beaver in the Northwest Territory was estimated as a 0.8 km (0.5 mi) radius of the lodge (Aleksiuk 1968). The maximum foraging distance from a food cache in an Alaskan riverine habitat was approximately 800 m (874 yds) upstream, 300 m (323 yds) downstream, and 600 m (656 yds) on oxbows and sloughs (Boyce 1981).

Mortality

Beavers live up to 11 years in the wild, 15 to 21 years in captivity (Merritt 1987, Rue 1967). Beavers have few natural predators. However, in certain areas, beavers may face predation pressure from wolves (*Canis lupus*), coyotes (*Canis latrans*), lynx (*Felis lynx*), fishers (*Martes pennanti*), wolverines (*Gulo gulo*), and occasionally bears (*Ursus spp*.). Alligators, minks (*Mustela vison*), otters (*Lutra canadensis*), hawks, and owls periodically prey on kits (Lowery 1974, Merritt 1987, Rue 1967).

Beavers often carry external parasites, one of which, *Platypsylla castoris*, is a beetle found only on beavers.

Historic

Because of the high commercial value of their pelts, beavers figured importantly in the early exploration and settlement of western North America. Thousands of their pelts were harvested annually, and it was not many years before beavers were either exterminated entirely or reduced to very low populations over a considerable part of their former range. By 1910 their populations were so low everywhere in the United States that strict regulation of the harvest or complete protection became imperative. In the 1930s live trapping and restocking of depleted areas became a widespread practice which, when coupled with adequate protection, has made it possible for the animals to make a spectacular comeback in many sections.

Habitat Requirements

All wetland cover types (e.g., herbaceous wetland and deciduous forested wetland) must have a permanent source of surface water with little or no fluctuation in order to provide suitable beaver habitat (Slough and Sadleir 1977). Water provides cover for the feeding and reproductive activities of the beaver. Lakes and reservoirs that have extreme annual or seasonal fluctuations in the water level will be unsuitable habitat for beaver. Similarly, intermittent streams, or streams that have major fluctuations in discharge (e.g., high spring runoff) or a stream channel gradient of 15% or more, will have little year-round value as beaver habitat. Assuming that there is an adequate food source available, small lakes [< 8 ha (20 acres) in surface area] are assumed to provide suitable habitat. Large lakes and reservoirs [> 8 ha (20 acres) in surface area] must have irregular shorelines (e.g., bays, coves, and inlets) in order to provide optimum habitat for beaver.

Beavers can usually control water depth and stability on small streams, ponds, and lakes; however, larger rivers and lakes where water depth and/or fluctuation cannot be controlled are often partially or wholly unsuitable for the species (Murray 1961; Slough and Sadleir 1977). Rivers or streams that are dry during some parts of the year are assumed to be unsuitable beaver habitat. Beavers are absent from sizable portions of rivers in Wyoming, due to swift water and an absence of suitable dwelling sites during periods of high and low water levels (Collins 1976b).

In riverine habitats, stream gradient is the major determinant of stream morphology and the most significant factor in determining the suitability of habitat for beavers (Slough and Sadleir 1977). Stream channel gradients of 6% or less have optimum value as beaver habitat. Retzer *et al.* (1956) reported that 68% of the beaver colonies recorded in Colorado were in valleys with a stream gradient of less than 6%, 28% were associated with stream gradients from 7 to 12%, and only 4% were located along streams with gradients of 13 to 14%. No beaver colonies were recorded in streams with a gradient of 15% or more. Valleys that were only as wide as the stream channel were unsuitable beaver habitat, while valleys wider than the stream channel were frequently occupied by beavers. Valley widths of 46 m (150 ft) or more were considered the most suitable. Marshes, ponds, and lakes were nearly always occupied by beavers when an adequate supply of food was available.

Foraging

Beavers are generalized herbivores; however, they show strong preferences for particular plant species and size classes (Jenkins 1975; Collins 1975a; Jenkins 1979). The leaves, twigs, and bark of woody plants are eaten, as well as many species of aquatic and terrestrial herbaceous vegetation. Food preferences may vary seasonally, or from year to year, as a result of variation in the nutritional value of food sources (Jenkins 1979).

An adequate and accessible supply of food must be present for the establishment of a beaver colony (Slough and Sadleir 1977). The actual biomass of herbaceous vegetation will probably not limit the potential of an area to support a beaver colony (Boyce 1981). However, total biomass of winter food cache plants (woody plants) may be limiting. Low marshy areas and streams flowing in and out of lakes allow the channelization and damming of water, allowing access to, and transportation of, food materials. Steep topography prevents the establishment of a food transportation system (Williams 1965; Slough and Sadleir 1977). Trees and shrubs closest to the pond or stream periphery are generally utilized first (Brenner 1962; Rue 1964). Jenkins (1980) reported that most of the trees utilized by beaver in his Massachusetts study area were within 30 m (98.4 ft) of the water's edge. However, some foraging did extend up to 100 m (328 ft). Foraging distances of up to 200 m (656 ft) have been reported (Bradt 1938). In a California study, 90% of all cutting of woody material was within 30 m (98.4 ft) of the water's edge (Hall 1970).

Woody stems cut by beavers are usually less than 7.6 to 10.1 cm (3 to 4 inches) dbh (Bradt 1947; Hodgdon and Hunt 1953; Longley and Moyle 1963; Nixon and Ely 1969). Jenkins (1980) reported a decrease in mean stem size cut and greater selectivity for size and species with increasing distance from the water's edge. Trees of all size classes were felled close to the water's edge, while only smaller diameter trees were felled farther from the shore.

Beavers rely largely on herbaceous vegetation, or on the leaves and twigs of woody vegetation, during the summer (Bradt 1938, 1947; Brenner 1962; Longley and Moyle 1963; Brenner 1967; Aleksiuk 1970; Jenkins 1981). Forbs and grasses comprised 30% of the summer diet in Wyoming (Collins 1976a). Beavers appear to prefer herbaceous vegetation over woody vegetation during all seasons of the year, if it is available (Jenkins 1981).

Cover

Lodges or burrows, or both, may be used by beavers for cover (Rue 1964). Lodges may be surrounded by water or constructed against a bank or over the entrance to a bank burrow. Water protects the lodges from predators and provides concealment for the beaver when traveling to and from food gathering areas and caches.

The lodge is the major source of escape, resting, thermal, and reproductive cover (Jenkins and Busher 1979). Mud and debarked tree stems and limbs are the major materials used in lodge construction although lesser amounts of other woody, as well as herbaceous vegetation, may be used (Rue 1964). If an unexploited food source is available, beavers will reoccupy abandoned lodges rather than build new ones (Slough and Sadleir 1977). On lakes and ponds, lodges are frequently situated in areas that provide shelter from wind, wave, and ice action. A convoluted shoreline, which prevents the buildup of large waves or provides refuge from waves, is a habitat requirement for beaver colony sites on large lakes.

Population and Abundance Trends

Trend and population data are not available for this province.

Distribution

The beaver is found throughout most of North America except in the Arctic tundra, peninsular Florida, and the Southwestern deserts (**Figure 16**) (Allen 1983, VanGelden 1982, Zeveloff 1988).

Figure 16. Geographic distribution of American beaver

Source: Linzey and Brecht 2002

Factors Inhibiting Populations

- While beavers readily adapt to living in urban areas near humans, they are limited primarily by the availability of permanent water with limited fluctuations and the accessibility of food.
- Riparian habitat along many water ways has been eliminated to plant agricultural crops, thus removing important habitat and food sources for beaver.
- Because beaver dams restrict fish passage, they are removed to restore fish passage.

4.4 Ponderosa Pine Forest

Rationale for Selection

The justification for Ponderosa pine as a focal habitat is the extensive loss and degradation of forests characteristic of this type, and the fact that several highly associated bird species have declining populations and are species of concern. Declines of ponderosa pine forest are among the most widespread and strongest declines among habitat types in an analysis of source habitats for terrestrial vertebrates in the Interior Columbia Basin (Wisdom *et al.* in press). In addition to the overall loss of this forest type, two features, snags and old-forest conditions, have been diminished appreciably and resulted in declines of bird species highly associated with these conditions or features (Hillis *et al*. 2001).

Terrestrial Habitat Conditions

Historic

Historically in the subbasin, old-growth ponderosa pine forests occupied areas between the shrubsteppe zone and moister forest types at higher elevations. Large, widely spaced, fire-resistant trees and an understory of forbs, grasses, and shrubs characterized these forests. Periodic fires maintained this habitat type. With the settlement of the subbasin, most of the old pines were harvested for timber, and frequent fires have been suppressed. As a result, much of the original forest has been replaced by dense second growth of Douglas-fir and ponderosa pine with little understory.

Current

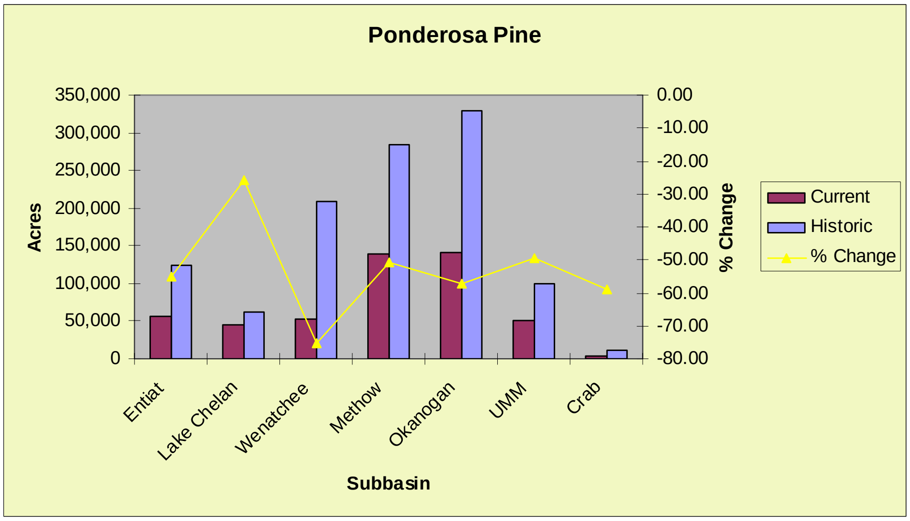
Extant ponderosa pine habitat within the Subbasin currently covers a wide range of seral conditions. Forest management and fire suppression have led to the replacement of old-growth ponderosa pine forests by younger forests with a greater proportion of Douglas-fir than pine stands (Wright and Bailey 1982).

Currently, much of this habitat has a younger tree cohort of more shade-tolerant species that gives the habitat a more closed, multi-layered canopy. For example, this habitat includes previously natural fire-maintained stands in which grand fir can eventually become the canopy dominant. Large late-seral ponderosa pine and Douglas-fir are harvested in much of this habitat type. Under most management regimes, typical tree size decreases and tree density increases.

Introduced annuals, especially cheatgrass and invading shrubs under heavy grazing pressure, have replaced native herbaceous understory species. Four exotic knapweed species *(Centaurea* spp.*)* are spreading rapidly through the ponderosa pine zone and threatening to replace cheatgrass as the dominant increaser after grazing (Roche and Roche 1988). Dense cheatgrass stands eventually change the fire regime of these stands often resulting in stand replacing, catastrophic fires. Bark beetles, primarily of the genus *Dendroctonus* and *Ips*, kill thousands of pines annually and are the major mortality factor in commercial saw timber stands.

Protection Status

Figure 17 Comparison of ponderosa pine habitat in province subbasins



Source: IBIS 2003

The protection status of ponderosa pine habitat for Ecoprovince subbasins is compared in (**Table 14**). In the Lake Chelan subbasin the protection status of remaining ponderosa pine habitat falls primarily within the "low" to "no protection" status categories As a result, this habitat type will likely suffer further degradation, disturbance, and/or loss in this subbasin.

Table 14. Ponderosa pine habitat GAP protection status in Lake Chelan subbasin

GAP Protection Status	Acres
High Protection	7,556
Medium Protection	4,175
Low Protection	28,030
No Protection	5,715

Source: IBIS 2003

Limiting Factors

Factors affecting ponderosa pine habitat are explained in detail in section 4.2.10.1 (Ashley and Stovall (unpublished report, 2004) and are summarized below:

A number of anthropogenic activities have contributed significantly to the loss and degradation of properly functioning ponderosa pine habitats. Timber harvesting, particularly at low elevations, has reduced the amount of old growth forest and associated large diameter trees and snags. Fire suppression/exclusion has contributed to habitat degradation, particularly reductions in characteristic herbaceous and shrub understory and increases in density of small shade-tolerant trees and invasive species. Remaining ponderosa pine overstories are at high risk of loss from stand-replacing fires caused by invasion of exotic plants, densely stocked understory, and increased fuel loads.

Ponderosa pine habitat has also been negatively impacted by human development, as well as agriculture, silviculture, and grazing practices. Urban and residential development and overgrazing have fragmented habitats and negatively impacted species with large area requirements. Poor grazing practices have also resulted in lack of recruitment of sapling trees, particularly pines. Hostile landscapes, particularly those in proximity to agricultural and residential areas, may be subject to high levels of human disturbance and may have high densities of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats). The timing (spring/summer versus fall) of restoration/silviculture practices such as mowing, thinning, and burning of understory removal may be especially detrimental to single-clutch species.

4.4.1 Pygmy Nuthatch (*Sitta pygmaea*)

Pygmy Nuthatch Life History, Key Environmental Correlates, and Habitat Requirements

Life History

Diet

The pygmy nuthatch diet varies seasonally and by location. The winter diet is primarily seeds in some populations and mostly insects in others. During the breeding season the diet mainly consists of insects and spiders. Beal (1907) reported that 31 pygmy nuthatch stomachs contained 83% animal matter and 17% vegetable matter. These individuals were collected in Monterey County, CA during the summer and contained the following arthropods: Hymenoptera (mostly wasps with a few ants) 38%, Hemiptera (mainly Cercropidae) 23%, Coleoptera (mainly weevils, plus some coccinellids) 12%, also caterpillars 8% and spiders 1%. The vegetable matter consisted entirely of seeds, mainly from conifers.

In contrast, Norris (1958), using year-round samples from Marin County, CA, found a diet, by weight, of 65% vegetable matter. He examined 73 stomachs collected in 9 different months. Vegetable food (all seeds of Bishop pine) exceeded 85% of diet from October to January. In late spring the proportion dropped to 39% in April 2% in May, 65% in June and July, and 42% in September. Insect food, most important in spring and fall, consisted of beetles (in 51% of the stomachs), mainly snout weevils (Curculionidae), leaf beetles (Chrysomelidae), bark beetles (Scolytidae), and wood- or bark-infesting larvae, but no Hymenoptera as in Beal's (1907) sample. Nestlings received food from most of the above groups, plus coccinellids. The oldest nestlings also received pine seeds with the hard integument removed. The stomachs of six fledglings had 0-98% pine seeds (average 45%) in them. Eight stomach samples collected in December from Napa County, CA, showed a much lower proportion of ponderosa seeds (range 0-65%, mean 39%; Norris 1958).

During the breeding season, pygmy nuthatches appear to select only a few insect taxa among the many available. In Oregon, the pygmy nuthatch breeding diet (by volume) consists of 45% weevils, 37% leaf beetles, and varying amounts of ants and bark-dwelling insects. Weevils disappear from the post-breeding diet, which consists of 59% leaf beetles, 3% weevils, and 38% other insects. Winter diet switches to only 12% leaf beetles, 25% weevils, 12% Hemiptera, 50%

other insects, and only 4% vegetable matter (seeds). The winter diet also includes twice as many bark-dwelling insects (7% cf. 3%) as in the post-breeding diet (Anderson 1976).

The amount of food in the stomach reaches its maximum in winter and spring: 0.18-0.20 g (wet weight) in November-May, compared with 0.13-0.15 g in June-September (Norris 1958).

Reproduction

Pygmy nuthatches produce one brood per year, and rarely produce a second replacement clutch (Kingery and Ghalambor 2001). It has the highest nest success, 86.8% (nests that successfully fledged at least one young), of 114 passerine species examined in North America (Martin 1995). The presence of helpers increases the production of offspring (Sydeman et al. 1988). Habitat quality also affects nest success; in good quality habitat, 64 breeding units fledged an average of 5.5 young, whereas in poorer habitat 77 units fledged an average of only 4.4 young (See also Limiting Factors below for more information on habitat features associated with breeding productivity). In central Arizona, nesting success is 80% (% of nests that successfully fledge > 1 young, n = 416 nests). This estimate of nest success breaks down by stages in the following way: 89% of nests survive through egg-laying, 85% survive through incubation period, and 80% survive through nestling period (T. Martin pers. comm.; see also Li and Martin 1991). In the Okanagan Valley, British Columbia, nest success of pygmy nuthatches is 81.9% for birds using nest boxes and using natural cavities. By stage, nest success breaks down as 89.7% of eggs hatching and 91.3% of nestlings fledging (n = 204 eggs, 183 young hatched, 167 fledglings; Cannings et al. 1987). In British Columbia, the number of young fledged per successful clutch ranges from 2-12 young in 66 (Campbell et al. 1997).

No information is available on lifetime breeding success. The number of broods normally reared per season is almost always only one (Norris 1958, Kingery and Ghalambor 2001). Second broods are likely to be rare because of the long period from egg-laying to full independence (72-78 d; Norris 1958). However, near Flagstaff, AZ two breeding units had two successful broods in one season (n = 147; Sydeman et al. 1988). Also, second broods are known to occasionally occur in the Okanagan Valley, British Columbia (Cannings et al. 1987). Second attempts at re-nesting after nest failure are also unusual. Two instances of re-nesting were reported by Norris (1958) and four instances (3 successful; n = 141) by Sydeman et al. (1988).

Only the female broods the young. Brooding is intermittent, with the greatest attentiveness during the first 2-3 hours after sunrise. Brooding bouts last about 60% as long as incubation bouts (Norris 1958). During the first 3 days of the nestling period, the female spends about 75% of daytime hours brooding young (mean bout length 12.7 minutes). Ambient temperature affects female attentiveness, in that colder morning temperatures result in greater brooding time. The amount of time the female spends brooding becomes progressively less as the young grow, but remains appreciable until the young reach 3 weeks old (Norris 1958). Both parents and any helpers also spend the night in cavity with the young (Norris 1958, Kingery and Ghalambor 2001). Males feed the brooding female on the nest and provision young when the female is off the nest.

No data on clutch initiation and size are available for the Black Hills region. S. p. pygmaea populations on the California coast appear to breed earlier than the interior populations of S. p. melanotis (Kingery and Ghalambor 2001). For S. p. pygmaea in Monterey County, CA, nests were occupied from 12 March and had young (n = 3) from 3 May-12 July (the latest dates come from pairs breeding at higher elevations; see Roberson 1993). The median egg date for S. p. pygmaea is 9 May (n = 38; Norris 1958). The median egg date for S. p. melanotis populations breeding at lower elevations is 28 May (ranges from 4 May-20 May; Kingery and Ghalambor 2001), and for populations breeding at high elevations in California and the Rocky Mountains the median egg date is 28 May (ranges from 4 May-20 June, n = 29; Norris 1958). Nests with young have been observed from 29 April-26 July (n = 84). In British Columbia nests with young have been observed from 1 May-1 September (53% occur 27 May- 18 June; n = 156; Campbell et al. 1997). In Spokane County, WA, nests with young have been observed from 29 Apr-3 July (n = 5). In Missoula County, MT, nests with young were observed from 14 May-11 Jun (n = 4). In Colorado, nests with young have been observed from 3 June-22 July (n = 19; Jones 1998). In New Mexico, nests with young have been observed from 19 May- 13 July (n = 39; Travis 1992).

Nesting

Males appear to take the lead in selecting the nest site, but data supporting this observation are lacking (Norris 1958). Pygmy nuthatches most often use ponderosa pine and other yellow longneedled pines throughout their range, but do occasionally use other conifers and quaking aspen (see Nesting Habitat above). The pygmy nuthatch is both a primary and secondary cavity nester. It typically excavates its own cavity, but will use and modify old woodpecker holes and natural cavities (Bent 1948, Norris 1958). In central Arizona, 73% of all nests were new excavations, 23% were in old cavities excavated in the previous years, and 4% were in natural cavities (n = 237 nests; T. Martin pers. comm.). Both sexes, and sometimes helpers, excavate the cavity and later bring material to the build the nest with (Norris 1958). Both sexes share in excavation equally and the average excavation bouts last 9.2 and 9.9 min for males and females respectively (Storer 1977). The excavating individual can be readily observed swinging back and forth, delivering several blows at the hole, then pausing motionless for a few seconds, before resuming excavation. Birds working inside and outside the cavity make a noise similar to an excavating woodpecker, but typically not as loud. One bird excavating inside the hole exited 3 times in 10 minutes to flip chips and sawdust into wind with its bill (Grinnell et al. 1930). The adults more typically make 3-15 blows per session (but up to 25 at a time), and average 6-7. Norris (1958) describes this behavior in detail. Birds may spend up to 63% of their entire day excavating (Norris 1958).

Migration

Pygmy nuthatches are sedentary and resident throughout their range; they do not migrate. No broad scale movements have been observed in any population to date.

Mortality

The estimated average life span of pygmy nuthatches is 1.7 years (the maximum is 6 years, n = 122; Kingery and Ghalambor 2001). However, this estimate is based on a relatively small number of birds and is not corrected for variation in the probability of re-sighting an individual. A larger sample of birds may yield a significantly higher estimate for life span (see Survival And Reproduction below). The pygmy nuthatch has a lower life expectancy than the very closely related brown-headed nuthatch, presumably due to its having larger broods, denser populations, a more “vigorous” way of life (manifested by vocal tempo, rate of feeding female and nestlings, and foraging activity generally), and living in a cooler climate (Norris 1958). The maximum recorded life span, based on recaptures of banded birds is 8 years and 2 months (Klimkiewicz et al. 1983, Klimkiewicz 1997).

Males and females are capable of breeding in their first year, however, first year males commonly assist parents as helpers before breeding on their own in their second year. In contrast, most females are likely to breed in their first year (Norris 1958). At the population level, approximately one third of all nests have between 1 and 3 helpers (Norris 1958; Sydeman et al. 1988).

No information is available on the proportion of the population that are non-breeders, although non-breeders are more likely to be males (Norris 1958). Because young birds are more likely to disperse from their parent's home range, estimating non-breeders is difficult.

The estimated annual adult survival rate is 65.0%, a high rate for a passerine bird (Martin 1995), and in stark contrast to the short estimated life span of 1.7 years (see above). Over 3 years in Marin County, CA, an average of 38% of color-banded birds remained alive in 1 of the 2 following breeding seasons (Norris 1958). First year birds have a 27% annual survival rate (Norris 1958). Sydeman et al. (1988) reported a higher survival rate for first-year birds of 44% (21 of 48), but also found an unclear pattern of autumn dispersal. Because first-year birds move and establish breeding sites that are 4 times farther away from their birthplaces compared to the distance adults move between breeding sites, first-year birds are less likely to use a discrete study area making it difficult to separate dispersal from mortality (Norris 1958). Norris (1958) reported as many yearlings in relation to adults in spring and summer as in fall and winter; the ratio of adults to sub-adults in spring and summer (probably including some dependent fledglings) is 1:1.46, while in the fall and early winter it is 1:1.30. Norris (1958) suggested that this indicates similar mortalities for yearlings and adults, but more information is needed to verify this claim.

Habitat Requirements

Pygmy nuthatches show a strong and almost exclusive preference for yellow pine forests. Their geographic range is almost co-extensive with that of ponderosa pine (Pinus ponderosa), Jeffrey pine (Pinus jeffrey), and similar species (Kingery and Ghalambor 2001). Among all breeding birds within ponderosa pine forests, the density of pygmy nuthatches is most strongly correlated with the abundance of ponderosa pine trees (Balda 1969). In Colorado 93% of breeding bird atlas observations occurred in coniferous forests, 70% of those in ponderosa pines. Indeed the distribution of pygmy nuthatches in Colorado coincides with that of ponderosa pine woodlands in the state (Jones 1998).

Several studies identify the pygmy nuthatch as the most abundant or one of the most abundant species in ponderosa forests (e.g. Mt. Charleston, NV, Arizona's mountains and plateaus, New Mexico, Colorado statewide, and Baja California, see Reassumes 1941; Brandt 1951; Norris 1958; Stallcup 1968; Balda 1969; Farris 1985; Travis 1992; Kingery 1998) as well as in other yellow long-needled pines such as those of coastal California and Popocatépetl, Mexico (Norris 1958, Paynter 1962).

In California's mountains, it favors open park-like forests of ponderosa and Jeffrey pines in the Sierra Nevada Mountains (Gaines 1988) but also ranges to 3050 m in open stands of large lodgepole pine in the White Mountains of California (Shuford and Metropulos 1996). In the Mogollon Rim region of central Arizona, it breeds and feeds in vast expanses of ponderosa pine that extend throughout the Colorado plateau, and, is also common in shallow snow-melt ravines that course through the pine forests. These snow-melt drainages contain white fir (Abies concolor), Douglas-fir (Pseudotsuga menziesii), Arizona white pine (Pinus strobiformis), quaking aspen (Populus tremuloides), and an understory of maples (Acer sp.; Kingery and Ghalambor 2001).

In New Mexico, it is most common in ponderosa pine, including ponderosa/oak and ponderosa/Douglas-fir forests (Kingery and Ghalambor 2001). In Washington, it uses Douglas-fir zones rarely, and then only those in or near ponderosa pines (Smith et al. 1997). In Summit County, CO, a small group of pygmy nuthatches occupy a small section of lodgepole pine at the edge of an extensive lodgepole forest (Kingery and Ghalambor 2001).

In coastal California (Sonoma, Marin, Monterey, San Luis Obispo Counties) pygmy nuthatches occur in the “coastal fog belt” (Burridge 1995) in Bishop pine (Pinus muricata), Coulter pine (Pinus coulteri), natural and planted groves of Monterey pine (Pinus radiata; Roberson 1993, Shuford 1993), other pine plantations (Burridge 1995), and wherever ponderosa pines grow (e.g., Santa Lucia Mountains, Monterey County; Roberson 1993).

In Mexico, where it occurs in arid pine forests of the highlands, it follows pines to their upper limits at tree line on Mount Popocatépetl (3,800-4,050 m; Paynter 1962) and Pico Orizaba (4,250 m; Cox 1895). In Distrito Federal, it is primarily restricted to coniferous forests above 3,000 m (Wilson and Ceballos-Lascurain 1993). Almost no other contemporary information is available on the habitat preferences of pygmy nuthatches in Mexican mountain ranges (S. Howell, J. Nocedal, A. Sada pers. comm.). It is known to favor pine and pine-oak woodlands, these pine species include ponderosa-type pines: *Pinus engelmanii*, *P. arizonica*, *P. montezumae* and non-ponderosa-types *Pinus teocote*, *P. hartwegii*, *P. leiophylla*, and *P. cooperi*. Associated Mexican tree *species in pygmy nuthatch habitat include oaks (Quercus rugosa, Q. castanea, Q. durifolia, and Q. hartwegii*), madrones (*Arbutus xalapensis* and *A. glandulosa*), and alders (*Alnus firmifolia*; Nocedal 1984, 1994, A. Sada pers. comm.). It also occurs, in small numbers, in fir (*Abies religiosa*) forests (Nocedal 1984, 1994).

Foraging Habitat

The pygmy nuthatch feeds almost exclusively in pines. It explores the whole tree for food, in this respect it is a more generalized feeder than chickadees and other nuthatches. Pygmy nuthatches typically seek static insect food in needle clusters, cones, twigs, branches, and trunks. It climbs over and under branches, from and to the outermost twigs and needles, and both up and down tree trunks (Bent 1948; Stallcup 1968; Bock 1969; Manolis 1977; McEllin 1978, 1979b; Ewell and Cruz 1998). It spends more time in areas with the highest density and greatest cubic feet of foliage (Balda 1967, 1969). Pygmy nuthatches forage higher in trees and farther from the trunk than the white-breasted nuthatch (Sitta carolinensis) and mountain chickadee (*Poecile gambeli*), but use various zones of the tree in more equal proportions than those flock associates (McEllin 1979b).

Time spent by pygmy nuthatches foraging in different zones of the tree remains relatively similar within the breeding and non-breeding seasons, but differs between seasons. Four studies that quantify time spent in different foraging zones confirm this but differ on the proportionate time spent in the various zones (Stallcup 1968, Larimer County, CO.; Bock 1969, Boulder County, CO.; McEllin 1978, 1979a, Larimer County, CO; Ewell and Cruz 1998, Boulder County, CO.).

These studies report that during the breeding season, the% age of time foraging in different zones of a tree are: trunks 3-35%, large branches 12-15%, small branches, 10-25%, and needles, twigs, and cone clusters, 34-74%. Foraging during the non-breeding season then shifts primarily to the cone clusters: trunks 1-23%; large branches, 7-16%; small branches, 22-34%; needles, twigs, and cone clusters, 34-71%. This shift reflects the greater reliance on pine seeds during the non-breeding season.

In Larimer County, CO, the time spent in foraging zones does not differ with respect to foraging height, tree diameter, or location within the tree, and, more time is spent at each foraging location in the non-breeding season than in the breeding season (McEllin 1978). In addition, the pygmy nuthatch uses a greater amount of a tree's vertical height during the nonbreeding season (foraging height averages 9.51 m " .051 SE in the breeding season and 10.40 " .056 SE in the non-breeding season; McEllin 1979b).

In Boulder County, CO, non-breeding birds spent 92.0% of their foraging time in ponderosa pines, 5.3% in Douglas firs, 1.4% in dead brush, and 1.1% on the ground. When in the pines, they spent 34.6% of their feeding time on the trunk, 25.4% on branches, and 22.0% on needles and twigs (Bock 1969). Some foraging on fallen pinecones during the non-breeding and breeding season has also been reported (Stallcup 1968).

Nesting Habitat

Because the pygmy nuthatch nests primarily in dead pines and live trees with dead sections, it prefers mature and undisturbed forests that contain a number of large snags (Szaro and Balda 1982). Pygmy nuthatch abundance correlates directly with snag density and foliage volume of the forest, but inversely with trunk volume, implying that it needs heterogeneous stands with a mixture of well spaced, old pines and vigorous trees of intermediate age (Balda et al. 1983). Scott (1979) illustrated the importance of snags for pygmy nuthatch populations by comparing two plots that had been harvested for trees, but differed in that snags were removed in one plot and left in the other. Pygmy populations decreased by half on the plot where snags had been removed (16.3 pairs/ ha to 7.6 pairs/ ha), whereas populations slightly increased on the plot where snags were left (18.7 pairs/ ha to 22.6 pairs/ ha; Scott 1979). This reliance on ponderosa pine forests with high amounts of foliage volume and numerous snags has led some authors to regard the pygmy nuthatch as one of best indicator species for overall "health" of bird communities in mature ponderosa pine forests (e.g. Szaro and Balda 1982).

Tree height

The mean height of nest trees for S. p. melanotis populations nesting in Colorado, Montana, and Arizona is 16.03 m (" 2.89 SE).

Diameter of nest tree

The mean diameter at breast height (dbh) of nest trees for S. p. melanotis populations nesting in Arizona is 47.83 cm " 10.35 SE.

Height of nest cavity

The mean height of the nest cavity for S. p. melanotis populations nesting in Colorado, Montana, and Arizona is 10.57 m (" 2.83 SE). Cavity height also varies by tree species: ponderosa pine, 1-21.3 m, mean 7.6 m (n = 78); Jeffrey pine, 2.4-7.6 m, mean 5.6 m. (n = 7); Bishop pine 3.4-15 m, mean 10.1 (n = 22); Douglas-fir 9-23 m, mean 14.8 (n = 7); quaking aspen, 9-23 m, mean 5.7 (n = 8).

Habitat surrounding nest tree

In a comparison of habitat characteristics surrounding the nest tree, Li and Martin (1991) compared an 11.3 radius circular plot around the nest to a random plot centered on a similar sized tree of the same tree species used for nesting. They found that the circular plots surrounding the nest trees had significantly more aspen and conifer snags, more conifers of greater than 15 cm (dbh), and fewer deciduous trees of greater than 15 cm (dbh) in comparison to the randomly selected plots (Li and Martin 1991).

Condition of nest tree

In central Arizona, pygmy nuthatches placed 78% of their nests in completely dead snags, 11% in the dead portions of live trees, and 11% in completely live trees (n = 18 nests; Li and Martin 1991).

Pygmy Nuthatch Population and Distribution

Historic

Little or no information exists on the historic range, but it is unlikely to differ significantly from the current distribution, which is closely tied to the distribution of ponderosa pines.

Current

The pygmy nuthatch is resident in ponderosa and similar pines from south central British Columbia and the mountains of the western United States to central Mexico. The patchy distribution of pines in western North America dictates the patchy distribution of the pygmy nuthatch throughout its range. The reliance on pines distinguishes pygmy nuthatches from other western nuthatches such as the red-breasted and white breasted, which are associated with fir/spruce and deciduous forests respectively (Ghalambor and Martin 1999). The following is a review of the distribution of populations in the United States, Canada, and Mexico (based on Kingery and Ghalambor 2001).

The pygmy nuthatch occurs in southern interior British Columbia, particularly in Okanagan and Similkameen valleys and adjacent plateaus (Campbell et al. 1997) south into the Okanagan Highlands and the northeast Cascades of Washington. It is scattered along the eastern slope of the Cascades from central Washington (Jewett et al. 1953, Smith et al. 1997) into Oregon and in the Blue Mountains in southwest Washington (Garfield County only; Smith et al. 1997) but widespread in Oregon along the west slope of the Cascades (Gabrielson and Jewett 1940, Jewett et al. 1953, Gilligan et al. 1994). It ranges south from the Cascades in Oregon into northern California and south into the Sierra Nevadas and nearby mountains of Nevada (Brown 1978). In the southern Sierra Nevadas it is found on the east and west side of the range in the Mono Craters and Glass Mountain region (Gaines 1988, Shuford and Metropulos 1996) and in the White Mountains of Nevada and California (Norris 1958, Brown 1978, Shuford and Metropulos 1996). It is also found throughout the mountain ranges of southern California, including the Sierra Madres in Santa Barbara County, the Mt. Pinos area (Kern and Ventura Counties), the San Gabriel and San Bernardino Mountains in Los Angeles and San Bernardino Counties (Norris 1958, B. Carlson, K. Garrett pers. comm.), the San Jacinto and Santa Rosa Mountains in

Riverside County (Norris 1958, B. Carlson pers. comm.), and in the Laguna and Cuyamaca Mountains, as well as Mt. Palomar, Volcan and Hot Springs Mountains of San Diego County (San Diego County Breeding Bird Atlas preliminary data, B. Carlson, P. Unitt pers. comm.). The range extends south into the Sierra Juarez and Sierra San Pedro Mártir Mountains in Baja California Norte, Mexico (Grinnell 1928, Norris 1958, A. Sada pers. comm.).

In eastern Washington, the pygmy nuthatch is common in the pine forests of Spokane County (Jewett et al. 1953, Smith et al. 1997) and adjacent Kootenai County, ID (Burleigh 10 1972). Only scattered records exist for the rest of Idaho's mountains (Burleigh 1972, Stephens and Sturts 1991) but pygmy nuthatches are well distributed in the Rocky Mountains of far western Montana (Montana Bird Distribution Committee 1996).

Pygmy Nuthatch Status and Abundance Trends

Status

The pygmy nuthatch is not currently listed as a threatened or endangered species by the U.S. Fish and Wildlife Service. However, it is listed as a "sensitive" species in the Rocky Mountain Region (R2) of the U.S. Forest Service. Sensitive species are those for which population viability is a concern as evidenced by: a) significant current or predicted downward trends in population numbers or density; or b) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution. The justification for the sensitive status of the pygmy nuthatch is based on its close association with unmanaged mature ponderosa pine forests, a habitat type that has substantially declined in recent years (e.g. Hutto 1989; Wisdom et al. 2000). The pygmy nuthatch also serves as a Management Indicator Species (MIS) within the Rocky Mountain Region (R2) and on many National Forests within the Southwestern Region (R3) (e.g. Coconino and Prescott National Forests, AZ and Cibola National Forest, NM). The indicator species designation exists because numerous lines of evidence suggest that negative changes in the population status of pygmy nuthatches within managed ponderosa pine forests may reflect adverse changes to the community as a whole (see also Diem and Zeveloff 1980). Within the Pacific Northwest Region (R6), the pygmy nuthatch was selected along with 39 other bird species to be the "focus" of a broad scale analysis of source habitats in the interior Columbia basin (Wisdom et al. 2000). The criteria for selecting the pygmy nuthatch as a focal species was based on a petition filed by the Natural Resources Defense Council with the Regional Forester of the Pacific Northwest Region (Wisdom et al. 2000).

At the state level, Arizona, Colorado, Idaho, Oregon, and Wyoming list the pygmy nuthatch as a species of special concern based on its status as an indicator species (Clark et al. 1989, Luce et al. 1997, Webb 1985). However, within each state different organizations take different positions on the status of the species, for example the Colorado Natural Heritage Program classifies it as "very common, demonstrably secure" (Kingery and Ghalambor 2001) and it is only ranked as being a species of "moderate concern" in Arizona by Arizona Partners in Flight (Hall et al. 1997).

Trends

Survey-wide estimates of all BBS routes suggest pygmy nuthatch populations are stable (Sauer et al. 2000). However, these estimates are based on small samples that do not provide a reliable population trend nor reliable trends for any states or physiographic regions, due to too few routes, too few birds, or high variability (Sauer et al. 2000). The lack of reliable data is particularly the case in the Black Hills, where there are too few data to perform even the most basic trend analysis (Sauer et al. 2000). Where long-term data are available for particular populations, natural fluctuations in population numbers have been documented. For example, a constant-effort nest-finding study in Arizona recorded a major population crash. On this site between 1991-1996 the number of nests found each year varied from 23-65 (mean = 50.2), whereas in the same site from 1997-1999, only 2-5 nests were found each year (Kingery and Ghalambor 2001). Likewise, Scott's (1979) study also portrays a pygmy nuthatch population swing, but no clear factor has been identified as being responsible for rapid changes in population numbers (see also Population Trend above). No definitive explanation currently exists for why some pygmy nuthatch populations may be prone to large fluctuations, but it is suspected that an intolerance to cold winter temperatures (see Communal Roosting below), and or a poor cone crop may play a role.

Factors Affecting Pygmy Nuthatch Population and Status

Key Factors Inhibiting Populations and Ecological Processes

There is good evidence for at least two main limiting factors in pygmy nuthatch populations: 1) the availability of snags for nesting and roosting, and 2) sufficient numbers of large cone-producing trees for food.

