4 The Assessment

4.1 Introduction

A focal species will be used to evaluate the health of the ecosystem and the effectiveness of management actions. Focal habitat types are used as the basis for the wildlife assessment. Fish focal species were defined that a) have special cultural significance, b) fulfill a critical ecological function, c) serve as an indicator of environmental health, d) are locally significant or rare as determined by applicable state or federal resource management agencies and/or are federally listed species.

Because wildlife species often are wide ranging and typically have varied habitat needs, key focal habitats were used as bio-indicators and several different species that are obligated to these habitats were selected for this evaluation. The three focal habitats and representative species selected for this evaluation are listed below.

Table 11. Wildlife focal habitats and their representative species within the Entiat subbasin

Focal Habitats	Wildlife Species Represented
Shrubsteppe	Sharp-tailed grouse, Grasshopper sparrow, Brewer's sparrow, Mule deer
Ponderosa – Mixed Hardwood	White-headed woodpecker, Pygmy nuthatch, Flammulated owl, Grey flycatchers
Riparian	Red-eyed vireo, Yellow-breasted chat, Beaver

Six anadromous and resident fish species were chosen as focal species. Each of these species is considered to be culturally important, three of the species are listed under the ESA and each species uniquely represent different and important habitat characteristics. The six species and their representative habitat types are listed below.

Table 12. Fish focal species and their representative habitats within the Entiat subbasin

Focal Fish Species	Habitats Represented
Spring Chinook	Mid elevation tributary streams, stream order 2-3.
Late-run Chinook	Mid and lower Entiat River mainstem
Coho	Lower-mid elevation mainstem and tributaries
Steelhead	Lower–mid elevation mainstem and tributaries
Pacific Lamprey	Undefined habitat, culturally important species.
Bull trout	Mid-upper elevation tributaries
Cutthroat trout	Upper elevation, higher gradient tributaries.

4.1.1 Terrestrial/Wildlife Methodology, Species and Habitat Selection

Methodology

The wildlife assessment was developed from a variety of "tools" including subbasin summaries, the Interactive Biodiversity Information System (IBIS), WDFW Priority Habitats and Species

(PHS) database, Washington GAP Analysis database, Partners in Flight (PIF) information, National Wetland Inventory maps, Ecoregion Conservation Assessment (ECA) analyses, and input from local state, federal, and tribal wildlife managers. Specific information about these data sources is located in Appendix A

Although IBIS is a useful assessment tool, it should be noted that the historic habitat maps have a minimum polygon size of 1 km^2 while current IBIS wildlife habitat maps have a minimum polygon size of 250 acres (T. O'Neil, NHI, personal communication, 2003). In either case, linear aquatic, riparian, wetland, subalpine, and alpine habitats are under-represented, as are small patchy habitats that occur at or near the canopy edge of forested habitats. It is also likely that micro habitats located in small patches or narrow corridors were not mapped at all. Another limitation of IBIS data is that they do not reflect habitat quality nor do they associate habitat elements (key ecological correlates [KECs]) with specific areas. As a result, a given habitat type may be accurately depicted on IBIS map products, but may be lacking quality and functionality. For example, IBIS data do not distinguish between shrubsteppe habitat dominated by introduced weed species and pristine shrubsteppe habitat. Washington State GAP data were also used extensively throughout the wildlife assessment. The GAP-generated acreage figures may differ from IBIS acreage figures as an artifact of using two different data sources. The differences, however, are relatively small (less than five percent) and will not impact planning and/or management decisions.

The ECA spatial analysis is a relatively new terrestrial habitat assessment tool developed by The Nature Conservancy (TNC). The ECA has not been completed in all areas within the greater Columbia River Basin. Where possible, however, WDFW integrated ECA outputs into Province/ subbasin plans. The major contribution of ECA is the spatial identification of priority areas where conservation strategies should be implemented. ECA products were reviewed and modified as needed by local wildlife area managers and subbasin planners.

Focal Representative Habitats

Focal representative habitats selected for the subbasin include ponderosa pine, shrubsteppe, and riparian wetlands. Neither the IBIS nor the Washington GAP analysis data recognize the historic presence of riparian wetlands. The current extent of this habitat type as reflected in these databases is suspect at best; however, riparian wetland habitat is a high priority habitat wherever it is found in the ecoprovince. Agriculture, a habitat of concern, is not included as a focal habitat type at the subbasin level. Focal wildlife habitat types are fully described in Appendix A.

Wildlife Focal Species

The focal species selection process is described in Appendix A. Province and subbasin planners identified focal species assemblages for each focal habitat type (Table 11).

Focal habitats selected for the subbasin include ponderosa pine, shrubsteppe, and riparian wetlands. Neither the IBIS nor the Washington GAP Analysis data recognize the historic presence of riparian wetlands. The current extent of this habitat type as reflected in these databases is suspect at best; however, riparian wetland habitat is a high priority habitat wherever it is found in the Province. Agriculture, a habitat of concern, is not included as a focal habitat type at the subbasin level.

Table 11. Focal species selection matrix for the Columbia Cascade Province

Common Name	Focal Habitat[1]	Status[2]		Native Species	PHS	Partners in Flight	Game Species
		Federal	State				
Sage thrasher	SS	n/a	C	Yes	Yes	Yes	No
Brewer's sparrow		n/a	n/a	Yes	No	Yes	No
Grasshopper sparrow		n/a	n/a	Yes	No	Yes	No
Sharp-tailed grouse		SC	T	Yes	Yes	Yes	No
Sage grouse		C	T	Yes	Yes	No	No
Pygmy rabbit		E	E	Yes	Yes	No	No
Mule deer		n/a	n/a	Yes	Yes	No	Yes
Willow flycatcher	RW	SC	n/a	Yes	No	Yes	No
Lewis woodpecker		n/a	C	Yes	Yes	Yes	No
Red-eyed vireo		n/a	n/a	Yes	No	No	No
Yellow-breasted chat		n/a	n/a	Yes	No	No	No
American beaver		n/a	n/a	Yes	No	No	Yes
Pygmy nuthatch	PP	n/a	n/a	Yes	No	No	No
Gray flycatcher		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

Ashley and Stovall 2004

Six bird species and two mammalian species were selected to represent three priority habitats in the Subbasin. Life requisite habitat attributes for each species assemblage were pooled to characterize a "range of management conditions", to guide planners in development of future habitat management strategies, goals, and objectives.

General habitat requirements, limiting factors, distribution, population trends, and analyses of structural conditions, key ecological functions, and key ecological correlates for individual focal species are included in Ashley and Stovall (unpublished report, 2004). The reader is further encouraged to review additional focal species life history information in Appendix A.

Establishment of conditions favorable to focal species will benefit a wider group of species with similar habitat requirements

4.2 Terrestrial/Wildlife Assessment

Areas Currently Under Protection Status

An estimated 25,130 acres (8 percent) are permanently protected in the Entiat Subbasin. These lands have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events of natural type are allowed to proceed without interference or are mimicked through management (high protection). Approximately 1.3 percent (3,926 acres) of the Subbasin has permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state (medium protection status). The majority of lands in the Subbasin (221,978 acres; 74 percent) has permanent protection from conversion of natural land cover for the majority of the area, but is subjected to uses of either a broad, low intensity type or localized intense type (low protection status). Approximately 16 percent (47,329 acres) of the lands within the Subbasin lack irrevocable easements or mandates to prevent conversion of natural habitat types to anthropogenic habitat types (no protection). Lands owned by WDFW fall within the medium and low protection status categories.

Additional habitat protection, primarily on privately owned lands, may be provided through the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). The CRP is intended to reduce soil erosion on upland habitats through establishment of reduce stream sedimentation and provide protection for riparian/riverine habitats using buffer strips comprised of herbaceous and woody vegetation.

Both programs provide short-term (CRP-10 years; CREP-15 years), high protection of habitats enrolled in either program. The U.S. Congress authorizes program funding /renewal, while the USDA determines program criteria. Program enrollment eligibility and sign-up is decentralized to state and local NRCS offices (R. Hamilton, FSA, personal communication, 2003).

Vegetation

Subbasin vegetation, wildlife habitat descriptions, and changes in habitat quantity, distribution, abundance, and condition are summarized in the following sections. Landscape level vegetation information is derived from the Washington GAP Analysis Project (Cassidy 1997) and IBIS data (2003).

Rare Plant Communities

The Subbasin contains 22 rare plant communities. Approximately 32 percent of the rare plant communities are associated with shrubsteppe habitat, and 68 percent with upland forest habitat.
Noxious Weeds

Changes in biodiversity have been closely associated with changes in land use. Grazing, agriculture, and accidents have introduced a variety of exotic plants, many of which are vigorous enough to earn the title noxious weed. Twenty-one species of noxious weeds occur in the Subbasin.

Vegetation Zones

Cassidy (1997) identified seven 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, grand fir, subalpine fir, and alpine parkland are not focal habitat types, but these vegetation zones occur extensively throughout the Subbasin.

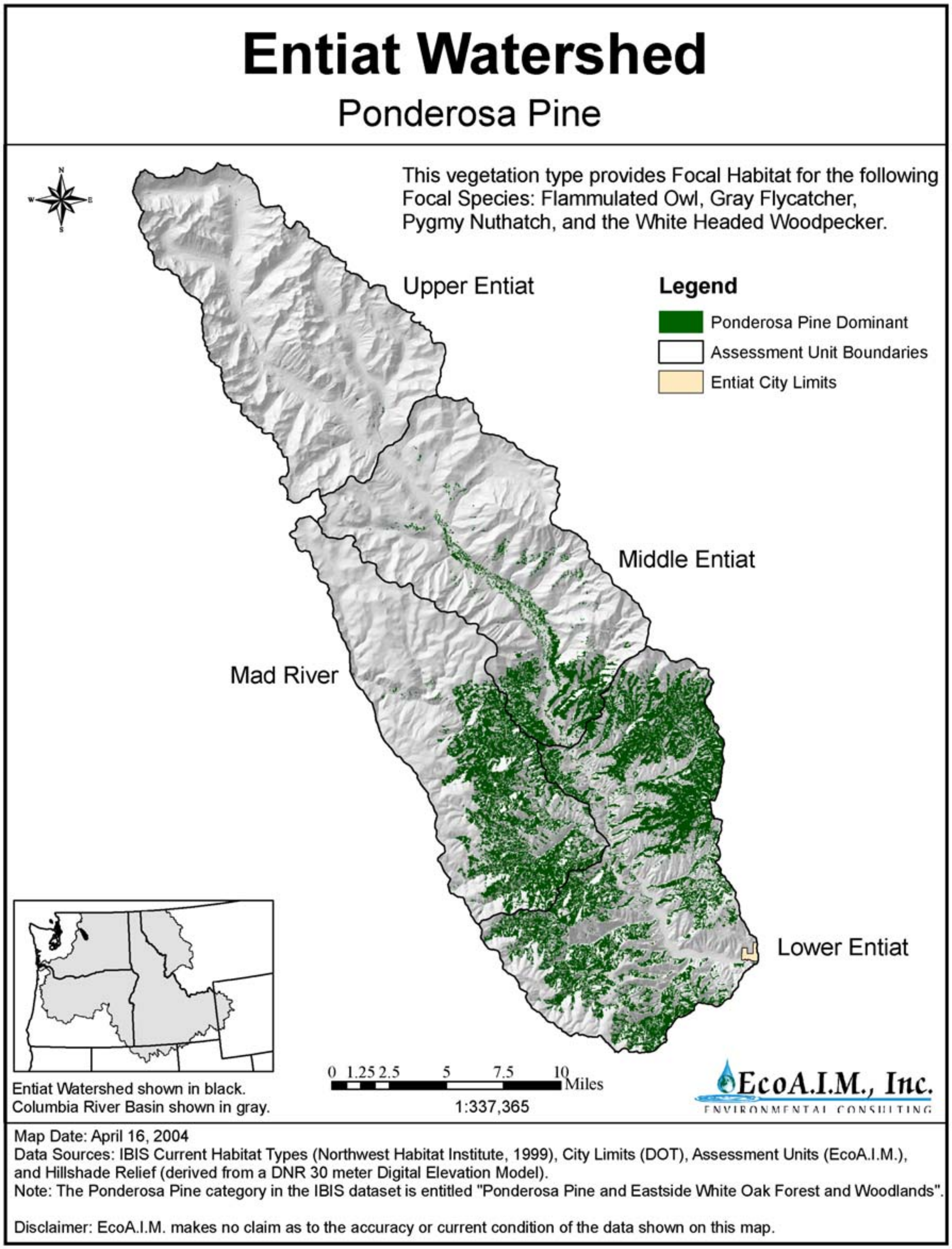

Figure 4. Ponderosa pine distribution in the Entiat subbasin

4.3 Ponderosa Pine

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 was replaced by dense second growth of Douglas-fir and ponderosa pine with little understory.

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). The best available information characterizing subbasin habitats is found in US Forest Service watershed assessments (USFS 1995, 1996). Approximately 24% of the subbasin is open forest habitat type (63,000 acres), including ponderosa pine habitat. Much of this habitat type in the subbasin was burned in severe, stand-replacing fires in 1988 and 1994, which burned approximately 29% of the subbasin. These areas lack live tree overstories.

Large late-seral ponderosa pine and Douglas-fir have been harvested in much of this habitat type. In combination with fire suppression, effects of these harvests have resulted in decreased tree size; increased tree density; decreased patch size; and decreased connectivity (USFS 1995, 1996).

Introduced annuals, especially cheatgrass and invading shrubs under historic heavy grazing pressure, have invaded or replaced native herbaceous understory species, particularly on low, dry sites. 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 have changed the fire regime of these stands often contributing to stand replacing, catastrophic fires.

Primary cavity excavator habitat (PCE) is important for many species of wildlife and is part of the functioning of an ecosystem. PCE habitat consists of standing dead trees, or live defective standing trees that provide cavities or potential cavities for vertebrates. Species such as Lewis woodpecker and flammulated owl prefer dead trees in open grassy conditions. Stands of well-spaced, large old trees with their fire scars, large broken-out limbs, dead sections and snags provide cavities for roosts and nests, insects to feed on, and water (springs, ponds, streams, and wetlands) for flammulated owls and bats. Additionally, dead downed trees provide cover, food, and dens for snowshoe hares, chipmunks, voles, ground squirrels, shrews, and others (USFS 1996 in NPPC 2002).

The 1970 fires in this drainage burned many thousands of acres and most big trees were salvaged. An examination of this fire area now shows almost no snags and the new trees are 2-6 inches in diameter. In other words, these acres no longer contain primary cavity excavator habitat. Some of this fire area burned again in 1988 (Dinkleman fire) and 1994 (Tyee fire), leaving the area with no standing dead trees and no down logs to provide any potential habitat (USFS 1996 in NPPC 2002).

It appears that PCE habitat may be below established levels over large areas of the Subbasin. This is a major problem in the lower elevations and in areas that have been burned by fires. Higher elevations and burned areas may have acceptable levels. Large areas will be devoid of standing and down PCE habitat for 50 – 100 years. This function will not completely return to these stands for 200-400 years (USFS 1996 in NPPC 2002).

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

The protection status of ponderosa pine habitat for subbasins within the Province is compared in Appendix A of this document. The protection status of remaining ponderosa pine habitat in all subbasins fall 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 all Province subbasins. Protection status of ponderosa pine habitat within the Subbasin is illustrated in Table 12.

Table 12. Ponderosa pine habitat GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	11
Medium Protection	545
Low Protection	43,248
No Protection	12,008

IBIS 2003

Factors Affecting Ponderosa Pine Habitat

Factors affecting ponderosa pine habitat are explained in detail in Appendix A and are summarized below:

- Timber harvesting, particularly at low elevations, has reduced the amount of old growth forest and associated large diameter trees and snags.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Overgrazing has resulted in invasion of exotic plants, resulting in altered understory conditions and increased fuel loads.

- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.
- Timber harvesting, particularly at low elevations, has reduced the amount of old growth forest and associated large diameter trees and snags.
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- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.

Ponderosa Pine Community

4.3.1 White-headed Woodpecker

The white-headed woodpecker represents species that require/prefer large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10–50% and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags grater than 31 in. in diameter at breast height (DBH). Abundant white-headed woodpecker populations can be present on burned or cut forest with residual large diameter live and dead trees and understory vegetation that is usually very sparse. Openness however, is not as important as the presence of mature or veteran cone producing pines within a stand.

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

4.3.2 Flammulated Owl

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

4.3.3 Gray Flycatchers

Gray flycatchers represent wildlife species that occupy the pine/shrubsteppe interface (pine savannah) with a shrub/bunchgrass understory. Gray flycatchers require nest trees 18 in. DBH and a tree height of 52 ft. for their reproductive life requisites.

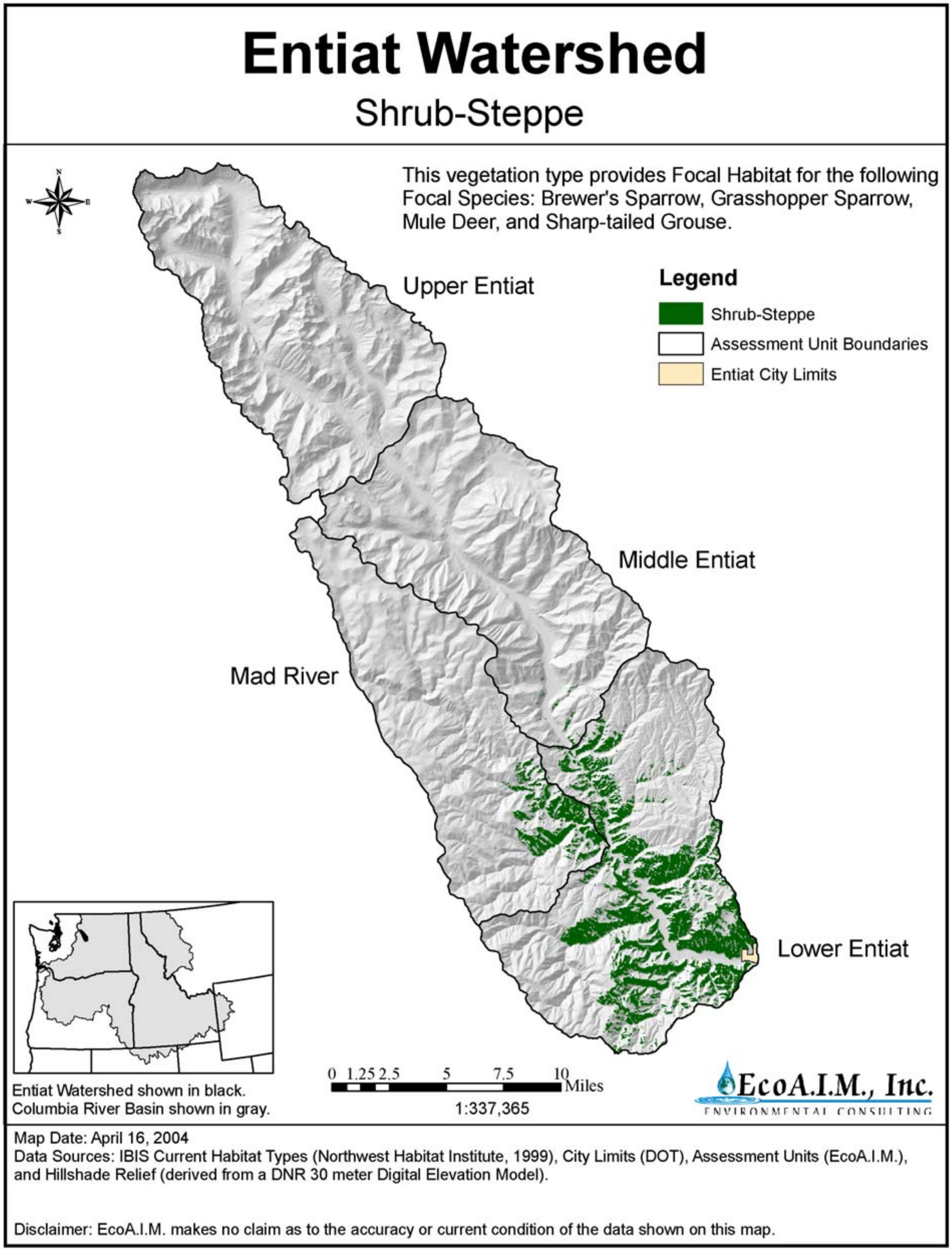

Figure 5. Shrubsteppe distribution in the Entiat subbasin

4.4 Shrubsteppe

The greatest changes in shrubsteppe habitat from historic conditions are the 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.

Historically, sage dominated steppe vegetation occurred throughout the majority of the lower elevations in the Entiat 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, a major component of the winter diet of sharp-tailed grouse. The drastic reduction of water birch in the Subbasin by early settlers is likely a major factor in the extirpation of sharp-tailed grouse (NPPC 2002).

Shrubsteppe and open forest habitat are preferred by deer in winter and by the other species throughout the year. 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).

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 percent 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

The protection status of shrubsteppe habitat for province subbasins is compared in Appendix A of this document. The protection status of remaining shrubsteppe habitats in all subbasins fall 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 all province subbasins. Protection status of shrubsteppe habitat within the Entiat subbasin is illustrated in Table 13.

Table 13. Shrubsteppe habitat GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	0
Medium Protection	2,331
Low Protection	17,066
No Protection	13,586

IBIS 2003

Factors Affecting Shrubsteppe Habitat

Factors affecting shrubsteppe habitat are explained in detail in Appendix A and are summarized below:

- Permanent habitat conversions of shrubsteppe/grassland habitats (e.g., approximately 60 percent of shrubsteppe in Washington [Dobler *et al.* 1996]) to other uses (e.g., agriculture, urbanization)
- Fragmentation of remaining tracts of moderate to good quality shrubsteppe habitat
- Degradation of habitat from past intensive grazing and invasion of exotic plant species, particularly cheatgrass, knapweeds and Dalmatian toadflax
- Degradation and loss of properly functioning shrubsteppe/grassland ecosystems resulting from the encroachment of urban and residential development and conversion to agriculture. 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 percent).
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities
- High density of nest parasites (brown-headed cowbird) and domestic predators (cats) may be present in hostile/altered landscapes, particularly those in proximity to agricultural and residential areas subject to high levels of human disturbance.

- Agricultural practices that cause direct or indirect mortality and/or reduce wildlife productivity. There are a substantial number of obligate and semi-obligate avian/mammal species; thus, threats to the habitat jeopardize the persistence of these species.
- Fire management, either suppression or over-use
- Invasion and seeding of crested wheatgrass and other introduced plant species which reduces wildlife habitat quality and/or availability

Shrubsteppe Community

4.4.1 Mule Deer

Mule deer were selected to represent species that require and prefer diverse, dense (30 to 60% shrub cover less than 5 ft. tall) shrubsteppe habitats comprised of bitterbrush, big sagebrush, rabbitbrush, and other shrub species with a palatable herbaceous understory exceeding 30% cover.

4.4.2 Brewer's Sparrow

Brewer's sparrow was selected to represent wildlife species that require sagebrush dominated sites. Brewer's sparrow prefers a patchy distribution of sagebrush clumps, 10-30% cover, lower sagebrush height (between 20 and 28 in.), 1981), 10 to 20% native grass cover, less than 10% non-native herbaceous cover, and bare ground greater than 20%. It should be noted, however, that shrublands comprised of snowberry, hawthorne, chokecherry, serviceberry, bitterbrush, and rabbitbrush were also used by Brewer's sparrows for nesting in southeast Washington. Specific, quantifiable habitat attribute information for this mixed shrub landscape could not be found.

