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.

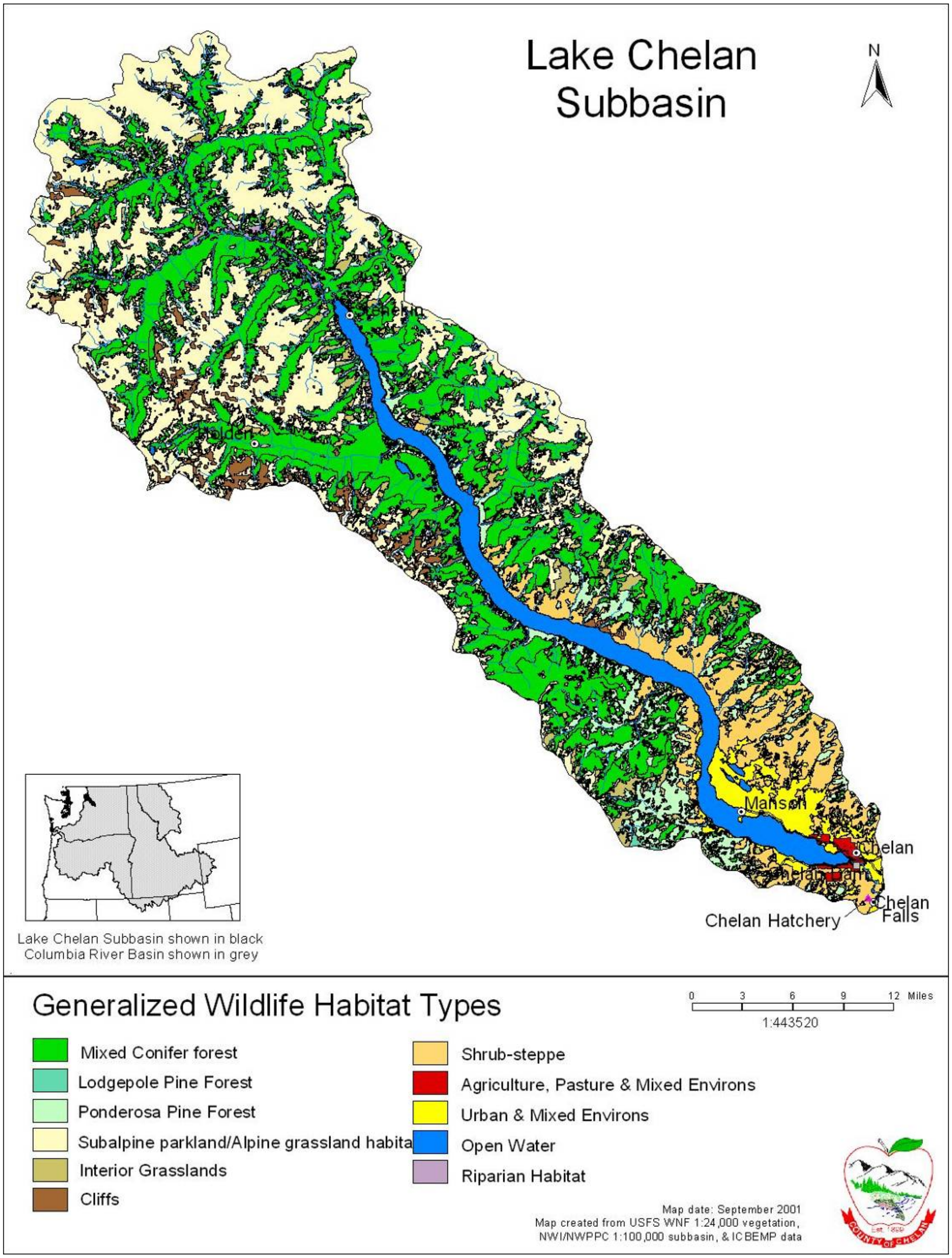
Table 6. Wildlife habitat types within Lake Chelan subbasin

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.