Nest Site Availability

Pygmy nuthatches depend on snags for nesting and roosting. In all cases where timber harvesting has reduced the number of available snags, the number of breeding pairs declines (McEllin 1979a; Brawn 1987, Brawn and Balda 1988a, Bock and Fleck 1995.). Experimental evidence on the role of nest sites in limiting population numbers comes from nest box addition studies. The addition of nest boxes increases breeding pairs by 67-200% and this increase is greater in selectively cut and clear-cut forests with reduced snag availability (Brawn 1987, Brawn and Balda 1988a, Bock and Fleck 1995). These experiments do not address use of boxes during the non-breeding season and the effect upon winter survival, but boxes are seldom used for roosting during non-breeding season (R. Balda pers. comm.). Further evidence that snag availability plays a role in limiting population numbers comes from estimates of population density on logged sites with and without nest boxes added. Addition of nest boxes increases the density of pygmy nuthatches on "severely thinned" and "moderately thinned" plots respectively, from 3 pairs/40ha to 10 pairs/40 ha and from 15/40ha to 25 pairs/40 ha (Brawn and Balda 1988a). Similarly, a comparison of unlogged, moderately thinned, and severely thinned plots showed that pygmy nuthatches will use natural and self-excavated cavities in unlogged forest (15 of 16 nests), but switch to nest boxes in moderately thinned (15 of 16 nests) and heavily thinned (10 of 10 nests) forests where snag availability has been reduced (Brawn 1988). See also Risk Factors Below.

Roost Site Availability

Pygmy nuthatches choosing roost sites during the non-breeding use a different set of characteristics compared to nest sites (see Communal Roost Sites above). In a heavily harvested forest near Flagstaff, AZ, birds chose atypical cavities with poorer thermal properties compared to adjacent unlogged forests (Hay and Güntert 1983). This suggests that a considerable reduction in snag densities may affect overwinter survivorship and possibly reproduction by forcing pygmy nuthatches to use cavities in snags they would normally avoid (Hay and Güntert 1983, Matthysen

1998). More research on the differences among snags is clearly needed in order to distinguish those factors that make some snags more desirable than others.

Availability of Foraging Substrate

Pygmy nuthatches differ from other nuthatches in that they prefer to forage amongst the foliage of trees rather than simply on the bark (see Foraging Habitat above). A number of lines of evidence suggest that because pygmy nuthatches rely heavily on pine seeds during the non-breeding season and preferentially feed in dense foliage, they are particularly sensitive to significant habitat alterations. For example, in a comparison of open forests that have been severely thinned of all snags and have a 75% reduction in pine foliage and forests that were only "moderately thinned", Brawn and Balda (1988a) found that even with the addition of nest boxes, pygmy nuthatch densities were significantly higher on the moderately thinned plot. These results suggest that foliage volume and food resources can influence pygmy nuthatch densities independent of cavity availability. In a comparison of "clear-cut", "heavy cut", "medium cut", "light cut", and "uncut" forests, Szaro and Balda (1986) similarly found that pygmy nuthatches and other species that select dense foliage became less abundant as the habitat became more "modified". Rosenstock (1996) concluded that pygmy nuthatches and other species that prefer to forage in more dense foliage decline in forests that have low canopy density, high canopy patchiness, and reduced vertical vegetation density, as commonly occur as a result of timber harvesting. Furthermore, there is also a general positive correlation between pygmy nuthatches and the diameter (dbh) of pine trees (Rosenstock 1996). Finally, Sydeman et al. (1988) report that pygmy nuthatches achieve higher breeding success in "undisturbed mature" forests compared to forests that were selectively cut in the past and were being continually cut for fuelwood. The "undisturbed forests" had not been disturbed for over 70 years and had a greater basal area of ponderosa pine (13.97 vs. 10.46 m2/hectare, fewer but larger ponderosa pines per hectare (50.65 vs. 40.37 cm dbh), and taller ponderosa pines (18.82 vs. 15.36 m) compared to the disturbed site (Sydeman et al. 1988). The undisturbed site also contained more junipers and oaks per hectare, and significantly more snags per hectare (112 vs. 24) than the disturbed site (Sydeman et al. 1988).

Risk Factors

The following is a prioritized list (beginning with the most important) of risk factors or threats faced by pygmy nuthatches. These risk factors are based on the most current knowledge available and are discussed in the context of the Black Hills.

Snag Availability

Pygmy nuthatches are dependent on snags for nesting and roosting, and reduced snag availability has been shown to have negative effects on populations (see Limiting Factors above). Because pygmy nuthatches nest and roost in excavated tree cavities, the importance of snags is manifested during both the breeding and non-breeding season. During the breeding season, numerous studies have documented a decline in the number of breeding pairs and a reduction in population density on sites where timber harvesting reduced the number of available snags (see Limiting Factors above). During the non-breeding season, studies show that timber harvests that remove the majority of snags, cause communally roosting groups to use atypical cavities with poorer thermal properties.

Foraging Habitat

Pygmy nuthatch populations rely heavily on the availability of pine seeds and arthropods that live on pines. In comparison to other nuthatches and woodpeckers, pygmy nuthatches forage more amongst the foliage of live trees rather than on the bark. The preferred foraging habitat for pygmy nuthatches appears to contain a high canopy density, low canopy patchiness, and increased vertical vegetation density, a common feature of mature undisturbed forests.

Loss of Continuous Habitat

Pygmy nuthatch populations are very sedentary. Young birds have been observed to only move 286.5 meters from their natal territories. Such limited dispersal reduces the number of individuals that emigrate and immigrate from local populations, which in turn reduces gene flow and demographic stability. Thus, in contrast to the majority of North America's songbirds, movement and dispersal patterns in pygmy nuthatch populations is limited to a relatively small geographic area. Therefore, pygmy nuthatches may need a greater amount of connectivity between suitable habitat potentially in comparison to other resident birds.

Timber Harvest

The effects of timber harvesting on bird communities as a whole may have both beneficial and negative effects. Because timber harvesting changes the structure, density, age, and vegetative diversity within forests, the new habitats created following timber harvesting activities may be either suitable or unsuitable to different species of birds. Furthermore, the type of timber harvesting (e.g. clear-cut, partial-cut, strip-cut) may also have differential consequences on the local bird community. No study to date has quantified the effects of timber harvesting on pygmy nuthatches in the Black Hills (but see Dykstra et al. 1997 for other species). Nevertheless, various lines of research suggest that some timber harvesting treatments have negative impacts on pygmy nuthatches (reviewed in Hejl et al. 1995; Finch et al. 1997). Comparisons between uncut mature forests and forests that have been subject to various silvicultural treatments reveal that the density of pygmy nuthatches is significantly reduced on harvested forests (e.g. Franzreb and Ohmart 1978, Brawn 1988, Sydeman et al. 1988), and these reduced numbers are significantly correlated with reduced snag density and the volume of ponderosa pine foliage. For example, Szaro and Balda (1979) report that the average number of breeding pygmy nuthatches over a three year period in uncut mature forests (582.5 ponderosa pines/ha) was 14 pairs / 40 ha, in a strip cut forest (145 ponderosa pines/ha) it was 4.0 pairs /40 ha, in a severely thinned forest (59.7 ponderosa pines/ha) 1.3 pairs /40 ha, and in a selectively cut forest (216.1 ponderosa pines/ha) that only removed some old mature trees 13.5 pairs /40 ha. Pygmy nuthatches were always found to be absent from clear cut forests (Szaro and Balda 1979). Similarly, Balda (1975) reports the number of breeding pairs on three uncut mature ponderosa pine forests to be 26, 15, and 43 pairs per 100 acres, whereas on two plots where all snags were removed the number of pairs dropped to 2 and 3 pairs per 100 acres. Scott (1979, 1983) reports that the before-and-after density of pygmy nuthatches dropped from 16.3 pairs/ 100 ha to 7.6 pairs/ 100 ha on plots where timber harvesting reduced the basal area of live trees from 110 to 64 square feet per acre and also resulted in the removal of all snags.

In contrast, on plots where timber harvesting reduced the basal area from 107 to 51 square feet per acre but no snags were removed, the number of breeding pairs increased from 18.7 pairs/ 100 ha to 22.6 pairs/ ha (Scott 1979). During the same time, pygmy nuthatch populations on control plots that had a standing basal area of 102 square feet per acre and were not cut, numbers increased from 13.6 pairs/ ha to 20.4 pairs/ ha (Scott 1979). The pygmy nuthatch was one of four species that showed a significant reduction in population density with a reduction in snags (Scott 1979, 1983). These results illustrate the importance of retaining snags during timber harvests. In addition, work by Balda (1969, 1975), Szaro and Balda (1986), O'Brien (1990) and Rosenstock (1996) all conclude that pygmy nuthatches prefer to forage in dense foliage and populations decline in forests that have low canopy density, high canopy patchiness, and reduced vertical density, which are a common result of timber harvesting activities. For example, even using "coarse" forest survey plot data, O'Brien (1990) found that the number of pygmy nuthatches was significantly correlated with both foliage volume of ponderosa pine and the estimated availability of food in ponderosa pines (computed using average canopy height and canopy closure; see O'Brien 1990 for more details). Furthermore, O'Brien (1990) found that the average number of pygmy nuthatches observed was much higher (6.5 vs. 1.5) and more birds were observed at more locations in a more remote less intensively managed forest than a forest intensively managed for timber. Using a somewhat similar approach, Rosenstock (1996) found a general positive correlation between pygmy nuthatches and the diameter of pine trees.

Dykstra et al. (1997) examined the effects of timber harvesting on birds in ponderosa pine forests in the Black Hills, but did not record the presence of pygmy nuthatches on either harvested or unharvested stands.

Recreation

Recreational activities can negatively impact bird populations through the accidental and purposeful taking of individuals, habitat modification, changes in predation regimes, and disturbance (Knight and Cole 1995; Marzluff 1997). In a recent review of the effects of recreation on songbirds within ponderosa pine forests, Marzluff (1997) hypothesized that "nuthatches" would experience moderate decreases in population abundance and productivity in response to impacts associated with established campsites (although pygmy nuthatch was not specifically identified). Impacts associated with camping that might negatively influence nuthatches include changes in vegetation, disturbance of breeding birds, and increases in the number of potential nest predators (Marzluff 1997). However, other recreational activities associated with resorts and recreational residences might moderately increase nuthatch population abundance and productivity (Marzluff 1997). This positive effect on nuthatch populations is likely to occur through food supplementation, such as bird feeders, that are frequently visited by pygmy nuthatches.

Livestock Grazing

No study to date has considered the effects of livestock grazing on the pygmy nuthatch or any other cavity-nesting bird. In the short-term it is unlikely that grazing would have any negative or positive impacts on the pygmy nuthatch because their foraging is largely confined to foliage in large trees. The long-term effects of grazing in ponderosa pine forests on pygmy nuthatches are difficult to predict. On one hand, grazing can reduce grass cover and plant litter that in turn can enhance survival of pine seedlings and reduce the frequency of low-intensity ground fires. On the other hand, heavy grazing can also change the recruitment dynamics of ponderosa pines and aspens that eventually would be used for breeding, roosting, and foraging and also alter the frequency of high-intensity crown fires. Studies that compare the vegetation characteristics and productivity of pygmy nuthatches in grazed and non-grazed forests could provide important information in this regard.

Mining

No study to date has considered the effects of mining on the pygmy nuthatch or other cavity nesting bird. However, mining or any related activity that resulted in a significant loss of snags or reduced the number of large mature trees could have negative consequences. Mining could also have negative consequences on pygmy nuthatches by disrupting breeding birds.

Prescribed Fire

Because fire is an important natural process in ponderosa pine forests and is an important factor in creating snags, the restoration of natural fire regimes has been proposed as a management tool (e.g. Covington and Moore 1994; Arno et al. 1995; Fule and Covington 1995). In particular, the use of prescribed fires to reduce fuel loads has been suggested as being necessary in order to return fire regimes to more "natural" conditions (e.g. Covington and Moore 1994; Arno et al. 1995). Because frequent, low intensity ground fires play an important role in maintaining the character of natural ponderosa woodlands (Moir et al. 1997), prescribed low intensity ground fires are presumed to have beneficial effects on the pygmy nuthatch. However, little information exists on the short- and long-term benefits of fire on pygmy nuthatches. The short-term effects of large crown fires appears to have negative effects on pygmy nuthatch populations because of a reduction in the sources of food and shelter (Brawn and Balda 1988b). Lowe et al. (1978) examining more long term effects, report that pygmy nuthatches were more common in an unburned plot, rather than on plots that had undergone stand replacing fires at various times in the previous 20 years. However, many of these burned sites may have been salvage logged, making it difficult to distinguish fire effects from logging effects (Finch et al. 1997). Similar problems have plagued other studies (e.g. Overturf 1979; Blake 1982; Aulenbach and O'Shea-Stone 1983) attempting to quantify the effects of fire on pygmy nuthatches and other birds within ponderosa pine forests (see Finch et al. 1997). The importance of experimental design is illustrated by Horton and Mannan (1988) who examined the effects of a prescribed broadcast understory fire on breeding birds in a ponderosa pine forest. They found that pygmy nuthatch densities dropped from 24.4 individuals / 40 ha to 14.2 individuals/ 40 ha following the prescribed fire (Horton and Mannan 1988), however, on non-burned control plots they found a similar decrease of 26.2 individuals / 40 ha to 15.8 individuals / 40 ha (Horton and Mannan 1988). These results suggest that the decrease in pygmy nuthatch numbers on the burned plots may have been unrelated to the prescribed fire. However, although this study incorporated a control plot, there was only a single replicate for the experimental and control treatments. Clearly, more research on the effects of low intensity and high intensity fires on pygmy nuthatch 59 populations is needed.

Thus, the current level of information makes it difficult to accurately predict the effects of fire on pygmy nuthatches. However, it seems reasonable to conclude that low intensity ground fires would have little or no negative effects, whereas high intensity crown fires would have significant negative short-term effects because of the reduction in foraging habitat.

Fire Suppression

Long-term fire suppression can lead to changes in forest structure and composition, and result in the accumulation of fuel levels that can lead to severe crown fires that replace entire stands of trees. Little information is available on populations of pygmy nuthatches prior to fire suppression policies, although evidence from Arizona and New Mexico suggest they were abundant (Scurlock and Finch 1997). Attempts to restore ponderosa pine forests to their pre- European structure and function (i.e. conditions prior to forest suppression) should have positive impacts on pygmy nuthatch populations, but too little information is currently available. Current work by Paul Beier and colleagues at Northern Arizona University is looking at the abundance and diversity of birds in a ponderosa pine forest that is being restored by the Bureau of Land Management to its historic condition. This work should provide some insight into how pygmy nuthatch populations respond to a large-scale effort to restore old-growth ponderosa pine.

Decades of fire suppression also increase the risk of large stand replacing fires. While the effects of fire on pygmy nuthatch populations remains unclear (see above), large crown fires are expected to have negative affects on pygmy nuthatches by reducing or eliminating sources of food and shelter (Brawn and Balda 1988b).

Non-Native Plant Establishment And Control

No study to date has investigated how the establishment or control of non-native plants influences pygmy nuthatches or any other cavity-nesting bird species in ponderosa pine forests. Some techniques employed to control non-native plants such as prescribed fires are expected to have little or no effect as long as these fires are low intensity ground fires. To the extent that establishment of non-native plants alters the recruitment of trees used for foraging or nesting, such as ponderosa pine or quaking aspen, there could be long-term impacts.

Fuelwood Harvest

Fuelwood harvesting occurs at two levels. At a large-scale, forest managers often harvest dead or diseased trees from large areas, particularly after fires, windstorms, and other natural events. The justification for removing dead and diseased trees is to reduce the accumulation of fuelwood that could lead to high-intensity fires. At a smaller-scale, standing dead trees, fallen trees and other downed woody debris are collected for firewood at campsites or other personal uses. Any fuelwood harvesting that removes standing snags is expected to reduce the population density of pygmy nuthatches (see Timber Harvest above). The harvesting of fallen trees and downed woody debris is not expected to have any negative consequences.

Insect Epidemics

Insect populations typically show large fluctuations over time. Within ponderosa pine forests, attention and concern over insect populations is primarily focused on the mountain pine beetle (*Dendroctonus ponderosae*) because of its potential to kill trees that would otherwise be desirable for harvesting. No study to date has investigated how pine beetle outbreaks influence pygmy nuthatch populations. The ultimate effects of insect epidemics may be related to the scale at which outbreaks occur. Small insect outbreaks that only kill small patches of trees may have beneficial effects on pygmy nuthatch populations, because the increase in tree mortality results in more snags for nesting and roosting. However, large-scale epidemics that result in large amounts of tree mortality could have negative consequences on pygmy nuthatches because of they rely heavily on the foliage of live pine trees for foraging. Thus, the ultimate net effect may be related to how extensive the outbreaks are. Clearly, further study in this area would be warranted.

Wildfire

See Prescribed Fire and Fire Suppression above.

Wind Events

Wind events have the potential to negatively influence pygmy nuthatch populations by blowing down snags used for nesting and roosting. During the non-breeding season, when large numbers of pygmy nuthatches communally roost in a single cavity (see Other Complex Interactions), severe wind events have the potential to harm large numbers of individuals by blowing down roost trees. During the breeding season, such risks are minimized because individuals are distributed among many snags used for breeding.

Other Weather Events

Cold temperatures, particularly during the winter months, have the potential to reduce pygmy nuthatch populations. Szaro and Balda (1986) report that breeding bird densities (including pygmy nuthatches) were highest following the mildest winter conditions and bird densities were lowest following a winter with the highest winter snowfall on record in their Arizona study sites. Given that pygmy nuthatches have a low tolerance to cold temperatures, as exemplified by their use of torpor and communal roosting, cold winter temperatures may have disproportionately greater effects on their populations.

4.4.2 White-headed Woodpecker (*Picoides Albolarvatus*)

The white-headed woodpecker (*Picoides albolarvatus*) is a year round resident in the Ponderosa pine (*Pinus ponderosa*) forests found at the lower elevations (generally below 950m). White-headed woodpeckers are particularly vulnerable due to their highly specialized winter diet of Ponderosa pine seeds and the lack of alternate, large cone producing, pine species.

Nesting and foraging requirements are the two critical habitat attributes limiting the population growth of this species of woodpecker. Both of these limiting factors are very closely linked to the habitat attributes contained within mature open stands of Ponderosa pine. Past land use practices, including logging and fire suppression, have resulted in significant changes to the forest structure within the Ponderosa pine ecosystem.

White-headed Woodpecker Life History, Key Environmental Correlates, and Habitat Requirements

Life History

Diet

White-headed woodpeckers feed primarily on the seeds of large Ponderosa pines. This is makes the white-headed woodpecker quite different from other species of woodpeckers who feed primarily on wood boring insects (Blood 1997, Cannings 1987 and 1995). The existence of only one suitable large pine (Ponderosa pine) is likely the key limiting factor to the white-headed woodpecker's distribution and abundance.

Other food sources include insects (on the ground as well as hawking), mullein seeds and suet feeders (Blood 1997, Joe *et al.* 1995). These secondary food sources are used throughout the spring and summer. By late summer, white-headed woodpeckers shift to their exclusive winter diet of Ponderosa pine seeds.

White-headed woodpeckers are monogamous and may remain associated with their mate throughout the year. They build their nests in old trees, snags or fallen logs but always in dead wood. Every year the pair bond constructs a new nest. This may take three to four weeks. The nests are, on average 3m off the ground. The old nests are used for overnight roosting by the birds.

The woodpeckers fledge about 3-5 birds every year. During the breeding season (May to July) the male roosts in the cavity with the young until they are fledged. The incubation period usually lasts for 14 days and the young leave the nest after about 26 days. White-headed woodpeckers have one brood per breeding season and there is no replacement brood if the first brood is lost.

The woodpeckers are not very territorial except during the breeding season. They are not especially social birds outside of family groups and pair bonds and generally do not have very dense populations (about 1 pair bond per 8 ha).

Nesting

Generally large Ponderosa pine snags consisting of hard outer wood with soft heartwood are preferred by nesting white-headed woodpeckers. In British Columbia 80% of reported nests have been in Ponderosa pine snags, while the remaining 20% have been recorded in Douglas fir snags. Excavation activities have also been recorded in Trembling Aspen, live Ponderosa pine trees and fence posts (Cannings *et al*. 1987).

In general, nesting locations in the South Okanagan, British Columbia have ranged between 450 - 600m (Blood 1997), with large diameter snags being the preferred nesting tree. Their nesting cavities range from 2.4 to 9 m above ground, with the average being about 5m. New nests are excavated each year and only rarely are previous cavities re-used (Garrett *et al.* 1996).

Migration

The white-headed woodpecker is a non-migratory bird.

Habitat Requirements

Breeding

White-headed woodpeckers live in montane, coniferous forests from British Columbia to California. They feed and reproduce in and are generally associated with a multitude of structural conditions within the ponderosa pine habitat type. Similarly, white-headed woodpeckers are present, but not dependent upon sapling/pole successional forest. According to NHI (2003) data, white-headed woodpeckers are not closely associated with any specific ponderosa pine structural conditions.

They seem to prefer a forest with a relatively open canopy (50-70% cover) and an availability of snags (a partially collapsed, dead tree) and stumps for nesting. The birds prefer to build nests in trees with large diameters with preference increasing with diameter. The understory vegetation is usually very sparse within the preferred habitat and local populations are abundant in burned or cut forest where residual large diameter live and dead trees are present.

Highest abundances of white-headed woodpeckers occur in old-growth stands, particularly ones with a mix of two or more pine species. They are uncommon or absent in monospecific Ponderosa pine forests and stands dominated by small-coned or closed-cone conifers (e.g., lodgepole pine or knobcone pine).

Where food availability is at a maximum such as in the Sierra Nevadas, breeding territories may be as low as 10ha (Milne and Hejl 1989). Breeding territories in Oregon are 104 ha in continuous forest and 321 ha in fragmented forests (Dixon 1995b). In general, open Ponderosa pine stands with canopy closures between 30 - 50 % are preferred. The openness however, is not as important as the presence of mature or veteran cone producing pines within a stand (Milne and Hejl 1989). In the South Okanagan, British Columbia, Ponderosa pine stands in age classes 8 -9 are considered optimal for white-headed woodpeckers (Haney 1997). Milne and Hejl (1989) found 68% of nest trees to be on southern aspects, this may be true in the South Okanagan as well, especially, towards the upper elevational limits of Ponderosa pine (800 - 1000m).

White-headed Woodpecker Population and Distribution

Population

Highest abundances of white-headed woodpeckers occur in old-growth stands, particularly ones with a mix of two or more pine species. They are uncommon or absent in monospecific ponderosa pine forests and stands dominated by small-coned or closed-cone conifers (e.g., lodgepole pine or knobcone pine). The exact population of the white-headed woodpecker is unknown but there are thought to be less than 100 of the birds in British Columbia.

Distribution

These woodpeckers live in montane, coniferous forests from southern British Columbia in Canada, to eastern Washington, southern California and Nevada and Northern Idaho in the United States. Woodpecker abundance appears to decrease north of California. They are uncommon in Washington and Idaho and rare in British Columbia. However, they are still common in most of their original range in the Sierra Nevada and mountains of southern California. The birds are non-migratory but do wander out of their range sometimes in search of food.

Figure 19. White-headed woodpecker year-round range

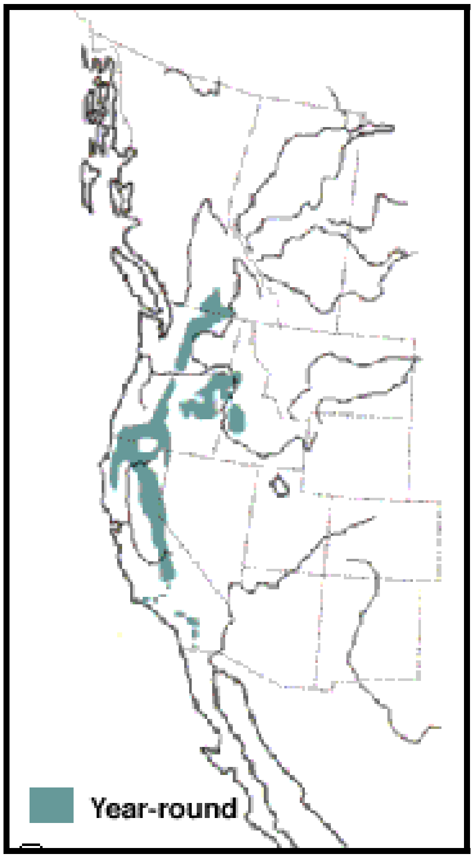
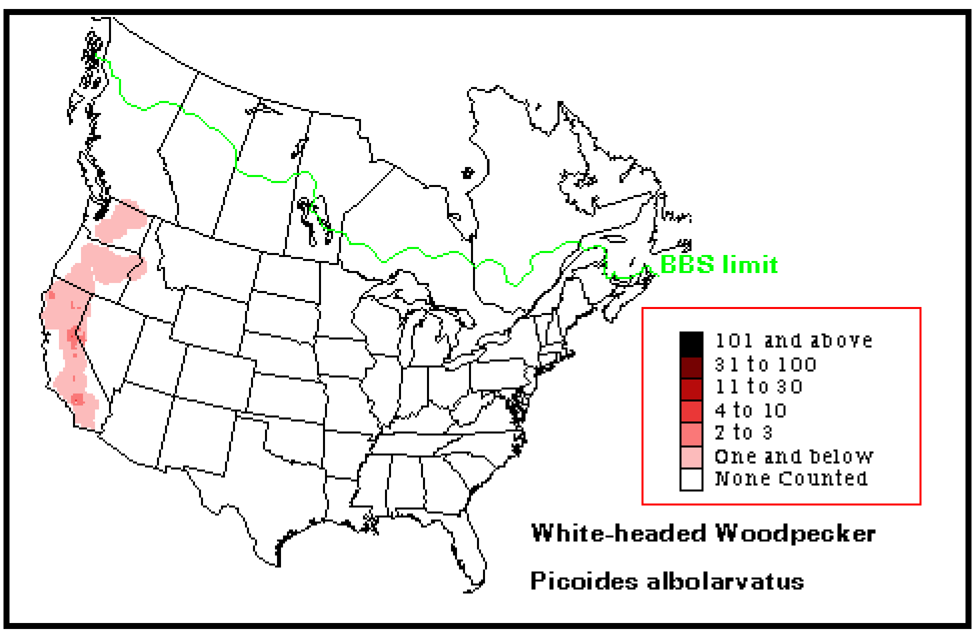
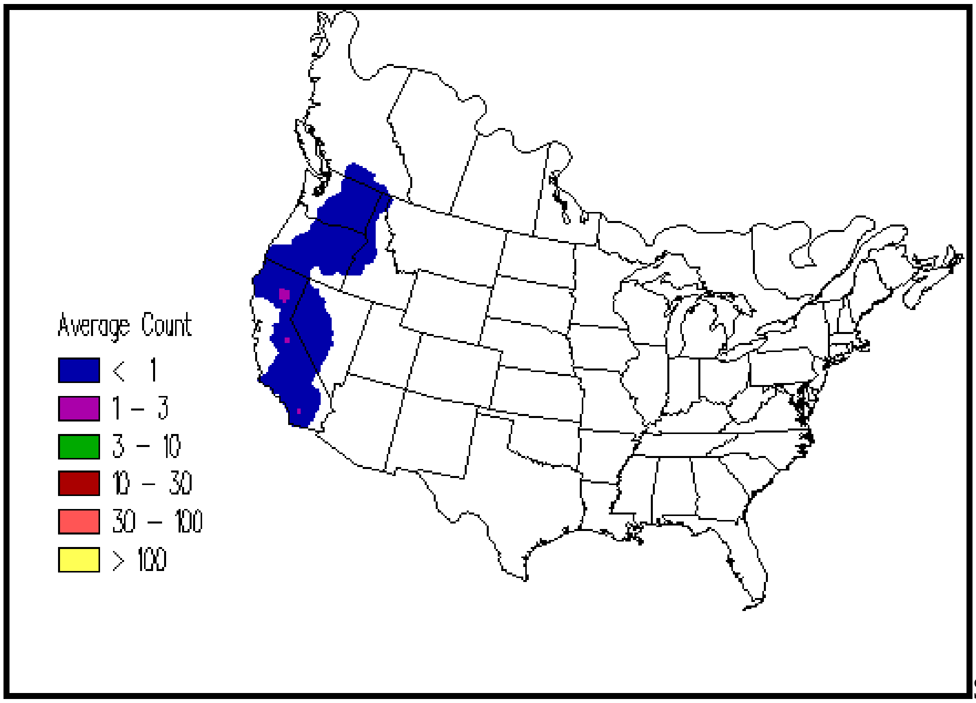


Figure 20. White-headed woodpecker breeding distribution



Source: BBS data in Sauer et al. 2000

Figure 21. White-headed woodpecker winter distribution



Source: CBC data in Sauer et al. 2003

Note: See (http://ww2.mcgill.ca/biology/undergra/c465a/biodiver/2000/whiteheaded-woodpecker/whiteheaded-woodpecker.htm)

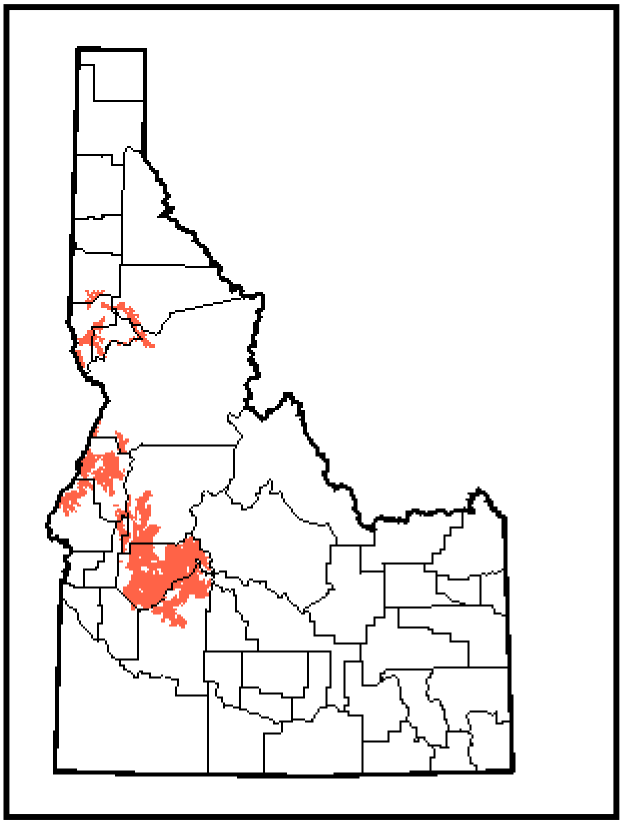


Figure 22. White-headed woodpecker Idaho distribution

Note: See http://imnh.isu.edu/digitalatlas/bio/birds/wdpkrs/whwo/whwo_map.htm

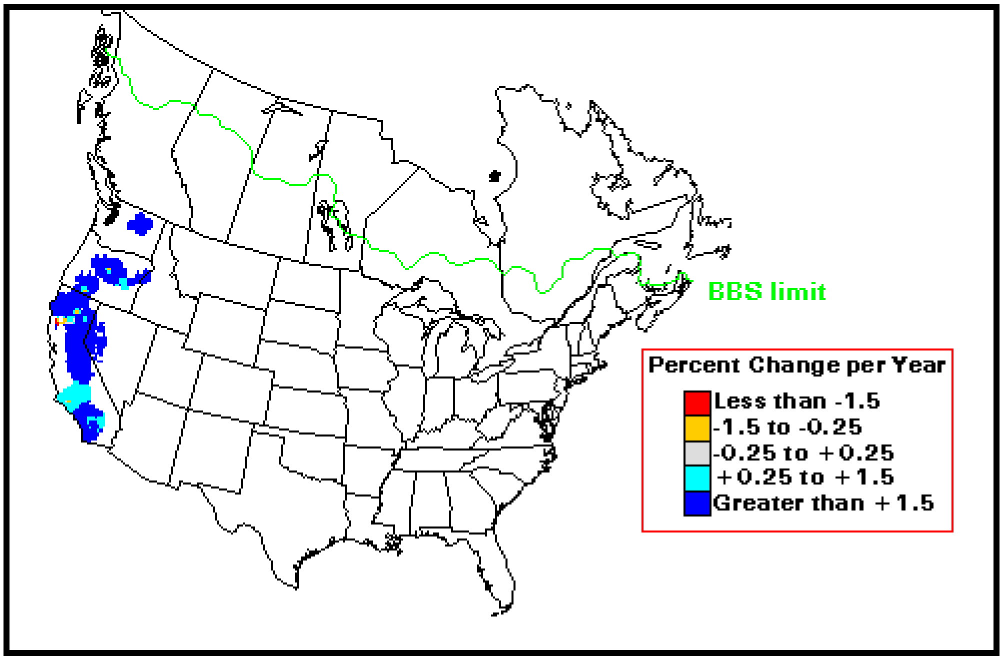
White-headed Woodpecker Status and Abundance Trends

Status

Although populations appear to be stable at present, this species is of moderate conservation importance because of its relatively small and patchy year-round range and its dependence on mature, montane coniferous forests in the West. Knowledge of this woodpecker's tolerance of forest fragmentation and silvicultural practices will be important in conserving future populations.

Trends

Figure 23. White-headed woodpecker Breeding Bird Survey population trend, 1966-1996



Source: Sauer et al. 2003

Factors Affecting White-headed Woodpecker Population and Status

Key Factors Inhibiting Populations and Ecological Processes

Logging

Logging has removed much of the old cone producing pines throughout the South Okanagan. Approximately 27, 500 ha of Ponderosa pine forest remain in the South Okanagan and 34.5 % of this is classed as old growth forest (Ministry of Environment Lands and Parks 1998). This is a significant reduction from the estimated 75% in the mid 1800s (Cannings 2000). The 34.5 % old growth estimate may in fact be even less since some of the forest cover information is incomplete and needs to be ground truthed to verify the age classes present. The impact from the decrease in old cone producing Ponderosa pines is even more exaggerated in the South Okanagan because there are no alternate pine species for the white-headed woodpecker to utilize. This is especially true over the winter when other major food sources such as insects are not available. Suitable snags (dbh>60cm) are in short supply in the South Okanagan.

Fire Suppression

Fire suppression has altered the stand structure in many of the forests in the South Okanagan. Lack of fire has allowed dense stands of immature Ponderosa pine as well as the more shade tolerant Douglas fir to establish. This has led to increased fuel loads resulting in more severe stand replacing fires where both the mature cone producing trees and the large suitable snags are destroyed. These dense stands of immature trees has also led to increased competition for nutrients as well as a slow change from a Ponderosa pine climax forest to a Douglas fir dominated climax forest.

Predation

There are a few threats to white-headed woodpeckers such as predation and the destruction of its habitat. Chipmunks are known to prey on the eggs and nestlings of white-headed woodpeckers.

There is also predation by the great horned owl on adult white-headed woodpeckers. However, predation does not appreciably affect the woodpecker population.

4.4.3 Flammulated Owl (*Otus Flammeolus*)

The flammulated owl is a Washington State Candidate species. Limited research on the flammulated owl indicates that its demography and life history, coupled with narrow habitat requirements, make it vulnerable to habitat changes. The flammulated owl is a species dependent on large diameter Ponderosa pine forests (Hillis *et al.* 2001). The mature and older forest stands that are used as breeding habitat by the flammulated owl have changed during the past century due to fire management and timber harvest.

Flammulated Owl Life History, Key Environmental Correlates, and Habitat Requirements

Life History

Diet

Flammulated owls are entirely insectivores; nocturnal moths are especially important during spring and early summer (Reynolds and Linkhart 1987). As summer progresses and other prey become available, lepidopteran larvae, grasshoppers, spiders, crickets, and beetles are added to the diet (Johnson 1963, Goggans 1986). The flammulated owl is distinctively nocturnal although it is thought that the majority of foraging is done at dawn and dusk.

Reproduction

Males arrive on the breeding grounds before females. In Oregon, they arrive at the breeding sites in early May and begin nesting in early June (Goggans 1986; E. Bull, personal communication). They call to establish territories and to attract arriving females. Birds pair with their mates of the previous year, but if one does not return, they often pair with a bird from a neighboring territory. The male shows the female potential sites from which she selects the one that will be used, usually an old pileated woodpecker or northern flicker hole.

Nesting

The laying of eggs happens from about mid-April through the beginning of July. Generally 2 - 4 eggs are laid and incubation requires 21 to 24 days, by female and fed by male. The young fledge at 21 -25 days, staying within about 100 yards of the nest and being fed by the adults for the first week. In Oregon, young fledge in July and August (Goggans 1986; E. Bull, personal communication). The young leave the nest around after about 25 days but stay nearby. In Colorado, owlets dispersed in late August and the adults in early October (Reynolds and Linkhart 1987).Sometimes the brood divides, with each parent taking one or two of the young. Adults and young stay together for another month before the young disperse.

Migration

The flammulated owl is one of the most migratory owls in North America. Flammulated owls are presumed to be migratory in the northern part of their range (Balda *et al.* 1975), and winter migrants may extend to neotropical areas in Central America. Flammulated owls can be found in Washington only during their relatively short breeding period. They migrate at night, moving through the mountains on their way south but through the lowlands in early spring.

Mortality

Although the maximum recorded age for a wild owl is only 8 years, 1 month, their life span is probably longer than this.

Habitat Requirements

General

The flammulated owl occurs mostly in mid-level conifer forests that have a significant Ponderosa pine component (McCallum 1994b) between elevations of 1,200 ft. to 5,500 ft. in the north, and up to 9,000 ft. in the southern part of its range in California (Winter 1974).

Flammulated owls are typically found in mature to old, open canopy yellow pine (Ponderosa pine [*Pinus ponderosa*] and Jeffrey pine [*Pinus jeffreyi*]), Douglas-fir (*Pseudotsuga menziesii*), and grand fir (*Abies grandis*) (Bull and Anderson 1978; Goggans 1986; Howie and Ritchie 1987; Reynolds and Linkhart 1992; Powers *et al.* 1996). In central Colorado, Linkhart and Reynolds (1997) reported that 60% of the habitat within the area defended by territorial males consisted of old (200-400 year) Ponderosa pine/Douglas-fir forest.

Flammulated owls are obligate secondary cavity nesters (McCallum 1994b), requiring large snags in which to roost and nest.