4.4.3 Sharp-tailed Grouse

Sharp-tailed grouse was selected to represent species that require multi-structured fruit/bud/catkin producing deciduous trees and shrubs dispersed throughout the landscape (10 to 40% of the total area). Other habitat conditions include:

- Native bunchgrass greater than 40% cover
- Native forbs at least 30% cover
- Visual obstruction readings (VOR) at least 6 in. least 75% cover deciduous shrubs and trees
- Exotic vegetation/noxious weeds less than 5% cover

4.4.4 Grasshopper Sparrow

Grasshopper sparrow was selected to represent species that require healthy steppe habitat dominated by native bunch grasses. Grasshopper sparrow require native bunchgrass cover greater than 15% and comprising greater than 60% of the total grass cover.

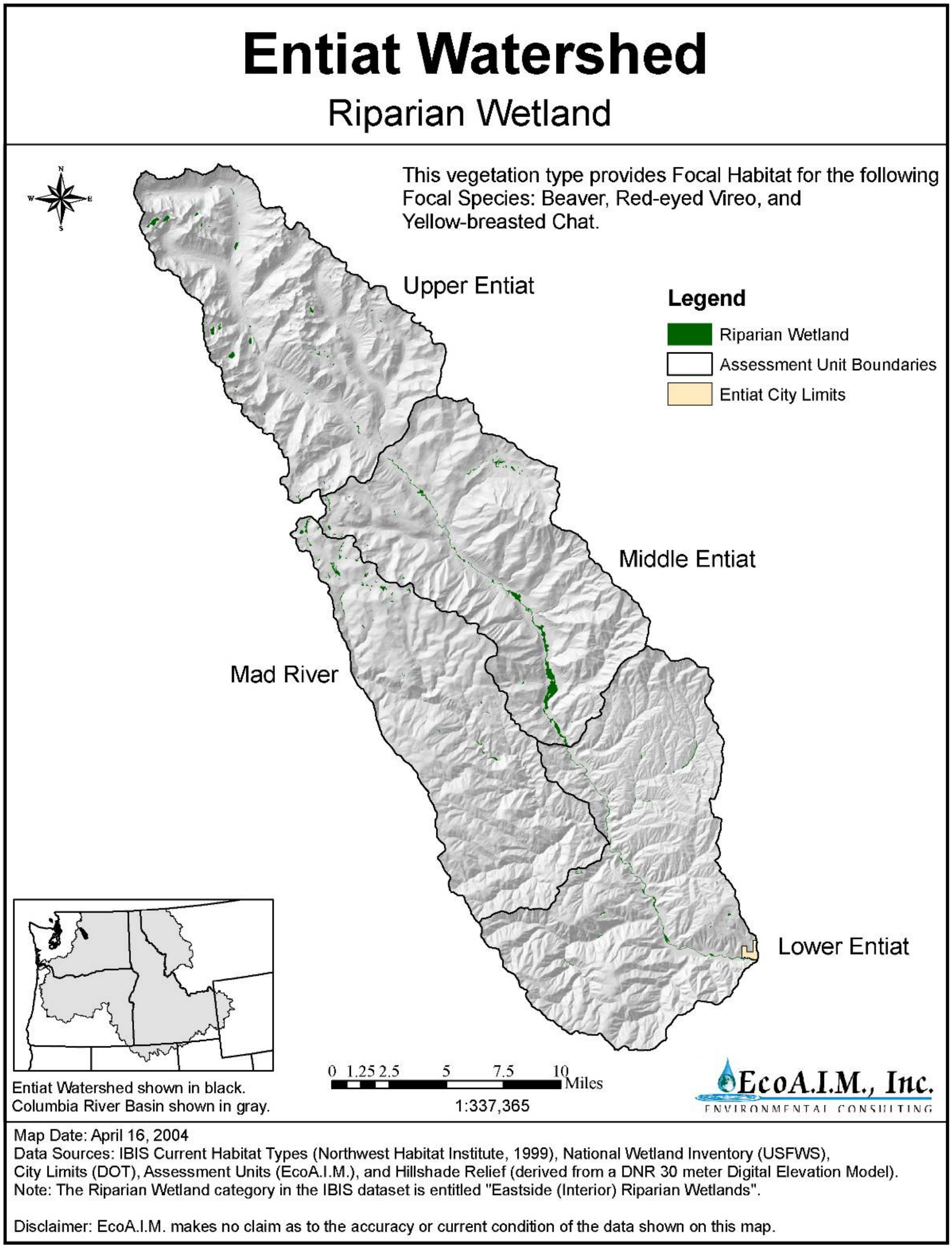

Figure 6. Riparian composition in the Entiat subbasin

4.5 Eastside (Interior) Riparian Wetlands

The eastside (interior) riparian wetlands habitat type refers only to riverine and adjacent wetland habitats in both the province 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 province and subbasin level. The lack of data is a major challenge as province 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 province 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.

Historically, 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.

Today, agricultural conversion, altered stream channel morphology, and water withdrawal have played significant roles in changing the character of streams and associated riparian areas. However, the Entiat subbasin is still host to some of eastern Washington's best remaining tracts of cottonwood gallery forests, found in the floodplain portions of the Subbasin. Large areas once dominated by cottonwoods, which contribute considerable structure to riparian habitats, are being lost. Because of its proximity to roads and other developed areas, much of the remaining riparian/floodplain habitat may be at risk of conversion to housing development.

Many species found in the riparian zone are the same as those inhabiting the adjacent uplands. The water and abundance of food in the riparian zone attracts these species. Acre for acre, riparian areas are more productive than the surrounding land. Some species, such as the water shrew, dipper, amphibians, some bats, many invertebrates and plants, are riparian obligates. An obligate species may not spend its whole life in a particular habitat, but it needs riparian habitat at some time in its life cycle for survival or reproduction.

Riparian conditions within the Entiat can be separated into three zones: 1) transport zone (headwaters and alpine/subalpine communities), 2) forested mountain slopes (transitional zone), and 3) depositional zone (shrubsteppe and open forest). Riparian vegetation in the transport zone consists of grand fir, Engelmann spruce, Douglas-fir, lodgepole pine, red cedar, cottonwood, grasses, and forbs. An estimated 6.6 miles of road are located within 300 feet of a stream channel in this zone and road densities are below 1.0 mile/mi^2 (CCCD 1999 in NPPC 2002). Riparian area impacts at developed campgrounds in this zone are localized and minimal, except for the concentrated use at Cottonwood Campground. Riparian zone function is good to excellent (CCCD 1999 in NPPC 2002).

Riparian vegetation in the transitional zone consists of cottonwood, red cedar, grand fir, with dogwood and alder in lower elevations, and the addition of Engelmann spruce and western hemlock in higher elevation reaches. There are 43 miles of road located within 300 feet of stream channel in this zone. Riparian zone function is fair to excellent (CCCD 1999 in NPPC 2002).

Riparian vegetation in the depositional zone consists primarily of deciduous species with alder, willow, cottonwood, aspen, elderberry, red osier dogwood, river birch, maple, and conifers (i.e., ponderosa pine and Douglas-fir) being the dominant species. In some reaches, loss of vigorous shrubs in the riparian zone has reduced instream organic input, reduced shade, and contributed to unstable stream banks and associated erosion. There are a total of 205 miles of road located within 300 feet of a stream in this zone. Many roads are native surface with minimal surface water control features. Stream adjacent roads and associated management have reduced large woody debris recruitment. Riparian zone function is poor to good (CCCD 1999 in NPPC 2002).

Overall, the trend in riparian habitat conditions is toward fewer riparian areas due to dams, grazing, trapping of beaver, forest fires, and other anthropogenic activities. The Rocky Reach Dam flooded productive bottomland. Although grazing has been reduced significantly from historical levels, there may still be some local areas of impacts in the Subbasin. Streambanks are destabilized, erosion and water temperatures have increased, water quantity and quality is diminished, soils are compacted, vegetation is altered and destroyed, and channel hydrology, morphology, and instream structure are altered (USFS 1996 in NPPC 2002).

While riparian habitats are temporarily destroyed by catastrophic events, such as the Tyee fire that burned 32 percent of the Subbasin in 1994, these events can be beneficial by retarding succession to primary stages. This in turn creates habitat diversity within the riparian zone. Beaver are apt to benefit from early and mid-successional stages as the stands recover (USFS 1996 in NPPC 2002).

The current extent of riparian wetland habitat throughout the Columbia Cascade Province is illustrated in Appendix A of this document.

Protection Status

The protection status of riparian habitat is compared by subbasin in Appendix A of this document. The vast majority of province riparian habitat is designated low or no protection status and is at risk for further degradation and/or conversion to other uses. The GAP protection status of riparian wetland habitat in the Subbasin is depicted in Table 14.

Table 14. Eastside riparian wetlands GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	0
Medium Protection	0
Low Protection	17
No Protection	77

IBIS 2003

Factors Affecting Eastside (Interior) Riparian Wetland Habitat

Factors affecting riparian wetland habitat are described in Appenix A and summarized below:

- Loss of habitat due to numerous factors including riverine recreational developments, inundation from impoundments, cutting and spraying of riparian vegetation for eased access to water courses, gravel mining, etc
- Habitat alteration from 1) hydrological diversions and control of natural flooding regimes (e.g., dams) resulting 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., and 2) stream bank stabilization which narrows stream channel, reduces the flood zone, and reduces extent of riparian vegetation
- Habitat degradation from livestock overgrazing which can widen channels, raise water temperatures, and reduce understory cover.
- Habitat degradation from conversion of native riparian shrub and herbaceous vegetation to invasive exotics such as reed canary grass, purple loosestrife, perennial pepperweed, salt cedar, indigo bush, and Russian olive
- Fragmentation and loss of large tracts necessary for area-sensitive species such as yellow-billed cuckoo
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.
- High energetic costs associated with high rates of competitive interactions with European starlings for cavities may reduce reproductive success of cavity-nesting species such as Lewis' woodpecker, downy woodpecker, and tree swallow, even when outcome of the competition is successful for these species
- Recreational disturbances (e.g., ORVs), particularly during nesting season, and particularly in high-use recreation areas

Riparian Community

4.5.1 Red-eyed Vireo

Red-eyed vireo was selected to represent species that require greater than 60% canopy closure. For their food and reproductive requirements red-eyed vireo require mature deciduous trees greater than 160 ft. tall. Greater than 10% of the shrub layer should be young cottonwoods.

4.5.2 American Beaver

Beaver were selected to represent species that require 40-60% tree/shrub canopy closure and shrub height greater than 6.6 ft. Beavers also require trees less than 6 in. DBH.

4.5.3 Yellow-breasted Chat

Yellow-breasted chat were selected to represent species that require riparian habitat with a shrub layer 3-13 ft. tall, 30-80% shrub cover, scattered herbaceous openings, and less than 20% tree cover.

The change in extent of the riparian wetland habitat type from c.1850 to 1999 is not included because of inaccurate IBIS (2003) data and geographic information system (GIS) products.

4.6 Agriculture

Because agriculture is not a focal wildlife habitat type and there is little opportunity to effect change in agricultural land use at the landscape scale, subbasin planners did not conduct an analysis of agricultural conditions.

Agricultural development in the Entiat subbasin has altered or destroyed native shrubsteppe habitat and fragmented riparian/floodplain habitat. Agricultural operations have increased sediment loads and introduced herbicides and pesticides into streams. Conversion to agriculture has decreased the overall quantity of habitat for many native species, but the loss of specific communities may be particularly critical for habitat specialists.

Although the preceding information is described, reliable quantification of effects at the subbasin level is lacking.

Protection Status

The IBIS (2003) data clearly indicate that nearly all of this cover type has no protection status within the Entiat subbasin. 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 15. Agriculture GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	0
Medium Protection	692
Low Protection	2,098
No Protection	5,044

IBIS 2003

4.7 Summary of Factors Affecting Focal Habitats and Focal Species

It is highly unlikely that the extent of shrub-steppe and riparian wetland and herbaceous habitats is now greater than what occurred historically in the province, as indicated by IBIS. IBIS data indicate a 55% reduction in ponderosa pine habitat from historic within the subbasin, but there is little reason to consider this an accurate quantification of this loss. Subbasin planners have little confidence in IBIS data at the subbasin level. For additional information regarding focal habitat changes throughout the ecoregion, see Appendix A.

Habitat data are incomplete and limited in value. Accurate habitat type maps, especially those detailing riparian and herbaceous wetland habitats, are needed to improve assessment quality and support management strategies/actions. Subbasin wildlife managers, however, believe that significant physical and functional losses have occurred to focal habitats from timber management, hydroelectric facility construction and inundation, agricultural, urban and residential development, fire suppression, livestock grazing and the spread of noxious weeds.

Since 1850, a number of human induced physical changes have redefined the quality and quantity of terrestrial habitat found in the mid and lower portions of the Subbasin. The most significant among these changes is habitat fragmentation compounded by degradation in overall habitat quality resulting from historic and current agricultural practices, timber management, mismanaged grazing, and commercial and residential development activities (NPPC 2002). Combinations of these activities have contributed to 1) alteration, reduction, and elimination of riparian habitat; 2) alteration and elimination of floodplains; 3) increased road densities and related erosion as well as loss of canopy cover; and 4) changes to overall vegetative composition and forage availability in both riparian and upland areas.

Agriculture

Agricultural development in the Entiat subbasin has altered or destroyed native shrubsteppe habitat and fragmented riparian/floodplain habitat. Agricultural operations have increased sediment loads and introduced herbicides and pesticides into streams. Conversion to agriculture has decreased the overall quantity of habitat for many native species, but the loss of specific communities may be particularly critical for habitat specialists.

Although the preceding information is described, reliable quantification of effects at the subbasin level is lacking.

Timber Management

Timber management activities, including extensive timber harvest in sections of the Entiat subbasin, have resulted in the widescale removal of large ponderosa pine trees between 1880 and the 1960s (USFS 1995, 1996). There is a lack of all forested vegetation types in excess of 24" DBH in the open forest type (USFS 1995). As a result of historical selective harvest in the ponderosa pine series, in addition to stand-replacing fires attributed to effects of fire suppression, large diameter, late successional habitat of this type is lacking in the basin. This removal is believed to have subsequently reduced populations of dependent wildlife 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.

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Livestock Grazing

Livestock grazing has negatively affected wildlife habitat in the Subbasin. In 1971, a cooperative agreement was reached between the Washington Department of Game, Entiat Valley Stockman's Association, and the Forest Service, to reduce grazing pressure in the Johnson Creek, Oklahoma Gulch, and Entiat Breaks in exchange for use in the Mud and Potato Creek drainages. The purpose of this agreement was to benefit conditions for mule deer on crucial winter ranges. Due to valley bottom overuse and excessive, detrimental grazing impacts in riparian zones, pastures in lower Mud and Potato Creeks were closed in summer 1993 (USFS 1995). Additionally, invasion by exotics, primarily cheatgrass and knapweed, is attributed primarily to historic overgrazing (USFS 1995).

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Commercial and Residential Development

While urban areas comprise only a small percentage of the land base within the Subbasin (0.1 percent), their habitat impacts are significant. Residential growth within the Subbasin is largely occurring along creeks and rivers. Channelization and development along water courses has eliminated riparian and wetland habitats. 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.

The conversion of forested uplands and riparian habitat to residential use has negatively affected wildlife habitat connectivity and composition. Road construction and dispersed residential development have impeded stream access and changed vegetative communities, resulting in the reduction of wildlife range and quality. Human activities have increased the number of fire starts, but historic fire control policies have kept the size of fires small, resulting in a buildup of fuel in the forested uplands of the Subbasin. This absence of fire has resulted in changes to the composition of the forest and plant communities, and the related capacity to store and transport water.

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Fire

Fire is a 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 in conjunction with past management practices has created unnatural vegetation patterns. Forested stand conditions on north/northeast facing slopes developed 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 had increased on south/southeast facing slopes where grasses were more prominent than they are today (USFS 1998 in NPPC 2002). In 1988 and 1994, stand-replacing wildfires occurred on large areas of the subbasin, including the majority of ponderosa pine and shrub-steppe habitats. These fires likely resulted from plural effects of invasion by noxious weeds, past fire suppression and efforts, timber management practices.

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Beaver trapping

Historic harvest eliminated beaver from much of the subbasin, resulting in decreases in riparian wetland habitat (USFS 1995).

Hydropower Development and Operation

In 1961, completion and operation of the Rocky Reach dam and hydroelectric project on the Columbia River inundated significant amounts of riparian and shrub-steppe habitat, resulting in: reductions in habitat quality and quantity relative to historic conditions; altered development of riparian habitats, and is impacting shoreline and backwater erosion and sedimentation.

Subbasin-specific effects are not quantified.

Noxious Weeds

Noxious weeds are prevalent in the lower Entiat Basin. Most focal habitats are located in the lower basin, and noxious weeds are nearly ubiquitous in focal habitats. Livestock grazing, development, timber management, recreation, and fire management all have played a role in the current noxious weed situation. Quantification is lacking at the subbasin level.

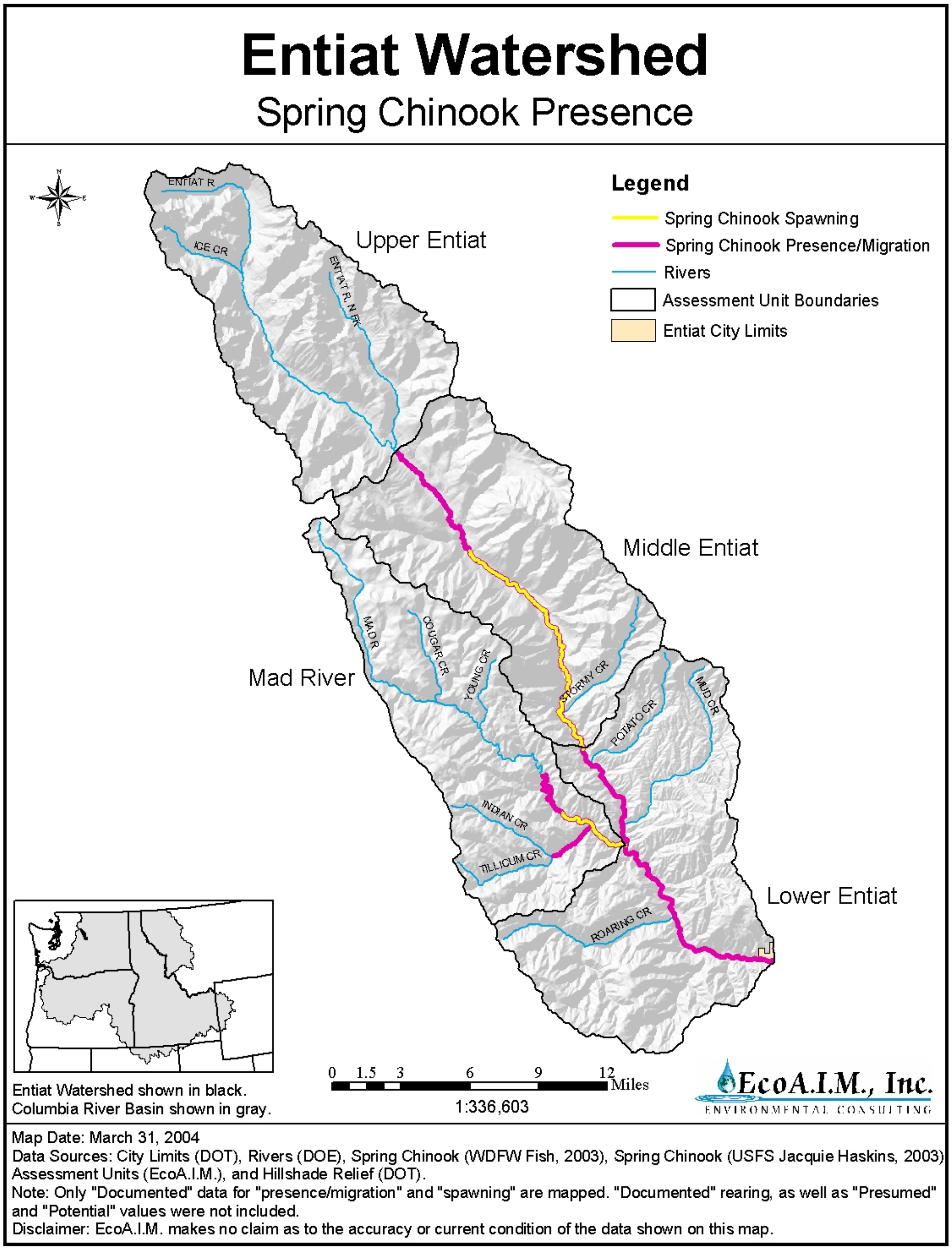

Figure 7. Spring chinook distribution in the Entiat subbasin

4.8 Aquatic/Fish Assessment

4.8.1 Fish Focal Species

Six anadromous and resident fish species were chosen as focal species. Spring chinook, late-run chinook, coho, steelhead, Pacific lamprey, bull trout, and cutthroat trout.

4.8.2 Spring Chinook (*Oncorhynchus tshawytscha*)

Rationale for Selection

Spring chinook salmon (stream type) are considered depressed throughout most of their current range and many stocks are at danger of extinction. All remaining populations and habitats are considered to be vital to the continued persistence of chinook salmon in the interior Columbia basin.

The Entiat spring chinook is included by NOAA Fisheries into the Upper Columbia ESU and listed as an endangered under the ESA. Spring chinook salmon utilize most of the lower Entiat subbasin and are sensitive to many environmental conditions and changes. Spring chinook provide a good biological indicatory of ecosystem health for the lower and middle reaches of the Entiat River.

Key Life History Strategies, Relationship to Habitat

Time of entry and spawning

Adult spring chinook begin entering the Entiat River basin in May. Spawning begins in very late July through September, peaking in mid- to late August (Chapman et al. 1995 CPa). The onset of spawning in a stream reach is temperature driven (usually when temperatures drop below 16 °C). Temperature may be influenced by riparian conditions. Land use within the Entiat and Mad rivers has affected riparian areas, conservation of remaining areas of riparian and restoration of riparian areas will increase production for many life stages.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Entiat or Mad rivers. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Healy (1991) reports the range of depths of spawning as between 41 to > 700 cm (~1-23 ft) and velocities of between 10 to 150 cm/s (.33-5 ft/s) for chinook salmon (this includes ocean-type chinook too). Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Healy (1991) reports that incubation and emergence success was related to oxygen levels and percolation through the gravel. When percolation was 0.03 cm/s (0.001 ft/s), survival to hatching was 97%. However, emergence reduced to 13% when percolation was 0.06 cm/s (0.002 ft/s). When oxygen fell below 13 ppm, mortality of eggs increased from 3.9% at 13 ppm to about 38% at 5 ppm.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases. Overall, Healy (1991) reports that spawning to emergence ranged from 40-100% (these estimates include ocean-type chinook too).