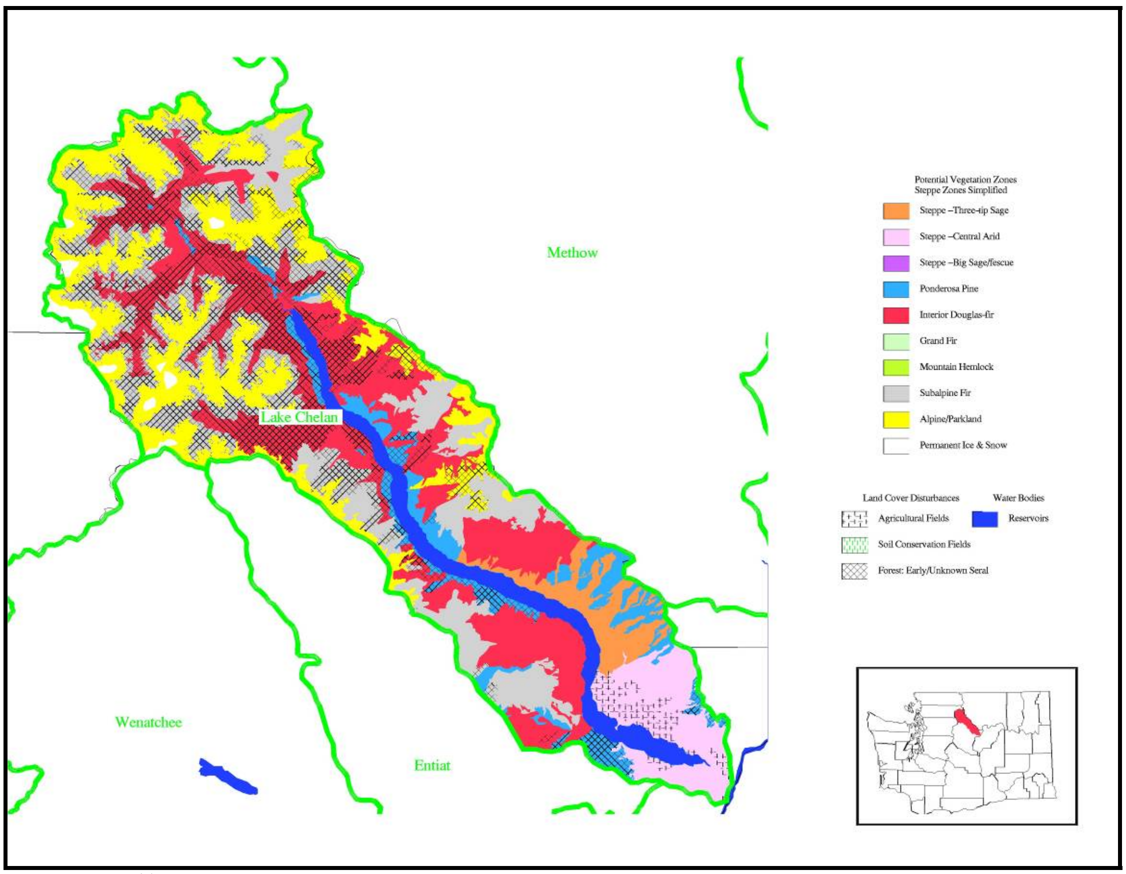
Agriculture is Habitat of Concern

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.

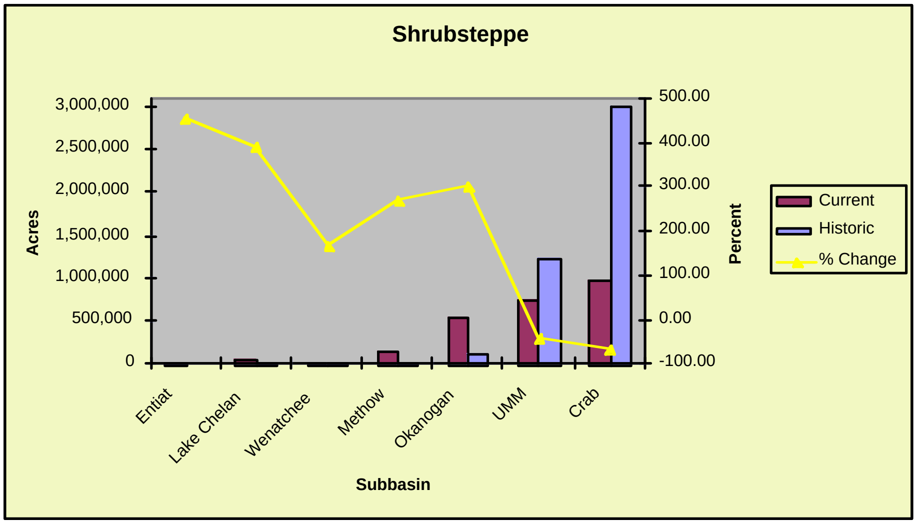
Fire has relatively little effect on native vegetation in the three-tip sagebrush zone, since three-tip sagebrush and the dominant graminoids resprout after burning. Three-tip sagebrush does not appear to be much affected by grazing, but the perennial graminoids decrease and are eventually replaced by 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

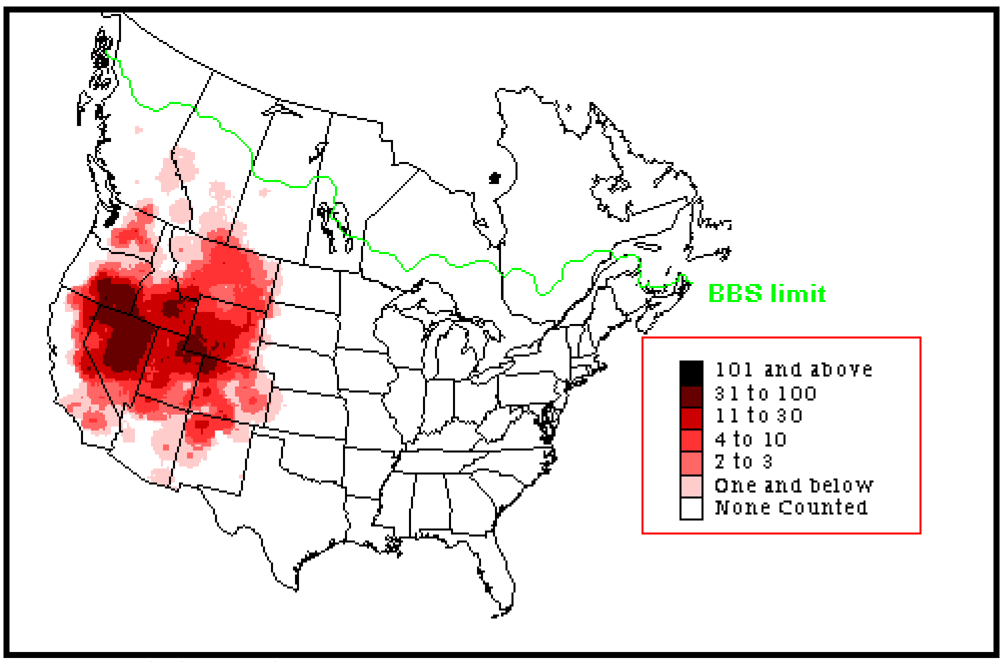
Washington is near the northwestern limit of breeding range for Brewer's sparrows. Birds occur primarily in Okanogan, Douglas, Grant, Lincoln, Kittitas, and Adams counties (Smith *et al.* 1997).