Nesting

Flammulated owls nest in habitat types with low to intermediate canopy closure (Zeiner *et al.* 1990). The owls selectively nest in dead Ponderosa pine snags, and prefer nest sites with fewer shrubs in front than behind the cavity entrance, possibly to avoid predation and obstacles to flight. Flammulated owls will nest only in snags with cavities that are deep enough to hold the birds, and far enough off the ground to be safe from terrestrial predators. The cavity is typically unlined, 11 to 12 in. deep with the average depth being 8.4 in. (McCallum and Gehlbach 1988). California black oak may also provide nesting cavities, particularly in association with ridge tops and xeric mid-slopes, with two layered canopies, tree density of 1270 trees/2.5 acres, and basal area of 624 $ft.^2$/2.5acres (McCallum 1994b). The nest is usually 3-39 ft. above the ground (Zeiner *et al.* 1990) with 16 ft. being the average height of the cavity entrance (McCallum and Gehlbach 1988).

Territories most consistently occupied by breeding pairs (>12 years) contained the greatest (>75%) amount of old Ponderosa pine/Douglas-fir forest. Marcot and Hill (1980) reported that California black oak (*Quercus kellogii*) and Ponderosa pine occurred in 67% and 50%, respectively, of the flammulated owl nesting territories they studied in northern California. In northeastern Oregon, Bull and Anderson (1978) noted that Ponderosa pine was an overstory species in 73% of flammulated owl nest sites. Powers *et al.* (1996) reported that Ponderosa pine was absent from their flammulated owl study site in Idaho and that Douglas-fir and quaking aspen (*Populus tremuloides*) accounted for all nest trees.

The owls nest primarily in cavities excavated by flickers (*Colates spp*.), hairy woodpeckers (*Picoides villosus*), pileated woodpeckers (*Dryocopus pileatus*), and sapsuckers (*Sphyrapicus spp*.) (Bull *et al.* 1990; Goggans 1986; McCallum 1994b). Bull *et al.* (1990) found that flammulated owls used pileated woodpecker cavities with a greater frequency than would be expected based upon available woodpecker cavities. There are only a few reports of this owl using nest boxes (Bloom 1983). Reynolds and Linkhart (1987) reported occupancy in 2 of 17 nest boxes put out for flammulated owls.

In studies from northeastern Oregon and south central Idaho, nest sites were located 16-52 ft. high in dead wood of live trees, or in snags with an average diameter at breast height (dbh) of >20 in. (Goggans 1986; Bull *et al.* 1990; Powers *et al.* 1996). Most nests were located in snags. Bull *et al.* (1990) found that stands containing trees greater than 20 in. dbh were used more often than randomly selected stands. Reynolds and Linkhart (1987) suggested that stands with trees >20 in. were preferred because they provided better habitat for foraging due to the open nature of the stands, allowing the birds access to the ground and tree crowns. Some stands containing larger trees also allow more light to the ground that produces ground vegetation, serving as food for insects preyed upon by owls (Bull *et al.* 1990).

Both slope position and slope aspect have been found to be important indicators of flammulated owl nest sites (Goggans 1986, Bull *et al.* 1990). In general, ridges and the upper third of slopes were used more than lower slopes and draws (Bull *et al.* 1990). It has been speculated that ridges and upper slopes may be preferred because they provide gentle slopes, minimizing energy expenditure for carrying prey to nests. Prey may also be more abundant or at least more active on higher slopes because these areas are warmer than lower ones (Bull *et al.* 1990).

Breeding

Breeding occurs in mature to old coniferous forests from late April through early October. Nests typically are not found until June (Bull *et al.* 1990). The peak nesting period is from mid-June to mid-July (Bent 1961). Mean hatching and fledging dates in Idaho were 26 June and 18 July, respectively (Powers *et al.* 1996).

In Oregon, individual home ranges averaged about 25 acres (Goggans 1986). Territories are typically found in core areas of mature timber with two canopy layers present (Marcot and Hill 1980). The uppermost canopy layer is formed by trees at least 200 years old. Core areas are near, or adjacent to clearings of 10-80% brush cover (Bull and Anderson 1978, Marcot and Hill 1980). Linkhart and Reynolds (1997) found that flammulated owls occupying stands of dense forest were less successful that owls whose territories contain open, old pine/fir forests.

Foraging

Flammulated owls prefer to forage in older stands that support understories, and need slightly open canopies and space between trees to facilitate easy foraging. The open crowns and park-like spacing of the trees in old growth stands permit the maneuverability required for hawk and glean feeding tactics (USDA 1994a).

In Colorado, foraging occurred primarily in old Ponderosa pine and Douglas-fir with an average tree age of approximately 200 years (Reynolds and Linkhart 1992). Old growth Ponderosa pine was selected for foraging, and young Douglas-firs were avoided. Flammulated owls principally forage for prey on the needles and bark of large trees. They also forage in the air, on the ground, and along the edges of clearings (Goggans 1986; E. Bull, personal communication; R. Reynolds, personal communication). Grasslands in and adjacent to forest stands are thought to be important foraging sites (Goggans 1986). However, Reynolds (personal communication) suggests that ground foraging is only important from the middle to late part of the breeding season, and its importance may vary annually depending upon the abundance of ground prey. Ponderosa pine and Douglas-fir were the only trees selected for territorial singing in male defended territories in Colorado (Reynolds and Linkhart 1992).

A pair of owls appear to require about 2-10 acres during the breeding season, and substantial patches of brush and understory to help maintain prey bases (Marcot and Hill 1980). Areas with edge habitat and grassy openings up to 5 acres in size are beneficial to the owls (Howle and Ritcey, 1987) for foraging.

Flammulated Owl Population and Distribution

Population

Historic

Current

There is only one recognized race of flammulated owl. There are several races described although they have not been verified. Some of these that may come about are: the longer winged population in the north part of the range, separated as *idahoensis*, darker birds from Guatemala as rarus, (winter specimen thus invalid), *meridionalis* from S. Mexico and Guatemala, *frontalis* from Colorado and borealis from central British Columbia to northeastern California.

Distribution

Historic

[No information to date]

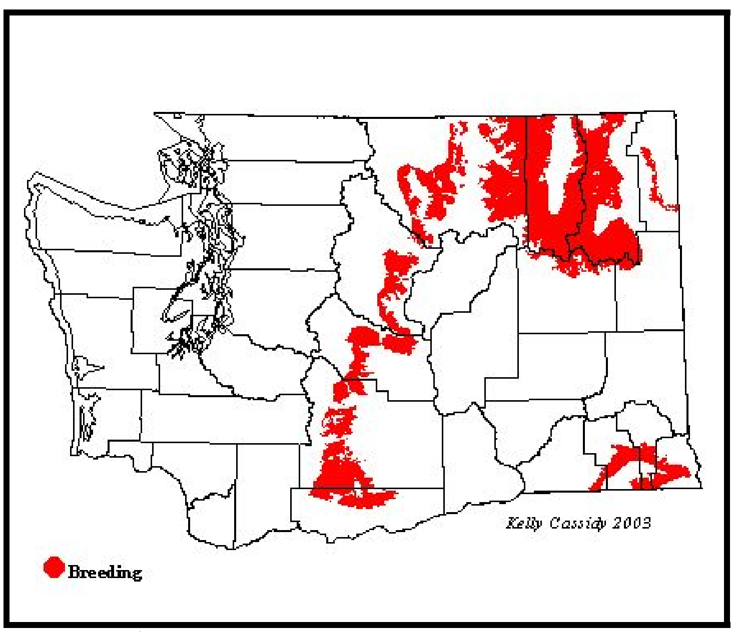
Current

Flammulated owl distribution is illustrated in **Figure 24**. Flammulated owls are uncommon breeders east of the Cascade in the Ponderosa pine belt from late May to August. There have been occasional records from western Washington, but they are essentially an east side species. Locations where they may sometimes be found include Blewett Pass (straddling Chelan and Kittitas Counties), Colockum Pass area (Kittitas County), and Satus Pass (Klickitat County).

Figure 24. Flammulated owl distribution

Source: Kaufman 1996

Figure 25. Flammulated owl distribution



Source: Kaufman 1996

Except for migration, this species is restricted to montane elevations with seasonally temperate climates. Climate may influence the distribution of the species indirectly through the prey base, (primarily nocturid moths) rather than directly through thermoregulatory abilities as this species tends to forage at night when the temperatures are lowest for the day (McCallum 1994b).

Flammulated Owl Status and Abundance Trends

Status

Flammulated owls are candidates for inclusion on the Washington Department of Fish and Wildlife endangered species list and are considered a species-at-risk by the Washington Gap Analysis and Audubon-Washington.

Because old-growth ponderosa pine is rarer in the northern Rocky Mountains than it was historically, and little is known about the local flammulated owl distribution and habitat use, the USFS has listed the flammulated owl as a sensitive species in the Northern Region (USDA 1994b). It is also listed as a sensitive species by the USFS in the Rocky Mountain, Southwestern, and Intermountain Regions, and receives special management consideration in the States of Montana, Idaho, Oregon, and Washington (Verner 1994).

Trends

So little is known about flammulated owl populations that even large scale changes in their abundance would probably go unnoticed (Winter 1974). Several studies have noted a decline in flammulated owl populations following timber harvesting (Marshall 1939; Howle and Ritcey 1987). However, more and more nest sightings occur each year, but this is most likely due to the increase in observation efforts.

Factors Affecting Flammulated Owl Population Status

Key Factors Inhibiting Populations and Ecological Processes

Disturbance (Natural or Managed)

The owls have been shown to prefer late seral forests, and logging disturbance and the loss of breeding habitat associated with it has a detrimental effect on the birds (USDA 1994a). Timber harvesting is often done in preferred flammulated owl habitat, and some of the species' habitat and range may be declining as a result (Reynolds and Linkart 1987b, Bull *et al.* 1990). Several studies have shown a decline in flammulated owl numbers following timber harvesting (Marshall 1957; Howle and Ritcey 1987).

A main threat to the species is the loss of nesting cavities as this species cannot create its own nest and relies on existing cavities. Management practices such as intensive forest management, forest stand improvement, and the felling of snags and injured or diseased trees (potential nest sites) for fire wood effectively remove most of the cavities suitable for nesting (Reynolds *et al.* 1989). However, the owls will nest in stands that have been selectively logged, as long as they contain residual trees (Reynolds *et al.* 1989).

The suppression of wildfires has allowed many ponderosa pines to proceed to the more shade resistant fir forest types, which is less suitable habitat for these species (Marshall 1957; Reynolds *et al.* 1989). Encroachment of conifers along ridgetops can also negatively impact the black oak component in the stand through competition of resources and shading resulting in loss of potential nest cavities for flammulated owls in live hardwood trees. Roads and fuelbreaks are often placed on ridgetops and the resultant removal of snags and oaks for hazard tree removal can result in the loss of existing and recruitment nest trees.

Flammulated owls are most susceptible to disturbance during the peak of their breeding season (June and July), which corresponds to the time when they are the most vocal. Clark (1988) cautions against the extensive use of taped calls, stating that they can disrupt courtship behavior. McCallum (1994b) mentions that owls are tolerant of humans, nesting close to occupied areas and tolerating observation by flashlight at night while feeding young. Wildlife viewing, primarily bird watching and nature photography has the potential to disrupt species activity and increase their risk of exposure to predation especially during the nesting season (Knight and Gutzwiller 1995) when birds are most vocal and therefore easier to locate.

The effects of mechanical disturbance have not been assessed, but moderate disturbance may not have an adverse impact on the species. Whether a nesting pair would tolerate selective harvesting during the breeding season is not known, however, mechanical disturbance that flushes roosting birds may be a threat to adult survival in October when migrating accipiters may be more common than in June, when the possibility of lost reproduction is greater (McCallum 1994b).

Pesticides

Aerial spraying of carbaryl insecticides to reduce populations of forest insect pests may affect the abundance of non-target insects important in the early spring diets of flammulated owls (Reynolds *et al.* 1989). Although flammulated owls rarely take rodents as prey, they could be at risk, like other raptors, of secondary poisoning by anticoagulant rodenticides. Possible harmful doses could cause hemorrhaging upon the ingestion of anticoagulants such as Difenacoum, Bromadiolone, or Brodifacoum (Mendenhall and Pank 1980).

Predators/Competitors

Predators include spotted and other larger owls, accipiters, long-tailed weasels (Zeiner *et al.* 1990), felids and bears (McCallum 1994b). Nest predation has also been documented by northern flying squirrel in the Pacific Northwest (McCallum 1994a).

As flammulated owls come late to breeding grounds, competitors may limit nest site availability (McCallum 1994b). Saw-whet owls, screech owls, and American kestrels compete for nesting sites, but flammulated owls probably have more severe competition with non-raptors, such as woodpeckers, other passerines, and squirrels for nest cavities (Zeiner *et al.* 1990, McCallum 1994b). Birds from the size of bluebirds upward are potential competitors. Owl nests containing bluebird eggs and flicker eggs suggest that flammulated owls evict some potential nest competitors (McCallum 1994b). Any management plan that supports pileated woodpecker and northern flicker populations will help maintain high numbers of cavities, thereby minimizing this competition (Zeiner *et al.* 1990).

Flammulated owls may compete with western screech-owls and American kestrels for prey (Zeiner *et al.* 1990) as both species have a high insect component in their diets. Common poorwills, nighthawks, and bats may also compete for nocturnal insect prey especially in the early breeding season (April and May) when the diet of the owls is dominated by moths. (McCallum 1994b).

Exotic Species Invasion/Encroachment

Flicker cavities are often co-opted by European starlings, reducing the availability of nest cavities for both flickers and owls (McCallum 1994a). Africanized honey bees will nest in tree cavities (Merrill and Visscher 1995) and may be a competitor where natural cavities are limiting, particularly in southern California where the bee has expanded its range north of Mexico.

Summary of Limiting Factors for Focal Habitats and Species

Several factors have altered the historic vegetation of much of the subbasin and thus, to varying degrees, the species that occupy it. These factors include grazing, timber management, mining, fire, agricultural and residential development, hydropower development and operation, and the spread of noxious weeds (NPPC 2002).

Grazing

Domestic sheep grazing at the turn of the century eliminated bighorn sheep from the area. Grazing has also affected riparian habitats and the condition of meadows and winter ranges. Grazing has altered plant species composition and biomass. Quantification is lacking.

Timber Management

Timber management activities, including extensive timber harvest in sections of the Lake Chelan subbasin, have resulted in the widescale removal of large ponderosa pine trees and subsequently reduced populations of dependant species, as well as snag dependent species in some areas. Logging has contributed to fragmentation of habitat, soil erosion, sediment delivery to creeks and streams, and changes to upland and riparian vegetative communities, including displacement of native plant communities with exotic species.

Mining

Mining currently is a minor activity in the Subbasin; however, in addition to the large claim at Holden, patented mining claims exist in private inholdings throughout the Subbasin. Specific information regarding impacts to wildlife is lacking.

Fire

Fire is the dominant agent of change in this Subbasin. Management attempts to influence ecosystem processes such as fire have had widespread and significant effects on the condition of wildlife habitat throughout the area, resulting in decreased habitat for some species and increased habitat for others. Fire suppression has created unnatural vegetation patterns. Forested stand conditions on north/northeast facing slopes have a higher number of smaller (pole-sized) stems per acre of Douglas-fir, lodgepole pine and *ceanothus*, causing the canopy to be more closed than would naturally have occurred. The bitterbrush component has increased on south/southeast facing slopes where grasses were more prominent than they are today (USFS 1998 in NPPC 2002).

Agricultural and Residential Development

Expansion of residential areas affects drainage, and homes built along streams have affected both water quality and the ability of the floodplain to function normally. Residential development has resulted in the loss of large areas of all focal habitat types. Disturbance by humans in the form of highway traffic, noise and light pollution, and various recreational activities have the potential to displace wildlife and force them out of their native areas or forces them to use less desirable habitat. Specific data are lacking.

Hydropower Development and Operation

Although Lake Chelan is a natural lake, its levels are now affected and controlled by the Lake Chelan Hydroelectric Project, a dam and powerhouse owned and operated by Chelan County Public Utility District, which is located at the mouth of the lake on the Chelan River. Fluctuations resulting from project operation have resulted in losses of riparian and wetland habitat along the shoreline, and erosion of banks.

Noxious Weeds

Noxious weeds are not prevalent in the upper Lake Chelan Basin (USFS 2000), but are pervasive in the lower basin where most focal habitats are located. Livestock grazing, development, timber management, recreation, and fire management all contributed to the introduction and spread of noxious weeds.

5 Aquatic Assessment

5.1.1 Introduction

The aquatic assessment for the Lake Chelan subbasin focuses on three focal species: bull trout, Kokanee, and Westslope cutthroat trout. An assessment of the focal species will help determine the health of the aquatic ecosystem in the subbasin. The aquatic assessment reflects the biological potential of the subbasin and the opportunities for restoration.

5.1.2 Focal Fish Species Selection and Rationale

Table 15. Fish focal species selection matrix for Lake Chelan Subbasin

Common Name	Status[1]		Native Species	Game Species
	Federal	State		
Bull trout	T	SC	Yes	Yes
Kokanee	No	FS	No	Yes
Westslope cutthroat trout	No	FS, SS	Yes	Yes

1 C = Candidate; SC = Species of Concern; T = Threatened; E = Endangered; FS = WDFW & Chelan PUD Focus Species, SS = Regional Forester's Sensitive Species

5.2 Bull Trout (*Salvelinus confluentus*)

Population Delineation, Status, and Characterization

Bull trout are a native species and listed as threatened under the federal ESA. The USFWS stated that bull trout were thought to be extirpated from Lake Chelan. Indigenous to the Lake Chelan subbasin, some remnant populations may still reside in remote headwater sections within the basin, but verified captures of bull trout have not occurred since the 1950s (Brown, 1984; Hagen, 1995) when they were commonly referred to as Dolly Varden.

Little is known about the historical status of this species in Lake Chelan. The historical population most likely exhibited both adfluvial and non-migratory (resident) life history patterns (Brown, 1984; Hagen, 1995). Many factors have been postulated on why bull trout may be extirpated from the basin. The floods of 1948-49 may have wiped out the bull trout's spawning areas, some pathogen may have reduced numbers, and fishing pressure may have reduced the number of remaining adults to a degree that they could not recover. Randy Morse reported in Brown (1984) that, "Dolly Varden fishing held up well until the fall of 1951, when the fish almost completely disappeared from the waters of Lake Chelan. They were seen in great numbers along the shores at Stehekin, covered with a gray fungus, sick and dying. Relatively few have been caught since that time." (FERC 2001).

While some biologists believe that it is more accurate to say that bull trout occupancy in the basin is unknown (Terrell, pers. comm. 2004), a recent Chelan Ranger District summary of the work of "numerous competent investigators" suggests that bull trout "have been absent from Lake Chelan for at least 20 years" (Archibald 2004). The methods used during this period of fieldwork investigation included creel census, stream surveys, electrofishing, and snorkeling. Since 1984 Chelan County PUD has conducted annual spawning ground surveys based on protocols set by WDW for surveys in 1981-82 (Archibald). Although the geographic and seasonal scope has not been comprehensive, the current body of evidence suggests expiration. According to another source, bull trout are still likely to occur in the lower Chelan River (De La Vergne, email comm. May 2004).

There is general agreement that bull trout occurred historically in Lake Chelan, the Chelan River and the Stehekin River and its tributaries. Opinions vary among biologists about which other streams in the subbasin supported bull trout. They probably occurred in Prince, Fish and Safety Harbor creeks on an incidental or opportunistic basis (Archibald 2004). Other biologists suggest they also probably occurred in Railroad and Twenty-five Mile creeks (Peven and De La Vergne, email comm. May 2004). De La Vergne contends that numerous other creeks on both the southern and northern shores could have been accessed by bull trout (email comm. May 2004).

Whatever the historical presence and extent of bull trout occupancy was, this species has not recovered. Why it has not recovered is unknown. The USFS suggests that introduced species have filled the predatory niche vacated by bull trout (USFS, 1999a, p. 28). Brown (1984) suggested angling pressure reduced spawner recruits to such a low level that populations were prevented from recovering. Regardless, their numbers remain at levels undetectable in creel surveys or tributary production surveys (DES, 2000a; DES, 2001c).

Population Management Regimes and Activities

Hatchery Effects

WDFW considered the reintroduction of bull trout to the lake and the Stehekin River. The agency decided that restoring bull trout in Lake Chelan is currently problematic because of the presence of brook trout, lake trout, and chinook salmon should not be attempted at this time. However, the agency believes that efforts to reintroduce non-migratory bull trout to various waters in the Chelan basin are justifiable. This could include tributaries and small mountain lakes that drain into the Stehekin River. Attempts to restore bull trout would be hampered by the presence of brook trout. The WDFW Draft Management Plan calls for the removal of angling limits for brook trout and possibly the use of electrofishing gear to physically remove brook trout from tributaries (Viola and Foster 2002). Increase in harvest of lake trout and chinook salmon may also be needed for bull trout to be self sustaining within the basin.

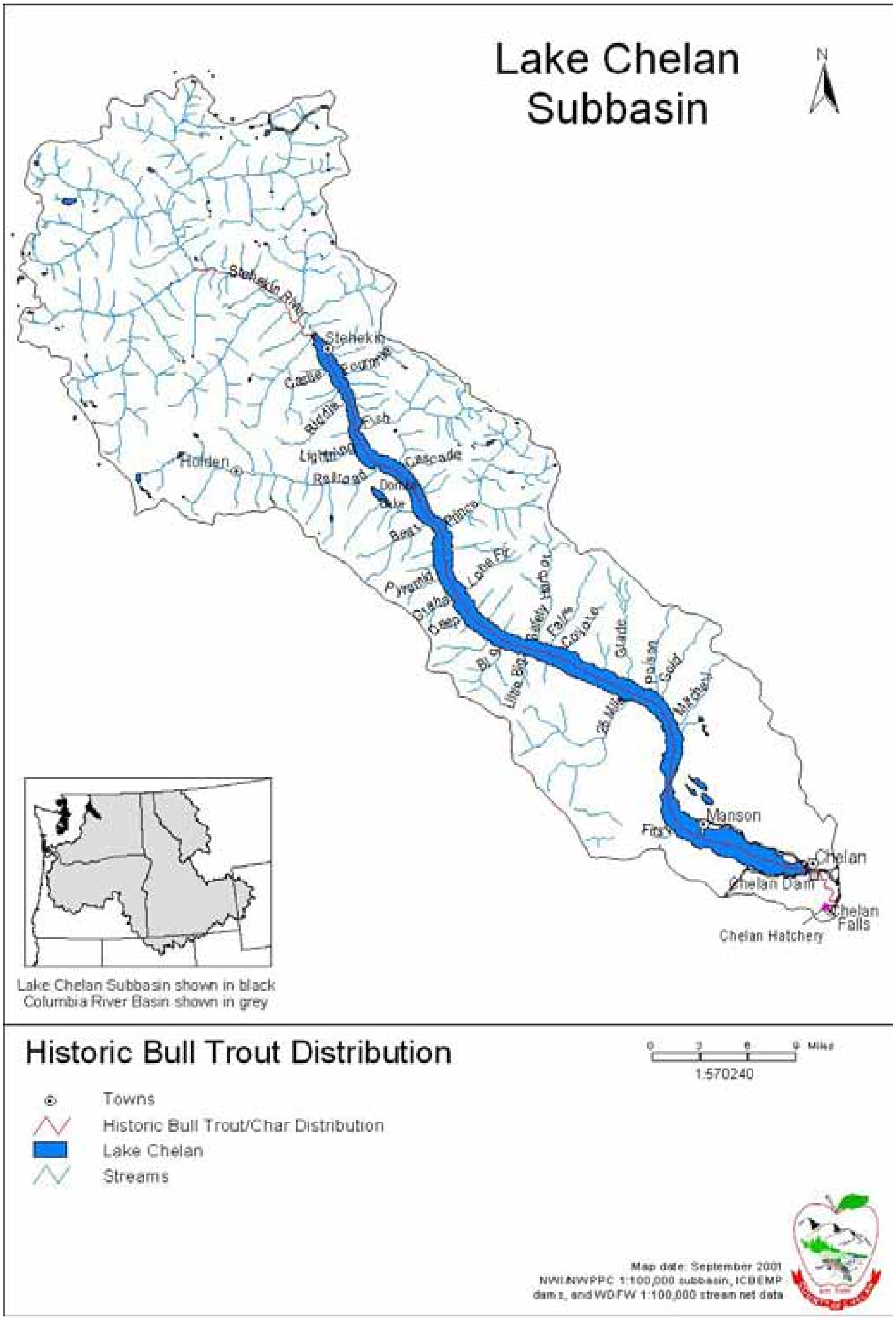
Hydroelectric Effects

Unknown.

Harvest Effects

Bull trout were actively fished until the early 1950s. Brown (1984) suggests, as mentioned above, that angling pressure reduced spawner recruits to such a low level that the populations were unable to recover and were eventually extirpated.

Figure 26. Known historical distribution of bull trout



NOTE: Stehekin tributaries should also be shown in red.

5.3 Kokanee (*Oncorhynchus nerka kennerlyi*)

Population Delineation, Status, and Characterization

Five primary tributaries contain the majority of the kokanee spawning in the Lake Chelan drainage and include First, Twenty-five Mile, Safety Harbor creeks, and two tributaries of the Stehekin River: Company and Blackberry creeks (Fielder 2000, DES 2001c). Since 1990, Company and Blackberry creeks have supported most of the kokanee spawning within the drainage, frequently upward of 95% (FERC 2002). Kokanee spawning surveys have been conducted annually in the aforementioned five tributaries to Lake Chelan and in five additional tributaries intermittently since 1984.

Annual spawning surveys on Company Creek suggest that kokanee survival decreased substantially between 1976 and 1981 (Brown 1984). This decline in kokanee spawners is believed to be a result of competition for food following introduction of mysis shrimp in 1968 and/or predation by chinook salmon that were first introduced in 1974 (Viola and Foster 2002).

From 1990 through 2000 spawning surveys indicate that kokanee runs are at much higher levels than have been seen since intensive surveys started in 1981 (Fielder, 2000). From 1984 through 1995, kokanee escapement in streams surveyed rarely exceeded 40,000 spawners. However, in 1996 and 1997, over 54,000 and 67,000 spawners, respectively, used the spawning streams. In 1999, the total estimated numbers of kokanee spawners (excluding spawning in the mainstem Stehekin River) exceeded 101,000 fish, which is the highest count on record (Fielder, 1999) and the escapement of 90,700 kokanee spawners in 2000 was nearly as high (Fielder, 2000).

One of the goals of fisheries investigations undertaken for the Lake Chelan Project relicensing application was to determine the efficacy of kokanee stocking/hatchery programs in terms of contribution to Lake Chelan spawning populations and sports fishery (DES, 2000a). DES (2000a) found that kokanee catch per unit effort (CPUE) was similar to previous studies since Chinook salmon and mysids have been established (see below; Brown 1984). Hatchery fish were determined to make up 40% of the fish sampled in the fishery, but growth pattern (determined by scale reading) was not confirmed for kokanee, and DES had relatively low confidence in their ability to determine hatchery origin of kokanee from scale analysis. Previous investigations (Peven 1989; Truscott and Peven 1988) were unable to find hatchery kokanee on the spawning grounds(See Appendix D)..

Population Management Regimes and Activities

Hatchery Effects

Kokanee have been planted in Lake Chelan since 1917 (Brown 1984). Origin of broodstock has varied over the years. From 1934 through 1966, kokanee fry were planted in the lake, with over 40,000,000 released (planting records for years prior to 1934 are not available) (FERC 2001). WDFW stocked only Lake Chelan stock kokanee fry into the lake from the early 1940s until about 1957. In 1957 Kootenay Lake stock kokanee were introduced into the lake as eyed eggs, and in 1966 Whatcom stock kokanee plus, Kootenay stock kokanee began to be stocked as eyed eggs and in later years as fry. Currently only Whatcom stock fry are being stocked (Viola and Foster 2002). Little is known about the success of these outplants, although since these fish were not indigenous to the lake, these plants were successful to some degree. However, many of the larger early plants were probably not successful as they were of swim-up fry placed in the lake in winter when plankton densities were low (FERC 2001).

Kokanee fry were planted extensively, with over 40,000,000 released in the main body of Lake Chelan from 1934 through 1966 (planting records for years prior to 1934 are not available) (FERC 2001). WDFW stocked only Lake Chelan stock kokanee fry into the lake from the early 1940's until about 1957. In 1957 Kootenay Lake stock kokanee were introduced into the lake as eyed eggs, and in 1966 Whatcom stock kokanee plus, Kootenay stock kokanee began to be stocked as eyed eggs and in later years as fry. Currently only Whatcom stock fry are being stocked (Viola and Foster 2002). Kokanee stocking records earlier than 1933 are missing. Little is known about the success of these outplants. Many of the larger early plants were probably not successful as they were of swim-up fry placed in the lake in winter when plankton densities were low (FERC 2001).

Prior to 1976 natural recruitment of kokanee was so successful that eventually they became over-populated and exhibited poor growth. Anglers were dissatisfied with the size of these fish. In order to increase the size of the kokanee WDFW stocked mysis shrimp (M*ysis relicta*) into the lake in 1968 to provide forage. Unfortunately, both young Kokanee (i.e. less than 10 inches in length) and Mysis compete for zooplankton species, and the mysis shrimp are mostly unavailable to larger kokanee because the diurnal migrations of Mysis shrimp do not correlate with the feeding habits of kokanee (Viola and Foster 2002).

As part of the 1975 application to relicense the Lake Chelan Project, Chelan PUD agreed to fund a WDFW hatchery program to plant 1.5 million kokanee fry annually into Lake Chelan. The primary goal of the enhancement program was to increase sport fishing opportunities by increasing the kokanee population. Under the terms of the cooperative agreement, Chelan PUD agreed to increase annual hatchery capacity at Chelan Falls FH to two million kokanee eggs (or 1.5 million fry). Kokanee releases since 1980 have totaled nearly 10,000,000 juveniles. However, only once have more than one million kokanee fry been planted in Lake Chelan since 1984, because the hatchery could not acquire sufficient eggs from outside sources to meet program objectives (FERC 2001).

WDFW began marking all kokanee released in the lake starting in 2003. During the annual creel survey, kokanee are examined for the presence of a mark that indicates the fish is of hatchery origin. They also collect scale samples and genetic samples from these fish that will allow an identification of origin (Viola and Foster 2002).

Harvest Effects

Catch rates of kokanee have varied considerably since 1940, when angler records were first available, and vary with both management actions and natural phenomena. Catch rates were highest (about 3.0 kokanee per hour) in the mid-1940s when the hatchery outplants were large. They were lowest in the 1950s and the 1980s. In the early 1950s, catch rates were less than 0.1 fish per hour. This may have been cause by a combined result of the catastrophic floods of 1948 and 1949 and the reduction in hatchery production. The population rebounded through the 1960s and 1970s (catch rates reached about 2.0 kokanee per hour) but then dropped to less than 0.1 fish per hour in the 1980s. This was likely a result of the introductions of landlocked chinook salmon, a predator of kokanee. In the 1990s, catch rates varied from 0.12 fish per hour to 0.338 fish per hour, depending on the season sampled (FERC 2001).

5.4 Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*)

Population Delineation, Status, and Characterization

In the late 1800s and early 1900s, cutthroat trout fishing was popular at Lake Chelan. Currently, few native cutthroat trout are caught by anglers (Brown 1984, Hagen 1995, DES 2000a, Hillman and Giorgi 2000), and creel and stream surveys suggests that cutthroat comprise a very small part of the Lake Chelan fish community. A combination of several factors have contributed to the decline of the cutthroat trout fishery: (1) the WDG trapped adult cutthroat trout from the Stehekin River, without replacement, to use as broodstock for a statewide hatchery program; (2) in 1917, WDG introduced non-native rainbow trout and kokanee salmon into the lake, most likely resulting in hybridization and decreased productivity; and (3) high harvest rates (4) logging in numerous watersheds, (5) contamination of Lake Chelan by mining in Railroad Creek, (6) urban development in the Wapato basin, (7) Lake level fluctuations and habitat changes resulting from hydroelectric production (Brown 1984, Fishery Mgmt.).

The population size of cutthroat trout in tributaries where they have been introduced (Twenty-five Mile Creek, Rainbow Creek, Railroad Creek, Pyramid Creek, Safety Harbor Creek, Mitchell Creek, Fish Creek, First Creek, Stehekin River, and Domke Lake), or their genetic relation to the historic native population, is not known. However, Brown (1984) found no historical or biological evidence of interbreeding with introduced Twin Lakes cutthroat trout. Further, the introduction of non-native rainbow trout and kokanee salmon into Lake Chelan by the WDG in 1917 has resulted in competition for spawning and rearing areas, as well as some hybridization and decreased productivity of cutthroat trout.

Relicensing studies in 1999 and 2000 were conducted to determine the current status of the fishery resources in Lake Chelan. An assessment of the salmonid population was made by electrofishing 100 meters (328 feet) in each of eight selected study streams. Cutthroat were captured in Grade, Safety Harbor, Prince and Fish creeks (DES 2000a). The status of the current sport fishery was evaluated with a roving creel investigation throughout the recreational fishery (DES 2000a). Only three cutthroat trout were noted during 1999 (CPUE of 0.001). Hagen (1997) did not estimate cutthroat trout CPUE in 1993 or 1994, while Brown (1984) estimated CPUE of 0.026 and 0.014 in 1981 and 1982, respectively.

Snorkeling surveys were also conducted in the spring, summer, and fall in 8 selected tributaries in 1999 and in 9 tributaries in 2000, to determine fish presence and use at the creek mouths and in the lower reaches of the streams, in particular by adult adfluvial trout and rainbow trout for staging upstream migration. Large adult rainbow and cutthroat trout were observed in Prince Creek in July of 1999. In 2000, resident trout were observed in all nine study streams and adfluvial trout were observed in First, Grade, Twentyfive Mile, Safety Harbor, Prince and Railroad creeks (DES 2000a).

The Lake Chelan population of native cutthroat trout usually begin spawning in mid-April and continue through June. The timing of trout spawning appeared to be delayed in 1999 (June 10 through August 10, with a majority spawning in July) by the high stream discharge in the tributaries due to the high snowpack, based on back-calculating time of emergence (DES 2001b). The timing of trout spawning appeared to be delayed in 1999, based on back-calculating time of emergence (DES 2000b). With the exception of Mitchell and Railroad creeks, spawning timing for the year 2000 was estimated to occur within the historical period (DES 2001a). Depth, velocity, and gradient barriers were identified by DES (2000a) that precluded cutthroat from reaching spawning areas at historic times.

The spawning timing of both adfluvial and resident trout appears to coincide with bridgelip sucker spawning, and competition for spawning habitat may occur. Since spawning substrate is limited in the stream channels (outside the Stehekin basin), the bridgelip sucker, which is a larger fish and occurs in greater numbers, may displace trout into less favorable spawning habitat. In addition, trout fry that emerge later than historic times, may encounter less favorable conditions and have lower survival (because of lower food sources available to them).

Population Management Regimes and Activities

Hatchery Effects

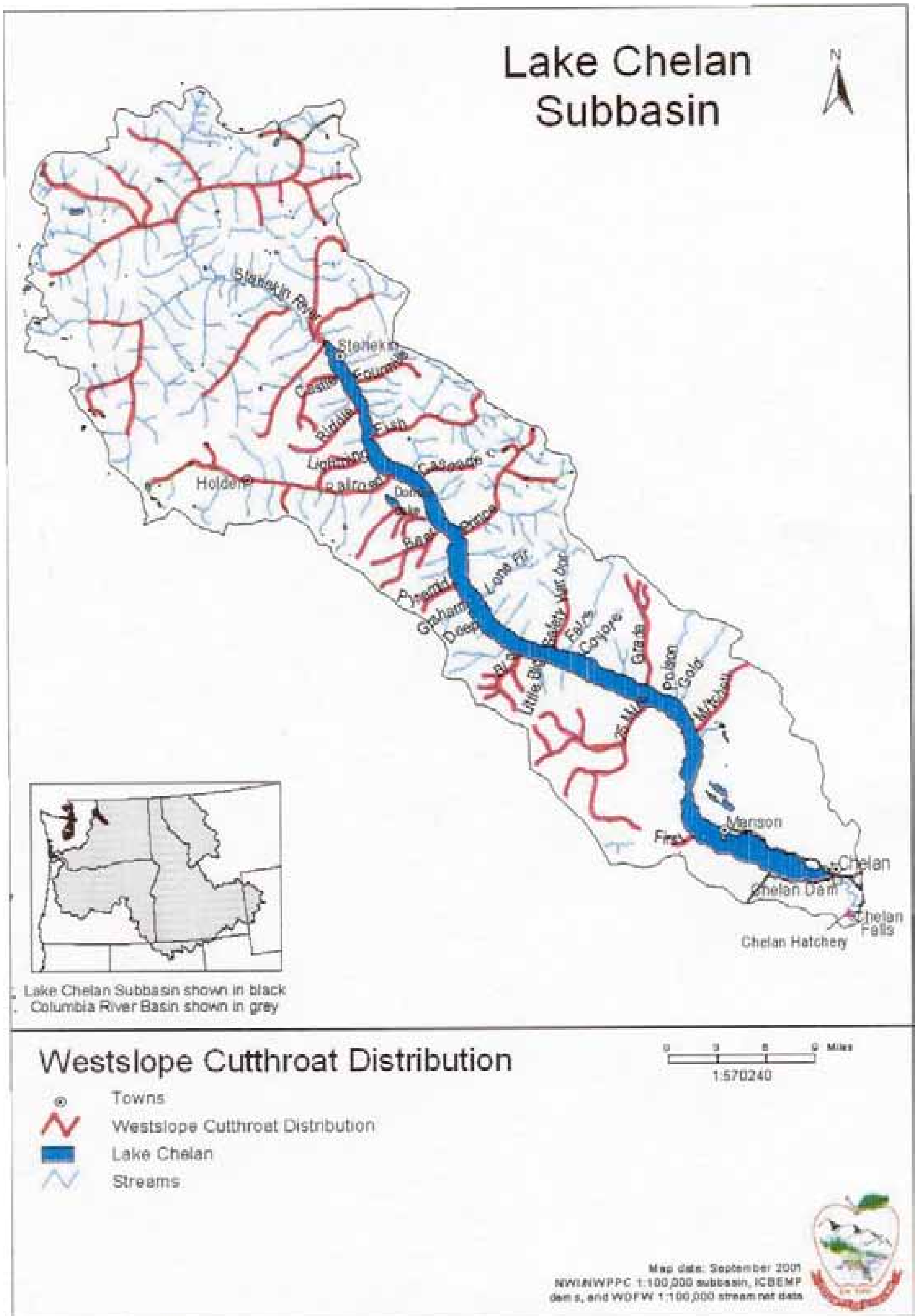
To improve the sport catch, WDG planted hatchery-reared cutthroat trout (Lake Chelan and Twin Lakes strains) in Lake Chelan and its tributaries sporadically from 1927 to 1976. The success of these plants is not known, but Brown (1984) speculated that the fish planted in the upper lake and Stehekin River during the later years had relatively high survival. An additional 87,498 cutthroat trout were released into Lake Chelan annually from 1993-94 and 1995-97. The results from the 1999 creel survey results (only 3 detected) suggest that these hatchery plants are not contributing to the creel of Lake Chelan (DES, 2000a).