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Fry

Spring chinook fry utilize near-shore areas, primarily eddies, within and behind large woody debris, undercut tree roots, or other cover (Hillman et al. 1989a; Healy 1991). Conservation and restoration of riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Downstream movement of parr from natal streams is well documented. French and Wahle (1959) found that juvenile chinook migrated past Tumwater Dam on the Entiat River (RM 33) from spring through late fall. Since 1992, sampling by WDFW has found spring chinook emigrating from the Chiwawa River as pre-smolts from late summer through the fall. In general, movement from the Chiwawa River included some yearlings leaving as early as March, extending through May, followed by subyearlings leaving through the summer and fall (until trapping ceases because of inclement weather; A. Murdoch, WDFW, personal communication). A similar movement of parr probably occurs in the Entiat River.

Movement of juvenile chinook from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Bjornn (1971) related subyearling chinook movement in an Idaho stream indirectly to declining temperature in the stream as fish try to find suitable overwintering habitat. Hillman and Chapman (1989) suggested that biotic factors, such as intraspecific interaction for available habitat with naturally- and hatchery- produced chinook, nocturnal sculpin predation, and interspecific interactions may accelerate movement of subyearlings from the mainstem Entiat River. This may or may not be true of the areas of the Entiat River which produce most of the spring chinook in that basin. Hillman et al. (1989) related subyearling chinook movement from an Idaho stream to declining temperatures, but acknowledged that it may consist of fish seeking higher-quality winter habitat, as suggested by Bjornn (1971).

Mullan et al. (1992) found most of the chinook rearing in Entiat river miles 3-6. In the Entiat River during the daytime, juvenile chinook used instream and overhead cover extensively, although as they got larger (and stream flows reduced), they sought areas that were deeper and higher velocity (Hillman et al. 1989 CPa). Substrate preference also changed as the juvenile chinook got larger and hydraulic conditions changed from predominantly sand, large boulder, and bedrock to sand, sand-gravel, and cobble. As temperatures dropped below 10 °C, salmon were observed primarily near boulder rip-rap, or concealed themselves in the substrate.

During nighttime hours during the warmer months, chinook moved inshore and rested all night in shallow, quiet water (Hillman et al. 1989 CPb). In the colder months, chinook sought deeper water with larger substrate. Entiat River spring chinook most likely use similar habitats as those in the Entiat River.

Conservation of high functioning habitat in the Entiat and Mad rivers, restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Entiat River spring chinook smolts begin migrating in March from natal areas. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, then they should be fixed.

Population Characterization

Distribution

Historic

Mullan (1987) felt that because of the geology of the region upstream of the current Grand Coulee Dam site, that that spring chinook were not very abundant, with the possible exceptions of the San Poil and Spokane River basins. Fulton (1968) described the historic distribution of spring chinook in the Entiat River. He relied heavily on the fieldwork of French and Wahle (1965) for his information on distribution. Fulton (1968) includes most of the mainstem Entiat as habitat for spring and summer chinook, noting that steep gradients of tributaries prevent salmon use.

Current

Hamstreet and Carie (2003) describe the current spawning distribution for spring chinook as between river miles 16 and 28 in the Entiat River and 1.5 to 5 in the Mad River, its major tributary. Also see Figure 8.

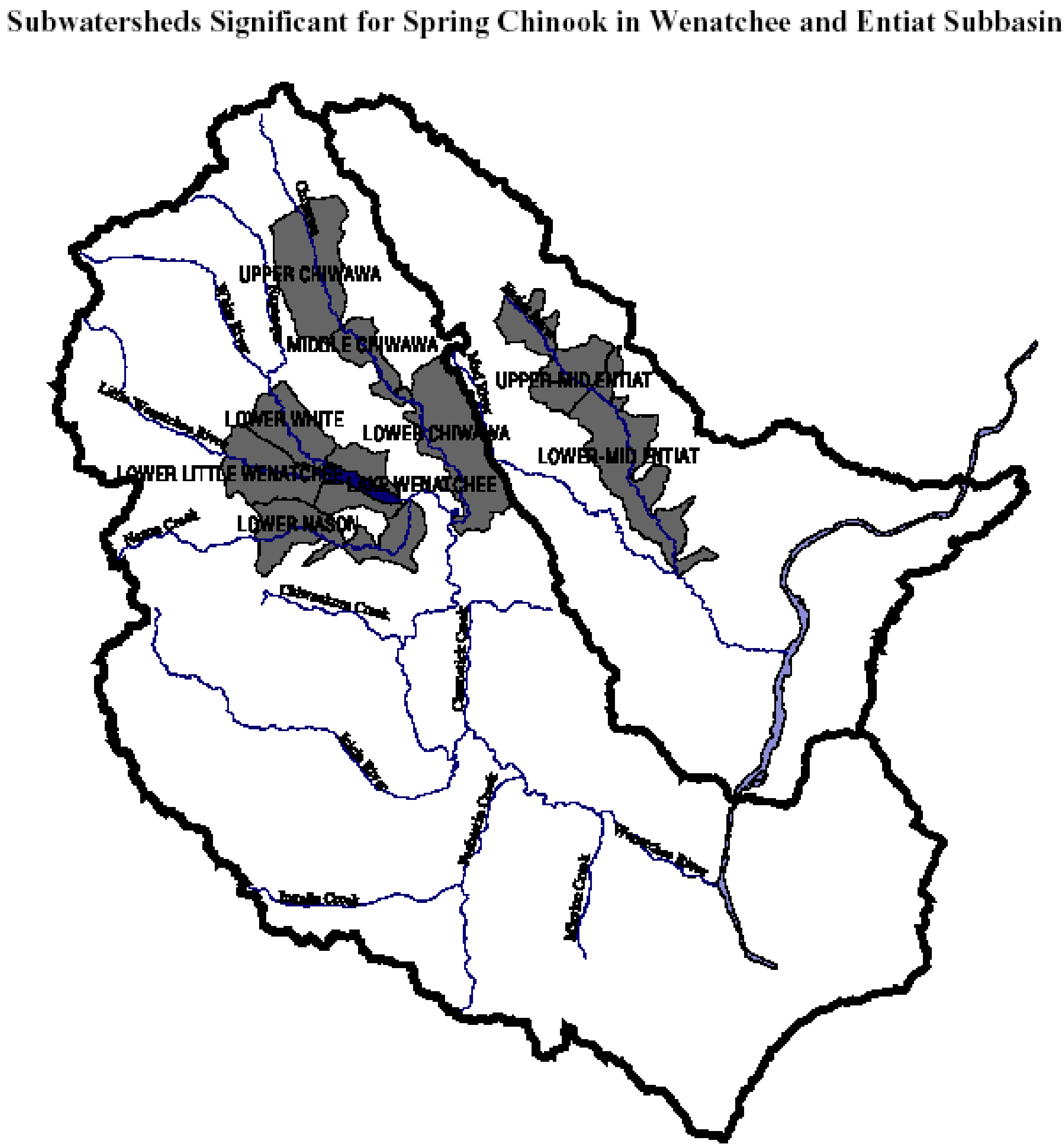

Figure 8. Significant spring chinook watersheds in Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 588,000-spring chinook was the best estimate of pre-development run sizes. Spring chinook were relatively abundant in upper Columbia River tributary streams prior to the extensive resource exploitation in the

1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, un-screened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of Upper Columbia basin salmonids.

Spring chinook counting at Rock Island Dam began in 1935. Numbers (adults and jacks) in the period 1935-39 averaged just over 2,000 fish. Average counts fluctuated on a decadal average from the 1940s to 1990s from just over 3,200 (1940s) to over 14,400 (1980s), with recent counts (2000-2002) averaging almost 29,000. The long-term average of spring chinook passing Rock Island Dam is just over 8,900.

Current

Redd counts in the Entiat River basin have been conducted since 1962. Decadal averages are 205, 143, 89, 33, and 81 between 1962 and 2002, with a long term average over the spanning years of 110.

For the Entiat River, Ford et al. (2001) recommended an interim recovery level of 500 spawners per year. The historic redd counts suggest an escapement ranging from 2 to 845, and has averaged 215 since 1962.

Productivity

Historic

Historic production of spring chinook is difficult to determine, although it was most likely not as high as sockeye or late-run chinook. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan 1987; Mullan et al. 1992), it is assumed that historic production of salmon was high, especially for summer/fall chinook and sockeye.

Current

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.). Mullan et al. (1992) postulated that current production may not be greatly different than historic for spring chinook. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced (e.g., over 80% in the lower Columbia River in the late 1930s, early 1940s). However, recent estimates of natural replacement rates for spring chinook suggest that they are not replacing themselves in most years until the broods of the late 1990s (A. Murdoch, personal communication).

There are still habitat areas in need of restoration within the Entiat Basin. By increasing known areas in need of restoration, it is reasonable to assume that production of spring chinook would increase.

Diversity

Because some areas within the Entiat Basin are in need of habitat improvements, diversity within the basin is believed to be lower than historic. While the Entiat population is still believed to be an *independent population* (see definition in Appendix _), increased habitat would most likely increase spatial and life history diversity.

Table 16. Summary of spring chinook presence in the Entiat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	High	Moderate	Moderate	Moderate
Current	Mod-high	Low-mod.	Low-mod.	Low-mod.

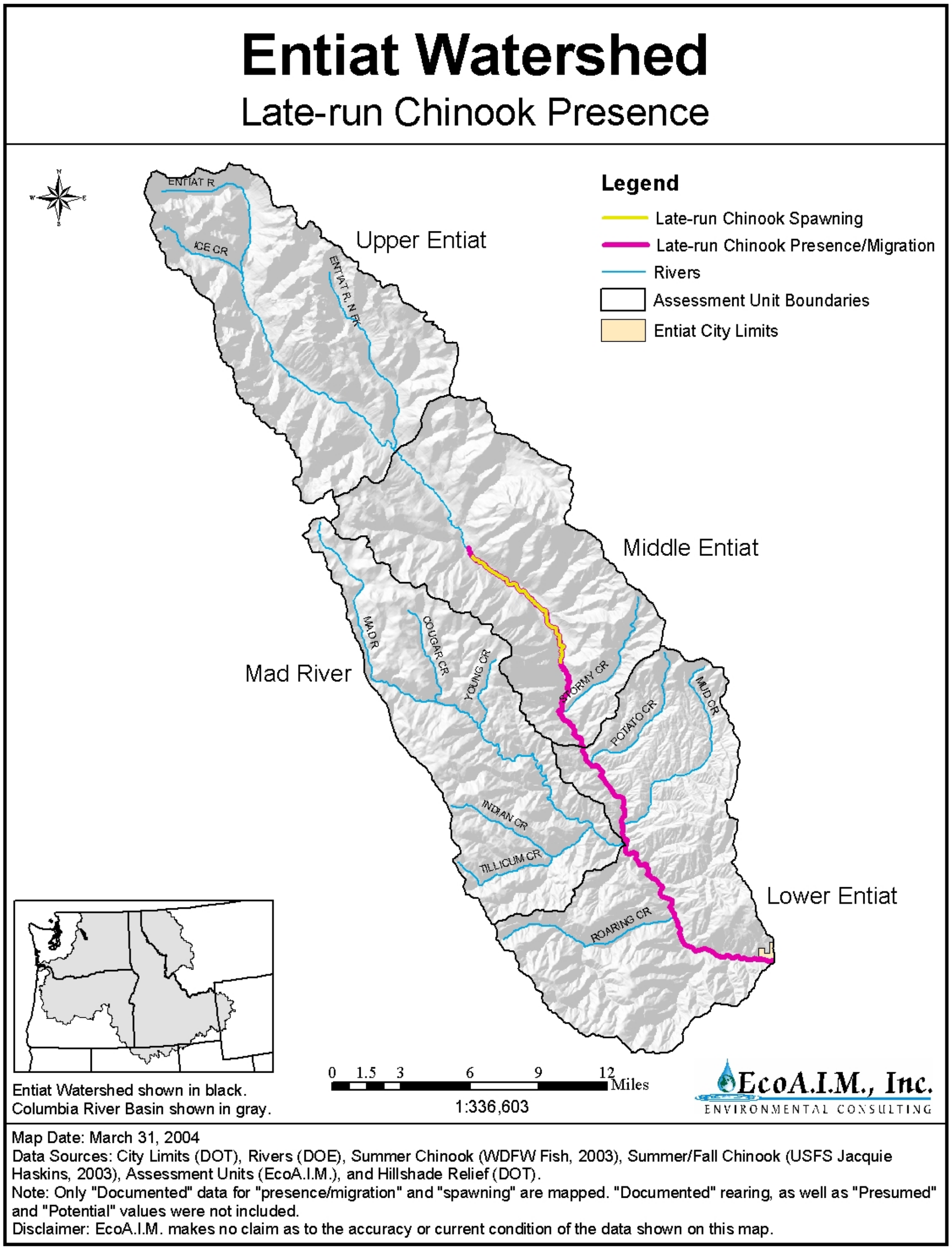

Figure 9. Late-run chinook distribution in the Entiat subbasin

4.8.3 Late-run Chinook Salmon (*Oncorhynchus tshawytscha*)

Rationale for Selection

Virtually all late-run Chinook salmon returning to the Entiat River spawn in 23 miles of the mainstem downstream of Preston Creek confluence. It is suspected that late-run Chinook salmon were not a dominant life history type in the Entiat River system (Craig and Suomela 1941); however, a great effort was made to establish late-run Chinook in the Entiat after the GCFMP. Intensive spawning survey monitoring of these fish has been ongoing since 1994. Because of the heavy reliance of late-run Chinook to the lower Entiat River, these fish are a good indicator of ecosystem health.

Key Life History Strategies, Relationship to Habitat

Time of entry and spawning

Adult summer/fall chinook begin entering the Entiat River basin in June. Spawning begins in very late September through mid November, peaking in mid- to late October. The onset of spawning in a stream reach is temperature driven (usually when temperatures drop below 16 °C). Temperatures in the mainstem Entiat are influenced by climate and tributary flows.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Entiat. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase or maintain the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Healy (1991) reports the range of depths of spawning as between 41 to > 700 cm (~1-23 ft) and velocities of between 10 to 150 cm/s (.33-5 ft/s) for chinook salmon (this includes spring-type chinook too). Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Healy (1991) reports that incubation and emergence success was related to oxygen levels and percolation through the gravel. When percolation was 0.03 cm/s (0.001 ft/s), survival to hatching was 97%. However, emergence reduced to 13% when percolation was 0.06 cm/s (0.002 ft/s). When oxygen fell below 13 ppm, mortality of eggs increased from 3.9% at 13 ppm to about 38% at 5 ppm.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases. Overall, Healy (1991) reports that spawning to emergence ranged from 40-100% (these estimates include spring-type chinook too).

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds. Because of naturally occurring conditions and major events like fire, tributary creeks have had heavy sediment load events in the last 10-15 years.

Fry

Fry emerge mostly in April and May. Most subyearling summer/fall chinook leave the probably leave the Entiat River within a few weeks after emergence, as has been observed within the Entiat River. In the Entiat River, Hillman and Chapman (1989) demonstrated that the rate of emigration of subyearling chinook was highest in June, then declined through the summer.

Summer/fall chinook fry utilize near-shore areas, primarily eddies, within and behind large woody debris, undercut tree roots, or other cover (Hillman et al. 1989a; Healy 1991). They noted that in the spring this type of habitat was scarce in the Entiat River, but where it did occur, it was fully occupied. Conservation and restoration of riparian areas and increases in off-channel habitat in the lower Entiat Basin may increase the type of habitat that summer/fall chinook fry utilize, although they may still emigrate through the system without utilizing these habitats.

Population Characterization

Distribution

Historic

Summer/fall chinook did not historically spawn in the Entiat River (Craig and Suomela 1941; Mullan 1987).

Current

Spawning of summer/fall chinook salmon in the Entiat River is a result of the Entiat National Fish Hatchery, which released chinook into the river between 1941 and 1976 (Mullan 1987). While late-run chinook may never have spawned naturally in the Entiat River, there does appear to be a self-sustaining population present currently. (Also see Figure 10.) This population is small in relation to the Entiat or Similkameen River basins.

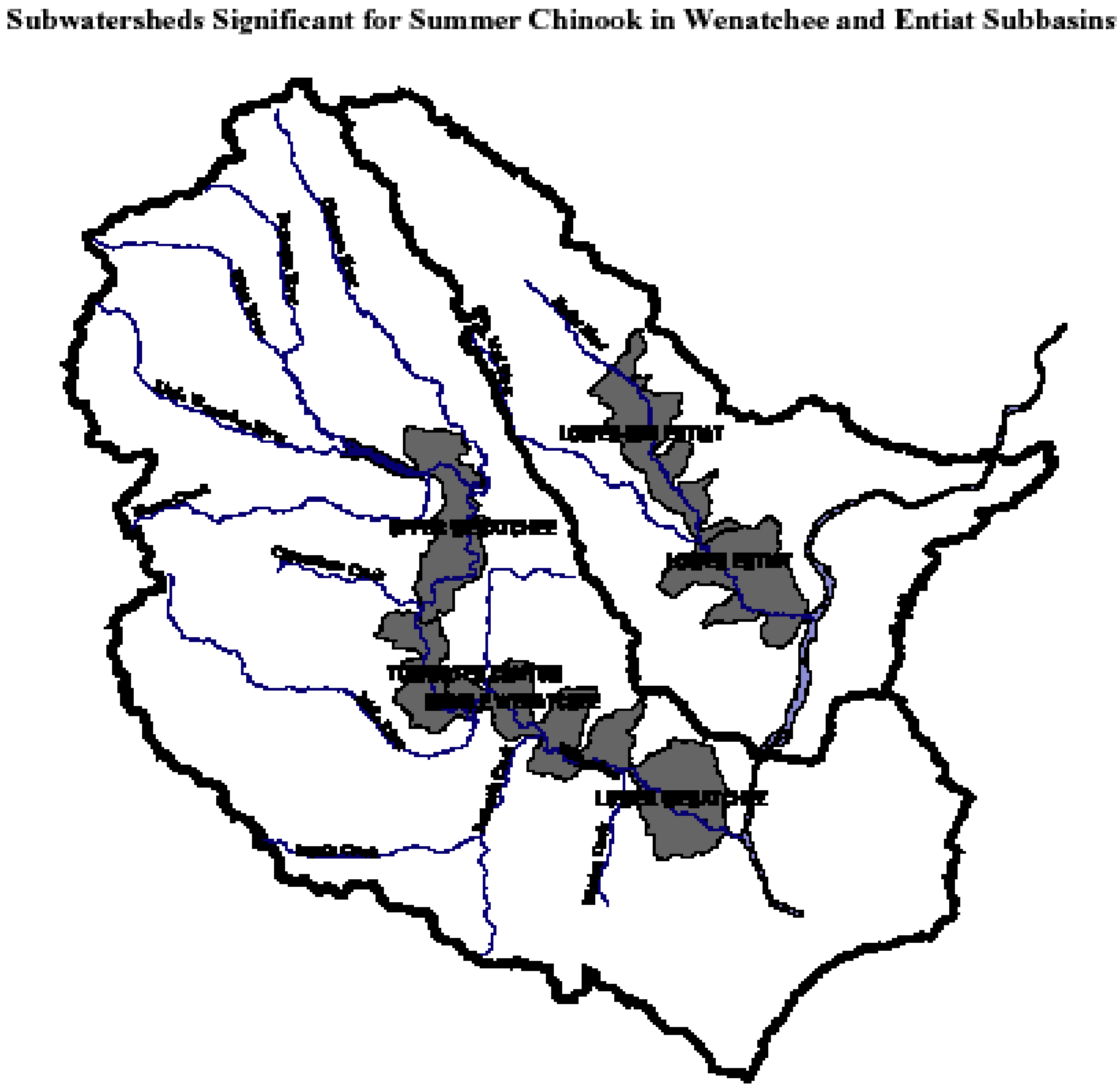

Figure 10. Significant late-run chinook watersheds in the Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 3.7 million summer chinook, (for the entire

Columbia Basin) was the best estimate of pre-development run sizes. Summer/fall chinook were very abundant in upper Columbia River and tributary streams prior to the extensive resource exploitation in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, un-screened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of Upper Columbia basin salmonids.

Historically, the late spring and summer components of the Columbia River chinook populations were the most abundant and heavily fished (Thompson 1951, Van Hyning 1968, Chapman 1986). Overfishing in the lower Columbia River rapidly depressed summer-run chinook. Spawning and rearing habitat extirpation and destruction accelerated the decline.

Decadal averages of summer/fall chinook escapements at Rock Island Dam from 1933 through 2002 show a rising trend. Harvest rates in the 1930s and 1940s were very high in the lower river fisheries, and no doubt had a large impact on the escapement at Rock Island (Mullan 1987). In 1951, when harvest rates in zones 1-6 (lower Columbia River) were reduced, numbers increased dramatically. Between the 1930s (starting in 1933) and 1960s (excluding 1968 and 1969) (Unfortunately, there were no counts at Rock Island Dam between 1968 and 1972.), total (adults and jacks) decadal average numbers of summer/fall chinook rose from just over 7,000 to almost 28,000. Numbers remained high in the 1970s until the mid-1980s, when they declined through the 1990s and have shown a sharp increase in the 2000s.

In the 1960s, dam counts became available at Rocky Reach Dam (1962) and Wells Dam (1967). These project counts of total summer/fall chinook show a different trend than Rock Island, which suggests the difference being the fish that spawn in the Entiat River were heavily affecting the trend at Rock Island Dam.

Current

Redd counts have been conducted in the Entiat River since 1957. Counts ranged from 0-55 between 1957 and 1991 (Peven 1992). Between 1994 and 2002, Hamstreet and Carie (2003) estimated the number of summer/fall chinook redds ranging between 15-218, averaging 75.

Productivity

Historic

Historic productivity of late-run chinook in the Entiat was non-existent.

Current

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Spawning habitat may be limiting for summer/fall chinook in the Entiat Basin, but, other factors, such as the potential changes to geo-fluvial processes may affect immediate rearing (or refuge) areas in the lower river more. It is unknown what affect this has on production.

Diversity

Because some areas within the Entiat Basin are in need of habitat improvements, diversity within the basin may be lower than historic. Increased habitat would most likely increase life history diversity.

Currently, genetic sampling has not found any differences among late-run chinook within the basin.

Table 17. Summary of late-run chinook presence in the Entiat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	Very Low	Very Low	Very Low	Very Low
Current	Moderate	Low	low	low

4.8.4 Coho (*Oncorhynchus kisutch*)

Rationale for Selection

Coho salmon were once considered extinct in the mid Columbia region, but have since been reintroduced to the Wenatchee and Methow sub-basins. Mullan (1984) estimated the historical run size at 38,000 to 51,000 adults to the Wenatchee, Entiat, and Methow rivers (Peven 2003). The Yakama Nation's substantial and concerted effort to reintroduce coho into the upper Columbia, using the Wenatchee and Methow sub basins during the feasibility phase of this work will be expanded to included the Entiat sub-basin after 2005.

Coho salmon prefer and occupy different habitat types, selecting slower velocities and greater depths than the other focal species; Habitat complexity and off-channel habitats such as backwater pools, beaver ponds, and side channels are important for juvenile rearing making coho good biological indicators for these areas.

Key Life History Strategies: Relationship to Habitat

Time of entry and spawning

Coho salmon enter the Wenatchee River in early September through late November. It is likely that coho timing to enter the Entiat River would be similar. Adults ascended the tributaries in the fall and spawning between mid-October and late December, although there is historical evidence of an earlier run of coho salmon (Mullan 1984). As cold water temperatures at that time of year preclude spawning in some areas, it is likely that coho salmon spawn in areas where warmer ground water up-wells through the substrate.