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

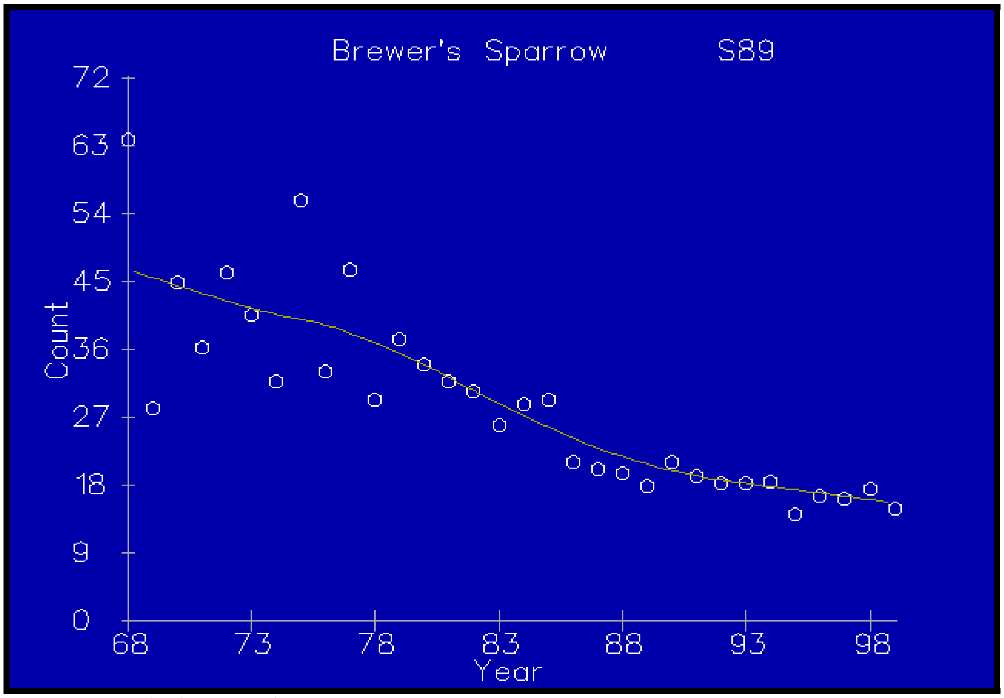
Breeding Bird Survey (BBS) data for 1966-1996 show significant and strong survey-wide declines averaging -3.7 % per year (n = 397 survey routes). The BBS data (1966-1996) for the Columbia Plateau are illustrated below. Significant declines in Brewer’s sparrow are evident in California, Colorado, Montana, 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

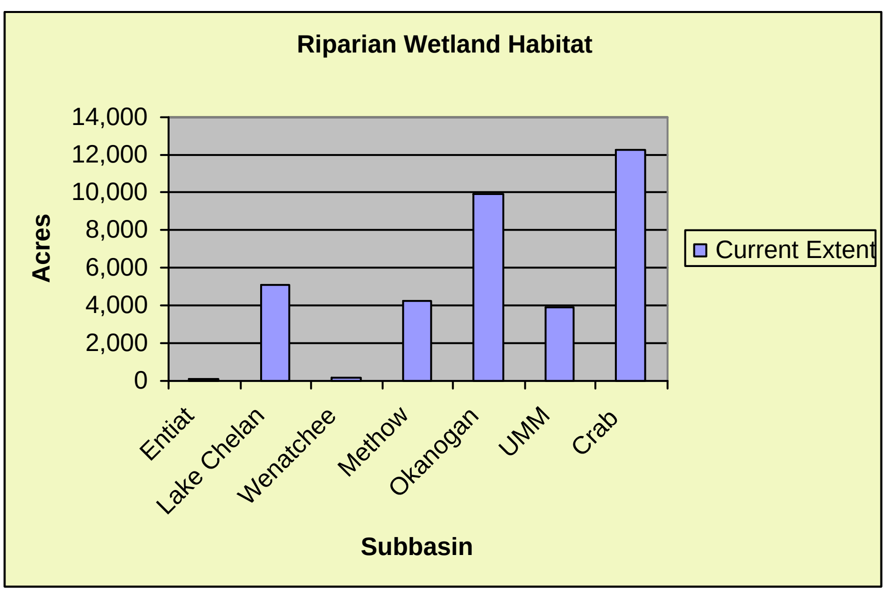
The riparian zone at Mitchell Creek was recently enhanced by planting shrubs. This has resulted in a dense but narrow band of riparian shrub habitat. The width of the riparian zone at Mitchell Creek is narrow because the creek channel is deeply incised in some areas, limiting the area suitable for riparian 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

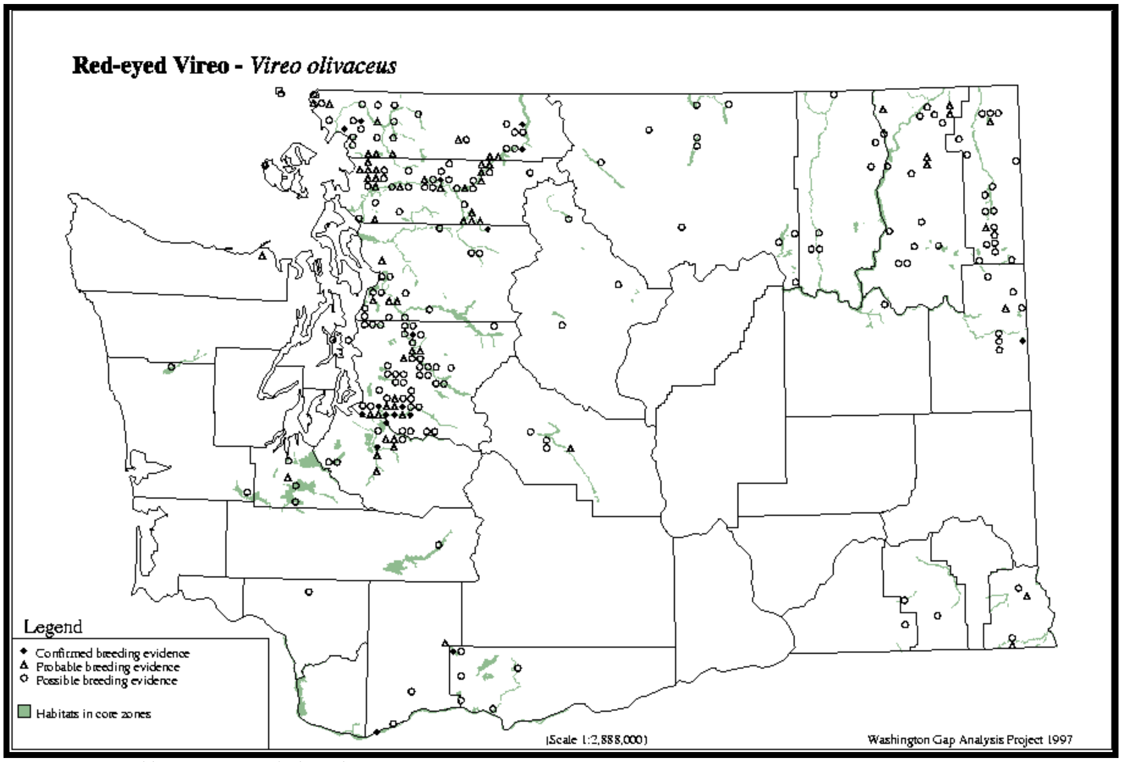
No data are available.