Cutthroat trout have been planted into the following tributaries to Lake Chelan: Twenty-five Mile Creek, Rainbow Creek, Railroad Creek, Pyramid Creek, Safety Harbor Creek, Mitchell Creek, Fish Creek, First Creek, Stehekin River, and Domke Lake. Since 1980, juvenile cutthroat have been stocked into Lake Chelan on nearly an annual basis, totaling nearly 2,000,000 cutthroat through 1999 (FERC 2001).

The cutthroat egg collection program in the Stehekin River, which occurred prior to construction of the Lake Chelan Project, included some plants of cutthroat fry back into Lake Chelan. While these fry releases totaled nearly 8.5 million, but most fish were planted in other waters throughout the state. While these fry releases totaled nearly 8.5 million, most of the fish were planted in other waters, which showed that the fish were unable to replace themselves, which eventually led to the collapse of the Stehekin cutthroat population (FERC 2002).

WDFW will attempt to increase cutthroat abundance, while decreasing rainbow trout populations in the lake and lake tributaries, over a period of five years. Lake Chelan endemic Twin Lakes stock cutthroat are being hatchery reared and released in the lake. To establish spawning runs, eyed eggs are also being stocked in tributaries (Fishery Mgmt.). Rainbows compete and hybridize with cutthroat. Current stocking of 100,000 rainbow into the lake will be replaced by ever increasing numbers of cutthroat until only cutthroat are stocked. Eighty% of the catchable size cutthroat stocked in the lake will have their adipose fin clipped off to identify them as legal "keepers." Simultaneously, WDFW will establish regulations that allow the legal harvest of only adipose clipped cutthroat (Viola and Foster 2002).

Figure 27. Westslope cutthroat trout distribution



Hydroelectric Effects

Historically, tributary inflows to Lake Chelan may have served as important spawning and rearing areas for native cutthroat. In 1928 the Chelan Electric Company completed a dam at the outlet of the Lake and began lake level manipulation for hydroelectric production. (Previous dams were built at the outlet of the lake beginning in 1892, some raising the lake level several feet. However, most of these were washed out during floods.) Habitat conditions in these tributary mouths have been altered by the Lake Chelan Hydroelectric Project. The Initial rising of the lake flooded some spawning areas at the upper end (Lake Chelan Fishery Problems 1967). Other effects include changes to the character of material deposited in deltas, changes to riparian vegetation, and changes in quantity and quality of water at these sites. Effects are limited to adfluvial cutthroat. Cutthroat refugia upstream from the glacial trough-wall zone (nearly vertical walls created by the glacier) are naturally isolated and not affected by lake level fluctuation (USFS 1998 [in] USFS 1999a).

Recent on-going work by the U.S. Forest Service (USFS) and WDFW has shown that deposits of alluvial gravels in the lake at the mouths of most lake tributaries, coupled with the current mode of lake level management is preventing spring spawning fish, including cutthroat trout from ascending these tributaries to spawn until June or July (historically, they were believed to have spawned from April to mid-June). In recent years only the latest spawning remnants of the original cutthroat spawning run have been able to enter tributaries and spawn. This greatly delayed spawning results in late emergence of fry and loss of the early rearing months of growth. Progeny are smaller and more vulnerable to predation, less able to compete for forage, and enter the winter at a size and weight that may compromise their survival (Viola and Foster 2002).

Tributary trout populations estimated during relicensing studies, particularly cutthroat trout, appear to be lower than those estimated by Brown (1984). Barriers to upstream spawning migration, in the form of depth, gradient, and/or velocity, were identified in most tributary mouths investigated (DES 2000a). The Natural Sciences Working Group, convened as a part of the dam relicensing application process, concluded that these barriers were created as a result of hydro project operations since 1981, the term of the second license, and are, most likely, contributing to the decline of trout populations in Lake Chelan tributaries (Chelan PUD 2001a).

Harvest Effects

High harvest rates in the late 1800s and early 1900s, rapidly reduced the abundance and productivity of cutthroat trout, a species typically vulnerable to high fishery exploitation (FERC 2001). WDFW current regulations allow angling at the mouth of lake tributaries on July 1 and allows anglers to catch late spawners prior to their entry into the tributaries, furthering the decline of cutthroat in Lake Chelan. New regulations will allow harvest of only adipose clipped cutthroat; prohibit angling near the mouths of tributaries where cutthroat typically concentrate; and encourage anglers to harvest rainbow trout, (which interbreed and compete with cutthroat trout) and lake trout (which are cutthroat predators). In addition, the WDFW Draft Management Plan calls for the removal of angling limits for brook trout and possibly the use of electrofishing gear to physically remove brook trout from tributaries (Viola and Foster 2002).

5.5 Aquatic Habitat Conditions

Introduction

The subbasin has been divided into three acquatic assessment units: Lake Chelan proper, the tributaries to the lake, and the Chelan River (bypassed reach).

Lake Chelan is characterized by deep, cold, clear water, little organic material in the sediments, high dissolved oxygen levels, and relatively low nutrient levels. This type of water body supports cold-water fish species, especially trout (FERC 2001).

Tributaries to Lake Chelan from Manson to Stehekin are similar to each other morphometrically. They are deeply incised stream channels with cobble, boulder and large gravel substrate, with fair to poor channel stability. The fish-rearing habitat is fair, with an adequate number of pools and riffles, but spawning habitat is limited due to the lack of appropriate-sized gravel. In some of the tributaries, the amount of woody debris in the stream channels is also very low. Instream cover for fish is limited to cobbles and boulders with a few pieces of woody debris (FERC 2001).

The Stehekin River, which provides most of the inflow to the lake, is very different from the other tributaries. It is not deeply incised, has a lower gradient, has a wide, broad floodplain, and has a mostly gravel substrate. Because it is not deeply incised, it has more meanders, so rearing capacity is excellent. It has good pool-to-riffle ratio, good spawning gravel, and plenty of large woody debris (P. Archibald, pers. comm. 9/11/01).

Tributaries in the Wapato Basin, except First Creek, are intermittent. They have a lower gradient than up-lake streams and less channel confinement, but have a similar gravel/cobble/boulder substrate. Except for First Creek, they generally do not sustain enough flow for fish (Archibald, pers. comm.,9/11/01).

Most of the Chelan River (bypassed reach) is currently unsuitable habitat for fish, given that it is dewatered most of the year. However, numerous species of fish are found in salvage operations conducted by Chelan PUD (see fish stranding survey reports). As part of its new license to operate Lake Chelan Dam, Chelan PUD will provide a year-round flow of 80 cfs, with an increase up to 320 cfs during the spring run-off. In conjunction with modification to the spawning substrate in the lowest portion of the river, the constant river flow will enhance existing spawning habitat for chinook salmon and steelhead, making it possible for these anadromous fish to be restored in the lower reach where the river enters the Columbia River. The net effect of the proposed implementation plan will be improvement to the biological function of the Chelan River (Chelan PUD 2003).

5.5.1 Lake Chelan Assessment Unit

Aquatic Habitat Conditions

Water Quality

Lake Chelan is characterized as ultra-oligotrophic (deep, low biological productivity, and high water clarity) and is considered one of the most pristine water bodies in North America. Periodic monitoring of the water quality of Lake Chelan began in the 1960s, and the first detailed baseline water quality characterization of the lake was completed in 1987. The results of this baseline study, two subsequent comprehensive studies and 1999 field studies are summarized in FERC, 2001, but are not reproduced here. FERC lists summary statistics for various water quality parameters that were measured in 1987 (Patmont et al. 1989); in 1995 (Congdon 1995); in 1996 (Sargeant 1997); and in 1999 (Anchor 2000).

The 1999 (Anchor, 2000) data indicate that water quality conditions in the lake have been very stable since baseline monitoring began in 1987. The lake remains ultra-oligotrophic, as evidenced by low total phosphorus (TP) and chlorophyll *a* concentrations. Seasonal epilimnetic TP has met the TMDL of 4.5 μg/l in each year studied. The stable high water quality of the lake is also reflected in nearly constant (and relatively minor) hypolimnetic oxygen depression. Lake level fluctuations resulting from current Chelan PUD operations did not appear to influence TP concentrations within the lake, as determined from multiple regression analyses. The WDOE classifies Lake Chelan as Lake Class (FERC 2002).

Management of nutrient loading to Lake Chelan is a critical component to maintaining its high clarity and quality. The biological productivity of the lake is nitrate and phosphorous-limited (Brown 1984, Patmont et al. 1989). Levels of chlorophyll *a*, zooplankton, and benthic organisms have been reported as quite low, particularly in the Lucerne basin (FERC 2001). The Wapato Basin contains most of the developed land in the watershed and contributes a proportionally greater% age of the total nutrient and bacterial loading to the lake (Anchor, 2000). In 1993, the EPA approved a TMDL for phosphorous in Lake Chelan, established at the threshold for maintaining its ultra-oligotrophic condition.

Although lake level was statistically correlated with fecal coli form levels, this is likely an artifact of seasonal differences in waterfowl abundance, recreation use and irrigation return flow that coincide with lake level fluctuations. The highest lake levels are maintained during the summer by Project operations. As a result, the highest lake levels also coincide with the highest seasonal population in the area, peak irrigation operations and waterfowl activity. Waterfowl activities appear to be the most likely source of the observed bacterial inputs (Anchor 2000, Patmont et al. 1989). Nevertheless, fecal coli form levels in the Wapato Basin have not exceeded applicable state water quality standards.

Other water-quality deficiencies documented in the lake have included elevated bacterial levels near water supply intakes, elevated metals (iron, zinc and arsenic) in Railroad Creek due to runoff from abandoned contaminated tailings at the Holden Mine, and elevated pesticide residues in lake sediments and fish populations. There also have been releases of pesticides, especially DDT, and polychlorinated biphenyls (PCBs) into Lake Chelan. In 1998, Lake Chelan was listed as an Impaired and Threatened Water Body due to the detection of elevated concentrations of DDT metabolites and PCBs in fish tissues (WDOE 1998). The historical reservoir of DDT present in sediment deposits of the lake appears to be at least partially responsible for elevated DDT metabolite concentrations detected in fish tissues (Davis and Johnson 1994, Davis and Serdar 1996). These levels are expected to decrease slowly over time as a result of natural sedimentation processes (FERC 2001).

Temperatures in Lake Chelan range seasonally from 2° C to 23° C at the surface. Both basins in Lake Chelan develop a seasonal thermocline at an average depth of 100 to 150 feet during the summer (Beck 1991). Summer surface temperatures in the Wapato Basin reach 23° C, while summer temperatures in the upper portions of the Lucerne Basin average 15 - 16° C. Deep-water temperatures in both basins average 5 - 6° C throughout the year. Surface temperatures in the

Wapato Basin are cooler in winter than in the Lucerne Basin due to the smaller volume (and therefore lower heat retention capacity) of the Wapato Basin (FERC 2001).

Water Quantity

Lake Chelan has a volume of 15.8 million acre-feet based on a water-surface elevation of 1,100 feet. The majority of the precipitation within the watershed falls as snow (from 150 in./yr. in upper basin, to approximately 11 in/yr. in City of Chelan) and accumulates to create the winter snow pack. The spring melt of the winter snow pack primarily extends from April 15 through July 15; the annual peak runoff occurs in June (FERC 2002).

The discharge from Lake Chelan is regulated to assure, with a 95-percent probability, that the reservoir will refill to the normal full pool elevation of 1,098 feet on or before June 30 of each year for the purposes of aesthetics and recreational use. The average minimum elevation of the reservoir over 44 years of operation (1952-1995) has been approximately 1,084.2 feet USGS. The annual drawdown of the lake begins in early October and refill generally begins in April (FERC 2002). As part of Chelan PUD's new license, the timing of filling and draw down will be modified slightly.

A 1925 water right issued to the Chelan Electric Company (Water Permit No. 584, now known as Water Right Certificate No. 319) allows Chelan PUD to use 4,000 cfs from the Chelan River for Project operation. The permit reserves 33,000 acre-feet per year for allocation as consumptive-use water rights, but allows Chelan PUD to continue to use any unappropriated portion of that amount for hydroelectric generation. Under a 1992 agreement with WDOE, the amount set aside for allocation as consumptive-use water rights was increased to 65,000 acre-feet (FERC 2002).

Consumptive uses of surface water in the Chelan watershed include irrigation and domestic and municipal water supply. Water rights have been allocated mainly within the Wapato Basin. The majority of existing consumptive surface-water rights are for irrigation. This use represents 79% of the total annual quantity and 63% of the total instantaneous rate of use (FERC 2002). WDOE (1995) estimates that water permits and certificates have been issued for an instantaneous withdrawal rate of 293.2 cfs and annual use of 39,500 acre-feet.

Riparian / Floodplain Condition and Function

Similar to historical occurrence, riparian areas along the shoreline of Lake Chelan are small, distinctly linear, and concentrated in the few areas of relatively flat terrain on tributary alluvial fans, in the Stehekin area, and in a few scattered pockets near Manson. The basin is mostly steep-sided, due to its formation by glacial activity, and consists of coarse substrates, including cobbles, boulders and bedrock. These coarse substrates are generally unsuitable for plant colonization and limit the extent of riparian and emergent vegetation on most areas along Lake Chelan. The long and narrow basin results in heavy wave action during the frequently windy conditions, which limits the establishment of riparian vegetation along most of the shoreline (Kaputa and Woodward 2002, FERC 2001).

Shoreline erosion has impacted three of these areas. The Stehekin River is the largest tributary, followed by Railroad Creek. There are approximately 50 small tributaries leading into the lake. Assuming a riparian corridor of less than 100 feet around these small tributaries, the total length of riparian areas is less than 1% of the total shoreline length (FERC 2002).

The growth of riparian vegetation is further aggravated by the current operation of the Hydroelectric Project, which consists of holding the lake at full pool for an extended period of time (June 30 through September 30). The growth of native riparian vegetation has been affected by this operating regime, because riparian areas at the tributary mouths and near the Stehekin River are inundated for an extended period of time during the growing season (April through October). Historical maps and drawings show a wetland area near Manson of approximately 24 acres that was inundated by the Project (FERC 2002).

Lake Conditions and Function

Development of the Hydroelectric Project raised the natural lake level by 21 feet and current Project requirements keep the pool full for three months of the year (the summer season), leading to shoreline erosion. An inventory of shoreline erosion identified 232 individual erosion sites with a combined length of 18.8 miles, or about 16% of the 118.8 mile of shoreline (Chelan PUD, 2000a). There are examples of slope instability, including some slumping, rockslides and debris flows, along portions of the relatively steep shoreline These are not only related to the Hydroelectric Project, but also to other human activities and natural factors such as weathering of the slope materials and groundwater seepage through fine soils. The average rate of recession at erosion sites is estimated to be about 0.14 feet per year, which is equivalent to a total loss of about 0.3 acres per year (FERC 2002).

The annual drawdown of Lake Chelan, beginning in October, exposes shoreline areas, affecting aquatic food organisms for fish and limiting recreation access at some docks and some boat launches. However, the drawdown does provide beneficial opportunities for lakeshore property owners to repair docks, access pump intakes and shoreline areas. The drawdown has the additional beneficial effect of inhibiting the proliferation of nuisance aquatic vegetation, particularly the exotic noxious weed Eurasian milfoil, *Myriophyllum spicatum* (FERC 2002).

Areas of Special Concern

Stehekin Flats

At the head of the lake, the delta of the Stehekin River forms a broad flat area known as Stehekin Flats, much of which is covered by silty sand. Stehekin Flats is inundated most of the year when lake levels are high, but is exposed when the lake is drawn down in late winter through spring. In early spring, wind passing down the valley can pick up dust from Stehekin Flats and carry it downlake into Stehekin Landing (FERC 2002).

In the spring of 2000, a study was conducted (ARS 2001) at Stehekin Landing to measure the amount and nature of the dust and obtain information about conditions in which the dust reaches the landing. Dust events were found to occur under conditions of northerly winds in excess of 5.5 meters per second (about 12 mph) when the reservoir level was below 1,093 feet. Nephelometer readings show that the average optical quality of the air at Stehekin Landing was better than two Class I sites (Alpine Lakes Wilderness and Three Sisters Wilderness) and a Class II site (Columbia River Gorge National Scenic Area). Further, results indicate that the dust does not violate any health-related or other air quality standards (FERC 2002).

Environmental / Population Relationships / Limiting Factors

The biological productivity of Chelan lake is limited and several water-quality deficiencies have been documented. Levels of nitrates, phosphorous, chlorophyll *a*, zooplankton, and benthic organisms are low, especially in the Lucerne basin, preventing the lake from supporting high densities of fish. The productivity of the lake is also hindered by elevated bacterial levels near water supply intakes and elevated pesticide residues (DDT and PCBs) in lake sediments and fish populations. Firs Creek and the lower Chelan River (in the vicinity of Chelan Falls and Hatchery) are on the EPA's 303d list for impaired water quality due to dissolved oxygen and Mitchell Creek made the list for irregularities in pH levels. Also, elevated metals (iron, zinc and arsenic) were detected in Railroad Creek.

Riparian vegetation is limited along the shores of Lake Chelan due to the steep-sided configuration of the drainage, the thin, rocky soils, and heavy wave action (FERC, 2001). Human activities also influence the extent and condition of riparian zones. There is considerable residential development (primarily seasonal homes) near the mouth of the Stehekin River where high quality riparian and wetland habitat has been removed and low areas filled in. Although no dwellings were located near the other tributaries studied, there is development occurring within the alluvial fans of other tributaries to Lake Chelan.

Developed camping areas are located adjacent to the Stehekin River and Mitchell, Big, Prince, and Fish creeks. These camping areas were heavily used during the 1999 field studies. There is an undeveloped campsite located at Grade Creek. Although most recreation activity was concentrated within the designated camping areas and trails, some activity was noted within riparian habitats. This may result in the trampling or cutting of riparian vegetation and disturbance of wildlife. Campers and day-users were also observed at Grade Creek; uncontrolled use of this area was partly responsible for somewhat degraded riparian conditions near the mouth of the creek.

Grazing and lake level changes due to hydroelectric operations have also reduced riparian habitat which is important for water, food production, and cover for many species. Specifically, large trees, snags, and woody debris are limited; and some riparian areas, particularly from Mitchell Creek downlake, lack not only the large tree component but also mid- to low-level shrubs and forbs/grasses (USFS, 1998).

Lake Chelan fish have also been impacted by competition and low LWD levels. Competition between native fish species and introduced game fish has reduced and possibly eliminated certain native fish populations. The importance of the recreational fishery, which is based largely on introduced species, could limit the ability to reintroduce bull trout (Chelan PUD 2001a). LWD is considered a navigational hazard so much of it is removed, limiting cover and reducing in-stream complexity for fish.

5.5.2 Tributaries Assessment Unit

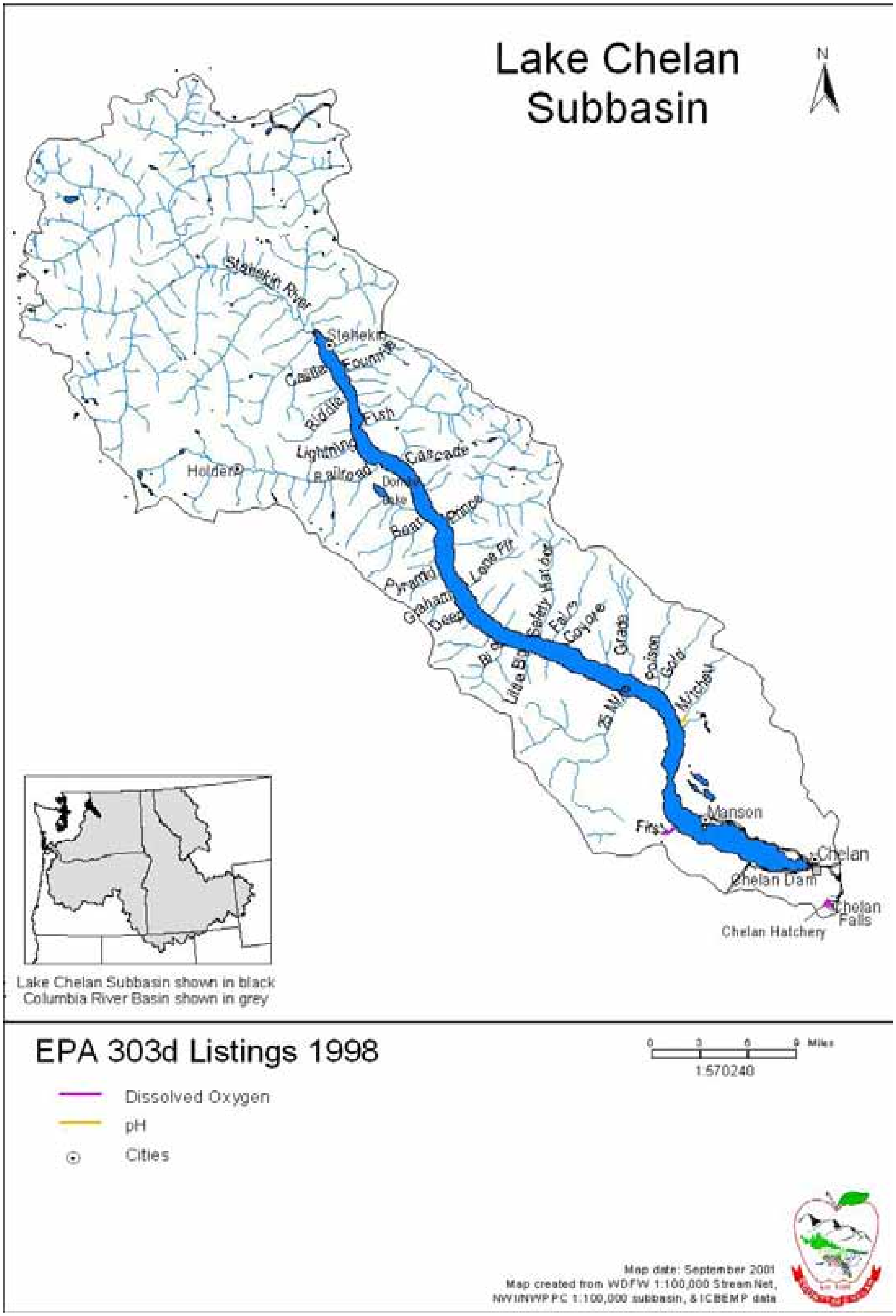
Aquatic habitat conditions vary greatly among the tributaries based on the configuration and aspect of the drainage, and human activities. Most of the tributaries have narrow, steep-walled drainages, deeply-incised channels, narrow bands of riparian vegetation alongside the streams, cobble and boulder substrate, low LWD, and fish passage barriers at the mouths of the tributaries. These conditions limit the quality, abundance and accessibility of fish rearing and spawning habitat. The Stehekin River, however, has a wide channel, a lower gradient, an extensive riparian zone and excellent spawning and rearing conditions. Appendix D shows characteristics of selected tributaries to Lake Chelan as recorded in September 1982 by Brown (1984) (in Chelan PUD 1998). This is a one-day record of certain characteristics of streams that support trout and kokanee. Appendix D gives a picture over time of flow characteristics for some of these streams.

Aquatic Habitat Conditions

Water Quality

The WDOE classifies Lake Chelan tributaries as Class AA (FERC 2002). First Creek is listed on the Environmental Protection Agency's (EPA's) 303d list for impaired water quality due to dissolved oxygen levels and Mitchell Creek is included due to pH levels (**Figure 28**).

Figure 28. EPA 303d water quality listings



Water Quantity

Table 16. Tributary maximum discharge and estimated base flow, April 4 - September 28, 2000

Creek	Maximum Peak Flow (cfs)	Date	Baseflow (cfs)	Date
First	97.8	April 14	7.6	May 15 – Sept 28
Mitchell	6.5	April 31	1.8	May 15 – Sept 28
Gold	11.1	April 20	0.7	June 1 – Sept 28
Grade	35.8	April 22	2.6	July 1 – Sept 28
Twenty-five Mile	145	May 23	8.5	July 1 – Sept 28
Safety Harbor	141[1]	June 8	5.3	July 1 – Sept 28
Prince	531	June 18	26.1	July 1 – Sept 28
Railroad	1,284	June 15	153	Aug 1 – Sept 28
Fish	526	June 21	24.6	July 1 – Sept 28
Stehekin River[2]	6,010	May 22	1,130	Aug 1 – Sept 28

1. Low confidence; gauge location was subject to excessive turbulence during high flows.
2. USGS year 2000 provisional data

Source: DES 2001a

Riparian/Floodplain Condition and Function

The USFWS National Wetlands Inventory (NWI) maps detailing the Lake Chelan area indicate small, localized wetlands along lake tributaries. Pockets of wetlands are identified on the Stehekin River delta entering the lake and within the bypassed reach exiting the lake. Chelan PUD conducted a detailed riparian zone investigation in 1999 along eight focus tributaries and the bypassed reach. The final riparian zone investigation report provides the results of the investigation (DES 2000d). Appendix C provides descriptions of the environmental setting and general conditions. According to the field investigations, conifer forest dominates the upper basin, and shrubsteppe habitat prevails in the lower basin. The Stehekin River was the only site in the study area with emergent wetlands (Kaputa and Woodward 2002).

The condition and extent of riparian habitats along the eight Lake Chelan focus tributaries varies considerably due to the drainage configuration, the aspect of the drainage, and the presence of human activities. Riparian habitat along many creeks (Grade, Mitchell, Box, Big, bear, Prince, and Fish) is limited by narrow steep-walled drainages or deeply incised creek channels. The Stehekin River, however, has a wide alluvial channel within a broad valley, is part of a long riparian corridor, and is surrounded by forests (Kaputa and Woodward 2002).

The aspect of the tributaries also influences the local microclimate and surrounding vegetation. Open conifer habitats and sandy soils with a lower proportion of organic material predominate at tributaries with a west to southwest aspect (Prince and Fish creeks). Sites with a northeast aspect (Box Canyon and Bear creeks), tend to have more dense vegetative cover within and adjacent to the riparian zone due to moisture retention and are characterized by heavy shade, cool temperatures, high humidity, and soils with high levels of organic material. Sites with a southwest aspect (Grade and Mitchell creeks) tend to have relatively drier shrubsteppe microclimates, narrow riparian corridors, and sandy soils low in organic material. The riparian zone at Mitchell Creek was recently enhanced by planting shrubs. This has resulted in a dense but narrow band of riparian shrub habitat (Kaputa and Woodward 2002).

Stream Channel Conditions and Function

Tributaries to Lake Chelan from Manson to Stehekin are similar to each other morphometrically. They are deeply incised stream channels with cobble, boulder and large gravel substrate, with fair to poor channel stability. The fish-rearing habitat is fair, with an adequate number of pools and riffles (FERC 2001), but spawning habitat may be limited by tributary access, the scarcity of spawning habitat, and possibly of species interactions. Cobbles and boulders dominate substrate in the study streams, with very little appropriately sized gravel for trout spawning (DES 2000b). The amount of woody debris in the stream channels is also very low. Instream cover for fish is limited to cobbles and boulders with a few pieces of woody debris (FERC 2001).

Tributaries in the Wapato Basin, except First Creek, are intermittent. They have a lower gradient than up-lake streams and less channel confinement, but have a similar gravel/cobble/boulder substrate. Except for First Creek, they generally do not sustain enough flow for fish (P. Archibald, pers. comm., 9/11/01).

The Stehekin River, which provides most of the inflow to the lake, is very different from the other tributaries. It is not deeply incised, has a lower gradient, has a wide, broad floodplain, and has a mostly gravel substrate. Because it is not deeply incised, it has more meanders, so rearing capacity is excellent. It has good pool-to-riffle ratio, good spawning gravel, and plenty of large woody debris (P. Archibald, pers. comm., 9/11/01).

Sediment deposits at the mouths of some tributaries have created barriers to fish spawning areas. A tributary barrier analysis that focused on eight representative tributaries showed sediment barriers in seven of the eight study tributaries (about 95% of all spawning occurs at these eight tributaries). These barriers become exposed to varying degrees when the lake level is drawn down below the normal maximum pool elevation of 1,100 USGS. All seven barriers are exposed when the lake is below an elevation of 1,090 USGS. These barriers are of concern whenever they are exposed, particularly during the period from April to June when cutthroat and rainbow trout are attempting upstream migration for spawning (FERC 2002).

A survey in the drawdown zone of nine study tributaries of Lake Chelan was conducted in April, 1999 (DES 2000b). Six of the tributaries had fish-passage barriers due to insufficient water depth, three of the tributaries had barriers due to high water velocity, and five of the tributaries had gradient barriers. **Table 17** lists the study tributaries, type of barrier present in each stream, lake elevation at which upstream passage would become possible and the dates in 1999 when passage became possible.

Table 17. Results of barrier assessment in alluvial fans, April 1999

Creek	Discharge (cfs)	Gradient barrier	Depth Barrier	Velocity Barrier	Passage Elevation (feet)	Date Passage Achieved
First	74	No	No	No	1,083	4/20/99
Twenty-five	107	No	No	No	1,083	4/20/99
Fish	27	Yes	Yes	No	1,090	6/3/99
Safety	30	Yes	Yes	Yes	1,092	6/12/99
Prince	73	Yes	Yes	Yes	1,092	6/12/99
Gold	19	No	Yes	No	1,092	6/12/99
Grade	23	Yes	Yes	No	1,094	6/16/99
Mitchell	27	Yes	Yes	No	1,095	6/17/99
Rail Road	176	No	No	Yes	1,097	6/23/99

Source: DES 2000b

Current operation of the hydroelectric project (e.g. the lake held at a constant elevation during summer months) does not allow adequate time for the streams to cut a channel through sediment deposits in the drawdown zone. The drawdown zone is exposed when the creeks have the lowest flows and insufficient energy to cut a channel through the sediment in the drawdown zone. The lake elevation is raised during the spring snowmelt when the streams have the highest energy and are most able to transport sediment. Instead of the stream cutting a channel through the sediment, additional material is transported and deposited in the drawdown zone. Depth, gradient and velocity barriers are caused by the Project operation because the lake elevation is raised and held constant when the creeks would have enough energy to cut a channel through the deposited sediments (FERC 2002). Under the terms of the new license, Chelan PUD, will physically remove some of the barriers, and will modify operations so the lake fills earlier, and is drawn down earlier giving fall storms the opportunity to cut through some of the sediment that accumulates at the tributary mouths (Chelan PUD 2003).

Environmental / Population Relationships / Limiting Factors

Natural production of trout in the tributaries to Lake Chelan (excluding the Stehekin River) is limited primarily by the scarcity of spawning habitat. Cobbles and boulders dominate substrate in the study streams, with very little appropriately sized gravel for trout spawning. Lake Chelan Hydroelectric Project operations and drainage configurations have also created fish-passage barriers to tributaries for spawning adfluvial trout due to insufficient water depth, high water velocity, and steep gradients (**Table 17**).

Human development and recreation activities influence the extent and condition of riparian zones. Developed camping areas are located adjacent to Mitchell Creek, Big Creek, Prince Creek, Fish Creek and the Stehekin River. There is an undeveloped campsite located at Grade Creek. These camping areas, particularly Mitchell Creek, Prince Creek, Fish Creek and the Stehekin River, were heavily used during field studies conducted in 1999. Although most recreation activity was concentrated within the designated camping areas and trails, some activity was noted within riparian habitats. This may result in the trampling or cutting of riparian vegetation and disturbance of wildlife. Campers and day-users were also observed at Grade Creek; uncontrolled use of this area was partly responsible for somewhat degraded riparian conditions near the mouth of the creek. However, recreation activities are a relatively insignificant factor influencing riparian habitats compared to human development. There is considerable residential development near the mouth of the Stehekin River where native vegetation has been removed and low areas filled-in. This development consists primarily of seasonal homes. Much of the development at the Stehekin River is adjacent to high quality riparian habitats, and human disturbance to riparian habitats and wildlife probably occurs. Although no dwellings were located near the other tributaries studied, there is development occurring within the alluvial fans of other tributaries to Lake Chelan (FERC 2002).

5.5.3 Chelan River/Bypassed Reach/Lake Chelan Project Tailrace Assessment Unit

Aquatic Habitat Conditions

Water Quality

The WDOE classifies the bypassed reach as Class A. Water quality parameters (nutrients, hardness, pH, conductivity, and fecal coli form levels) are expected to be similar to those in Lake Chelan because there are no significant sources of soluble minerals, nutrient input, sewage discharges or septic tank drainfields within the bypassed reach. Levels of oxygen and dissolved gas are within water quality standards because water entering the bypassed reach is within standards, the shallow stilling basin prevents formation of high dissolved gas levels, there are no sources of chemical or biological oxygen demand, and turbulent falls in Reach 3 expose flows to air. Shoreline erosion within the bypassed reach could affect turbidity under high flow conditions during spill events, but most of the highly unstable bank areas have been armored. Water quality in the tailrace is similar to that in the bypassed reach (FERC 2002).

When there is water in the bypassed reach, its temperature is determined by water temperatures in the lower end of Lake Chelan (range seasonally from 2° C to 23° C at the surface). Near-surface water from the lake enters the Chelan River as it flows over a shallow sill at the outlet of the lake. Water flowing through the penstock and discharged from the powerhouse into the tailrace is neither cooled nor heated in transit. Water spilled into the bypassed reach is either cooled or heated based on the total flow (mass volume) released, the width-to-depth ratio of the river, air temperature, and solar radiation. A small amount of ground water, about 2 cfs, enters the bypassed reach in the steep areas within the gorge, but the cooling effect of this flow is negligible except at low flows of less than 100 cfs (R2 and IA 2000, Chelan PUD unpublished data).

Water Quantity

Storage operations of the Lake Chelan Hydroelectric Project alter the natural hydrograph of the Chelan River, resulting in flows that are lower than natural inflows from April to June and higher than natural inflows from mid-August to February. No water is discharged into the bypassed reach (the Chelan River) except during the spring spill period, typically from May to July, and occasionally during fall/winter storms. The river conveys the combined flows spilled into the bypassed reach and the powerhouse discharge from the tailrace into the Columbia River at the community of Chelan Falls. When reservoir outflow is less than the hydraulic capacity of the Project (2,300 cfs), all of the outflow is directed through the powerhouse and into the tailrace which flows into the Columbia River (FERC 2002). The minimum, average and maximum daily flows for the Chelan River (powerhouse releases and spill from the dam) from 1905-1996 are 0 cfs, 2,041 cfs and 18,400 cfs, respectively (These flows, calculated values provided by Chelan PUD since Project development, were recorded as USGS Gage No. 12452500, Chelan River at Chelan, Washington). Perennial flow in the Chelan River will be provided as part of Chelan PUD's new license (Chelan PUD 2003).

Following construction of the powerhouse tailrace, several events have occurred that have resulted in channel modifications in the vicinity of the tailrace. Construction of the Rocky Reach Project resulted in back-watering of the Columbia River into the tailrace, and the construction of the railroad and Chelan Falls Road have resulted in the redirection of bypassed reach flows into the lower tailrace, about 1,300 feet downstream of the powerhouse. Redirection of bypass flows into the lower tailrace has resulted in the deposition of gravels and sediment into the lower 400 feet of the tailrace. The high quality of gravel and consistent flow regime from the powerhouse discharge provide conditions that support spawning by summer and fall chinook salmon (FERC 2002).

Riparian/Floodplain Condition and Function

The Chelan River descends through a steep-walled gorge to a broad floodplain and is bordered by shrubsteppe, open coniferous forest, cliffs, and urban areas. Vegetation is sparse, mostly restricted to upper and lower reaches, and consists primarily of deciduous trees and shrubs. (FERC 2002).

Stream Channel Conditions and Function

Prior to the development of the dam, the Chelan River naturally drained Lake Chelan. The 3.9-mile-long river channel, which is currently bypassed except during spillage flows, quickly changes from a shallow broad outwash plain to a narrow-walled valley, and then a rapid descending narrow gorge (FERC 2002).

The bypassed reach gradient varies widely (0.4-9.0%), and is relatively steep at several points. The bypassed reach is essentially an erosive feature and is divided into 4 sections (**Figure 5**). Reach 1 extends from the diversion dam (Lake Chelan outlet) downstream for 2.29 miles. The bed of this low gradient (1%) segment is primarily composed of large cobbles and small boulders, with gravels generally limited to the margins of the river channel. Streamside vegetation is scarce along this reach of the river and is mainly present as patches of cottonwoods and alders and isolated conifer stands which are significantly removed from the wetted perimeter for most of the year. Reach 1 just below the dam is approximately 100 feet to 140 feet wide; it then narrows toward the middle of the segment, and widens again at the lower end, spreading into multiple channels. Fish habitat within this reach is primarily riffles and runs, with some of the runs becoming pools at low flows (FERC 2002).

Reach 2 is 0.75 miles long. The gradient in this section is low (1%), similar to Reach 1. This section of the river is confined by steep hillslopes and, consequently, is much narrower than Reach 1. Large cobbles and boulders, somewhat larger than those in Reach 1, dominate the substrate. There is little streamside vegetation present in this reach. Fish habitat within this reach is primarily composed of riffles (FERC 2002).

Reach 3 is the gorge section of the bypassed reach and is 0.38 miles in length. It is characterized by a steep gradient (9%) channel that is located in a narrow canyon confined by steep bedrock walls. The river channel becomes as narrow as 15 to 20 feet wide through the gorge section. Bedrock and large boulders comprise much of the river bottom, and fish habitat conditions in this reach are generally poor due to the dominance of bedrock. The deep pools and groundwater that enters in this reach may provide thermal refugia during summer, but fish passage from Reach 3 to Reaches 1 and 2 is unlikely because of impassable barriers (waterfalls and cascades) (R2 and IA, 2000). Several deep plunge pools (20 feet to 30 feet depth) occur below waterfalls and steep bedrock cascades (FERC 2002).

Reach 4 is a 0.49-mile-long section of the bypassed reach that extends from the mouth of the gorge to the powerhouse tailrace. Reach 4 has a low gradient of 0.4% and a fairly unconfined channel. Reach 4 is an active alluvial zone where large and small boulders, cobbles and gravels originating from the highly erosive banks in Reaches 1 and 2 are deposited after being flushed through the gorge by high-flow events. Substrates in Reach 4 are composed of boulders and large cobbles in the thalweg and large gravels deposited on high bars by high flows. The river channel in this reach widens rapidly as it exits the gorge and enters the Columbia River floodplain, splitting into multiple channels about 1,000 feet upstream of the backwater of the Columbia River. The fish habitat in this reach is mostly composed of riffles and runs (FERC 2002).

