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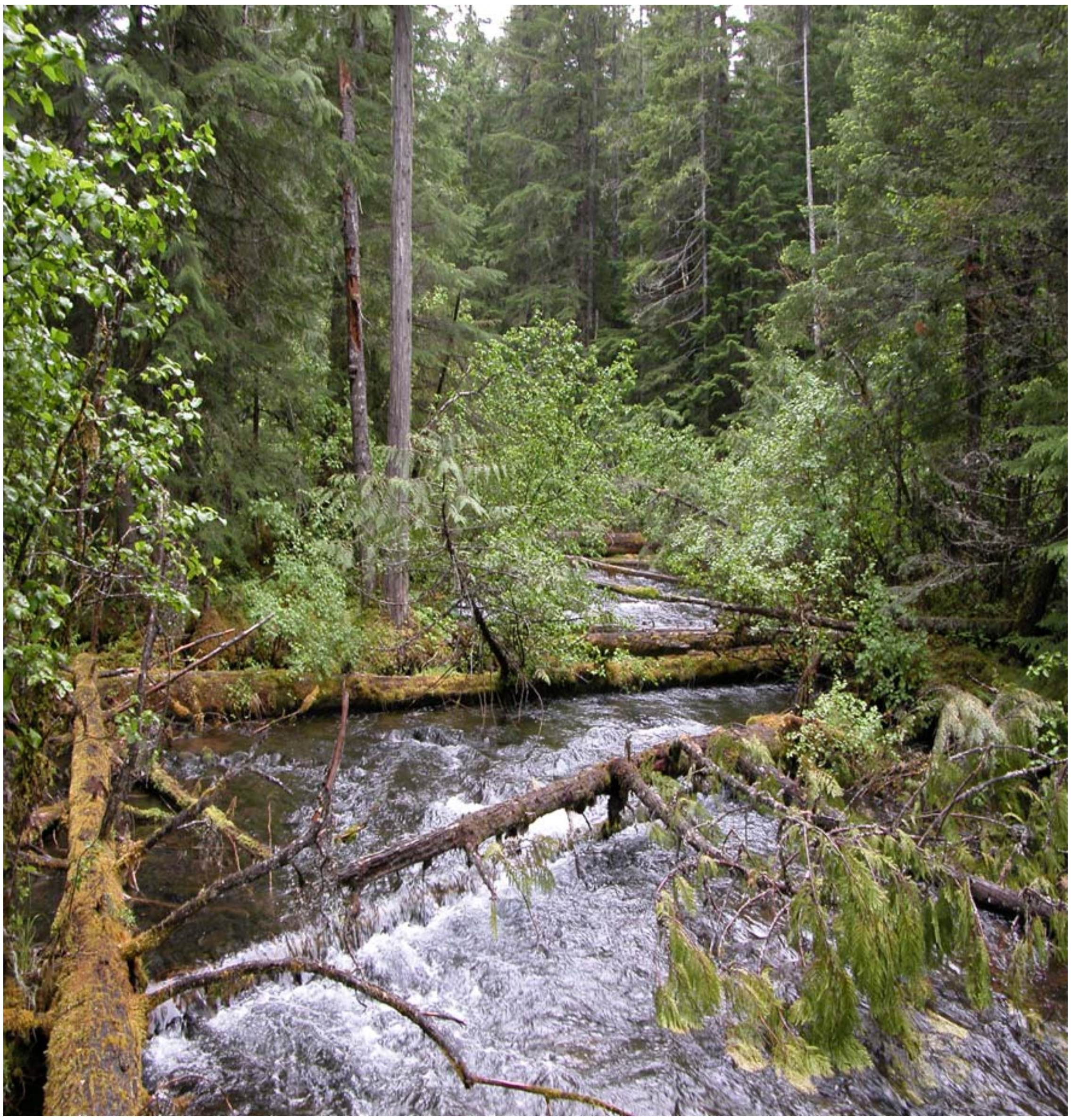
Clackamas River Bull Trout Reintroduction Feasibility Assessment



Pinhead Creek, a suitable bull trout spawning and rearing tributary to the upper Clackamas River.

Clackamas River Bull Trout

Reintroduction Feasibility Assessment

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for the

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# Acknowledgements

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Note to Reader

This feasibility assessment is not a decision document, nor does it convey a decision to reintroduce bull trout into the Clackamas River Subbasin. Should a proposal be developed to reintroduce bull trout into the Clackamas River Subbasin, the responsible federal and state agencies would initiate required rule-making and decision-making processes. These processes would include opportunities for public involvement as well as necessary environmental analysis and regulatory compliances.

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Executive Summary

Bull trout were abundant and widely distributed in the Clackamas River Subbasin. They were a historical component of the river's native fish assemblage that evolved over thousands of years. Presently, bull trout are extirpated from the Clackamas River Subbasin. Bull trout were listed as threatened under the Endangered Species Act by the U.S. Fish and Wildlife Service in 1998. The 2002 draft bull trout recovery plan specified the need for completing an assessment to determine the feasibility of reintroduction in the Clackamas River Subbasin. Accordingly, the Clackamas River Bull Trout Working Group (CRBTWG) completed the following feasibility assessment. The feasibility assessment focuses on whether or not a reintroduction is biologically possible (i.e., "Can it be done?"). Four questions are examined:

- Is there a high level of confidence that bull trout are no longer present that would serve as a natural gene bank?
- Is there suitable habitat remaining, what conditions or stressors currently prevent bull trout from occupying suitable habitats, and have these been corrected?
- Is suitable habitat reasonably expected to be recolonized through natural processes if conditions are improved?
- Is a suitable or compatible donor population(s) available that can itself tolerate some removal of individuals?

The feasibility assessment does not attempt to determine "Should a reintroduction be done?" or "How should it be done?" Answering these two latter questions would be done after a proposed action is developed in a coordinated, multi-agency manner, including public involvement.

There is a very high level of confidence that bull trout have been locally extirpated from the subbasin. Primary factors for their decline began in the early 20th Century and extended into the 1970s. They include migration barriers from hydroelectric and diversion dams, direct and incidental harvest in the sport and commercial fisheries, targeted eradication with bounty fisheries, and habitat and water quality degradation from forest management and agricultural activities. These factors are believed to be sufficiently remedied such that they would not impede the success of a reintroduction attempt.

Bull trout require very cold water for spawning and rearing. The portion of the subbasin providing suitable bull trout spawning and rearing habitat today includes the tributaries and headwaters of the Clackamas River upstream of the Collawash River confluence. This portion of the subbasin contains six separate habitat patches totaling approximately 70 miles of suitable spawning and rearing habitat. Habitat patches range in size, configuration, and condition.

The nearest five potential donor stocks in the Lower Columbia River portion of the Coastal evolutionary lineage of bull trout were examined. They are found in the nearby Willamette, Lewis, Hood, Klickitat, and Deschutes river basins. The donor stocks are located considerable distances from the Clackamas River Subbasin, and in many cases migration barriers preclude their movement making natural recolonization of the subbasin extremely unlikely. Two river basins contain bull trout that likely have the necessary characteristics and associated low level of risk (both demographically and genetically) to serve as donor stocks for a reintroduction into the Clackamas River:

- Lewis River Basin – Two interacting local populations: Pine Creek and Rush Creek.

- Lower Deschutes River Basin (Metolius River Subbasin) – Three interacting local populations: Whitewater River; Jefferson, Candle, and Abbot River Complex; and Canyon, Jack, Heising, and Mainstem Metolius River Complex.

Other potential bull trout donor stocks that contain the necessary characteristics but are at an intermediate level of risk (both demographically and genetically) include:

- The Mainstem McKenzie River local population in the Willamette River Basin (McKenzie River Subbasin).

- The Warm Springs River and Shitike Creek local populations in the Lower Deschutes River Basin.

Nonnative brook trout can have significant negative effects on bull trout distribution and abundance. However, recent studies suggest that certain habitat variables play a strong role in determining the level of effect. Brook trout are present in low abundance in one of the six suitable habitat patches (Upper Clackamas River above Cub Creek) where a bull trout reintroduction could take place. Their presence is due to several decades of stocking headwater lakes with outflow tributaries that connect to downstream suitable habitat. The Oregon Department of Fish and Wildlife discontinued stocking brook trout in the early part of this decade in those headwater lakes in any of the suitable habitat patches where there is an outflow connection to downstream suitable bull trout spawning and rearing habitat. As such, brook trout would not be a significant factor in determining the success of a reintroduction of bull trout in the Clackamas River Subbasin.

Bull trout coexisted with a multitude of other native fish species in the Clackamas River for thousands of years, likely feeding on a variety of different prey species. Historically, anadromous salmon and steelhead were likely the most abundant fish in the subbasin and they probably comprised a significant portion of the bull trout diet. However, current abundance and distribution of anadromous salmon and steelhead in the subbasin is greatly reduced from historic levels. Bull trout, if reintroduced, may be more dependent upon other native fish species as a prey base, such as mountain whitefish and large-scaled suckers, both of which are present and abundant along with other potential prey such as dace, sculpin, northern pike minnow, and several species of trout. Available information on bull trout populations in the Lower Columbia River Basin suggest that, while possibly important, bull trout persistence is not dependent upon the presence of anadromous salmon in all systems.

Due to the multitude of variables that contribute to mortality of juvenile Pacific salmon, including other fish and avian predators, the rate of bull trout predation on juvenile salmon and the potential effect of that predation are unquantifiable. Despite evidence that bull trout prey on juvenile anadromous salmonids when they are available, bull trout and Pacific salmon co-occur in many areas throughout the western United States. Although the distribution and abundance of Pacific salmon in the Clackamas River is reduced significantly from historical levels, the remaining native fish assemblage is considered by local fish biologists to be healthy. For these reasons, it is believed there is a sufficient forage base to support a bull trout reintroduction in the Clackamas River and further, that if reintroduced, predation on juvenile salmon would not likely negatively affect the status of salmon and steelhead populations in the subbasin.

In sum, given the following:

- a high level of confidence that bull trout have been locally extirpated,
- the causes for their decline have been sufficiently mitigated,
- high quality habitat is available in sufficient amounts,
- nearby donor stocks are unlikely to naturally recolonize,
- suitable donor stocks are available that can withstand extraction of individuals,
- nonnative brook trout presence is restricted to a small portion of the suitable habitat and not a likely threat, and
- a diverse and abundant fish assemblage would serve as a sufficient prey base with no obvious threats posed by bull trout to these species,

the overall conclusion based on the scope of the assessment is: *reintroduction of bull trout into the Clackamas River Subbasin is feasible*.

Other factors to be considered in developing a proposed action for reintroduction include: establishment of goals and objectives; specific donor stock(s) to be used; type, quantity, and duration of propagule extraction from the donor stock(s); method of translocation; fish disease screening; specific location(s) and habitat patch(es) for propagule release; additional management actions needed; and specific monitoring and evaluation requirements. Once a proposed action is developed in a collaborative, multi-agency/stakeholder manner involving public review and input, additional considerations and environmental analysis including some of the following need to be further investigated: socio-economic impacts (positive and negative); ecological affects to other native fish species; and ESA regulatory responsibilities for affected agencies and parties. Should a reintroduction be implemented, an adaptive management approach is encouraged in order to incorporate monitoring and evaluation results and feedback into necessary adjustments to achieve developed goals and objectives.

Glossary and Common Abbreviations

Adfluvial
A life history strategy in which bull trout migrate from tributary streams to a lake or reservoir to mature. Adfluvial bull trout return to a tributary to spawn.

Age class
A group of individuals of a species that have the same age, *e.g.*, 1 year old, 2 year old, etc.

Alleles
Alternative forms of a gene that can occupy the same locus on a particular chromosome.

Anadromous
A fish that is born in freshwater, migrates to the ocean to grow and live to adulthood, and then returns to freshwater to spawn (reproduce).

Artificial propagation
The use of artificial procedures to spawn adult fish and raise the resulting progeny in fresh water for release into the natural environment, either directly from the hatchery or by transfer into another area.

Basin
The area of land drained by a river and its tributaries. The term basin is used as it applies to the designated basins of the Columbia River as defined by the Northwest Power and Conservation Planning Council.

BLM
Bureau of Land Management.

Bypass
A structure in a dam that provides a route for fish to move through or around a dam without going through the turbines.

Char
A fish belonging to the genus *Salvelinus* and related to both the trout and salmon. The bull trout, Dolly Varden trout, brook trout, and the lake trout are all members of the char family. Char occur throughout boreal ecosystems in the northern hemisphere, including North America, Europe, and Asia.

CRBTWG
Clackamas River Bull Trout Working Group.

Core area
The combination of core habitat (*i.e.*, habitat that could supply all elements for the long-term security of bull trout) and a core population (a group of one or more local bull trout populations that exist within core habitat) constitutes the basic unit on which to gauge recovery within a recovery unit. Core areas require both habitat and bull trout to function, and the number (replication) and characteristics of local populations inhabiting a core area provide a relative indication of the core area's likelihood to persist. A core area represents the closest approximation of a biologically functioning unit for bull trout.

Core habitat
Habitat that encompasses spawning and rearing habitat (resident populations), with the addition of foraging, migrating, and overwintering habitat if the population includes migratory fish. Core habitat is defined as habitat that contains, or if restored would contain, all of the essential physical elements to provide for the security of and allow for the full expression of life history diversity of one or more local populations of bull trout. Core habitat may include currently unoccupied habitat if that habitat contains essential elements for bull trout to persist or is deemed critical to recovery.

Core population
A group of one or more bull trout local populations that exist within core habitat.

CTWS
Confederated Tribes of the Warm Springs.

Distinct population segment (DPS)
A listable entity under the Endangered Species Act that meets tests of discreteness and significant according to U.S. Fish and Wildlife Service policy. The U.S. Fish and Wildlife Service has formally determined there are five bull trout distinct population segments across the species range within the coterminous United States--Klamath River, Columbia River, Jarbidge River, Coastal, and St. Mary-Belly River. Each meets the tests of discreteness and significance under joint policy of the U.S. Fish and Wildlife Service and National Marine Fisheries Service (61 FR 4722), and these are the units against which recovery progress and delisting decisions will be measured.

Discharge (stream)
With reference to stream flow, the quantity of water that passes a given point in a measured unit of time, such as cubic meters per (cms) second or, often, cubic feet per second (cfs).

Effective population size (Ne)
The number of reproducing individuals in an ideal population that would lose genetic variation due to genetic drift or inbreeding at the same rate as the number of reproducing adults in the real population under consideration. Typically, Ne is less than either a population's total number of sexually mature adults present or the total number of adults that reproduced. Effective population number can be defined either in terms of the amount of increase in homozygosity (inbreeding effective number) or the amount of allele frequency drift (variance effective number).

Entrainment
Process by which aquatic organisms are pulled through a diversion, turbine, spillway, or other device.

ESA
Endangered Species Act (federal).

Extirpated
Elimination of a species from a particular local area.

Fine sediment (fines)
Sediment with particle sizes of 2.0 mm (.08 inch) or less, including sand, silt, and clay.

Fish ladder
A device to help fish swim around a dam.

Floodplain
The land adjacent to a stream channel, typified by flat ground and periodic floodwater submersion.

Flow regime
The quantity, frequency and seasonal nature of a stream's flow.

Fluvial bull trout
A life history in which bull trout migrate from tributary streams to larger rivers to mature. Fluvial bull trout migrate to tributaries to spawn.

Foraging, migrating, and overwintering habitat (bull trout)
Relatively large streams and mainstem rivers, including lakes or reservoirs, estuaries, and nearshore environments, where subadult and adult migratory bull trout forage, migrate, mature, or overwinter. This habitat is typically downstream from spawning and rearing habitat and contains all the physical elements to meet critical overwintering, spawning migration, and subadult and adult rearing needs. Although use of foraging, migrating, and overwintering habitat by bull trout may be seasonal or very brief (as in some migratory corridors), it is a critical habitat component.

Functionally extirpated
Describes a species that has been extirpated from an area; though a few individuals may occasionally be found, they are not thought to constitute a viable population.

Genotype
The set of alleles (variants of a gene) possessed by an individual at a particular locus or set of loci.

Habitat connectivity (stream)
Suitable stream conditions that allow fish and other aquatic organisms to move freely upstream and downstream. Habitat linkages that connect to other habitat areas.

Headwaters
The source of a stream. Headwater streams are the small swales, springs, creeks, and streams that are the origin of most rivers. These small streams join together to form larger streams and rivers or run directly into larger streams and lakes.

Hybridization
A crossing of individuals of different genetic composition, typically different species, that results in hybrid offspring.

Hydrologic unit code (HUC)
Watersheds that are classified into four types of units: regions, subregions, accounting units, and cataloging. The units from the smallest (cataloging units) to the largest (regions). Each unit is identified by a unique hydrologic unit code consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

Hyporheic zone
The area of saturated sediment and gravel beneath and beside streams and rivers that contribute to subsurface flows. Water movement is mainly in a downstream direction**.**

IMST
Independent Multidisciplinary Science Team.

Intermittent stream
A stream that flows only at certain times of the year as when it receives water from springs (or by surface water) or when water losses from evaporation or seepage exceed the available streamflow.

Interspecific competition
Competition for limiting, shared resources between two or more different species.

Introgression (genetic)
The spread of genes from one species into the gene pool of another by hybridization or by backcrossing (interbreeding between hybrid and parental species or between hybridized individuals).

Local population
A group of bull trout that spawn within a particular stream or portion of a stream system. Multiple local populations may exist within a core area. A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. For most waters where specific information is lacking, a local population may be represented by a single headwater tributary or complex of headwater tributaries. Gene flow may occur between local populations (*e.g.*, those within a core population), but is assumed to be infrequent compared with that among individuals within a local population.

Metapopulation
A group of semi-isolated local populations of bull trout that are interconnected and that probably share genetic material. May also include unoccupied habitats depending on the equilibrium between extinction and recolonization among habitats.

Migratory corridor
Stream reaches used by bull trout to move between habitats. A section of river or stream used by fish to access upstream spawning areas or downstream lake environments.

Migratory
A life history in which bull trout migrate from spawning and rearing habitat to lakes, reservoirs, or larger rivers to grow and mature, or to seek refuge.

NMFS
National Marine Fisheries Service.

Nonnative species
A species not indigenous to an area, such as brook trout in the western United States.

ODFW
Oregon Department of Fish and Wildlife.

Peak flow (stream)
The greatest stream discharge recorded over a specified period of time, usually a year, but often a season. Sometimes also defined by the frequency of occurrence or modeled return interval of specific flows (e.g., a 100-year peak flow event).

PGE
Portland General Electric.

Phenotype
Expressed physical, physiological, and behavioral characteristics of an organism that may be due to genetics, the environment, or an interaction of both.

Piscivorous
Describes fish that prey on fish for food.

Population
A group of individuals that belong to the same species and freely interbreed.

Recovery subunit (bull trout)
Portions of larger recovery units treated separately to improve management efficiency. For example, the Clark Fork Recovery Unit is divided into Upper Clark Fork, Lower Clark Fork, Priest, and Flathead recovery subunits.

Recovery unit (bull trout)
The major unit for managing recovery efforts. Each recovery unit is described in a separate chapter in the recovery plan. A distinct population segment may include one or several recovery units. Most recovery units consist of one or more major river basins. Several factors were considered in identifying recovery units, for example, biological and genetic factors, political boundaries, and ongoing conservation efforts. In some instances, recovery unit boundaries were modified to maximize efficiency of established watershed groups, encompass areas of common threats, or accommodate other logistic concerns. Recovery units may include portions of mainstem rivers (*e.g.*, Columbia and Snake rivers) when biological evidence warrants inclusion. Biologically, recovery units are considered groupings of bull trout for which gene flow was historically or is currently possible.

Redd
A nest constructed by female fish of salmonid species in streambed gravels where eggs are deposited and fertilization occurs. Redds can sometimes be distinguished in the streambed gravel by a cleared depression, and an associated mound of gravel directly downstream.

Resident
A life history in which bull trout do not migrate, but reside in tributary streams their entire lives.

Riparian area
An area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

RM
River Mile.

Salmonid
Fish of the family Salmonidae, including trout, salmon, chars, grayling, and whitefish. In general usage, the term most often refers to salmon, trout, and chars (subfamily Salmoninae).

Scour
Concentrated erosive action by stream water, as on the outside curve of a bend; also, a place in a streambed swept clear by a swift current. Scour specifically refers to the transport of riverbed material by stream flow.

Smolt
A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater environment to a saltwater environment.

Spawning and rearing habitat (bull trout)
Stream reaches and the associated watershed areas that provide all habitat components necessary for spawning and juvenile rearing for a local bull trout population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident or migratory fish and may also support sub-adults and adults from local populations of resident bull trout. Most generally defined by occurrence of suitably cold water temperatures and suitable stream sizes.

Spawning escapement
The number of adult fish from a specific population that survive spawning migrations and enter spawning grounds.

Stochastic
Describes a natural event or process that is random or unpredictable. Examples include environmental conditions such as rainfall, runoff, and storms, or life-cycle events, such as survival or fecundity rates.

Stock
The fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season. A group of fish belonging to the same population, spawning in a particular stream in a particular season.

Subbasin
A smaller drainage area within a basin. The term subbasin is used as it applies to the designated subbasins of the Columbia River as defined by the Northwest Power and Conservation Planning Council.

Subpopulation
Breeding groups within a larger population between which migration is significantly restricted.

Subwatershed
A smaller watershed area within a watershed. The topographic perimeter of the smaller watershed area containing a tributary stream within a defined watershed.

Transplant
To move naturally reproducing fish from one stream system to another without the use of artificial propagation.

USACE
United States Army Corps of Engineers.

USFS
United States Forest Service.

USFWS
United States Fish and Wildlife Service.

Water yield
The quantity of water available from a stream at a given point over a specified duration of time.

Watershed
The area of land from which rainfall (and/or snow melt) drains into a stream or other water body. Watersheds are also sometimes referred to as catchments, drainage basins, or drainage areas. Ridges of higher ground generally form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

WDAFS
Western Division of the American Fisheries Society.

WDFW
Washington Department of Fish and Wildlife.

Woody material
Woody material such as trees and shrubs; includes all parts of a tree such as root system, bowl, and limbs. Large wood refers to the woody material whose average diameter is greater than 24 inches, and whose length is greater than 50 feet.

Chapter 1 – History, Status, and Draft Recovery Plan Guidance for Bull Trout in the Clackamas River Subbasin

1.1 Introduction

This assessment investigates the feasibility of reintroducing bull trout (*Salvelinus confluentus*) into the Clackamas River Subbasin, a tributary of the Willamette River (Figure 1. 1). Bull trout were a historic component of the native fish assemblage in the Clackamas River, but they are now locally extirpated (Buchanan et al. 1997, Ratliff and Howell, 1992). Although bull trout are presently widespread within their historic range in the coterminous United States, they have declined in overall distribution and abundance during the last century (USFWS 2002), and they were listed in 1998 as threatened under the federal Endangered Species Act (ESA).

For the past two decades, local fish biologists have informally discussed the possibility of reintroducing bull trout into the Clackamas River Subbasin. In 2004, the Clackamas River Bull Trout Working Group (CRBTWG) began exploring this more formally. Many fish species reintroductions have occurred throughout the United States without a thorough assessment or documented plan. Many of these efforts were unsuccessful and in most cases there was insufficient documentation to evaluate these failed attempts (Williams et al. 1988).

This assessment represents a collaborative, comprehensive examination of the various factors involved in determining whether or not a bull trout reintroduction into the Clackamas River is feasible. Inevitably, it is easy to jump ahead to the various factors and issues involved in contemplating a potential reintroduction of bull trout into the Clackamas River. Some of these factors and issues include which is the best donor stock, where should bull trout be released, what method of translocation should be used, and what are the ecological impacts of reintroduction? The authors have focused this assessment specifically on the biological feasibility of reintroduction – that is, "Can a reintroduction of bull trout into the Clackamas River be done?" This specific focus thereby determines the scope of this feasibility assessment. This assessment, itself, does not attempt to determine "Should a reintroduction be done?" or "How should it be done?" Once the feasibility of a reintroduction is established, only then can a proposed action be developed in coordination with multi-agency policy and decision-makers to investigate the latter two questions further through administrative and regulatory procedures. It is imperative that reviewers of this assessment understand its breadth and scope. The authors of this assessment explore, in detail, all of the facets of the first and most fundamental question: "Can a reintroduction of bull trout into the Clackamas River be done?" The assessment answers this question and goes further to provide valuable baseline information that would be useful in addressing the latter two questions, should a reintroduction effort be pursued.

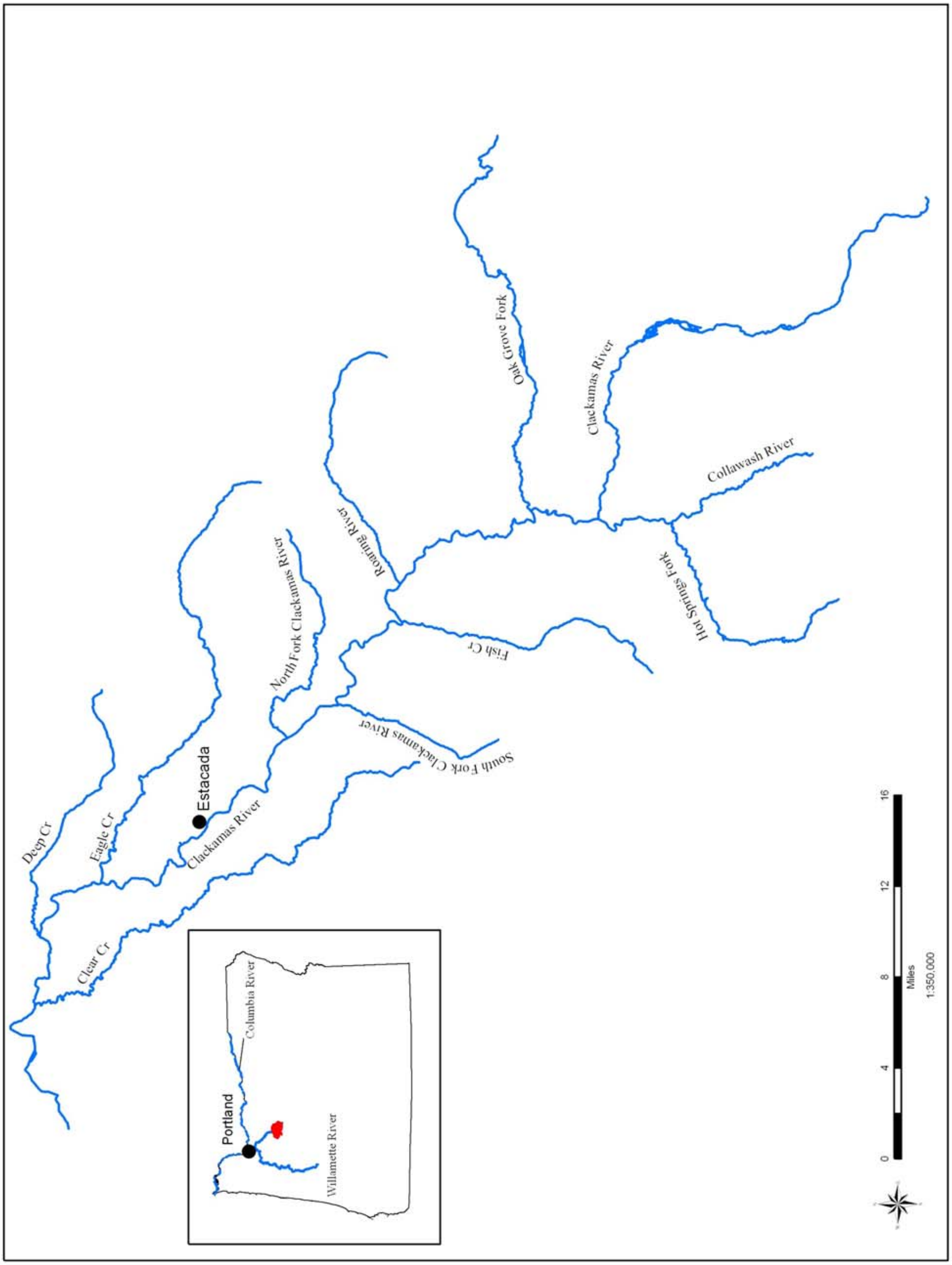

Figure 1. 1. Clackamas River Subbasin Vicinity Map.