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.

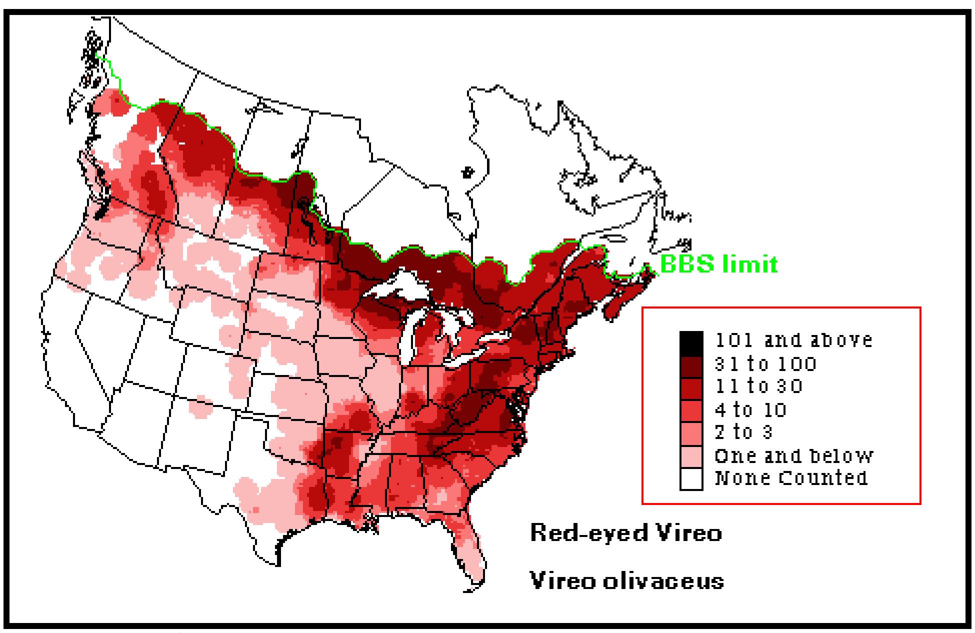
The patchy distribution in Washington for this species correlates with the distribution of large black cottonwood (*Populus trichocarpa*) groves, which are usually limited to riparian areas. The red-eyed vireo is one of the most abundant species in the northeastern United States, but is much less common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

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



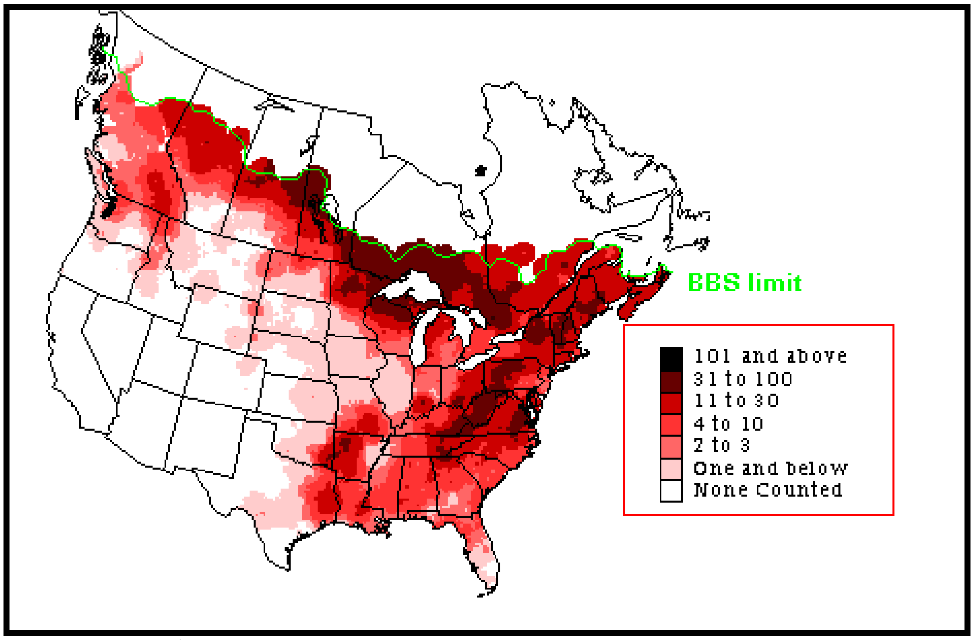
Source: Washington GAP Analysis Project 1997