Most of the Chelan River (bypassed reach) is currently unsuitable habitat for fish, given that it is dewatered most of the year. However, the tailrace area affords limited habitat and food organisms for juvenile fish (Chelan PUD 1998). Following construction of the tailrace, development of the Rocky Reach Project resulted in back-watering of the Columbia River into the tailrace. In addition, the placement of the railroad and Chelan Falls Road have resulted in the redirection of bypassed reach flows into the lower tailrace, about 1,300 feet downstream of the powerhouse. Redirection of bypass flows into the lower tailrace has resulted in the deposition of gravels and sediment into the lower 400 feet of the tailrace. In addition, erosion and transport of sand and gravel along the bypassed reach have partially filled a portion of the Project tailrace, creating approximately 1.8 acres of spawning habitat for anadromous salmonids (FERC 2002).

Fish species from the Rocky Reach reservoir have access to the tailrace channel up to the powerhouse and, during spill, to the lower end of the bypassed reach up to the natural barriers located in the gorge. The tailrace channel is always open to ingress and egress of fish from the Columbia River. Juvenile downstream migrant upper Columbia spring chinook and upper Columbia steelhead may temporarily reside in the tailrace channel. Bull trout have also been observed in this area. Chelan PUD has received undocumented reports of steelhead spawning in the tailrace (Tony Eldred, WDFW, September 26, 2000, Natural Sciences Working Group meeting). A spring spawning survey of the tailrace in 2001 found only one possible steelhead redd. During spill, the lower end of the bypass reach may be inhabited by juvenile chinook, steelhead, and bull trout, and adults of this species may explore this area during their migrations through the Columbia River (FERC 2002).

The fish present in the tailrace are likely transient residents that depend on the ecosystem of the Columbia River for food, cover, and other habitat needs for most life stages. The high quality of gravel and consistent flow regime from the powerhouse discharge are probably the reasons this area is heavily used by spawning fish of species that need areas of gravel with flowing water for spawning habitat. Juveniles resulting from this spawning activity would use the Columbia River for rearing and feeding (Kaputaand Woodward 2002).

Finally, an inventory of erosion identified 21 erosion sites along the bypassed reach (Chelan PUD, 2000a). All are on Chelan PUD land, but none are attributable to the hydroelectric project since the range of flows has not changed substantially, and the ongoing erosion processes are essentially the same as those that were occurring prior to Project construction.

Environmental / Population Relationships / Limiting Factors

The lack of perennial flow in the Chelan River limits the use of the lower reach of the river by Columbia River salmonids but will be enhanced with the return of year-round flows as part of Chelan PUD’s new license.

6 Inventory

6.1.1 Introduction

The inventory for the Lake Chelan subbasin summarizes fish and wildlife protection, restoration, and artificial production. Projects and programs focus on protection, restoration, and research. The inventory provides a baseline of activity from which future management decisions can be made and will have the greatest value when reviewed in conjunction with the limiting factors resulting from the assessment. A comparison of past actions with limiting factors should help assess the efficacy of current actions, indicate the areas of project gasp and guide management decisions.

6.2 Terrestrial

Shrubsteppe Focal Habitat and Brewer's Sparrow and Mule Deer Focal Species

Table 18. Projects related to shrubsteppe habitat and/or representative focal species

Responsible Agency	BPA Project # or Other Funder	Project Duration	Project Title	Project Description, Rationale, and Results
CCPUD	CCPUD $1,050.	Completed in 2003	Bitterbrush Planted for Mule Deer	**Project Description:** Bitterbush seed collected and cleaned and/or purchased from local seed crops and planted within the Chelan basin **Rationale & Results:** To provide cover and winter forage for mule deer
CCPUD	CCPUD $8,000	Completed in 2003	Deer Point Bitterbrush Progagation	**Project Description:** Propagated 10,000 bitterbrush plants to be planted in Deer Point fire area in 2004 (shrubsteppe & ponderosa pine habitat) **Rationale & Results:** To restore deer winter range
CCPUD	CCPUD, 33 man-days labor	Completed in 2003	Chelan Butte Habitat Management	**Project Description:** Enhanced and maintained deer and bird water and feeding structures

			Area	**Rationale & Results:** To improve wildlife habitat
CCPUD	CCPUD, 29 man-days labor	2002	Bitterbrush Seed Collection & Old Fence Removal	**Project Description:** Removed old, abandoned fence lines and collected bitterbrush seed for future plantings **Rationale & Results:** To improve mule deer winter range
CCPUD	CCPUD, 19 man-days labor	2000	Safety Harbor Creek Bitterbrush Pruning	**Project Description:** Pruned bitterbrush within one mile down-lake from Safety Harbor Creek **Rationale & Results:** Enhance forage on deer winter range
CCPUD & USFS	CCPUD, 49 man-days (1999) & 13 man-days (2000) labor	1999 & 2000	Water Guzzler Repair and Maintenance	**Project Description:** Repaired, rebuilt, and modified water guzzlers **Rationale & Results:** To provide water for big game, birds, and other wildlife
USFS	USFS	2002-Ongoing	Chelan Basin Cooperative Weed Control	**Project Description:** Treated noxious weeds along main roads **Rationale & Results:** To reduce weed infestation and degradation of shrubsteppe habitat and slow spread of Dalmation toadflax to 25-Mile Creek and areas uplake of Mitchell Creek
USFS	CCPUD	1,740 acres completed April, 2004; Ongoing	Deer Point Fire Winter Range Rehabilitation	**Project Description:** Seeded 1,740 acres of shrubsteppe winter range habitat; future efforts will focus on cheatgrass infestations **Rationale & Results:** To slow spread of noxious weeds
USFS	Holden Mine Remediation	Negotiations are ongoing	Holden Mine Remediation	**Project Description:** North Shore Land Acquisition: Acquire 1-200 acres of shrubsteppe habitat; Remove LC Reclamation District pipeline (Antilon Lake to Safety Harbor) burned in 1970

	Funds		Projects	and 2002 fires **Rationale & Results:** To prevent conversion of shrubsteppe habitat to residential uses; To prevent wildlife entanglement, collapse of buried pipeline and obstruction of migration corridors in shrubsteppe habitat
USFS	USFS	Ongoing	Natural Fuels Projects	**Project Description:** Mechanical treatments and prescribed burning in 25-Mile Creek and lower elevation north shore areas, and Slide Ridge and Forest Mountain areas on south shore **Rationale & Results:** To manage wildfires, protect wildlife habitat, and increase growth and availability of forage
USFS	CCPUD $17,500.	Completed in 2004	Deer Point Fire Emergency Rehabilitation	**Project Description:** Planted 10,000 bitterbrush plants on 4000 acres of shrubsteppe, ponderosa pine, and lodgepole pine habitat burned in Deer Point fire **Rationale & Results:** To reduce post fire erosion and weed infestation and restore deer winter range
USFS	CCPUD $7,500.	Completed in 2003	Deer Point Bitterbrush Inventory	**Project Description:** Conducted inventory of bitterbrush plant survival within 40,000 acres burned by Deer Point wildfire on north shore of Lake Chelan (shrubsteppe & ponderosa pine habitat) **Rationale & Results:** To determine where to restore bitterbrush for deer winter range
USFS	USFS	2001-2004	Rex Creek Fire Area: Crupina Weed Control	**Project Description:** Seeded 5000 acres of shrubsteppe and ponderosa pine habitat with native grass following 2001 Rex Creek fire; Crupina hand-pulled annually; herbicides will be used beginning in 2004 **Rationale & Results:** To control noxious weeds (e.g. Crupina)

				and prevent further degradation of mule deer and mountain goat winter range
USFS	CCPUD	2000	Grade & Camas Creeks Prescribed Burn	**Project Description:** Conducted 946 acre prescribed burn on mule deer and big-horn sheep winter range along north shore of LC **Rationale & Results:** To increase growth and availability of bitterbrush and other forage
USFS	CCPUD	1999	Bear Mtn. Native Grass Planting	**Project Description:** Planted native grasses on south shore of LC in area burned by 1976 fire **Rationale & Results:** To provide forage for deer on winter deer range and control noxious weeds
USFS	CCPUD	1999	Mitchell and Poison Creek Prescribed Burn	**Project Description:** Conducted 1300 acre prescribed burn on mule deer and bighorn sheep winter range along north shore of LC **Rationale & Results:** To increase growth and availability of bitterbrush and other forage
USFS	CCPUD	1998	30 Acre, So. Shore Forage Planting	**Project Description:** Planted buckwheat, balsamroot, and bitterbrush on 30 acres on south shore of LC burned by Tyee Fire **Rationale & Results:** To increase growth and availability of bitterbrush, grasses, and other forage for deer
USFS	CCPUD	1998	25-Mile Creek and Box Canyon prescribed	**Project Description:** Conducted 200 acre prescribed burn on mule deer winter range on south shore of LC **Rationale & Results:** To increase growth and availability of

			burn	bitterbrush and other forage
USFS	CCPUD	1998	Seed Propagation	**Project Description:** Propagated bitterbrush and other forage seed for south shore of LC **Rationale & Results:** To rehabilitate deer winter range
WDFW	CCPUD $17,500.	2002	Chelan Butte and Navarre Coulee Habitat Management Areas	**Project Description:** Purchased herbicides, fuels, seed, and fencing **Rationale & Results:** To improve deer winter range on south side of Lake Chelan
WDFW	CCPUD	2001	Mule Deer Habitat Use: GPS	**Project Description:** Purchased six GPS radio collars to place on adult mule deer does on winter range along north shore of LC **Rationale & Results:** To identify the habitat and areas used by deer to guide future habitat improvements
WDFW	CCPUD	2000	Bear Mountain Grass Seeding	**Project Description:** Seeded and re-seeded 25 acres of deer winter range and wildlife habitat with alfalfa, wild rye, and other grasses on south shore of LC **Rationale & Results:** To establish forage and control noxious weeds

Riparian Focal Habitat and Red-eyed Vireo and American Beaver Focal Species

Table 19. Projects related to riparian habitat and/or representative focal species

Responsible Agency	BPA Project # or Other Funder	Project Duration	Project Title	Project Description, Rationale, and Results
USFS	Holden Mine Remediation Funds	Negotiations are ongoing	Holden Mine Remediation Projects	**Project Description:** 100 acres of riparian, stream, and forested habitat would be treated to reduce or remove environmental contaminants associated with mine.. Other projects: Domke Lake Milfoil control, 60-70 acres of wetland/lacustrine habitat; Stehekin Delta, 50 acres of channels and islands created; Antilon Lake, stabilize lake level and limit recreation to designated sites; Dry Lake/Stink Creek, restore and diversify 10 acres wetland; Coyote Creek, plant cedars and stabilize roads on 50 acre wetland **Rationale & Results:** To provide, diversify, and restore riparian, wetland, and fisheries habitat, structure, and function
CCPUD	CCPUD, 33 man-days labor	Completed in 2003	Chelan Butte Habitat Management Area	**Project Description:** Created check dams in creek bottoms to slow erosion and enhance riparian habitat **Rationale & Results:** Improved fish and wildlife habitat
CCPUD	CCPUD, 11 man-days labor	2000	Riparian Plantings	**Project Description:** Planted cuttings (e.g., cottonwood, willow, and red-osier dogwood) in riparian bottom lands scoured by fires. **Rationale & Results:** To Restore riparian habitat

Ponderosa Pine Forest Focal Habitat and Pygmy Nuthatch, White-headed Woodpecker, and Flammulated Owl

Table 20. Projects related to ponderosa pine habitat and/or representative focal species

Responsible Agency	BPA Project # or Other Funder	Project Duration	Project Title	Project Description, Rationale, and Results
USFS	Holden Mine Remediation Funds	Negotiations are ongoing	Holden Mine Remediation Projects	**Project Description:** 100 acres of riparian, stream, and forested habitat would be treated to reduce or remove environmental contaminants associated with mine. Other projects: Remove LC Reclamation District pipeline (Antilon Lake to Safety Harbor) burned in 1970 and 2002 fires. **Rationale & Results:** To prevent wildlife entanglement, collapse of buried pipeline and obstruction of migration corridors in ponderosa pine habitat
USFS	USFS	To be implemented over next 5 yrs.	Pot Peak Fuel Reduction	**Project Description:** Will thin 565 acres of ponderosa pine **Rationale & Results:** To restore old-growth habitat and reduce risk of stand replacement in treated areas
USFS	USFS	Began in 2004	Antilon Lake and Alta Coulee Fuels Reduction	**Project Description:** Thinned 6,300 acres and conducted 12,500 acre prescribed burn on ponderosa pine habitat in area between Antilon Lake and Alta coulee **Rationale & Results:** To reduce fuels, establish a more frequent low intensity fire cycle, and restore ponderosa pine woodland, especially large fire resistant trees
USFS	USFS	Ongoing	Natural Fuels Projects	**Project Description:** Mechanical treatments and prescribed burning in 25-Mile Creek and lower elevation north shore areas, and Slide Ridge and Forest Mountain areas on south shore

				Rationale & Results: To manage wildlife, protect wildlife habitat, and increase growth and availability of forage
USFS	USFS	2001-2004	Rex Creek Fire Area: Crupina Weed Control	**Project Description:** Seeded 5000 acres of shrubsteppe and ponderosa pine habitat with native grass following 2001 Rex Creek fire; Crupina hand-pulled annually; herbicides will be used beginning in 2004 **Rationale & Results:** To control noxious weeds (e.g. Crupina) and prevent further degradation of mule deer and mountain goat winter range
USFS	CCPUD $17,500.	Completed in 2004	Deer Point Fire Emergency Rehabilitation	**Project Description:** Planted 10,000 bitterbrush plants on 4000 acres of shrubsteppe, ponderosa pine, and lodgepole pine habitat burned in Deer Point fire **Rationale & Results:** To reduce post fire erosion and weed infestation and restore deer winter range
CCPUD	CCPUD $8,000	Completed in 2003	Deer Point Bitterbrush Propagation	**Project Description:** Propagated 10,000 bitterbrush plants to be planted in Deer Point fire area in 2004 (ponderosa pine & shrubsteppe habitat) **Rationale & Results:** To restore deer winter range
USFS	CCPUD $7,500.	Completed in 2003	Deer Point Bitterbrush Inventory	**Project Description:** Conducted inventory of bitterbrush plant survival within 40,000 acres burned by Deer Point wildfire on north shore of LC (ponderosa pine & shrubsteppe habitat) **Rationale & Results:** To determine where to restore bitterbrush for deer winter range

Other Lake Chelan Subbasin Habitat Types

Table 21. Projects related to other Lake Chelan subbasin habitat types

Responsible Agency	BPA Project # or Other Funder	Project Duration	Project Title	Project Description, Rationale, and Results
CCPUD	CCPUD, 3 man-days labor	2002	Chelan Butte & Navarre Coulee HMAs: Kestrel Nest Boxes	**Project Description:** Built kestrel nest boxes **Rationale & Results:** Provided nesting sites for kestrels
CCPUD & USFS	CCPUD, 13 man-days labor	2000	Water Guzzler Repair and Maintenance	**Project Description:** Repaired, rebuilt, and modified water guzzlers **Rationale & Results:** To provide water for big game, birds, and other wildlife

6.3 Aquatic

Projects and programs listed in the aquatic assessment focus on conservation, restoration, and research.

Lake Chelan Assessment Unit

Table 22. Projects in Lake Chelan assessment unit

Responsible Agency	BPA Project # or Other Funder	Project Duration	Project Title	Project Description, Rationale, and Results
CCPUD		2003	Lake Chelan Hydroelectric Project (FERC #637): Offer of Settlement	**Project Description:** Enhances fish & wildlife habitat, revises lake level regime, stocks fish, replaces survey monuments, and protects resources. **Rationale & Results:** Provides protection, mitigation, & enhancement measures for resources affected by Lake Chelan Project.
DNR	ID#AL-41, Aquatic Lands Enhancement Account $12,887	4/2/04 emailed DNR for date	Willow Point Waterfront Park	**Project Description:** Enhanced recreation via picnic area, toilets, landscaping and enlargement of parking area. **Rationale & Results:** Developed public access site on Lake Chelan.
Ecology	Environmental Assessment	1984	Basic Water Monitoring Program: Fish Tissue and Sediment Samples	**Project Description:** Collected and analyzed fish (organic pesticides, PCBs, heavy metals) and sediment (priority pollutants excluding volatile organs) samples at ten locations in Washington, including Lake Chelan. **Rationale & Results:** Distinctive array of pollutants, usually at low concentrations. Elevated levels of DDT

				in the central region of the state.
Ecology	Environmental Assessment	1994	Washington State Pesticide Monitoring Program: Fish Tissue and Sediment	**Project Description:** Fourteen fish tissue samples and five sediment samples were collected from six sites, including Lake Chelan, and tested for pesticides, PCBs and other compounds. **Rationale & Results:** See Report at Ecology website.
NPS		1968	Lake Chelan National Recreational Area	**Project Description:** Established the Lake Chelan NRA. **Rationale & Results:** Provides public outdoor recreation; conserves resources; minimizes conflicts.
USFS		1995-2000	Watershed Analyses	**Project Description:** Completed watershed analyses North Shore, Middle, and Upper Chelan. **Rationale & Results:** To develop goals and priorities for ecosystem restoration projects and meet requirements of NWFP.
WDFW	WDFW (including partnerships & cost-sharing)	1974-78, 1990-Ongoing[?]	WDFW landlocked chinook stocking	**Project Description:** Introduced landlocked chinook salmon to provide a trophy fishery for Lake Chelan. **Rationale & Results:** Landlocked chinook population has remained at low levels in recent years but has been a very popular sport fishery.
WDFW (formerly WDG)	Chelan PUD	1985-86, 1993-94	Lake Chelan Fishery Investigations	**Project Description:** Creel Censuses (Kokanee and Rainbow Trout) and plankton surveys. **Rationale & Results:** Low population densities of

				plankton in Lake Chelan, Kokanee: Low catch per unit of effort.
WDFW & and Chelan Ranger District	Lake Chelan Sportsman's Association	1996	Large Woody Debris Removal	**Project Description:** Over 700 tons of LWD (flood debris) removed from Lake Chelan. **Rationale & Results:** Some of the LWD used to enhance fish habitat in Prince and Safety Harbor creeks.

Tributaries Assessment Unit

Table 23. Projects in the tributaries assessment unit

Responsible Agency	BPA Project # or Other Funder	Project Duration	Project Title	Project Description, Rationale, and Results
CCPUD		2003	Lake Chelan Hydroelectric Project (FERC #637): Offer of Settlement	**Project Description:** Enhances fish & wildlife habitat, removes tributary barriers, stocks fish, and protects resources. **Rationale & Results:** Provides protection, mitigation, & enhancement measures for resources affected by Lake Chelan Project.
CCPUD	CCPUD	1984 – Ongoing	Kokanee and Chinook Spawning Surveys	**Project Description:** Conduct annual spawning surveys (First, Twentyfive Mile, Safety Harbor, Company & Blackberry creeks). **Rationale & Results:** To determine tributaries used by kokanee and chinook for spawning. Annual reports summarize results.
Ecology	Environmental Assessment	1996	Effects of Holden Mine on Railroad Creek	**Project Description:** Studied effects of Holden Mine on water sediments and benthic invertebrates of Railroad Creek. **Rationale & Results:**
USFS		1995-2000	Watershed Analyses	**Project Description:** Completed watershed analyses for First/Twenty-five Mile Creek, & Antoine creeks. **Rationale & Results:** To develop goals and priorities for ecosystem restoration projects and meet

				requirements of NWFP.
USFS	WSDOT/USFS	1999-2000	First Creek Project	**Project Description:** Replaced 2 highway culverts with bridges, applied longterm revegetation measures to stabilize streambanks and restore ecosystem function, and installed rock/log channel structures to modify in-channel passage problems and provide resting and spawning habitat **Rationale & Results:** Physical channel connectivity restored between Lake Chelan and National Forest waters in First Creek. Post-project spawning surveys reported 1215 kokanee, a 123% increase in a 17-year average of 544 spawners. Use of the restored habitat is taken as evidence of immediate success of the project.
USFS, Wenatchee National Forest		1992-94	Mitchell Creek Watershed Restoration	**Project Description:** Constructed several fish habitat enhancement structures in Mitchell Creek. **Rationale & Results:** May account for an increase in trout population in this creek.
WDFW (formerly WA. Dept. of Game)	CCPUD	1984	Lake Chelan Fishery Investigation Report	**Project Description:** Identified tributaries that support adfluvial trout and kokanee, and estimated standing crop and linear meters of stream accessible to rainbow trout and kokanee (BROWN 1984). **Rationale & Results:** Twenty-three tributaries support adfluvial trout and kokanee populations. Accessible stream: 10,002 linear m (rainbow trout) & 6,044 (kokanee). Standing Crop: 18,104 (rainbow trout) & 658 (cutthroat trout).

WDFW (formerly WA. Dept. of Game)	CCPUD	2000	Population Study: Electrofishing	**Project Description:** Assessed salmonid population by electrofishing in eight study streams(DES 2000a). **Rationale & Results:** Determined efficacy of the kokanee, cutthroat and rainbow trout stocking/hatchery programs.
WDFW (formerly WA. Dept. of Game)	CCPUD	1999-2000	Snorkeling Surveys: Adult Adfluvial Trout and Rainbow Trout	**Project Description:** Conducted snorkeling surveys of eight tributaries in 1999 & nine in 2000. **Rationale & Results:** Determined fish presence and use at creek mouths and in lower reaches of the streams, for staging upstream migration.
WDFW(formerly WDG)		1965 & 1991	Twenty-five Mile Creek Spawning Channel	**Project Description:** Replaced spawning gravel in the Stehekin River and constructed spawning channel on Twenty five Mile Creek **Rationale & Results:** Restored kokanee spawning habitat after the floods of 1948 / 49.
WDFW, DOT, WSP, USFS (Chelan Ranger District), CCCD, WCC, LCSA, Save Chelan Alliance, and three private landowners		1999	First Creek Culvert Removal and Bridge Construction	**Project Description:** Removed two state highway culverts and replaced them with bridges. **Rationale & Results:** Restored kokanee and rainbow trout access to and production from several miles of First Creek. 1,215 Kokanee Spawners in First Creek during 1999, a 123% increase over 17-yr. avg. of 544.

WDFW & and Chelan Ranger District	LCSA	1996	LWD Placement: Prince and Safety Harbor Creeks	**Project Description:** LWD (flood debris from Lake Chelan) placed in Prince and Safety Harbor creeks to enhance fish habitat enhancement would be beneficial to cutthroat trout, rainbow trout, and kokanee. **Rationale & Results:** Several of the LWD pieces captured bedload creating vertical drops & passage barriers at low flow.

Chelan River, Bypassed Reach, and Lake Chelan Project Tailrace Assessment Unit

Table 24. Projects in the Chelan River, Bypassed Reach, and Lake Chelan Project Tailrace assessment unit

Responsible Agency	BPA Project # or Other Funder	Project Duratio n	Project Title	Project Description, Rationale, and Results
CCPUD		2003	Lake Chelan Hydroelectric Project (FERC #637): Offer of Settlement	**Project Description:** Restores flow to bypassed reach, enhances salmon & steelhead spawning habitat, and protects resources. **Rationale & Results:** Provides protection, mitigation, & enhancement measures for resources affected by Lake Chelan Project.

7 Interpretation and Synthesis

7.1 Terrestrial-

7.1.1 Introduction

The terrestrial interpretation and synthesis for the Lake Chelan subbasin plan summarizes information in terms of key findings and advances hypotheses for existing conditions. The section reviews each of the focal species in spatial and linear contexts, comparing current and historic conditions. For further information related to wildlife, see Appendix A.

7.1.2 Key findings and hypothesis

Shrubsteppe

Focal species: Brewer's sparrow, mule deer

Key findings

- Degradation of habitat from intensive grazing and invasion of exotic plant species.
- Fire management, either suppression or over-use, and wildfires.
- Invasion and seeding of crested wheatgrass and other introduced plant species which reduces wildlife habitat quality and/or availability.
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities.
- Human disturbance during breeding/nesting season, parasitism.

Working hypothesis

1. Reduction of habitat diversity/function has occurred from invasion of exotic vegetation, wildfires, and grazing.
2. Habitat loss and fragmentation, coupled with poor quality of existing habitat has resulted in the extirpation or reduction of shrubsteppe obligate species.

Eastside (Interior) Riparian Wetlands

Focal species: beaver, red-eyed vireo

Key findings

- Habitat degradation from livestock overgrazing which can widen channels, raise water temperatures, reduce understory cover, etc.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.

Working hypothesis

3. Loss of habitat diversity/function has resulted from invasion of exotic vegetation and grazing.

4. Habitat loss and fragmentation, coupled with poor quality of existing habitat has resulted in the extirpation or reduction of riparian obligate species.

Ponderosa pine

Focal species: white-headed woodpecker, flammulated owl, pygmy nuthatch

Key findings

- Timber harvesting has reduced the amount of old growth forest and associated large diameter trees and snags.

- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.

- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.

- Overgrazing has resulted in lack of recruitment of sapling trees, particularly pines.

- Invasion of exotic plants has altered understory conditions and increased fuel loads.

- Fragmentation of remaining tracts has negatively impacted species with large area requirements.

- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.

Working hypothesis

5. Habitat has been lost due to timber harvest, fire reduction (and subsequent intensive wildfires), mixed forest encroachment, and development.

6. Habitat diversity and function has been lost from invasion of exotic vegetation and grazing.

7. Loss of habitat and habitat diversity/function has resulted in extirpation or reduction of ponderosa pine obligate species.

7.1.3 Reference Conditions

Shrubsteppe

Abundance and productivity

Table 25. Abundance and productivity currently, historically and projected

	Current	Historic	Potential	Future w/no action
Brewer's sparrow	Low	Moderate	Low-Moderate	Potentially Extinct
Mule deer	Moderate	Moderate-High	Moderate	Low-Moderate

Near term opportunities

- Preserve existing high quality and restorable shrubsteppe habitat, with emphasis placed on adjacency to protected ownerships (public land, conservation easements), prioritize by size and connectivity of existing habitat patches.
- Control undesirable exotic vegetation using integrated pest management principals to control both existing weeds and addressing factors that contribute to weed establishment and dominance.
- Re-plant desired natives in conjunction with weed control activities.
- Integrate shrubsteppe habitat composition objectives with fire management planning.

Eastside (Interior) Riparian Wetlands

Abundance and productivity

Table 26. Abundance and productivity currently, historically and projected

	Current	Historic	Potential	Future w/no action
Red-eyed vireo	Low-Moderate	Moderate	Low-Moderate	Low-Moderate
Beaver	Low	Moderate	Low-Moderate	Low-Moderate

Near term opportunities

- Preserve and restore existing high quality and restorable riparian wetlands habitat, with emphasis placed on restoration of protected ownerships (public land, conservation easements), prioritize by size of potential riparian habitats.
- Establish riparian buffer zones to reduce negative effects of livestock, recreation, and vegetation manipulations.

- Control undesirable exotic vegetation using integrated pest management principals to control both existing weeds and addressing factors that contribute to weed establishment and dominance.
- Re-planting desired natives in conjunction with weed control and establishment of protective buffers.

Ponderosa pine

Abundance and productivity

Table 27. Abundance and productivity currently, historically and projected

	Current	Historic	Potential	Future w/no action
Pygmy nuthatch	Low	Moderate	Low-Moderate	Potentially Extinct
White-headed woodpecker	Low	Moderate	Low-Moderate	Potentially Extinct
Flammulated owl	Low	Moderate	Low-Moderate	Potentially Extinct

Near term opportunities

- Protect remnant large diameter ponderosa pines, and retain all snags and large diameter downed logs where feasible.
- Plan fire management activities to re-establish native pine savannah characteristics.

Summary of abundance and productivity

Table 28. Summary of abundance and productivity

	Current	Historic	Potential	Future w/no action
Terrestrial				
Shrubsteppe				
Brewer’s sparrow	Low	Moderate	Low-Moderate	Potentially Extinct
Mule deer	Moderate	Moderate-High	Moderate	Low-Moderate
Riparian				
Red-eyed vireo	Low-Moderate	Moderate	Low-	Low-Moderate

			Moderate	
Beaver	Low	Moderate	Low-Moderate	Low-Moderate
Ponderosa pine				
Pygmy nuthatch	Low	Moderate	Low-Moderate	Potentially Extinct
White-headed woodpecker	Low	Moderate	Low-Moderate	Potentially Extinct
Flammulated owl	Low	Moderate	Low-Moderate	Potentially Extinct

7.2 Aquatic

7.2.1 Introduction

This synthesis and interpretation of information presented in the assessment section of this plan, focuses on three fish species; westslope cutthroat trout (WSCT), bull trout, and kokanee salmon. WSCT currently appear to be reduced from historic abundance. Bull trout have not been observed since the 1950s, and kokanee, introduced to Lake Chelan in 1917, have shown extreme fluctuations in abundance. The key findings, hypotheses statements and assumptions are by focal species and assessment units.

Information that supports the hypothesis and assumptions used above can be found in: Brown, L.G. 1984; Chelan PUD. 1998; FERC 2001; Hagen 1995; Hillman and Giorgi 2000; Viola and Foster 2002; DES 2000; Kanda, N. 1998; Leary, R.F., F.W. Allendorf, and S.H. Forbes. 1993. (Full citation in References.)

7.2.2 Key findings, hypothesis statements and assumptions

Westslope cutthroat trout (WSCT)

Key Findings Tributaries Assessment Unit:

- Spawning habitat is naturally limited (except in the Stehekin River Basin), but rearing and other features are essentially in tact.
- Spawning and rearing competition occurs with native bridgelip suckers and introduced rainbow trout and brook trout. Rainbow trout may also breed with WSCT, further affecting genetic integrity.
- Most spawning streams (excluding First, Twenty-five Mile Creek and the Stehekin River) are currently difficult to reach at historic spawning times because of the barriers that have been created at their mouths.
- Key factors limiting production are most likely caused by interactions with exogenous species, and maladaptive spawning times in smaller spawning streams.
- Railroad Creek, downstream of Holden mine, has been lost to production because of mining activities.

Key Findings Tributaries and Lake Assessment Units:

- Westslope cutthroat trout are found throughout the Chelan Basin, but are most abundant in Lucerne Basin. Exact status has not been determined.
- Historic populations were reduced by over harvest, hatchery practices, and introduction of exogenous species.
- With the exception of Twenty-five Mile Creek, First Creek, and the Stehekin River, barriers (velocity, deposition, and depth) have formed at spawning tributary mouths. Most other habitat features remain (except for LWD in the lake which is removed for navigation purposes).

- Based on anecdotal information on early catch rates of WSCT in newspapers and other sources, the current population of WSCT appears to be much reduced from historic times. High catch rates in the 19th century and historic and current hatchery practices have most probably lead to their decline.

Working hypotheses

Lake Chelan Assessment Unit

8. Development of barriers at tributary mouths has negatively affected spawning and subsequent fry survival of WSCT.

Lake Chelan and Tributary Assessment Units

9. Interactions with non-native species have negatively affected WSCT spawning and rearing.
10. Harvest regulations and hatchery practices have reduced adult abundance.

Key assumptions

- Interactions with rainbow trout and suckers limit spawning success.
- Interactions with rainbow trout, lake trout, brook trout, and Chinook salmon may limit initial rearing, both within natal streams and the lake.
- Predation by Chinook salmon and lake trout may decrease spawner recruits. WSCT are spawning later than they did historically in the smaller tributaries.
- Delayed spawning access to spawning habitat may decrease initial rearing success after emergence.
- WSCT and Chinook salmon or lake trout inhabit the same areas at certain life stages
- WSCT early rearing takes place in natal tributaries

Bull trout

Key findings (all assessment units)

Bull trout have not been documented within the Chelan Basin since the 1950s.

- It is not clear why they may be extinct, but potential reasons are: over harvest, loss of spawning grounds due to high floods in 1948 and 1949; or a catastrophic disease outbreak, or a combination of above factors.
- Introduced rainbow trout, lake trout, and brook trout (and kokanee salmon) may inhibit re-introduction of bull trout through competition during rearing, foraging, or spawning phases.
- Brook trout are known to reduce genetic integrity of bull trout when they interbreed (and are sterile)1

[1] Hybridization results in offspring that are frequently sterile (Leary et al. 1993), although recent genetics work has shown that reproduction by hybrid fish is occurring at a higher level than previously suspected (Kanda 1998).

- Current spawning and rearing areas within the Stehekin, and other tributaries are functioning near pristine levels
- Railroad Creek has been lost to production because of mining activities.

Working hypothesis

11. Bull trout are still present in smaller tributaries as non-migratory ecotypes.
12. Spawning and early rearing habitat will not limit bull trout re-introduction.
13. Competition with exogenous species will reduce the success of bull trout re-introduction.
14. All life histories of bull trout can be successfully reintroduced into the Chelan Basin

Key Assumptions

- Bull trout populations may be discovered in headwater tributaries.
- Spawning and rearing habitat is mostly in tact.
- Because of established species assemblages (see below), establishment of adfluvial forms of bull trout is not possible.
- Competition with brook and lake trout, and potentially Chinook salmon may decrease the likelihood that bull trout can be re-introduced into the Basin.
- Redd imposition by kokanee may decrease the viability of bull trout eggs.

Kokanee salmon

Key findings

- Kokanee were introduced in 1917 and have provided a large recreational fishery ever since.
- Kokanee populations have been volatile and could be related to predator abundance, competition with native and exotic species for forage, and general lake productivity.
- Spawning habitat is not limiting.
- Introductions of hatchery fish have not been shown to increase natural production or harvest rates.

Working hypothesis

15. Rearing in Lake Chelan is limited by lake productivity and competition with other species.
16. Total adult abundance is impacted by predation by lake trout and chinook.
17. Hatchery plantings increase the total abundance of kokanee available for spawning or harvest.

Key Assumptions

- Competition with mysids, juvenile WSCT, juvenile chinook salmon, and other native species may limit production of kokanee.
- Predation by lake trout and Chinook salmon has a significant effect on the number of spawners in a given year.

7.2.3 Reference Conditions

Westslope cutthroat trout

From anecdotal information on early catch rates of WSCT in newspapers and other sources, the current population of WSCT appears to be much reduced from historic times. High catch rates in the 19th century, hatchery practices in the early 20th century, and negative interactions with exogenous species have all lead to their decline.

Abundance and productivity

Table 29. Abundance and productivity currently, historically and projected

	Current	Historic	Potential	Future w/no action
WSCT	Low	high	moderate	low

Near-term opportunities

- Spawning habitat in most Lake Chelan tributaries (excluding the Stehekin Basin) is naturally limited, although in relatively good shape. Chelan PUD has agreed to physically remove some barriers and modify lake levels under the terms of their new license (CPUD 2003). This will increase the likelihood that WSCT will be able to access spawning habitat in those streams where barriers have been documented within the presumed historic time frame, which probably will increase production.
- Eliminating rainbow trout plantings will help reduce negative interactions during spawning and potentially during rearing too. Reducing brook trout will also aid in reducing the potential negative interactions during rearing. Reductions of Chinook salmon and lake trout may also increase the likelihood for increased production by lowering predation.
- Preservation of existing high quality habitat in the Stehekin Basin is essential in maintaining the largest spawning and early rearing habitat in the Basin.

Bull trout

Bull trout were originally the apex predator of the Chelan Basin. While the total historic population will never be known, it was large enough to support a fishery until the early 1950s.

Abundance and productivity

Table 30. Abundance and productivity currently, historically and projected

	Current	Historic	Potential	Future w/no action
Bull trout	Potentially extinct	Mod.-high	Low-mod.	Potentially extinct

Near-term opportunities

- Eliminating or reducing lake trout will help reduce the potential negative interactions during rearing if a reintroduction program is started for adfluvial fish. Reducing or eliminating brook trout will also aid in reducing the negative interactions during spawning and rearing within streams. Reducing the abundance of Chinook salmon may also increase the likelihood of successful re-introduction.
- Preservation of existing high quality habitat in the Stehekin Basin is essential in maintaining the largest spawning and early rearing habitat in the Basin.

Kokanee

Kokanee salmon were introduced into Lake Chelan in 1917, and subsequent plantings have been ongoing.

Abundance and productivity

Table 31. Abundance and productivity currently, historically and projected

	Current	Historic	Potential	Future w/no action
Kokanee	Mod.-high	Mod.-high	Mod.-high	Mod.-high

Near-term opportunities

- Eliminating lake trout and chinook salmon plantings will help reduce predation, however, a species interaction model developed in coordination with Chelan PUD will help determine the trophic affects of removing top predators and its impact on other species. While it is probable that a reduction of chinook and lake trout is possible, it is unlikely that tot removal is possible since both species reproduce naturally within the basin.
- Preservation of existing high quality habitat in the Stehekin Basin is essential in maintaining the largest spawning habitat in the Basin.
- Reduction of mysids will increase survival of juvenile kokanee (trophic consequences of this action will be inferred from the model mentioned above).

Table 32. Summary of abundance and productivity

	Current	Historic	Potential	Future w/no action

Aquatic				
Westslope cutthroat	Low	High	Moderate	Low
Bull trout	Potentially extinct	Mod.-high	Low-mod.	Potentially extinct
Kokanee	Mod.-high	Mod.-high	Mod.-high	Mod.-high

8 Management Plan

8.1.1 Introduction

The information below will be used by subbasin planners and state salmon recovery personnel to aid in the conservation and restoration of important habitat that will aid in the recovery of focal species.

The management plan is made up of five components: the vision for the subbasin; biological objectives; strategies; research, monitoring and evaluation; and ESA and CWA requirements. Since the biological objectives are linked to the working hypotheses, we have inserted them here also for better clarity.

8.1.2 Vision

The Vision Statement for the Lake Chelan Subbasin is largely based on the Chelan County Watershed Planning Association Goal Statements for water resources. These goals are based on a sustainable future for the landscape, the economy, and the people in our subbasin.

Our vision for the landscape is to balance habitat conservation with human uses to ensure the long-term health of plant, fish, wildlife and human communities.

Our vision for the economy is based on efficient management and use of natural resources including reliable water supplies, fish and wildlife populations, and aquatic and terrestrial habitats.

Our vision for the people is to manage natural resources to promote social and economic well-being and to improve or maintain our quality of life. We will work together to foster increased understanding of the importance of natural resource conservation.

8.2 Terrestrial

8.2.1 Biological Goals, Objectives and Strategies

8.2.2 Shrubsteppe

Goal

Provide sufficient quantity and quality shrubsteppe habitat to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing sagebrush-dominated shrubsteppe toward conditions 1, 2 and 3 identified in the Inventory and Assessment (Appendix A)..