This feasibility assessment is based in part on recommendations in the U. S. Fish and Wildlife Service's (USFWS) Draft Bull Trout Recovery Plan (draft recovery plan) (USFWS 2002), which calls for such assessments in order to restore, where habitat is deemed sufficient, distribution to previously occupied areas (i.e., historic habitat). Restoring bull trout to historic habitat is a major recovery goal and objective listed in the draft recovery plan and it is particularly relevant to habitats in the western portion of the species' range due to the extensive loss of distribution and the documented extirpation of multiple bull trout populations. The Willamette River, a tributary of the Lower Columbia River, has experienced extirpations of bull trout from three, and perhaps four, major subbasins, including the Clackamas River.

Although the overall recovery strategy is to reduce and minimize threats affecting bull trout and their habitat in the Willamette River Basin, the magnitude of bull trout extirpations, combined with the size of the basin and low probability of natural recolonization, will likely require reintroductions.

Epifanio et al. (2003) outlined four questions that should be addressed before implementing a reintroduction program. The CRBTWG reviewed the four questions and adapted them to provide the focus and structure for this feasibility assessment:

1. Is there a high level of confidence that bull trout are no longer present that would serve as a natural gene bank?
2. Is there suitable habitat remaining, what conditions or stressors have prevented bull trout from occupying suitable habitats, and have these been corrected?
3. Is suitable habitat reasonably expected to be recolonized through natural processes if conditions are improved?
4. Is a suitable or compatible donor population(s) available that can itself tolerate some removal of individuals?

This feasibility assessment addresses the four questions above, as well as other issues the CRBTWG identified as necessary to address in an evaluation of a possible bull trout reintroduction effort in the Clackamas River. An overview of the various sections of the assessment is provided below.

Each chapter in this assessment begins by outlining the key questions pertinent to that chapter and ends with a brief summary providing specific recommendations or conclusions where appropriate.

Chapter 1 reviews the history of bull trout and the reasons for their decline, provides a summary of interagency efforts confirming the absence of bull trout in the Clackamas River Subbasin, and highlights key recommendations from the draft recovery plan (USFWS 2002).

Chapter 2 assesses important habitat considerations, outlining both the presumed historical distribution of bull trout in the Clackamas River and the current suitable habitat.

Chapter 3 provides an analysis of potential donor stocks and addresses genetic considerations.

Chapter 4 addresses potential ecological interactions between bull trout and nonnative brook trout and between bull trout and native fish species, including those listed under the ESA. Chapter 4 also examines food web considerations and the adequacy of a prey base to support a self-sustaining, reintroduced population of bull trout.

Chapter 5 summarizes the preceding chapters, outlines additional considerations should a reintroduction be proposed, and identifies the need for an adaptive management approach.

An earlier draft of this assessment (November 2006) was prepared and distributed for review. At the request of the Oregon Department of Fish and Wildlife (ODFW), an independent scientific review of the earlier draft was completed by the State of Oregon Independent Multidisciplinary Science Team (IMST). The earlier draft was also reviewed by other local bull trout experts. Changes to the earlier draft are incorporated into this final assessment based on feedback from the IMST and other reviewers. A detailed response to each comment made by the IMST is appended at the end of this document.

Geographic Area of Focus

The primary geographic area of focus for this assessment is the Clackamas River and its tributaries upstream of North Fork Dam at river mile (RM) 30 (Figure 1. 2). Approximately 71 percent of the land in this portion of the subbasin is under federal ownership, administered by the U. S. Forest Service (USFS) and the Bureau of Land Management (BLM). Approximately 2. 8 percent is in tribal ownership on the extreme eastern edge of the watershed (Confederated Tribes of the Warm Springs Reservation). No suitable bull trout spawning and rearing habitat is known to occur downstream of the North Fork Dam. The only suitable spawning and rearing habitat for bull trout occurs in the headwaters of the subbasin on lands administered by the USFS.

In the Clackamas River Subbasin within the National Forests boundary (171,051 hectares), there are 165,540 hectares (413,850 acres) of National Forest ownership or 96. 8 percent of the land base, 1,602 hectares (4006 acres) BLM or 1 percent of the land base, and 3,909 hectares (9,772 acres) of private or 2. 2 percent of the land base approximately.

The Upper Clackamas River which consists of the entire watershed upstream of the river’s confluence with Collawash River and where all suitable bull trout spawning and rearing habitat is located, encompasses 40,624 hectares (101,560 acres). The majority of this 5^{th} field hydrologic unit code (HUC) watershed is in U. S. Forest Service ownership at 38,105 hectares (95,263 acres) or 93. 8 percent; 2,240 hectares (5,600 acres) or six percent are in tribal ownership (outside of the national forest boundary); and 64. 4 hectares (161 acres) or 0. 2 percent are in private ownership.

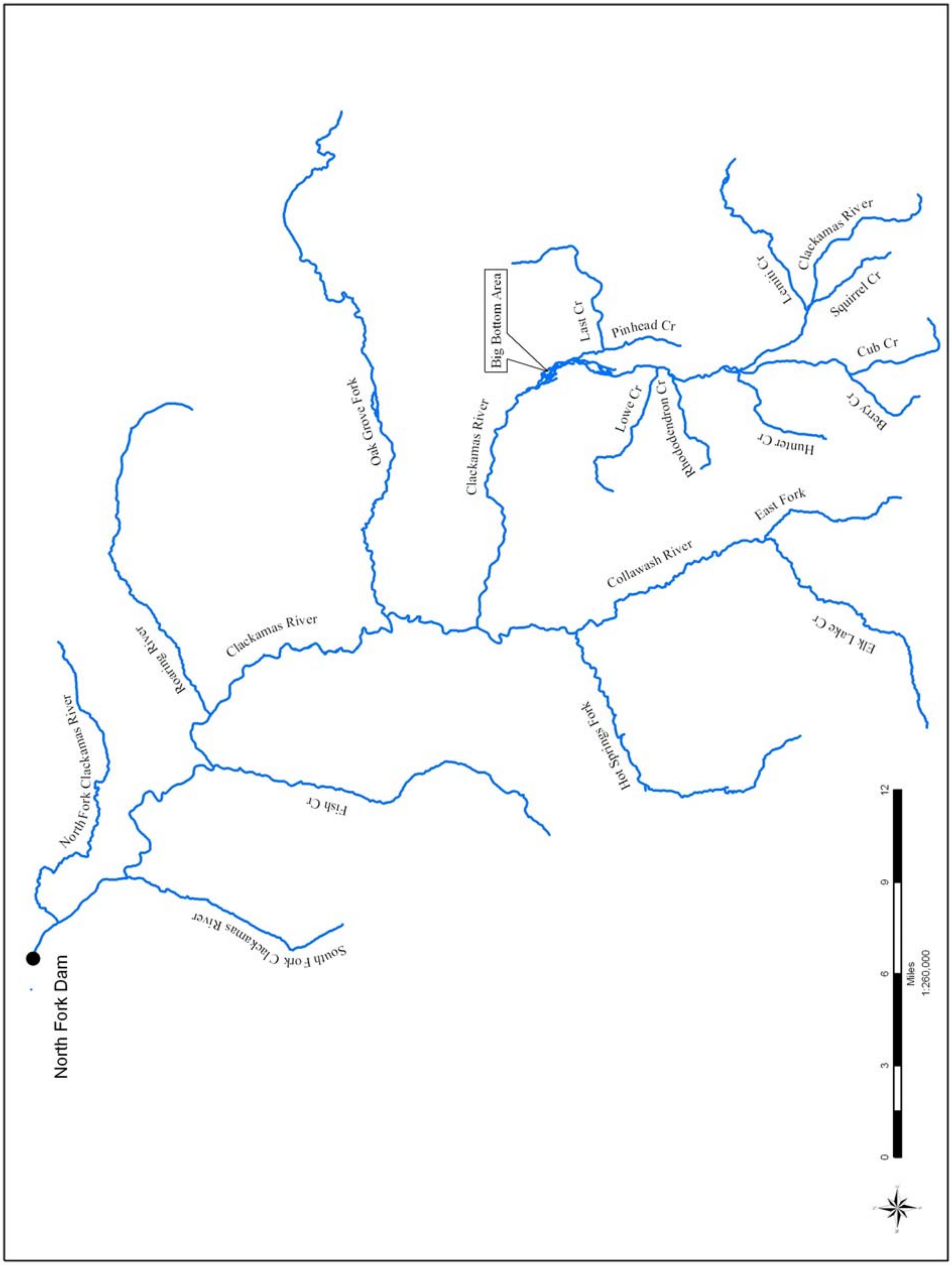

Figure 1. 2. Clackamas River Subbasin Upstream of North Fork Dam.

The Clackamas River Bull Trout Working Group (CRBTWG)

The Clackamas River Bull Trout Working Group (CRBTWG) is comprised of local fish biologists who work in the Clackamas River Subbasin. The CRBTWG originated in the early 1990s with three primary partners: ODFW, Portland General Electric (PGE), and USFS. Beginning in 1999, the federal recovery planning efforts that followed the 1998 listing of bull trout provided the mechanism to expand the collaborative partners in the CRBTWG to include representation from other local, state, federal, and tribal governments. In 2001, efforts were initiated to begin implementing actions outlined in the draft recovery plan, thus reuniting the CRBTWG with additional partner representation. Joining the CRBTWG was Clackamas County, the Confederated Tribes of the Warm Springs (CTWS), and the USFWS.

The key questions to be addressed in Chapter 1 are:

- What is the historical distribution of bull trout in the Clackamas River?
- Are bull trout still present in the Clackamas River?
- What were the causes/factors for their decline?
- Have those causes/factors been corrected?
- What are the key recommendations from the draft recovery plan for the Clackamas River Subbasin?

1.2 Willamette River Basin Overview

The distribution and abundance of bull trout has declined dramatically throughout its range, especially west of the Cascade Mountains in Oregon (Ratliff and Howell 1992, Goetz 1994, Buchanan et al. 1997). Because of the present or threatened destruction, modification or curtailment of its habitat or range, the USFWS listed bull trout in the lower 48 states in 1998 as threatened under the ESA.

With the exception of the McKenzie River, bull trout in the Willamette River Basin of western Oregon have been extirpated from all subbasins where they were found historically. The dates of last verified observations of bull trout from each subbasin are: 1963 from the Clackamas River, 1953 in the South Santiam River, 1945 in the North Santiam River, and 1990 in the Middle Fork Willamette River (Figure 1. 3).

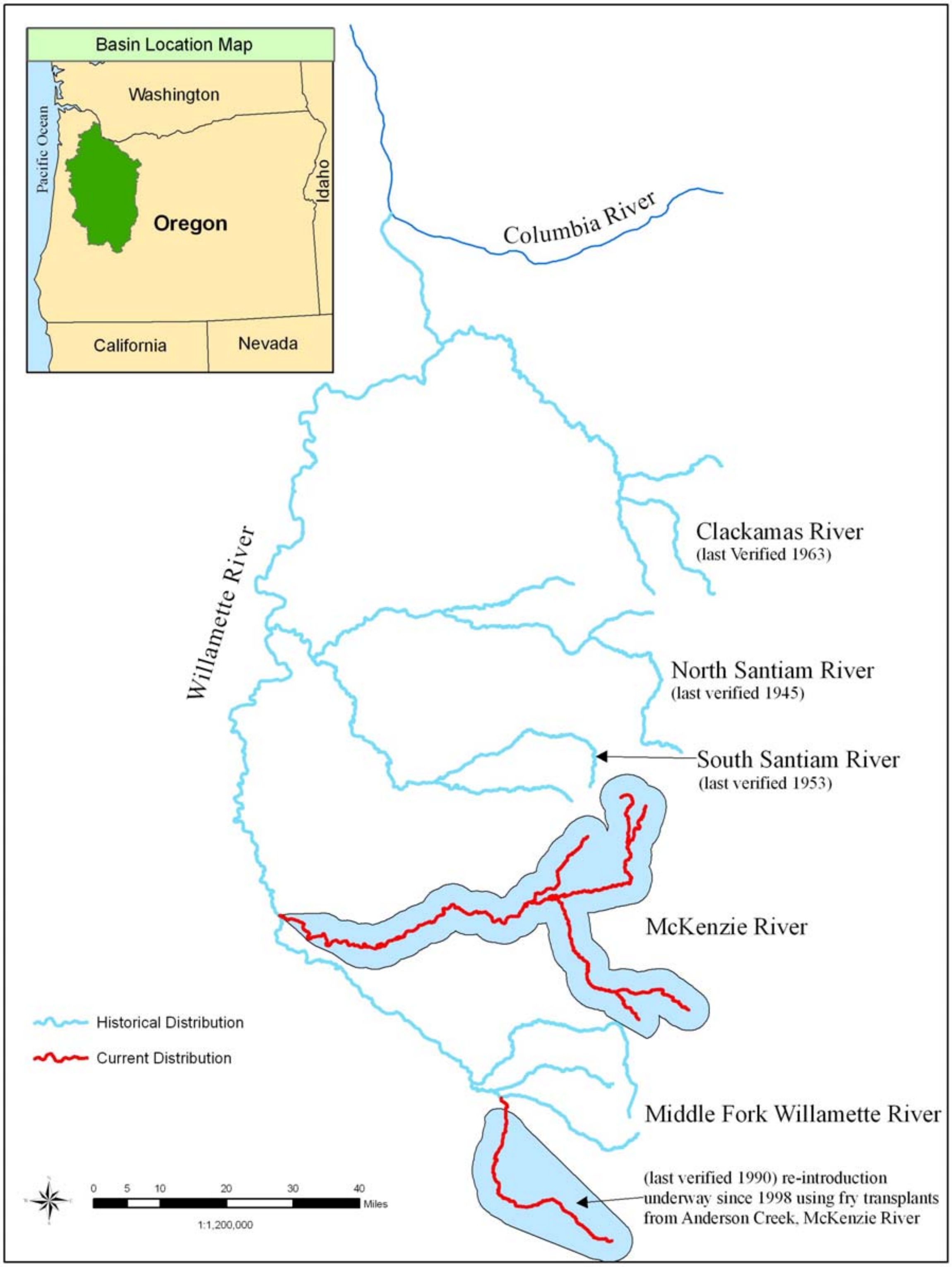

Figure 1. 3. Historic vs. Current Bull Trout Distribution in the Willamette River Basin.

As noted above, the historic population of bull trout in the Middle Fork Willamette is thought to have been extirpated. However, a small number of bull trout currently exist in the upper Middle Fork Willamette River, most likely from an effort to transplant bull trout fry from the McKenzie River to rearing areas above Hills Creek Reservoir. Transplants of fry occurred from 1997 to 2005 and will continue again starting in 2007. Limited bull trout spawning likely representing recruitment of adults from these transplants was documented in the Middle Fork Willamette River in 2005 and 2006.

The McKenzie River currently supports two small isolated populations of bull trout, each numbering less than 100 spawning adults, and one migratory population in the mainstem McKenzie River comprised of approximately 130 spawning adults. The two isolated populations in the McKenzie River resulted from the construction of Trail Bridge Dam in 1963 on the upper mainstem McKenzie River, and Cougar Dam in 1963 on the South Fork McKenzie River. These two dams isolated bull trout above them and fragmented what was historically a single McKenzie River population.

1.3 Clackamas River Subbasin Overview

The last documented bull trout observation in the Clackamas River system was in 1963 (Goetz 1989), although anecdotal evidence suggests they were present in the subbasin through the early to mid-1970s (Zimmerman 1999). Compared to other subbasins of the Willamette River historically occupied by bull trout, a relatively significant amount of information, both verified and anecdotal, is available for the Clackamas River. Most historical records from the Clackamas River refer to bull trout as “Dolly Varden” because bull trout were not widely recognized as a distinct char species until the work of Cavender (1978) and Haas and McPhail (1991). A chronology of available information is detailed below:

Verified Reports and Citations

- The oldest record of bull trout in the Clackamas River Subbasin occurred in 1878 when a specimen collection was made by Livingston Stone. This specimen was located by the CRBTWG in 2005 and currently resides in the Smithsonian Institute, in Washington D. C.
- Murtagh et al. (1992) cited a newspaper article in a 1914 edition of the Estacada Progress that offered a prize for the largest “Dollar-Varden” caught in the Clackamas River.

- Extensive creel surveys of trout anglers were conducted by the Oregon Game Commission (OGC) in 1941 and 1946. In 1941, 28 “Dolly Varden” were caught in a seven-mile reach of the Clackamas River (RM 48 to 55) extending from Indian Henry and the Alder Flat, upstream to one mile above the mouth of the Collawash River (Nielson and Campbell 1941). The study reach included the extreme lower reaches of the Oak Grove Fork Clackamas and Collawash rivers. Total effort during the April 12 to October 15, 1941 trout season was 7,956 angling hours. “Dolly Varden” comprised 0. 3 percent of the total trout catch, and 12 “Dolly Varden” exceeded 14 inches in length. In 1946, the study area along the mainstem Clackamas River was shortened by one mile and the trout season was shortened (May 11- October 10). However, total effort in 1946 (7,734 angling hours) was similar to 1941 (Campbell 1947a). Two “Dolly Varden” were caught in 1946 and comprised 0. 04 percent of the total trout catch. One “Dolly Varden” exceeded 16 inches in length. In addition to bull trout caught within the Clackamas River study area, Campbell (1947b) reported an additional two “Dolly Varden” were caught in 1946 in the Clackamas or Collawash Rivers outside the study area.
- The annual creel census conducted by the OGC included “Dolly Varden” between 12 and 14 inches caught in the Clackamas River in 1960 (Stout 1960).
- One “Dolly Varden” was captured in North Fork Reservoir during a 1963 OGC trap net survey (Stout 1963).
- The OGC reported in 1964, “limited numbers of “Dolly Varden”…are widely scattered in the drainage” (Hutchison and Aney 1964).
- Massey and Keeley (1996) reported two 16 to 18 inch bull trout caught by an angler in 1973 from the mainstem Clackamas River near the mouth of the Oak Grove Fork.

Anecdotal Reports

- Cole Gardiner recalled catching bull trout in the late 1930s in the Clackamas River at Memaloose Bridge and the canyon above Faraday. He said that anglers threw them on the bank (Cole Gardiner, angler, personal communication, September 15, 1997).
- Dick Pugh reported that his father, who worked for PGE, fished in the subbasin since the 1920s. He caught “Dolly Varden” as recently as 1953-1954 in the Collawash River and the Clackamas River near the mouth of the Collawash River. Mr. Pugh did not recall the size of the fish. The fish were typically hung on fence posts. He never heard of bull trout being caught in the Oak Grove Fork (Dick Pugh, angler, personal communication, September 22, 1997).
- Eberl and Kamikawa (1992) referred to anecdotal evidence that bull trout were once “plentiful” in Berry Creek, and probably Cub Creek.
- Massey and Keeley (1996) received an anecdotal report of two 18 to 20 inch bull trout caught by an angler in 1959 from the Collawash River near the mouth of the Hot Springs Fork.

- Gene McMullen reported that as a child (late 1930s and 1940s) he used to catch fish that he suspected were bull trout in the Collawash River and the Big Bottom area of the Clackamas River. The largest was 12 inches, but he recalled seeing larger fish on the bottom of a deep pool on the Collawash River near the mouth of the Hot Springs Fork. Mr. McMullen described the fish as “char-like,” although he was uncertain whether the fish were bull trout, brook trout, or brown trout (Gene McMullen, angler, personal communication, September 22, 1997).
- Chet Green reported that his father used to catch “Dollies” in the 1920s in the Clackamas River above Three Lynx. Mr. Green has never caught a bull trout himself in the Clackamas River Subbasin, although he has fished extensively in the Oak Grove Fork and the Collawash River for years (Chet Green, angler, personal communication, September 22, 1997).
- Brian Nordlund reported that he caught a bull trout about 14 inches long in the spring or early summer of 1963, but it could have been “a year or two later. ” The fish was caught in the pool beneath the short falls right above the Three Lynx/Oak Grove Powerhouse on the mainstem of the Oak Grove Fork. Mr. Nordlund further stated that his brother caught a second “Dolly” a couple years later in the same pool (Brian Nordlund, angler and fish biologist, personal communication, March 7, 2005).

Based on the size of bull trout recorded in creel records dating from the 1940s and the locations where fish were caught, at least a portion of the bull trout population in the Clackamas River Subbasin is strongly suspected to have had a fluvial life history.

1.4 Historical Distribution of Bull Trout in the Clackamas River Subbasin

The historical distribution of bull trout in the Clackamas River Subbasin is approximated using assembled information on sightings, documented occurrences, and known distribution of extant bull trout populations elsewhere in the Lower Columbia River Basin. A review by ODFW in 1998 of historical records and anecdotal accounts suggests that bull trout distribution once extended from North Fork Reservoir upstream to the Big Bottom area of the mainstem Clackamas River, as well as the lower Collawash River and the lower Oak Grove Fork of the Clackamas River (Zimmerman 1999). No information exists regarding historic abundance or the location of bull trout spawning and rearing areas. The extent to which adult bull trout utilized the lower Clackamas River below the site of the river’s first hydroelectric dam (Cazadero Dam) is unknown. Bull trout from the Clackamas River Subbasin conceivably migrated to the upper Willamette River mainstem above Willamette Falls or to Lower Columbia River tributaries (Zimmerman 1999). Figure 1. 4 shows the presumed historical distribution of bull trout in the Clackamas River Subbasin for the time period during the mid- to late-1800s. The CRBTWG assumed that bull trout were not historically present upstream of waterfall barriers known to impede upstream movement of anadromous salmon and steelhead species. This assumption is consistent with bull trout presence in other river systems in the Willamette River Basin and other basins in the Lower Columbia River Basin. The historical distribution of bull trout in the Clackamas River Subbasin as reported in Buchanan et al. (1997) was updated by the CRBTWG based on this primary assumption and additional review of historical records, sightings, and anecdotal information as previously presented.

The CRBTWG used a tiered approach, described below, to approximate the historical distribution of bull trout in the Clackamas River Subbasin.

Tier One – All sections of rivers and streams upstream of waterfall barriers known to impede the upstream movement of anadromous salmon and steelhead species were excluded.

Tier Two – All site locations where there are confirmed sightings of bull trout from specimen collections, documented creel surveys, or fish sampling records by state or federal fish biologists were included. In the upper portion of the subbasin, multiple confirmed sightings within close proximity of one another (within four to five miles) were determined to be sufficient by the CRBTWG to map entire segments of river as confirmed historical bull trout presence. River segments mapped for confirmed historical bull trout presence in Figure 1. 4 include:

- The Clackamas River from approximately RM 43 (upstream of the Roaring River confluence) to approximately RM 58 (roughly two miles upstream from the Collawash River confluence).
- The Oak Grove Fork from its mouth upstream approximately one-half mile.
- The Collawash River from its mouth upstream to the Hot Springs Fork confluence (RM 0 to ~4).

Two additional confirmed historical sightings occur in the lower and middle portions of the subbasin. These include a collection in 1878, along the lower section of the Clackamas River near Clear Creek and another in 1963, in North Fork Reservoir (Stout 1963) along the middle section of the Clackamas River. Since these confirmed historical sightings are of considerable distance from one another and from those in the upper portion of the subbasin, the CRBTWG mapped only a short segment of river as "confirmed presence" just upstream and downstream of these locations.

Tier Three – All segments of rivers and streams for which there are anecdotal records (i.e., angler reports) of historical bull trout sightings were mapped. This third tier takes in a considerable number of river and stream segments in the middle and upper portions of the subbasin. These include:

- The Clackamas River from below the North Fork Clackamas River confluence (RM 30) upstream to the Roaring River confluence (RM 42. 8).
- Roaring River from its mouth upstream to a waterfall barrier at RM 3. 5.
- The Clackamas River from approximately RM 58 (roughly two miles upstream from the Collawash River confluence) upstream to approximately RM 74 at the confluence of Cub Creek.
- Cub and Berry creeks, tributaries to the upper Clackamas River.

Tier Four – All remaining segments of rivers and streams were mapped within the "probable historic distribution" for bull trout. These segments are considered likely to have contained bull trout historically given the wide-ranging nature of bull trout and more favorable habitat conditions assumed to exist in the mid- to late-1800s.

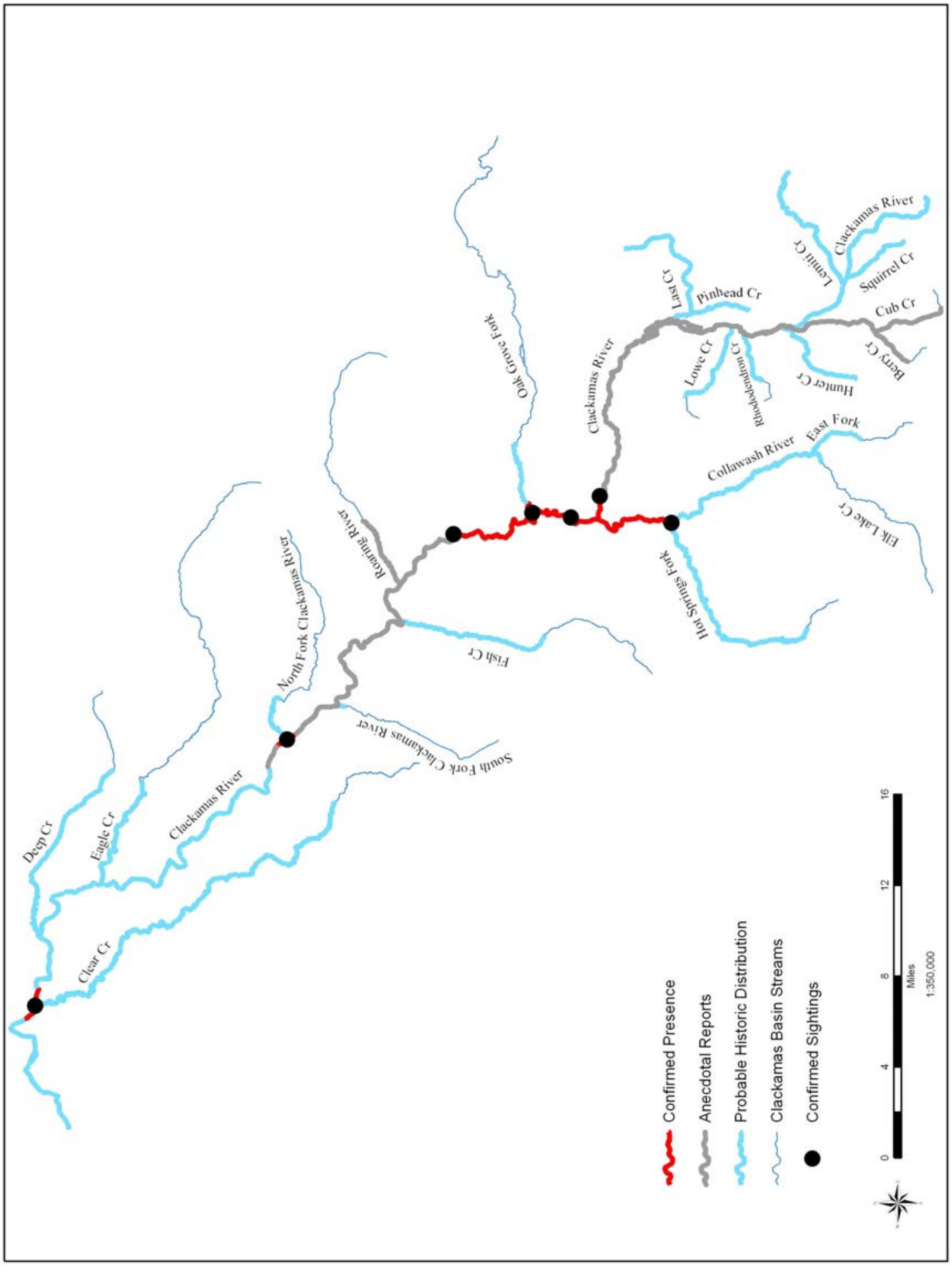

Figure 1. 4. Historical Distribution of Bull Trout in the Clackamas River Subbasin.

1.5 Overview of Bull Trout Surveys in the Clackamas River Subbasin

One of the earliest documented collections of bull trout (or "Dolly Varden" as they were known then) in the Columbia River Basin came from Livingston Stone in the lower Clackamas River in 1878 (Smithsonian Institution 2005). Yet, despite the elapsed time from that early collection, little else was known about bull trout in the Clackamas River, other than they were present in the watershed in the 19th Century and much of the 20th. Until the 1980s or later, when focused bull trout studies first began, this scarcity of information was common for most river systems containing these native char (Dodson and Brun 2003).