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

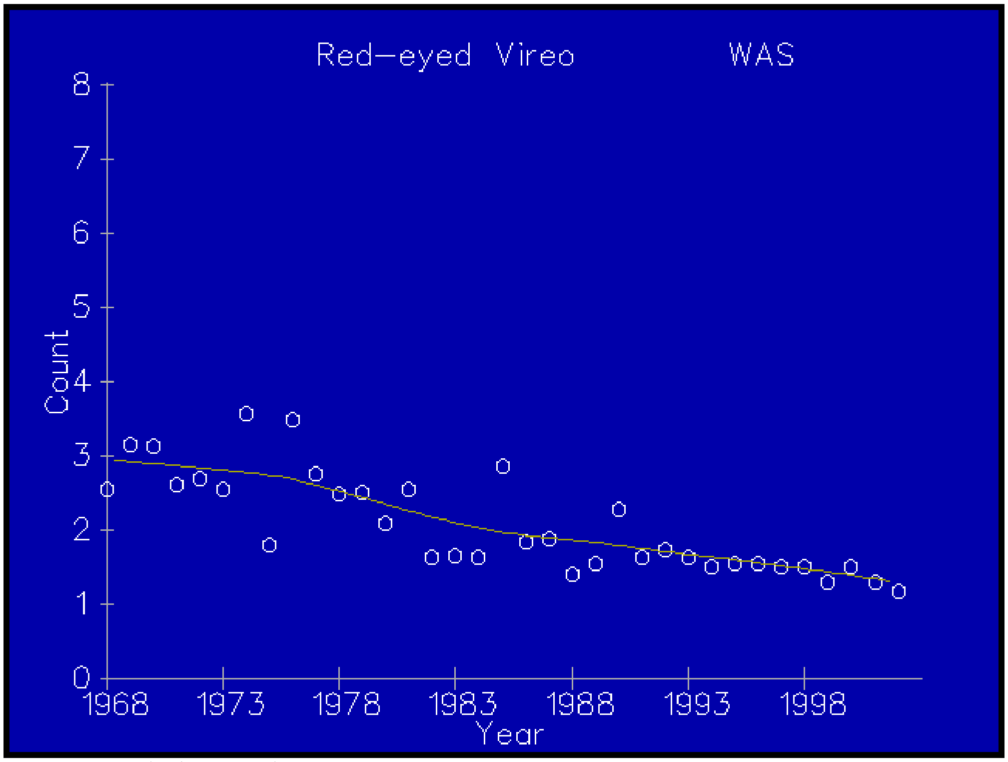
The red-eyed vireo is secure, particularly in the eastern United States. Within the state of Washington, the red-eyed vireo is locally common, more widespread in northeastern and southeastern Washington and not a conservation concern (Altman 1999).

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

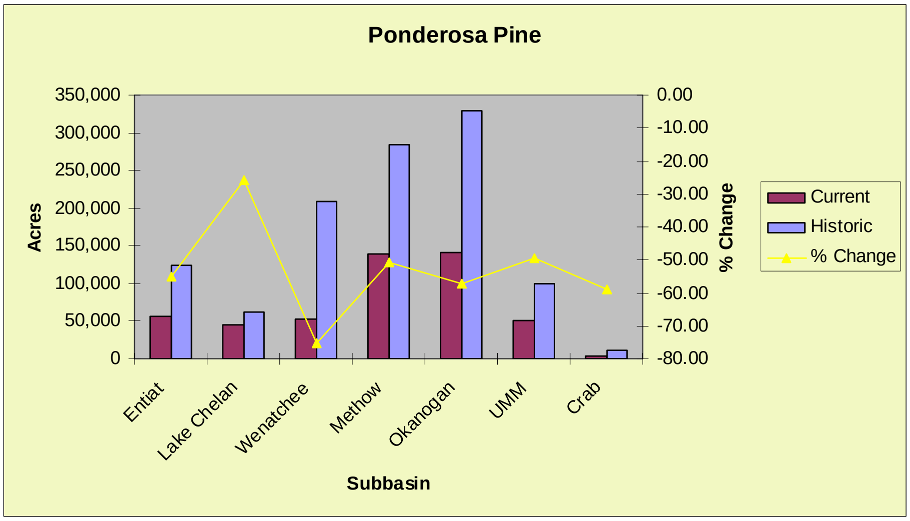
Extant ponderosa pine habitat within the Subbasin currently covers a wide range of seral conditions. Forest management and fire suppression have led to the replacement of old-growth ponderosa pine forests by younger forests with a greater proportion of Douglas-fir than pine stands (Wright and Bailey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