Habitat Objective 1

Determine the necessary amount, quality, and juxtaposition of shrubsteppe by the year 2008.

Strategy

- Select and implement methodology, alternative to IBIS or GAP, to accurately characterize shrubsteppe habitat in the Lake Chelan subbasin.

Habitat Objective 2

Based on findings of Objective 1, identify and provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

Strategies

- Utilize federal, state, tribal, and local government programs, such as USDA "Farm Bill" programs, to conserve shrubsteppe habitat.
- Achieve permanent protection of shrubsteppe through acquisition, conservation easement, cooperative agreements, etc.
- Emphasize conservation of large blocks and connectivity of high quality shrubsteppe habitat.
- Promote local planning and zoning to maintain or enhance large blocks of habitat.

Habitat Objective 3

Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving agricultural practices, fire management, weed control, livestock grazing practices, and road management on existing shrubsteppe.

Strategies

- Implement habitat stewardship projects with private landowners.
- Develop fire management protocols (protection and prescribed burning) to produce desired shrubsteppe habitat conditions.
- Wenatchee National Forest plan, Chelan County Watershed Mgt Plan, North Cascades National Park General Management Plan, WDFW Wildlife Area Management Plan, Colville Tribes Integrated Resource Management Plan.
- Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan.
- Develop and implement a coordinated, cross-jurisdictional road management plan.

Biological Objective 1

Determine population status of Brewer's sparrow by 2008.

Strategies

- Select survey protocol and measure abundance of focal species.
- Select survey protocol and measure diversity and richness of species assemblages within shrubsteppe.

Biological Objective 2

Within the framework of the Brewer's sparrow population status determination, inventory other shrubsteppe obligate populations to test assumption of the umbrella species concept for conservation of other shrubsteppe obligates.

Strategy

- Implement federal, state, tribal management and recovery plans.

Biological Objective 3

Maintain and enhance mule deer populations consistent with state/tribal herd management objectives.

Strategies

- Implement state and tribal management plans.
- Ensure mule deer habitat needs are met on federal, state, and tribal managed lands during land use planning.
- Maintain mule deer populations within private landowner tolerances.

8.2.3 Ponderosa Pine

Goal

Provide sufficient quantity and quality ponderosa pine habitats to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing ponderosa pine toward conditions 1a, 1b, 2 and 3 identified in 3.1.7.1.3 (Inventory and Assessment).

Habitat Objective 1

Determine the necessary amount, quality, and juxtaposition of ponderosa pine habitats by the year 2008.

Strategy

- Select and implement methodology, alternative to IBIS or GAP, to accurately characterize ponderosa pine habitat in the Lake Chelan subbasin.

Habitat Objective 2

Based on findings of Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

Strategies

- Utilize federal, state, tribal, and local government programs to conserve ponderosa pine habitat.
- Achieve permanent protection of ponderosa pine through acquisition, conservation easement, cooperative agreements, etc.
- Emphasize conservation of large blocks and connectivity of high quality ponderosa pine habitat.
- Promote local planning and zoning to maintain or enhance large blocks of habitat.

Habitat Objective 3

Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silvicultural practices, fire management, weed control, livestock grazing practices, and road management in existing and restored ponderosa pine habitat.

Strategies

- Implement habitat stewardship projects with private landowners.
- Develop fire management protocols (protection and prescribed burning) to produce desired ponderosa pine habitat conditions.
- Wenatchee National Forest plan, Chelan County Watershed Mgt Plan, North Cascades National Park General Management Plan, WDFW Wildlife Area Management Plan, Colville Tribes Integrated Resource Management Plan.
- Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan.
- Develop and implement a coordinated, cross-jurisdictional road management plan.

Biological Objective 1

Determine population status of white-headed woodpecker, flammulated owl, and pygmy nuthatch by 2008.

Strategies

- Select survey protocol and measure abundance of focal species.
- Select survey protocol and measure diversity and richness of species assemblages within ponderosa pine.

Biological Objective 2

Within the framework of the focal species population status determinations, inventory other ponderosa pine obligate populations to test assumption of the umbrella species concept for conservation of other ponderosa pine obligates.

Strategy

- Implement federal, state, tribal management and recovery plans.

8.2.4 Riparian Wetlands

Goal

Provide sufficient quantity and quality riparian wetlands to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing riparian wetland habitats toward conditions 1a, 1b, and 2 identified in 3.1.7.3.3 (Inventory and Assessment).

Habitat Objective 1

Determine the necessary amount, quality, and connectivity of riparian wetlands by the year 2008.

Strategy

- Select and implement methodology, alternative to IBIS or GAP, to accurately characterize riparian wetlands habitats in the Lake Chelan subbasin.

Habitat Objective 2

Based on findings of Habitat Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

Strategies

- Utilize federal, state, tribal, and local government programs, to conserve riparian wetlands habitat.
- Achieve permanent protection of riparian wetlands through acquisition, conservation easement, cooperative agreements, etc.
- Emphasize conservation connectivity of high quality riparian wetlands habitat.
- Promote local planning and zoning to maintain or enhance riparian wetlands habitat.

Habitat Objective 3

Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silviculture, agricultural practices, fire management, weed control, livestock grazing practices, and road construction and maintenance on and adjacent to existing riparian wetlands.

Strategies

- Implement habitat stewardship projects with private landowners.
- Develop fire management protocols (protection and prescribed burning) to produce desired riparian wetlands habitat conditions.
- Wenatchee National Forest plan, Chelan County Watershed Mgt Plan, North Cascades National Park General Management Plan, WDFW Wildlife Area Management Plan, Colville Tribes Integrated Resource Management Plan.
- Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan.
- Develop and implement a coordinated, cross-jurisdictional road management plan.

Biological Objective 1

Determine population status of beaver and red-eyed vireo chat by 2008.

Strategies

- Select survey protocol and measure abundance of focal species.

- Select survey protocol and measure diversity and richness of species assemblages within riparian wetland habitats.

Biological Objective 2

Within the framework of the focal species population status determinations, inventory other riparian wetlands obligate populations to test assumption of the umbrella species concept for conservation of other riparian wetlands obligates.

Strategy

- Implement federal, state, tribal management and recovery plans.

Biological Objective 3

Based on findings of Biological Objective 1 and Habitat Objective 2, maintain and enhance beaver populations where appropriate and consistent with state/tribal management objectives.

Strategies

- Protect, and where necessary restore, habitat to support beaver.
- Reintroduce beaver into suitable habitat where natural recolonization may not occur.
- Through state harvest restrictions, protect beaver populations at a level sufficient to allow natural and reintroduced beaver populations to perpetuate at levels that will meet Habitat Objective 2.

8.3 Research, Monitoring and Evaluation Plan

Introduction

The Research, Monitoring, and Evaluation (RME) plan for the subbasin is intended as a tool that will allow managers to evaluate the efficacy of employed strategies in achieving corresponding focal habitat objectives for the subbasin. If implemented, elements of the plan will also facilitate coordination and tracking of management activities within the subbasin, periodic review of progress, and a basis for recommended adjustments to management direction over time (adaptive management).

The RME plan, as presented, consists of a variety of quantitative elements, ranging from scientific wildlife and vegetation surveys, spatial analyses of project location and acreage, to simple enumeration of land use projects/regulations commented upon by cooperating agencies.

Organization of the RME plan is as follows:

Research

- Research needs, with justification, are also listed. Detailed research project design is not presented, however, being beyond the scope of the current planning effort
- Existing Data Gaps, as identified through the subbasin planning process, are listed in this section, because many will require effort above routine monitoring and evaluation to address

Monitoring and Evaluation

- Focal habitat monitoring methodology, and Management Plan strategies addressed
- Focal species monitoring methodology, and Management Plan strategies addressed

8.3.1 Existing Data Gaps and Research Needs

In the course of subbasin plan development, a number of data gaps were identified. Some of these gaps will be filled as data is collected via the monitoring and evaluation process as the plan is implemented. Others will require formal research efforts to address. Data gaps and research needs identified during development of the subbasin plan are listed in the tables below.

As part of the adaptive management philosophy of subbasin planning, managers believe that additional research needs not yet identified will become apparent over time. These needs should be addressed in future subbasin plan iterations.

Table 33. General Lake Chelan subbasin data gaps and research needs

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
General		
Testing of assumption that focal habitats are functional if a focal species assemblage’s recommended management conditions are achieved		Coordinated government & NGO effort

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
Testing of assumption that selected species assemblages adequately represent focal habitats		Coordinated government & NGO effort
Current, broad-scale habitat data	Spatial data collection and GIS analysis	Coordinated government & NGO effort

8.3.2 Riparian Wetland

Table 34. Riparian wetland data gaps and research needs

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
Riparian Wetlands		
Recommended Priority Order of Research Needs		
Refinement of recommended management conditions for Riparian Wetlands	Research need; use for update to future subbasin plan iterations	Coordinated government & NGO effort.
Data are needed on all aspects of red-eyed vireo and beaver ecology in the subbasin.		Coordinated government & NGO effort
Data Gaps		
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current riparian wetland data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Riparian habitat quality data. Assessment data do not address habitat quality.	Monitoring activities	Subbasin managers
Refined habitat type maps	Spatial data collection and GIS	Subbasin managers

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
	analysis	
GIS soils products including wetland delineations	Spatial data collection and GIS analysis	Subbasin managers
Local population/distribution data for red-eyed vireo, , and beaver	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers

8.3.3 Ponderosa Pine

Table 35. Ponderosa pine data gaps and research needs

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
Ponderosa Pine		
Recommended Priority Order of Research Needs		
Data are needed on all aspects of white-headed woodpecker nesting ecology and habitat use within the Lake Chelan subbasin		Coordinated government & NGO effort
Data are needed on all aspects of pygmy nuthatch nesting ecology and habitat use within the Lake Chelan subbasin		Coordinated government & NGO effort
Data are needed on all aspects of flammulated owl nesting ecology and habitat use, specifically related to the size, configuration, and abundance of grassy openings for foraging and clumped thickets of sapling/pole trees for roosting		Coordinated government & NGO effort
Research to determine if restored sites attract white-headed woodpeckers and provide viable habitat, to include recommendations on effective treatment conditions		Coordinated government & NGO effort
Research to determine if restored sites attract pygmy nuthatches and provide viable habitat, to include		Coordinated government &

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
recommendations on effective treatment conditions		NGO effort
Research to determine whether an intensively harvested landscape that meets snag and large tree objectives support viable white-headed woodpecker populations		Coordinated government & NGO effort
Research to determine whether a managed site attracts flammulated owls and provides viable habitat. Identification of the most effective treatment processes and conditions most effective.		Coordinated government & NGO effort
Data Gaps		
Refinement of recommended management conditions for Ponderosa pine: collect current ponderosa pine structural condition/habitat variable data	Management Objective for Ponderosa pine	Subbasin managers
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current ponderosa pine data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Habitat quality data. Assessment data do not address habitat quality.	Coordinated, standardized monitoring efforts); Spatial data collection and GIS analysis	Subbasin managers
Finer resolution GIS habitat type maps that include structural component and KEC data.	Coordinated, standardized monitoring efforts); Spatial data collection and GIS analysis	Subbasin managers
GIS soils products	Spatial data collection and GIS	Subbasin

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
	analysis	managers
Identify current distribution and population levels of white-headed woodpeckers, pygmy nuthatches and flammulated owls	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Identify current and potential areas of high quality flammulated owl habitat (short-term strategy i.e., <2 years).	Habitat Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Monitor white-headed woodpecker, pygmy nuthatch and flammulated owl distributions within the Lake Chelan subbasin, to determine current distributions, population levels and population trends	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers

8.3.4 Shrubsteppe

Table 36. Shrubsteppe data gaps and research needs

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
Shrubsteppe		
Recommended Priority Order of Research Needs		
Data are needed on all aspects of Brewer’s sparrow nesting ecology, especially area requirements to maintain populations		WDFW, Subbasin managers
Data are needed on all aspects of Brewer's sparrow nesting ecology, particularly relationship to livestock grazing and pesticide use		WDFW, Subbasin managers
An assessment of the viability of small populations of Brewer’s sparrow in fragments of habitat versus those in large contiguous blocks		WDFW, Subbasin managers
Data Gaps		
Accurate habitat type maps are needed to improve	Coordinated,	Subbasin

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
assessment quality and support management strategies and actions, including, updated and fine resolution historic/current shrubsteppe data and GIS products e.g., structural conditions and KEC ground-truthed maps	standardized monitoring efforts; Spatial data collection and GIS analysis	managers
Habitat quality data. Assessment data bases do not address habitat quality	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Refined habitat type maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
GIS soils products, including wetland delineations	Spatial data collection and GIS analysis	Subbasin managers
Local population/distribution distribution for Brewer's sparrow	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Monitor Brewer's sparrow distribution within the Lake Chelan subbasin, to determine current distribution, population level and population trends	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Evaluate the role of fire, mowing, and other management treatments to maintain/improve shrupsteppe habitat quality	Coordinated, standardized monitoring	Subbasin managers

Research Needs And Data Gaps	Strategy To Address	Agency/ Personnel
	efforts	

8.3.5 Focal Habitat and Species Monitoring Methodology

Recommended monitoring and evaluation strategies contained below for each focal habitat type, including sampling and data analysis and storage, are derived from national standards established by Partners in Flight for avian species (Ralph et al, 1993, 1995) and habitat monitoring (Nott et al, 2003). Deer sampling methodology follow standard protocols established by the Washington Department of Fish and Wildlife. In addition, protocols for specific vegetation monitoring/sampling methodologies are drawn from USDA Habitat Evaluation Procedure standards (USFWS 1980a and 1980b). A common thread in the monitoring strategies which follow is the establishment of permanent census stations to monitor bird population and habitat changes.

Wildlife managers will include statically rigorous sampling methods to establish links between habitat enhancement prescriptions, changes in habitat conditions and target wildlife population responses.

Specific methodology for selection of Monitoring and Evaluation sites within all focal habitat types follows a probabilistic (statistical) sampling procedure, allowing for statistical inferences to be made within the area of interest. The following protocols describe how M&E sites will be selected (from WDFW response to ISRP available: http://www.cbfwa.org/files/province/cascade/projects/199609400resp.pdf):

- Vegetation/HEP monitoring and evaluation sites are selected by combining stratified random sampling elements with systematic sampling. Project sites are stratified by cover types (strata) to provide homogeneity within strata, which tends to reduce the standard error, allows for use of different sampling techniques between strata, improves precision, and allows for optimal allocation of sampling effort resulting in possible cost savings (Block et al. 2001). Macro cover types such as shrubsteppe and forest are further sub-cover typed based on dominant vegetation features i.e.,% shrub cover,% tree cover, and/or deciduous versus evergreen shrubs and conifer versus deciduous forest. Cover type designations and maps are validated prior to conducting surveys in order to reduce sampling inaccuracies.

- Pilot studies are conducted to estimate the sample size needed for a 95% confidence level with a 10% tolerable error level (Avery 1975) and to determine the most appropriate sampling unit for the habitat variable of interest (BLM 1998). In addition, a power analysis is conducted on pilot study data (and periodically throughout data collection) to ensure that sample sizes are sufficient to identify a minimal detectable change of 20% in the variable of interest with a Type I error rate of not more than 0.10 and P = 0.9 (BLM 1998, Hintze 1999, Block et al. 2001). M&E includes habitat trend condition monitoring on the landscape scale (Tier 1-HEP) and plant community monitoring (Tier 2) i.e., measuring changes in vegetative communities on specific sites.

- For HEP surveys, specific transect locations within strata are determined by placing a Universal Transverse Mercator (UTM) grid over the study area (strata) and randomly selecting “X” and “Y” coordinates to designate transect start points. Random transect azimuths are chosen from a computer generated random number program, or from a standard random number table. Data points and micro plots are systematically placed along the line intercept transect at assigned intervals as described in Part 2 – monitoring section of the proposal. Sample sizes for statistical inferences are determined by replication and systematic placement of lines of intercept within the strata with sufficient distance between the lines to assume independence and to provide uniform coverage over the study site.

- Permanent vegetation monitoring transect locations are determined by placing a UTM grid over the strata and randomly selecting “X” and “Y” coordinates to designate plot locations as described for HEP surveys. One hundred meter baseline transect azimuths are randomly selected from a random numbers table. Ten perpendicular 30 meter transects are established at 10 meter intervals along the baseline transect to form a 100m x 30m rectangle (sample unit). Micro plot and shrub intercept data are collected at systematic intervals on the perpendicular transects.

By systematically collecting and analyzing plant species frequency, abundance, density, height, and% cover data, vegetative trends through time can be described. Likewise, the effectiveness of exotic weed control methods can be evaluated and weed control plans can be adjusted accordingly.

Presence of all exotic weeds i.e., knapweeds, yellow starthistle, etc. will be mapped in GIS using Global Positioning System (GPS) equipment. This information will be used to develop an annual exotic vegetation control plan.

Causes of seeding or planting failure will be identified and planting methods/site preparation will be modified as necessary. Data will be collected and analyzed, and, where necessary, changes in the management plan (adaptive management) will be identified and implemented.

General and site specific M&E protocols, outlining monitoring goals and objectives and specific sampling designs are included in the following monitoring section.

In addition to defining habitat and species population trends, monitoring will also be used to determine if management actions have been carried out as planned (implementation monitoring). In addition to monitoring plan implementation, monitoring results will be evaluated to determine if management actions are achieving desired goals and objectives (effectiveness monitoring) and to provide evidence supporting the continuation of proposed management actions. Areas planted to native shrubs/trees and/or seeded to herbaceous cover will be monitored twice a year to determine shrub/seeding survival, and causes of shrub mortality and seeding failure i.e. depredation, climatic impacts, poor site conditions, poor seed/shrub sources.

Monitoring of habitat attributes and focal species in this manner will provide a standardized means of tracking progress towards conservation, not only within the Lake Chelan subbasin, but within a national context as well. Monitoring will provide essential feedback for demonstrating adequacy of conservation efforts on the ground, and guide the adaptive management component that is inherent in the subbasin planning process.

8.3.6 Riparian Wetlands

Focal Species: Red-eyed vireo (*Vireo olivaceous*) and American beaver (*Castor canadensis*)

Overall Habitat and Species Monitoring Strategy

- Establish monitoring program for protected and managed Riparian Wetland sites to monitor focal species population and habitat changes and evaluate success of efforts.
- Establish permanent censusing stations to monitor bird population and habitat changes.

Focal Habitat Monitoring

Factors Affecting Habitat

- Direct loss of riparian deciduous and shrub understory
- Fragmentation of wetland habitat
- Agricultural and suburban development and disturbance
- Reduction in water quality
- Organochlorines such as dieldrin or DDE may cause thinning in egg shells which results in reproductive failure (Graber et al. 1978; Ohlendorf et. al. 1980; Konermann et. al. 1978).

Riparian Wetlands Working Hypothesis Statement

The proximate or major factors affecting this focal habitat type are direct loss of habitat due primarily to urban/agricultural development, reduction of habitat diversity and function resulting from exotic vegetation, livestock overgrazing, fragmentation and recreational activities. The principal habitat diversity stressor is the spread and proliferation of invasive exotics. This coupled with poor habitat quality of existing vegetation have resulted in extirpation and or significant reductions in riparian habitat obligate wildlife species.

Recommended Range of Management Conditions

18. Well-distributed range of 20 to 100% tree canopy closure (cottonwood and other hardwood species), with a mature cottonwood component including trees at least 160 feet tall
19. Multi-structure/age tree canopy (includes trees less than 6 inches in diameter and mature/decadent trees)
20. Forty to 80% native shrub cover (greater than 50% comprised of hydrophytic shrubs), with scattered herbaceous openings
21. Multi-structured shrub canopy greater than 3 feet in height, at least 10% of which are comprised of young cottonwoods

Focal Habitat Monitoring Strategies

Establish an inventory and long-term monitoring program for protected and restored riparian wetlands to determine success of efforts.

22. Identify riparian wetland sites within the subbasin that support populations of focal species for this habitat.
23. Evaluate habitat site potential on existing public lands and adjacent private lands for protection. (short-term strategy i.e., < 2 years).
24. Enhance habitat on public lands and adjacent private lands.
25. Identify high quality/functional privately owned riparian wetlands sites that are not adjacent to public lands (long-term strategy 2 to 15 years).
26. Establish permanent censusing stations to monitor bird population and habitat changes

Sampling Design

HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type. (Riparian zone width within portions of the subbasin will require modification of this 100 foot buffer requirement.)

In addition, at any permanently established avian species monitoring site established within the Riparian Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b)

Herbaceous

Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular $0.5m^2$ microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

Shrub

Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible “hits” per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible “hits” per 100 ft segment).

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

Tree

Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Other

At any permanently established avian species monitoring site established within the Riverine Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003) (http://www.birdpop.org/DownloadDocuments/manual/HSAManual03.PDF).

Analysis

Transects are divided into 100 ft. segments, and total transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean).

$$\text{Sample size equation: } n = \frac{t^2 \times s^2}{E^2}$$

Where: t = value at 95% confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring: American beaver and Red-eyed Vireo

Rationale

Maintaining and enhancing beaver and red-eyed vireo populations within the subbasin will assure the maintenance and rehabilitation of riparian wetlands.

Limiting Factors

27. Loss of deciduous tree cover and sub-canopy/shrub habitat in riparian zones. 2.) Conversion of riparian habitat due to channelization, agriculture, and development, 3) flooding of habitat resulting from hydropower facilities, 4) habitat fragmentation, 5) degradation of existing habitats from overgrazing and introduced weedy vegetation, and 6) tree/shrub removal in riparian areas. Proximity to agriculture, suburban development creates a hostile landscape where a high density of nest parasites, such as, brown cowbird and predation by domestic cats may occur. Disturbance from agriculture, silviculture, road management and recreational activities can also cause nest abandonment.

Assumptions

28. Addressing factors that affect riparian wetlands, will also address red-eyed vireo, beaver and other wetland obligate species limiting factors. 2) If riparian wetland habitat is of sufficient quality, extent, and distribution to support viable red-eyed vireo and beaver populations, the needs of most other riparian wetland obligate species will also be addressed and habitat functionality could be inferred. 3) If habitat is present sufficient to support avian focal species, suitable habitat will be present to support beaver. 4) Beaver will persist in these habitats if appropriate protection measures to preclude overharvest are implemented.

Sampling Strategy

Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 25% increase in abundance of yellow warbler with a power of 0.8 or greater. This protocol is based on the point count survey (Ralph et al. 1993, Ralph et al. 1995), with each survey station referred to as a "point count station." In addition to these bird survey data, information about the distance at which individual birds are detected will also be collected, allowing absolute density estimated to be made using distance-sampling methodology (e.g., the program DISTANCE).

Methods

We will survey birds on randomly selected (stratified) points along the riparian corridor. Each site will have 4 100-m fixed-radius point counts (Ralph et al. 1993) established along a transect and spaced 200m apart (Fig 4). Each point will be marked with a permanent fiberglass stake (1m electric fence post) and colored flagging will be placed on shrubs at 50 and 100m from the point in each of the 4 cardinal directions to aid in determining distance. Counts at each point will be 5 minutes in duration during which all birds seen or heard will be noted, along with their sex (if known), distance from the point (within 50m, >50 but <100m, or beyond 100m), and behavior (singing, calling, silent, or flying over the site). Surveys will be conducted once each in May and June and within prescribed weather parameters (e.g., no rain and low wind).

Analysis

Analysis is described by Nur et al. (1999). Absolute density estimation (see Buckland et al. 1993) can be estimated using the program DISTANCE, a free program

available on the World-Wide Web (http://www.ruwpa.st-and.ac.uk/distance); an example is given in Nur et al. (1997). In brief: for species richness and species diversity, these can be analyzed as total species richness or as species richness for a subset of species; the same is true for species diversity. Species diversity can be measured using the Shannon index (Nur et al. 1999), also called the Shannon-Weiner or Shannon-Weaver index. Statistical analysis can be carried out using linear models (regression, ANOVA, etc.), after appropriate transformations (examples in Nur et al. 1999).

8.3.7 Ponderosa Pine

Focal Species: Flammulated owl *(Otus flammeolus)*, white-headed woodpecker (*Picoides albolarvatus)*, pygmy nuthatch (*Sitta pygmaea*)

Overall Habitat and Species Monitoring Strategy

Establish monitoring program for protected and managed Ponderosa pine sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat

- Direct loss old growth forest and associated large diameter trees and snags
- Fragmentation of remaining Ponderosa pine habitat
- Agricultural and sub-urban development and disturbance
- Hostile landscapes which may have high densities of nest parasites, exotic nest competitors, and domestic predators
- Fire suppression/wildfire
- Overgrazing
- Noxious weeds
- Silvicultural practices
- Insecticide use.

Ponderosa Pine Working Hypothesis Statement

The near term or major factors affecting this focal habitat type are direct loss of habitat due primarily to timber harvesting, fire reduction/wildfires, mixed forest encroachment, development, recreational activities, reduction of habitat diversity and function resulting from invasion by exotic species and vegetation and overgrazing. The principal habitat diversity stressors are the spread and proliferation of mixed forest conifer species within ponderosa pine communities due primarily to fire reduction and intense, stand-replacing wildfires, and invasive exotic weeds. Habitat loss and fragmentation (including fragmentation resulting from extensive areas of undesirable vegetation) coupled with poor habitat quality of existing vegetation (i.e., lack of old growth forest and associated large diameter trees and snags) have resulted in significant reductions in ponderosa pine habitat obligate wildlife species.

Recommended Range of Management Conditions

Recognizing that extant ponderosa pine habitat within the subbasin currently covers a wide range of seral conditions, wildlife habitat managers have identified three general ecological / management conditions that, if met, will provide suitable habitat for multiple wildlife species at the subbasin scale within the ponderosa pine habitat type. These ecological conditions correspond to life requisites represented by a species' assemblage that includes white-headed woodpecker (Picoides albolarvatus), flammulated owl (Otus flammeolus), and pygmy nuthatch (Sitta pygmaea)

Mature ponderosa pine forest: The white-headed woodpecker represents species that require/prefer large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10 - 50% and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags greater than 31 inches DBH).

Multiple canopy ponderosa pine mosaic: Flammulated owls represent wildlife species that occupy ponderosa pine sites that are comprised of multiple canopy, mature ponderosa pine stands or mixed ponderosa pine/Douglas-fir forest interspersed with grassy openings and dense thickets. Flammulated owls nest in habitat types with low to intermediate canopy closure (Zeiner et al. 1990), two layered canopies, tree density of 508 trees/acre (9 foot spacing), basal area of 250 feet2/acre (McCallum 1994b), and snags greater than 20 inches DBH 3-39 feet tall (Zeiner et al. 1990). Food requirements are met by the presence of at least one snag greater than 12 inches DBH/10 acres and 8 trees/acre greater than 21 inches DBH.

3. Heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age: pygmy nuthatches represent those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 inches DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

Focal Habitat Monitoring Strategies

Establish an inventory and long-term monitoring program for protected and managed Ponderosa pine habitats to determine success of efforts. Subbasin managers recognize that restoration of late-successional forest is a long-term process, but these short-term (i.e., up to 15 years) strategies reflect the commitment and initiation of the process of management.

29. Identify Ponderosa pine habitat sites within the subbasin that support populations of focal species for this habitat.

30. Evaluate habitat site potential on existing public lands and adjacent private lands for protection of focal species habitat (short-term strategy i.e., < 2 years).

31. Enhance habitat on public lands and adjacent private lands (intermediate strategy 2 to 10 years)

32. Identify high quality/functional privately owned Ponderosa pine sites that are not adjacent to public lands (long-term strategy 2 to 15 years).

33. Establish permanent censusing stations to monitor bird population and habitat changes.

Sampling Design

Permanent survey transects will be located within Ponderosa pine habitats using HEP protocols. HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type.

In addition, at any permanently established avian species monitoring site established within the Riverine Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b)

Herbaceous

Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

Shrub

Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment).

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

Tree

Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Measurement of Attributes (Habitat Conditions)

>10 snags/40 ha (>30cm DBH and 1.8m tall)

> Method: A direct count in the 1/10 acre circle plot at the end of each 100 ft segment of the transect. DBH (measured with a loggers tape) and condition is noted for each snag. Snag condition scale follows Parks et al. (1997).

>20 trees /ha (>21" DBH)

> Method: A direct count in the 1/10 acre circle plot. DBH measured with a logger's tape.

Ponderosa Pine – old growth: >10 trees/ac (>21" DBH w/ >2 trees >31" DBH)

> Method: A direct count in the 1/10 acre circle plot. DBH measured with a logger's tape.

10-50% canopy closure

Method: A line intercept 'hit' or 'miss' measurement. Ten direct measurements along each 100 foot section of the transect (one every 10 feet) taken with a moosehorn densitometer.

> 1.4 snags/ac (>8" DBH w/ >50% >25")

Method: A direct count in the 1/10 acre circle plot at the end of each 100 ft segment of the transect. DBH (measured with a loggers tape) and condition is noted for each snag. Snag condition scale follows Parks et al. (1997).

Other

At any permanently established avian species monitoring site established within the ponderosa pine habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Analysis

Transects are divided into 100 ft. segments, and total transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: $n = \frac{t^2 \times s^2}{E^2}$

Where: t = value at 95% confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring: Flammulated Owl

Rationale

The Flammulated owl is listed as candidates for inclusion on the WDFW endangered species list and is considered a species-at-risk by the Washington GAP Analysis and Audubon-Washington. Flammulated owls are highly structurally dependent on the Ponderosa Pine habitat. Therefore, it is important to maintain and enhance the structure and function of ponderosa pine habitats for flammulated owls.

Limiting Factors

1) Silvicultural practices that reduce habitat quality 2) pesticide use 3) predation/competitors 4) exotics.

Assumptions

1) Addressing factors that affect ponderosa pine, will also address flammulated owl and other ponderosa pine obligate species limiting factors. 2) If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable flammulated owl and white-headed woodpecker populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy

The following methods are designed to, 1.) facilitate delineation of current distribution and population levels of flammulated owls, and 2) identify current and potential areas of high quality flammulated owl habitat (short-term strategy i.e., <2 years).

Methods

Nighttime surveys will be conducted throughout potentially suitable Flammulated Owl breeding habitat, which will be determined according to habitat use reported in the literature, other reports, GIS habitat mapping, and other reported sightings the species.

Routes will be randomly selected from within the potential habitat area using a stratified sampling scheme. Each route should have between 10-12 stations, distributed along the route at equal intervals of .5 km, a standard methodology based on the distance owls can be heard on a calm night (at least 1.0 km) and the average size of territories (<500 m across) (Reynolds and Linkhart 1984, Howle and Ritchie 1987, Van Woudenberg and Christie 1997). The location of the starting point of the route, and of each station along the route, should be recorded as precisely as possible using a GPS (Global Positioning System). Each route should be surveyed three times per year during May-July – the time of year when vocal activity of the majority of species is greatest. Conduct surveys between 2200 and 0100 hours (Howle and Ritcey 1987, Groves et al. 1997). An attempt should be made to conduct the survey at the same time of night each year. At the beginning of the breeding season the greatest calling intensity for the Flammulated Owl is during much of the evening, and then after nestling hatching singing is "later at night" (Reynolds and Linkhart 1987).

Surveys should only be conducted under favorable conditions: wind speeds <20 km per hour, a wind speed of Beaufort 3 or less and no precipitation (including rain and/or snow). Temperatures should be close to the average for the season and efforts should be made to avoid extremely cold temperatures because of evidence that owls may be less vocal in very cold weather (Takats 1998a).

Surveys will consist of visiting a point for two minutes to listen for Flammulated Owls calling, and if no owls are heard then a male territorial call will be imitated or played from tape for one minute. After listening for an additional two minutes, the observer will then walk to the next point while still listening for calling owls. (Two minutes appears to be adequate for most spontaneously calling owls to be detected, at least during the period of peak calling activity. In Alberta, relatively few additional owls were detected during a third minute of listening (Takats, pers. comm.). In Ontario, more than 70% of 5 species of owls that were detected over a 5 minute period (included playback) were detected in the first two minutes (Takats 1997, 1998b)

Playback recordings should be as clear and loud as possible without distortion. Digital technology is recommended (CD-ROM, solid state, or digital tape) as the sound quality can be better controlled and is less likely to deteriorate over time. The audio equipment should be of sufficient quality that it will not distort the sound at loud volumes. We suggest the volume be such that the recording can be heard at 400m, but not at 800m (to minimize bias at the next survey station due to owls hearing the recording from the previous station). If possible, the volume should be measured at a standard distance (e.g., 1m from the speakers) using a decibel meter.

The recording should include both the silent listening periods as well as the playback sequence time period. A soft 'beep' or other sound can be used to indicate the start of the first silent listening period, and another beep to indicate the end of the final listening period. This will ensure that the time is fully standardized at each station, and reduce the need for participants to keep checking their watches.

Surveyors should be asked to estimate the approximate direction and distance to the first position where they detect each owl and plot location on a map. This data can help to determine whether the same owls are being detected at different stations along the route, to adjust for some of the variation in detection rates, and to aid in daytime nest searches.

Male presence is not adequate to determine habitat suitability as many males may remain unmated (Reynolds and Linkart 1987a, McCallum 1994a). The nests should be monitored so that success can be determined. Parallel transects 50 m apart through areas where owls were detected were surveyed in June and early July to try and find nest site locations. Since most of the calls heard in the field are from territorial reproductive males, nests can be located by systematic nest searches during the day (Bull et al. 1990). Once territory boundaries are delineated, all suitable nesting cavities (tree cavities with entrance diameters >4 cm) within territories will be checked for nesting owls (Linkart and Reynolds 1997).

Nest sites will be searched for using a pinhole camera system attached to a telescoping pole that reaches approximately 11 m high (Proudfoot 1996). This is an effective nest finding technique, but is limited to cavities within reach. Tree scratching (with a stick) can also used, which imitates a predator climbing the nest tree and often stimulates incubating or brooding females to look out of the nest cavity entrance (Bull et al. 1990). Observation of a female Flammulated Owl at a cavity entrance will document a nest site.

Analysis

Data from the surveys described here are similar to those of the Breeding Bird Survey, though some modifications may be required in the future. A wide variety of methods have been developed for analysis of BBS data (James et al. 1996, Link and Sauer 1994, 1998), but there is still some disagreement as to which methods are best (James et al. 1996, Link and Sauer 1994a, Link and Sauer 1994b, Thomas 1996). There are two main methods currently being used by the coordinators of the BBS. One involves route regression using estimating equations (Link and Sauer 1994), which assumes that trends may differ among routes, and calculates a weighted mean of the trends within routes. The selection of weighting factors is strongly dependent upon the sampling scheme used to select routes. An alternate approach involves a generalized linear model assuming over-dispersed Poisson residuals and a log-link function (Link and Sauer 1998). This approach assumes that trends are similar within a broader region, and allows more robust modeling of nonlinear population changes (e.g., year to year fluctuations). A simplified version of this latter approach has been used for analysis of population trends in Ontario (Lepage et al 1999, Francis and Whittam 2000), but it is not yet known whether this is the most appropriate analysis method.

The power of the survey technique will be investigated after its first three years in its present design to determine the actual variance. This will allow us to determine the number of routes required to detect our objective of a 35% change by 2020.

Finally, we recommend that relevant data be made publicly available, preferably over the Internet. This will encourage further research into analysis methods, thus ensuring that maximum use is made of the data for conservation purposes. However, care should be taken to protect sensitive information, such as precise nesting locations of rare species.

Focal Species Monitoring: White-headed Woodpecker

Rationale

Suitable white-headed woodpecker habitat includes large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10 - 50% and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags greater than 31 inches DBH). Maintaining white-headed woodpecker populations will require that this mature/old growth component of ponderosa pine habitat is maintained or enhanced within the subbasin.

Limiting Factors

34. 1) Silvicultural practices that reduce habitat quality 2) pesticide use 3) predation/competitors 4) exotics.

Assumptions

If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable white-headed woodpecker populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy

Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 25% increase in abundance of white-headed woodpecker with a power of 0.8 or greater.

Methods

The method used, point counts, is derived from Dixon (1998)

Point counts

Each observer will conduct one transect per day individually. Survey low-elevation transects first to assure accessibility. The protocol for point counts will follow standardized methods for variable circular plots (Reynolds et al. 1980, Ralph et al.1995, Hutto and Hoffland 1996), but modified to better census white-headed woodpeckers.

When to survey

Point counts should be conducted between April 1 and May 15 when the detectability of White-headed Woodpeckers is highest and most stable. After this period the woodpeckers typically excavate from within the nest cavity and become less visible and less vocal. Counts should begin at official sunrise and end no later than 1030 and 1100. Each transect will be visited once.

Point count timing

Counts will begin as soon as the observer arrives at the station and will be comprised of a 5-minute listening period without the use of tape playbacks followed by a 6-minute sequence of tape playbacks of White-headed Woodpecker calls and drums for a total count of 11 minutes. Data from the two types of counts will be recorded separately-with a code-on a the bird data sheet.

Tape playback procedure

Tape playback procedures will essentially follow the Payette National Forest Protocol for Broadcast Vocalizations (Payette National Forest 1993). The tape playback sequence should begin immediately after the 5-min unsolicited point count-be ready to start the tape at exactly 5 min. A total of four 30-second tape-playbacks of White-headed Woodpecker drums and calls will be projected at 1-min intervals (e.g. using a Johnny Stewart™ game caller); that is, begin the first sequence of vocalizations to the north. During the one minute pause after the first sequence, rotate 90° for the second sequence, pause, then rotate another 90° for the third sequence of vocalizations after the second one minute break. When the third sequence is complete, rotate 90° for the fourth and final sequence for a total of 6 minutes of tape-playbacks.

When not to survey

Surveys will not be conducted during heavy rain, fog, or when wind interferes with an observer's ability to detect calls (greater than 20 mph). If the weather appears prohibitive, wait 1 to 1.5 hours, or until you cannot reasonably complete the transect by 1100 hours. If the weather puts you in danger, STOP-your safety comes first.

What to record

Record all species detected, visual or auditory. At the bottom of the data sheet, record any birds you might have detected either before or after a point count, or between stations.

Focal Species: Pygmy Nuthatch

Rationale

Suitable pygmy nuthatch habitat contains heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age. Pygmy nuthatch represents those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 inches DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

Limiting Factors

35. Silvicultural practices that reduce habitat quality; 2) fragmentation; 3) predation/competitors; 4) exotics.

Assumptions

If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable pygmy nuthatch populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy

This is a survey development need.