Prespawning

Coho entering in September and October hold in larger pools prior to spawning, later entering fish may migrate quickly upstream to suitable spawning locations. The availability and number of deep pools and cover is important to off set potential prespawning mortality. Intact riparian habitat will increase the likelihood of in stream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat need for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Burner (1951) reported the range of depths for coho spawning to be between 8 and 51 cm. Coho salmon spawn in velocities ranging from 0.30 to 0.75 m/s and may seek out sites of groundwater seepage (Sandercock 1991).

Incubation and emergence

The length of time required for eggs to incubate in the gravel is largely dependent on temperature. Sandercock (1991) reported that the total heat requirement for coho incubation in the gravel (spawning to emergence) was 1036 (±138) degree (°C) days over zero. The percentage of eggs and alevins that survive to emergence depends on stream and streambed conditions. Fall and winter flooding, low flows, freezing of gravel, and heavy silt loads can significantly reduce survival.

Fall and winter flooding may negatively affect incubation and emergence success, especially in years of extreme flow. Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and the conditions have improved in most watersheds.

In the Wenatchee sub-basin, coho fry emerge from the gravel in April or May (K. Murdoch, personal communication). It is likely that coho in the Entiat Basin will have similar emergence timing.

Fry

Juvenile coho salmon generally distribute themselves downstream shortly after emergence and seek out suitable low gradient tributary and off channel habitats. They congregate in quiet backwaters, side channels, and shady small creeks with overhanging vegetation (Sandercock 1991). Conservation and restoration of riparian areas, and off channel habitat in natal streams within the Entiat Basin would increase the type of habitat fry use.

Parr

Coho salmon prefer slower velocity rearing areas than chinook salmon or steelhead (Lister and Genoe 1970; Allee 1981; Taylor 1991) Recent work completed by the Yakama Nation supports these findings (Murdoch et. al. 2004). Juvenile coho tend to overwinter in riverine ponds and other off channel habitats. Overwinter survival is strongly correlated to the quantity of woody debris and habitat complexity (Quinn and Peterson 1996). Conservation of and restoration of high functioning habitat in natal tributaries along and restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Naturally produced coho smolts in the Wenatchee Basin emigrate between March and May (Murdoch et. al. 1994). Emigration timing for coho in the Entiat River will likely be the same. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, they should be fixed.

Population Characterization

Distribution

Historic

Coho salmon were once considered extirpated in the upper Columbia River (Fish and Hanavan 1948; Mullan 1984), but have since been reintroduced. Mullan (1984) estimated that upstream of the Yakima River, the Methow River and Spokane River historically produced the most coho, with lesser runs into the Wenatchee and Entiat. The historic run of coho in the Entiat River was estimated to be 9000-13000 adults annually (Mullan 1984). There are conflicting reports of whether the Okanogan subbasin historically produced coho (Craig and Suomela 1941; Vedan 2002). Because the historic stock of coho salmon no longer occur in the upper Columbia River system, the Entiat subbasin coho are not addressed under the ESA or by the WDFW (1994) SASSI (Peven 2003).

Information regarding the historic distribution of coho salmon within the Entiat River basin is limited, but similar to the Wenatchee River, they will likely spawned in lower and mid-elevation tributaries and the main-stem.

Current

Currently, coho have not been reintroduced to the Enitat River, although limited natural production in the Enitat has occurred as a direct result of the coho reintroduction efforts in the Wenatchee and Methow sub-basins. The Yakama Nation is developing a plan to release coho in the Entiat basin in 2005.

Abundance

Historic

Historically 120,000-166,500 coho were attributed to the mid-and upper Columbia tributaries (Yakima, Wenatchee, Entiat, Methow, and Spokane Rivers: Mullan 1984). Mullan (1984) estimated that the Entiat River supported adult returns of approximately 9,000-13,000 coho.

There were two previous attempts in the twentieth century to rebuild coho populations though these two programs were not designed or intended to rebuild upriver runs. They were for harvest augmentation. Releases did not occur in the natural production habitat areas within the watershed.. Between the early 1940s and the mid 1970s, the USFWS raised and released coho as part of their mitigation responsibilities for the construction of Grand Coulee Dam (Mullan 1984). Chelan PUD also had a coho hatchery program until the early 1990s. While some natural production may have occurred from these releases, the programs overall were not designed to re-establish naturally spawning populations, and relied on lower river stocks that were not suited to the upper Columbia (Peven 2003). All coho releases under the Chelan PUD program (197-1993) were made from the Turtle Rock Fish Hatchery, located in the middle of the Columbia River above Rocky Reach Dam. The release location likely contributed to the inability to produce a naturally spawning coho run. This reach of the Columbia River does not provide suitable coho spawning and rearing habitat.

Current

The Yakama Nation, as the lead agency, has implemented a substantial reintroduction program designed to restore naturally reproducing coho salmon through the development a locally adapted stock, while releasing acclimated smolts in natural production areas. The reintroduction effort in the Wenatchee has resulted in the ongoing development of a locally adapted broodstock, which would be used to reintroduce coho to the Entiat sub-basin and natural production. The first generation of naturally produced coho smolts emigrated from the Wenatchee River basin in 2002 with an estimated population size of

17,000 (Murdoch et al. 2004). In 2003, approximately 36,700 naturally produced coho smolts emigrated from the Wenatchee River (T. Miller, WDFW, unpublished data).

The reintroduction of coho salmon to the Entiat sub-basin will substantially increase the abundance of coho in mid-Columbia region.

Productivity

Historic

Historic production of coho salmon is difficult to determine, although it was most likely not as high as or late-run chinook.

Current

Current coho productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc). There are still habitat areas in need of restoration within the Entiat Basin. By increasing known areas in need of restoration, it is reasonable to assume that production of reintroduced coho would increase.

Diversity

Because hatchery stocks were used to reintroduced coho salmon (and develop a local broodstock) to mid-Columbia tributaries, spatial and life history diversity within the Entiat basin will initially be lower than the historic populations of coho salmon. However, coho reintroduction in Entiat basin will increase the diversity of the locally adapting stock in mid-Columbia tributaries. As increased natural production occurs diversity will likely increase. Increased habitat will most likely increase spatial and life history diversity for coho salmon in mid-Columbia tributaries.

Table xx. Summary of coho salmon population characterization.

	Distribution	Abundance	Productivity	Diversity
Historic	High	Mod-high	Moderate	High
Current	Low	Low	Low	Low

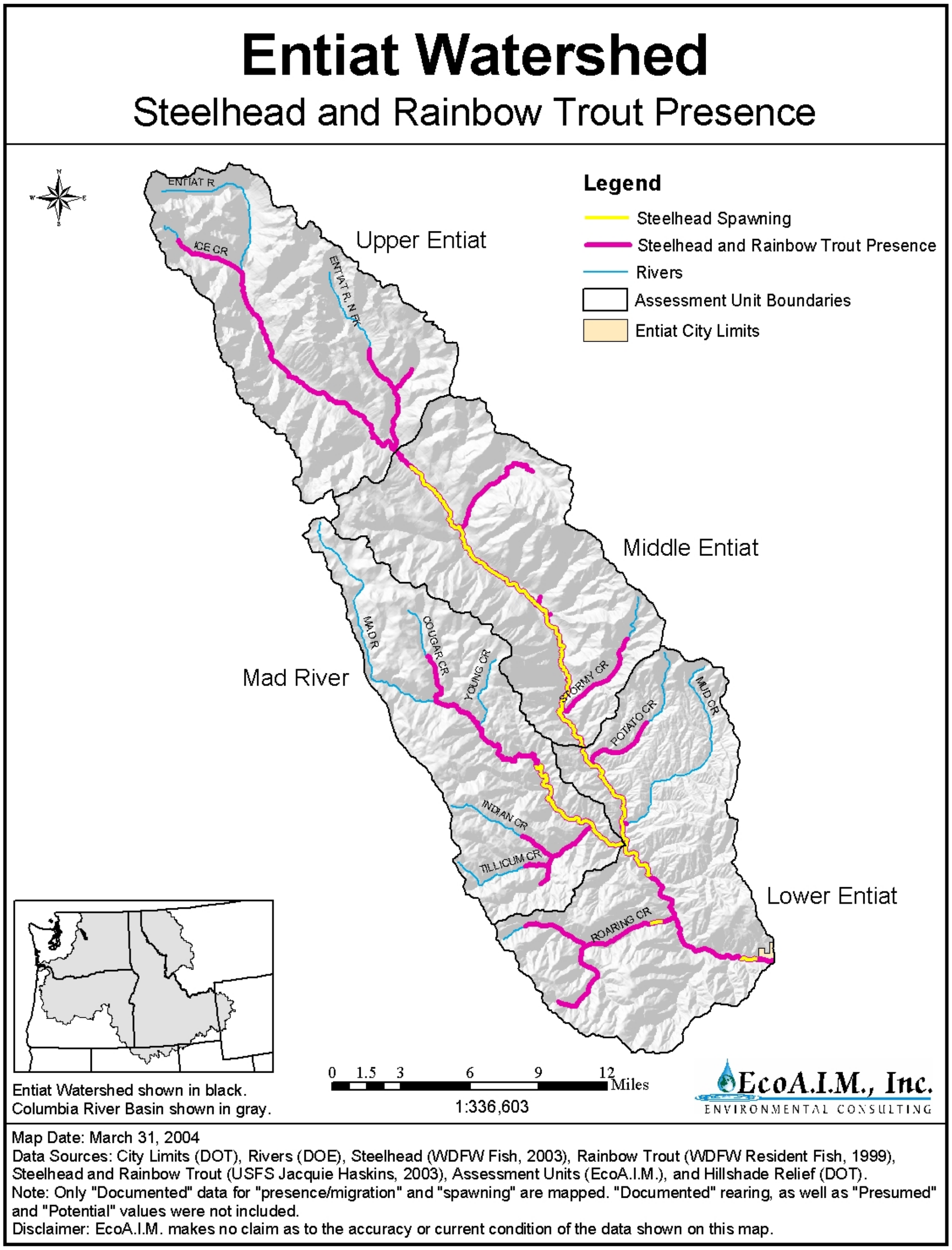

Figure 11. Steelhead trout distribution in the Entiat subbasin

4.8.5 Steelhead Trout (*Oncorhynchus mykiss*)

Rationale for Selection

The Entiat steelhead is included by NOAA Fisheries into the Upper Columbia ESU and is listed as an endangered under the ESA. Steelhead trout use all of the major tributaries of the Entiat subbasin except the upper Entiat due to existing barrier to passage (Figure 17). Steelhead juvenile spend two or more years in the Entiat mainstem and tributaries using many different habitat types making them a good biological indicator of ecosystem health.

Key Life History Strategies, Relationship to Habitat

Time of entry and spawning

Adult steelhead enter the Entiat River basin from August through the following April. Spawning begins in very late March through April, potentially going into May, peaking in mid- to late April in the Mad River (Archibald 2003). The onset of spawning in a stream reach is temperature driven. Other factors may influence steelhead spawning compared to salmon species because of the time of year spawning occurs.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Entiat River or natal tributaries. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Wydoski and Whitney (2003) report that spawning is usually found at a mean depth of 0.7 to 1.34 ft and water velocities of 1.8 to 2.3 fps. Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Incubation success is dependent on factors such as water flow through the redds and temperature (Pauley et al. 1996). Eggs usually hatch in 4 to 7 weeks and fry emerge 2 to 3 weeks after that (Shapovalov and Taft 1954).

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Fry

In the Entiat River, Hillman and Chapman (1989) found most juvenile steelhead rearing in Tumwater Canyon. During daylight, age-0 steelhead used slower, shallower water than chinook, stationed individually over small boulder and cobble substrate (Hillman et al. 1989 CPa). As they grew, they picked deeper and faster habitat over cobble and boulders. As with chinook juveniles, in winter, they concealed themselves in interstitial spaces among boulders near the stream bank, but did not cluster together. No interaction was observed between chinook and steelhead at anytime (Hillman et al. CPa, CPb).

During nighttime hours, steelhead moved downstream and closer to shore. At dawn, steelhead moved upstream. Most steelhead chose sand and boulder substrates, and during winter, chose deeper, larger substrate (Hillman et al. 1989 CPb).

Hillman and Miller (2002) remarked that in ten years of surveying the Chiwawa River, age-0 steelhead most often used riffle and multiple channel habitats, but were also found associated with debris in poll and glide habitat.

It is reasonable to assume that Entiat Basin steelhead utilize similar habitats as those in the Entiat Basin.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Downstream movement of parr from natal streams occurs within the Entiat Basin (Murdoch et al. 2001). French and Wahle (1959) found that juvenile steelhead migrated past Tumwater Dam on the Entiat River (RM 33) from spring through late fall. Since 1992, sampling by WDFW has found steelhead emigrating from the Chiwawa River as pre-smolts beginning in spring, but primarily in the fall. In general, movement from the Chiwawa River included some yearlings leaving as early as March, extending through May, followed by subyearlings leaving through the summer and fall (until trapping ceases because of inclement weather; A. Murdoch, WDFW, personal communication). Similar timing of movement probably occurs in the Entiat Basin.

Movement of juvenile steelhead from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Hillman and Chapman (1989) suggested that biotic factors, such as intraspecific interaction for available habitat with naturally- and hatchery- produced chinook, nocturnal sculpin predation, and interspecific interactions may accelerate movement of chinook and steelhead juveniles from the mainstem Entiat River. It is reasonable to assume that similar behavior is seen in Entiat River steelhead.

Mullan et al. (1992) found that most steelhead reared in the lower portions of the Entiat and Mad rivers. The amount of habitat diversity and complexity in these reaches compared to other reaches was believed to be responsible for this behavior.

Conservation of high functioning habitat in natal tributaries and the Mad and Entiat rivers, restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Entiat River steelhead smolts begin migrating in March from natal areas. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, then they should be fixed.

Population Characterization

Distribution

Historic

Steelhead historically used all major (and some minor) tributaries within the Upper Columbia Basin for spawning and rearing (Chapman et al. 1994). Fulton noted the mainstem Entiat and Mad Rivers as producing steelhead.

Current

Current distribution in the Entiat is believed to be similar to historic, although some minor tributaries may not encourage certain life history phases because of habitat degradation from natural and human-caused reasons. (See Figure .

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 554,000 steelhead (for the entire Columbia Basin) was the best estimate of pre-development run sizes. Steelhead were relatively abundant in upper Columbia River tributary streams prior to the extensive resource exploitation in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, un-screened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of Upper Columbia basin salmonids.

Steelhead counts began at Rock Island Dam in 1933, and annual counts averaged 2,800 between 1933 and 1939 (these numbers do not reflect large fisheries in the lower river that took place at that time, estimated by Mullan et al. (1992) as greater than 60%).

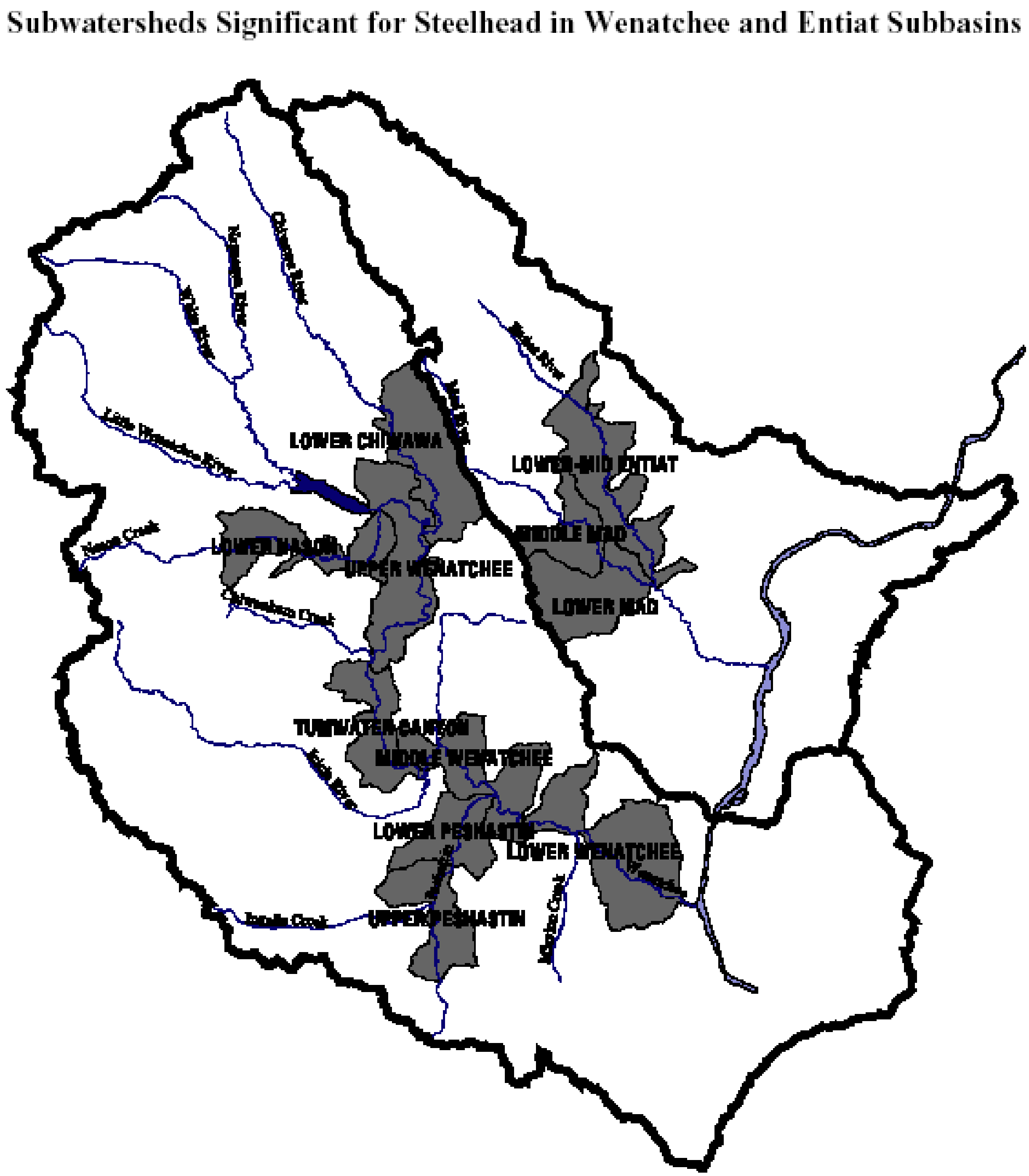

Figure 12. Significant steelhead watersheds in the Wenatchee and Entiat subbasins (RTT 2004)

Average decadal numbers changed little in the 1940s and 1950s (2,600 and 3,700, respectively). Large hatchery releases began in the 1960s, and the average counts increased to 6,700. In the 1970s, counts averaged 5,700 and 16,500 in 1980s (record count of about 32,000 in 1985). In the 1990s, counts decreased, following a similar trend as chinook, to 7,100, while, similar to chinook, they have increased substantially so far in the 2000s, with an average of over 18,000 (a high of 28,600 in 2001).

Current

Beginning in 1997 (no survey was conducted in 1998), the USFS has been conducting limited spawning ground surveys for *O. mykiss* in the Mad River (Archibald 2003). The area covered has increased from the first 3 miles of the Mad River to up to 10 miles (currently the first 7 miles) of the Mad River. Roaring Creek has been surveyed too, but apparently not the mainstem Entiat River. The number of "definite" redds has ranged from 0 (1999) to 38 (2003), averaging 13. Beginning in 2003, the FWS began conducting steelhead spawning surveys on the mainstem Entiat River from approximately RM 2 through28. Eighty redds were found during the first year of the survey (K.Terrell, personnal communication to C.Peven May, 2004)

Ford et al. (2001) recommended interim recovery levels of about 500 naturally produced spawners for the Entiat, using similar criteria that were used for spring chinook.

Productivity

Historic

Historic production of steelhead is difficult to determine, although it was most likely not as high as sockeye or late-run chinook. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan et al. 1992); it is assumed that historic production of steelhead was higher than current.

Current

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for steelhead. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced. However, recent estimates of natural replacement rates for steelhead suggest that they are not replacing themselves in most years until the broods of the late 1990s (Peven 2003).

There are still habitat areas in need of restoration within the Entiat Basin. By increasing known areas in need of restoration, it is reasonable to assume that production of steelhead would increase.

Diversity

Because some areas within the Entiat Basin are in need of habitat improvements, diversity within the basin is believed to be lower than historic. While the Entiat population is still believed to be an independent population, increased habitat would most likely increase spatial and life history diversity.

Currently, genetic sampling has not found any differences among steelhead within the basin.

Table 18. Summary of steelhead presence in the Entiat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	High	Low-moderate	Moderate	High
Current	Mod-high	Low	Low	Moderate

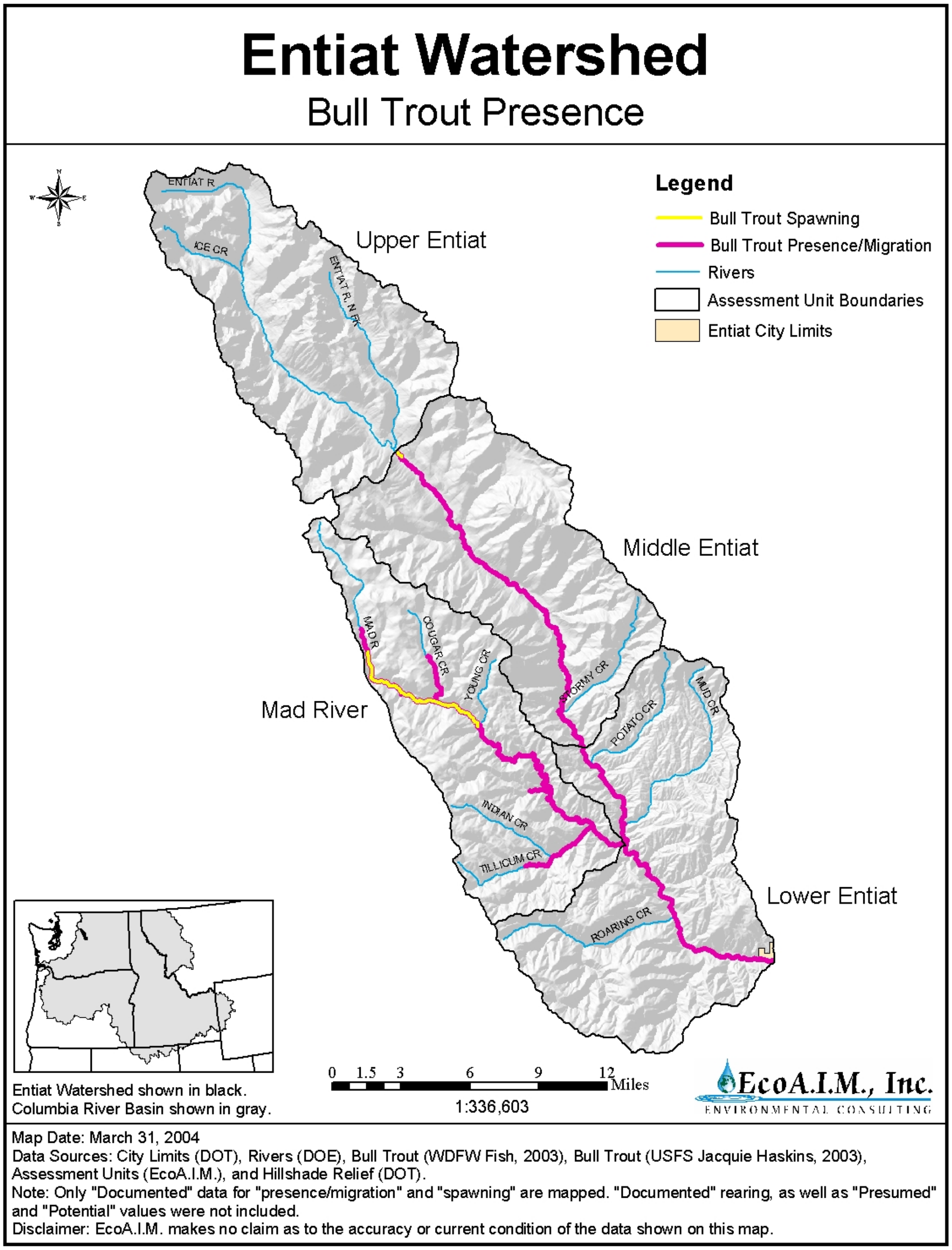

Figure 13. Bull trout distribution in the Entiat subbasin

4.8.6 Bull Trout (*Salvelnius confluentus*)

Rationale for Selection

The Entiat bull trout is included by the USFWS into the Columbia River distinct population segment (DPS) and are listed as threatened under the ESA. Bull trout are found throughout much of the Entiat subbasin, particularly in the mid and upper elevation streams, although it is not certain if these fish are able to establish themselves above Entiat Falls. Adults showing a fluvial life form use the mainstem as a migration, and possible feeding corridor. Bull trout are sensitive to environmental changes, especially water temperature making them a good biological indicator of ecosystem health in the mid and upper elevations.