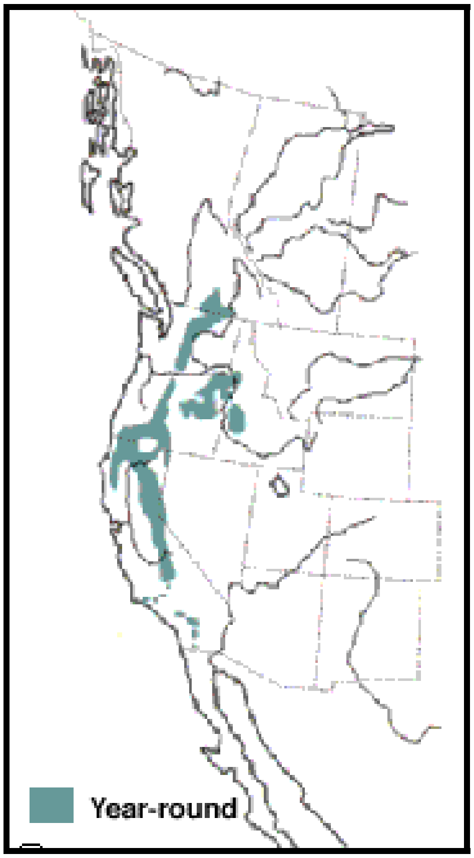
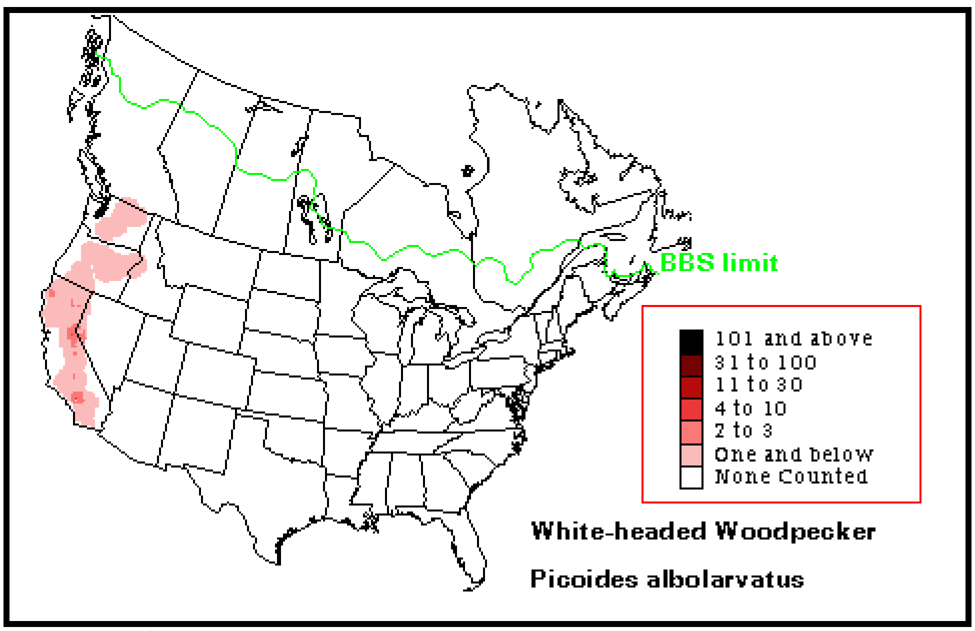
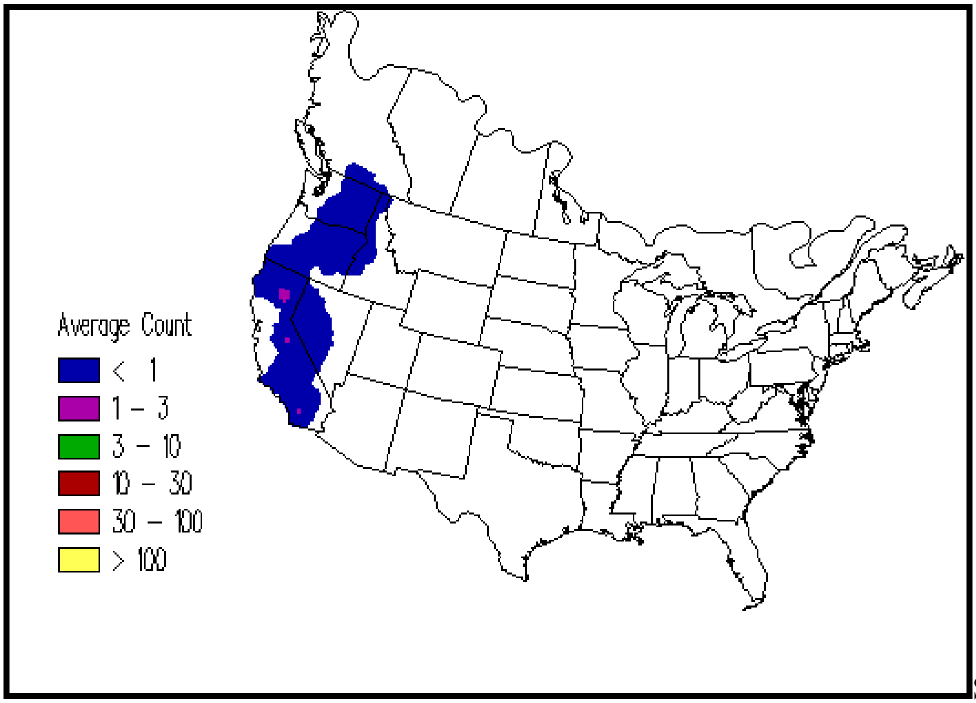


Figure 20. White-headed woodpecker breeding distribution



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)

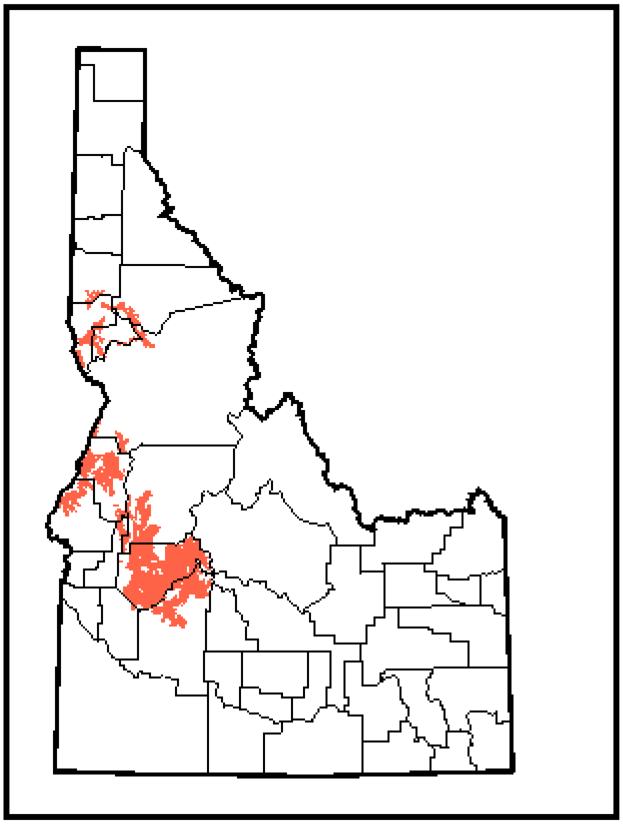


Figure 22. White-headed woodpecker Idaho distribution

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

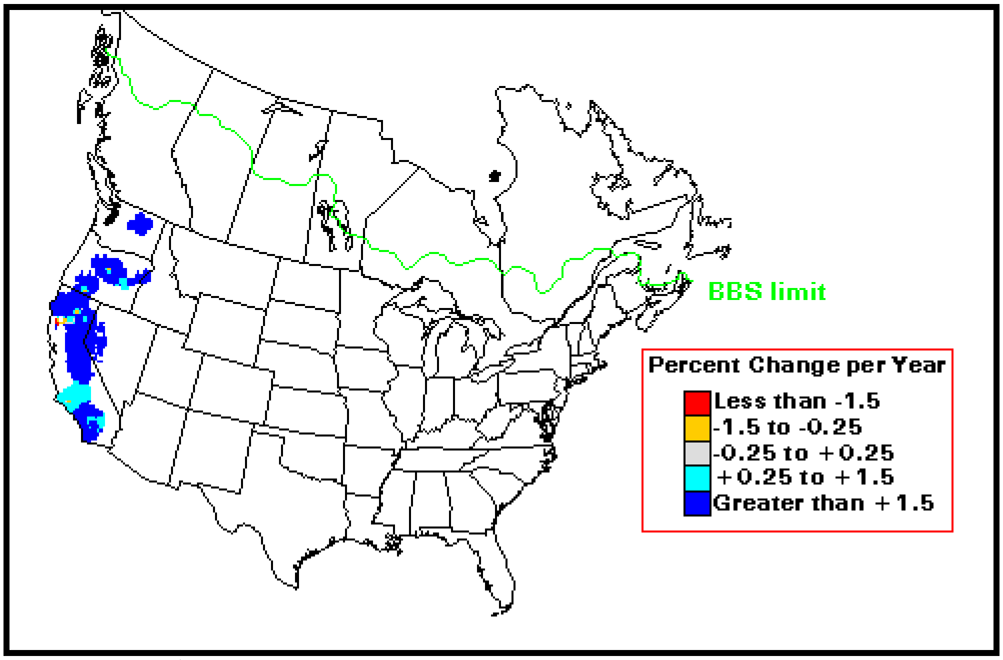
White-headed Woodpecker Status and Abundance Trends