In the Clackamas River Subbasin, increasing interest in the status of Clackamas River bull trout began shortly after 1989 when the American Fisheries Society listed the bull trout as a species "of special concern" (Williams et al. 1989, cited in Buchanan et al. 1997). Bull trout had only been accepted as a species separate from Dolly Varden in 1980 by the American Fisheries Society, after Cavender (1978) described their taxonomic status. In October 1992, bull trout were petitioned to be listed under the federal ESA by several Montana conservation organizations. These rapid developments spurred biologists from ODFW, PGE, and the USFS to begin surveying portions of the Clackamas River Subbasin thought most likely to contain a remnant bull trout population (Eberl and Kamikawa 1992, Zimmerman 1999).

Initial surveys in a number of streams occurred in 1990, 1991, and 1992, but no bull trout were found. More extensive surveys occurred in 1992, 1998, 1999, and again in 2004, but all failed to document the presence of bull trout in the subbasin. The presence/absence surveys that occurred during this timeframe (1990 – 2004) varied in geographic scope, survey effort, and survey methodology. These survey efforts are summarized below:

Early 1990s Survey Efforts (1990 – 1992)

ODFW and the Estacada Ranger District of the USFS received occasional, unverified reports of bull trout caught in the upper tributaries of the Clackamas River Subbasin up to the early 1990s. These reports, combined with suitable bull trout habitat identified by local fish biologists, suggested the need for surveys to find any relict local populations. Fish biologists from ODFW and USFS conducted numerous surveys throughout 1990-1992. A brief summary of these surveys, as reported in Eberl and Kamikawa (1992) is provided below:

1990 Surveys

- Cub Creek (upper Clackamas River tributary): Electrofished by ODFW in mid-July. Cutthroat trout were captured.
- Last Creek (tributary to Pinhead Creek): Electrofished by USFS in the summer. Cutthroat trout of various life stages were captured. This stream was electrofished again by ODFW in 1992.
- Pinhead Creek (tributary to the upper Clackamas River): Electrofished by ODFW in mid-July. It was electrofished again in late-September. All captures were rainbow or cutthroat trout, young coho salmon, or sculpin. Adult spring Chinook were spawning above the area of survey.

- Berry Creek (tributary of Cub Creek): Electrofished in mid-July by ODFW. Cutthroat trout of different life stages were captured.
- Shellrock Creek (tributary to the Oak Grove Fork): Electrofished in late-July by ODFW. Cutthroat trout were present.
- Chief Creek (tributary to Shellrock Creek): Electrofished by ODFW in late-July. Various life stages of cutthroat trout were identified.
- Hunter Creek (tributary to the upper Clackamas River): Electrofished by ODFW in mid-July. Sculpin and various life stages of cutthroat trout were recorded.
- Lowe Creek (tributary to the upper Clackamas River): Sampled using unknown methods (assumed to be electroshocking) in mid-July by ODFW. Various age classes of cutthroat trout were sampled.
- Rhododendron Creek (tributary to the upper Clackamas River): Electrofished by ODFW in mid-July. Various life stages of cutthroat were found.
- Squirrel Creek (tributary of the upper Clackamas River): Electrofished by ODFW in mid-July. Various life stages of cutthroat trout were captured.

1991 Surveys

- Stone Creek (tributary to the Oak Grove Fork): Electrofished by USFS in August. Surveyors found moderate numbers of cutthroat trout.
- Collawash River (tributary to Clackamas River): Day-time snorkel survey by USFS in late-September targeting potential adult bull trout spawners. Native rainbow trout and Chinook salmon were observed.
- Elk Lake Creek (tributary to Collawash River): Electrofished in mid-September by USFS; also day-time snorkel survey in late-September by USFS to target potential adult bull trout spawners. Cutthroat trout and rainbow trout were encountered.
- Upper Clackamas River: day-time snorkel survey in September by USFS targeting potential adult bull trout spawners. Brook trout were observed spawning in this area.

1992 Surveys

In 1992, a more in-depth sampling of selected streams for bull trout was incorporated into a cooperative Challenge Cost Share project between the USFS and ODFW. The 1990-1991 survey efforts summarized above were widely spread throughout the Clackamas River Subbasin with limited effort devoted to any one stream. Eberl and Kamikawa (1992) selected four streams thought to have characteristics potentially suitable to support bull trout: Farm, Berry, Pinhead, and Dickey creeks. These four streams were selected for more intensive surveys because they were higher elevation and/or cold, spring-fed streams that also contain high levels of cover. All four streams were surveyed below natural waterfall barriers that limit upstream access for anadromous fish species (i.e., salmon and steelhead).

Hankin and Reeves Level III surveys were utilized to identify where stream habitat units having complex physical characteristics of abundant woody material, substrate cover, and/or undercut banks might be located. Stream units identified with the above physical complexity that appeared most suitable for bull trout were subsequently sampled via electroshocking. One stream, Pinhead Creek, was not surveyed with a Level III survey since it had an abundance of complex habitat and woody material in many of the habitat units and would have consumed prohibitive amounts of survey time. Dickey Creek was only partially electrofished because of low stream conductivity, high fish mortality during sampling, and limits on time available. Berry, Farm, and Pinhead creeks were electrofished as originally planned. Night snorkeling to locate bull trout was contemplated but deferred when no evidence of bull trout was discovered during electrofishing efforts.

In addition to the focused efforts on the above four streams, survey crews daytime snorkeled three major rivers during the late summer to target potential adult bull trout spawners. The three rivers included the upper Clackamas River (four miles), Collawash River (four miles), and East Fork Collawash River (two and one-half miles). No bull trout were observed (Eberl and Kamikawa 1992).

Late 1990s Survey Efforts (1995 and 1998 – 1999)

In 1995, a bull trout snorkel survey effort was implemented on approximately 10 miles of the mainstem Clackamas River near its headwaters (Zimmerman 1999). No bull trout were reported.

Additional bull trout presence/absence surveys were conducted in 1998 and 1999, but they failed to find any bull trout in the upper portion of the subbasin. Mark Zimmerman (1999) of ODFW led the survey effort. Prior to initiating surveys, he reviewed all of the available historic information known to exist for bull trout in the Clackamas River. His effort compiled historic agency survey records and anecdotal reports of bull trout in the subbasin. Field surveys were then completed over two years, with informal walking surveys implemented on ten streams in September and October of 1998. Survey crews recorded qualitative physical habitat characteristics of stream reaches walked. Water temperature and connectivity data was collected at the lower and upper limits of reaches surveyed. As streams were walked, surveyors also utilized hook and line sampling with artificial lures. Captured fish were identified and measured before release.

From Eberl and Kamikawa (1992), a total of five streams were selected to be snorkel surveyed in 1999. Daytime snorkeling on Berry, Cub, Farm, Dickey, and Elk Lake creeks was decided as the most effective method, especially for the possibility of observing bull trout fry. Resident salmonids and one sculpin were recorded in the 1999 snorkel surveys. Hook-and-line sampled streams documented cutthroat trout in the upper Clackamas and Oak Grove Fork watersheds, while only rainbow trout were captured in the streams sampled in the Collawash River Watershed. No bull trout were captured or observed in any of the 1998-1999 surveys (Zimmerman 1999).

2004 Survey Effort

As part of this feasibility assessment, the CRBTWG discussed the need for a definitive, statistically valid study to determine if bull trout were still present in suitable habitat remaining in the Clackamas River Subbasin. Previous presence/absence surveys, although numerous and widespread, were statistically weak. In order to address the first question raised by Epifanio et al. (2003); *"Is there a high level of confidence that bull trout are no longer present that would serve as a natural gene bank?"*; the CRBTWG in 2004 conducted a final presence/absence survey for bull trout in the Clackamas River Subbasin using the survey protocol developed by Peterson et al. (2002) for the Western Division of the American Fisheries Society (WDAFS). As described by Strobel (2005):

> *This protocol estimates sampling efficiencies for different methods and combine(s) that information with data on the distribution of bull trout densities to estimate detectability of small bull trout (less than 150 mm total length). Single sample estimates of detectabililty can be combined to estimate the number of samples required to estimate an acceptably low probability of presence, provided that bull trout are not detected. Technically, failure to detect bull trout should be interpreted to mean that bull trout are unlikely to occur with the distribution of densities assumed in the WDAFS protocol.*

A sampling frame or area of habitat was selected for detecting the probability of bull trout presence. Sampling units were made up of individual stream segments nested within the sampling frame. These sampling units were completely surveyed. Since water temperature is a known major determinant for bull trout presence (Dunham and Chandler 2001; Dunham et al. 2003), a review of all temperature sets for tributaries in the Clackamas River Subbasin upstream of North Fork Dam were reviewed. Streams with maximum temperatures exceeding 15 degrees Celsius were not included in the sampling frame. The upper Clackamas River above its confluence with the Collawash River remained the only watershed with suitable amounts of cold water stream habitat that fit the desired sampling frame. Additionally, streams found in this portion of the subbasin that are less than two meters (~seven feet) in summer wetted width or are too large to night snorkel safely were not selected for sampling units. The Peterson et al. (2002) protocol calls for sampling units to be bounded by block-nets during snorkel surveys. Since this requirement was difficult to implement in remote, sometimes hazardous terrain, during darkness, an alternative was developed by Jason Dunham, a coauthor of the protocol. In lieu of the protocol's 50-meter sampling units enclosed by block nets, sampling units were enlarged to 200 meters in length without enclosure by block nets to reach equivalent detection probabilities. Using the adjusted protocol, a total of 40 sampling units were randomly selected.

Surveys were implemented via single-pass night snorkeling that began on August 18 and were completed on October 1, 2004. Upper and lower limits of sampling units were flagged or marked. Each unit was sampled by two or three experienced snorkelers from the USFS, USFWS, or SWCA Environmental Consultants, who were funded by PGE. The survey protocol called for all brook trout and bull trout to be counted and estimates of lengths recorded. Rainbow and cutthroat trout less than 200 mm total length were estimated in each unit by qualitative rankings of absent, few, or abundant. These were ranking determinations made by the snorkel surveyors completing each sampling unit. Other aquatic species were recorded when found and habitat information of interest, such as instream woody material and overall habitat quality, was also recorded.

An extension of the WDAFS protocol also allows for the use of earlier collected data and professional experience, expertise and other forms of prior knowledge to contribute to assessments of continued bull trout presence (Peterson and Dunham 2003). Strobel (2005) described its use:

> *In a system where considerable experience and survey effort have rendered the possibility of an undetected bull trout population unlikely, and a conservative level of probability can be assigned to the presence of bull trout, this level of probability can be combined with those derived from individual sampling units to increase power. Nine local fish biologists with independent knowledge and experience in the upper Clackamas watershed were individually surveyed to obtain estimates of the probability of bull trout being present in the basin, based on professional judgment. Estimates of probability were made without consideration of the results of the bull trout surveys conducted in the summer of 2004. The results from this survey of local expertise were then summarized and used to establish a conservative estimate of the probability that bull trout exist in the upper Clackamas River watershed, based on experience and survey efforts prior to the 2004 surveys.*

The 2004 snorkel surveys failed to detect bull trout in any of the sampled units. Surveys were completed for 21 sampling units, equaling 4. 2 kilometers (2. 5 miles) of stream or 9. 3 percent of the sampling area or frame. The 2004 surveys had an overall power to detect the presence of bull trout in the upper portion of the subbasin sampled of 88 percent. The Peterson and Dunham (2003) protocol allows prior surveys, knowledge, and local information by professional fish biologists to be incorporated into the overall calculation for power of detection. Strobel (2005) surveyed a number of professional fish biologists with local survey experience in the subbasin and determined their collective estimates of the probability of bull trout surviving in the subbasin ranged from 0. 01 to 5. 0 percent. Considering these estimates by local biologists, Strobel (2005) used a much more conservative estimate of 10 percent that bull trout might still occur within the subbasin. The overall power to detect the presence of bull trout increases to 99 percent using Strobel’s conservative estimate of prior knowledge. There remains an extremely low probability that juvenile bull trout may be present in the upper portion of the subbasin sampled at densities below the range observed for other populations.

Additional Fish Surveys and Fish Enumerations in the Clackamas River Subbasin

While the survey efforts summarized above were directed at locating remnant bull trout, many other fish surveys, inventories, and enumerations have also been conducted in several rivers and streams within the subbasin over the past several decades. Although too long to specifically list all of these efforts here, some include: upper limits of fish distribution electrofishing surveys, steelhead and Chinook spawning surveys, monitoring and evaluation snorkel surveys of habitat restoration and improvement projects, pre- and post-hydroelectric development snorkel surveys, fish trapping and photo counting at hydroelectric passage facilities, and a long-term system of cooperatively funded smolt traps that have been operated in the upper subbasin. No bull trout have been detected in any of these other survey or inventory efforts.

Given the cumulative results from past survey efforts and the most recent 2004 statistically oriented, probabilistic sampling effort, CRBTWG members are confident that bull trout have been extirpated in the Clackamas River Subbasin.

1.6 Causes for Decline of Bull Trout in the Clackamas River Subbasin

A broad overview of the causes of decline and extirpation of bull trout in the Western United States is presented in Appendix A. A hypothesis for the local extirpation of bull trout from the Clackamas River Subbasin is provided in Appendix B. The following section provides a summary of the primary factors believed responsible for the decline and extirpation of bull trout in the subbasin.

Dams and Diversions

As early as 1890, the State Fish Commission reported a diversion dam across the Clackamas River near Gladstone that impeded salmon passage. Initially, the dam was a partial barrier to salmon migration. In 1891, the height of the dam was increased and it became a full passage barrier to salmon. H. D. McGuire, the Oregon Fish and Game Protector, filed a complaint against the mill owner (Taylor 1999) and a ladder was installed in 1895 correcting the problem (Wallis 1960). Diversion dams for a variety of purposes existed on many tributaries to the lower Clackamas River from the late 1840s and into the early 1900s. Most of these diversion dams were built without fish passage provisions (Cramer and Associates 2001).

Hydroelectric dams on the mainstem Clackamas River historically presented migration challenges to bull trout. Cazadero Dam (known today as Faraday Dam) was built on the Clackamas River in 1904. The original fish ladder providing access over Cazadero Dam washed out in 1917 and was not rebuilt until 1939. Anadromous fish species, bull trout, and other fish species were blocked from migratory corridors and passage into the upper portions of the subbasin during this 22-year timeframe. River Mill Dam was built soon after Cazadero Dam in 1912, and is located just a few miles downriver. This is the first dam that fish encounter as they migrate upstream from the lower Clackamas and Willamette rivers. The original ladder for River Mill Dam, built in 1912, was modified in 1972 when the entrance was enlarged, attraction flows increased, and an adult fish trap installed. This steep and winding ladder had been thought to impede passage of spring Chinook salmon (Murtagh et al. 1992). The present-day Faraday Dam has a 2. 74-kilometer-long (1. 7 miles) ladder (North Fork fishway) that provides passage past both the Faraday and North Fork dams. North Fork Dam is the third, most upstream hydroelectric dam on the mainstem Clackamas River that was built in 1958. For downstream migrating fish, North Fork Dam has a collection facility that routes them into a pipeline, bypassing all three mainstem dams and exiting below River Mill Dam. Downstream migrants may also leave North Fork Reservoir via the spillway during high flows or through the turbines. These fish must then pass downstream through the Faraday and River Mill projects which are not equipped with juvenile bypass facilities.

Fisheries Management

Historical fisheries management activities were likely a major factor in ultimately extirpating bull trout from the Clackamas River Subbasin. Given its close proximity to the Portland metropolitan area, the Clackamas River historically had and continues to receive heavy angling pressure. Prior to the 1940s, early fisheries management actions focused largely on three areas:

1. trapping salmon and steelhead to supply eggs for early hatchery operations;
2. designation of early sport harvest limits and enforcement; and
3. stocking of high mountain lakes with fingerling trout (in many instances introducing nonnative brook trout).

Prior to 1940, the native trout population in the river system was abundant and sport catch of bull trout was not unusual. Jiggs Pederson, an early USFS employee who worked on trails and roads in the 1920s and 1930s, recalls anglers fishing for trout and bull trout using everything from red huckleberries to live mice floated on small pieces of wood (Pederson 2003). Access to much of the upper subbasin was limited to a few gravel roads or more commonly, foot trails which limited overall trout harvest. Gene McMullen, who fished the upper waters on the Collawash and Clackamas rivers in the late 1940s and early 1950s, recalled with some regret he and two fellow anglers coming out of the roadless country with weekly limits amounting to 100 trout. This was probably commonplace for the time and era. Gene’s understanding was, “that after the road penetrated this country, the fishing steadily declined” (McMullen 1994).

With the advance of the road system into the upper subbasin, the native trout populations quickly became over-fished, and fisheries managers turned to trout stocking as a means to meet the demand of increased angling pressure. Fisheries managers also recognized that stocking of fingerling trout would not provide a good return to anglers. Based on investigations completed in the Clackamas River (Lockwood 1948), the 1947 annual report of the Oregon Fisheries Division recommended stocking catchable-sized rainbow trout. Beginning in the 1950s, large numbers of hatchery rainbow trout were being stocked along the roads paralleling the Clackamas and Collawash rivers. By the 1970s, Whitt (1978) reported that over 100,000 hatchery catchable trout were being stocked annually in the Clackamas River and its tributaries. Throughout the 1980s and into 1990s, annual stocking of catchable rainbow trout in the Clackamas River expanded almost two-fold to near 190,000 per year (Murtagh et al. 1992). The Clackamas River became one of the largest trout fisheries in the State of Oregon, with more than a quarter million angler days annually. The large, hatchery supported fishery also negatively affected native steelhead production. A 1988 creel survey revealed that nearly 10,000 hatchery and 800 wild steelhead smolts were harvested in the fishery along with 1,000 coho smolts (Murtagh et al. 1992). In 1968, nonnative summer steelhead was introduced from Skamania and Foster stocks to create a new fishery. Summer steelhead was particularly popular with anglers because they have a long period of freshwater residency and are readily caught. The summer steelhead fishery was primarily in the Clackamas River above North Fork Dam, the same areas where bull trout were last reported. By 1979, summer steelhead harvests were averaging over 5,000 fish per year in the Clackamas River (Murtagh et al. 1992).

In the 1950s and 1960s, during the period of rapid growth in the trout fishery within the Clackamas River, a strong negative attitude was developed towards bull trout. Anglers and fisheries managers considered bull trout to be a voracious predator on juvenile salmon and steelhead, and they quickly gained a reputation as a “trash” fish. Anglers were encouraged to kill bull trout if caught. Fisheries managers even organized fishing derbies and provided bounties to eradicate bull trout from the Clackamas River.

Bull trout were also likely impacted by early commercial fisheries. Bull trout may have been intercepted as a by-catch in commercial fishery nets and traps set in the lower Clackamas and Columbia rivers. As stated earlier, there is evidence that the historic population of bull trout in the Clackamas River exhibited a fluvial life history and may have even contained an anadromous life history component. Bull trout were found historically in the same vicinity as areas of intense commercial fishing operations on the lower Clackamas and Columbia rivers. For instance, Livingston Stone established the first operating fish hatchery in the Columbia Basin in 1877, at the confluence of Clear Creek and the Clackamas River (Cramer & Associates 2001). It is believed that near this location he secured the Clackamas River “Dolly Varden” specimen during the winter of 1877-1878 that is kept at the National Museum (Smithsonian Institution 2005). Overfishing by commercial fisheries in the vicinity presented a problem for the hatchery in securing enough adult Chinook for spawning (Mattson 1950).

In 1876, a commercial harvesting fish trap near the mouth of the Clackamas River nearly closed off the entire river to upstream migrating salmon (U. S. Commission of Fish and Fisheries 1877, cited in Taylor 1999). In 1877, more than 1,000 drift nets, many reaching 1,200 feet in length, were also being set on the Columbia River (Taylor 1999). In 1893, approximately 12,000 adult spring Chinook were harvested by gillnetters in the lower Clackamas River (Smith 1974). By 1908, salmon abundance had declined to the degree that only five or six commercial fisherman still operated on the Clackamas River. In 1910, commercial fishing seasons were designated for the Clackamas River (Taylor 1999).

In the Columbia River estuary, an area often exploited by the historic commercial fisheries, a recent USFWS review of old State of Oregon seining records at the head of the Columbia River estuary, indicated bull trout were caught in seines while apparently foraging in that location (Yoshinaka 2002). Historically, the Clackamas River bull trout population may have utilized the Columbia River estuary for rearing.

Forest Management

Timber was the most important industry in Clackamas County from the late 1950s through the early 1990s (Bryson and Levine 1987). More than three-quarters of the lands in the Clackamas River Subbasin are forested. The USFS (Mt. Hood National Forest) manages over 70 percent of the lands in the subbasin, most of that occurring in the upper subbasin above North Fork Dam. The BLM also manages a small amount of public forestland. Much of the private and county timberlands are scattered in the lower elevation areas of the subbasin.

Aquatic habitat throughout much of the subbasin has been degraded by past clear-cut, timber harvesting and removal of trees in the riparian zone, removal of large wood from stream channels, and road building (Murtagh et al. 1992). Increased sediment loading throughout much of the lower subbasin has decreased stream habitat quality, as well as increased stream temperatures and altered stream channel stability. Road building and regeneration harvesting of forest stands affects hydrologic function and increases peak flows. In some areas of the subbasin the road network is extensive, resulting in high road densities. Prior to the Northwest Forest Plan (USDA and USDI 1994), many riparian corridors were harvested of old-growth timber, and salvage logging conducted after the 1964 flood event further reduced large wood available to streams. It will take decades before these impacted riparian areas will produce mature and old-growth conifers that will once again provide full streamside shading and contribute to large wood recruitment in streams (Horning 1999). Many streams were “cleaned” of large wood in mistaken attempts to improve fish passage during the 1960s and 1970s. The loss of complex, in-stream habitat has had a negative effect on fish habitat productivity.

Agricultural Practices

Bryson and Levine (1987) reported agriculture as second in economic importance to timber production in Clackamas County. Agricultural lands occur at lower elevations primarily in the lower portion of the subbasin and make up approximately one-eighth of the total landbase. Primary crops include berries, fruit, field crops, trees (both Christmas tree farming and nurseries), and livestock. Agricultural activities commonly result in the direct loss of streamside vegetation and an increase in withdrawal of water for irrigation (Murtagh et al. 1992). Likely impacts to aquatic habitat include loss of streamside shade hence increased water temperature, loss of large wood recruitment hence a decrease in habitat complexity, increased bank erosion and sedimentation, and loss of habitat through lack of instream flows.

Residential Development and Urbanization

The majority of residential, commercial, and municipal development has taken place in the lower portion of the subbasin. Major cities within the subbasin include Gladstone and Oregon City near the confluence of the Clackamas and Willamette rivers, Happy Valley, Damascus, Boring, Sandy, Estacada, and Colton. While less than 10 percent of the land base is classified as residential or commercial, recent growth and urban expansion in the last two decades has resulted in a large footprint on the lower mainstem and tributaries. Aquatic habitat-related impacts likely include an increase in impervious surfaces hence altered streamflow regimes and more rapid runoff, loss of riparian vegetation, conversion of forested uplands and loss of wetlands, stream channelization, and reduced water quality through increases in use and run-off of pollutants and pesticides.

1.7 Curtailment of the Causes for Decline of Bull Trout in the Clackamas River Subbasin

It has been over four decades since the last verified and documented capture of a bull trout in the Clackamas River (Zimmerman 1999). While angler reports of bull trout catch followed for approximately a decade after the last verified report, abundance was likely so low that the population was no longer viable. By this time, the population likely entered an unrecoverable population trajectory where extinction was inevitable. Any small impact, individual or cumulative, was likely to send the population into an extinction vortex (Gilpin and Soulé 1986). At about this time, sport angling for catchable rainbow trout and summer steelhead in the upper portion of the subbasin above North Fork Dam was just beginning to boom. Since bull trout are known to be extremely voracious and susceptible to anglers, it is conceivable that heavy sport angling pressure is what finally claimed this population (Post et al. 2003).

Investigating the curtailment of the causes for decline and extirpation of bull trout in the Clackamas River is necessary to evaluate the essential factors which would most influence the success of a reintroduction effort. The CRBTWG has identified primary factors essential to successful reintroduction efforts as fisheries management (particularly sport fishing upstream of North Fork Dam), forest management (i.e., aquatic habitat protection), and hydroelectric dams (passage and screening). Curtailment of other factors (i.e., agricultural practices, residential development and urbanization) that likely contributed to the extirpation of bull trout in the Clackamas River are addressed below; however, the curtailment of these other factors are believed to be secondary in ensuring the success of a reintroduction effort.

Dams and Diversions

Historic diversion dams present in the late 1800s and early 1900s no longer exist in the lower Clackamas River Subbasin on river or stream segments that would impede bull trout migration.

Beginning in the late 1990s, PGE began federal relicensing proceedings for its hydroelectric dams in the Clackamas River Subbasin. In their final license application to the Federal Energy Regulatory Commission (FERC) and in an accompanying Settlement Agreement amongst more than 30 local, state, federal, and tribal governments, non-governmental organizations, and other interested stakeholders, PGE proposed to make several upstream and downstream fish passage improvements for the three dams along the mainstem Clackamas River. One improvement, already completed, was the reconstruction of the River Mill Dam fish ladder. Other improvements include upgrades to the downstream fish collection facility and bypass at North Fork Dam, construction of a new fish trap and handling facility at the North Fork fishway, and new downstream fish passage facilities at River Mill Dam.

The USFWS has not finalized passage and screening criteria specific to bull trout. In the interim, the criteria developed by the National Marine Fisheries Service (NMFS) for anadromous salmonids have guided fish passage facility improvements for the Clackamas River mainstem hydroelectric dams, and it is believed they should be effective for bull trout.

Fisheries Management

With the ESA listings of salmon and steelhead in the late 1990s, fisheries management practices (i.e., sport fishing regulations and stocking of catchable rainbow trout) for the portion of the subbasin upstream of North Fork Reservoir changed substantially. Stocking of catchable rainbow trout within the Clackamas River became restricted to reservoirs (i.e., North Fork Reservoir, Lake Harriet, and Timothy Lake) and was discontinued altogether along the mainstem and tributaries upstream of North Fork Reservoir. As such, sport fishing regulations changed substantially. Bag limits became restricted to adipose fin-clipped trout only, effectively turning all of the river and tributary sections upstream of North Fork Reservoir into a catch-and-release fishery on native trout. Additionally, angling is restricted to the use of artificial flies and lures only. No bag limit or size restrictions are imposed for brook trout. The changes in sport fishing regulations also curtailed angling for salmon or steelhead upstream of North Fork Dam, as this area is considered a wild fish sanctuary and no hatchery salmon or steelhead are allowed upstream of North Fork Dam. Sport fishing in the lower subbasin downstream of North Fork Dam is focused on hatchery salmon and steelhead. All waters in the Willamette Zone for the State of Oregon's sport fishing regulations are closed to angling for bull trout. Commercial fisheries have not operated in the Clackamas River Subbasin since the early 1900s. Commercial fisheries in the Columbia River mainstem and estuary are limited to tribal fisheries and limited gillnet fisheries for Chinook and coho salmon.

Beginning in 2003, the ODFW and USFS began collaborating on stocking of high mountain lakes in the upper portion of the subbasin. ODFW no longer stocks brook trout in lakes with outlets to rivers and streams that provide suitable bull trout spawning and rearing habitat.

With the significant changes in angling regulations, primarily in the upper subbasin above North Fork Dam, the CRBTWG believes this factor for decline has been addressed. Additional changes to angling regulations in the upper portion of the subbasin are believed unnecessary to support a successful reintroduction of bull trout.

Forest Management

The majority of lands in the upper portion of the subbasin are public forestlands administered by the USFS and BLM. These lands are managed in accordance with Mt. Hood National Forest Land and Resource Management Plan (USFS 1990) and Salem District BLM Resource Management Plan (USDI 1995), respectively, as amended by the 1994 Northwest Forest Plan (USDA and USDI 1994). The 1994 Northwest Forest Plan established an Aquatic Conservation Strategy (ACS) with protective measures, standards and guidelines, and land allocations to maintain and restore at-risk fish species of which bull trout were included. The ACS Riparian Reserve land allocation extends two full site potential tree heights (300 feet minimum) on both sides of all fish-bearing streams and prohibits scheduled timber harvest. These plans provide substantial protections for watersheds and aquatic habitats on public lands in the upper subbasin administered by the USFS and BLM.