Key Life History Strategies, Relationship to Habitat

Spawning

Bull trout spawn in the Entiat River basin from September through October based on FWS bull trout spawning surveys. The onset of spawning in a stream reach is temperature driven, apparently at the onset of dropping temperatures.

Prespawning

When adults are migrating upstream to spawning areas, they associate with cover; debris, deep pools, and undercut banks. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Fraley and Shepard characterized selected areas as having low compaction and low gradient, and potentially near upwelling influences and proximity to cover. In general, mean velocities over redds range from 0.13-2.0 fps, with water depth ranging from 0.71-2.0 ft. Brown (1992) noted that these metrics comported well with those found within the Entiat Basin. Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Optimum incubation for bull trout is lower than other salmonids (2-4 °C; in Brown 1992). Because of the lower temperatures, bull trout development within the redd is usually longer than other salmonids. Emergence may take another three weeks after hatching.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga

(1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Because bull trout development within the redd takes a long period of time, they may be more vulnerable to increases in sediments or degradation other water quality (Fraley and Shepard 1989).

Fry

Fry (< 100 mm) are usually found in shallow, slow backwater side channels or eddies, in association with fine woody debris. Age-0 bull trout are consistently found near the substrate, usually over gravel-cobble areas.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Hillman and Miller (2002) state that most juvenile bull trout are consistently found in multiple channels, pool, and riffles, and a few in glides. Juveniles were found in association with the stream bottom over rubble and small boulder substrate or near woody debris.

Downstream movement of juveniles (> 100 mm) from natal streams probably occurs within the Entiat Basin. Since 1992, sampling by WDFW has found bull trout emigrating from the Chiwawa River, having two modes; one in spring, and the other in the fall.

Movement of juvenile bull trout from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Murdoch et al. (2001) also speculated that movement in the fall may also be correlated to the size and age at which bull trout become piscivorous.

Conservation of high functioning habitat in natal tributaries, restoration of riparian and geofluvial processes in or near known and potential juvenile rearing areas will have the highest likelihood of increasing parr survival.

Another factor that may have impacts on bull trout production in the Entiat Basin is competition with brook trout. Brook trout are found in the upper Entiat, but may not be distributed throughout the basin (P. Archibald, USFS).

Population Characterization

Distribution

Historic

While detailed historic distribution is difficult to determine (Rieman et al. 1997), bull trout are believed to have been historically present in the Entiat River (Brown 1992; Mongillo 1993).

Current

The USFWS (2002) has identified two sub populations of bull trout in the Entiat River, one fluvial population in the mainstem Entiat and one in the Mad River, a tributary to the Entiat. Primary bull trout spawning and rearing areas are in the Mad River and the mainstem Entiat River from the Entiat Falls downstream to the National Forest boundary (USFWS 2002).

Abundance

Historic

There is currently no information available to assess what historic abundance of bull trout was in the Entiat River Basin.

Current

Bull trout redd surveys have been conducted by the USFS in the Entiat River Basin since 1989, primarily in the Mad River. Since 1989, the number of redds observed has averaged 24, and has increased, primarily since 1997. Archibald and Johnson (2002) attribute the increase in bull trout redds in the Mad River to the closure of bull trout fishing in 1992 and the closure to all fishing (from the mouth to Jimmy Creek) since 1995. USFWS has conducted bull trout redd surveys in the mainstem Entiat as an incidential observation during spring/summer Chinook spawning surveys. Starting in 2004, USFWS will begin a concerted effort to determine the extent of habitat use by spawning bull trout within the mainstem of the Entiat.

Productivity

Historic

Historic productivity of bull trout within the Entiat Basin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (harvest).

Current

Current productivity appears to be improving based on redd counts and other factors (see above).

Diversity

Historic diversity was most likely higher than current based on some habitat degradation and management practices. If habitat restoration occurs, there will most likely be an increase in spatial and potentially life history diversity.

Table 19. Summary of bull trout presence in the Enitat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	High	Moderate	Moderate	High
Current	Mod.-high	Low-moderate	Low-moderate	Mod.-high

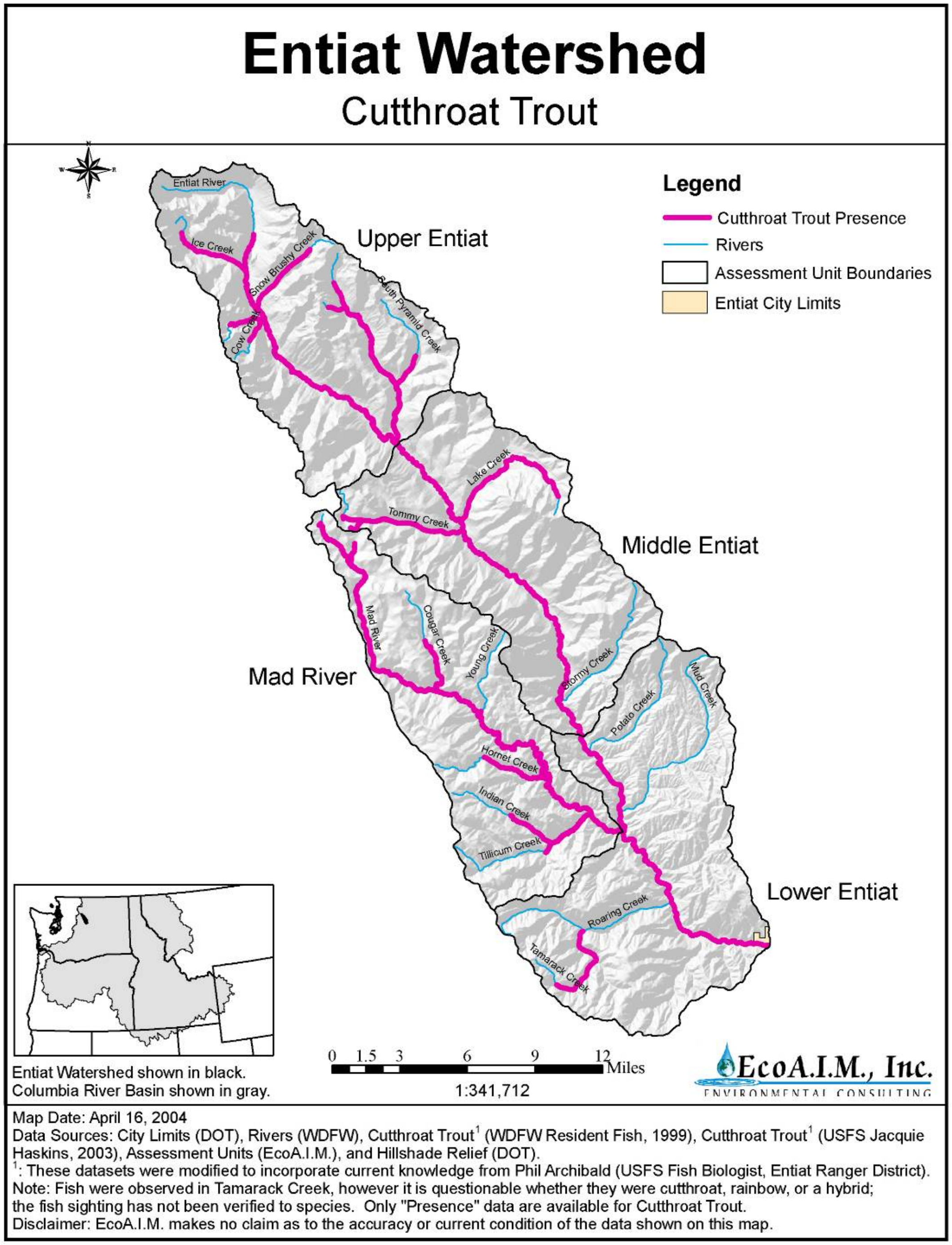

Figure 14. Westslope cutthroat trout distribution in the Entiat subbasin

4.8.7 Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*)

Rationale for Selection

Westslope cutthroat trout are known to exist throughout most of the high elevation streams within the Entiat subbasin. There are concerns about the status of this species due to genetic introgression (especially with introduced rainbow trout), depressed and fragmented populations or stocks, and loss of migratory life histories. The USFWS considers the westslope cutthroat trout a species of concern. The USFWS received a formal petition to list the westslope cutthroat trout as threatened pursuant to the ESA. A status review determined a listing of the species was not warranted at this time.

Cutthroat trout inhabit mid to high elevation streams, and may be the only salmonid species existing in various reaches. Cutthroat trout are sensitive to environmental changes, especially water temperature making them a good biological indicator of ecosystem health in the mid and upper elevations.

Key Life History Strategies, Relationship to Habitat

Spawning

Westslope cutthroat trout (WSCT) spawn between March and July, when water temperatures begin to warm. Spawning and rearing streams tend to be cold and nutrient poor.

Prespawning

When adults are migrating upstream to spawning areas, they associate with cover; debris, deep pools, and undercut banks. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Adult cutthroat trout need deep, slow moving pools that do not fill with anchor ice in order to survive the winter. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. USFWS (1992) state that WSCT redds are usually found in water that is about 0.7 ft deep with mean velocities of 1.0 to 1.3 fps.

Incubation and emergence

Eggs incubate for several weeks and emergence occurs several days after hatching (USFWS 1999).

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Fry

After emergence, fry are usually found in shallow, slow backwater side channels or eddies, in association with fine woody debris.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Juvenile cutthroat trout overwinter in the interstitial spaces of large stream substrate.

Hillman and Miller (2002) state that most juvenile WSCT are consistently found in multiple channels and pools.

Downstream movement of juveniles from natal streams probably occurs within the Entiat Basin.

Movement of juvenile WSCT within streams is most likely related to changing habitat requirements as the fish grows, or winter refuge.

Conservation of high functioning habitat in natal tributaries, restoration of riparian and geofluvial processes in or near known and potential juvenile rearing areas will have the highest likelihood of increasing parr survival.

Another factor that may have impacts on bull trout production in the Entiat Basin is competition with brook trout. Brook trout are found in the upper Entiat, but may not be distributed throughout the basin (P. Archibald, USFS).

Population Characterization

Distribution

Historic

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan Basin (Williams 1998). From Williams (1998):

Apart from Lake Chelan and the Pend Oreille River where an abundance of relatively large cutthroat commanded the attention of pioneers, cutthroat trout in streams were obscured by their headwater location and small body size . . . Accordingly, the ethnohistorical record is mostly silent on the presence or absence of cutthroat. The picture is further blurred by the early scattering of cutthroat from the first trout hatchery in Washington (Stehekin River Hatchery, 1903) by entities (Department of Fisheries and

Game and county Fish Commissions) dissolved decades ago along with their planting records. The undocumented translocation of cutthroats by interested non-professional starting with pioneers is another confusing factor that challenges determination of historical distribution.

Recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Entiat and Yakima River basins (Behnke 2002).

Overall, Behnke (1992) believed that the disjunct populations in Washington State probably were transported here through the catastrophic ice-age floods.

Current

Through stocking programs that began with Washington state's first trout hatchery in the Stehekin River valley in 1903 (that targeted WSCT), WSCT have been transplanted in almost all available stream and lake habitat (Williams 1998).

In the Entiat, WSCT sustain themselves in 80 miles within 16 streams and 140 acres in 8 lakes (Williams 1998).

Abundance

Historic

There is currently no information available to assess what historic abundance of WSCT was in the Entiat River Basin. Numerical abundance has not been documented or estimated for WSCT. Westslope cutthroat were not thought to have been very abundant where they occurred in the headwater locations within the Methow, Entiat, and Entiat basins (Williams 1998; USFWS 1999; Behnke 2002).

Current

There are no known estimates of current abundance within the Entiat River Basin

Productivity

Historic

Historic productivity of WSCT trout within the Entiat Basin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (hatchery plants).

Current

There are no known estimates of current abundance within the Entiat River Basin.

Diversity

Historic diversity was most likely higher than current based on some habitat degradation. If habitat restoration occurs, there will most likely be an increase in spatial and potentially life history diversity.

Table 20. Summary of westslope cutthroat trout presence in the Entiat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	Low-Moderate	Low	Moderate	High
Current	Low-Moderate	Low	Low-Moderate	Moderate-High

4.8.8 Pacific Lamprey (*Lampetra tridentate*)

Rationale for Selection

Very little is known about Pacific lamprey populations or stocks in the Upper Columbia and the Entiat. Pacific lamprey is a culturally and commercially important specis to the Yakima Nation and the Confederated Tribes of the Colville Reservation. Pacfic lamprey is also been listed by the USFWS as a species of conern.

Key Life History Strategies, Relationship to Habitat

Distribution

Historic

Historical distribution of Pacific lamprey in the Columbia and Snake Rivers was coincident wherever salmon occurred (Simpson and Wallace 1978). It is likely that Pacific lamprey occurred historically within the Entiat Basin. If we assume that Pacific lamprey and salmon used the same streams, one could conclude that Pacific lamprey occurred in the mainstem Entiat and Mad Rivers.

Current

Pacific lamprey still exist in the Entiat system, but the distribution is mostly unknown. BioAnalysts (2000) used anecdotal information to describe the extent of Pacific lamprey distribution Entiat Basin. However, they cautioned that the following description may be confounded by the presence of river lamprey. In most cases, observers they cited reported the occurrence of lamprey but did not identify the species. Thus, the descriptions below may apply to both species. Juvenile lamprey have been found near RM 16, within the hatchery, and near the mouth (BioAnalysts 2000).

Abundance

Historical abundance of Pacific lamprey is difficult to determine because of the lack of specific information. However, lamprey were (and continue to be) culturally significant to the Native American tribes in the Columbia Basin.

Current

There are currently no abundance information except perhaps dam count differences between Rocky Reach and Wells. However, comparing counts among different projects is problematic because of sampling inconsistencies, the behavior of lamprey in counting stations, and the ability of lamprey to bypass counting stations undetected (BioAnalysts 2000).

Productivity

There currently is no information on historic and current productivity on Pacific lamprey. However, it is reasonable to assume that current production is lower than historic.

Diversity

Current distribution within the Entiat Basin may be impacted within smaller tributaries, but this is not known. Current diversity is most likely similar to historic.

Table 21. Summary of Pacific lamprey presence in the Entiat subbasin

	Distribution	**Abundance**	**Productivity**	**Diversity**
Historic	Higher than present	Higher than present	Higher than present	?
Current	?	?	?	?

4.9 Relationships of Salmonid Populations to the Ecosystem

4.9.1 Introduction

The biotic communities of aquatic systems in the Upper Columbia Basin are highly complex. Within communities, assemblages and species have varying levels of interaction with one another. Direct interactions may occur in the form of predator-prey, competitor, and disease- or parasite-host relationships. In addition, many indirect interactions may occur between species. For example, predation of one species upon another may enhance the ability of a third species to persist in the community by releasing it from predatory or competitive constraints. These interactions continually change in response to shifting environmental and biotic conditions. Human activities that change the environment, the frequency and intensity of disturbance, or species composition can shift the competitive balance among species, alter predatory interactions, and change disease susceptibility. All of these changes may result in community reorganization.

Community Structure

Few studies have examined the fish species assemblages within the Upper Columbia Basin. Most information available is from past surveys, dam passage studies, and northern pikeminnow studies. The available information indicates that about 41 species of fish occur within the Upper Columbia Basin (from the mouth of the Yakama River upstream to Chief Joseph Dam). This is an underestimate because several species of cottids (sculpins) live there. Of the fishes in the basin, 15 are cold-water species, 18 are cool-water species, and 8 are warm-water species. Most of the cold-water species are native to the area; only four were introduced (brown trout (Salmo trutta), brook trout (Salvelinus fontinalis), lake whitefish (Coregonus clupeaformis), and Atlantic salmon (S. salar). Four of the 18 cool-water species are exotics (pumpkinseed (Lepomis gibbosus), walleye (Stizostedion vitreum), yellow perch (Perca flavescens), and smallmouth bass (Micropterus dolomieu)), while all warm-water species are exotics.

About half of the resident species in the upper basin are piscivorous or fish eating. Ten cold-water species, 7 cool-water species, and 5 warm-water species are known to eat fish. About 59% of these piscivores are exotics. Before the introduction of exotics, northern pikeminnow (Ptychocheilus oregonensis), sculpin (Cottus spp.), white sturgeon, bull trout (Salvelinus confluentus), rainbow trout (O. mykiss), cutthroat trout (O. clarki), and burbot (Lota lota) were the primary piscivores in the region. Presently, burbot are rare in the upper basin and probably have little effect on the abundance of juvenile salmonids in the region. The status of white sturgeon in the upper basin is mostly unknown, although their numbers appear to be quite low.

Introduced species such as walleye, smallmouth bass, and channel catfish (Ictalurus punctatus) are important predators of salmonids in the Columbia River. Channel catfish are rare and likely have little to no effect on abundance of salmonids. Other piscivores, such as largemouth bass (M. salmoides), black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), brown bullhead (Ameiurus nebulosus), yellow perch, and pumpkinseed are either rare or not known to prey heavily on juvenile anadromous fish.

What follows is a more detailed discussion of interactions between fish, birds, and mammals and spring chinook and summer steelhead in the Upper Columbia Basin.

Competition

Competition among organisms occurs when two or more individuals use the same resources and when availability of those resources is limited. That is, for competition to occur, demand for food or space must be greater than supply (implies high recruitment or that the habitat is fully seeded) and environmental stresses few and predictable. Two types of competition are generally recognized: (1) interference competition, where one organism directly prevents another from using a resource through aggressive behavior, and (2) exploitation competition, where one species affects another by using a resource more efficiently. Although competition is difficult to demonstrate, a few studies conducted within the Upper Columbia Basin indicate that competition may affect the production of chinook salmon and steelhead in the basin.

Chinook/steelhead

Perhaps the most likely form of interspecific competition would be between juvenile chinook and steelhead. Hillman et al. (1989) investigated the interaction between juvenile chinook and steelhead in the Entiat River between 1986 and 1989. They reported that chinook and steelhead used dissimilar daytime and nighttime habitat throughout the year. During the daytime in summer and autumn, juvenile chinook selected deeper and faster water than steelhead. Chinook readily selected stations associated with brush and woody debris for cover, while steelhead primarily occupied stations near cobble and boulder cover. During winter days, chinook and steelhead used similar habitat, but Hillman et al. did not find them together. At night during both summer and winter, Hillman et al. found that both species occupied similar water velocities, but subyearling chinook selected deeper water than steelhead. Within smaller streams, chinook were more often associated with pools and woody debris during the summer, while steelhead occurred more frequently in riffle habitat. Hillman et al. (1989) concluded that interaction between the two species would not strongly negatively affect production of either species, because disparate times of spawning tended to segregate the two species. This conclusion is consistent with the work of Everest and Chapman (1972) in Idaho streams.

Redside shiners

Under appropriate conditions, interspecific interaction may also occur between redside shiners and juvenile salmon and trout. Hillman (1991) studied the influence of water temperature on the spatial interaction between juvenile chinook and redside shiners in the field and laboratory. In the Entiat River during summer, Hillman (1991) noted that chinook and shiners clustered together and that shiners were aggressive toward salmon. He reported that the shiners used the more energetically profitable positions, and that they remained closer than chinook to instream and overhead cover. In laboratory channels, shiners affected the distribution, activity, and production of chinook in warm (64-68°F) water, but not in cold (54-59°F) water (Hillman 1991). In contrast, chinook influenced the distribution, activity, and production of shiners in cold water, but not in warm water. Reeves et al. (1987) documented similar results when they studied the interactions between redside shiners and juvenile steelhead. Although Hillman (1991) conducted his fieldwork in the lower Entiat River, shiners are also present in the Entiat, Methow, and Okanogan rivers and are abundant in the mainstem Columbia River. At warmer temperatures, shiners likely negatively affect the production of chinook salmon and steelhead in the upper basin.

Coho salmon

It is unknown if the re-introduction of coho salmon into the Upper Columbia Basin may affect the production of chinook and steelhead, although the results of extensive predation and competition studies associated with the YN's current reintroduction efforts indicate that the reintroduction of coho is unlikely to negatively affect production of chinook and steelhead. One of the first studies in the upper basin that addressed effects of coho on chinook and steelhead production was conducted by Spaulding et al. (1989) in the Wenatchee River. This work demonstrated that the introduction of coho into sites with naturally produced chinook and steelhead did not affect chinook or steelhead abundance or growth. However, because chinook and coho used similar habitat, the introduction of coho caused chinook to change habitat. After removing coho from the sites, chinook moved back into the habitat they used prior to the introduction of coho. Steelhead, on the other hand, remained spatially segregated from chinook and coho throughout the study. More recent studies conducted by Murdoch et al. (2004) found that juvenile coho, chinook, and steelhead used different microhabitats in Nason Creek, and at the densities tested, coho did not appear to displace juvenile chinook or steelhead from preferred microhabitats.

Various salmonids

Most adult salmonids within the upper basin are capable of preying on juvenile chinook and steelhead. Those likely to have some effect on the survival of chinook and steelhead include adult bull trout, rainbow/steelhead trout, cutthroat trout, brook trout, and brown trout. Because brown trout are rare in the region, they probably have little effect on the survival of other salmonids. The other salmonids often occur in the same areas as chinook and steelhead and are known to be important predators of chinook and steelhead (Mullan et al. 1992). Of these, bull trout and rainbow trout are probably the most important. These species occur together in most tributaries; hence the probability for interaction is high. The presence of both fluvial and adfluvial stocks of bull trout in the region further increases the likelihood for interaction there.