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

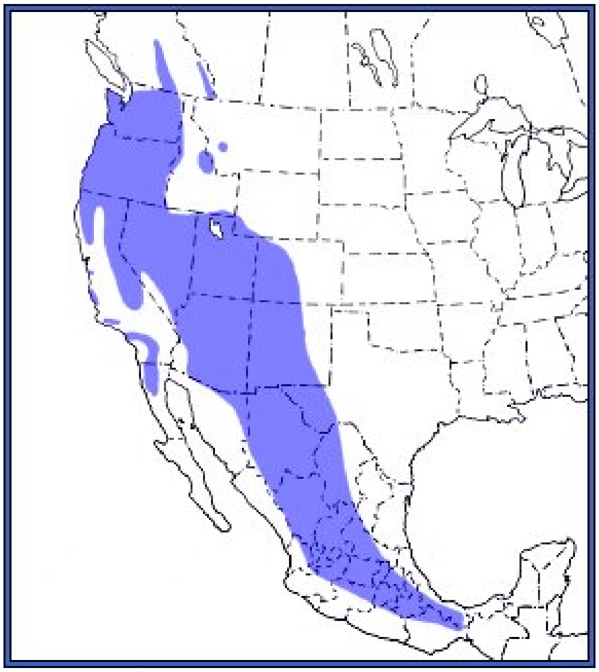
Historic

[No information to date]

Current

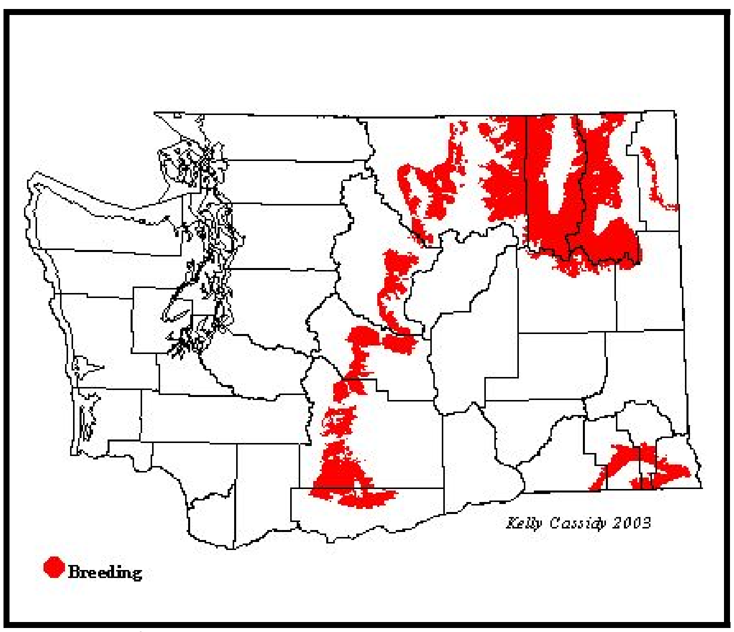
Flammulated owl distribution is illustrated in **Figure 24**. Flammulated owls are uncommon breeders east of the Cascade in the Ponderosa pine belt from late May to August. There have been occasional records from western Washington, but they are essentially an east side species. Locations where they 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.