Forest management activities on non-federal lands are regulated by the State of Oregon Forest Practices Rules. County, state, and private timberlands managed in accordance with these rules occur primarily in the lower portion of the subbasin most likely outside of historical bull trout spawning and rearing habitat. However, streams within the lower portion of the subbasin (i.e., Rock, Clear, Richardson, Deep, and Eagle creeks) may have provided important rearing, overwintering and foraging habitat for bull trout historically. These streams, while currently impacted to some degree by urbanization, may still provide overwintering and foraging habitat for bull trout if a reintroduced population in the upper subbasin were to expand into the lower Clackamas River Subbasin and the Willamette River. No additional changes or protections regarding forest management activities on public or non-public forest lands are believed necessary to support a successful reintroduction of bull trout in the Clackamas River Subbasin.

Agricultural Practices

Similar to non-federal timberlands, agricultural lands occur primarily in the lower portion of the subbasin, most likely outside historical bull trout spawning and rearing areas. Although degraded to a degree from agricultural practices, streams within the lower portion of the subbasin could provide important migratory habitat for sub-adult or adult bull trout. No additional changes or protections regarding agriculture practices are believed necessary to support a successful reintroduction of bull trout in the Clackamas River Subbasin.

Residential Development and Urbanization

Residential development and urban growth is likely to continue to expand in the lower portion of the subbasin. Areas where expansion is expected to continue are located in sub-watersheds to tributaries in the lower portion of the subbasin, similar to where non-federal timberlands and agricultural lands are located. The difference here is that anticipated residential, commercial, and industrial expansions will likely be tied much more closely to urban centers which are predominantly in the lower portions of tributary streams in the lower subbasin outside of likely historical spawning and rearing habitat for bull trout.

1.8 Key Recommendations from the Willamette Chapter of the Draft Bull Trout Recovery Plan

Bull trout were listed as threatened in the Columbia and Klamath River Distinct Population Segments (DPS) on June 10, 1998 (50 CFR 17, Vol. 63(111):31647-31673). Concurrently, a proposed rule was published to list all remaining bull trout within three additional DPS's in the contiguous U. S. (Coastal/Puget Sound, Jarbidge River, and St. Mary/Belly Rivers). In November, 1999, a final rule determined threatened status for "all populations of bull trout within the United States," thus making the original listing coterminous (50 CFR 17, Vol. 64(210):58910-58936), meaning the five DPSs were consolidated into one listed taxon. Furthermore this rule stated that: "for the purposes of consultation and recovery, we (USFWS) recognize these five DPSs (Columbia River, Klamath River, Coastal-Puget Sound, Jarbridge River, and St Mary-Belly River) as interim recovery units" because of their uniqueness and significance.

At the time of publication of the draft bull trout recovery plan (October 2002), the Willamette Basin was identified as a "recovery unit," one of 27 recovery units described within the coterminous listing. Almost immediately upon publication, the USFWS recognized that these units may not meet the USFWS standard for "recovery units" and decided to call them "management units. " Consequently, "recovery units" as described in the draft bull trout recovery plan are interchangeable with "management units".

The Willamette River Bull Trout Recovery Unit Team (Recovery Unit Team) identified the Upper Willamette River as a "core area" (i.e., the closest approximation of a biologically functioning unit for bull trout). This core area includes the McKenzie and Middle Fork Willamette rivers, and the short stretch of the Willamette River that connects these two subbasins. The Recovery Unit Team identified the Clackamas River Subbasin as "core habitat," which is defined as habitat that could supply all the necessary elements for the long-term security of bull trout, including spawning, rearing, foraging, migrating, and overwintering.

Bull trout were also documented historically in the North and South Santiam subbasins, but these river systems were not designated core habitat in the draft recovery plan because of uncertainties regarding their current ability to support bull trout. The North and South Santiam rivers are considered "research need" areas.

Recovery Goals and Objectives

The overall recovery goal identified in the draft bull trout recovery plan is to ensure the long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed throughout the species native range so that the species can be delisted from the ESA. To achieve this goal, the following objectives were identified for bull trout in the Willamette River Recovery Unit:

- Maintain current distribution of bull trout and restore, where habitat is deemed sufficient, distribution to previously occupied areas within the Willamette River Recovery Unit.
- Maintain stable or increasing trends in abundance of adult bull trout.
- Maintain and restore suitable habitat conditions for all bull trout life history stages.
- Conserve genetic diversity and provide opportunity for genetic exchange.

Recovery Criteria

Draft recovery criteria for the Willamette River Recovery Unit reflect the stated objectives, evaluation of population status, and recovery actions necessary to achieve the overall goal. Draft recovery criteria address population distribution, population abundance, population trends, and habitat connectivity.

Distribution criteria will be met when bull trout are distributed among three or more local populations in the recovery unit: two in the Upper Willamette River core area and one in the Clackamas River core habitat. In addition to this feasibility assessment, similar assessments are needed to evaluate the feasibility of reintroducing bull trout into historic habitats in the Middle Fork Willamette River Subbasin (Salt Creek, Salmon Creek, and the North Fork Middle Fork Willamette River) and North and South Santiam subbasins.

Draft abundance criteria will be met when estimated abundance of adult bull trout is from 900 to 1,500 or more individuals in the Willamette River Recovery Unit. The recovered abundance range was derived from the professional judgment of the Willamette River Bull Trout Recovery Unit Team in estimating the productive capacity of identified local populations and potential habitat. These abundance goals may be refined as more information becomes available through monitoring and research.

Trend criteria will be met when adult bull trout exhibit stable or increasing trends in abundance in the Willamette River Recovery Unit based on a minimum of 15 years of monitoring data.

Connectivity criteria will be met when intact migratory corridors among all local populations provide opportunity for genetic exchange and diversity. In the Upper Willamette River core area, meeting connectivity criteria will require the establishment of upstream and downstream fish passage facilities at Cougar, Trail Bridge, Dexter, Lookout Point, and Hills Creek dams.

The Willamette River Recovery Unit and Strategy for Recovery

The combination of core habitat and a core population (i.e., bull trout inhabiting a core habitat) constitutes the basic core area upon which to gauge recovery within a recovery unit. Within a core area, many local populations may exist. The Clackamas River is designated core habitat, not a core area, because it currently does not contain any known local populations, but does contain habitat thought to be suitable for bull trout. The Clackamas River Subbasin has been identified as a potential area for reintroducing bull trout. Successful reestablishment of bull trout in the Clackamas River would contribute to meeting recovery criteria for bull trout in the Willamette River Basin by restoring distribution to a previously occupied area, improving the long-term outlook for bull trout recovery in the Willamette River Recovery Unit, and by safeguarding bull trout persistence by spreading potential extinction risks.

The Role of Reintroduction in Recovery

Section 3(3) of the ESA lists artificial propagation and transplantation (or reintroduction) as methods that may be used for the conservation of listed species. While transplantation has played an important role in the recovery of other listed fish species, the overall recovery strategy for bull trout in the Willamette River Recovery Unit, where possible, will emphasize identifying and correcting threats affecting bull trout and their habitat.

However, due to the size of the Willamette River Basin and the extirpation of bull trout in multiple subbasins, transplantation, in addition to the current effort to rehabilitate bull trout in the Middle Fork Willamette River Subbasin, will likely be necessary for bull trout recovery within the Willamette River Recovery Unit. The Willamette Chapter of the draft recovery plan (USFWS 2002) describes several information needs required for transplantation. Transplantation actions will follow the joint policy of the USFWS and the NMFS regarding transplants of listed species (65 FR 56916). Also, an appropriate plan would need to be approved to consider the effects of transplantation on other species, as well as on the donor bull trout population(s). Transplanting listed species must be authorized by the USFWS through a 10(a)(1)(A) recovery permit or other applicable regulatory tools, and methods must meet applicable state fish-handling and disease policies.

Therefore, to achieve recovery in the time frame that is specified in the Willamette Chapter of the draft recovery plan, some form of reintroduction is likely necessary. The current Willamette River bull trout local populations have been isolated and functioning at low abundance for a long period of time. As a result, a program to immediately increase the number of individual fish in the core area and to infuse new genetic material into existing populations to avoid loss of alleles and heterozygosity (Spruell et al. 1999) is warranted. The Willamette Chapter of the draft recovery plan suggests that feasibility assessments should be completed to identify streams with the greatest potential to support local populations of bull trout and to identify the best available source of genetic material (donor population).

Chapter 2 – Habitat

This chapter investigates the various habitat considerations involved in assessing the feasibility of bull trout reintroduction in the Clackamas River Subbasin. Historical occupancy of the subbasin is examined to highlight those areas that were likely inhabited. Next, key habitat requirements for bull trout are examined as a precursor to evaluating current conditions and determining those areas providing suitable habitat. Key questions addressed in this chapter include:

- What are the key habitat requirements for bull trout?
- Is there suitable habitat present in the Clackamas River Subbasin of sufficient quantity to support a reintroduction of bull trout? And, if so,
- What are the characteristics of these suitable habitat areas (referred to as patches) and how are they spatially arranged on the landscape in relationship to what is known about bull trout ecology, life histories, and habitat use.

2.1 Key Habitat Requirements for Bull Trout

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence the species' distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and availability of migratory corridors (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Howell and Buchanan 1992; Pratt 1992; Rich 1996; Rieman and McIntyre 1993; Rieman and McIntyre 1995; Sedell and Everest 1991; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear, but these specific characteristics are not necessarily present throughout all watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), individuals of this species should not be expected to simultaneously occupy all available habitats (Rieman et al. 1997).

<u>Temperature</u>

Bull trout are found primarily in cold streams, although individual fish are found in larger, warmer river systems throughout the Columbia River Basin (Buchanan and Gregory 1997; Fraley and Shepard 1989; Rieman et al. 1997; Rieman and McIntyre 1993; Rieman and McIntyre 1995). Water temperature above 15 degrees Celsius (59 degrees Fahrenheit) is believed to limit bull trout distribution, a limitation that may partially explain the patchy distribution within a watershed (Dunham et al. 2003).

Spawning areas are often associated with cold water springs, groundwater inputs (i.e., subsurface flow), and the streams with the coldest summer water temperatures in a given watershed (Baxter et al. 1999; Pratt 1992; Rieman et al. 1997; Rieman and McIntyre 1993). Water temperatures during spawning generally range from five to nine degrees Celsius (41 to 48 degrees Fahrenheit) (Goetz 1989). The requirement for cold water during egg incubation has generally limited the spawning distribution of bull trout to high elevations in areas where the summer climate is warm (McPhail and Baxter 1996). Rieman and McIntyre (1995) found in the Boise River Basin that no juvenile bull trout were present in streams below 1,613 meters (5,000 feet) (Rieman and McIntyre 1995). Similarly, in the Sprague River Basin of south-central Oregon, Ziller (1992) found in four streams with bull trout that "numbers of bull trout increased and numbers of other trout species decreased as elevation increased. In those streams, bull trout were only found at elevations above 1,774 meters (5,500 feet)."

Goetz (1989) suggested optimum water temperatures of about seven to eight degrees Celsius (44 to 46 degrees Fahrenheit) for rearing bull trout and two to four degrees Celsius (35 to 39 degrees Fahrenheit) for egg incubation. For Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water [eight to nine degrees Celsius (46 to 48 degrees Fahrenheit), within a temperature gradient of eight to 15 degrees Celsius (46 to 60 degrees Fahrenheit)] available in a plunge pool.

Bull trout more typically occupy rivers and streams with cold temperatures. However, in some instances bull trout have been found in rivers and streams with warmer water temperatures. In Nevada, adult bull trout have been collected at sites with a water temperature of 17.2 degrees Celsius (63 degrees Fahrenheit) in the West Fork of the Jarbidge River (Selena Werdon, U. S. Fish and Wildlife Service, personal communication, August 5, 1998) and have been observed in Dave Creek where maximum daily water temperatures were 17.1 to 17.5 degrees Celsius (62.8 to 63.6 degrees Fahrenheit) (Werdon 2001). In the Little Lost River, Idaho, bull trout have been collected in water having temperatures up to 20 degrees Celsius (68 degrees Fahrenheit); however, these fish made up less than 50 percent of all salmonids when maximum summer water temperature exceeded 15 degrees Celsius (59 degrees Fahrenheit) and less than 10 percent of all salmonids when temperature exceeded 17 degrees Celsius (63 degrees Fahrenheit) (Gamett 1999). In the Lostine River system in northeast Oregon, migratory bull trout were observed in waters exceeding 21 degrees Celsius (daily maximum temperature) for several weeks (Phil Howell, U.S. Forest Service, personal communication).

Suitable Habitat or "Patch" Size

Although bull trout are widely distributed over a large geographic area, they exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993). Increased habitat fragmentation reduces the amount of available habitat and increases isolation from other populations of the same species (Saunders et al. 1991). Burkey (1989) concluded that when species are isolated by fragmented habitats, low rates of population growth are typical in local populations and their probability of extinction is directly related to the degree of isolation and fragmentation. Without sufficient immigration, growth for local populations may be low and probability of extinction high (Burkey 1989, 1995).

Metapopulation concepts of conservation biology theory have been suggested relative to the distribution and characteristics of bull trout, although direct empirical evidence is limited to a case study in central Idaho (Dunham and Rieman 1999; Rieman and Dunham 2000; Rieman and McIntyre 1993). A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1994). For inland bull trout, metapopulation theory is likely most applicable in larger river basins where habitat consists of discrete patches or collections of habitat capable of supporting local populations. Local populations are, for the most part, independent and represent discrete reproductive units. Long-term, low-rate dispersal patterns among component populations influences the persistence of at least some of the local populations (Rieman and Dunham 2000). Ideally, multiple local populations distributed throughout a watershed provide a mechanism for spreading risk because the simultaneous loss of all local populations is unlikely. However, habitat alteration, primarily through the construction of impoundments, dams, and water diversions has fragmented habitats, eliminated migratory corridors, and in many cases isolated bull trout in the headwaters of tributaries (Dunham and Rieman 1999; Rieman and Dunham 2000; Rieman et al. 1997; Spruell et al. 1999). Accordingly, human-induced factors as well as natural factors affecting bull trout distribution have likely limited the expression of the metapopulation concept for bull trout to patches of habitat within the overall distribution of the species (Dunham and Rieman 1999). However, despite the theoretical fit, the relatively recent and brief time period during which bull trout investigations have taken place does not provide certainty as to whether a metapopulation dynamic is occurring (e.g., a balance between local extirpations and recolonizations) across the range of bull trout or whether the persistence of bull trout in large or closely interconnected habitat patches (Dunham and Rieman 1999) is simply reflective of a general deterministic trend towards extinction of the species where the larger or interconnected patches are relics of historically wider distribution (Rieman and Dunham 2000). Recent research (Whiteley et al. 2003) does, however, provide stronger genetic evidence for the presence of a metapopulation process for bull trout, at least in the Boise River Basin of Idaho.

Connectivity and Migratory Corridors

Multiple local populations distributed and interconnected throughout a watershed provide a mechanism for spreading risk from stochastic events (Hard 1995; Healy and Prince 1995; Rieman and Allendorf 2001; Rieman and McIntyre 1993; Spruell et al. 1999). Current patterns in bull trout distribution and other empirical evidence, when interpreted in view of conservation theory, indicate that further declines and local extinctions are likely (Dunham and Rieman 1999; Rieman and Allendorf 2001; Rieman et al. 1997; Spruell et al. 2003). Based in part on guidance from Rieman and McIntyre (1993), bull trout core areas with fewer than five local populations are at increased risk of extirpation; core areas with between 5 to 10 local populations are at intermediate risk of extirpation; and core areas which have more than 10 interconnected local populations are at diminished risk of extirpation.

Maintaining and restoring connectivity between existing populations of bull trout is important for the persistence of the species (Rieman and McIntyre 1993). Migration and occasional spawning between populations increases genetic variability and strengthens population variability (Rieman and McIntyre 1993). Migratory corridors allow individuals access to unoccupied but suitable habitats, foraging areas, and refuges from disturbances (Saunders et al. 1991).

Bull trout in the coterminous United States are distributed over a wide geographic area consisting of various environmental conditions. Bull trout also exhibit considerable genetic differentiation among populations. Therefore, we expect there should be considerable phenotypic variability related to variability in environmental conditions and possibly local adaptation in some cases. However, direct evidence supporting this hypothesis is lacking. Some readily observable examples of differentiation between populations include external morphology and behavior (e.g., size and coloration of individuals; timing of spawning and migration). Conserving many populations across the range of the species is crucial to adequately protect genetic and phenotypic diversity of bull trout (Hard 1995; Healy and Prince 1995; Leary et al. 1993; Rieman and Allendorf 2001; Rieman and McIntyre 1993; Spruell et al. 1999; Taylor et al. 1999). Changes in habitats and prevailing environmental conditions are increasingly likely to result in extinction of bull trout if genetic and phenotypic diversity is lost.

Migratory corridors link seasonal habitats for all bull trout life stages. For example, in Montana, migratory bull trout make extensive migrations in the Flathead River system (Fraley and Shepard 1989), and resident bull trout in tributaries of the Bitterroot River move downstream to overwinter in tributary pools (Jakober 1995). The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993, Gilpin 1997, Rieman et al. 1997). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed, or stray, to non-natal streams. Local bull trout populations that are extirpated by catastrophic events may also become reestablished by migrants (Rieman et al. 1997).

Road Density

Roads have the potential to adversely affect several habitat features, (e.g., water temperature, substrate composition and stability, sediment delivery, habitat complexity, and connectivity) (Baxter et al. 1999; Trombulak and Frissell 2000). Roads may also isolate streams from riparian areas, causing a loss in floodplain and riparian function. Roads located within riparian areas may reduce the amount of woody material recruited to the stream system and may also narrowly constrict a stream channel reducing its floodplain area. The aquatic assessment portion of the Interior Columbia Basin Ecosystem Management Project provided a detailed analysis of the relationship between road densities and bull trout status and distribution (Quigley and Arbelbide 1997). The assessment found that bull trout are less likely to use streams in highly roaded areas for spawning and rearing, and do not typically occur where average road densities exceed 1.1 kilometers per square kilometer (1.7 miles per square mile).

Roads may affect aquatic habitats considerable distances away. For example, increases in sedimentation, debris flows, and peak flows affect streams longitudinally so that the area occupied by a road can be small compared to the entire downstream area subjected to its effects (Jones et al. 2000; Trombulak and Frissell 2000). Upstream from road crossings, large areas of suitable habitats may become inaccessible to bull trout due to fish passage barriers (e.g., culverts). Within the Boise River basin of central Idaho, it was found that road density was negatively related to occurrence of bull trout, but this influence was weak in relation to the influences of habitat size and isolation (Dunham and Rieman 1999)

Other Habitat Variables (woody material, pools, spawning substrate, etc.)

All life stages of bull trout are associated with complex forms of cover, including large woody material, undercut banks, boulders, and pools (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Pratt 1992; Rich 1996; Sedell and Everest 1991; Sexauer and James 1997; Thomas 1992; Watson and Hillman 1997). Jakober (1995) observed bull trout overwintering in deep beaver ponds or pools containing large wood in the Bitterroot River drainage, Montana, and suggested that, because of the need to avoid anchor ice in order to survive, suitable winter habitat may be more restricted than summer habitat. Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993).

Bull trout tend to use spawning habitat that consists of low-gradient stream reaches with loose, clean gravel according to Fraley and Shepard (1989). In the Swan River, Montana, abundance of bull trout redds (spawning areas) was positively correlated with the extent of bounded alluvial valley reaches, which are likely areas of groundwater to surface water exchange (Baxter et al. 1999). In a comparison of hyporheic flows to springs, the survival of bull trout embryos planted in stream areas of groundwater upwelling used by bull trout for spawning were significantly higher than embryos planted in areas of surface-water recharge not used by bull trout for spawning (Baxter and McPhail 1999). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

2.2 Habitat Suitability Analysis

The CRBTWG used a three-tiered approach in completing the bull trout habitat suitability analysis for the Clackamas River Subbasin. The CRBTWG set out first to answer the second key question posed at the beginning of this chapter: *"Is there suitable habitat present in the Clackamas River of sufficient quantity to support a reintroduction of bull trout?"* Next, available suitable habitat for bull trout was geographically organized into sub-watershed boundaries, representing discrete "patches." Sub-watershed boundaries used to delineate patches were primarily at the 7th field HUC scale. A patch is defined as a sub-watershed area containing a sufficient quantity of suitable habitat for bull trout spawning and rearing. Finally, once suitable habitat patches were defined across the landscape, data were compiled and summarized to characterize each patch and evaluate their interconnectedness. In summary, the three-tiered approach used in the habitat suitability analysis is as follows:

> **Tier One** – Is there suitable habitat remaining in the Clackamas River Subbasin to support a reintroduction of bull trout?
>
> **Tier Two** – If so, how is the habitat organized across the landscape in terms of patches?
>
> **Tier Three** – What are the characteristics of each patch and how are they interconnected across the landscape?

Tier One: Is There Suitable Habitat Remaining in the Clackamas River Subbasin?

There are various habitat categories for different life stages of bull trout (i.e., migratory, spawning, rearing, etc.). These different categories of habitat have differing thresholds for determining suitability. For example, adult and sub-adult bull trout may endure higher water temperatures when traveling through migratory corridors but then seek out much colder streams or tributaries for spawning. Rather than focus on all of various habitat categories for the different life stages of bull trout, the CRBTWG focused on the category of habitat where the criteria are most stringent and likely to be most limiting in the subbasin. Hence, the habitat analysis focuses exclusively on combined spawning and rearing habitat, where cold water temperature is the primary criterion in determining suitability (Dunham et al. 2003).

Clackamas River Subbasin from North Fork Reservoir to Collawash River Confluence

The initial area of focus for determining presence of suitable spawning and rearing habitat for bull trout in the Clackamas River Subbasin is that portion upstream of North Fork Dam at RM 30 (Figure 1.2). This larger, initial focus area includes major tributaries such as the North Fork Clackamas River, South Fork Clackamas River, Fish Creek, Roaring River, Oak Grove Fork, Collawash River, and upper Clackamas River (above the Collawash River confluence). Stream temperature monitoring data for all of the tributaries entering the Clackamas River from North Fork Dam to the Collawash River confluence were examined in relationship to threshold values for determining suitable bull trout spawning and rearing habitat. Based on available literature (Dunham et al. 2003), the CRBTWG established a criterion of 15 degrees Celsius maximum stream temperature for determining suitable spawning and rearing habitat. None of the tributaries to the mainstem Clackamas River downstream of the Collawash River confluence maintain stream temperatures below the 15 degrees Celsius maximum criterion set by the CRBTWG. Therefore, none of these tributaries were investigated further for spawning and rearing habitat suitability. Special attention was given to the Oak Grove Fork because it provides cold water flows that are diverted at Lake Harriet Dam by Portland General Electric (PGE) for hydroelectric power generation. Under PGE’s current license, no minimum flow releases are required at Lake Harriet Dam located at RM 5.1. Consequently, all streamflow in the lower Oak Grove Fork is derived primarily from tributary flows downstream from the dam. The current summer streamflow in the lower Oak Grove Fork does not meet the 15 degrees Celsius maximum water temperature criterion set forth by the CRBTWG. However, PGE is currently undergoing relicensing of its project, and a settlement agreement offered by PGE and the relicensing collaborative stakeholders to the Federal Energy Regulatory Commission provides for the release of minimum instream flows below Lake Harriet Dam that would likely cool the water temperature in the lower Oak Grove Fork. The resultant cooling of water temperatures from the proposed minimum instream flows have been estimated from a water temperature model, but are not expected to be below the 15 degrees Celsius maximum water temperature criterion (Tim Shibahara, Portland General Electric, personal communication).

Clackamas River Subbasin upstream of (including) the Collawash River

A more detailed spawning and rearing habitat suitability analysis was conducted in the Clackamas River upstream of the Collawash River confluence, including the Collawash River Watershed (Figure 2.1). Several groundwater-fed, cold water tributaries are known to contribute flows to the mainstem Clackamas River upstream of the Collawash River. This portion of the subbasin (i.e., that area upstream from and not including the Collawash River) is hereafter referred to as the Upper Clackamas River Subbasin. Known groundwater-fed, cold tributaries in the Upper Clackamas River Subbasin include Pinhead, Last, Hunter, Cub, Berry, and Lemiti creeks.

Streams and rivers of particular interest in the Collawash River Watershed (i.e., those believed most likely to meet the 15 °C maximum water temperature criterion) include Dickey Creek, East Fork Collawash River, Elk Creek, and upper Hot Springs Fork above the Bagby Research Natural Area (RNA).

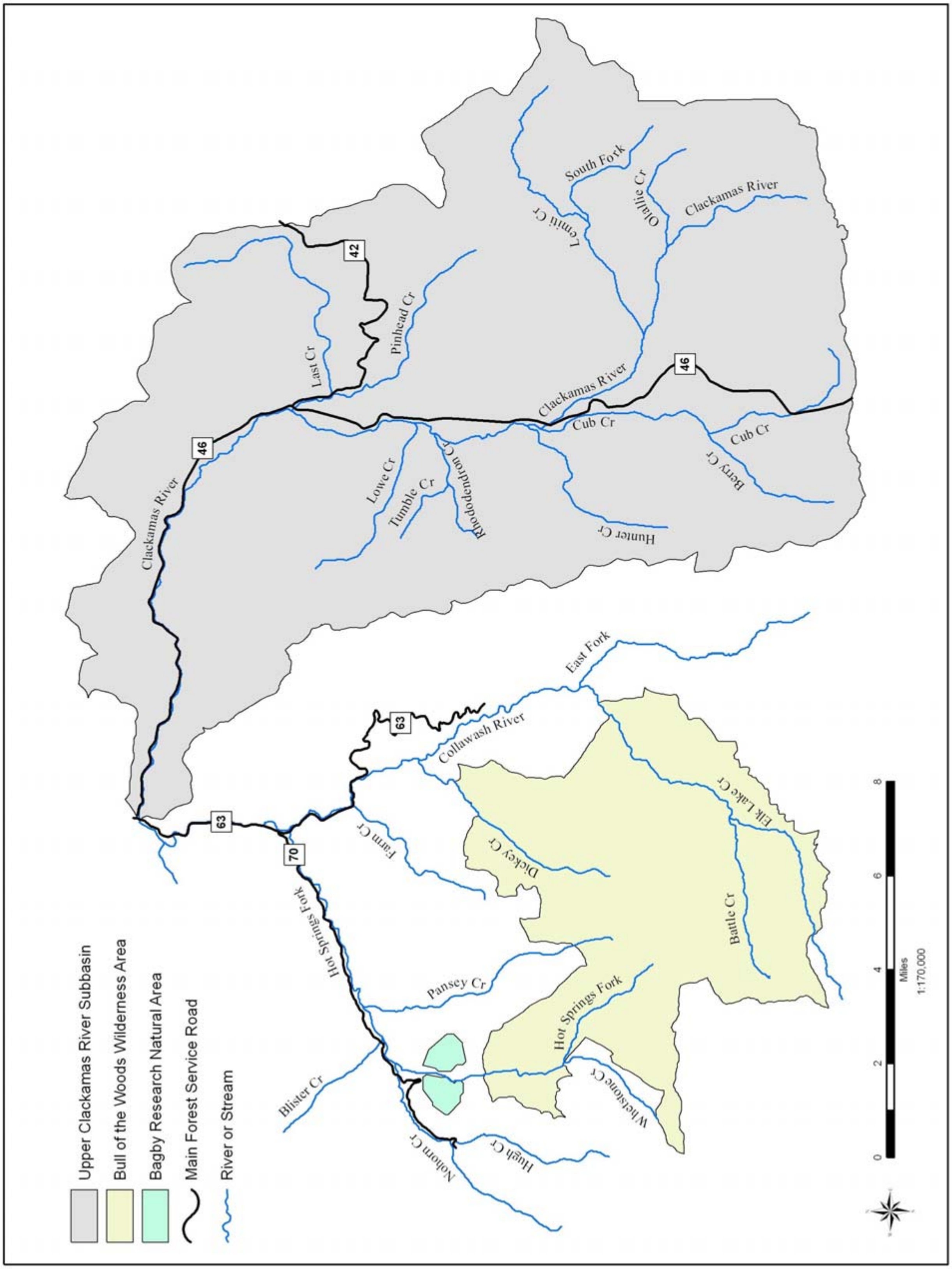

Figure 2.1. Clackamas River Subbasin Upstream of Collawash River.

Extent of Accessible Bull Trout Spawning and Rearing Habitat

The rivers and streams investigated for suitable bull trout spawning and rearing habitat include only those portions historically accessible to anadromous salmon and steelhead, as stated previously. Figure 2.2 identifies the extent of accessible bull trout spawning and rearing habitat for rivers and streams in the Clackamas River Subbasin upstream of and including the Collawash River. As seen in Figure 2.2, there are numerous small streams mapped as potential bull trout spawning and rearing streams. These include small, narrow streams of short distance for which there are no natural barriers that would limit upstream migration of anadromous species. Upon closer review of these small streams, the CRBTWG questioned whether or not they would be capable of supporting bull trout spawning and rearing.