Bull trout are opportunistic feeders and will eat just about anything including squirrels, birds, ducklings, snakes, mice, frogs, fish, and insects (Elliott and Peck 1980; Goetz 1989), although adult migrant bull trout eat primarily fish. Because adult migrant bull trout occur throughout the upper basin, including the mainstem Columbia River (Stevenson et al. 2003), they likely prey on juvenile salmonids. In the upper Wenatchee Basin, Hillman and Miller (2002) noted that juvenile chinook and steelhead were rare in areas where adult bull trout were present. Like northern pikeminnow, adult bull trout frequent the tailrace areas of Upper Columbia dams. These areas provide concentrated prey items, which include juvenile chinook and steelhead. It is likely that adult bull trout prey heavily on migrant salmon and steelhead in these areas. Indeed, Stevenson et al. (2003) found bull trout staging near the Wells Hatchery outfall, apparently seeking opportunistic feeding opportunities. As the number of bull trout increase in the upper basin, the interaction between them and salmon and steelhead will increase.

Rainbow/steelhead trout feed on chinook fry in the upper basin. In the Wenatchee River, for example, Hillman et al. (1989) observed both wild and hatchery rainbow/steelhead feeding on chinook fry. Predation was most intense during dawn to dusk. At that time, rainbow/steelhead occupied stations immediately adjacent to aggregations of chinook. Hillman et al. (1989) noted that within the prey cluster, the largest, light-colored chinook were closest to shelter and seldom eaten. Small, darker-colored chinook were farther from escape cover and usually eaten by predators. Hillman et al. (1989) suggest that predator-mediated interaction for shelter was strong and contributed to the rapid decline in chinook numbers in May. Although this work was done in the Wenatchee River, the results probably hold for other tributaries where the two species occur together.

Although adult salmonids prey on juvenile salmonids in the upper basin, the predation rate is unknown. Because of the abundance of both bull trout and rainbow/steelhead trout in the upper basin, it is reasonable to assume that large numbers of fry are consumed by these fish.

Predation

Fish, mammals, and birds are the primary natural predators of salmonids in the Upper Columbia Basin. Although the behavior of various salmonids precludes any single predator from focusing exclusively on them, predation by certain species can nonetheless be seasonally and locally important. Recent changes in predator and prey populations along with major changes in the environment, both related and unrelated to development in the Mid-Columbia Basin, have reshaped the role of predation.

Although several fish species can consume salmonids in the upper basin, northern pikeminnow, walleyes, and smallmouth bass have the potential for significantly affecting the abundance of juvenile anadromous fish. These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Channel catfish also have the potential to significantly affect the abundance of juvenile salmonids, but because they are rare in the Upper Columbia, they likely have a small effect on survival of juvenile salmonids there. Native species such as sculpins and white sturgeon also prey on juvenile anadromous fish. Below is a discussion on the importance of specific predators on the production of salmonids in the Upper Columbia Basin.

Sculpins

Sculpins are native and relatively common in the upper basin. Although sculpins are not considered a major predator of outmigrating anadromous fish, they do prey on small chinook and steelhead. In the Entiat River, Hillman (1989) noted that large concentrations (20 fish/11 sq. ft.) of juvenile chinook and steelhead occupied inshore, shallow, quiet-water positions on the streambed during the night. Hillman (1989) found that many sculpins moved into these areas at night and preyed heavily on chinook and steelhead fry. Predation on fry appeared to be limited to sculpins larger than 3.3 in. and ceased when prey reached a size larger than 2 in. The number of fry eaten per night appeared to be related to sculpin size, with the largest sculpins consuming the most fry per individual.

Because sculpins are abundant in Upper Columbia River tributaries, they are likely an important agent of mortality of salmonid eggs and fry. As chinook and steelhead fry grow, they are released from this source of mortality. It is unknown what fraction of the chinook and steelhead population is removed by sculpins.

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Birds

Currently, there is little information on the effects of bird predation on the abundance of juvenile salmon and trout in the upper basin. Fish-eating birds that occur in the project area include great blue herons (Ardea herodias), gulls, osprey (Pandion haliaetus), common mergansers (Mergus merganser), American dippers (Cinclus mexicanus), cormorants (Phalacrocorax spp.), Caspian terns, belted kingfishers (Ceryle alcyon), common loons (Gavia immer), western grebes (Aechmophorus occidentalis), black-crowned night herons (Nycticorax nycticorax), and bald eagles (Haliaeetus leucocephalus). According to Wood (1987a, 1987b), the common merganser limited salmon production in nursery areas in British Columbia. He found during smolt migrations that mergansers foraged almost exclusively on juvenile salmonids (Wood 1987a). Maximum mortality rate declined as fish abundance increased (i.e., dispensatory mortality) and did not exceed 10% for any salmonid species. Wood (1987b) also estimated that young mergansers consumed almost one-half pound of subyearling chinook per day. Thus, a brood of ten ducklings could consume between four and five pounds of fish daily during the summer.

Cormorants may take large numbers of juvenile salmon and trout in the upper basin. Roby et al. (1998) estimated that cormorants in the estuary consumed from 2.6 to 5.4 million smolts in 1997, roughly 24% of their diet, and most were hatchery fish. Although Caspian terns are not common in the project area, there is evidence that they consume fish from the project area. Bickford found both PIT-tags and radio tags at a Caspian Tern nesting area near Moses Lake. Tag codes indicated that consumed fish were from the Upper Columbia region (Peven 2003).

Mammals

No one has studied the influence of mammals on numbers of juvenile chinook in the Upper Columbia Basin. Observations by Ashley and Stovall indicate that river otters (Lutra Canadensis) occur throughout the region. BioAnalysts found evidence of otters fishing the Entiat, Chiwawa, Entiat, and Methow rivers, and Icicle Creek. Otters typically fished in pools with LWD. According to Hillman and Miller (2002), juvenile chinook are most abundant in these pool types, thus, the probability for an encounter is high. Dolloff (1993) examined over 8,000 otoliths in scats of two river otters during spring 1985 and found that at least 3,300 juvenile salmonids were eaten by them in the Kadashan River system, Alaska. He notes that the true number of fish eaten was much higher, as it is unlikely that searchers found all the scats deposited by the otters. Other predators, such as raccoon (Procyon lotor) and mink (Mustela vison) also occur in tributaries throughout the Upper Columbia Basin. Their effects on numbers of salmon and trout are unknown.

Black bears (*Ursus americanus*) are relatively common in the Upper Columbia Basin and frequent streams used by spawning salmon during autumn. Studies have shown that salmon are one of the most important meat sources of bears and that the availability of salmon greatly influences habitat quality for bears at both the individual level and the population level. Observations by crews conducting chinook spawning surveys in the upper basin indicate that bears eat chinook, but it is unknown if the bears remove per-spawned fish or are simply scavenging post-spawned fish. Regardless, there is no information on the roll that bears play in limiting survival and production of salmon and trout in the upper basin.

4.10 Aquatic Habitat Conditions

4.10.1 Assessment Methodology

Recently, the Entiat Watershed Planning Unit Habitat Subcommittee members worked with Mobrand Biometrics, Inc. to model Chinook salmon response to various restoration scenarios using the Ecosystem Diagnosis and Treatment (EDT) methodology. Time and funding resources were not available to complete other species analysis.

EDT is an analytical method relating habitat features and biological performance to support conservation and recovery planning. It acts as an analytical framework that brings together information from empirical observation, stakeholders and local experts, and other models and analyses tools.

This section presents the initial EDT "Diagnosis" for planning restoration and protection of salmon habitat in the Entiat River subbasin. The Diagnosis is based on an assessment of the relative contributions of environmental factors to the biologic performance of naturally produced Chinook salmon.

The EDT analysis consisted of two phases with unique objectives:

> <u>Watershed Assessment (Diagnosis)</u>: To complete a watershed assessment with respect to Chinook salmon (the focal or diagnostic species selected for the Entiat), assessing current and historic measures of population performance relative to habitat conditions, and to derive strategic priorities for protection and restoration actions.
>
> <u>Analysis of Action Alternatives (Treatment)</u>: To assess how various future management actions might contribute to the long-term enhancement or restoration of biologic productivity of salmonid species – specifically Chinook salmon.

In the assessment phase, the EWPU Habitat subcommittee characterized baseline reference conditions with regard to both environmental conditions and population performance measures. Two baseline reference scenarios were characterized: historic (predevelopment) conditions and current conditions. The comparison of these scenarios forms the basis of the diagnostic conclusions about how the Entiat subbasin and associated salmon performance have been altered by human development. The historic reference scenario also serves to define the natural limits to potential recovery actions within the subbasin.

During the analysis of action alternatives, five alternative management scenarios were modeled. These alternatives were based on and consistent with alternatives developed and outlined in the Entiat River Inventory and Analysis (CCCD 1998), and contained in the Entiat Final Coordinated Resource Management Plan/First Draft WRIA 46 Management Plan (CCCD 2002).

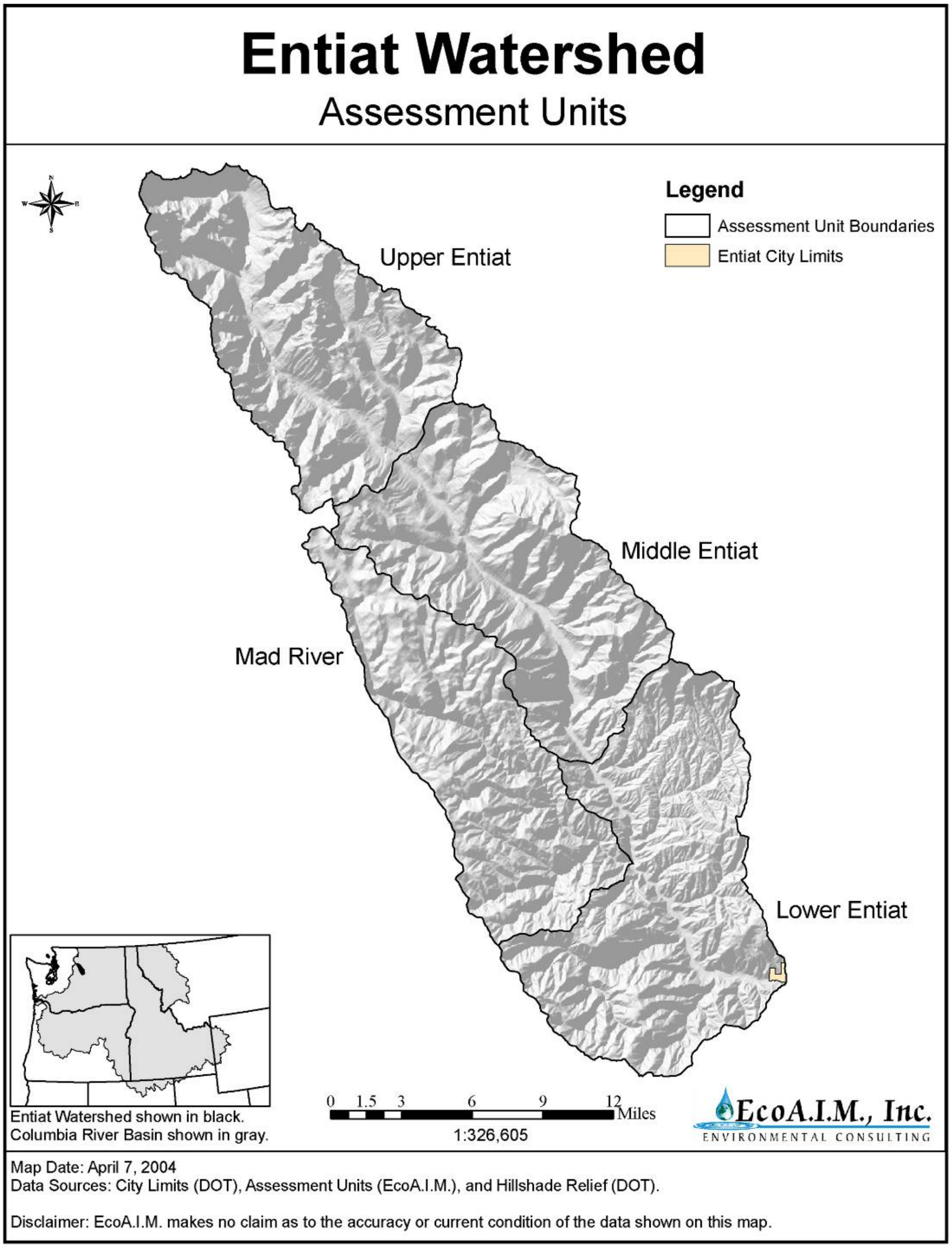

Figure 15. Assessment units in the Entiat subbasin

Basis of the EDT Analysis

As mentioned above, the EDT analysis describes how certain salmonid populations interact with their environment, relative to habitat conditions. The EWPU Habitat Subcommittee defined 24 specific stream reaches within the Entiat subbasin used by Chinook salmon, and evaluated approximately 40 habitat attributes for each of these reaches. The Planning Unit also performed field site visits to validate habitat condition assumptions against current conditions.

Because of the substantial complexity of how well various life stages of Chinook salmon survive in different reaches at different times of the year, a computer-based computational model is necessary to track all of the interactions and assumptions to provide resource managers defensible decision-making tools. The primary output of the EDT modeling process describes a population's "biological performance" (in this case, the Entiat spring Chinook and Entiat summer [late-run] Chinook populations) with respect to the different treatments.

Biological performance can be defined in terms of three elements: 1) biologic productivity, 2) environmental capacity, and 3) life history diversity. These measures are characteristics of the ecosystem that describes a population's persistence, abundance, and distribution potential. These three elements are also the core performance measures used by the NOAA Fisheries (formerly NOAA National Marine Fisheries Service) as part of its viable population concept. Each measure is defined briefly below

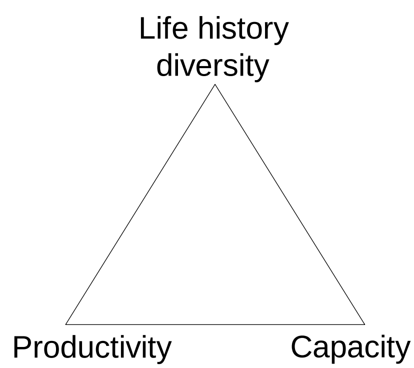

Figure 16. Three core performance measures of biological performance

Productivity. This element represents the relative success of the species to complete its life cycle within the environment it experiences. It determines resilience to mortality pressures, such as from fishing, dams, and further habitat degradation. Habitat quality (including water quality) is a major determinant of a population's productivity. (*The productivity rate is the reproductive rate measured over a full generation that would occur at low population density, i.e., when competition for resources among the population is minimal.)*

Capacity. This element defines how large a population can grow within the environment it experiences, as a result of finite space and food resources. It determines the effect of this upper limit on abundance to survival and distribution. *Habitat quantity* is a major determinant of the environmental capacity to support population abundance.

Life History Diversity. This element represents the multitude of pathways through space and time available to, and used by, a species in completing its life cycle. Populations that can sustain a wide variety of life history patterns are likely to be more resilient to the influences of environmental change. Thus a loss of life history diversity is an indication of declining health of a population and perhaps its environment.

Assessment Units

The Entiat subbasin is very diverse in elevation and environmental conditions. While the subbasin contains some of the most pristine habitat found throughout the Columbia River basin, it experienced considerable habitat degradation in the lower portions of the drainage. For the purposes of this assessment, the Entiat Subbasin has been dissected into four distinct Assessment Units, indicated below:

1. Lower Entiat River Assessment Unit extends from the mouth of the mainstem Entiat River to the Potato Moraine.
2. Middle Entiat River Assessment Unit extends from the Potato Moraine to Entiat Falls (upper extent of anadromous fish).
3. Upper Entiat River Assessment unit extends from Entiat Falls to the headwater streams.
4. Made River Assessment Unit extends from its confluence with the Entiat River to its headwaters.

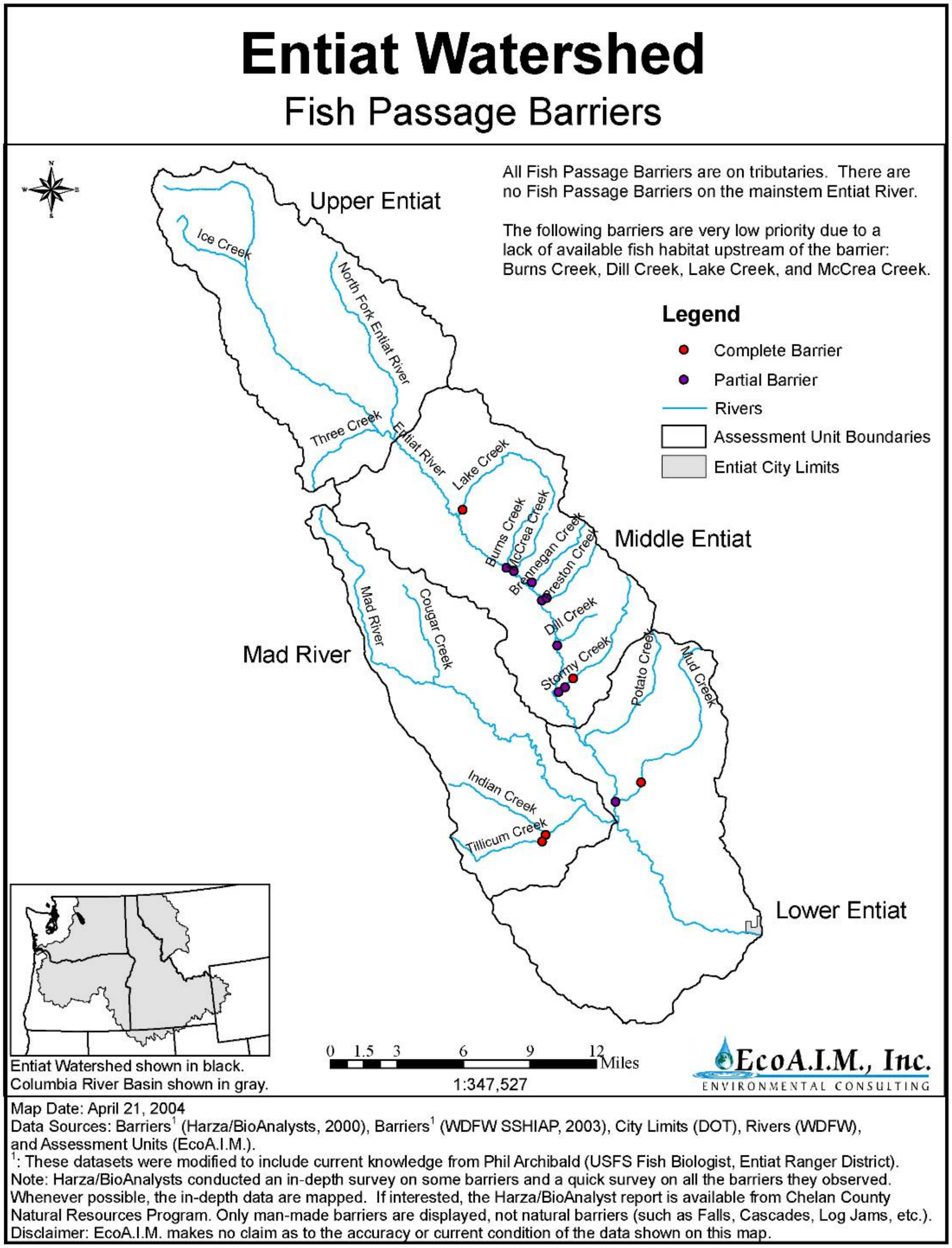

Figure 17. Fish passage barriers in the Entiat subbasin

4.10.2 Lower Entiat River Assesment Unit

Assessment Unit Description

The Lower Entiat Assessment Unit includes lesser tributaries and mainstem river from the Potato Moraine at RM 16.2 to the Entiat's confluence with the Columbia River (elevation 713 feet) at RM 0.0. The primary tributaries include Potato, Mud and Roaring Creeks.

Topography is characterized by non-glaciated mountain slopes strongly dissected by relatively high density, low order tributary streams. Steep, narrow V-shaped fluvial valleys are characteristic, with side slopes commonly ranging from 30-60%. Much of the AU is privately owned with most developments adjacent to the Entiat River and bottoms of the tributaries. Primary land use includes irrigated orchard and pasture. Significant urban development is limited to the city of Entiat (approximately 960 people).

Precipitation ranges from around 30" in tributary headwater areas to less then 10" along the Columbia River, with about 20-24" falling in the valley bottom. Approximately 75% of total precipitation falls from October through March. Most winter precipitation falls as snow; however, rain is not unusual at lower elevations. Temperatures can be extreme during both summer and winter months.

Assessment Unit Condition

The Entiat valley has been influenced by many natural disturbance events such as wildfire, flooding, earthquakes, landslides, glaciation, and volcanic eruptions (CCCD, 2004). Human influences have altered riparian and upland conditions, primarily from timber harvest, fire suppression, and livestock grazing (Archibald et al., 2002). Road construction, residential and agricultural development within the riparian zone has reduced or eliminated vegetation in many areas, and diminished sources of large wood recruitment as well as shade. Most of the mainstem Entiat River has been substantially altered due to channelization and flood control measures implemented in the 1950's, resulting in a simplified channel with little structural complexity that would benefit salmonid production. Culverts on some tributaries have created barriers for fish (Figure 17). Although soils are highly erodible and sediment deposition is a dominant natural process within this zone, removal of vegetation and surface soil disturbances has exacerbated fine sediment delivery and stream bank instability in areas.

Water Quality

Water quality for the lower mainstem Entiat River is generally in good to excellent condition, although it has been affected in the past by land management practices mentioned above. Tributaries and the portion of the mainstem Entiat River within the lower Entiat River assessment unit are classified as Class A (excellent) under state water quality standards.

USFS temperature data collected annually since the early 1990's show exceedences of state water quality temperature standard during July - September for each year of monitoring. Monitoring has also indicated that pH levels occasionally exceed state standards in this Assessment Unit, although these levels are believed to be at natural condition. Due to excursions beyond water quality standards, the lower mainstem Entiat was on the State's 303(d) list from 1992 until the 2002/2004 list:

Washington state 303d listings in the Entiat subbasin

Biennial List Year	Parameter(s) Listed
1992	pH
1994	pH and temperature
1996	pH, temperature, instream flow
1998	Instream flow
2000	n/a; the EPA did not require states to submit a 303(d) list in 2000.
	Temperature

Occasional temperature exceedences may have occurred naturally prior to settlement of the Entiat valley; however, the number and frequency of exceedences is likely elevated from natural levels due to a combination of decreased riparian vegetation/shade as a result of flood, development, and wildfire events and increased width-to-depth ratios due to past channelization/flood control projects.

High summer stream temperatures are likely increased during low flow years due to irrigation water withdrawals. The Stream Network Temperature Model developed for the Entiat River showed that increases in riparian shade would moderate instream temperatures during late summer months (Hendrick and Monahan, 2003).