8.3.8 Shrubsteppe

Focal Species: Brewer's sparrow (*Spizella breweri*), mule deer (*Odocoileus hemionus hemionus*)

Overall Habitat and Species Monitoring Strategy

Establish monitoring program for protected and managed shrubsteppe sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors Affecting Habitat

- Direct loss shrubsteppe due to conversion to agriculture, residential, urban and recreation developments
- Fragmentation of remaining shrubsteppe habitat, with resultant increase in nest parasites
- Fire Management, either suppression or over-use, and wildfires
- Invasion of exotic vegetation
- Habitat degradation due to overgrazing, and invasion of exotic plant species
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities.

Shrubsteppe Working Hypothesis Statement

The near term or major factors affecting this focal habitat type are direct loss of habitat due primarily to conversion to agriculture, reduction of habitat diversity and function resulting from invasion of exotic vegetation and wildfires, and livestock grazing. The principal habitat diversity stressor is the spread and proliferation of annual grasses and noxious weeds such as cheatgrass and knapweeds that either supplant and/or radically alter entire native bunchgrass communities significantly reducing wildlife habitat quality. Habitat loss and fragmentation (including fragmentation resulting from extensive areas of undesirable vegetation) coupled with poor habitat quality of extant vegetation have resulted in extirpation and/or significant reductions in shrubsteppe obligate wildlife species.

Recommended Range of Management Conditions

Condition 1: Sagebrush dominated shrubsteppe: The Brewer's sparrow was selected to represent wildlife species that require sagebrush dominated sites, but prefer a patchy distribution of sagebrush clumps 10-30% cover, lower sagebrush height (between 20 and 28 inches), native grass cover 10 to 20% (Dobler 1994), non-native herbaceous cover less than 10% , and bare ground greater than 20% (Altman and Holmes 2000).

Condition 2 - Diverse shrubsteppe habitat: Mule deer were selected to represent species that require/prefer diverse, dense (30 to 60% shrub cover less than 5 feet tall) shrubsteppe habitats comprised of bitterbrush, big sagebrush, rabbitbrush, and other shrub species (Leckenby 1969; Kufeld et al. 1973; Sheehy 1975; Jackson 1990; Ashley et al. 1999) with a palatable herbaceous understory exceeding 30% cover (Ashley et al. 1999).

Focal Habitat Monitoring Strategies

Establish an inventory and long-term monitoring program for protected and managed shrubsteppe habitats to determine success of management strategies. Subbasin managers recognize that restoration of shrubsteppe is still very much a fledgling field, and complete restoration of degraded or converted shrubsteppe may not be feasible. These monitoring strategies reflect the commitment to and initiation of the process of longterm management.

36. Identify shrubsteppe habitat sites within the subbasin that support populations of Brewer's sparrow
37. Evaluate habitat site potential on existing public lands and adjacent private lands for protection of focal species habitat (short-term strategy i.e., < 2 years).
38. Enhance habitat on public lands and adjacent private lands (intermediate strategy; 2 to 10 years)
39. Identify high quality/functional privately owned shrubsteppe sites that are not adjacent to public lands (long-term strategy 2 to 15 years).
40. Establish permanent censusing stations to monitor bird population and habitat changes.

Sampling Design

Permanent survey transects will be located within shrubsteppe habitats using HEP protocols. HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type.

Sampling Methods (USFWS 1980a and 1980b)

Bare ground or cryptogram crust

Measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

The% age of the microplot consisting of either bare ground or cryptogram crust is estimated via ocular estimate.

Herbaceous

Measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular $0.5m^2$ microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

Herbaceous cover% age is measured via an ocular estimate of the% age of the microplot shaded by any grass or forb species.

Shrub

Canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment).

Shrub canopy cover is measured on a line intercept 'hit' or 'miss'. Measurements are taken every 2 or 5 feet, depending upon shrub density.

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

Tree

Canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Other

At any permanently established avian species monitoring site established within the shrubsteppe habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Analysis

Transects are divided into 100 ft. segments, and total transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: $n = \frac{t^2 \text{ x } s^2}{E^2}$

Where: t = value at 95% confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring: Brewer's Sparrow

Rationale

The main premise for focal species selection is that the requirements of a demanding species assemblage such as Brewer's sparrow encapsulate those of many co-occurring less demanding species. By directing management efforts toward the requirements of the most exigent species, the requirements of many cohabitants that use the same habitat type are met. Therefore, managing habitat conditions for a species assemblage comprised of these three species should provide life requisite needs for most other shrubsteppe obligate species.

Limiting Factors

41. Conversion of native shrubsteppe habitat for agricultural purposes, 2) habitat fragmentation; 3) degradation of existing habitats from overgrazing and introduced weedy vegetation, 4) brush removal, 5.) wildfire

Assumptions

42. Addressing factors that affect shrubsteppe habitat will address Brewer's sparrow; 2) If shrubsteppe habitat is of sufficient quality, extent, and distribution to support Brewer's sparrow populations, the needs of most other shrubsteppe obligate species will also be addressed and shrubsteppe functionality could be inferred.

Sampling Strategy

Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 35% increase in abundance of key species with a power of 0.8 or greater.

Methods

We will survey birds on 64 sites in different vegetation types and levels of fragmentation. Each site will have 4 100-m fixed-radius point counts (Ralph et al. 1993) established along a transect and spaced 200m apart (Fig 4). The outer points of the point-count circles will describe a rectangular plot of 16ha that will be the focus of all survey work in Objectives 2-4. Each point will be marked with a permanent fiberglass stake (1m electric fence post) and colored flagging will be placed on shrubs at 50 and 100m from the point in each of the 4 cardinal directions to aid in determining distance. Counts at each point will be 5 minutes in duration during which all birds seen or heard will be noted, along with their sex (if known), distance from the point (within 50m, >50 but <100m, or beyond 100m), and behavior (singing, calling, silent, or flying over the site). Surveys will be conducted once each in May and June and within prescribed weather parameters (e.g., no rain and low wind).

Focal Species Monitoring: Mule Deer

Rationale

Mule deer inhabit all habitats within the subbasin. The largest concentration of mule deer is found on the north shore of Lake Chelan during winter. Shrubsteppe habitat quality determines the size and persistence of mule deer populations within the subbasin, as they are both critical winter habitat and the limiting factor for this species in the subbasin. Mule deer have been selected as a focal species due to the significant economic, recreational, and cultural values this species provides.

Limiting Factors

43. flooding of habitat resulting from hydropower facilities, 2) loss of habitat due to urban and suburban development, 3) road and highway construction, 4) degradation of existing habitats from overgrazing and introduced weedy vegetation, 5) alteration of historic fire regimes, 6) past silvicultural practices, 7) deer control efforts necessitated by agricultural damage, 8) natural predation and over-harvest by hunters, 9) disease and parasites

Assumptions

Addressing factors that affect shrubsteppe habitats, will also address mule deer and other shrubsteppe obligate species limiting factors.

Management Objective

The population management objective for mule deer will be to increase or maintain populations within the limitations of available mule deer habitat and landowner tolerance (agricultural damage). Population monitoring variables and objectives are established in the Washington Department of Fish and Wildlife Game Management Plan (WDFW 2003). A valuable tool unique in this subbasin are the 12, annual winter wildlife surveys conducted by Chelan PUD as a condition of the Lake Chelan hydroelectric project operating license. In areas with periodically high mule deer populations and significant agricultural damage complaints, WDFW will regulate populations as appropriate through hunter harvest.

Monitoring Methods

Mule deer populations will be monitored using a combination of post hunting surveys, winter surveys and harvest data. Current surveys allow the monitoring of age/sex ratios to determine if management objectives established in the Game Management Plan (WDFW 2003) are being met for post-season buck survival (> 15 bucks/100 does) and fawn production and recruitment. Harvest data is used as an indicator of population trend.

Evaluation Strategies

44. Use winter aerial, boat and ground surveys to classify mule deer to determine post-hunt buck/fawn to doe ratios and population size trends.

45. Monitor harvest level of bucks and antlerless deer using mandatory hunter report system.

46. Model the Chelan and Methow PMU mule deer populations (Lake Chelan divides two population management units, both of which extend beyond the subbasin border).

8.4 Aquatic

8.5 Westslope Cutthroat Trout

8.5.1 Biological Objectives

47. Make historic spawning grounds available to westslope cutthroat trout (WSCT) earlier by removal of tributary barriers or lake level management by 2008 (assuming new license is issued to Chelan PUD)

48. Eliminate the introductions of non-native species that have negative impacts on WSCT by 2010.

49. Decrease the abundance or remove key exogenous species by 2015.

50. Reduce direct harvest impacts on naturally produced WSCT by 2010.

8.5.2 Strategies

51. Mechanically remove barriers to WSCT spawning streams

52. Produce a comprehensive fish stocking plan for all species of interest that have potential to negatively affect WSCT.

53. Increase harvest on chinook salmon and lake trout.

54. Remove harvest limit on brook trout and rainbow trout.

55. Determine early life history requirements of WSCT

56. Assess whether kokanee spawning disrupts WSCT fry emergence

57. Delay opening of fishing near tributary mouths until after the spawning season

8.5.3 Consistency with ESA and CWA Requirements

ESA consistency

Bull trout are currently the only focal species that are listed under the ESA. In the Chelan Basin, bull trout have not been sited since the 1950s. Therefore, any actions taken to increase WSCT will consider potential interactions with bull trout if they are found within the Chelan Basin.

Clean Water Act compliance

Lake Chelan is considered ultra oligotrophic and in excellent condition. However, Railroad Creek still suffers from mining activities from the 1930s to 1950s. Current plans call for the clean up of the mine tailings which have been identified as the major source of contaminants.

A consortium of local agencies and the Washington State Department of Ecology have formed the Lake Chelan Water Quality Committee. This Committee was formed to provide a framework within which to monitor the water quality characteristics of Lake Chelan.

8.5.4 Research, Monitoring and Evaluation

Research, monitoring and evaluation are linked to each hypothesis and its biological objectives and strategies and conclude each hypothesis table.

Table 37. WSCT working hypothesis 1, objectives, strategies, and research

Working hypothesis WSCT 1 for Lake and Tributary Assessment Units: *Interactions with exogenous species have negatively affected WSCT spawning and rearing.*
Key findings supporting hypothesis: ➢ WSCT compete with suckers and rainbow trout during spawning ➢ Rainbow trout interbreed with WSCT where they occur together ➢ Brook trout and rainbow trout compete for food in natal streams with juvenile WSCT ➢ Juvenile kokanee and chinook salmon all compete for limited zooplankton in Lake Chelan ➢ Adult kokanee spawn during observed fry emergence
Biological objectives: ➢ Eliminate the introductions of non-native species that have negative impacts on WSCT by 2010. ➢ Decrease the abundance or remove key exogenous species by 2015.
Strategies: 1. Produce a comprehensive fish stocking plan for all species of interest that have potential to negatively affect WSCT. Removing known species from plantings (e.g., rainbow trout) will reduce the impact on spawning and rearing. Because populations of species such as kokanee salmon, brook and rainbow trout are already established, eliminating more plantings will help other efforts aimed at reducing their impacts on WSCT. 2. Remove harvest limit on brook trout and possibly rainbow trout Removing the harvest limits on brook trout, and potentially rainbow trout will reduce their abundance and decrease the likelihood that these species can negatively impact WSCT on the spawning grounds or rearing areas. 3. Assess whether kokanee spawning disrupts WSCT fry emergence Adult kokanee have been observed spawning during fry emergence on Company Creek. Kokanee may be dislodging pre-emergent fry at times that may not be beneficial to fry

survival

4. Determine early life history requirements of WSCT

Understanding early life history requirements of WSCT will increase our understanding of potential interactions with other species.

The priorities of the strategies are: 1, 2, 4, 3 based on the potential impacts and feasibility of implementing programs that would occur under these strategies.

Research

Hypothesis: *Interactions with exogenous species have negatively affected WSCT spawning and rearing.*

To determine the potential negative interactions, the following information would be needed to test the hypothesis:

I. Tributaries Assessment Units

Current information:

- Brook trout and rainbow trout are established within most, if not all assessment units
- Spawning habitat is limited in the smaller tributaries to Lake Chelan
- Kokanee salmon spawn in most streams that WSCT are found

Additional informational needs:

- Intensive spawning ground investigations of WSCT to determine if suckers and rainbow trout are displacing WSCT and whether rainbow are interbreeding with WSCT

  By intensively monitoring spawning areas during migration and spawning, interactions between WSCT and rainbow and suckers could be systematically recorded. Other species that interact with WSCT should be recorded too.

  Currently, known areas of spawning of WSCT are: 25-Mile, Safety Harbor, Railroad, Prince, Fish, Four-mile creeks, and the Stehekin River drainage. Representative areas within these a subsample of these streams would be surveyed at least once per week from May through July.

- Juvenile life history information, so we understand what factors may be limiting production (and when juveniles enter the lake for adfluvial ecotypes).

  Understanding WSCT early life history will enable researchers to determine negative interactions between WSCT and other species, and will assist in developing management actions to reduce the negative impacts.

Anticipated results/interpretations:

- Interactions between rainbow trout and suckers limit spawning success of WSCT

It is anticipated that other interactions (e.g., competition for food) will be observed between WSCT and other species. However, it is important that researchers understand that not all interactions are negative. It will be important to clearly define which interactions could be interpreted as negative prior to the study.

- Interactions will be identified that limit WSCT survival

  It is anticipated that interactions will be identified that potentially limit production. It is important that is also determined if any interactions with other species are shown to potentially increase production.

- Early life history needs, including habitat preferences, species interactions, and lake entry (for adfluvial ecotypes).

  By "following" juvenile WSCT early rearing, including emergence timing, interactions with kokanee spawners, rainbow and sucker fry (and potentially Chinook and kokanee salmon fry in the lake (if it is shown that fry emigrate to the lake).

  Some species interaction may displace WSCT into Lake Chelan.

  By either trapping or observing, it is anticipated that lake entry will also be determined. This will increase our understanding of WSCT life history needs and potential other impacts within Lake Chelan (see below).

Potential management applications

- Remove non-native species that negatively affect WSCT by traps, increased catch limits, and other physical means.
- Decrease negative interactions with native species by making spawning habitat more available earlier for some populations.
- Increase spawning habitat

Approach (general experimental design)

- Snorkeling surveys to:
  1. observe WSCT spawning, and interactions with other species;
  2. determine early life history needs and interactions with other species;
  3. observe whether kokanee are disrupting emergence timing of WSCT.
- Electrofish:
  1. to determine numbers and diversity of fish within a sample reach
- Determine fry emergence timing, based on temperature and observed spawning within a sample reach;
- Remove exogenous species from a sample reach and compare to a "control" reach

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Snorkeling will be conducted in four streams, representing the diversity of WSCT spawning habitat. These streams will be located near the lower limit of their range in the lake (e.g., 25-Mile Creek), towards the middle (e.g., Prince Creek), near the upper (e.g., Fish Creek), and in the Stehekin drainage (e.g., Company Creek).

Temporal scale

- It is suggested that this study take place over two generations of WSCT (6-10 years).
- Observations would be taken during three main time periods:
    1. pre-spawning
    2. during spawning
    3. during emergence
- Further definition on whether there could be a randomized design where not every stream was looked at each year will be further investigated since this would decrease the budget.

Application

- The results of this research would apply to WSCT and the species that are shown to negatively interact with it.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: USFWS, USFS, and NPS

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.

- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public

II. Lake Chelan Assessment Unit

Current information:

- Mysids, brook trout, rainbow trout, lake trout, Chinook and kokanee salmon are established within the lake
- Lake trout and chinook salmon are large enough to prey on juvenile or adult WSCT
- Lake Chelan does not produce large quantities of zooplankton

Informational needs:

- Species interactions within the lake.

  Understanding species interactions within the lake will enable managers to make informed decisions on which management strategies to follow.

- WSCT movement within the lake

  Understanding WSCT movement within the lake will increase our understanding of potential interactions with predators and competitors

Anticipated results/interpretations:

- Stomach analysis will determine that lake trout and Chinook salmon are preying on WSCT.
- WSCT stomach analysis will show which plankton and other invertebrates they are keying on.

  Species interactions may be difficult to determine within the lake because of logistical problems with sampling. However, indirect information from stomach analyses, plankton tows, etc., will enable researchers to make inferences on these potential interactions.

Potential management applications

- Reduce abundance of lake trout and Chinook salmon.
- Immediately stop planting both species into the lake

Approach (general experimental design)

- Detailed stomach analysis of lake trout and Chinook salmon caught at different times of the year and in different locations
- Detailed stomach analysis of WSCT, rainbow trout, and other species
- Active tag tracking of WSCT, and potentially other competitors or predators

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- WSCT will be tagged at various life stages at various locations around the lake and within tributaries

Temporal scale

- It is suggested that this study take place over two years
- Further definition on whether there could be a randomized design where not every stream was looked at each year will be further investigated since this would decrease the budget.

Application

- The results of this research would apply to WSCT and the species that are shown to negatively interact with it.

Budget (concurrent with tributary work)

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: USFWS, WDFW, USFS, and NPS

Deliverable (concurrent with tributary work)

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data (concurrent with tributary work)

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.

All data will be available upon request to other agencies or the public

Table 38. WSCT working hypothesis 2, objectives, strategies, and research

Working hypothesis WSCT 2:

- *Development of barriers at tributary mouths has negatively affected spawning and subsequent fry survival of WSCT.*

Key findings supporting hypothesis:

- With the exception of 25-Mile Creek, First Creek, and the Stehekin River, barriers (velocity, deposition, and depth) have formed at spawning tributary mouths. Most other habitat features remain (except for LWD in the lake which is removed for navigation purposes).

Biological objectives:

- Make historic spawning grounds available to WSCT earlier by removal of tributary barriers or lake level management by 2008 (assuming new license is issued to Chelan PUD)

Strategies:

1. Mechanically remove barriers to WSCT spawning streams

   Studies conducted in 1999 and 2000 showed that WSCT were spawning one- two months later than in the late 1970s-early 1980s.

   By a combination of lowering the lake slightly earlier in the fall (freshets may help flush physical barriers out at mouth tributaries), mechanically removing (when needed), and filling the lake slightly earlier in the spring (inundating barriers), barriers at tributary mouths will not impede WSCT passage into spawning areas.

Data Gaps and additional informational needs:

- Determine after barriers are removed whether spawning time has changed.

Research

Hypothesis: *Modifications in lake levels have negatively affected spawning and subsequent fry survival of WSCT.*

To determine whether removing barriers at the mouth of WSCT spawning streams has reduced WSCT production, the following information would be needed to test the hypothesis:

Tributaries Assessment Units

Current information:

- Most spawning streams (excluding First, Twenty-five Mile Creek and the Stehekin River) are currently difficult to reach at historic spawning times because of the barriers that have been created at their mouths.

Additional informational needs:

- Precise spawning time of WSCT in sample tributaries that have shown to have barrier problems before and after barrier removal

  By understanding spawning time prior to barrier removal, it will us understand the effects of removal

- Fry emergence and early life history needs within sample streams before and after barrier removal

  Understanding WSCT early life history will enable researchers to determine the effects of barrier removal.

Anticipated results/interpretations:

- WSCT will reach historic spawning areas earlier than they do presently.

  By removing physical barriers, WSCT will be able to reach their spawning areas closer to historic times, which may reduce competition with other species, e.g., suckers.

- Fry will emerge sooner, better able to synchronize with food production, and potential negative impacts from kokanee spawners

  It is anticipated that if WSCT spawn sooner, fry will emerge sooner and will better able to survive.

Potential management applications

- Remove barriers.
- Increase spawning habitat

Approach (general experimental design)

- Pre barrier removal:
  1. Obtain precise spawning dates in sample streams.
  2. Determine fry emergence in sample streams.
- Post barrier removal:
  1. Obtain precise spawning dates in sample streams.
  2. Determine fry emergence in sample streams.
- Determine fry emergence timing, based on temperature and observed spawning within a sample reach;

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Two streams will be chosen that are currently known to have barriers at their mouths.

Temporal scale

- It is suggested that this study take place over three years.
- Year one would be pre-barrier removal. Years two and three would be post barrier removal.

Application

- The results of this research would apply to WSCT and possibly rainbow trout.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: Chelan PUD, USFWS, USFS, and WDFW.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public

Table 39. WSCT working hypothesis 3, objectives, strategies, and research

Working hypothesis WSCT 3:

Harvest regulations and hatchery practices have reduced adult abundance.

Key findings supporting hypothesis:

- Based on anecdotal information on early catch rates of WSCT in newspapers and other sources, the current population of WSCT appears to be much reduced from historic times.

High catch rates in the 19th century and historic and current hatchery practices in have all lead to their decline.

Biological objectives:

- Eliminate the introductions of non-native species that have negative impacts on WSCT by 2010.
- Decrease the abundance or remove key exogenous species by 2015.
- Reduce direct harvest impacts on WSCT by 2010.

Strategies:

1. Produce a comprehensive fish stocking plan for all species of interest

A comprehensive fish stocking plan will consider all impacts of introduced fish, and will determine the types of fish introduced, best release locations and timing.

In the past, many management decisions on Lake Chelan have not been well coordinated, or were made based on false information (e.g., Mysids, which were introduced into Lake Chelan to increase the size of kokanee, but ended up being competitors for the same resource). By having a coordinated plan, all species that are impacted will be regarded prior to fish releases.

2. Increase harvest on Chinook salmon and lake trout

Increasing harvest on Chinook salmon and lake trout will have a direct effect on the number of WSCT spawners. Spawning WSCT will increase and productivity will increase.

3. Remove harvest limit on brook trout and rainbow trout

Reducing the numbers of brook and rainbow trout will reduce competition for spawning and rearing habitat in the tributaries. Reducing competition for spawning and rearing habitat will increase survival of WSCT, and subsequent productivity.

4. Delay opening of fishing near tributary mouths until after the spawning season.

By delaying the opening of fishing near tributary mouths, fishers will not be able to target WSCT when they are either staging for spawning, or post spawning return to Lake Chelan.

Reducing direct harvest on vulnerable adults will increase the number of adult fish surviving, and since WSCT are iteroparous, more adults surviving after spawning means more adults will spawn again, thus increasing productivity.

The priorities of the strategies are: 1,4,3,2 based on the potential impacts and feasibility of implementing programs that would occur under these strategies.

Data Gaps and additional informational needs:

- Determine public acceptance of changed harvest regulations prior to initializing

Estimates of adult abundance prior to and after regulations/hatchery practices are changed.

Research

Hypothesis: *Harvest regulations and hatchery practices have reduced adult abundance.*

To determine whether harvest regulations and current hatchery practices are reducing the numbers of adult WSCT, the following information would be needed to test the hypothesis:

Tributary and Lake Assessment Units

Current information:

- Current populations of WSCT are low based on creel and stream surveys.

Additional informational needs:

- Estimate of current population

  By understanding what the current population may be, researchers might be able to determine what effects changes in harvest regulations and hatchery practices may have.

- Species interactions within the lake.

  Understanding species interactions within the lake will enable managers to make informed decisions on which management strategies to follow.

Anticipated results/interpretations:

- The abundance of WSCT will be made, with low confidence because of the numerous assumptions that will be necessary to generate this estimate..

  Since current inference suggests that abundance is low, many assumptions will have to be made to estimate the WSCT abundance in the lake. Statistical confidence will most likely be low, with a wide range in the estimate.

- Stomach analysis will determine that lake trout and Chinook salmon are preying on WSCT.
- WSCT stomach analysis will show which plankton and other invertebrates they are keying on.

  Species interactions may be difficult to determine within the lake because of logistical problems with sampling. However, indirect information from stomach analyses, plankton tows, etc., will enable researchers to make inferences on these potential interactions.

Potential management applications

- Increase harvest on lake trout and Chinook salmon.

- Stop stocking Chinook salmon and rainbow trout
- Removal of other exotic species from the lake (e.g., mysids)

Approach (general experimental design)

- Estimate total abundance:
    1. Based on extensive spawner survey;
    2. Based on total current habitat use
- Detailed stomach analysis of lake trout and Chinook salmon caught at different times of the year and in different locations
- Detailed stomach analysis of WSCT, rainbow trout, and other species
- Observation near spawning tributary mouths when adfluvial trout are staging and returning to the lake

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Four sites within Lake Chelan will be randomly picked after determining a larger number of sites within the lake where useful data may be obtained..

Temporal scale

- It is suggested that this study take place over two years.

Application

- The results of this research would apply to WSCT, rainbow trout, Chinook salmon, lake trout, potentially brook trout.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: WDFW, USFWS, and USFS.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public

Table 40. Relationship of WSCT hypotheses, objectives, and strategies

Summary of relationship between hypotheses, biological objectives, and strategies			
	Hypothesis WSCT 1	**Hypothesis WSCT 2**	**Hypothesis WSCT 3**
	Interactions with non-native species have negatively affected WSCT in the Chelan Basin	*Development of barriers at tributary mouths have negatively affected spawning and subsequent fry survival of WSCT*	*Harvest regulations and hatchery practices have reduced adult abundance*
Biological Objectives			
Make historic spawning grounds available to WSCT earlier by removal of tributary barriers and lake level management by 2008 (assuming new license is issued to Chelan PUD)		X	
Eliminate the introductions of non-native species that have negative impacts on WSCT by 2010	X		X
Decrease the abundance or remove key exogenous species by 2015	X		X
Reduce direct harvest impacts on WSCT by 2006	X		X
Strategies			
Mechanically remove barriers to WSCT spawning streams		X	
Produce a comprehensive fish stocking	X		X

plan for all species of interest			
Increase harvest limit on Chinook salmon and lake trout	X		X
Remove harvest limit on brook trout and possibly rainbow trout.	X		X
Delay opening of fishing near tributary mouths until after the spawning season			X
Determine early life history requirements of WSCT	X	X	
Assess whether kokanee spawning disrupts fry emergence	X		

Table 41. WSCT monitoring and evaluation indicators

Indicators that will be monitored and evaluated									
General characteristics	**Specific indicators**	**Strategies**							
Biological		*Mechanically remove barriers to WSCT spawning streams*	*Produce a comprehensive fish stocking plan for all species of interest*	*Increase harvest limit on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout and possibly rainbow trout.*	*Delay opening of fishing near tributary mouths until after the spawning season*	*Determine early life history requirements of WSCT*	*Assess whether kokanee spawning disrupts fry emergence*
Adults	Escapement/ Number	X	X	X	X	X		X
	Age structure		X	X				
	Size			X				
	Sex ratio			X				
	Run timing	X		X				X
	Origin (hatchery/ wild)		X					
	Fecundity							
Redds	Number	X		X	X	X		
	Distribution	X			X			X
	Timing	X			X			X
Parr/	Abundance	X	X	X	X		X	X

Juveniles	Distribution/ Habitat use	X	X		X	X	X	
	Size	X			X		X	X
Interactions	Predator/ prey		X	X	X		X	
	Displacement	X	X		X		X	X
	Interbreed		X		X			
Habitat								
Water Quality	MWMT and MDMT							
	Turbidity							
	Conductivity							
	pH							
	Dissolved oxygen							
	Nitrogen							
	Phosphorus							
Habitat Access	Road crossings							
	Diversion dams							
	Timing	X					X	X
	Barriers	X						
Habitat Quality	Dominant substrate						X	
	Embeddedness						X	
	Depth fines						X	
	LWD (pieces/km)						X	
	Pools (pools/km)						X	
	Residual pool depth						X	
	Fish cover						X	
	Side channels and backwaters						X	
Channel condition	Stream gradient	X						
	Width/depth ratio	X						
	Wetted width							
	Bankfull width							
	Bank stability							

Riparian Condition	Riparian structure						X	
	Riparian disturbance						X	
	Canopy cover						X	
Flows and Hydrology	Streamflow	X					X	
Watershed Condition	Watershed road density							
	Riparian-road index							
	Land ownership							
	Land use							

Table 42. WSCT monitoring needs

Commonality between monitoring needs								
Category	**Metric or method**	**Strategies**						
		Mechanically remove barriers to WSCT spawning streams	*Produce a comprehensive fish stocking plan for all species of interest*	*Increase harvest limit on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout and possibly rainbow trout.*	*Delay opening of fishing near tributary mouths until after the spawning season*	*Determine early life history requirements of WSCT*	*Assess whether kokanee spawning disrupts fry emergence*
Adults	Spawning ground surveys	X		X	X			
	Estimate of abundance		X	X	X	X		
	Interactions with native species	X	X			X		
	Interaction with exogenous species	X	X	X	X	X		
	Stomach analysis			X				
	Movement	X		X		X		
	Run timing	X	X	X	X	X		
Juveniles	Emergence timing	X			X		X	X
	Distribution				X		X	X

	Interactions with native species	X	X	X			X	
	Interaction with exogenous species	X	X	X	X		X	X
	Abundance		X		X		X	X
Methods	Snorkel	X			X		X	X
	Electro-fish	X			X		X	X
	Active tag & track			X				
	Hook & line			X	X			
	Creel survey			X	X	X		
	Stomach analysis		X	X				
Scale	Spatial	2 streams	2 streams Through-out lake	Through- out lake	2 streams	4 streams	4 streams	2 streams
	Temporal	3 years	2 years	6-10 years	6-10 years	3 years	3 years	3 years

Table 43. WSCT planning and design of strategy implementation

Planning, design and standards								
Category	**Metric/ responsibility**	**Strategies**						
		Mechanically remove barriers to WSCT spawning streams	*Produce a comprehensive fish stocking plan for all species of interest*	*Increase harvest limit on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout and possibly rainbow trout.*	*Delay opening of fishing near tributary mouths until after the spawning season*	*Determine early life history requirements of WSCT*	*Assess whether kokanee spawning disrupts fry emergence*
Evaluation planning	Evaluation responsibility	Chelan PUD	PUD, WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	PUD, WDFW, USFWS, USFS, NPS
	Decision responsibility	PUD, WDFW, USFWS, USFS, NPS	WDFW/ USFWS	WDFW	WDFW	WDFW	USFWS	USFWS
	Public feedback	2 x/yr	3 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr
	Potential cost share (mostly personnel)	PUD	PUD, WDFW, USFWS, USFS, NPS	WDFW	WDFW	WDFW	WDFW, USFWS, USFS, NPS	PUD, WDFW, USFWS, USFS, NPS

*Sampling design**	Monitoring	E	S/T	E	E	E	S/T	E
	Frequency	1 x/yr (2 mo.)	3 x/yr	3 x/yr	3 x/yr	1 x/yr	3 x/yr	1 x/yr
	Methods	Snorkel	Creel survey, hook & line	Creel survey, hook & line	Creel survey, hook & line	Creel survey, hook & line	Snorkel	Snorkel
Statistical Considerations	Significance level	α =0.10	n/a	n/a	n/a	n/a	n/a	n/a
	Hypothesis	WSCT 2	WSCT 1, 3	WSCT 3	WSCT 1, 3	WSCT 3	WSCT 1, 3	WSCT 1
Performance standards	Reference	Current spawn timing	Current abund.	Current abund.	Current abund.	Current abund.	Current emergence timing, lake entry	Current emergence
	Desired effect	Earlier spawn timing	Higher abund.	Higher abund.	Higher abund.	Higher abund.	Earlier emergence and longer stream life	Earlier emergence

E = effectiveness; S/T = status/trend monitoring

Table 44. WSCT data management

Data information and archive								
		Strategies						
		Mechanically remove barriers to WSCT spawning streams	*Produce a comprehensive fish stocking plan for all species of interest*	*Increase harvest limit on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout and possibly rainbow trout.*	*Delay opening of fishing near tributary mouths until after the spawning season*	*Determine early life history requirements of WSCT*	*Assess whether kokanee spawning disrupts fry emergence*
Quality Assurance/ control	Agency responsible for developing QA/QC	Chelan PUD	PUD, WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	WDFW, USFWS, USFS, NPS	PUD, WDFW, USFWS, USFS, NPS
Data management	Format	PDA in field	Document/ matrices	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field
	Stored	CD/CPU	CD/CPU	CD/CPU	CD/CPU	CD/CPU	CD/CPU	CD/CPU
	Updated	6 mo.	2 mo.	yearly	yearly	yearly	6 mo.	6 mo.
	Access	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site

Report preparation	Format	Formal	Formal	Tech. memo	Tech. memo	Tech. memo	Formal	Formal
	Presentation	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final
	Incorporation of comments	After sent to manage-ment agencies, then public	After sent to manage-ment agencies, then public	After sent to manage-ment agencies,	After sent to manage-ment agencies,	After sent to manage-ment agencies,	After sent to manage-ment agencies, then public	After sent to manage-ment agencies, then public

Table 45. WSCT evaluation

Evaluation								
		Strategies						
		Mechanically remove barriers to WSCT spawning streams	*Produce a comprehensive fish stocking plan for all species of interest*	*Increase harvest limit on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout and possibly rainbow trout.*	*Delay opening of fishing near tributary mouths until after the spawning season*	*Determine early life history requirements of WSCT*	*Assess whether kokanee spawning disrupts fry emergence*
Scientific	strengths	-already have base-line info.; -observation relatively simple;	-coordinated plan will incorporate competing interests; -better ability to recover or restore native species	-reduces one limiting factor	-reduces one limiting factor -can test empirically (remove from one stream section)	-reduces one limiting factor	-data can be empirically gathered -will foundation for other management actions	-data can be empirically gathered
	weaknesses	-time of year could render obs. diff. (high run-off); -not enough WSCT to detect difference in some streams	-unavail-ability of eggs, or proper genetic stock; -unintended species interactions	-response of WSCT will be complicated by other factors	-observation of interactions may be difficult to determine	-may be difficult to observe response	-observation of interactions may be difficult to determine	-observation of interactions may be difficult to determine

Decision-making	Determine if alternatives should be needed	If data suggests barriers are not problem and WSCT are still not reaching spawning grnds at appr. time	Alternatives to this point have not been coordinated and current negative species interactions are thought to be deleterious to native species	Determine public opposition to plan before implement-ting.	Pursue other options if the study is inconclusive.	Pursue other options if the study is inconclusive.	Other approaches may be necessary, but will not be known until after information is collected.	Pursue other options if the study is inconclusive.
	Management response to changes in indicators	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches
Public	Review format	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation
	Comment format	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentati on	Written, verbal @ presentation	Written, verbal @ presentati on	Written, verbal @ presentation	Written, verbal @ presentation
	Incorporation of comments	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency

8.6 Bull Trout

8.6.1 Biological Objectives

58. Determine if bull trout exist in the basin by 2008.

59. If bull trout are found, attain self sustaining non-migratory populations of bull trout (if feasible) by 2025.

60. Reduce abundance of exogenous stocks that may hinder reintroduction by 2010.

61. Ensure historic habitat remains in tact by 2008

8.6.2 Strategies

62. Explore likely places that may hold reserves of non-migratory bull trout

63. Reintroduce bull trout into historic habitat, if feasible

64. Determine predator-prey relationships in Lake Chelan.

65. Determine potential interactions with established populations prior to introduction.

66. Increase harvest on Chinook salmon and lake trout.

67. Remove harvest limit on brook trout.

68. Preserve (or restore) geo-fluvial processes in all tributaries

8.6.3 Consistency with ESA and CWA Requirements

ESA Consistency

Bull trout are currently the only focal species that are listed under the ESA. In the Chelan Basin, bull trout have not been observed since the 1950s. One of the suggested approaches within this management plan is to increase investigations to confirm whether any non-migratory ecotypes may still exist in remote headwater sections of some streams. If bull trout are not found (or potentially if they are and introduced in other segregated areas), additional efforts may attempt to reintroduce them to increase the abundance of the Columbia River Distinct Population Segment, although this population, under section 10(j) of the ESA would be “experimental” would not be subject to the same level of limitations and requirements that accompany ESA status generally.

Clean Water Act Compliance

Lake Chelan is considered ultra oligotrophic and in excellent condition. However, Railroad Creek still suffers from mining activities from the 1930s to 1950s. Current plans call for the clean up of the mine tailings which have been identified as the major source of contaminants.

A consortium of local agencies and the Washington State Department of Ecology have formed the Lake Chelan Water Quality Committee. This Committee was formed to provide a framework within which to monitor the water quality characteristics of Lake Chelan.

8.6.4 Research, Monitoring and Evaluation

Research, monitoring and evaluation are linked to each hypothesis and its biological objectives and strategies and conclude each hypothesis table.

Table 46. Bull trout working hypothesis 1, objectives, strategies, and research

Working hypothesis BT 1: *Bull trout are still present in smaller tributaries as non-migratory ecotypes.*
Key findings supporting hypothesis: ➢ Bull trout have not been documented within the Chelan Basin since the 1950s. ➢ It is not clear why they may be extinct, but potential reasons are: over harvest, loss of spawning grounds due to high floods in 1948 and 1949; or a catastrophic disease outbreak, or a combination of above factors.
Biological objectives: 1. Determine if bull trout exist in the Basin by 2008.
Strategies: 1. Explore likely places that may hold reserves of non-migratory bull trout

If bull trout still remain within the Basin, the potential exists to use that stock for reintroduction in other areas within the basin.

Data Gaps and additional informational needs:

- Extensive surveys are needed to determine whether bull trout exist in areas that have not been surveyed to date.

Research

Hypothesis: *Bull trout are still present in smaller tributaries as non-migratory ecotypes.*

To determine whether bull trout still exist in the Chelan Basin, the following information would be needed to test the hypothesis:

Tributaries Assessment Units

Current information:

- Bull trout have not been documented within the Chelan Basin since the 1950s

Additional informational needs:

- Determine potential upper geographic limits of likely bull trout occurrence within selected streams

  By understanding what the upper limits of bull trout occurrence could be within a stream, researchers will be able to know how far upstream within the likely stream they should investigate.

- Determine which streams to investigate

  Based on historical information and current understandings of bull trout habitat needs, researchers will be able to focus their efforts.

Anticipated results/interpretations:

- Non-migratory ecotypes of bull trout may be found.

  Until a systematic investigation has occurred that all stakeholders collaboratively agree to, the question of whether bull trout still exist in the Chelan Basin will remain unanswered.

Potential management applications

- If found, protection of critical habitat.
- If found, use for potential reintroduction in other areas within the basin

Approach (general experimental design)

- Literature review of temperature related limit of bull trout occurrence in streams (e.g., work by Mullan et al. 1992 in the Methow).

- Determination of likely streams where bull trout may remain

  1. Review historic information of previously surveyed streams

  2. Review habitat characteristics in potential streams that either have not been previously surveyed, or have not been completely surveyed.

- Survey likely streams looking for redds, or by snorkeling (at night). Sampling will follow American Fisheries Society protocols for bull trout presence-absence surveys (Peterson et al. 2001).

Statistical analyses

- These approaches are generally assessments, so no formal analyses, other than descriptive statistics and graphing methods will be necessary.

Spatial scale

- The Stehekin Basin will be the area of focus.

Temporal scale

- It is suggested that this study take place over two years.