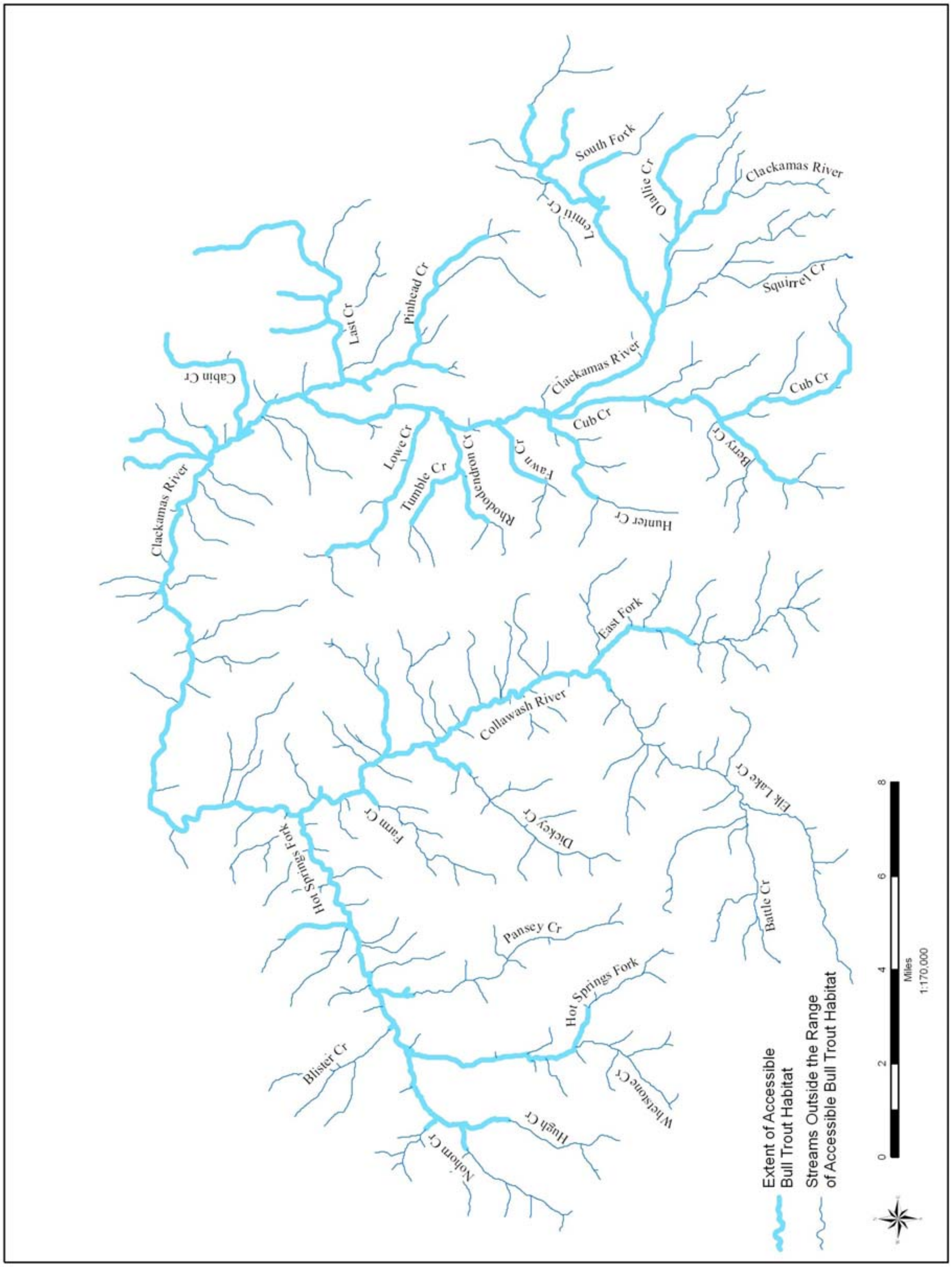

Figure 2.2 Extent of Accessible Bull Trout Spawning and Rearing Habitat; Clackamas River Subbasin Upstream of Collawash River.

Stream Size

The CRBTWG conducted an informal review of river systems containing bull trout to develop a relationship between stream size and bull trout presence. The CRBTWG found that most streams known to contain local populations of bull trout have summer low-flow widths of two meters (6.6 feet) or greater (Dunham and Rieman 1999). Therefore, the CRBTWG assumed streams less than two meters (6.6 feet) in summer low-flow width are too small to support bull trout spawning and rearing. Stream size was then used as another suitable spawning and rearing habitat delineation criterion. All stream survey data collected by the U.S. Forest Service in the Upper Clackamas River Subbasin were examined to develop a relationship between watershed size and summer low-flow width. A logarithmic regression was developed (Figure 2.3). Watersheds less than 1,742 acres in size likely to contain streams or stream segments that are less than two meters (6.6 feet) in summer low-flow width.

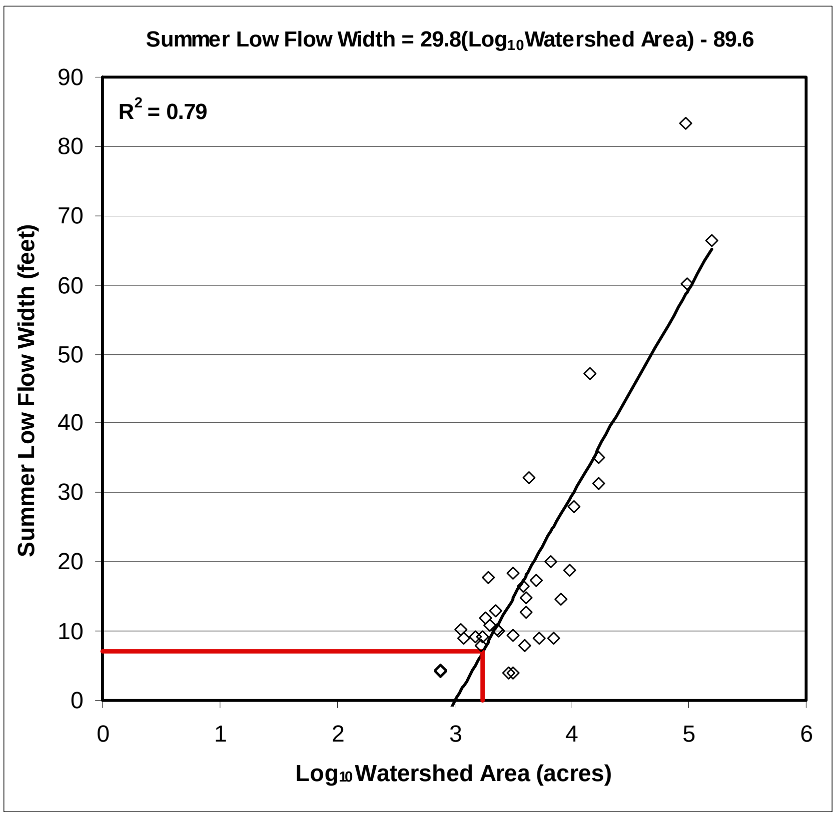

Figure 2.3. Relationship Between Watershed Size and Stream Size (summer low-flow width) in the Clackamas River Subbasin Upstream of and Including the Collawash River.

Geographic Information System (GIS) analysis was completed using a stream coverage derived from a 10-meter tau-DEM (digital elevation model) to screen out small, narrow streams from further consideration. GIS computed watershed area for every stream segment at its nearest downstream node (e.g., point of tributary intersect). Streams and stream segments with watershed areas less than 1,742 acres in size were highlighted (Figure 2.4) and excluded from further suitable habitat analysis.

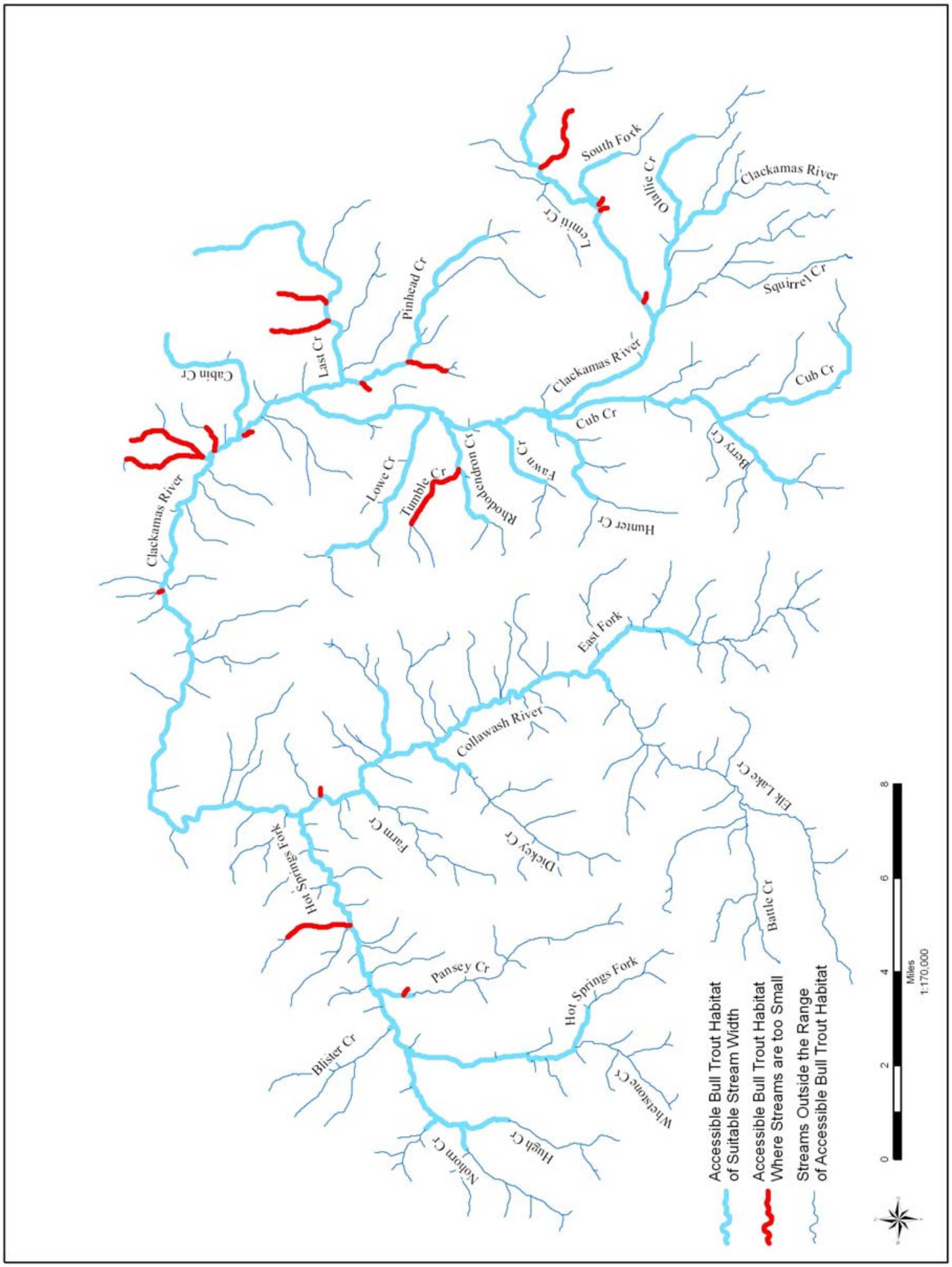

Figure 2.4. Extent of Accessible Bull Trout Spawning and Rearing Habitat of Suitable Stream Width; Clackamas River Subbasin Upstream of Collawash River.

Water Temperature

Water temperature is a critical component to the survival and distribution of bull trout. The CRBTWG reviewed existing literature on the relationship between bull trout presence and water temperature. Based on this review, the CRBTWG established another suitable spawning and rearing habitat delineation criterion based on water temperature. The CRBTWG assumed rivers and streams with an hourly maximum water temperature greater than 15 degrees Celsius would not be suitable for bull trout spawning and rearing. The CRBTWG recognizes there is a range of water temperatures for which bull trout spawning, egg incubation/emergence, and rearing take place. The working group selected 15 degrees Celsius as the criterion so that it would not underestimate the amount of suitable habitat. This criterion applies to the period of summer temperature record (June through September) when the daily maximum temperature for a single hourly reading exceeds 15 degrees Celsius (Dunham et al. 2003).

The CRBTWG used available water temperature data to determine suitable habitat for bull trout. Continuous summertime, water temperature data were not available for several streams in the Collawash River Watershed (i.e., Pansey, Blister, Nohorn, Whetstone, and Buckeye creeks). However, point measurements made during low-flow stream surveys conducted over the last two decades by U.S. Forest Service fish biologists indicate these streams are typically quite warm in the summer months (greater than 15 degrees Celsius maximum water temperature) and therefore, were considered unlikely suitable. As stated earlier, streams originally identified by the CRBTWG within the Collawash River Watershed thought to contain water temperatures cold enough to provide suitable spawning and rearing habitat for bull trout included Dickey Creek, East Fork Collawash River, Elk Creek, and the upper Hot Springs Fork above the Bagby RNA. Large portions of Dickey Creek, Elk Creek, and the upper Hot Springs Fork are within the Bull of the Woods Wilderness Area and contain intact, old-growth riparian reserves that offer full shading to these streams and their tributaries. Point measurements made near the mouth of the East Fork Collawash River in the mid-1990s indicated cold water temperatures, suggesting the possibility that this river may meet the suitable bull trout spawning and rearing habitat criterion. However, a continuous recording water temperature thermograph placed at mouth of the East Fork Collawash River during the summer of 2004 indicated several periods in July and August with high water temperatures (Figure 2.5).

Continuous water temperature data have been collected sporadically over the years and in many areas of the subbasin. Figure 2.5 identifies the maximum water temperatures for rivers and streams in the Clackamas River Subbasin upstream of, and including, the Collawash River. In order to capture maximum stream temperature, the majority of water temperature data were collected during summer months. Hourly temperatures were recorded for each of the rivers and streams shown in Figure 2.5. Hourly temperatures were analyzed to separate the rivers and streams into the following categories: less than 9 degrees Celsius, 9.1 – 12 degrees Celsius, 12.1 – 15 degrees Celsius, and greater than 15 degrees Celsius.

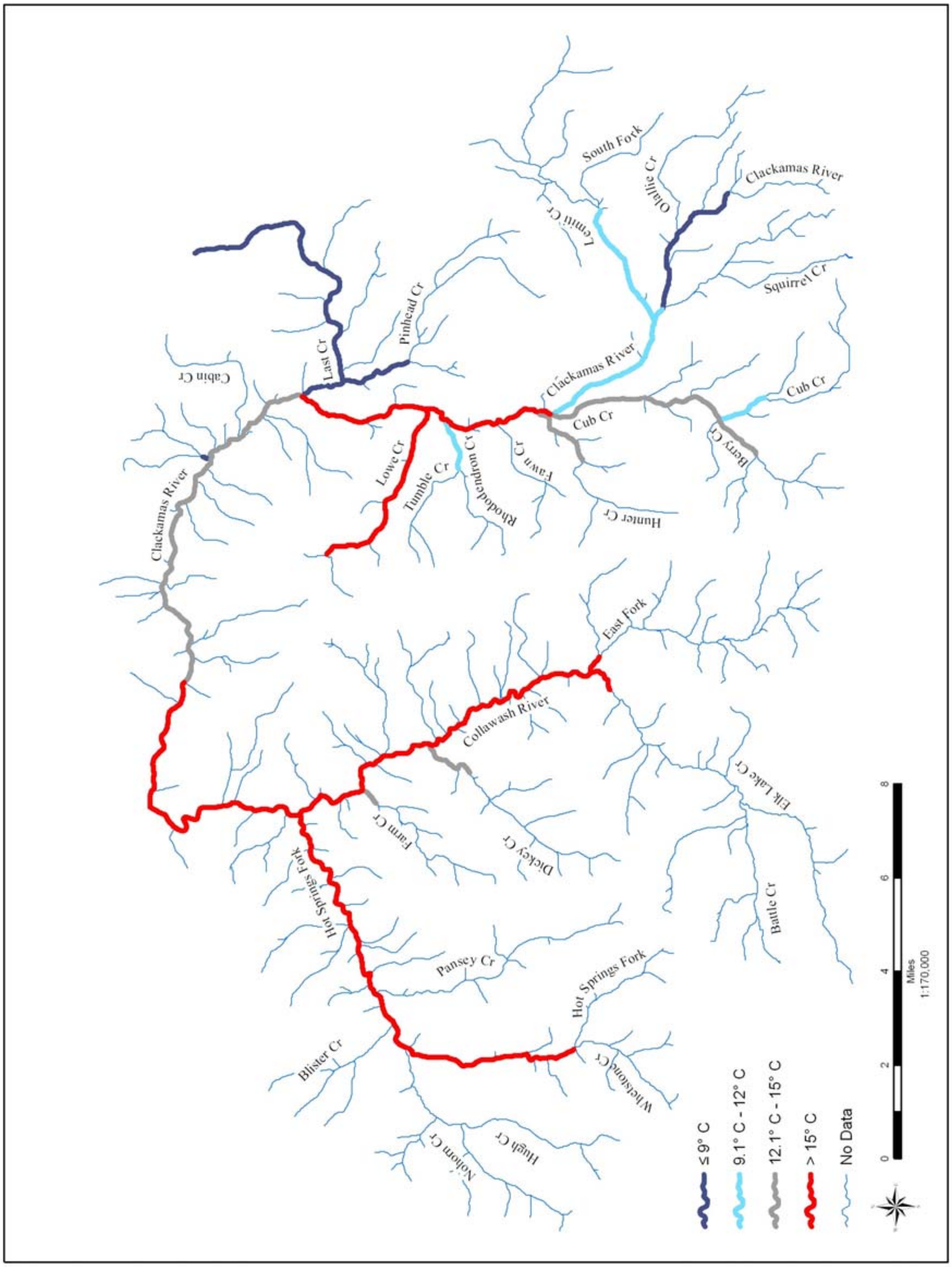

Figure 2.5 Daily Maximum Stream Temperature for Extent of Accessible Bull Trout Spawning and Rearing Habitat; Clackamas River Subbasin Upstream of Collawash River.

Only two streams in the Collawash River Watershed were found to be below the maximum temperature criterion: Farm and Dickey creeks, both westside tributaries to the mainstem Collawash River upstream from the Hot Springs Fork confluence. Given the short distances of available habitat (0.5 miles and 1.4 miles for Farm and Dickey creeks, respectively) and their isolation from other nearby cold water rivers or streams, the CRBTWG dismissed these streams from further consideration, thereby turning attention exclusively to the Upper Clackamas River Subbasin.

The majority of cold water rivers and streams capable of providing suitable bull trout spawning and rearing habitat are located in the Upper Clackamas River Subbasin. A comprehensive effort was made, in 2004, to collect continuous summertime water temperature data in streams throughout the Upper Clackamas River Subbasin. All streams believed large enough to support bull trout spawning and rearing were evaluated. All available continuous summer water temperature data is summarized in Table 2.1. Table 2.1 also provides a review of compliance with the Department of Environmental Quality (DEQ) standard for bull trout spawning of 12 degrees Celsius. The rolling seven-day average of maximum daily temperatures was computed for each site where water temperature data were collected to determine compliance with the DEQ bull trout spawning standard. Both the rolling seven-day average of maximum daily temperatures and the number of days the DEQ standard was exceeded are given in Table 2.1.

Streams within the Upper Clackamas River Subbasin capable of providing suitable bull trout spawning and rearing habitat ranked from coldest to warmest are:

<u>Less than 9 degrees Celsius Maximum Water Temperature [Coldest]</u>

- Pinhead Creek
- Last Creek
- upper Clackamas River (above Squirrel Creek)

<u>9.1 – 12 degrees Celsius Maximum Water Temperature</u>

- Rhododendron Creek
- upper Clackamas River (from Cub Creek upstream to Squirrel Creek)
- upper Cub Creek (above Berry Creek)
- Lemiti Creek
- Squirrel Creek

<u>12.1 – 15 degrees Celsius Maximum Water Temperature [Warmest]</u>

- upper Clackamas River (throughout the Big Bottom reach)
- Hunter Creek
- lower Cub Creek (mouth to Berry Creek)
- Berry Creek

Stream temperatures in the Upper Clackamas River Subbasin tend to be cold, reaching or exceeding 15 degrees Celsius at only three locations in 2004. The only streams to exceed 9 degrees Celsius mean temperature in September during the expected peak spawning period (McPhail and Baxter 1996) were the Clackamas River below Cub Creek confluence, Lowe Creek, Hunter Creek, and lower Cub Creek. The mainstem of the Clackamas River below Cub Creek confluence consistently exceeded the DEQ bull trout spawning standard (12 degrees Celsius seven-day rolling average of maximum daily temperatures), as did Lowe Creek, Hunter Creek, and Berry Creek in 2004. Lower Cub Creek exceeded the standard in 2004, but remained below it in 1999. All other river and stream sites evaluated (Table 2.1) met the DEQ bull trout spawning temperature standard in the years that they were monitored. The DEQ spawning temperature standard is conservatively lower compared to the actual range of temperatures for which bull trout have been observed during spawning (Dunham et al. 2003).

Table 2.1. Summary of Water Temperature Data for River Segments and Streams in the Upper Clackamas River Subbasin.

Stream	River km	Year	Max. Temp (^{0}C)	Aug. Mean (^{0}C)	Sept. Mean (^{0}C)	DEQ compliant? (^{0}C, # days exceeded)
Clackamas River	91.7	2004	16.6	13.2	10.9	NO (16.1, 93)
Clackamas River	105.1	2000	14.8	11.1		NO (14.2, 69)
Clackamas River	105.1	2001	13.5	10.4	9.1	NO (13.0, 32)
Clackamas River	105.1	2002	13.8	9.9	8.6	NO (13.4, 32)
Clackamas River	105.1	2003	13.9	10.5	9.1	NO (13.5, 60)
Clackamas River	105.1	2004	14.7	10.8	9.1	NO (13.6, 63)
Clackamas River	112.7	1997	13.7	10.4	8.9	NO (13.2, 39)
Clackamas River	112.7	2004	15.7	11.6	9.4	NO (15.1, 73)
Clackamas River	119.9	2004	10.6	8.6	7.3	YES (10.2, 0)
Clackamas River	127.1	2004	8.9	5.8	5.1	YES (8.6, 0)
Pot Creek	0.1	1998	9.0	7.3	6.6	YES (8.8, 0)
Pinhead Creek	0.5	1996	8.8	7.0	6.5	YES (8.5, 0)
Pinhead Creek	0.5	2004	9.4	7.3	6.9	YES (9.2, 0)
Last Creek	0.1	2001	7.8	6.8	6.5	YES (7.5, 0)
Last Creek	0.1	2004	8.3	7.3	6.9	YES (8.1, 0)
Fall Creek	0.0	2004	9.4	6.8	6.4	YES (9.2, 0)
W. Fork Pinhead	0.0	2002	7.0	6.3	6.6	YES (7.0, 0)
Lowe Creek	1.0	2004	15.3	12.9	9.8	NO (14.9, 51)
Rhododendron Creek	0.0	2001	11.3	9.9	8.6	YES (11.2, 0)
Hunter Creek	0.4	2004	15.0	11.4	9.3	NO (14.5, 66)
Cub Creek	0.0	1999	12.2	9.9	7.8	YES (11.7, 0)
Cub Creek	0.0	2004	14.3	11.4	9.2	NO (13.8, 59)
Cub Creek	6.3	2004	10.3	8.6	7.7	YES (10, 0)
Berry Creek	0.0	2004	14.0	11.0	8.9	NO (13.5, 51)
Lemiti Creek	0.0	1998	11.7	9.8	8.7	YES (11.3, 0)
Squirrel Creek	0.1	2004	11.5	7.6	6.3	YES (10.5, 0)

Potential Global Climate Change Implications

Several scientists have made recent predictions of global climate changes and their associated impacts relating to stream temperatures and streamflow regimes in the Pacific Northwest (ISAB 2007, Poff et al. 2002). These predictions indicate a general trend towards stream temperature warming and altered precipitation regimes that could lead to increased rain-on-snow events, lower snow packs, and changes in high and low streamflows. The CRBTWG acknowledges this newly emerging body of information and science and the potential for implications relating to future suitability of bull trout spawning and rearing habitat in the Clackamas River Subbasin. The majority of suitable bull trout spawning and rearing streams in the Upper Clackamas River Subbasin are ground-water or spring-fed, and the CRBTWG assumes they would be largely buffered from potential water temperature increases that could arise from predicted global climate changes. Moreover, many of the suitable habitat patches contain streams that are very cold and would have to warm up by several degrees Celsius before they would become unsuitable. Climate change is an uncertainty that cannot be dismissed. However, extrapolating from existing work to local changes in climate and stream environments is not possible, even if there was certainty around predicted regional climate changes. The recent work on bull trout and climate change is based on air temperature and elevation isoclines. In the dataset analyzed by Dunham et al. (2003), air temperature only explained 20 percent of the variability in actual stream temperatures. Climate changes would have to be quite extreme in order to affect the large amount of suitable, coldwater bull trout habitat present in the Clackamas River Subbasin.

Tier Two: How is the Suitable Habitat Organized in Terms of Patches?

The CRBTWG used a three-step process to determine bull trout spawning and rearing habitat suitability for the area of the Clackamas River Subbasin upstream of, and including, the Collawash River Watershed (Figure 2.6). This included a sequential analysis where all available habitat within the extent of historically accessible habitat was first considered, then very small streams (i.e., less than 6.6 feet summer low-flow width) were removed, and finally a water temperature criterion selectively refined the focus to a smaller subset of river segments and streams within the Upper Clackamas River Subbasin. The three-step process excluded all streams within the Collawash River Watershed, narrowing the scope of focus to river and stream segments within the Upper Clackamas River Subbasin only (i.e., that portion of the subbasin upstream from the Collawash River). Figure 2.7 displays the suitable bull trout spawning and rearing habitat within the Upper Clackamas River Subbasin.

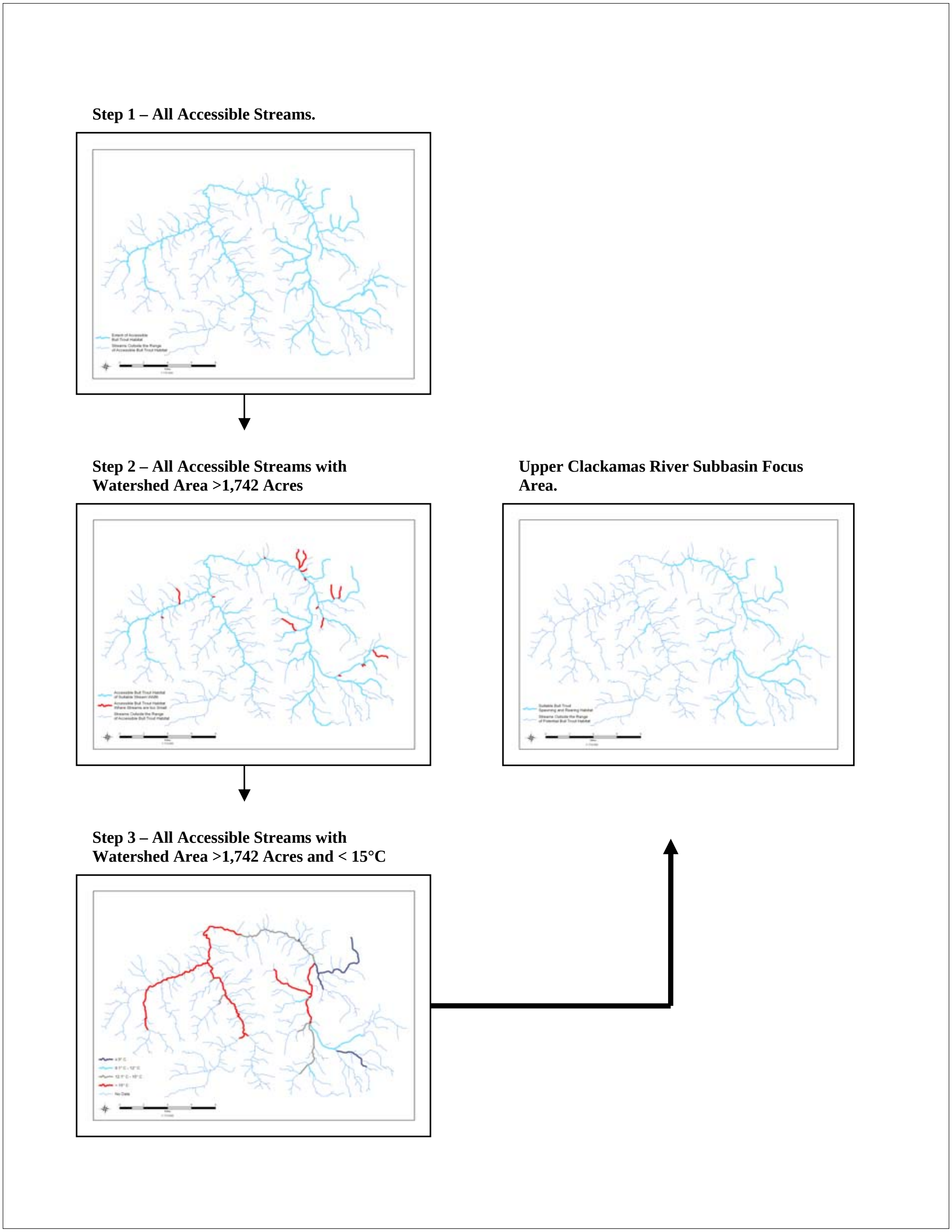

Figure 2.6. Three-step Process Used for Bull Trout Habitat Suitability Analysis for the Clackamas River upstream of (including) the Collawash River.