Very cold winter temperatures are a natural occurrence. Frazil and anchor ice are a common winter phenomena, and can occupy most of the substrate in lower reaches in cold winters following dry summers. Winter water temperatures are likely lower than historic conditions due to altered riparian and in-channel conditions. Continuous water temperature monitoring at Entiat RM 1.4 (Keystone gage) since March 2002 shows extended periods (19 days) of minimum temperatures below 42.5º F during the late-run Chinook spawning period of October through early November. Entiat River winter (incubating) minimum stream temperatures were ≤ 33º F for prolonged periods (32 days) during the winter of 2002-2003.

BioAnalysts, Inc. (2002) evaluated water temperature, dissolved oxygen (intragravel and water column), and egg/alevin mortality in 24 chinook redds in the lower 3.5 miles of the Entiat River weekly during a study period from 11/18/2001 through 12/29/2001 and biweekly from 1/6/2002 through 3/23/2002. Trend analysis indicated that the survival of chinook within redds decreased significantly during the study period. The highest egg mortality (76% of 160 eggs sampled) occurred during the week of 1/6-12/2002 when intragravel DO was 12.15 mg/L, and mean daily water temperatures ranged between 1º C and 2.5º C. Entiat River Chinook fry did not emerge until late April, likely due to colder water temperatures (BioAnalysts, Inc. 2002).

Contaminants

A large portion of the subbasin's residential land and the majority of irrigated cropland are located along in the lower Entiat River valley. Consequently, the use of herbicides and pesticides in lower Entiat could impact riparian areas, water quality, and focal species health. However, no indication of water quality degradation due to chemical inputs has been noted at the WDOE ambient water quality station (46A070) near the mouth (RM 1.4) of the Entiat River

Results of tests for toxic materials, based on samples from two suckers (Catostomaus sp.) collected in the slack water area near the mouth of the Entiat, showed elevated levels of total DDT (4,4 DDT; 2,4 DDD and DDE) and its breakdown products. Low levels of HCB and PCB's were also detected (Davis and Serdar, 1996). Because fish sampled may have accumulated these toxic materials while residing in the Columbia River, tests are considered inconclusive and information concerning bio-accumulation of toxic materials is lacking.

Fecal coli form levels are generally within acceptable limits however, occasional exceedences of Clean Water Act standards have occurred (CCCD, 2003). Although fecal coli form counts have been and continue to be low, future growth in the Entiat valley may present the potential for water quality problems associated with septic systems. Unrestricted livestock access to streams and increases in the number of hobby farms/ranchettes have the potential to result in elevated fecal coli form levels.

The Entiat National Fish Hatchery is known to contribute waste materials directly to the Entiat River . There is no empirical information available to indicate the effect of hatchery effluence to the downstream environment.

Fine Sediment

The lower Entiat River is a relatively low gradient stream allowing for increased sediment deposition. Due to watershed and riparian conditions mentioned above, sediment and cobble embeddedness levels appear to be higher than expected. The 11-year average for measured fine sediments (less than 1mm diameter) in the lower mainstem sampling reach is 16.93% of the substrate composition. The 11-year trend appears to be increasing (Archibald, 2004). Increases in sediment load in this assessment unit are hypothesized to be primarily associated with catastrophic events (e.g. debris torrents and erosion) following severe fire and flood in the 1970's. Several of the small tributaries (e.g. Roaring Creek) in this assessment unit also have higher sediment loads contributing to high percent fines in this assessment unit.

Water Quantity

Flow

Lower Entiat mainstem and tributary flows are highly variable and very responsive to local weather. Surface runoff is rapid on side slopes and moderate on ridges and colluvial swales.

Low flows are a natural occurrence within the subbasin, and naturally limiting to production of some salmonid species. Peak flow timing is assumed to be at or near historic conditions, with current peak flows showing signs of recovery from past fires. However, channel simplification has resulted in faster, more intense runoff in the lower mainstem during storm events and annual snowmelt and has diminished the quality and quantity of current habitat available at given flows.

The 1998 303d list included instream flow as a concern in the lower Entiat River from the town of Ardenvoir (RM 10.0) to the mouth. Irrigation withdrawal is considered to be a relatively minor contribution to lower flows. Average cumulative irrigation water use occurring in the subbasin during August is estimated to be approximately 6-7% (measured at, the Keystone gage, RM 1.4). Additional reach-level effects from irrigation system conveyance inefficiency are not well understood. However, some areas may have an effect of 10 to 13 % from total water withdrawal (water use plus conveyance inefficiency).

Riparian Floodplain

Riparian as well as floodplain function has been substantially changed from historic condition. The construction of roads and homes in the floodplain, filling, diking and channel straightening have reduced or eliminated floodplain connection and function within some areas of the lower Entiat River assessment unit.

Riparian conditions near the confluence with the Columbia River show substantial vigor and contribute positively to stream channel diversity and properly functioning conditions.

However, in many reaches within the Assessment Unit, reduction or total loss of vigorous shrubs in the riparian zone has reduced instream organic input and shade, and contributed to unstable stream banks and associated erosion and has significantly reduced large wood recruitment into the stream channel. Percent canopy cover in the Lower Entiat ranges from 0 to 25 percent.

High road density, a high number of road miles in the riparian corridor, and road maintenance practices have increased sediment delivery to the lower mainstem. All subwatersheds within the Lower Entiat AU have more than 2.7 miles of road per square mile, and 205 miles of road were identified within 300 feet of streams (WNF, 1996).

In-Channel Conditions

Habitat Diversity, Habitat Quantity and Channel Stability

Prior to early settlement of the valley, the Lower Entiat was more sinuous and less entrenched. Because of flood control measures and other developments, channel morphology is now substantially entrenched with high width-to-depth ratios and very little useable (salmonid) habitat complexity and diversity.

The quality and frequency of large pool habitat has been reduced by approximately 85% since the 1930s throughout the Assessment Unit. Current opportunities for large wood recruitment are limited. Substrate in the lower mainstem consists primarily of cobbles (2.5 - 10 inches) and numerous small boulders with some interspersed gravel. The channel is characterized as a series of shallow riffles and glides that transport smaller sized substrate (spawning sized gravels) downstream, rather than depositing it.

Off-channel habitat has been substantially reduced. Tributaries and other areas once contained important off-channel habitat for rearing salmonid, but most are located on developed lands (roads, rip rapped banks, check dams, culverts, etc.) resulting in a loss of this key habitat (WNF 1996; Archibald et al., 2002).

As a result of past actions, the quality and quantity of rearing and holding habitat, off-channel winter rearing habitat, and spawning habitat are considered to be fair to poor throughout most of the Lower Entiat River Assessment Unit.

Fish Passage Barriers

There are no physical passage barriers in the lower mainstem Entiat River. The SSHIAP barriers GIS layer (2003) indicates the following barriers in tributaries (Figure 17):

Mud Creek: there is a culvert at the Entiat River Road that is a partial barrier.

Unnamed Tributary to Mud Creek: there is a culvert with unknown blocking status.

Because tributary temperatures may be elevated somewhat during low flow years, thermal barriers to this habitat may exist during the late summer months.

Elevated water temperatures and lack of habitat complexity (i.e. quality pools) likely have impeded or impaired salmonid migration during the late summer and autumn months.

Ecological Conditions

Pathogens

Pathogens to salmonid species may have increased as a result of hatchery operations and fish species introductions. Ecosystem Diagnosis and Treatment outputs suggest that pathogens may have a low to moderate affect primarily to summer rearing fish. There are no observations or formal studies conducted in the Entiat subbasin to verify these findings.

Predation

Bird and fish predation on salmonid juveniles is likely to have increased due to the overall loss of habitat complexity and associated reduction in hiding cover. Smolt releases from the Entiat National Fish Hatchery likely result in increased avian predation. Reduced in-channel habitat diversity and development of Lake Entiat (Rocky Reach Hydro Project) have increased the abundance of non-native fish species, particularly predators such as the Northern Pikeminnow and bass.

Mammal predation on adult salmonids is likely decreased from the historic reference condition due to displacement of these animals. There are no studies conducted in the Entiat subbasin to verify this finding.

Food

Food resources (macro invertebrate production) for juvenile salmonids have possibly declined from historic reference condition as a result of increased water temperatures and decreased organic inputs and nutrient loads. Reduced salmonid carcasses, reduced riparian / leaf litter and reduced floodplain function have likely lowered nutrient content and benthic macro invertebrate production within the lower Entiat. Results from 2002 WDOE Environmental Assessment Program macroinvertebrate sampling at RM 1.4 show that benthic macroinvertebrate community condition is generally healthy; however, specific characteristics of community condition (only one species of stonefly; relatively large percentage of scrapers) indicate slight degradation. The lack of other stonefly species suggests temperature impairment. Nutrient driven periphyton production may be influencing scraper percentages, and causing occasional pH exceedences.

Harassment

Harassment (or poaching) to late-run Chinook salmon (and other focal species) likely occurs in the lower Entiat River but to an unknown extent. Harassment to these fish is largely a function of lack of hiding cover coupled with recreation use of the river. At this time there is no formal public outreach to educate people of the sensitivity of these fish to disturbance, especially during adult holding and spawning times.

Introduced Species

Steelhead stocking (100,000 per year) occurred until 1999. It is not understood what inter-species or intra-species interactions may have occurred. Salmonid species interactions in the lower river are elevated as a result of juvenile spring chinook out-plantings from the USFWS Entiat NFH (RM 6.0). IHN and C. shasta are pathogens found only in returning adult. There is no information concerning these pathogens in other populations throughout the subbasin. BKD is occasionally a problem in the hatchery when river water is used.

Hatchery operations that segregated domestic from wild stocks may have reduced the genetic fitness of focal species stocks. Although genetic samples from spring chinook and steelhead have been collected, the DNA analysis results are not yet available to help determine the genetic status of stocks.

Environmental/Population Relationships

The lower Entiat River is a crucial migration corridor for the migratory life histories/stages of bull trout, steelhead, spring and summer chinook, and westslope cutthroat trout. Spawning and rearing conditions for salmonids in the lower mainstem Entiat River are considered to be in poor condition.

Pre-spawning and spawning adults find a shortage of deep resting pools and limited gravels suitable for redd formation. During the winter incubation period, water over redds is shallow (less than one foot deep) and cools more quickly, resulting in extended egg incubation periods. Low water temperatures can also cause in the formation of anchor ice that can damage redds, eggs and emerging fry. The tendency for anchor ice to form is increased in reaches with little or no canopy closure due to diminished or no riparian vegetation. In addition to anchor ice, sedimentation and gravel scour are potential sources of pre-emergence mortality. Adult overwintering habitat is lacking.

The combination of natural and artificial channel confinement severely limits the availability of suitable early rearing habitat. Food supply has been reduced and high flow refuge habitat (primarily created via LWD recruitment) is lacking due to the loss of riparian vegetation. Current velocity refugia are primarily associated with riprap and afford little cover from avian or piscine predators. Late rearing habitat also lacks in-channel diversity. The lack of cover and increased summer stream temperatures, particularly as flows drop in the summer and fall, may be limiting salmonid productivity through density dependant mechanisms.

Areas of Special Interest

Maintaining existing riparian habitat and floodplain function is of special interest in the Lower Entiat (MCMCP, 1998; Andonaegui, 1999; UCRTT, 2002). Preserving access to the lower portion of tributaries (primarily Mad, Roaring, Mud and Potato Creeks) for refuge and cover during disturbance events is also important, as natural upstream fish passage barriers (such as high gradient boulder cascades) prevent utilization of many tributaries (e.g. Shamel Creek, Roundy Creek and Tyee Creek). Maintaining and improving good water quality is of special interest.

Limiting Factors

- Loss of channel complexity affects both habitat quality and quantity for fry and juvenile rearing life stages. Loss of large pools below the Mad River confluence has reduced holding habitat for adult Chinook and steelhead.

- Loss of anadromous carcasses and lost riparian has reduced nutrient and food supply. Refugia from high flows and cover from avian or piscine predators is notably lacking. Predation on juvenile salmonids by pikeminnow and bass is likely to be elevated due to Lake Entiat.

- Lost riparian shade likely contributes to elevated high temperatures, which may limit habitat availability. And likely impedes migration during the later summer months.

- Impaired riparian and floodplain conditions contributes to freezing temperatures and anchor ice over much of this area in winter. Low instream flows and low winter stream temperatures, and associated anchor and frazil ice, occasionally displace or kill winter rearing juveniles. Wintertime lows and the formation of anchor ice in the lower mainstem Entiat and Mad Rivers may be a greater limiting factor than summertime highs (USFS WNF 1996).

- Channel segments are highly confined and lack effective floodplain function. Stream energy is not well dissipated, resulting in a poor distribution of water velocities, channel downcutting, bank erosion and loss of spawning gravel recruitment. Channel confinement severely limits the availability of suitable early rearing habitat

- Elevated fine sediment levels contribute to reduced incubation success, reduced benthic-invertebrate production, and reduced over-winter rearing habitat. Sedimentation, gravel scour, and anchor ice heighten pre-emergence mortality, while fish in early rearing stages are left without adequate food or refuge from predators.

Functional Relationship of Lower Entiat River Assessment Unit with the Subbasin

The Lower Entiat is a Category 2 watershed, with no (0) significant subwatersheds. In general, substantial loss of habitat complexity and diversity, and loss of riparian vegetation/floodplain function has occurred in this AU. The lower Entiat does act as a migration corridor for spring chinook salmon, steelhead bull trout, and westslope cutthroat trout. It is also provides spawning and rearing habitat for steelhead and summer chinook salmon (UCRTT, 2002).

Opportunities for restoring full expression of life histories for multiple populations do exist, and the lower mainstem could support additional salmonid production.

4.10.3 Middle Entiat River Assessment Unit

Assessment Unit Description

The Middle Entiat River Assessment Unit extends from the Potato Moraine (RM 16.2) upstream to Entiat Falls (RM 33.8) which is a natural barrier to anadromous passage. Channel morphology in this segment of the mainstem is glacially influenced. Low gradient, meandering, alluvial channels with broad, well-defined floodplains are typical. Tributaries to the mainstem and included in this Assessment Unit are Stormy; Preston, McCrea, Tommy, Fox, Lake, Brennegan, and Pope creeks.

Topography in the Middle Entiat is the result of alpine glaciation, which significantly affected the upper half of the Entiat subbasin. The valley has a characteristic U-shaped appearance, and the Potato Moraine indicates the downstream influence of the glacier on channel geomorphology and bed material (glacial till). Glaciation resulted in steep hanging valleys and a moderately broad floodplain that contains water-stratified silt, sand, gravel and cobbles. The geology of this area makes the landscape more susceptible to natural disturbance events such as mud/debris torrents or scouring. Hill slopes are generally very steep and highly unstable; soils that often consist of pumice or ash exist in many areas.

Precipitation in the Middle Entiat along the mainstem is about 24 inches annually. Average precipitation increases with elevation, with some tributary headwater areas producing in excess of 5 inches each year. Most winter precipitation falls as snow, with some rain occurring at lower elevations. During an average winter, temperatures range from the teens to the 40s; average daily summer temperatures range between 60 and 70 degrees.

Essentially all private ownership occurs along the mainstem Entiat River between RM 16 and the USFS boundary (RM 26); No significant agricultural use occurs within this Assessment Unit. Land use consists of residential/recreation cabins, irrigated pasture/lawn and recreation. The majority of land is publicly owned.

Assessment Unit Condition

Past logging practices, fire suppression activities, roading, private development and past over-grazing have been the prime causes of degradation in the Middle Entiat (Archibald et al., 2002; 2003). The upper area of the Assessment Unit maintains many attributes similar to the historic reference condition. Conditions in the lower portion of the AU have been altered and are considered to range from fair to good.

Within this Assessment Unit is the “Stillwater” area. The Entiat River within this area has high sinuosity, fair to very good habitat conditions for anadromous production. Reaches within this area provide for the primary spawning and rearing of chinook and steelhead within the subbasin. This area will also be key to potential coho salmon re-introduction efforts.

Water Quality

Water quality in the Middle Entiat is generally at or near pristine condition. The middle mainstem Entiat River has never been placed on the WDOE 303(d) list of water quality impaired streams. Tributaries and the portion of the mainstem below the USFS boundary (RM 26) are classified as Class A (excellent) according to state water quality standards; from RM 26 to Entiat Falls (RM33.8), streams are classified as Class AA (extraordinary).

It is likely that stream temperatures within the area from Preston Creek to the Forest Boundary will regularly exceed State standards for Class AA rivers (61°F) during most summers, based on natural conditions alone (Archibald et al., 2003). From the USFS boundary at RM 26 downstream to RM 18, the river flows through an increasingly wider U-shaped valley where it exhibits increased sinuosity and a lower gradient compared to all other areas of the Entiat River. In this area (Stillwater reach) where stream temperatures would be naturally expected to increase as well, a temperature moderating influence was observed in 1999-2002. The moderating zone lies between RM 21 and RM 16, and is most likely related to the depth of alluvial aquifer / glacial till deposits here.

Contaminants

Herbicides may enter the water system and degrade water quality. Potential fecal coli form inputs from increasing development and associated septic systems and livestock use are the primary concern with respect to future effects on water quality.

Fine Sediment

The effect of human activities on fine sediment in the Stillwater and in the upper portion of the AU has yet to be determined; however, riparian clearing and roading has likely resulted in bank erosion and increased sediment delivery in the Stormy and Preston Creek area. Altered ground cover as a result of moderate to heavy historic sheep grazing and timber harvest activities (including road building) dating back to the turn of the century, has not been adequate in some areas to protect the soil surface from erosive forces.

Sediment (mean percent fines <1.0mm) range from approximately 6% in upper (higher gradient) stream reaches to approximately 15% in lower (lower gradient) reaches. Sediment input is primarily from recent intense fires, although extensive roading in some areas contributes sediment to streams. The 11-year trend (based on data from three fine sediment sampling reaches) appears to be decreasing sediment inputs (Archibald, 2003).

Water Quantity

Flow

The Middle Entiat is subject to high runoff from rapid melt or rain-on-snow events. Major precipitation events associated with spring runoff when snowmelt was rapid have led to flash floods or mud/debris flows (Archibald et al., 2002; Archibald et al., 2003). Response is characterized by rapid sediment transport in high gradient reaches.

Currently, hydrologic function in the Middle Entiat is near baseline/historic reference conditions. Past grazing activities may have contributed to the lowering of the water table in historically wet meadows. Other alterations may exist due to past high intensity fires, although these conditions are considered to be within the range of natural variation.

The Washington Department of Ecology 1998 303d list indicated that low flows from RM 10 (Ardenvoir) to RM 27.7 are natural, and little water use occurs in the Middle Entiat AU (CCCD, 2004). Current water use is primarily associated with residences, lawn/pasture irrigation and recreational campgrounds.

Riparian and Floodplain Condition

Riparian condition and floodplain function is considered to be in fair to excellent condition. Fair conditions exist in localized areas (20-30% of AU stream area) where fire, riparian clearing / development, channel simplification (dikes to prevent channel migration) and grazing have resulted in lost side channel connectivity, lost recruitment of large wood into the stream channel, accelerated channel migration and erosion. Past logging and roading has affected tributary riparian condition, particularly in Preston and Brennegan creeks. The Stillwater area remains functionally intact, is generally in good condition, although localized areas have been altered.

Roads present in the riparian area near the mainstem Entiat River and some tributaries are a major cause of riparian fragmentation. The USFS identified 43 miles of road within 300 feet of stream channels (WNF 1996; CCCD, 2004). Road density in some areas is second highest on the Entiat Ranger District (>2.4 mi/mi^2). The majority of the roads were built after the 1970 Entiat Fires to support salvage logging sales and attendant jammer-logging road building (Archibald et al., 2003). Road densities in Preston and Brennegan creeks (most are contour roads that cross the creeks) are as high as 6mi/sq.mi. Riparian clearing and roading has resulted in a loss of side channel habitats, backwater pools and stream / riparian interface and a loss of off-channel refugia for juvenile salmonids. Where off channel habitat does exist, it is in stable condition.

In-Channel Condition

Habitat Diversity, Habitat Quantity and Channel Stability

Stream and fish habitat conditions range from fair to good. General channel features, such as sinuosity and width/depth ratios, exhibit near normal features. Localized bank erosion, and loss of habitat diversity and channel complexity is apparent due to stream channel clearing and development in floodplain/ riparian areas.

The Stillwater section from Potato moraine (RM 16.1) to McCrea Creek (~RM 25) retains a more natural channel with much higher sinuosity, typical bankfull width and width-to-depth ratios, numerous log jams, undercut banks and deep pools. Spawning-sized gravels are abundant here.

Large woody debris is significantly lacking within areas of the AU due to past activities mentioned above. Box Canyon also restricts the through-movement of large wood, thus limiting recruitment. The trend for large wood in the stream is increasing due to blow-down of dead trees from past fires. Current large pool frequency and quality are good in the Stillwater, averaging approximately 35% of the habitat area. Pool spacing is at every 5 to 7 bankfull channel widths (close to the expected geomorphic potential), although still below USFS standards.

Streambank condition is generally good from the Potato moraine to Entiat Falls (Archibald et al., 2003). Overall human disturbance is minimal with only the Entiat River Road (to Cottonwood Trailhead) and the Entiat trail system providing access to the river. However, in lower gradient areas there is stream bank loss due to lateral channel migration, which has been accelerated by bank clearing and development in floodplain/riparian areas. The reaches of the upper mid-Entiat River are >90 percent stable.

Fish Passage Barriers

Fish passage throughout the mainstem of this Assessment Unit is good for anadromous fish, bull trout and cutthroat trout (Archibald et al., 2002) and at the historic reference condition (Figure 17). Passage in tributary streams is hindered or blocked, primarily for juvenile life stages, by natural and man-made barriers. The amount of habitat upstream of tributary culvert barriers is limited. The SSHIAP inventory has identified 18 fish passage barriers in the tributary streams from the Potato Moraine to Entiat Falls.

Ecological Conditions

Food

Salmonid populations have been significantly reduced in this Assessment Unit from the historic reference condition. As a result, carcass availability and nutrient supply for macroinvertebrate production has been reduced, thereby reducing the available food source for all native fish species in this area. Loss of side channel habitats, backwater pools, stream/riparian interface, and beaver in lower gradient areas has also likely diminished nutrient input from historic reference conditions.

Harassment

Harassment and potentially poaching on chinook salmon and adult fluvial bull trout likely occurs in the Middle Entiat Assessment Unit but to an unknown extent. Harassment to these fish is largely a function of lack of hiding cover coupled with recreation use of the river. At this time there is no formal public outreach to educate people of the sensitivity of these fish to disturbance, especially during adult holding and spawning times.

Introduced Species

Hatchery operations and past stocking may have reduced the genetic fitness of focal species stocks and resulted in competition for habitat. The Entiat National Fish Hatchery raises and releases spring chinook into the Entiat watershed (CCCD, 2004). There is the potential for genetic integration between hatchery and naturally spawning spring chinook. There is also the potential for increased competition for rearing habitat between hatchery and naturally spawned fish.

Although genetic samples from spring Chinook and steelhead have been collected, DNA analysis results are not yet available to help determine the genetic status of stocks. Introduction of non-native eastern brook trout has resulted in a self-sustaining population primarily above Entiat Falls. Brook trout are occasionally found downstream (within 2-miles) of Entiat Falls (Andonaegui, 1999). Interactions between brook trout and focal species have not been evaluated.