Application

- The results of this research would apply to bull trout and possibly WSCT.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: USFWS, NPS, USFS, and potentially WDFW.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public

Table 47. Bull trout working hypothesis 2, objectives, strategies, and research

Working hypothesis BT 2:

Spawning and early rearing habitat will not limit bull trout re-introduction.

Key findings supporting hypothesis:

- Current spawning and rearing areas within the Stehekin, and other tributaries are functioning near pristine levels

Biological objectives:

- Ensure historic habitat remains in tact by 2008.

Strategies:

1. Preserve (or restore) geo-fluvial processes in all tributaries

   Preserving (or restoring) geo-fluvial processes within tributaries will aid in either increasing (restoring) or ensuring that spawning habitat remains functional. Natural geo-fluvial processes will also aid in ensuring that pool formation and associated cover are occurring, which will aid in tributary rearing of bull trout.

2. Reintroduce bull trout into historic habitat, if feasible

   Introduction of bull trout will depend on available broodstock, feasibility of using hatcheries, and whether there is a high likelihood that they can maintain a self-sustaining population.

Data Gaps and additional informational needs:

Spawning and early rearing habitat conditions.

Research

Hypothesis: *Spawning and early rearing habitat will not limit bull trout re-introduction.*

To determine whether current habitat conditions warrant potential reintroduction (or building if they are found) bull trout into the Chelan Basin, the following information would be needed to test the hypothesis:

Tributaries Assessment Units

Current information:

- Potential bull trout habitat exists within most historic habitat.
- Access to most habitat is not limited, except downstream of the Holden mine on Railroad Creek.

Additional informational needs:

- Determine whether potential historic habitat niches are filled with current, established populations of exogenous species

  To determine whether bull trout will have access to potential historic habitat, it is important to understand the current use of this habitat by other species

- Determine whether presumed historic habitat is accessible

  Based on historical information and current understanding of bull trout habitat needs, researchers will be able to focus their efforts.

Anticipated results/interpretations:

- Brook trout, and potentially rainbow trout fill available niches within presumed historic bull trout habitat.

  Brook trout are known to compete and breed with bull trout, reducing the likelihood of successful introduction and reducing genetic integrity. Rainbow trout aggression may displace bull trout within certain habitat types.

- Historic habitat is mostly in tact, and accessible, especially in the upper Stehekin Basin.

  Except for the lower basin, where some riparian and geo-fluvial processes have been disrupted, the Stehekin River Basin is largely in historical condition. Other potential bull trout tributaries have not been substantially altered, except perhaps 25-Mile Creek, from road and other development.

Potential management applications

- Elimination of brook trout.
- Preservation of existing quality habitat

Approach (general experimental design)

- Determine likely bull trout habitat by general stream surveys
- Compare those habitats to areas where extant populations of bull trout exist.
- Within those surveys, also assess access
- Determine whether exogenous species are occupying available “typical” bull trout habitat.

Statistical analyses

- These approaches are generally assessments, so no formal analyses, other than descriptive statistics and graphing methods will be necessary.

Spatial scale

- Sample streams where bull trout are thought to have occurred historically.

Temporal scale

- It is suggested that this study take place over two years.

Application

- The results of this research would apply to bull trout, brook trout, and potentially rainbow trout and WSCT.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: USFWS, USFS, and WDFW.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public.

Table 48. Bull trout working hypothesis 3, objectives, strategies, and research

Working hypothesis BT 3:

Competition with exogenous species will reduce the success of bull trout re-introduction.

Key findings supporting hypothesis:

- Introduced lake trout and brook trout (and kokanee salmon) may inhibit re-introduction of bull trout through competition during rearing, foraging, or spawning phases.
- Brook trout are known to reduce genetic integrity of bull trout when they interbreed (and are sterile).

Biological objectives:

1. Reduce abundance of exogenous stocks that may hinder reintroduction by 2010.

Strategies:

1. Increase harvest on Chinook salmon and lake trout

Reducing the abundance of Chinook salmon and lake trout will reduce the likelihood of any negative impacts these species may have in competing with reintroduced bull trout.

2. Remove harvest limit on brook trout

Reducing the abundance of brook trout will increase the likelihood of successful reintroduction on bull trout. Brook trout are known to out-compete bull trout during juvenile rearing, decrease genetic integrity when interbreeding with bull trout, and may compete for limited spawning habitat in smaller tributaries.

3. Determine predator-prey relationships in Lake Chelan.

Understanding the complex interactions between predators and prey will increase our knowledge on whether adfluvial forms of bull trout can be successfully reintroduced.

4. Determine potential interactions with established populations prior to introduction.

Understanding all potential interactions between key species will increase our knowledge on whether bull trout can be reintroduced into the Chelan Basin (for all ecotypes).

These strategies could be carried out simultaneously.

Data Gaps and additional informational needs:

- Potential negative interactions between lake trout and Chinook salmon with bull trout.
- Predictions of reduced abundance of these species are needed *before* these strategies are in place.

Research

Hypothesis: *Competition with exogenous species will reduce the success of bull trout re-introduction*.

To determine whether competition with exogenous species will reduce the likelihood of bull trout reintroduction into the Chelan Basin, the following information would be needed to test the hypothesis:

I. Tributaries Assessment Units

Current information:

- Chinook salmon, lake trout, brook trout, and rainbow trout support self-sustaining populations within the Chelan Basin.
- Spawning habitat is limited within smaller tributaries.

Additional informational needs:

- Determine whether potential historic habitat niches are filled with current, established populations of exogenous species

  To determine whether bull trout will have access to historic habitat, it is important to understand the potential use of this habitat by other species

Anticipated results/interpretations:

- Currently, brook trout will inhibit bull trout reintroduction into some streams.

  Brook trout are known to compete and breed with bull trout, reducing the likelihood of successful introduction and reducing genetic integrity

Potential management applications

- Reduction or elimination of brook trout, and reduction of rainbow trout.

Approach (general experimental design)

- Compare sections of streams with exogenous species and those without
- Remove brook and rainbow trout by hook and line, weirs, or electrofishing

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Sample streams where bull trout are thought to have occurred historically.

Temporal scale

- It is suggested that this study take place over two years.

Application

- The results of this research would apply to bull trout, Chinook salmon, brook trout, and potentially rainbow trout and WSCT.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: USFWS, USFS, and WDFW.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.

- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public.

II. Lake Assessment Unit

Current information:

- Chinook salmon and lake trout are established within Lake Chelan.

Additional informational needs:

- Determine predator-prey relationships within the lake.

  Understanding current predator-prey relationships will help determine potential success of reintroducing adfluvial bull trout.

Anticipated results/interpretations:

- Lake trout and Chinook salmon have replaced bull trout as the apex predators in Lake Chelan.

  Food is limited within Lake Chelan because it is oligotrophic. There may not be enough prey species for bull trout if Chinook salmon and lake trout already prey on available prey items

Potential management applications

- Reduction, or elimination of lake trout and Chinook salmon.

Approach (general experimental design)

- Increase harvest,
- Capture of adults on spawning grounds (primarily Chinook).
- Tag lake trout to determine spawning areas

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Sample locations within the lake, and potentially streams if spawning ground capture is desired.

Temporal scale

- It is suggested that this effort take place over five years.

Application

- The results of this research would apply to bull trout, Chinook salmon, lake trout, brook trout, and potentially rainbow trout and WSCT.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: USFWS, USFS, and WDFW.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public.

Table 49. Bull trout working hypothesis 4, objectives, strategies, and research

Working hypothesis BT 4:

All life histories of bull trout can be successfully reintroduced into the Chelan Basin.

Key findings supporting hypothesis:

- Introduced Chinook salmon, lake trout and brook trout (and kokanee salmon) may inhibit re-introduction of bull trout through competition during rearing, foraging, or spawning phases.

Biological objectives:

- If bull trout are not found, develop pilot reintroduction program for non-migratory populations by 2010.
- If bull trout are found, attain self sustaining non-migratory populations of bull trout (if feasible) by 2025

Strategies:

1. Reintroduce bull trout into historic habitat (if feasible)

   By reintroducing bull trout into historic habitat within the basin, a more native species assemblage will be in place (if successful).

   This will also aid in the recovery of bull trout in the Columbia Cascade Province by increasing (and restoring) additional habitat, thus overall production to the DPS.

Data Gaps and additional informational needs:

- Potential negative interactions between brook trout, lake trout and Chinook salmon with bull trout.
- Whether acceptable brood stock is available.
- Whether there is an acceptable (and accessible) hatchery site.
- Whether hatchery bull trout will successfully spawn in the wild.

Research

Hypothesis: *All life histories of bull trout can be successfully reintroduced into the Chelan Basin*.

To determine whether bull trout reintroduction into the Chelan Basin will succeed, the following information would be needed to test the hypothesis:

I. Tributaries Assessment Units

Current information:

- Bull trout have not been confirmed within the Basin since the 1950s.
- Brook trout, rainbow trout, Chinook salmon, and lake trout have self-sustaining populations within the basin.
- There currently are no bull trout hatcheries within the state of Washington.
- Potential brood stock has not been identified.

Additional informational needs:

- Determine whether a bull trout hatchery is feasible.

  If appropriate broodstock is not found within the Chelan Basin, it is important to determine the feasibility of a hatchery program.

- Identify appropriate broodstock and whether that population can withstand an experimental hatchery program (egg mining).

  Without an appropriate broodstock, a hatchery program cannot proceed. It is also important to understand *before* any gametes are taken from the donor population whether it can withstand the removal of gametes for its own health.

Anticipated results/interpretations:

- Some type of hatchery site can be found within the Basin, probably in the Stehekin Valley.

    Depending on the needs (e.g., raceways run on surface water; concrete ponds run on ground water, etc.), a site can be found within the Stehekin Valley, or another tributary with access.

- Appropriate, broodstock, within the geographic area (CCP) will be found.

    Donor populations, like the Chiwawa River spawning population may be deemed appropriate for use in a hatchery program.

- Removing gametes will present a high risk to the donor population.

    Depending on the scale of the hatchery program, removing gametes from any extant population of bull trout may risk the health of that population.

Potential management applications

- Build bull trout hatchery.
- Capture broodstock from extant population.

Approach (general experimental design)

- Determine feasibility of hatchery program by surveying likely sites within areas that access will be approved.
- Examine likely donor populations, estimating total abundance.
- Develop experimental hatchery program in phases, beginning with low levels of production until agreed upon success criteria are met for "Phase I."

Statistical analyses

- Both descriptive statistics and graphing methods will be used to analyze data.

Spatial scale

- Examine likely areas within Chelan Basin, and move outside the Basin if necessary (within close proximity).

Temporal scale

- Feasibility of hatchery sites and donor population should take one year. If both are feasible, then experimental hatchery evaluation should take 10 years.

Application

- The results of this research would apply to bull trout.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: USFWS, NPS, USFS, and WDFW.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public.

Table 50. Relationship of bull trout hypotheses, objectives, and strategies

Summary of bull trout hypotheses, objectives, and strategies				
	Hypothesis BT 1	**Hypothesis BT 2**	**Hypothesis BT 3**	**Hypothesis BT 4**
	Bull trout are still present in smaller tributaries as non-migratory ecotypes	*Spawning and early rearing habitat will not limit bull trout re-introduction*	*Competition with exogenous species will reduce the success of bull trout re-introduction*	*All life histories of bull trout can be successfully re-introduced into the Chelan Basin.*
Biological Objectives				
Determine if bull trout still exist in the Basin by 2008	X			
Attain self sustaining populations of bull trout (if feasible) by 2020				X
Reduce abundance of exogenous species that may hinder reintroduction by			X	

2010				
Ensure historic habitat remains in tact by 2008		X		
Strategies				
Explore likely places that may hold reserves of non-migratory bull trout	X			
Reintroduce bull trout into historic habitat, if feasible		X		X
Determine predator-prey relationships in Lake Chelan			X	
Determine potential interactions with established populations prior to introduction.			X	
Increase harvest on Chinook salmon and lake trout.			X	
Remove harvest limit on brook trout			X	
Preserve (or restore) geo-fluvial processes in all tributaries		X		

Table 51. Bull trout monitoring and evaluation indications

Indicators that will be monitored and evaluated								
General characteristics	**Specific indicators**	**Strategies**						
Biological		*Explore likely places that may hold reserves of non-migratory bull trout*	*Reintroduce bull trout into historic habitat, if feasible*	*Determine predator-prey relationships in Lake Chelan.*	*Determine potential interactions with established populations prior to introduction*	*Increase harvest on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout*	*Preserve (or restore) geo-fluvial processes in all tributaries*

Adults	Escapement/ Number		X		X	X	X	
	Age structure		X		X	X	X	
	Size		X		X	X	X	
	Sex ratio		X					
	Run timing	X	X		X	X	X	
	Origin (hatchery/ wild)		X					
	Fecundity		X			X	X	
Redds	Number	X	X		X	X		
	Distribution	X	X		X			
	Timing	X	X		X			
Parr/ Juveniles	Abundance	X	X		X			
	Distribution/ Habitat use	X	X		X			
	Size	X	X		X			
Interactions	Predator/ prey		X	X	X	X	X	
	Displacement		X	X	X	X	X	
	Interbreed		X		X		X	
Habitat								
Water Quality	MWMT and MDMT	X	X					X
	Turbidity							X
	Conductivity							X
	pH							X
	Dissolved oxygen	X						X
	Nitrogen							X
	Phosphorus							X
Habitat Access	Road crossings	X	X					X
	Diversion dams		X					X
	Timing	X	X					
	Barriers	X	X					X
Habitat Quality	Dominant substrate	X						X
	Embeddedness							X
	Depth fines							X
	LWD (pieces/km)	X	X					X
	Pools (pools/km)	X	X					X

	Residual pool depth	X						X
	Fish cover	X	X					X
	Side channels and backwaters							X
Channel condition	Stream gradient							X
	Width/depth ratio							X
	Wetted width							X
	Bankfull width							X
	Bank stability							X
Riparian Condition	Riparian structure	X						X
	Riparian disturbance							X
	Canopy cover							X
Flows and Hydrology	Streamflow	X						X
Watershed Condition	Watershed road density							X
	Riparian-road index							X
	Land ownership							X
	Land use							X

Table 52. Bull trout monitoring needs

Commonality between monitoring needs								
Category	**Metric or method**	**Strategies**						
		Explore likely places that may hold reserves of non-migratory bull trout	*Reintroduce bull trout into historic habitat, if feasible*	*Determine predator-prey relationships in Lake Chelan.*	*Determine potential interactions with established populations prior to introduction*	*Increase harvest on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout*	*Preserve (or restore) geo-fluvial processes in all tributaries*
Adults	Spawning ground surveys	X	X		X	X	X	
	Estimate of abundance	X	X			X	X	
	Interactions with native species		X	X	X		X	

	Interaction with exogenous species		X	X	X		X	
	Stomach analysis		X	X			X	
	Movement	X	X	X	X		X	
	Run timing	X	X	X	X	X	X	
Juveniles	Emergence timing		X		X		X	
	Distribution	X	X		X		X	
	Interactions with native species		X		X		X	
	Interaction with exogenous species		X		X			
	Abundance	X	X				X	
Methods	Snorkel	X	X		X		X	
	Electro-fish	X	X		X		X	
	Active tag & track		X			X	X	
	Hook & line			X		X	X	
	Creel survey		X	X		X	X	
	Stomach analysis	X	X	X	X		X	
Scale	Spatial	Primarily Stehekin Basin	TBD	Throughout lake	2 sample streams and 4 lake sites	Throughout lake, and two sample streams	2 sample streams	2 sample streams
	Temporal	2 years	10 years	3 years	3 years	3 years	3 years	2 years

Table 53. Bull trout planning and design of strategy implementation

Planning, design and standards								
Category	**Metric/ responsibility**	**Strategies**						
		Explore likely places that may hold reserves of non-migratory bull trout	*Reintroduce bull trout into historic habitat, if feasible*	*Determine predator-prey relationships in Lake Chelan.*	*Determine potential interactions with established populations prior to introduction.*	*Increase harvest on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout*	*Preserve (or restore) geo-fluvial processes in all tributaries*
Evaluation planning	Evaluation responsibility	USFWS	USFWS, NPS	WDFW, USFWS, NPS	USFWS, WDFW, USFS, NPS	WDFW, USFWS, NPS	WDFW, USFWS, NPS	USFWS, USFS, NPS

	Decision responsibility	USFWS, USFS, NPS	USFWS	WDFW	USFWS, WDFW, NPS	WDFW	USFWS, WDFW	USFS, NPS
	Public feedback	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr
	Potential cost share	USFWS, USFS, NPS	USFWS, WDFW, USFS, NPS	WDFW	USFWS, WDFW, USFS, NPS	WDFW	WDFW, USFWS, USFS, NPS	USFWS, USFS, NPS
*Sampling design**	Monitoring	S/T	S/T	E	E	E	E	S/T
	Frequency	3 x/yr	3 x/yr	3 x/yr	3 x/yr	3 x/yr	3 x/yr	3 x/yr
	Methods	Snorkel, electro-fish	Snorkel, electro-fish creel survey	Creel survey, hook & line	Snorkel, electro-fish, creel survey, hook & line	Creel survey, hook & line	Creel survey, hook & line	Various monitoring methods
Statistical Considerations	Significance level	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Hypothesis	BT 1	BT 2, 4	BT 3	BT 3	BT 3	BT 3	BT 2
Performance standards	Reference	No observations	No observations	Presumed effects	Presumed effects	Presumed effects	Presumed effects	Current conditions
	Desired effect	Local populations	Local populations	Empirical observations or inferences	Empirical observations or inferences	Empirical observations or inferences	Empirical observations or inferences	Current or better conditions

* E = effectiveness; S/T = status/trend monitoring

Table 54. Bull trout data management

Data information and archive								
		Strategies						
		Explore likely places that may hold reserves of non-migratory bull trout	*Reintroduce bull trout into historic habitat, if feasible*	*Determine predator-prey relationships in Lake Chelan.*	*Determine potential interactions with established populations prior to introduction.*	*Increase harvest on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout*	*Preserve (or restore) geo-fluvial processes in all tributaries*
Quality Assurance/ control	Agency responsible for developing QA/QC	USFWS	USFWS, NPS	WDFW, USFWS, NPS	USFWS, WDFW, USFS, NPS	WDFW, USFWS, NPS	WDFW, USFWS, NPS	USFWS, USFS, NPS
Data management	Format	PDA (with GPS coordination) in field	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field

	Stored	CD/CPU	CD/CPU	CD/CPU	CD/CPU	CD/CPU	CD/CPU	CD/CPU
	Updated	2 mo.	2 mo.	6 mo.	6 mo.	6 mo.	6 mo.	6 mo.
	Access	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site
Report preparation	Format	Formal	Formal	Formal	Tech. memo	Tech. memo	Tech. memo	Formal
	Presentation	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final
	Incorporation of comments	After sent to manage-ment agencies, then public	After sent to manage-ment agencies, then public	After sent to manage-ment agencies,	After sent to manage-ment agencies,	After sent to manage-ment agencies,	After sent to manage-ment agencies, then public	After sent to manage-ment agencies, then public

Table 55. Bull trout evaluation

Evaluation								
		Strategies						
		Explore likely places that may hold reserves of non-migratory bull trout	*Reintroduce bull trout into historic habitat, if feasible*	*Determine predator-prey relationships in Lake Chelan.*	*Determine potential interactions with established populations prior to introduction.*	*Increase harvest on Chinook salmon and lake trout.*	*Remove harvest limit on brook trout*	*Preserve (or restore) geo-fluvial processes in all tributaries*
Scientific	strengths	-rigorous observations will enable managers to aid in bull trout recovery; Agreed-to prior to study by all stakeholders	-increase range of threatened species (if feasible);	-may help define feasibility of reintroduce-tion of adfluvial populations	-will increase the knowledge needed to determine the feasibility of reintroduction	-reduces one limiting factor	-data can be empirically gathered -may build foundation for other management actions	-data can be empirically gathered
	weaknesses	-limitation because of accessibility, run off, or other abiotic factors may make the results inconclusive	-unavail-ability of eggs, or proper genetic stock; -unintended species interactions	-results will be difficult to obtain interpret	- results will be difficult to obtain interpret	-may be difficult to observe response	-observation of interactions may be difficult to determine	-many variables affect observations

Decision-making	Determine if alternatives should be needed	If data suggests that bull trout do not exist within basin	If this strategy is feasible, then it will take a number of years to determine success	Pursue other options if the study is inconclusive	Pursue other options if the study is inconclusive.	Determine public opposition to plan before implement-ting.	Other approaches may be necessary, but will not be known until after information is collected.	n/a
	Management response to changes in indicators	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches prior to determining if program is successful	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches
Public	Review format	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation
	Comment format	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentati on	Written, verbal @ presentation	Written, verbal @ presentation
	Incorporation of comments	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency

8.7 Kokanee Salmon

8.7.1 Biological Objectives

69. Reduce negative interactions with mysids by 2015

70. Increase juvenile survival and increase abundance of adults in lake by 2010

71. Ensure self-sustaining populations by 2015.

8.7.2 Strategies

72. Reduce abundance of mysids

73. Increase harvest on Chinook salmon and lake trout.

74. Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate.

8.7.3 Consistency with ESA and CWA Requirements

ESA consistency

Bull trout are currently the only focal species that are listed under the ESA. In the Chelan Basin, bull trout have not been sited since the 1950s.

Clean Water Act compliance

Lake Chelan is considered ultra oligotrophic and in excellent condition. However, Railroad Creek still suffers from mining activities in from the 1930s to 1950s. Current plans call for the clean up of the mine tailings which have been identified as the major source of contaminants.

A consortium of local agencies and the Washington State Department of Ecology have formed the Lake Chelan Water Quality Committee. This Committee was formed to provide a framework within which to monitor the water quality characteristics of Lake Chelan.

8.7.4 Research, Monitoring and Evaluation

Research, monitoring and evaluation are linked to each hypothesis and its biological objectives and strategies and conclude each hypothesis table.

Table 56. Kokanee hypothesis 1, objectives, strategies, and research

Working hypothesis K 1: *Rearing in Lake Chelan is limited by lake productivity and competition with other species*.
Key findings supporting hypothesis: ➢ Kokanee populations have been volatile and could be related to predator abundance, competition with native and exotic species for forage, and general lake productivity. ➢ Spawning habitat is not limiting
Biological objectives: ➢ Reduce negative interactions with mysids by 2015.
Strategies: 1. Reduce abundance of mysids Mysids are known to compete with juvenile kokanee for the limited zooplankton base of Lake Chelan (even though they were put in there to increase their size). Reducing their abundance (a program is underway in the Canadian Okanogan Basin), juvenile kokanee will have more forage, and survival, and subsequent production will increase. Data Gaps and additional informational needs: ➢ Time series of information on abundance of mysids ➢ Development of reduction program based on experience from Canadians
Research Hypothesis: *Rearing in Lake Chelan is limited by lake productivity and negative interactions with other species*.

To determine whether kokanee rearing is limited in Lake Chelan, the following information would be needed to test the hypothesis:

I. Lake Assessment Unit

Current information:

- Lake Chelan is oligotrophic.
- Mysids have been established in the lake since the early 1970s.

Additional informational needs:

- Determine if additional productivity information is needed.

  Past efforts have collected lake information concerning general lake productivity. It needs to be determined if further information is needed.

- Current abundance of mysids.

  To understand kokanee-mysid interactions properly (see below), it is essential to estimate the total abundance of mysids.

- Better understanding of mysid-kokanee interactions.

  To understand whether the kokanee population is being impacted by mysids, it is important to better understand their interactions.

Anticipated results/interpretations:

- Additional productivity information will not be needed.

  Previous information will suffice in our understanding of lake productivity.

- Mysid abundance has remained relatively constant over time.

  Compared to historic abundance estimates, the mysid population has most likely remained at relatively stable levels.

- Mysids compete for the same food as kokanee during their lake residency.

  Mysids are known to compete for the same food items as kokanee where they have been introduced except in the West Arm of Kootenay Lake..

Potential management applications

- Begin mysid reduction program based on existing programs in Canada.

Approach (general experimental design)

- Literature search for Lake Chelan productivity.
- Mysid sampling.
- Kokanee stomach sampling.

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Four sampling sites will be chosen throughout the lake that past research has shown to contain both mysids and kokanee.

Temporal scale

- Two years.

Application

- The results of this research would apply to kokanee, mysids, and potential other predators of mysids.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: WDFW.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public.

Table 57. Kokanee hypothesis 2, objectives, strategies, and research

Working hypothesis K 2: *Total adult abundance is impacted by predation by lake trout and chinook*

Key findings supporting hypothesis:

- ➢ Kokanee populations have been volatile and could be related to predator abundance, competition with native and exotic species for forage, and general lake productivity.

Biological objectives:

- ➢ Increase juvenile survival and increase abundance of adults in the lake by 2010.

Strategies:

1. Increase harvest on Chinook salmon and lake trout

   Increasing harvest on Chinook and lake trout will increase the abundance of adult kokanee making it back to spawning areas, and will increase the productivity of the total population

Data Gaps and additional informational needs:

- ➢ Development of a predator-prey relationship between kokanee and lake trout and Chinook salmon

Research

Hypothesis: *Total adult abundance is impacted by predation by lake trout and chinook.*

To determine whether kokanee abundance is limited in Lake Chelan by Chinook and lake trout, the following information would be needed to test the hypothesis:

I. Lake Assessment Unit

Current information:

- ➢ Chinook have been established in the lake since the 1970s
- ➢ Lake trout were established in the lake in the 1980s
- ➢ Both species have the ability (size) to prey on kokanee

Additional informational needs:

- ➢ Estimate Chinook salmon and lake trout abundance.

  To understand predator-prey interactions properly, it is essential to estimate the total abundance of each within the lake.

- ➢ Develop predator-prey model to help understand dynamics of predator-prey species interactions.

  The information needed within the model may need to be collected, or historical information may be available.

Anticipated results/interpretations:

- Chinook abundance levels will be medium to low, and Lake trout abundance will be low.

  These estimates will be difficult to obtain, but some information is needed to determine potential impacts to kokanee and potentially other species.

- Predator prey relationships exist for Chinook salmon and to a lower level for lake trout.

  Because lake trout generally inhabit deeper waters, it is likely that they encounter kokanee less often than Chinook salmon.

Potential management applications

- Increase harvest on lake trout and Chinook salmon.

Approach (general experimental design)

- Spawning ground counts for kokanee and Chinook salmon.
- Hook and line capture of Chinook salmon and lake trout in the lake.
- Stomach sampling.

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Four sampling sites will be chosen throughout the lake that past research has shown to contain both Chinook salmon and lake trout.

Temporal scale

- Two to three years (depending on sample sizes obtained).

Application

- The results of this research would apply kokanee, Chinook salmon, and lake trout (and potentially other species preyed upon by Chinook and lake trout).

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: WDFW, USFWS, USFS, and NPS.

Deliverable

- Draft annual report due December 15 of the year the research takes place

- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public.

Table 58. Kokanee hypothesis 3, objectives, strategies, and research

Working hypothesis K 3: *Hatchery plantings increase the total abundance of kokanee available for spawning or harvest*

Key findings supporting hypothesis:

- Introductions of hatchery fish have not been shown to increase natural production or harvest rates

Biological objectives:

- Ensure self-sustaining populations by 2015.

Strategies:

1. Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate

   Past evaluations have not shown significant numbers of hatchery released fish in the spawning populations or sport harvest, regardless of how they were released. By reducing or eliminating hatchery plants (after rigorous monitoring and evaluation), natural production and satisfactory harvest rates may be maintained. Resources now spent on kokanee could then be applied to WSCT and bull trout.

Data Gaps and additional informational needs:

- Rigorous evaluation of the success of hatchery plantings in terms of contribution to spawning grounds and harvest rates.
- Development of a contingency plan if evaluation shows that hatchery plants are ineffective.
- Determination of whether kokanee need hatchery plantings to be self-sustaining

Research

Hypothesis: *Hatchery plantings increase the total abundance of kokanee available for spawning or harvest.*

To determine whether hatchery plants of kokanee will increase abundance in Lake Chelan, the following information would be needed to test the hypothesis:

I. Lake Assessment Unit

Current information:

- Kokanee have been planted into Lake Chelan since 1917.
- Currently, there is a self-sustaining population of kokanee.
- Past attempts to verify hatchery plants in the fishery or on the spawning grounds have not shown any significant contribution from these plants.

Additional informational needs:

- Continuing evaluation of positive or negative affects of hatchery plants to the self-sustaining populations.

  Without an evaluation plan, there is no way to determine whether this program is effective (i.e., meeting its goal).

- Determine whether the self-sustaining populations of kokanee could support a sport fishery without hatchery plants.

  This would enable managers to either; 1) confirm the need for the program, or 2) determine that the program is not necessary and use the current money and effort for other purposes (e.g., WSCT).

Anticipated results/interpretations:

- Hatchery plants of kokanee do not significantly increase catch rates or spawner abundance.
- Release of hatchery fish do not survive in great numbers post release
- Hatchery fish are not negatively impacting self-sustaining populations.
- Hatchery fish are not found on the spawning grounds in great numbers, or competing for food in great numbers within the lake.

Potential management applications

- Reduce or eliminate hatchery releases.
- Use money for kokanee program for other species.

Approach (general experimental design)

- Mark and recapture studies.
- Increase capture methods on spawning grounds and in creel/hook and line surveys.
- Stomach analysis from lake (determine competition between hatchery and naturally produced fish).
- Possibly modify release locations to increase fidelity for the purposes of the study.

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Four sampling sites will be chosen throughout the lake that past research has shown to contain kokanee.
- Determine index areas within four spawning ground tributaries (e.g., within Company Creek, Blackberry Creek, 25-Mile Creek, and Safety Harbor Creek).

Temporal scale

- Ten years (this should encompass 2-3 life cycles).

Application

- The results of this research would apply kokanee.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort: Chelan PUD, WDFW, USFWS, USFS, and NPS.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.

➢ All data will be available upon request to other agencies or the public.

Table 59. Relationship of kokanee hypotheses, objectives, and strategies

Summary of relationship between kokanee hypotheses, objectives, and strategies			
	Hypothesis K 1	**Hypothesis K 2**	**Hypothesis K 3**
	Rearing in Lake Chelan is limited by lake productivity and competition with other species	*Total adult abundance is impacted by predation by lake trout and Chinook*	*Hatchery plantings increase the total abundance of kokanee*
Biological Objectives			
Reduce negative interactions with mysids by 2015	X		
Increase juvenile survival and increase abundance of adults in lake by 2010		X	
Ensure populations are self-sustaining populations by 2015			X
Strategies			
Reduce abundance of mysids	X		
Increase harvest limit on Chinook salmon and lake trout		X	
Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate.			X

Table 60. Kokanee monitoring and evaluation indicators

Indicators that will be monitored and evaluated		
General characteristics	**Specific indicators**	**Strategies**

Biological		*Reduce abundance of mysids*	*Increase harvest limit on Chinook salmon and lake trout*	*Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate.*
Adults	Escapement/ Number		X	X
	Age structure		X	X
	Size		X	X
	Sex ratio		X	X
	Run timing		X	X
	Origin (hatchery/ wild)		X	X
	Fecundity			X
Redds	Number		X	X
	Distribution		X	X
	Timing		X	X
Parr/ Juveniles	Abundance	X	X	X
	Distribution/ Habitat use	X	X	X
	Size	X	X	X
Interactions	Predator/ prey		X	X
	Displacement			X
	Interbreed			
Habitat				
Water Quality	MWMT and MDMT			
	Turbidity			
	Conductivity			
	pH			
	Dissolved oxygen			
	Nitrogen			
	Phosphorus			
Habitat Access	Road crossings			
	Diversion dams			
	Timing			
	Barriers			
Habitat Quality	Dominant substrate			
	Embeddedness			
	Depth fines			

	LWD (pieces/km)			
	Pools (pools/km)			
	Residual pool depth			
	Fish cover			
	Side channels and backwaters			
Channel condition	Stream gradient			
	Width/depth ratio			
	Wetted width			
	Bankfull width			
	Bank stability			
Riparian Condition	Riparian structure			
	Riparian disturbance			
	Canopy cover			
Flows and Hydrology	Streamflow			
Watershed Condition	Watershed road density			
	Riparian-road index			
	Land ownership			
	Land use			

Table 61. Kokanee monitoring needs

Commonality between monitoring needs				
Category	**Metric or method**	**Strategies**		
		Reduce abundance of mysids	*Increase harvest limit on Chinook salmon and lake trout*	*Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate.*
Adults	Spawning ground surveys		X	X
	Estimate of abundance		X	X
	Interactions with native species			X
	Interaction with exogenous species		X	X
	Stomach analysis		X	X

	Movement		X	X
	Run timing		X	X
Juveniles	Emergence timing			X
	Distribution			X
	Interactions with native species	X		X
	Interaction with exogenous species	X	X	X
	Abundance	X	X	X
Methods	Snorkel			X
	Electro-fish			X
	Active tag & track			X
	Trawl net	X		X
	Hook & line	X	X	X
	Creel survey	X	X	X
	Stomach analysis	X	X	X
Scale	Spatial	4 lake transects	4 lake transects	4 lake transects, 2 streams
	Temporal	5 years	5 years	5 years

Table 62. Kokanee planning, design, and standards

Planning, design and standards for implementation				
Category	**Metric/ responsibility**	**Strategies**		
		Reduce abundance of mysids	*Increase harvest limit on Chinook salmon and lake trout*	*Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate.*
Evaluation planning	Evaluation responsibility	WDFW	WDFW, USFWS, NPS	WDFW, USFWS, USFS, NPS
	Decision responsibility	WDFW, USFWS, USFS, NPS	WDFW/ USFWS	WDFW
	Public feedback	2 x/yr	3 x/yr	2 x/yr
	Potential cost share	PUD, WDFW, NPS	WDFW, USFWS, USFS, NPS, PUD,	WDFW, USFWS, USFS, NPS
*Sampling design**	Monitoring	E	S/T	E
	Frequency	3 x/yr	3 x/yr	3 x/yr
	Methods	Zooplankton trawl	Creel survey, hook & line	Snorkeling, electro-fishing, creel survey, hook & line

Statistical Considerations	Significance level	α =0.10	n/a	n/a
	Hypothesis	K 1	K 2	K 3
Performance standards	Reference	Current abundance	Current abundance	Current species assemblage
	Desired effect	Lower abundance	Lower abundance	Agreed to species assemblage

* E = effectiveness; S/T = status/trend monitoring

Table 63. Kokanee data management

Data information and archive				
		Strategies		
		Reduce abundance of mysids	*Increase harvest limit on Chinook salmon and lake trout*	*Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate.*
Quality Assurance/ control	Agency responsible for developing QA/QC	WDFW	WDFW	WDFW, USFWS, USFS, NPS
Data management	Format	PDA in field	Document	PDA in field
	Stored	CD/CPU	CD/CPU	CD/CPU
	Updated	6 mo.	2 mo.	yearly
	Access	Updates/ Drafts- Web site	Updates/ Drafts- Web site	Updates/ Drafts- Web site
Report preparation	Format	Formal	Tech. memo	Formal
	Presentation	Updates, final	Updates, final	Updates, final
	Incorporation of comments	After sent to management agencies, then public	After sent to management agencies, then public	After sent to management agencies,

Table 64. Kokanee evaluation

Evaluation				
		Strategies		
		Reduce abundance of mysids	*Increase harvest limit on Chinook salmon and lake trout*	*Develop planting schedule of hatchery fish that meets native fish production goals and ensures satisfactory harvest rate.*
Scientific	strengths	-reduce impacts on numerous species	-reduces one limiting factor	-coordinated plan will incorporate competing interests; -better ability to recover or restore native species

	weaknesses	-program will be difficult to implement	-response of kokanee will be complicated by other factors	-unavailability of eggs, or proper genetic stock; -unintended species interactions
Decision-making	Determine if alternatives should be needed	If program is not feasible	Determine public opposition to plan before implement-ting.	Alternatives to this point have not been coordinated and current negative species interactions are thought to be deleterious to native species
	Management response to changes in indicators	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches
Public	Review format	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation	Advertise web page where draft info is available, then presentation
	Comment format	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation
	Incorporation of comments	Lead agency	Lead agency	Lead agency

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10 Acronyms and Abbreviations

BLM	Bureau of Land Management
BPA	Bonneville Power Administration
BOR	Bureau of Reclamation
BiOP	Biological Opinion
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
Colville Tribes	Confederated Tribes of the Colville Reservation
CRITFC	Columbia River Inter-Tribal Fish Commission
CPUE	Catch Per Unit Effort
CRMP	Cultural Resources Management Plan
CWA	Clean Water Act
DNR	Washington Department of Natural Resources
DOE	U. S. Department of Energy
DOI	U.S. Department of the Interior
DOT	Washington Department of Transportation
DPS	Distinct Population Segment
EA	Environmental Assessment
Ecology	Washington State Department of Ecology
ECP	Eco-regional Conservation Planning
EDT	Ecosystem Diagnostic & Treatment
EIS	Environmental Impact Statement
EMS	Energy Management System
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Environmentally Significant Unit
FERC	Federal Energy Regulatory Commission
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
GMA	Growth Management Act
HCP	Habitat Conservation Plan
HEP	Habitat Evaluation Procedure
HGMP	Hatchery Genetic Management Plan
huc	habitat
IBIS	Interactive Biological Information System
ISRP	Independent Scientific Review Panel
JFC	Joint Fisheries Committee
LCSA	Lake Chelan Sportsmen's Association
LFA	Limiting Factors Analysis
NPS	National Park Service
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPPC	Northwest Power Planning Council
NWFP	Northwest Forest Plan

PA	Programmatic Agreement
PMU	Population Management Unit
PUD	Public Utility District
RC&D	North Central Washington Resource Conservation & Development Council
RM	river mile
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment Project
TMDL	Total Maximum Daily Load
TSS	Total Suspended Sediment
UGA	Urban Growth Area
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WCC	Washington Conservation Corp.
WDFW	Washington Department of Fish and Wildlife
WQI	water quality index
WSP	Washington State Parks
Yakama Nation	Confederated Tribes and Bands of the Yakama Indian Nation
YFRM	Yakama Fisheries Resource Management

11 Technical Appendices

Appendix A. Ashley and Stovall. 2004. Columbia Cascade Province Wildlife Assessment. WDFW. Olympia, Washington.

Appendix B. IBIS. 2003. Tables of Wildlife Species Occurrence, T&E, Partners in Flight, Historical References, and Environmental Setting in the Lake Chelan Subbasin.

Appendix C. Habitat Summaries for Ecologies Common to the Pacific Northwest.

Appendix D. Washington Department of Fish and Wildlife. 2002. Lake Chelan Fishery Management Plan.

Appendix E. Lake Chelan Relicensing. Available: http://www.chelanpud.org/relicense/ [May 2004]