In Tier Two, the CRBTWG identified individual bull trout spawning and rearing habitat patches. A patch is defined as a group of river segments and/or streams within close geographic proximity that provide suitable habitat for bull trout spawning and rearing. Patch boundaries were developed at a watershed scale in a manner that largely conforms to watershed boundaries at the 7^{th} field HUC scale. Therefore, patches are somewhat geographically separated from one another. The CRBTWG is not presupposing how bull trout might actually utilize suitable habitat within a patch, rather it recognized the need to organize available habitat into logical groupings to provide a more detailed assessment of watershed conditions and fish habitat quality. A total of six habitat patches are identified in the Upper Clackamas River Subbasin (Figure 2.8). These include:

1. Clackamas River mainstem and small tributaries along the Big Bottom Area
2. Pinhead Creek Watershed (including Last Creek)
3. Upper Clackamas River mainstem above Cub Creek (including Lemiti, Squirrel, and Ollalie Creeks)
4. Cub Creek Watershed (including Berry Creek)
5. Hunter Creek Watershed
6. Rhododendron Creek Watershed

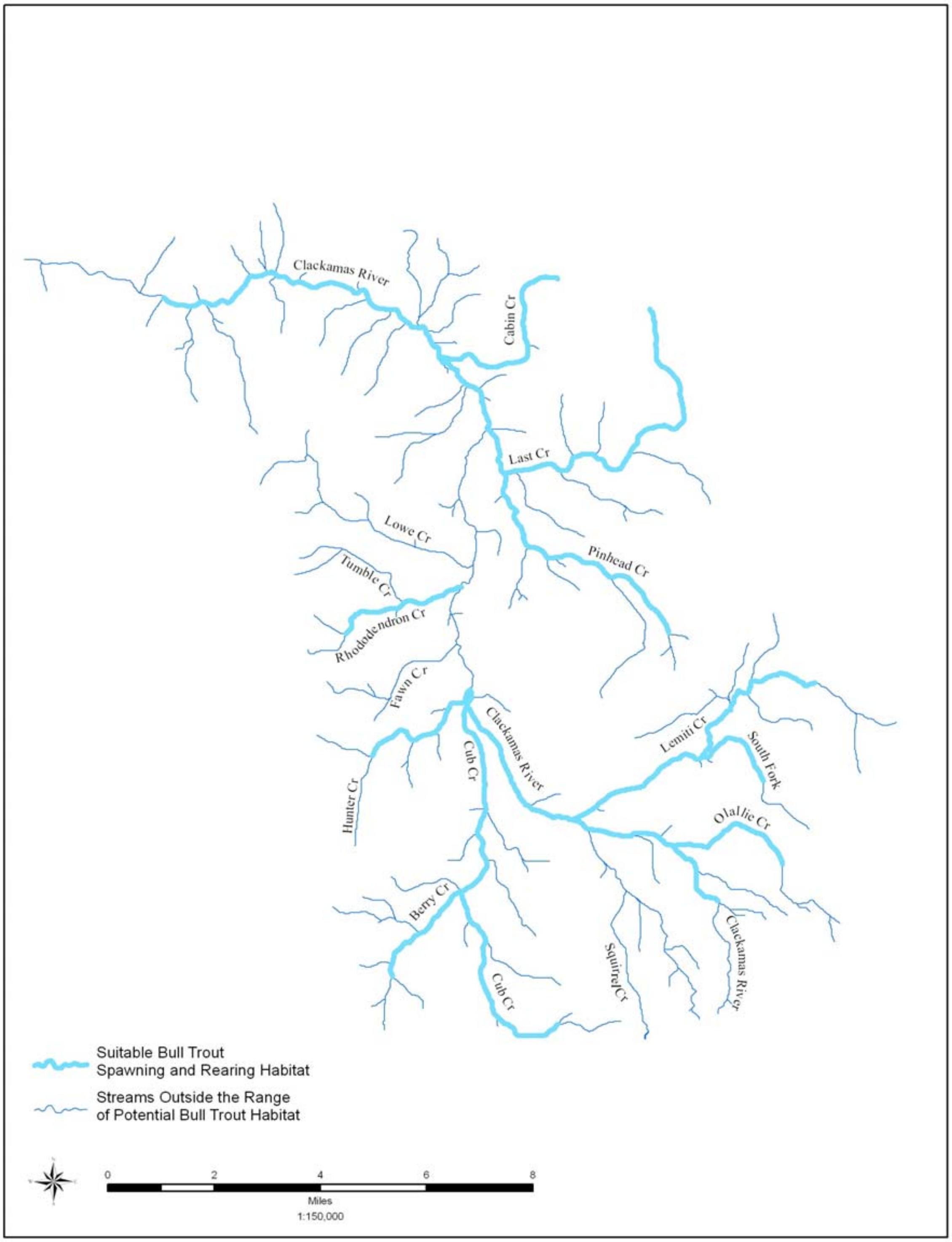

Figure 2.7 Suitable Bull Trout Spawning and Rearing Habitat in the Upper Clackamas River Subbasin.

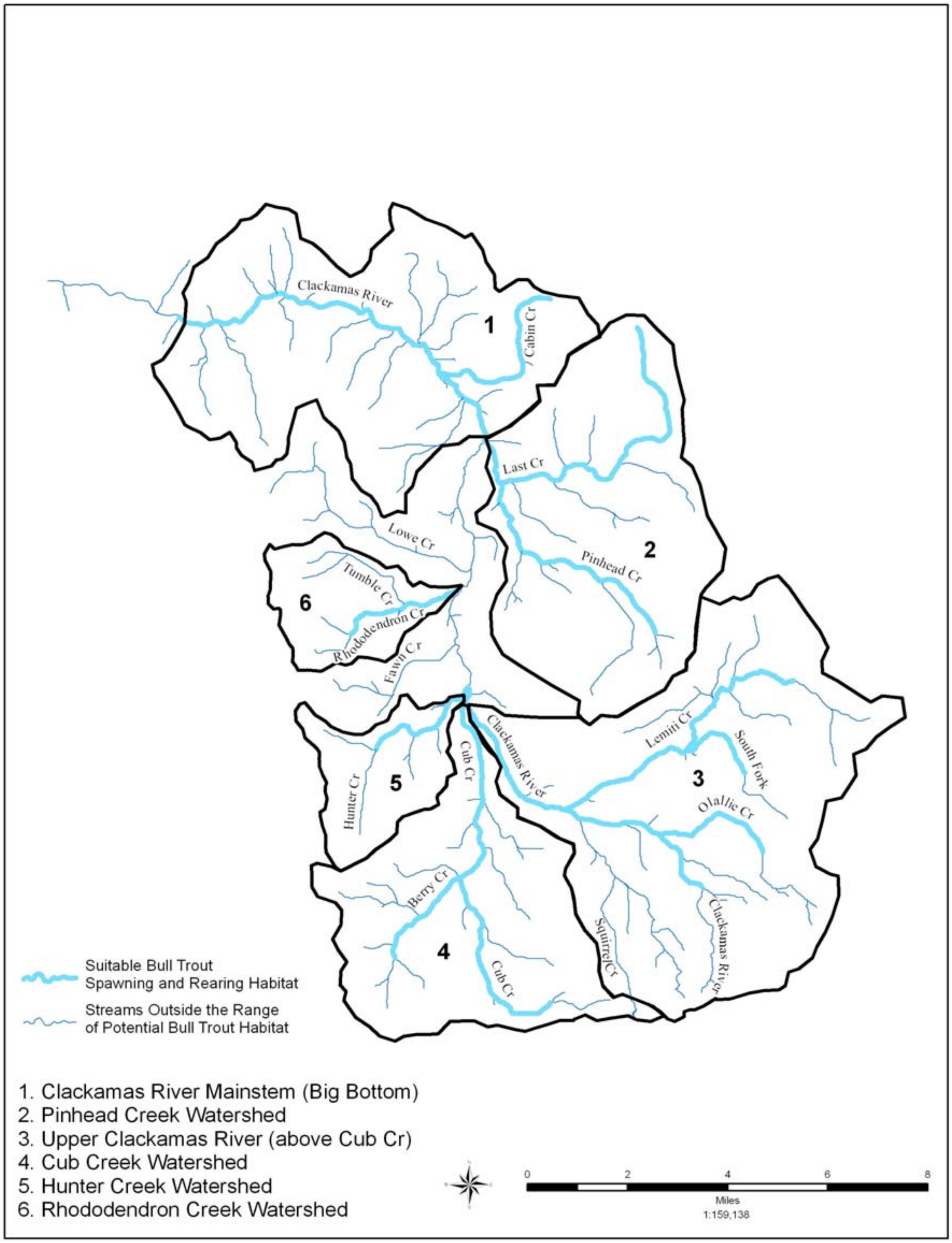

Figure 2.8 Suitable Bull Trout Spawning and Rearing Habitat Patches in the Upper Clackamas River Subbasin.

Tier Three: Patch Characterization

The six suitable bull trout spawning and rearing habitat patches located in the Upper Clackamas River Subbasin (Figure 2.8) differ from one another in several characteristics. This section of Chapter 2 describes the characteristics of the six patches under four broad categories and also describes the connectivity between them. The four broad categories used to characterize the patches include physical characteristics, watershed conditions, land management allocations, and fish habitat. Patch connectivity examines how the patches are distributed across the aquatic landscape and how they are interconnected in relation to bull trout occupancy and dispersal.

Four of the six habitat patches contain two or more sub-watersheds. Each sub-watershed contributes available bull trout spawning and rearing habitat to the overall patch. For example, Patch 1 (Clackamas River Mainstem along Big Bottom) is comprised of four separate sub-watersheds: Big Bottom, Cabin Creek, Pot Creek, and the Upper Clackamas River near Austin Hot Springs. Patch 5 (Hunter Creek Watershed) and Patch 6 (Rhododendron Creek Watershed), on the other hand, are each comprised of one sub-watershed only. Sub-watersheds approximate the size and actual boundaries of watersheds delineated at the 7th field HUC scale.

Physical Characteristics

Table 2.2 summarizes the physical characteristics of the six habitat patches in the Upper Clackamas River Subbasin. The habitat patches range in size from 4,104 acres to 25,572 acres. Patch 3 (Upper Clackamas River above Cub Creek) is the largest in size, while Patch 5 (Hunter Creek Watershed) and Patch 6 (Rhododendron Creek Watershed) are roughly equivalent in size and are smallest; 4,151 and 4,104 acres, respectively. Patch 3 (Upper Clackamas River above Cub Creek) also contains the greatest amount of total stream miles, 67.0 miles, with a drainage density of 1.6 mi/mi^2. Patch 6 (Rhododendron Creek Watershed), contains the lowest amount of stream miles, 6.9 miles, with a drainage density of 1.1 mi/mi^2. Total stream miles include all ephemeral, intermittent, and perennial stream channels in the watershed, therefore including more lineal stream distance than the amount of available bull trout spawning and rearing habitat.

A watershed's flow regime can be characterized by its dominant parent geology: High Cascades versus Western Cascades (Tague and Grant 2004). Watersheds in the High Cascades strata are younger geologically, tend to be more stable in regards to earthflows and landslides, and typically contain stable streamflows derived primarily from cold groundwater and springs. Watersheds in the Western Cascades strata are geologically older, tend to be much less stable in regards to earthflow and landslide activity, and have more flashy streamflows derived primarily from surface waters. The Upper Clackamas River Subbasin is heavily influenced by its dominant parent geology and hence is more characteristic of the Upper McKenzie River system than to other Willamette River tributaries.

Table 2.2. Physical Characteristics of Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Patch	Name	Watershed	Watershed Size		Streams		Flow Regime		Landslide Potential		
			Acres	Sq. Miles	Total Miles (all streams)	Drainage Density	High Cascades Geology	Western Cascades Geology	Low	Medium	High
			acres	mi^2	mi	mi/mi^2	% wtrshd	% wtsrhd	% wtrshd	% wtrshd	% wtrshd
1	Clackamas River (Big Bottom)	Big Bottom	9,592.7	15.0	25.5	1.7	14%	86%	57%	23%	20%
		Cabin Cr	3,150.8	4.9	5.4	1.1	28%	72%	61%	22%	17%
		Upper Clack	7,481.8	11.7	15.6	1.3	0%	100%	48%	14%	38%
		Total	20,225.0	31.6	46.5	1.5	11%	89%	54%	20%	26%
2	Pinhead Creek	Pinhead Cr	7,486.6	11.7	15.2	1.3	100%	0%	64%	32%	4%
		Last Cr	9,610.8	15.0	18.6	1.2	100%	0%	63%	28%	9%
		Total	17,097.0	26.7	33.8	1.3	100%	0%	64%	30%	7%
3	Upper Clackamas	Upper Clack	11,551.0	18.0	36.9	2.0	100%	0%	91%	8%	1%
		Lemiti Cr	9,425.1	14.7	20.6	1.4	100%	0%	92%	8%	0%
		S. Fk Lemiti Cr	2,227.3	3.5	3.1	0.9	100%	0%	100%	0%	0%
		Olallie Cr	2,368.0	5.1	6.3	1.2	100%	0%	89%	11%	0%
		Total	25,572.0	41.4	67.0	1.6	100%	0%	92%	7%	<1%
4	Cub Creek	Cub Cr	9,127.7	14.3	22.3	1.6	100%	0%	86%	14%	0%
		Berry Cr	5,373.7	8.4	10.1	1.2	100%	0%	73%	27%	0%
		Total	14,501.0	22.7	32.3	1.4	100%	0%	81%	19%	0%
5	Hunter Creek	Hunter Cr	4,151.0	6.5	8.0	1.2	100%	0%	86%	6%	7%
6	Rhododendron Creek	Rhododen-dron Cr	4,104.0	6.4	6.9	1.1	19%	81%	60%	29%	11%

Patch 2 (Pinhead Creek Watershed), Patch 3 (Upper Clackamas River above Cub Creek), Patch 4 (Cub Creek Watershed), and Patch 5 (Hunter Creek Watershed) occur entirely within the High Cascades geology. Consequently, these patches not only contain stable, cold groundwater-contributed streamflows but are also geologically stable (i.e., the majority of watershed area is in the Low category for landslide potential). Both Patch 1 (Clackamas River Mainstem along Big Bottom) and Patch 6 (Rhododendron Creek Watershed) are dominated by Western Cascades geology, 89 percent and 81 percent, respectively. Patch 6 (Rhododendron Creek Watershed), in particular, tends to be characteristically more flashy in regards to streamflows offering lower summer baseflows and more rain-on-snow influenced winter flows. These streamflow characteristics tend to be less pronounced for Patch 1 (Clackamas River Mainstem along Big Bottom) given the large amount of upstream contributing watershed areas dominated by High Cascades geology (Figure 2.9).

Patch 1 (Clackamas River Mainstem along Big Bottom) contains the greatest percentage of watershed area, 26 percent, in the High landslide potential category. Patch 3 (Upper Clackamas River above Cub Creek) and Patch 4 (Cub Creek Watershed) are considered the most geologically stable of the six suitable habitat patches in the Upper Clackamas River Subbasin. Figure 2.10 displays the landslide potential for each patch.

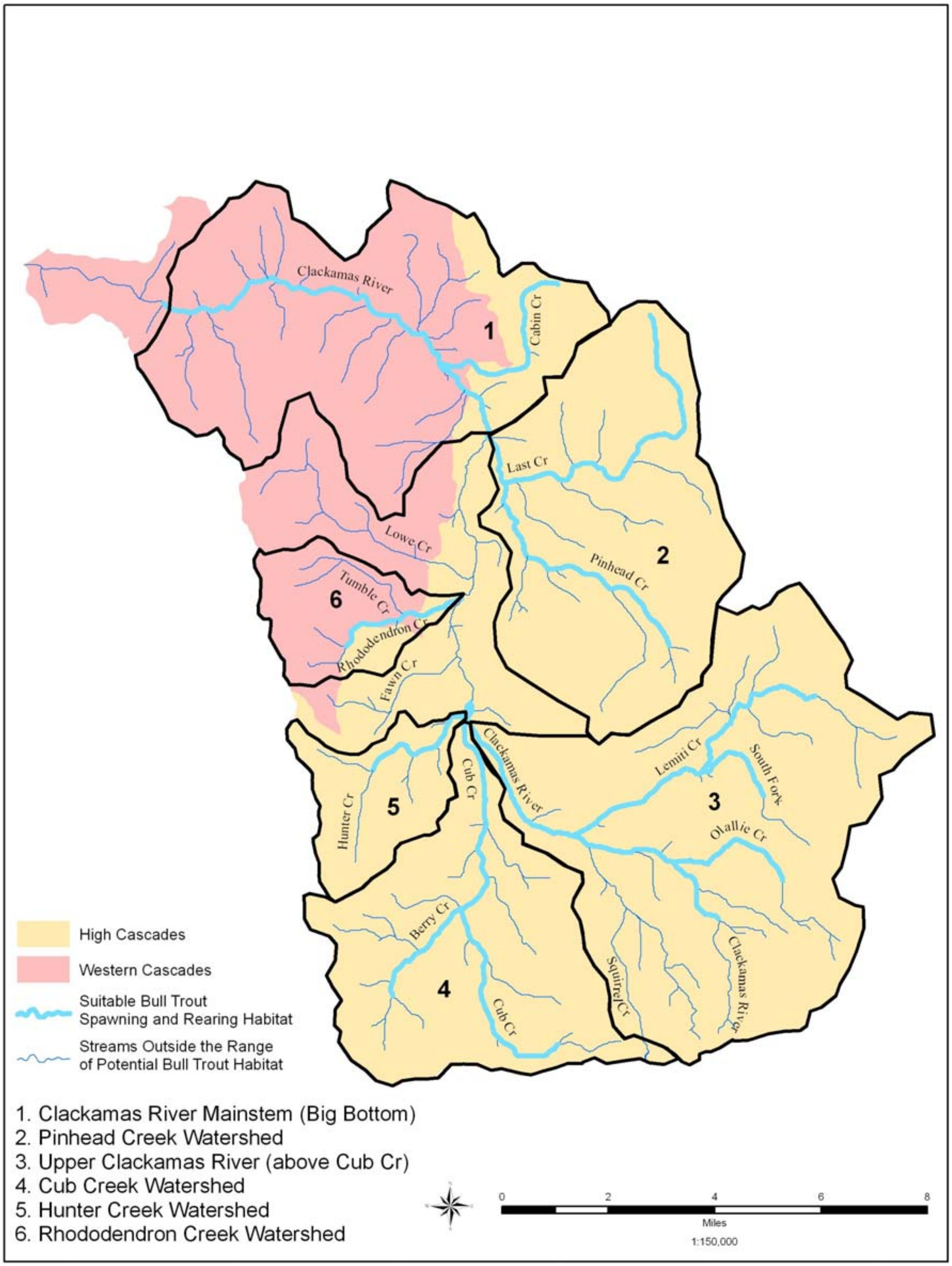

Figure 2.9. Underlying Geologies for Suitable Habitat Patches in the Upper Clackamas River Subbasin.

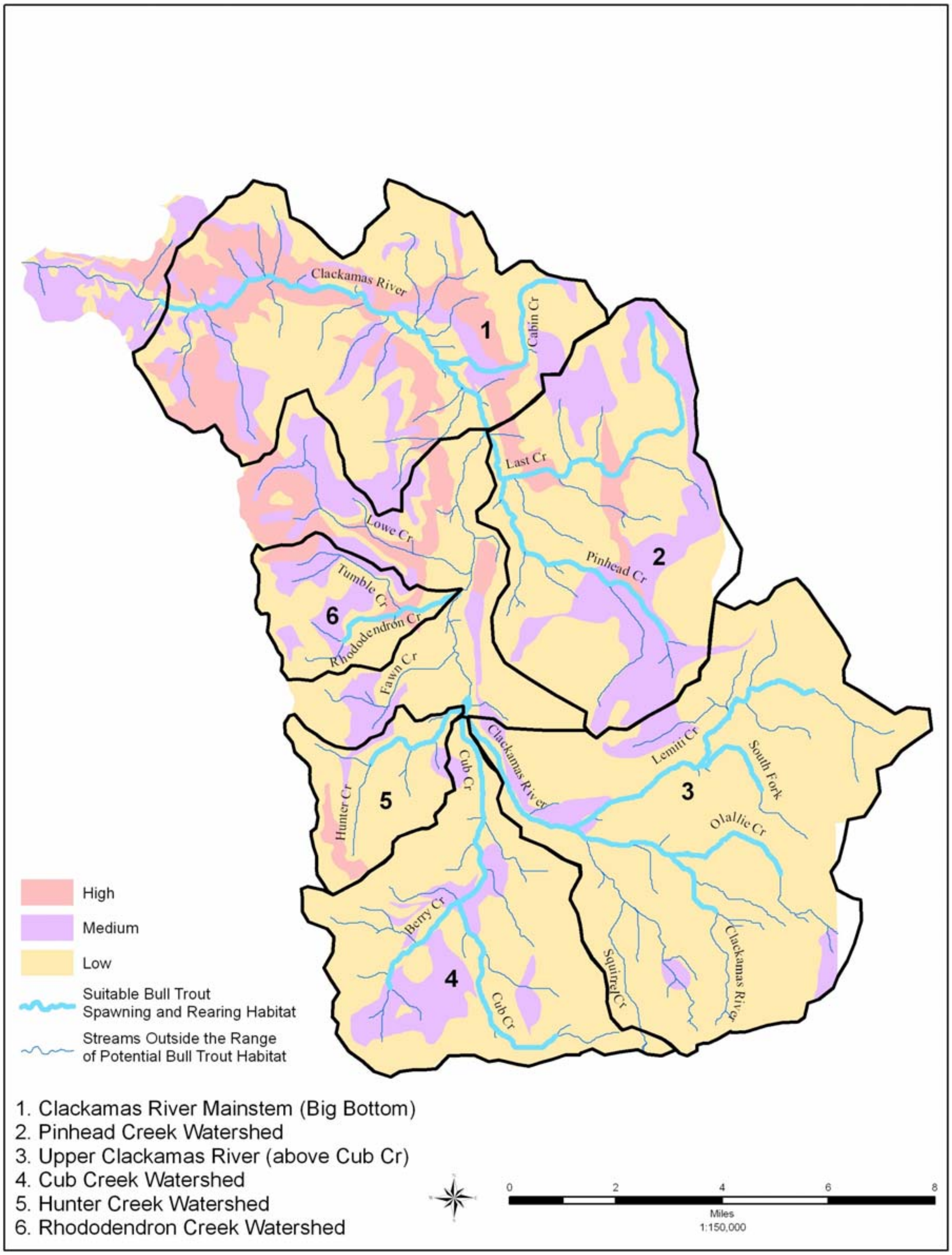

Figure 2.10. Landslide Potential for Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Watershed Conditions

Table 2.3 summarizes the watershed conditions for the six habitat patches in the Upper Clackamas River Subbasin. Patch 1 (Clackamas River Mainstem along Big Bottom) contains the greatest mileage of roads and has the highest road density of 3.6 mi/mi^2. Patch 3 (Upper Clackamas River above Cub Creek) has a total of 88.6 miles of road but the lowest road density at 2.1 mi/mi^2. Figure 2.11 shows the road density for each of the six habitat patches in the Upper Clackamas River Subbasin. As stated earlier, roads may affect watershed condition in several ways: increased sediment production, altered timing of hydrograph, and loss of riparian shade and large wood recruitment. There is, however, no evidence that road density has affected peak flows in the Upper Clackamas River Subbasin (USFS 1995). This is probably due to the spring-fed nature of much of the Upper Clackamas River Subbasin. Inventories of possible culvert-related fish passage barriers by U.S. Forest Service fish biologists indicate that none of the roads within each of the six suitable habitat patches pose a migration barrier to resident or anadromous fish species within the river and stream segments identified as suitable bull trout spawning and rearing habitat. Given the geologic stability of the Upper Clackamas River Subbasin (USFS 1995), the CRBTWG does not believe the current road network would deter success of a bull trout reintroduction effort.

The composition of riparian reserves within a watershed serves as an indicator of watershed condition and is primarily indicative of past timber harvesting practices prior to the 1994 Northwest Forest Plan. Past timber harvesting occurred within riparian reserves primarily along ephemeral and intermittent streams but also along perennial streams, with varying degrees of streamside buffers retained, from the late 1940s through the early 1990s (USFS 1995). Therefore, various portions of the riparian reserve network within the watersheds do not currently meet the desired future conditions associated with late seral (typically old-growth) characteristics. Patch 1 (Clackamas River Mainstem along Big Bottom) contains the greatest percentage of riparian reserve in the late seral condition, whereas Patch 6 (Rhododendron Creek Watershed) contains the greatest percentage of riparian reserve in the early seral condition (Table 2.3).

Hydrologic recovery is a measure of how hydrologically impaired a watershed is as a result of past clear-cut timber harvest practices. When large vegetative openings are created from clear-cut timber harvesting, snow tends to accumulate at greater depths as compared to undisturbed sites with forested canopies. These areas of greater snow accumulation are then subject to rapid melt and run-off during warmer precipitation events within the rain-on-snow zone of the watershed. The result can be an increase in streamflows, channel erosion, and sediment production and transport. The Aggregate Recovery Percentage (ARP) Model is used to indicate a watershed's degree of hydrologic impairment from past clear-cut timber harvesting. The lower the ARP value, the greater degree of hydrologic impairment indicated. Patch 6 (Rhododendron Creek Watershed) has the lowest ARP value at 76.3 percent, indicating the greatest degree of hydrologic impairment. Patch 3 (Upper Clackamas River above Cub Creek) has the highest ARP value at 88.7 percent, indicating the least degree of hydrologic impairment.