Environmental/Population Relationships

The Middle Entiat AU provides critical spawning and rearing habitat for anadromous salmonids. Of the areas within the subbasin affected by land use practices and flood control projects, the Middle Entiat has been least modified. Suitable spawning and rearing habitats are present, although certain habitat conditions have been diminished in localized areas due to past timber/fire/roading activities, and development. These activities have likely reduced potential carrying capacity for salmonid production.

In general, spawning and rearing conditions for salmon and steelhead are considered to be good to excellent above the moraine, with adequate cover, favorable velocities and high flow refuge habitat (WNF 1996; CCCD, 2004). Primary summer Chinook spawning is found between the moraine (RM 16.1) and RM 18.7. Spring Chinook tend to spawn in the seven mile "index area" between RM 21 and RM 28; early rearing also occurs in this more pristine area. Steelhead spawning occurs in the mainstem between Stormy Creek (RM 18) and Fox Creek (RM 28).

From the McCrea confluence upstream to Entiat Falls, fish habitat in the mainstem Entiat has been modified from the condition found in 1930's surveys, yet the amount of pool habitat and large woody debris within this reach is good (CCCD, 2004). Primarily bull trout and other resident fish utilize the fair to excellent quality habitat in this zone; spring chinook and summer steelhead use is limited to the lower reaches due to natural barriers (CCCD, 2004). The trend in habitat condition is variable and uncertain, and some channel sections have been locally impacted by timber harvest in tributaries, and by road crossings.

Areas of Special Interest

Maintaining intact areas of mainstem and side channel riparian habitat in the Stillwater Reach between the moraine and Fox Creek is important to maintain natural chinook and steelhead production in the Entiat subbasin (MCMCP, 1998; Andonaegui, 1999). Maintain increasing trend in LWD recruitment and pool formation below Fox Creek will enhance habitat diversity and carrying capacity.

Maintaining existing fluvial processes and floodplain connectivity/habitats from the Potato Moraine to Entiat Falls is also of interest (UCRTT, 2004). Fluvial processes are now good within this reach, but they are at risk from future development pressure in bottomlands (UCRTT, 2004).

Limiting Factors

- Past stream clean-outs and salvage logging activities after major fire events have affected stream channel complexity (UCRTT, 2004) and habitat diversity in some reaches.
- The loss of large wood and key side channel habitat (particularly in low gradient sections) likely limits juvenile/rearing salmonid productivity
- Surface erosion and sediment delivery hazard is high in many areas. Highly erosive uplands deliver sediment to streams, particularly Fox, McCree, Brenegan, Preston, and Mud creeks, and the mainstem Entiat between Fox and Stormy creeks (UCRTT, 2002)
- Harassment or poaching of spawning salmonids may occur at campgrounds and other access points (UCRTT, 2004).
- Lack of nutrients, particularly the loss of large numbers of salmon carcasses, has resulted in a loss in primary biologic productivity and reduced food resources for salmonids.

Functional Relationship of Middle Entiat within the Entiat Subbasin

The Middle Entiat is a Category 1 watershed, with two (2) significant subwatersheds, including the Upper Mid-Entiat and the Lower Mid-Entiat. The Middle Entiat is critical habitat for Chinook salmon, steelhead, and bull trout production and is designated as a Key Watershed in the Northwest Forest Plan (UCRTT, 2004).

4.10.4 Upper Entiat River Assessment Unit

Assessment Unit Description

The Upper Entiat River Assessment Unit (Upper Entiat) extends from Entiat Falls (RM 33.8) to the headwater area of the subbasin. This AU contains strongly glaciated land types with high subsurface water storage capacity. The primary tributary to the mainstem is the North Fork Entiat River. All nine of the major lakes of the Entiat subbasin are found in the Upper Entiat (Andonaegui, 1999).

Precipitation averages 34-36” annually in the mainstem area of the Upper Entiat below the North Fork. Upstream from here, precipitation levels continue to increase with elevation. Some tributary headwaters areas receive an annual average of 54-56”, the highest of all levels found within the subbasin. Almost all winter precipitation falls as snow.

Soils in the Upper Entiat have high porosity, low surface moisture retention and are easily eroded. Subsurface water, seeps and springs contribute to weathering of bedrock, soil creep, and mass wasting in localized areas of tributary watersheds (Archibald et al., 2003). Avalanche chutes and debris tracks are associated with low order channels. Glacial till deposits intercept runoff from upper slopes and seepage along lower slopes, and are important in regulating stream flow and temperature (Archibald et al., 2003).

All land within the Upper Entiat is managed by the US Forest Service. There are seven developed campgrounds and many recreational trails. Over the past decade, recreation on the Entiat Ranger District has increased steadily, with weekends typically running over 100 percent capacity and weekday use during July and August at 50 to 60% (CCCD, 2004).

Assessment Unit Condition

General watershed conditions in the Upper Entiat are good to excellent. Aquatic habitat is stable and assumed to be similar to historic conditions, and stream channels are mostly within wilderness or unroaded areas. Management effects have been relatively minor, and the natural occurrence of fire is the primary disturbance mechanism. Historic concentrated sheep grazing has affected conditions in localized areas, although dispersed recreation, localized grazing, and trail impacts are current management areas of interest (CCCD, 2004).

Resident fish, particularly rainbow and cutthroat trout, dominate the Upper Entiat (USFS, 1996; Andonaegui, 1999). Non-native eastern brook trout and hatchery reared cutthroat and rainbow are also present. Anadromous fish are absent from this AU due to the natural barrier at Entiat Falls.

Water Quality

Water quality in the Upper Entiat is essentially in pristine condition (Mullan et al., 1992). Coarse and fine sediment are recruited by naturally occurring debris flows, and fines are transported through the Upper Entiat with minimal deposition (Andonaegui, 1999; CCCD, 2004).

Water Quantity

The current flow regime is at or near the historic reference condition (USFS, 1996; Andonaegui, 1999), although historic beaver trapping may have diminished water storage capacity and altered flow regimes to a minor degree. Percolation and storage of ground water by deep glacial till deposits and abundant seeps, springs and tributaries moderate stream temperatures and provide thermal refugia (Archibald et al., 2003).

Riparian Floodplain

Riparian and floodplain attributes are stable and considered to be in good to excellent condition and are at or near the historic reference condition. Riparian reserves are providing adequate shade, large woody debris recruitment, habitat protection, and connectivity in all subwatersheds of the Upper Entiat Assessment Unit.

Road densities in the Upper Entiat are low. A total of 5.9 miles of road are found in riparian areas (0.05 miles of road/square mile) (Archibald et al., 2003). Overall road density is 0.4 miles/square mile, and all subwatersheds have less than one mile of road per square mile. The highest trail densities (162.7 miles of trails) are found within the

Upper Entiat (Andonaegui, 1999). Some localized compaction and disturbance of riparian vegetation is noted due primarily to trails and recreation, although these are minor at the subbasin scale.

In-Channel Conditions

Habitat Diversity, Habitat Quantity and Channel Stability

In channel habitat conditions in the Upper Entiat are considered to be good to excellent, and near historic reference condition due to minimal human disturbance (USFS, 1996; Andonaegui, 1999). Only the Entiat River Road (to Cottonwood Trailhead) and the Entiat trail system provide access to the mainstem Entiat River.

Habitat diversity is provided by side channels, boulders and large woody debris. Streams substrate is primarily cobble/gravel. The number of large pools is similar to or higher than the number observed during 1930’s stream surveys. Overall, channels and stream banks are in good condition (Archibald et al., 2003), as most are within wilderness or unroaded areas.

Some channel modifications from historic have likely occurred as a result of historic actions including beaver trapping and concentrated sheep grazing. Erosion/degradation of bank stability as a result of recreational use/trails is occurring only in localized areas (Andonaegui, 1999).

Fish Passage Barriers

There are no man-made barriers to passage within the Upper Entiat (Figure 17). Entiat Falls (RM 33.8) located at the lower end of this AU acts as natural barrier to the upstream migration of all anadromous species (Archibald et al., 2003; Andonaegui, 1999).

Ecological Conditions

Introduced Species

Many ecologic attributes remain intact from the historic reference condition. However, the Upper Entiat has been affected by extensive stocking of hatchery reared rainbow and westslope cutthroat trout in streams and especially the high lakes, and the introduction of eastern brook trout above Entiat Falls.

Eastern brook trout are no longer stocked, and all government stocking of cutthroat and rainbow trout ceased in1996 (Andonaegui, 1999; Archibald et al., 2003). A self-sustaining population of brook trout now exists in this AU.

Introductions of rainbow and hatchery reared westslope cutthroat trout into habitats previously occupied only by westslope cutthroat trout have resulted in widespread introgression, with many cases of westslope/redband hybrids identified as westslope cutthroat trout. The main concerns regarding the status of resident species are: genetic introgression, especially with introduced rainbow trout; depressed and fragmented populations; and the loss of migratory life histories (Archibald et al., 2003).

Environmental/Population Relationships

The Upper Entiat has been minimally affected by past activities, and fish habitat condition is stable and assumed to be similar to the historic condition. Although anadromous species access to habitat is blocked by Entiat Falls, this AU provides good to excellent habitat for resident fish species.

Areas of Special Interest

Protection of the existing hydrologic regime, riparian condition, floodplain function, aquatic habitat and channel condition is of special interest.

Limiting Factors

No factors that limit the production of endemic fish species in the Upper Entiat have been identified. The productivity of cutthroat trout may be limited by genetic introgression and the presence of brook trout.

Functional Relationship of Upper Entiat Assessment Unit with the Subbasin

The Upper Entiat provides good/excellent spawning and rearing habitat for resident trout species. Due to the quality of existing habitat, the goal is maintaining conditions in this portion of the subbasin, and minimizing recreation impacts. The elimination of eastern brook trout would improve conditions for endemic resident fish.

4.10.5 Mad River Assessment Unit

Assessment Unit Description

The Mad River Assessment Unit, consisting of the entire mainstem river and its tributaries drains approximately 58,300 acres. The Mad River originates from a glaciated basin near the crest of Tyee Ridge and flows southeasterly through a U-shaped valley for nearly 24 miles. It joins the west bank of the Entiat River at RM 10.5, just upstream from the town of Ardenvoir. Notable tributaries to the mainstem Mad River include Cougar, Hornet and Tillicum Creeks. Several alpine lakes, including Mad Lake (source of the Mad River) are also found within the Mad AU.

Annual precipitation within the Mad River watershed ranges from 20 inches per year near the confluence with the Entiat River, to 60 inches per year in the headwaters and at higher elevations. The majority of the annual precipitation falls in the form of snow, during late fall and winter (October to March). Percolation and storage of ground water by deep glacial till deposits and abundant seeps, springs and tributaries moderate stream temperatures and provide thermal refugia within the Mad River above Cougar Creek.

Approximately 95% of the Mad AU is publicly owned. An extensive 85-mile system of single-track multiple-use trails exists and provides for a wide variety of recreational activities. Lands privately owned by individual landowners constitute the remaining 5% of the total Mad watershed area (Archibald et al., 2003a). Private development/land use is limited to the area along the lower 2-miles of the mainstem Mad River, and lower Tillicum Creek.

Assessment Unit Condition

The primary natural disturbance process within the Mad River watershed is forest fire.

Current watershed attributes are considered to be in generally good to excellent condition. However, past commercial mining and packer operations in the Maverick Saddle area, unregulated sheep grazing, subsequent grazing allotments, wildfire, logging, road construction and development have degraded some habitat attributes to varying degrees.

Water Quality

The Mad River has no Clean Water Act 303(d) designated reaches. Data from sampling conducted at the Mill Camp Bridge (RM 0.25) from May 1995 through October 1996 showed good pH, dissolved oxygen, fecal coli form, nitrate/nitrite, and turbidity levels. Occasional nutrients inputs are associated with development/land use in the Ardenvoir area occur along the lower mile of the Mad River and around its confluence with the Entiat River (Archibald et al., 2003a), although these are considered to be minor.

Temperature

Maximum water temperatures often exceed 61°F in the lower Mad River (CCCD, 2004) during summer high temperatures, although water temperatures are believed to be at or near the historic reference condition. Essentially no direct management of riparian and valley bottom vegetation has occurred from RM 4 to the headwaters (nearly 20 miles). The effects of past wildfires in riparian areas may exacerbate natural high temperature conditions during low flow years. Cooler temperatures are noted in the upper watershed due to ground water input in the Cougar to Jimmy Creek reach. These areas provide for the primary bull trout spawning within the Entiat subbasin.

Fine Sediment

It is likely that sediment yield in the Mad River is at or near the historic reference condition. Eleven years of fine sediment data collected between the Mill Camp Bridge (RM 0.25) and Pine Flat campground (RM 4.0) indicate that sediment loads in the lower Mad River average 16.9% composition fines ($\leq$1.0 mm). Measurements indicate sediment rates are moderately variable within a range of 12 to 19%, but in a long-term stable and a decreasing trend. County road maintenance activities (side-casting of material into the lower Mad River approximately ¾ mile upstream of the mouth) likely result in increased sediment input to the stream.

Water Quantity

Flow conditions in the Mad River Assessment Unit are likely near the historic reference condition, relatively stable and functioning appropriately (Archibald et al., 2003a). Streamflow data collected from 1991-1995 at the USGS gage (RM 0.2) in Ardenvoir show average annual streamflow is 60cfs. Base flows and flow timing appear unchanged from pre-fire conditions. Average annual peak flows recorded during the same years from mid-May to early June ranged from 300 to 400 cfs, with average annual base flows recorded September to January about 20 to 40 cfs. In the lower Mad River, surface runoff is rapid, water storage is reduced, flows are poorly regulated and can be flashy depending on precipitation and runoff events.

Water use occurring in the lower Mad River is insignificant in comparison to total subbasin use. There are 4 surface water certificates and permits worth a potential total diversion of 70.2 cfs; surface and ground water claims total a potential withdrawal of 0.3cfs (CCCD, 2004). It has been advised that new water diversions from the Mad River during May and June should be limited until further study demonstrates that additional water could be withdrawn without adversely affecting current channel conditions or levels of fish production (CCCD, 2004).

Riparian Floodplain

Riparian and Floodplain Condition

Floodplain function is generally in fair to good condition in this Assessment Unit.

The connectivity of the floodplain from the mouth of Mad River to Pine Flats Campground (RM 4) has been greatly reduced by orchards, the town of Ardenvoir, County Road #119, and Forest Service Road #5700.

Riparian attributes are generally in fair to good condition in this Assessment Unit. In the upper mainstem and headwaters areas (Young Creek to Blue Creek) riparian condition is good, with greater than 90% of riparian reserves intact. Upper Mad riparian areas provide adequate shade, large woody debris recruitment and subwatershed connectivity, and provide refugia for steelhead, bull trout and cutthroat trout. In the area from Pine Flats Campground (RM 4) upstream to Young Creek, greater than 65% of the riparian area was burned during the 1994 fire. Riparian conditions are fair, with post-fire recovery proceeding rapidly and according to natural processes.

In the lower mainstem Mad from the mouth to Pine Flats Campground (~RM 4) road encroachment, agriculture, and development have resulted in a loss of loss of riparian connectivity and function. Effects of management activities are considered to be relatively minor at the watershed scale, although this lower area provides for chinook spawning and approximately 50% of steelhead spawning habitat.

The majority of roads within the Mad Assessment Unit are found within the lower Mad River and the Tillicum Creek drainage, a legacy from the days of jammer logging and fire salvage in the 1970s. High road densities in Tillicum Creek may contribute to modest alteration of flow timing and runoff patterns. The highest riparian road density (>2.4 mi/mi^2) is found in the lower and middle Mad River, where spring chinook and steelhead are known to spawn. The lower 2-3 miles of the mainstem Mad River is confined by the County road. Lower mainstem habitat conditions for spring Chinook and steelhead are considered poor, although refugia conditions are fair.

In-Channel Conditions

Habitat Diversity, Habitat Quantity and Channel Stability

In general, stream channel conditions and function are in good condition from Pine Flats Campground upstream to the Mad River headwaters. Human disturbance is minimal with only the Mad River trail providing access to the river. Habitat conditions have been greatly modified in the lower Mad River from the mouth to Pine Flats Campground (RM 4), and stream channel conditions and function are in fair to poor condition. In the 1995/97 survey of the Mad River, the mouth to Pine Flats Campground had an average bankfull width/depth ratio within the expected range of its channel type. However, this area has been developed, channelized and artificially constrained.

Embeddedness levels are in good condition upstream from Pine Flats Campground (Archibald et al., 2003a). From Pine Flats downstream to the mouth, artificial confinement of the channel near the town of Ardenvoir, wood removal following the 1970 Gold Ridge fire, and higher percentages of larger substrate have reduced the ability of the river to retain adequate amounts of gravel and cobble-sized substrate, thus adversely affecting spawning and rearing habitat availability for Chinook and steelhead.

The majority of the Mad River and its tributaries are in good condition for large woody debris (Archibald et al., 2003a). Historically, the mouth of Mad River to Pine Flats Campground was thought to be highly complex with abundant LWD. However, existing large wood in the stream channel is reduced. Counts from 1990 and 1995-1997 stream surveys showed only 10 pieces/mile in the lower Mad River.

Most Mad River reaches have experienced a considerable increase (195%) in pool habitat from conditions documented during 1930's (WNF, 1996). The low numbers of pools noted in the 1930's survey is most likely due to the Mad River Gorge Fire of 1888 which intensively burned potential and downed pool-forming LWD. Post 1994 Tyee fire surveys conducted in 1995-1997 show that large pool frequency and condition upstream of Pine Flats Campground is in fair to good condition, although a decrease in pool frequency from 1990 in the Pine Flats to Young Creek area was noted.

Off-channel areas from Pine Flats Campground to Mad Lake are hydrologically connected to main channels and are in good condition (Archibald et al., 2003a). The occurrence of off channel habitat is tightly linked to natural channel confinement by bedrock (Archibald et al., 2003a). In the lower mainstem, floodplain developments have reduced off-channel habitat. Side channels made up only 1% of the wetted habitat area in both the 1990 and 1995/97 stream surveys.

Throughout most of the Mad River watershed, streambank erosion and mass wasting is mainly due to natural bank-cutting at the apex of channel bends. General streambank condition from Pine Flats Campground upstream is in good condition (Archibald et al., 2003a). Streambank conditions in the area from the mouth to Pine Flats Campground are fair. Active bank erosion of the lower Mad River is due mainly to human activity at the town of Ardenvoir, and the close proximity of roads.

Fish Passage Barriers

Historically, fish passage was affected by migration barriers. The last remaining man-made passage barrier within the Mad River watershed, an irrigation diversion dam at Mad River mile 0.26, was reconstructed in November 1994 to be fully passable at all flows for steelhead, spring chinook, bull trout and cutthroat trout (Archibald et al., 2003a). In 2001 and again in 2002 a "swimming pool" was created (and then dismantled) in the lower

Mad River near Mill Camp. Currently, no man-made passage barriers to fish are present on the mainstem Mad River (Archibald et al., 2003a). In Tillicum Creek near RM 2, two potential barriers to steelhead passage exist within ¼ mile of one another. A natural barrier exists slightly upstream of the upper barrier (Figure 17).

The SSHIAP (WDFW, 2003) Barriers GIS layer shows the following natural fish passage issues:

- Cougar Creek has a natural falls (~RM 2.5) that is a complete fish passage barrier.
- Mad River (upstream from Jimmy Creek) has a complete barrier due to cascades, gradient or velocity.
- Mad River (downstream from Alma Creek) has a log jam that is a partial fish passage barrier.
- Tillicum Creek has a natural falls (RM 3.8) that is a complete fish passage barrier.

Ecological Conditions

Many ecologic attributes remain intact from the historic reference condition. Cutthroat trout are known to occur in the headwaters and upper Mad River, its major tributaries and Mad Lake The headwaters of the Mad River are considered to have genetically “pure” and "good" phenotypic representatives of westslope cutthroat trout (Archibald et al., 2003b).. The confluence of Cougar Creek and Mad River is known to be a critical area within the subbasin for bull trout spawning and rearing.

Food

A lack of anadromous salmonid carcasses and nutrient inputs is noted, although 1992 macroinvertebrate sampling data showed good health of the aquatic community. Macroinvertebrate species diversity and abundance are considered indicative of the good health of the aquatic community and of general good water quality for the Mad River (Archibald et al., 2003a).

Pathogens

Steelhead smolts were out-planted (until 1999) in the Mad River; impacts to fish health resulting from pathogens is unknown.

Introduced Species

In those areas of the watershed accessible to anadromous fish, the issue of non-native fish versus native fish is complicated because it is accepted that the native salmon and steelhead stocks (coho, summer steelhead and spring chinook) present prior to European settlement were eliminated (by barriers to passage) from the Entiat by the 1930’s. Following the 1930’s, the Grand Coulee Maintenance Project began the stocking of salmonids which, in the Entiat, included sockeye, a species not native to the Entiat, coho, steelhead, and chinook stocks trapped at Rock Island Dam and/or introduced from the lower Columbia River. Subbasin-wide, the genetic makeup of westslope cutthroat trout is considered to be intact, although extensive introductions from populations reared out of the subbasin may have affected this species (Archibald et al., 2003a). It is not understood to what degree hatchery steelhead out-plants interact or spawn with cutthroat trout.

Environmental/Population Relationships

The Entiat and Mad Rivers currently support runs of steelhead, bull trout, and spring and late-run chinook salmon. Coho salmon were once present in the Entiat watershed (Mullan et al., 1992; CCCD, 2004), but are now considered extinct. Sockeye salmon were also introduced into the Entiat River at one point. Notably, both coho and sockeye have recently been found utilizing the Entiat River (CCCD, 2004). The Entiat River and the Mad River interact by providing connectivity and habitat for different life stages, i.e. the majority of bull trout spawning occurs in the Mad River but the Entiat River provides holding and rearing habitat and connectivity to other watersheds and subbasins (Archibald et al., 2003a).

Areas of Special Interest

Protection of existing riparian bottomlands in the lower Mad River (MCMCP, 1998; Andonaegui, 1999; UCRTT, 2002), aquatic habitat, fluvial processes, and floodplain function are of special interest in the Mad River (UCRTT, 2002).

Limiting Factors

- Wintertime low temperatures and the formation of anchor ice in the lower Mad River may limit salmonid production (WNF, 1996). Anchor ice formations associated with loss of riparian cover and changes in channel morphology are a limiting factor (UCRTT, 2002).
- A lack of overwintering juvenile rearing habitat, especially in the lower watershed limits productivity and distribution of steelhead and chinook (Andonaegui 1999; CCCD, 2004).
- Sediments may limit productivity due to un-forested and erosive uplands (UCRTT, 2004).
- River access may allow harassment or poaching of bull trout (UCRTT, 2004) and other species.
- The road constricts the channel increasing flow velocities and limiting habitat diversity on mainstem from Pine Flat Campground downstream to mouth (Archibald et al., 2003).

Functional Relationship of Mad River within the Entiat Subbasin

The Mad River is a stronghold for bull trout and provides a migration corridor, spawning, and rearing habitat for spring chinook, steelhead, bull trout, and cutthroat trout. The Mad River AU has been designated as a Category 1 watershed, with three (3) significant subwatersheds, including the Upper Mad River, Middle Mad River, and Lower Mad River (UCRTT, 2004). It serves as critical refugia and habitat for maintaining and recovering at-risk-stocks of anadromous salmonids and resident fish species.