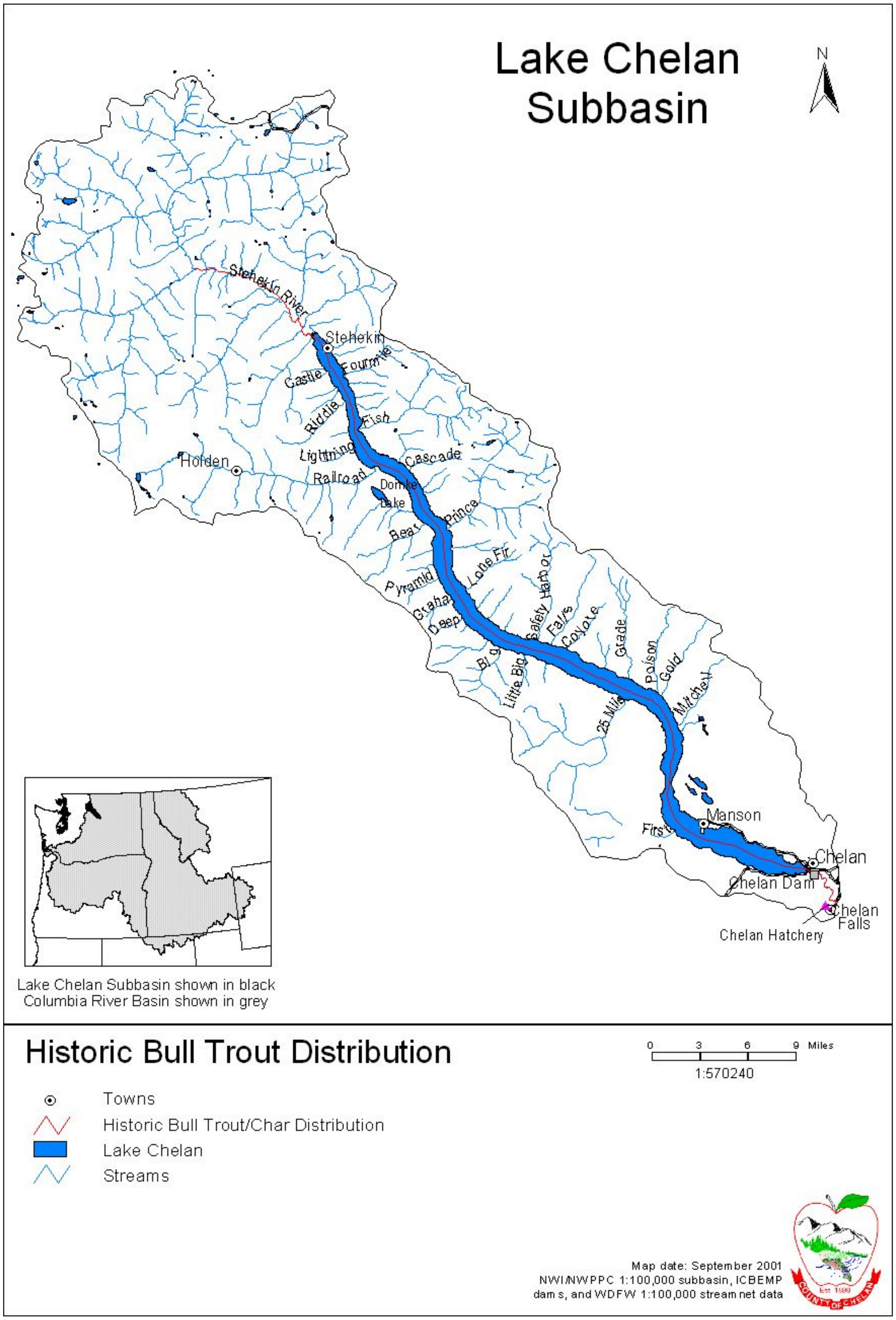
Hydroelectric Effects

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

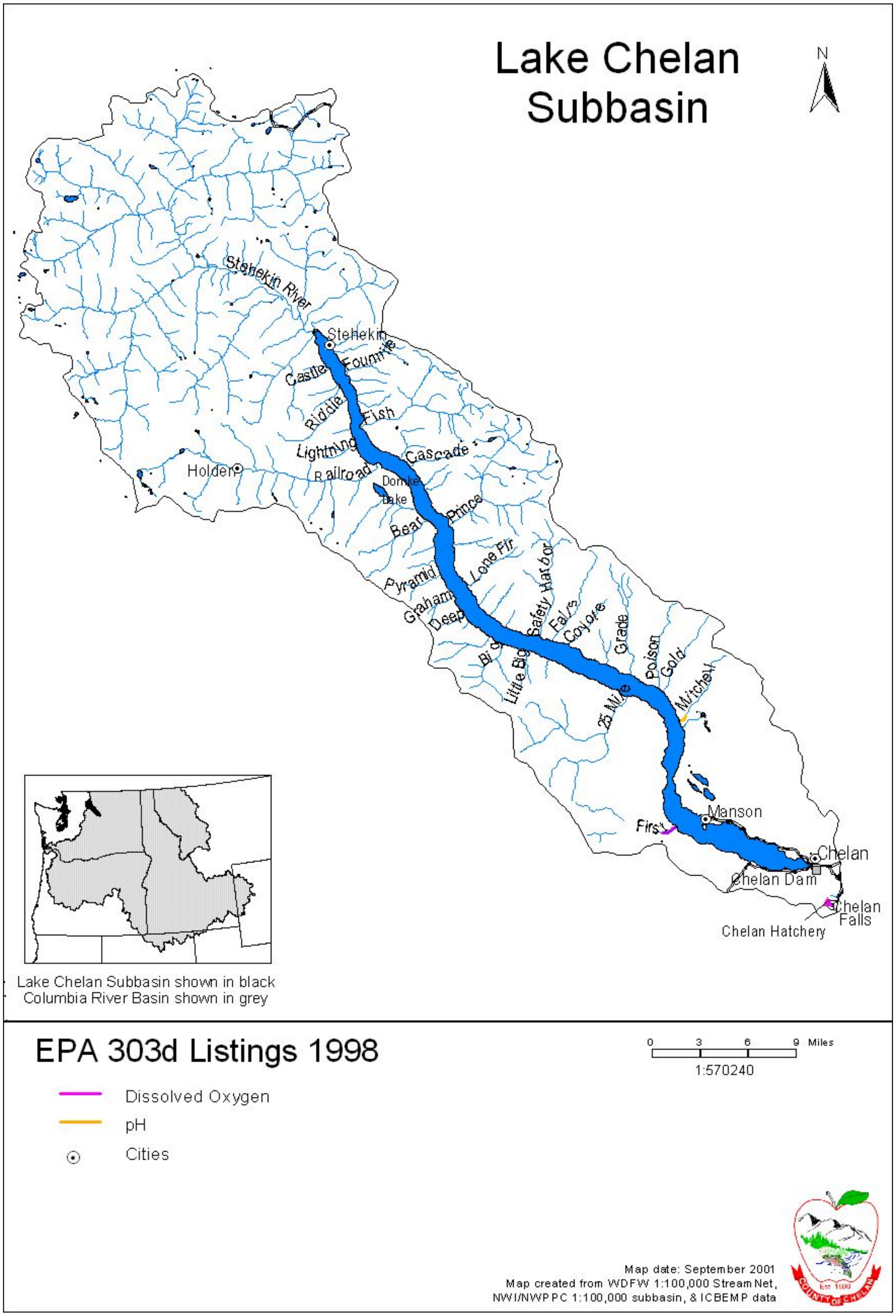
Aquatic habitat conditions vary greatly among the tributaries based on the configuration and aspect of the drainage, and human activities. Most of the tributaries have narrow, steep-walled drainages, deeply-incised channels, narrow bands of riparian vegetation alongside the streams, cobble and boulder 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.