Table 2.3. Watershed Conditions of Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Patch	Name	Watershed	Roads		Riparian Reserves				Hydrologic Recovery
			Total Miles	Road Density	Total Acres	Amount in Early Seral	Amount in Mid Seral	Amount in Late Seral	ARP
			mi	mi/mi^2	ac	% wtrshd	% wtrshd	% wtrshd	%
1	Clackamas River (Big Bottom)	Big Bottom	55.1	3.7	2,355	12%	32%	57%	82.5%
		Cabin Cr	19.9	4.0	704	8%	31%	61%	81.4%
		Upper Clack	38.6	3.3	1,682	14%	22%	64%	85.0%
		Total	113.6	3.6	4,741	12%	28%	60%	83.3%
2	Pinhead Creek	Pinhead Cr	35.5	3.0	847	23%	28%	49%	78.8%
		Last Cr	54.6	3.6	1,064	18%	15%	67%	76.7%
		Total	90.1	3.4	1,912	21%	21%	58%	77.6%
3	Upper Clackamas	Upper Clack	48.1	2.7	2,975	5%	45%	50%	91.8%
		Lemiti Cr	29.7	2.0	758	1%	90%	9%	83.8%
		S. Fk Lemiti Cr	5.9	1.7	306	3%	95%	2%	92.1%
		Olallie Cr	4.9	1.0	204	33%	29%	38%	90.4%
		Total	88.6	2.1	4,242	5%	56%	39%	88.7%
4	Cub Creek	Cub Cr	37.9	2.7	2,028	18%	29%	53%	85.0%
		Berry Cr	28.1	3.3	1,413	15%	26%	59%	84.8%
		Total	66.0	2.9	3,441	17%	28%	55%	84.9%
5	Hunter Creek	Hunter Cr	21.1	3.2	839	17%	35%	48%	81.7%
6	Rhododendron Creek	Rhododen-dron Cr	15.7	2.4	844	27%	20%	53%	76.3%

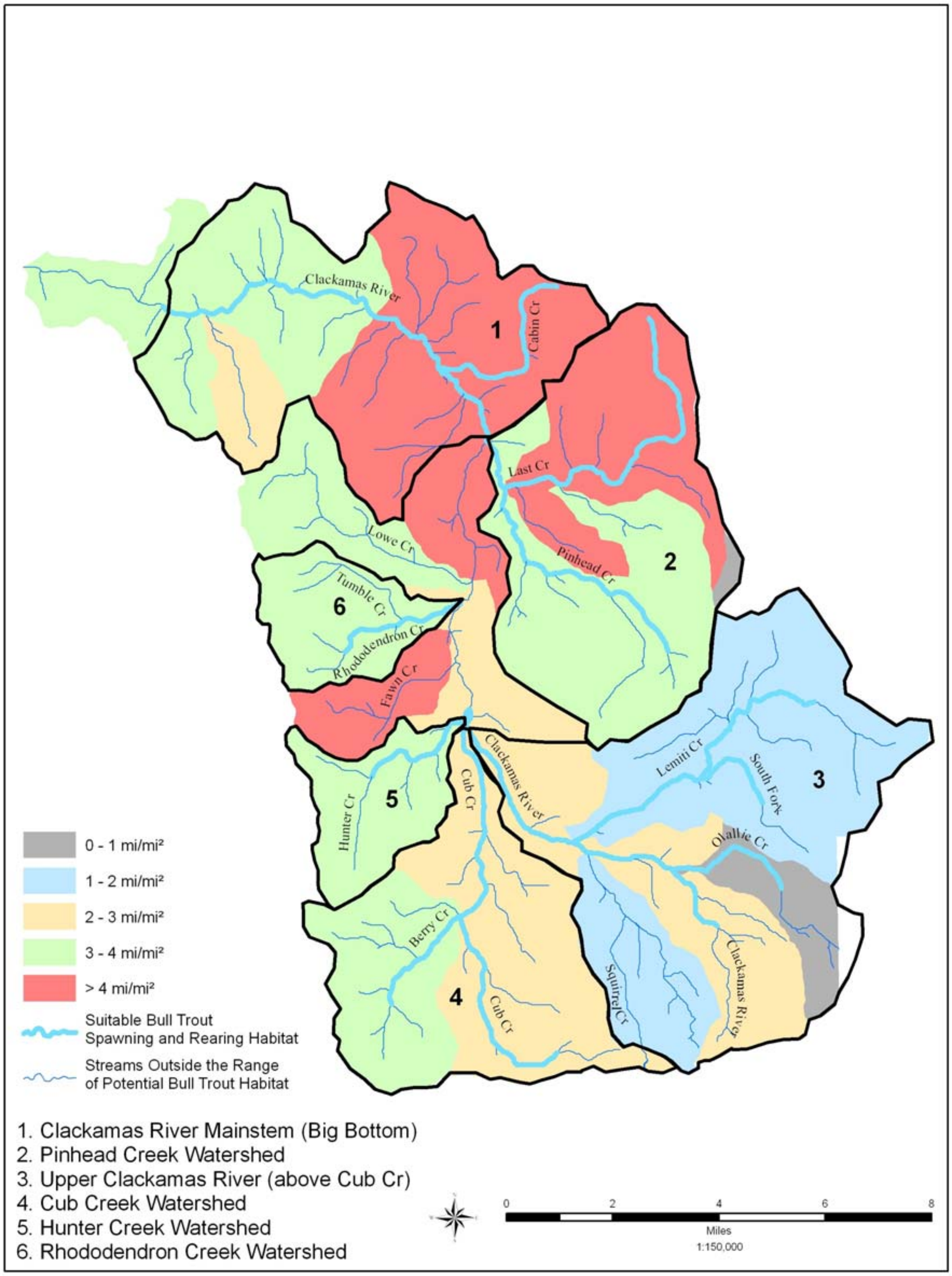

Figure 2.11. Road Densities for Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Land Allocations

There are many different land allocations within the Upper Clackamas River Subbasin, as identified in the 1990 Mt. Hood National Forest Land and Resource Management Plan (USFS 1990) and amended by the 1994 Northwest Forest Plan (USDA and USDI 1994). A broad-scale overview of the major land allocations within the Upper Clackamas River Subbasin was completed looking at three general categories: Administratively Withdrawn Areas (AWAs), Late-Successional Reserves (LSRs), and Matrix. Riparian Reserves are also a land allocation but were summarized above under the *Watershed Condition* section of this chapter. AWAs were created under the 1994 Northwest Forest Plan to recognize those areas identified in local national forest and BLM land management plans that include recreation and visual areas, back country, and other areas where management emphasis precludes scheduled timber harvest. LSRs are large management areas created under the 1994 Northwest Forest Plan to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth forest related species. Limited stand management (i.e., timber harvest) is permitted within LSRs, but is subject to review by the Regional Ecosystem Office (REO). Matrix is a land allocation that comprises all other federal lands that occur outside of AWAs, LSRs, and Riparian Reserves. A scheduled timber harvest is programmed for all Matrix lands. Future timber harvest and road building activities are expected on Matrix lands. Table 2.4 summarizes the three major Northwest Forest Plan land allocations for the six suitable habitat patches in the Upper Clackamas River Subbasin.

AWAs occur within five of the six suitable habitat patches. Patch 5 (Hunter Creek Watershed) is the only patch without an AWA. The largest AWA is an A5 Unroaded Recreation Area located just east of Sisi Butte (USFS 1990) which straddles the ridge extending into two suitable habitat patches: Patch 2 (Pinhead Creek Watershed) and Patch 3 (Upper Clackamas River above Cub Creek) (see Figure 2.12), accounting for 6 percent and 5 percent of the watershed areas within each patch, respectively. The primary management goal of an A5 Unroaded Recreation Area is to provide a variety of year-round unroaded recreation opportunities in a semi-primitive, non-motorized setting and undeveloped forest environment. Patch 4 (Cub Creek Watershed) contains an AWA that is designated as an A9 Key Site Riparian Area (USFS 1990), comprising 5 percent of its watershed area. The A9 Key Site Riparian Area occurs along Berry Creek and lower Cub Creek where the primary land management goal is to maintain or enhance habitat and hydrologic conditions of selected riparian areas, notable for their exceptional diversity, high natural quality and key role in providing for the continued production of riparian dependent resource values. Another A9 Key Site Riparian Area occurs on the eastern side of Rhododendron Ridge in the headwaters of Patch 6 (Rhododendron Creek Watershed), comprising 5 percent of its watershed area. Patch 1 (Clackamas River Mainstem along Big Bottom) contains a fairly large A9 Key Site Riparian Area along the river's mainstem throughout the Big Bottom Area. However, the majority of this particular A9 Key Site Riparian Area is overlaid by a much larger LSR as seen in Figure 2.12, hence the only acreage listed in Table 2.4 is for that small area falling outside of the more restrictive LSR land allocation boundary.

Table 2.4. Northwest Forest Plan Land Allocations for Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Patch	Name	Watershed	Administratively Withdrawn		Late Reserves		Matrix	
			Total Acre	% Wtrshd	Total Acres	% wtrshd	Total Acres	% wtrshd
			ac	% wtrshd	ac	% wtrshd	ac	% wtrshd
1	Clackamas River (Big Bottom)	Big Bottom	90	<1%	1,301	14%	8,202	86%
		Cabin Cr	57	2%	163	5%	2,931	93%
		Upper Clack	5	0%	2,839	38%	4,638	62%
		Total	152	1%	4,303	21%	15,771	78%
2	Pinhead Creek	Pinhead Cr	1,071	14%	2,410	32%	4,006	54%
		Last Cr	0	0%	1,243	13%	8,366	87%
		Total	1,071	6%	3,653	21%	12,372	72%
3	Upper Clackamas	Upper Clack	0	0%	11,297	98%	255	2%
		Lemiti Cr	1,273	14%	1,640	17%	3,635	39%
		S. Fk Lemiti Cr	0	0%	1,015	46%	577	26%
		Olallie Cr	0	0%	1,102	47%	**	**
		Total	1,273	5%	15,054	59%	4,467	17%
4	Cub Creek	Cub Cr	474	5%	3,227	35%	5,426	59%
		Berry Cr	280	5%	0	0%	5,094	95%
		Total	754	5%	3,227	22%	10,520	73%
5	Hunter Creek	Hunter Cr	0	0%	139	3%	4,012	97%
6	Rhododendron Creek	Rhododendron Cr	194	5%	75	2%	3,834	93%

** Land outside Forest boundary.

A single large LSR, the Upper Clackamas LSR, occurs throughout much of the Upper Clackamas River Subbasin as seen in Figure 2.12. The LSR follows the river corridor along the Clackamas River and broadens into the uplands as it extends into the headwaters of the watershed (USDA and USDI 1998). As such, the majority of the LSR occurs within Patch 3 (Upper Clackamas River above Cub Creek) occupying 59 percent of its watershed area. The LSR occupies 22 percent of the watershed area in Patch 4 (Cub Creek Watershed) and 21 percent in both Patch 1 (Clackamas River Mainstem along Big Bottom) and Patch 2 (Pinhead Creek Watershed). It occurs in a small portion of Patch 5 (Hunter Creek Watershed) and Patch 6 (Rhododendron Creek Watershed); 3 percent and 2 percent, respectively.

The Matrix land allocation dominates the land area of all suitable habitat patches except for Patch 3 (Upper Clackamas River above Cub Creek), where it constitutes only 17 percent of the watershed area. Matrix lands heavily dominate Patch 5 (Hunter Creek Watershed) and Patch 6 (Rhododendron Creek Watershed), 97 percent and 93 percent, respectively. In the remaining three suitable habitat patches, Matrix lands represent roughly three-quarters of the watershed area: Patch 1 (Clackamas River Mainstem along Big Bottom) at 78 percent, Patch 2 (Pinhead Creek Watershed) at 72 percent, and Patch 4 (Cub Creek Watershed) at 73 percent. Even as such, the Mt. Hood Land and Resource Management Plan (as amended by the Northwest Forest Plan) provides strong management direction and guidance to maintain and restore the riparian resources that provide for suitable bull trout habitat.

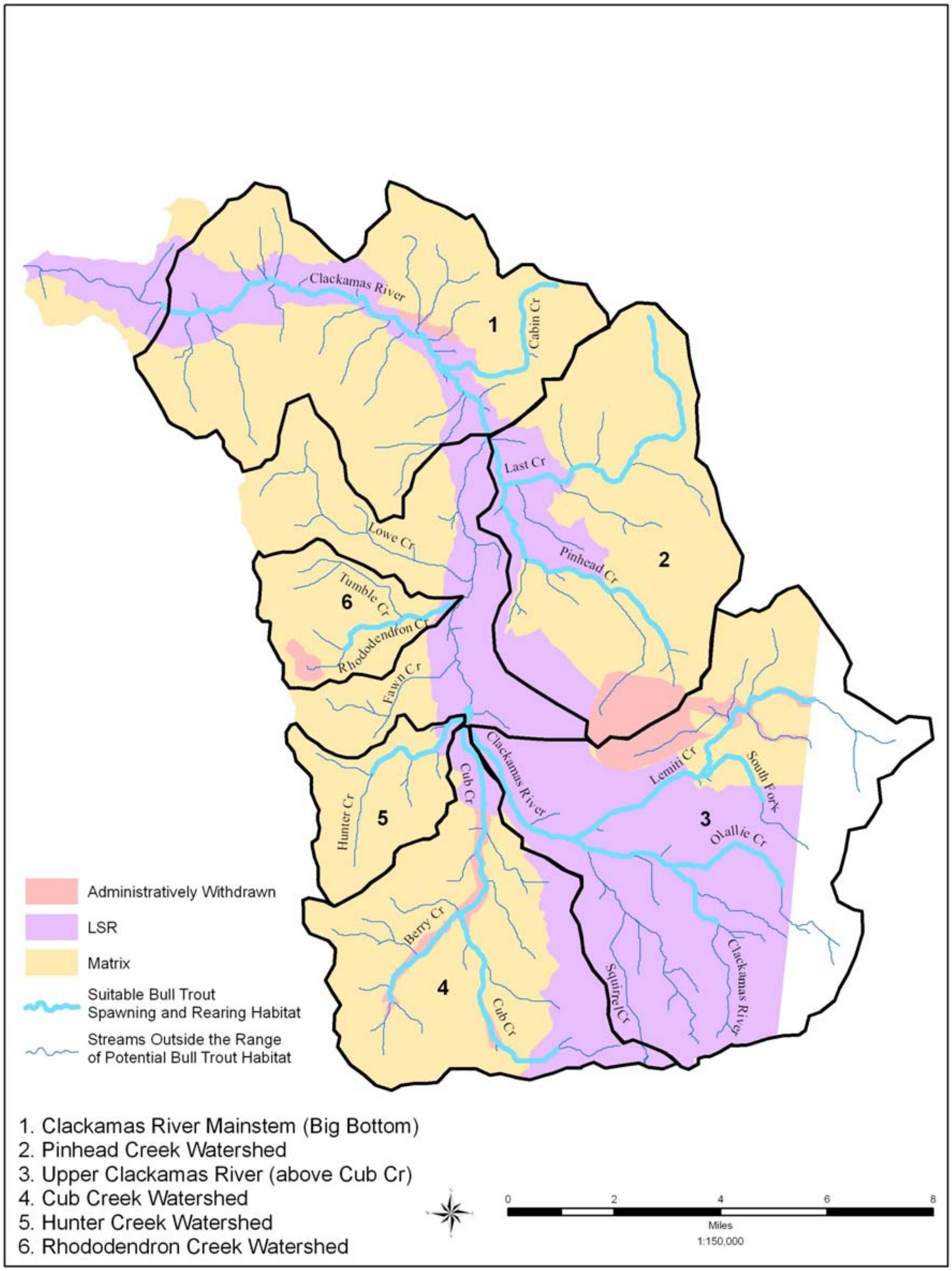

Figure 2.12. Northwest Forest Plan Land Allocations for Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Fish Habitat

There is a total of 70.1 miles (112.8 kilometers) of suitable bull trout spawning and rearing habitat among the six habitat patches in the Upper Clackamas River Subbasin (Table 2.5). Patch 3 (Upper Clackamas River above Cub Creek) contains 20.4 miles of suitable bull trout spawning and rearing habitat; the most habitat of all six patches. Patch 1 (Clackamas River Mainstem along Big Bottom) and Patch 2 (Pinhead Creek Watershed) contain similar amounts of suitable spawning and rearing habitat at 17.6 miles and 17.0 miles, respectively. Patch 4 (Cub Creek Watershed) provides a total of 10.1 miles of habitat, roughly half the amount compared to Patch 3. Patch 5 (Hunter Creek Watershed) and Patch 6 (Rhododendron Creek Watershed) are considerably smaller in watershed size and hence provide far less suitable spawning and rearing habitat than the other patches; 2.1 miles and 2.9 miles, respectively.

The majority of streams contributing habitat in each of the patches have been surveyed by U.S. Forest Service fish biologists for habitat conditions (Table 2.5). Data from U.S. Forest Service stream surveys were collected in accordance with an inventory and data collection protocol originally developed for the USDA Forest Service Pacific Northwest Region in 1989. The protocol is reviewed and updated annually. The most recent version of the protocol is *Stream Inventory Handbook, Level I and II, Pacific Northwest Region, Region 6, 2007, ~Version 2.7.*

Patch 1 (Clackamas River Mainstem along Big Bottom) has not been surveyed in its entirety since this area along the Clackamas River contains a very complex system of braided channels, side channels, and backwaters making it difficult to conduct a standardized survey. The dominant character of this habitat patch is defined by the mainstem river and its complex channel network. Therefore, even though stream survey data are available for the other streams within this patch, the CRBTWG decided against using that data to characterize the overall habitat patch. Given this, the habitat analysis presented below focuses only on streams surveyed within Patches 2 through 6. Survey data are collected at the reach scale for individual streams; however, the habitat summaries and comparisons below (presented in metric units of measurement) standardize and aggregate all data for the various reaches and streams surveyed within each patch and are reported as a function of the total habitat area ($meters^2$) available within the patch.

Stream Gradient

Stream reaches surveyed in Patches 2 through 6 range in gradient from one to 13 percent. Reaches 4 and 5 of Cub Creek in Patch 4 (Cub Creek Watershed) and reaches 3 and 5 of Lemiti Creek in Patch 3 (Upper Clackamas River above Cub Creek) are one percent gradient. Reach 2 of Rhododendron Creek in Patch 6 (Rhododendron Creek Watershed) represents the steepest stream reach at 13 percent gradient (Figure 2.13).

Pool Habitat

Pool habitat data is summarized based on three different metrics: habitat composition (% pool habitat available), pool density (total # pools per kilometer), and primary pool density (# pools ≥3 feet maximum depth per kilometer).

Table 2.5. Amount of Suitable Bull Trout Spawning and Rearing Habitat in the Upper Clackamas River Subbasin.

Patch	Name	Watershed	Amount of Suitable Spawning and Rearing Habitat mi	km	Stream Survey Data Available source
1	Clackamas River (Big Bottom)	Big Bottom	7.4	11.9	Not surveyed
		Cabin Cr	4.7	7.5	USFS 1992
		Upper Clack	5.5	8.8	USFS 1991 and 1997
			17.6	28.3	
2	Pinhead Creek	Pinhead Cr	7.5	12.1	USFS 1996 and 2002
		Last Cr	9.4	15.2	USFS 1990 and 2002
			17.0	27.3	
3	Upper Clackamas	Upper Clack	7.3	11.7	USFS 1991 and 1997
		Lemiti Cr	8.4	13.5	USFS 1998
		S. Fk Lemiti Cr	2.0	3.2	USFS 1998
		Olallie Cr	2.8	4.5	Not surveyed
			20.4	32.9	
4	Cub Creek	Cub Cr	7.7	12.4	USFS 1993 and 1999
		Berry Cr	2.4	3.8	USFS 1989
			10.1	16.2	
5	Hunter Creek	Hunter Cr	2.1	3.4	USFS 1990
6	Rhododendron Creek	Rhododendron Cr	2.9	4.7	USFS 1990 and 2001
		Total	70.1	112.8	

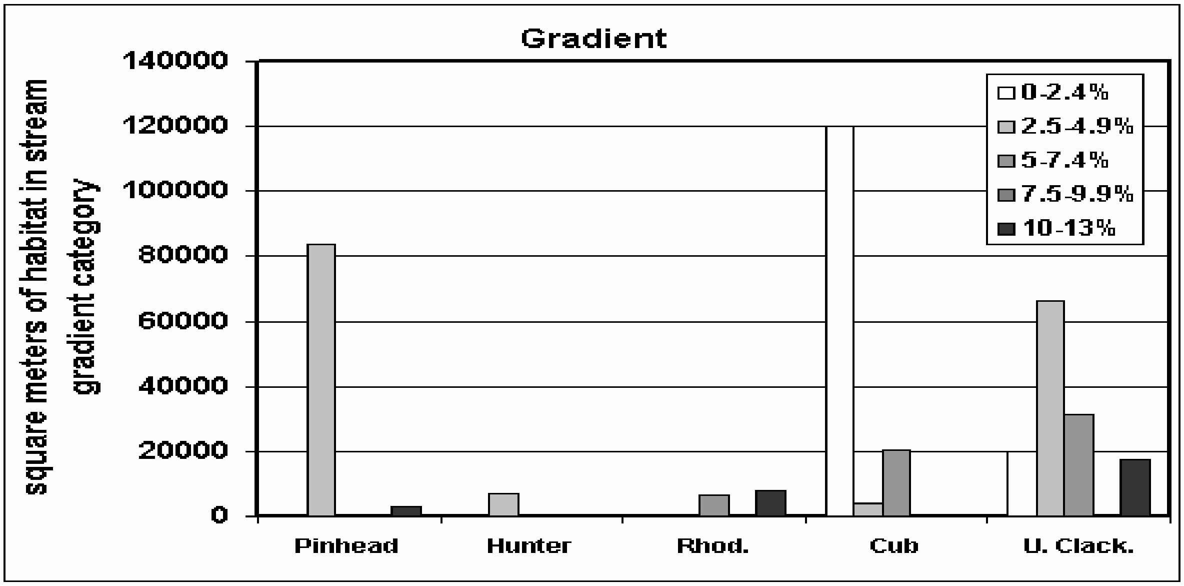

Figure 2.13. Channel Gradients for Stream Reaches Surveyed in Suitable Habitat Patches in the Upper Clackamas River Subbasin.

The percentage of available pool habitat varies greatly for stream reaches surveyed in Patches 2 through 6. Reach 2 of Pinhead Creek in Patch 2 (Pinhead Creek Watershed) has the highest pool habitat composition at 61 percent, while Reach 2 of Last Creek located in the same patch has the lowest pool habitat composition at less than one percent. Assessing Patches 2 through 6 overall, streams in Patch 4 (Cub Creek Watershed) have the highest percentage of pool habitat available, followed by Patch 3 (Upper Clackamas River above Cub Creek), Patch 2 (Pinhead Creek Watershed), Patch 6 (Rhododendron Creek), and Patch 5 (Hunter Creek Watershed) from highest to lowest (Figure 2.14).

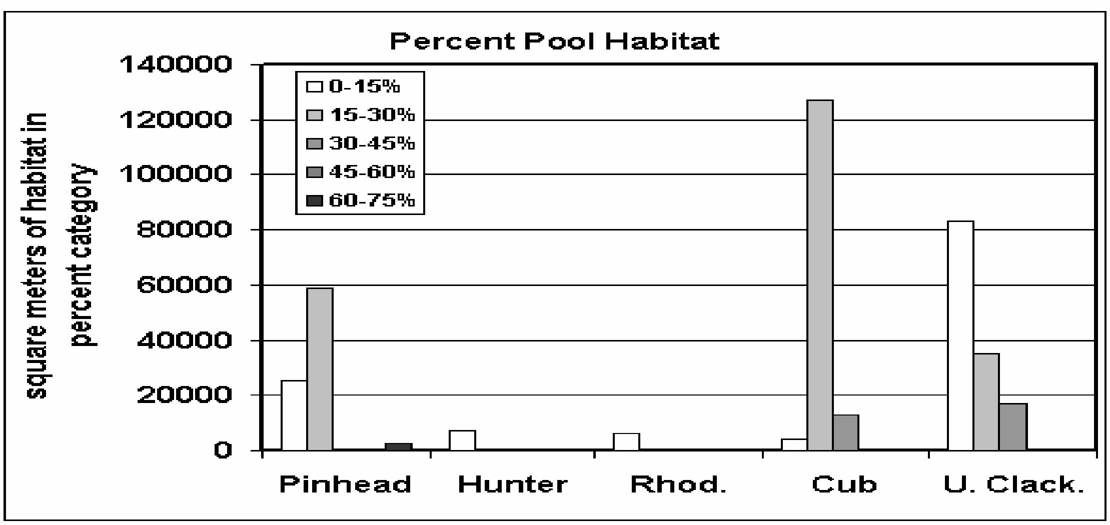

Figure 2.14. Pool Habitat Composition (% pool habitat available) for Stream Reaches Surveyed in Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Pool density (total # of pools per kilometer) also varies greatly for those stream reaches surveyed in Patches 2 through 6. Reach 2 of Pinhead Creek in Patch 2 (Pinhead Creek Watershed) has the highest pool density of 72 pools per kilometer, while Reach 2 of Last Creek also in the same patch has the lowest pool density at less than one pool per kilometer. Overall, streams in Patch 6 (Rhododendron Creek Watershed) have the highest pool density, followed by Patch 4 (Cub Creek Watershed), Patch 3 (Upper Clackamas River above Cub Creek), Patch 2 (Pinhead Creek Watershed), and Patch 5 (Hunter Creek Watershed) from highest to lowest (Figure 2.15).

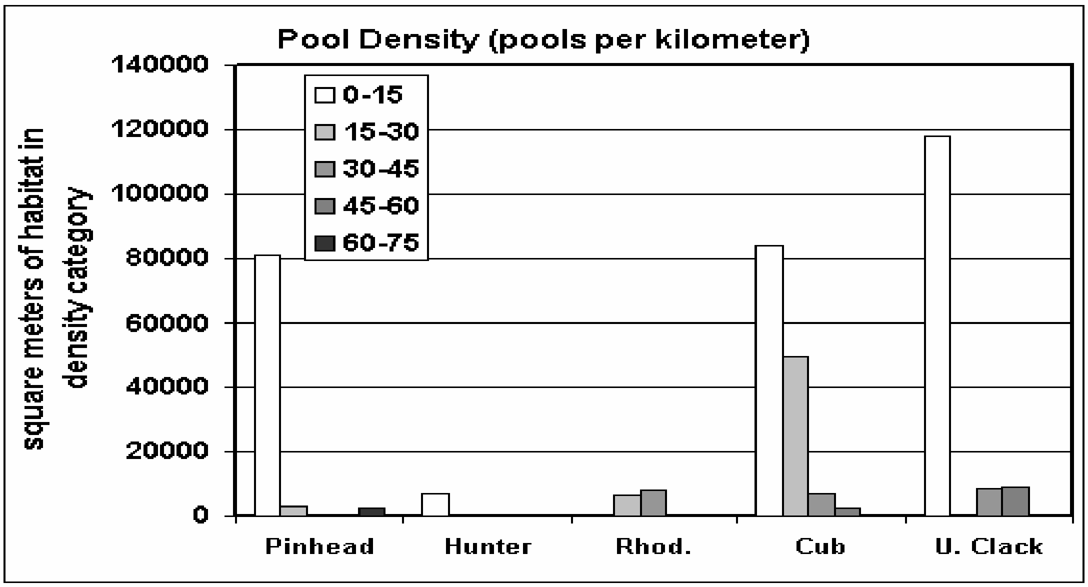

Figure 2.15. Pool Density (total # of pools per km) for Stream Reaches Surveyed in Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Primary pool density is a metric similar to pool density, but only includes deep pools ≥ 3 feet in maximum depth at summer low flow. Reach 4 of the Upper Clackamas River above Cub Creek in Patch 3 (Upper Clackamas River above Cub Creek) has the highest primary pool density at 9.4 pools ≥3 feet maximum depth per kilometer while Reach 1 of Last Creek in Patch 2 (Pinhead Creek Watershed) has the lowest at 0.3 pools ≥3 feet maximum depth per kilometer. Overall, streams in Patch 3 (Upper Clackamas River above Cub Creek) have the highest primary pool density, followed by Patch 4 (Cub Creek Watershed), Patch 5 (Hunter Creek Watershed), Patch 2 (Pinhead Creek Watershed), and Patch 6 (Rhododendron Creek Watershed) from highest to lowest (Figure 2.16).

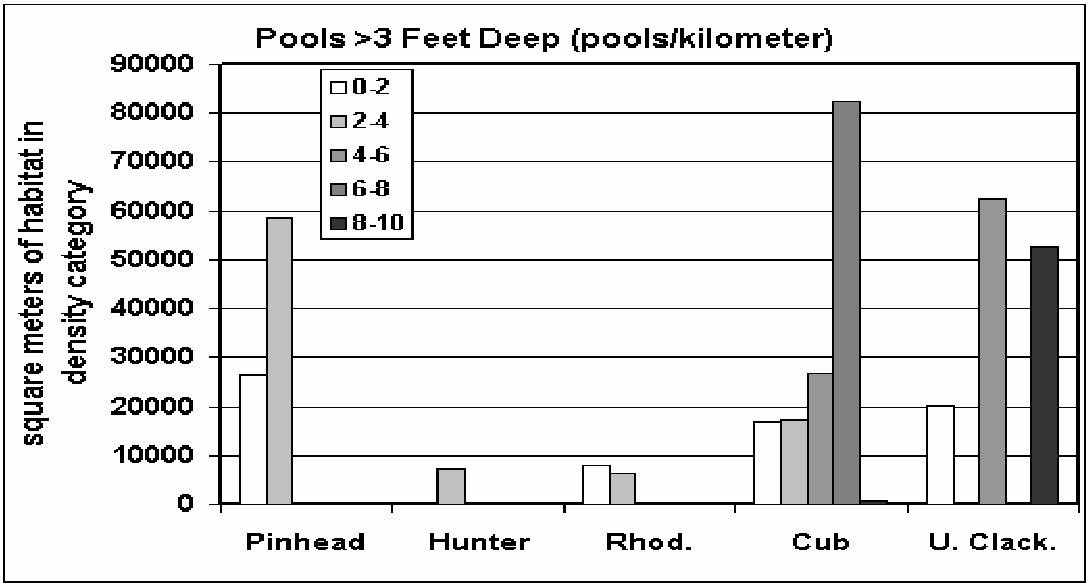

Figure 2.16. Primary Pool Density (# pools ≥3 ft. max. depth per km) for Stream Reaches Surveyed in Suitable Habitat Patches in the Upper Clackamas River Subbasin.

<u>Large Wood</u>

Large wood density is extremely variable for stream reaches surveyed in suitable habitat patches in the Upper Clackamas River Subbasin. Large wood is considered a piece of wood occurring within the stream channel's bankfull width that is ≥24 inches in average diameter and ≥50 feet in length. Large wood density ranges from a high of 178 pieces per kilometer for Reach 1 of Last Creek in Patch 2 (Pinhead Creek Watershed) to a low of less than one piece per kilometer for Reach 5 of Lemiti Creek in Patch 3 (Upper Clackamas River above Cub Creek). Assessing large wood density overall for surveyed stream reaches within Patches 2 through 6, Patch 2 (Pinhead Creek Watershed) has the highest large wood density overall followed by Patch 4 (Cub Creek Watershed), Patch 6 (Rhododendron Creek Watershed), Patch 3 (Upper Clackamas River above Cub Creek), and Patch 5 (Hunter Creek Watershed) from highest to lowest (see Figure 2.17).

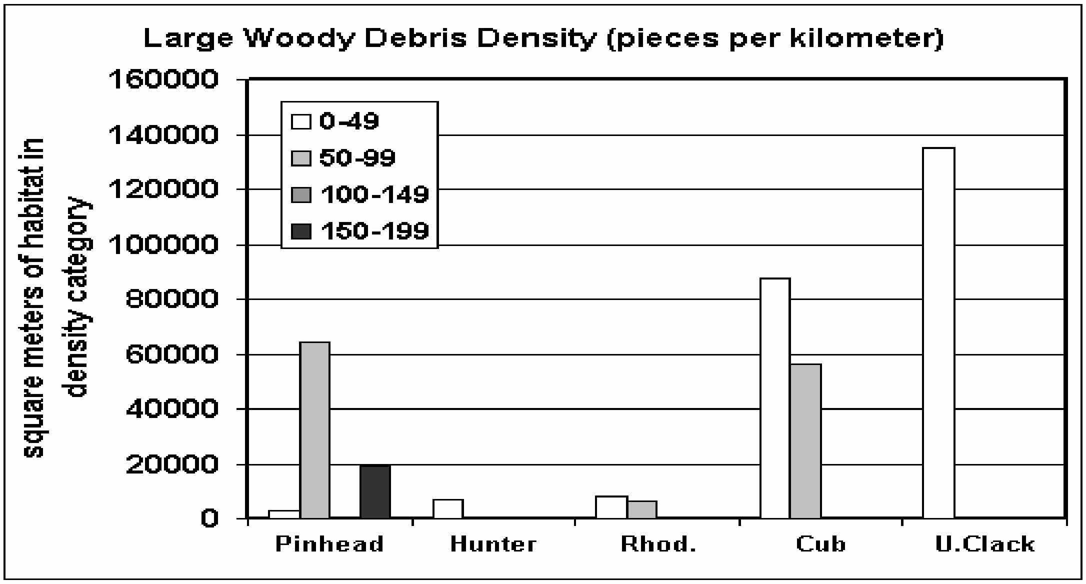

Figure 2.17. Large Wood Density (# pieces per km) for Stream Reaches Surveyed in Suitable Habitat Patches in the Upper Clackamas River Subbasin.

<u>Bankfull Width to Summer Wetted Width Ratio</u>

The bankfull width to summer wetted width ratio is a fish habitat evaluation metric developed by the CRBTWG to assess year-round stability in streamflow. The bankfull channel width represents the channel-forming flow, which on average is equivalent to a 1.3 year flow event for watersheds in the Western Cascades of Oregon. Channels with streamflow that are derived primarily from groundwater and springs fluctuate (i.e., rise and fall) very little seasonally throughout the year, particularly during periods of environmental extremes. Therefore, the difference between the channel-forming flow (bankfull) and summer wetted width is small. Channels with these more even and regular streamflows throughout the year typify those types of streams known to be occupied by remnant, extant populations of bull trout found in the Lower Columbia River Basin (i.e., Metolius River, South Fork McKenzie River, and Rush Creek – tributary to the Lewis River). The CRBTWG established the ratio of bankfull channel width to summer wetted channel width as a measure of seasonal streamflow stability. As this ratio approaches 1.0, a channel's seasonal streamflows are likely to vary only slightly throughout the year. The larger this ratio is, the more variation there is likely to be in a channel's seasonal streamflows. Stream channels with a higher ratio would tend to have more pronounced high winter flows and low summer baseflows, typical of a "flashy" stream in the Western Cascades geology.

Bankfull width to summer wetted width ratio varies from approximately 1.0 for several reaches [Reach 1 on Pinhead Creek, Reach 3 on Last Creek, and Reach 1 on West Fork Last Creek in Patch 2 (Pinhead Creek Watershed); Reaches 5 and 8 on the Upper Clackamas River in Patch 3 (Upper Clackamas River above Cub Creek); and Reach 2 on Cub Creek in Patch 4 (Cub Creek Watershed)] to 1.9 for Reach 2 on Rhododendron Creek in Patch 6 (Rhododendron Creek Watershed). Overall, when assessing this particular fish habitat evaluation metric for Patches 2 through 6, Patch 2 (Pinhead Creek Watershed) appears to offer the most stable streamflow environments year-round that are typically considered to be more favorable for bull trout spawning and rearing, followed by Patch 4 (Cub Creek Watershed), Patch 3 (Upper Clackamas River above Cub Creek), Patch 5 (Hunter Creek Watershed), and Patch 6 (Rhododendron Creek Watershed) from most stable to least (Figure 2.18).

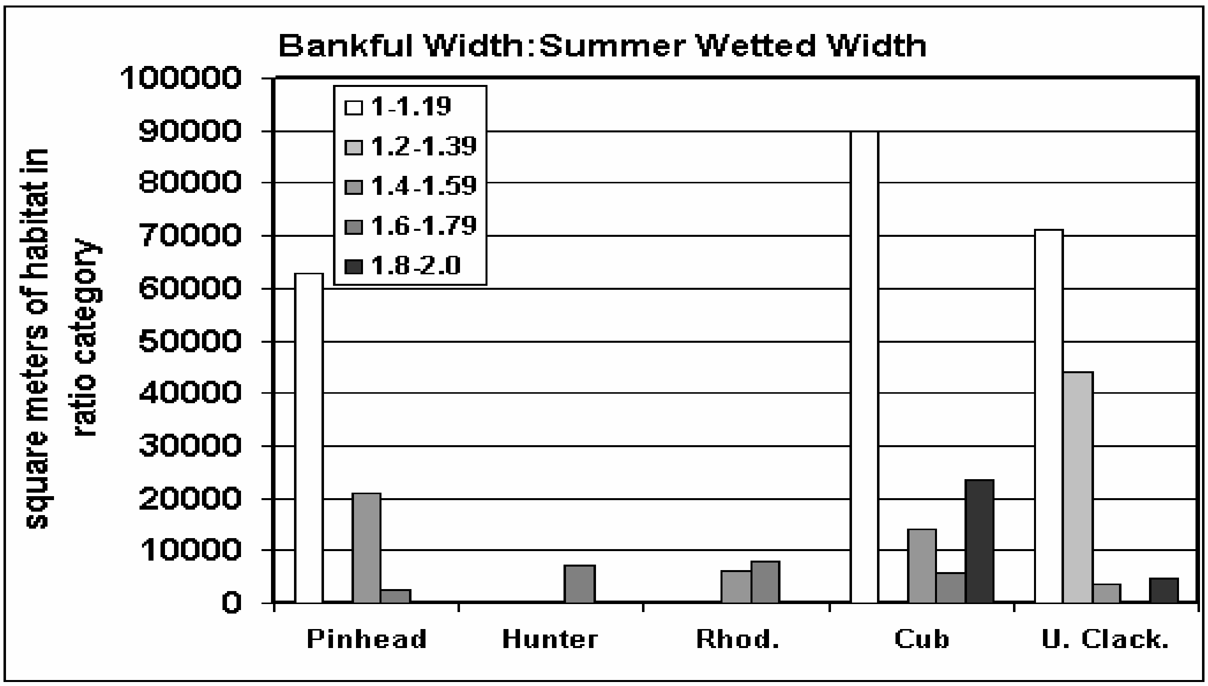

Figure 2.18. Bankfull width to Summer Wetted Width Ratio for Stream Reaches Surveyed in Suitable Habitat Patches in the Upper Clackamas River Subbasin.

Patch Connectivity

The Upper Clackamas River Subbasin contains a total of 70.1 miles of suitable bull trout spawning and rearing habitat organized into six separate habitat patches. These patches range in size (i.e., watershed area), availability of bull trout spawning and rearing habitat, and condition. The largest patch, Patch 3 (Upper Clackamas River above Cub Creek), occurs in the headwaters of the subbasin and contains very cold, stable year-round flows. Patch 1 (Clackamas River Mainstem along Big Bottom), occurs lowest in the subbasin and is predominantly occupied by the river's mainstem. As described above, this section of river contains a myriad of braided channels and off-channel areas. This particular patch is unique and different from the other five patches in this respect. Members of the CRBTWG believe this patch would serve as a primary foraging area for migratory adult and sub-adult bull trout since it is also utilized by juvenile salmon and steelhead. In addition to providing suitable spawning and rearing habitat, Patch 1 (Clackamas River Mainstem along Big Bottom) may also function as an important ecological area for the reestablishment of bull trout in the Upper Clackamas River Subbasin – that is, serving as a primary foraging grounds for adult and sub-adult migratory bull trout that spawn and rear in other nearby patches. Patch 1 illustrates how connectivity between patches is important for ecological reasons as well as providing for gene flow and recolonization potential.

Table 2.6 displays a matrix illustrating the migration distances between various patches in the patch network for the Upper Clackamas River Subbasin. Patch 1 (Clackamas River Mainstem along Big Bottom) and Patch 2 (Pinhead Creek Watershed) adjoin one another, as do Patch 3 (Upper Clackamas River above Cub Creek) and Patch 4 (Cub Creek Watershed). The greatest migratory distance between the patches is 5.9 miles along the mainstem Clackamas River between Patches 1 or 2 and Patches 3 or 4.

Table 2.6. Matrix of Patch Interconnectedness for Suitable Habitat Patch Network in the Upper Clackamas River Subbasin: Migration distances between patches (miles).

Patch	Name	1 Clackamas River (Big Bottom)	2 Pinhead Creek	3 Upper Clackamas	4 Cub Creek	5 Hunter Creek	6 Rhododendron Creek
1	Clackamas River (Big Bottom)	--	Adjoining	5.9	5.9	5.4	2.9
2	Pinhead Creek	Adjoining	--	5.9	5.9	5.4	2.9
3	Upper Clackamas River	5.9	5.9	--	Adjoining	0.6	3.0
4	Cub Creek	5.9	5.9	Adjoining	--	0.6	3.0
5	Hunter Creek	5.4	5.4	0.6	0.6	--	2.5
6	Rhododendron Creek	2.9	2.9	3.0	3.0	2.5	--

Although many rivers and streams in the Clackamas River Subbasin upstream of North Fork Reservoir have water temperatures that are determined unsuitable for bull trout spawning or rearing, none of those reaches pose a migration barrier based on water temperature or water quality. Additionally, upstream and downstream fish passage is provided around all three of PGE's hydroelectric dams on the Lower Clackamas River by fish ladders and a juvenile bypass facility. Bull trout would have access to the Clackamas River below the hydroelectric projects and have the potential to be connected to other bull trout populations through the Willamette and Columbia river systems.

2.3 Summary and Conclusions

Bull trout occurred historically throughout much of the entire Clackamas River Subbasin prior to human created migration barriers, intentional removal efforts, and habitat modifications during the post-European settlement era beginning after the mid-1800s. Bull trout require cold, clean water in complex river and stream habitats with low levels of fine sediments. These habitat requirements are most stringent for the spawning and rearing life stages of bull trout. The portion of the Clackamas River Subbasin providing suitable spawning and rearing habitat today is limited to that area of the mainstem and its tributaries in the headwater area of the subbasin upstream of the Collawash River confluence. This portion of the subbasin, referred to as the Upper Clackamas River Subbasin, contains a total of 70.1 miles of suitable spawning and rearing habitat organized into six separate habitat patches. These patches range in size, configuration, and condition. The most downstream patch occurs along the mainstem Clackamas River known as Big Bottom. This complex reach of the river, provides suitable spawning and rearing habitat, and would also likely serve as an important foraging area for migratory adult and sub-adult bull trout. The other patches occur either adjacent to, or up to, a maximum distance of 5.9 river miles upstream into the headwaters of the subbasin. The amount of suitable habitat and patch characteristics in the Clackamas River Subbasin compare very favorably to other river systems in the Lower Columbia River with extant bull trout populations (e.g., Lewis, McKenzie, and Deschutes rivers).

Chapter 3 – Conservation Genetic Considerations and Donor Stock Suitability

A primary concern in any reintroduction effort is the preservation of genetic fitness of both the donor stock and newly founded population. Genetic information can significantly enhance the proper selection of a source stock (Williams et al. 1988) and may prove valuable in ensuring the likely future success of the founding population. This chapter summarizes the conservation genetic issues that the CRBTWG considered in evaluating the feasibility of reintroducing bull trout into the Clackamas River. This chapter does not address specific reintroduction strategies. However, an overview of possible reintroduction strategies is given in Appendix C. Appendix C summarizes previous bull trout propagation efforts, other bull trout reintroductions within the State of Oregon, and advantages and disadvantages of three possible reintroduction strategies: artificial propagation, captive rearing, and transplantation. This chapter is not intended to be an all-inclusive summary of conservation genetic issues associated with reintroduction efforts, but rather, it touches on some of the key topics that are central to determining the feasibility of undertaking such an effort in the Clackamas River Subbasin. The following questions are addressed in this chapter:

- Is there a genetically suitable donor stock(s) of bull trout for use in the Clackamas River Subbasin?

- What are the potential genetic impacts to the donor stock(s) as a result of lost individuals?

A donor stock should be comprised of fish that most closely resemble the bull trout that historically inhabited the Clackamas River (e.g., genotype, phenotype, behavior, and life history expression). However, because little is known about the biology and evolutionary history of bull trout that historically occupied the Clackamas River, and no genetic material is available for analysis, the CRBTWG was limited to an assessment of biological information from other local populations, existing studies of the evolution and biogeography of bull trout, information derived from historical creel data from the Clackamas River, and from recent regional bull trout genetic analyses. A synthesis of this information will assist in determining the most appropriate donor stock(s) to consider in a reintroduction of bull trout.

3.1 Life History Strategies Likely Used by Clackamas River Bull Trout

Historically, the closest bull trout populations to the Clackamas River would have been above Willamette Falls in the Santiam, McKenzie, and Middle Fork Willamette Basins; the Lewis River Basin downstream from the confluence of the Willamette and Columbia rivers in Washington; or the Hood, Klickitat and Deschutes rivers at the east-end of the Columbia River Gorge. Willamette Falls, located just above the confluence of the Clackamas and Willamette rivers, was a historic barrier to fish migrating upstream in summer and fall (i.e., coho, fall chinook and summer steelhead), but flows in the winter and spring permitted passage of spring chinook, winter steelhead, and likely bull trout. Bull trout populations still exist in the Lewis, Hood, Klickitat and Deschutes river basins, but they have been extirpated from several subbasins in the Willamette River Basin including the North and South Santiam and the Middle Fork Willamette rivers.

Bull trout exhibit both resident and migratory (i.e., fluvial) life-history strategies, as do many other salmonids. Resident bull trout spend their entire life within the stream or tributary within which they spawn and rear. Migratory bull trout spawn in tributary streams where they rear for up to four years, after which they migrate to either a larger river, lake, reservoir, or coastal waters, where they continue to forage for several years until they make a return migration back to the smaller (usually the natal) tributary to spawn (Rieman and McIntyre 1993). Resident fish may range from 150 to 300 millimeters in length while migratory fish may exceed 600 millimeters (Rieman and McIntyre 1993).

Some migratory bull trout populations have exhibited the ability to convert from fluvial to adfluvial life history forms where large dams have formed reservoirs. Examples of bull trout populations that exhibit this behavior from the lower Columbia River tributaries include the South Fork McKenzie River population above Cougar Dam in the Willamette River Basin, the Laurance Lake population above Clear Branch Dam in the Hood River Basin, the Lake Billy Chinook population above Round Butte Dam in the Deschutes River Basin, and the populations in Swift and Yale reservoirs in the Lewis River Basin.

With two exceptions, the Klickitat River Basin and portions of the Deschutes River Basin, no bull trout populations in the lower Columbia River exhibit a resident life history type, nor is there evidence they existed historically. In the Deschutes River Basin, adfluvial and resident bull trout overlap in the Metolius River upstream of Lake Billy Chinook. The dual life history strategy (i.e., migratory and resident) is likely an important part of the life history strategy of bull trout and other salmonids. Such life history diversity as cited in Rieman and McIntyre (1993) is thought to stabilize populations in highly variable environments or to enable refounding segments of populations that have disappeared. A particular life history strategy may dominate under stable conditions, but another life-history strategy may dominate under a changing or unstable environment (Rieman and McIntyre 1993).

Based on the dominant life history characteristics from other lower Columbia River bull trout populations, the CRBTWG believes that the historic bull trout population in the Clackamas River was likely fluvial (i.e., migratory). Historical Clackamas River creel data further confirms this because the relative size and locations of observed bull trout catch is representative of what would be expected for a fluvial population versus a resident population (e.g., large fish observed in medium to large rivers in the subbasin). Furthermore, resident bull trout populations generally reside in headwater areas of river systems that are relatively less impacted by anthropogenic activities that typically impact migratory populations of bull trout such as logging, road building, construction and operation of dams, and over-fishing. If a resident population of bull trout historically existed in the Clackamas River, the CRBTWG expects there to be a higher likelihood it would still be present. However, as discussed in Chapter 1, the possibility of a remnant bull trout population in the Clackamas River has been thoroughly investigated over the last two decades and the CRBTWG has concluded that bull trout are extirpated from the subbasin.

3.2 Spatial Processes

As described in Spruell et al, 2003, bull trout population structure can be divided into at least three major genetically differentiated groups (or lineages) of bull trout. These lineages are depicted in Figure 3.1 and are characterized as: (1) “Coastal,” including the Deschutes River and all of the Columbia River drainage downstream, as well as most coastal streams in Washington, Oregon, and British Columbia; (2) “Snake River,” which includes the John Day, Umatilla, and Walla Walla rivers; and (3) “Upper Columbia River,” which includes the entire basin in Montana and northern Idaho. More detail regarding the three lineages is presented in Appendix D.

Choosing a donor stock, or perhaps multiple stocks, from the “coastal” evolutionary bull trout lineage, which includes populations from the lower Columbia River tributaries including, and downstream of, the Deschutes River, would best preserve and protect the lineage. Based on available genetic and biogeographic information, there is no obvious reason to exclude the possibility of considering any “coastal” bull trout populations for a donor stock, such as populations from the Olympic Peninsula or Puget Sound. However, there is a higher likelihood that bull trout from lower Columbia River tributaries shared genetic material among each other, more so than with other populations north or south of the Columbia River. Nearby bull trout populations would be subject to more similar environmental conditions and likely better adapted to conditions in the Clackamas River Subbasin than more distant populations. The use of bull trout from other lineages (i.e., the upper Columbia or Snake lineages) may undermine the coastal lineage by introducing maladapted fitness traits (i.e., alleles). Any of the coastal lineage local bull trout populations are likely to carry the alleles to preserve and protect the coastal lineage regardless of localized and specific adaptations. Local adaptations confer increased fitness for individuals in a given set of environmental conditions. Although these adaptations are important locally, each of the local populations is likely to contain the evolutionary potential that is characteristic of the coastal evolutionary lineage. This evolutionary potential is important, since it would allow for future adaptations of bull trout specific to the Clackamas River Subbasin.

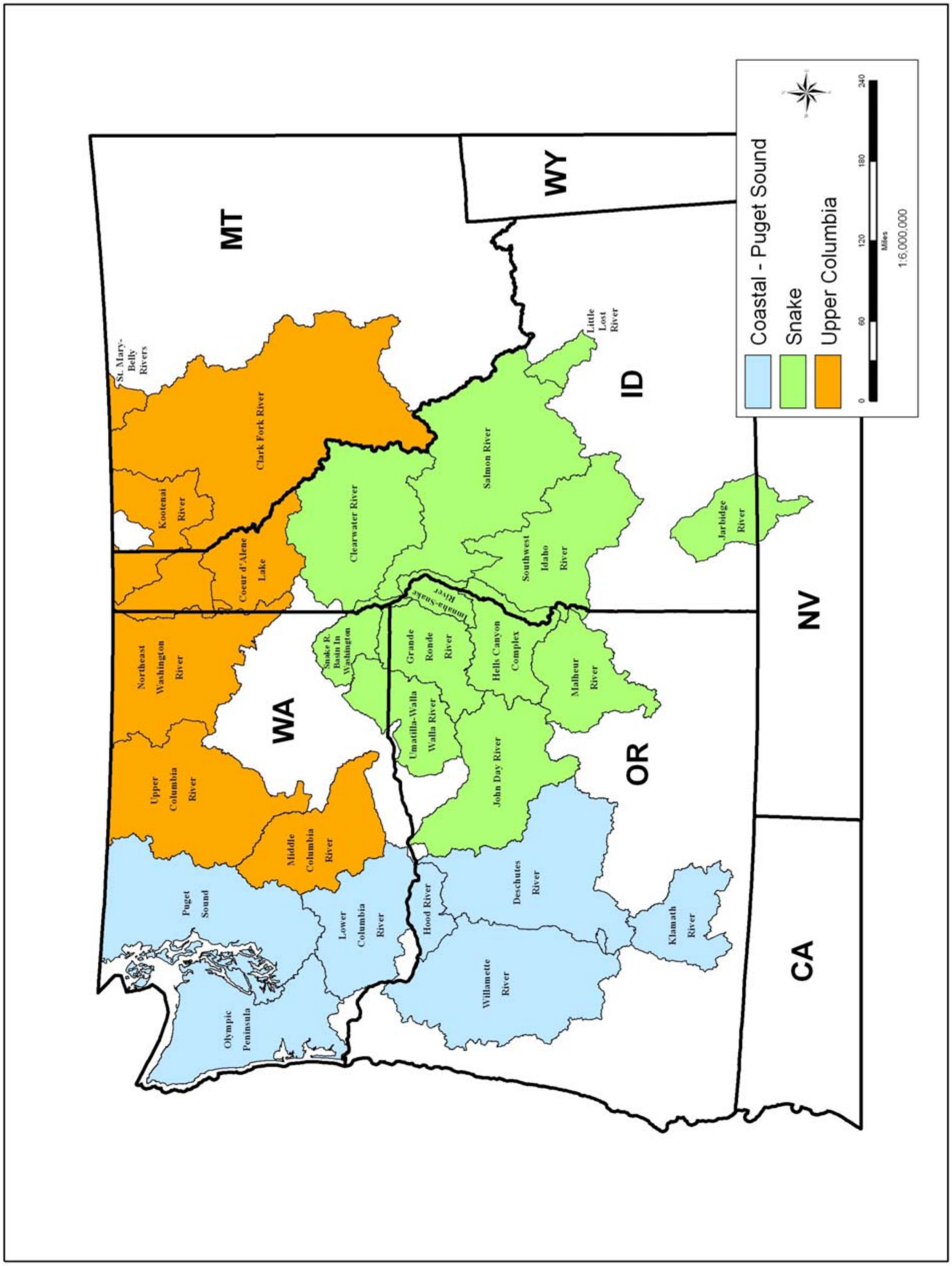

Figure 3.1. Bull Trout Evolutionary Lineages in Oregon, Washington, Idaho, Montana, and Nevada.

The extent to which the lower Columbia River bull trout populations mixed historically is unknown. Aggregations of bull trout populations once may have acted as metapopulations, but may now be too fragmented, depressed, or contracted to be recognized as metapopulations (Whitesel et al. 2004). Bull trout populations are usually connected through low rates of migration and there is evidence of some partially isolated local populations of bull trout that have some degree of gene flow among them (USFWS 2002). Migration and gene flow among local populations ensures that alleles within a metapopulation will be present in most local breeding populations and can be acted upon by natural selection (Allendorf and Leary 1986).

Extant populations in the lower Columbia River included in the “coastal” lineage include bull trout from the Willamette, Lewis, Hood, Klickitat, and Deschutes rivers (Figure 3.2). The dominant life history form of these populations is migratory (fluvial), supporting the CRBTWG’s conclusion that the historical bull trout population in the Clackamas River was also fluvial. Although intuitively it seems most appropriate to chose a within-basin donor stock (i.e., Willamette River Basin) for a Clackamas River reintroduction, available information on genetic relationships suggests there are genetic differences among most populations in the lower Columbia River (Spruell et al. 2003), consistent with bull trout throughout their range (Costello et al. 2003; Spruell et al. 2003; Taylor et al. 2001; Whiteley et al. 2003). For example, substantial differentiation has been observed among physically connected habitats in the upper and lower Deschutes River (Spruell 2005), the Clark Fork system (Neraas and Spruell 2001), and the South Fork of the Boise River (Whiteley et al. 2006). Therefore, the historical bull trout population from the Clackamas River may not have been any more closely related to bull trout from the McKenzie River (Willamette River Basin) than to bull trout from the Lewis or Deschutes rivers. From an evolutionary lineage perspective, the best available information suggests no one donor population from lower Columbia River tributaries is better suited than another for a Clackamas River reintroduction. The potential lower Columbia River tributary donor populations of bull trout are depicted in Figure 3.2 and include tributaries of the Willamette, Lewis, Hood, Klickitat, and Deschutes rivers. Each nearby donor stock is located a considerable distance away from the Clackamas River Subbasin and in many cases the presence of migration barriers make natural recolonization highly unlikely. Therefore, a translocation would be necessary in order to reestablish bull trout in the subbasin.

In order to evaluate potential risks to donor stocks, the CRBTWG relied on earlier efforts by the USFWS to provide the necessary background and theoretical basis for describing bull trout evolutionary/genetic theory and maintaining genetic diversity as it relates to long-term persistence of the species. The USFWS’s May 2004 publication, “Bull Trout Recovery Planning: A review of the science associated with population structure and size” (Whitesel et al. 2004), contains a synthesis of our current understanding of bull trout conservation genetic issues and is the basis for examining questions associated with the reintroduction feasibility assessment for the Clackamas River Subbasin. Appendix D, Genetic Conservation Considerations, is an excerpt taken from the USFWS’s May 2004 publication by Whitesel et al. (2004).

In brief, population structure is often complicated and dynamic. Isolated local populations function autonomously, demographically independent of other local populations. Local populations that are not isolated may exchange genetic material on a regular basis and be structured as part of a larger metapopulation. In addition, relatively large groups of local populations or groups of metapopulations that share an evolutionary trajectory may be structured as evolutionary (or conservation) units. Effective population size is associated with the population unit being considered and has both a temporal and spatial element (Allendorf and Ryman 2002; Waples 2002). When N_e less than 50 for an isolated population, inbreeding depression may be expected to occur over relatively few generations (e.g., 2-5 generations). When N_e less than 500 for an isolated population or single metapopulation, loss of genetic variation due to genetic drift may be expected to occur over tens of generations. When N_e less than 5,000 for an entire species or evolutionary lineage within which some gene flow occurs, loss of evolutionary potential may be expected to occur over hundreds of generations.

Bull trout specific benchmarks have been developed concerning the minimum N_e necessary to maintain genetic variation important for short-term fitness and long-term evolutionary potential. These benchmarks are based on the results of a generalized, age structured, simulation model, VORTEX (Miller and Lacy 1999), used to relate N_e to the number of adult bull trout spawning annually under a range of life histories and environmental conditions (Rieman and Allendorf 2001). In this study, the authors estimated N_e for bull trout to be between 0.5 and 1.0 times the mean number of adults spawning annually. Rieman and Allendorf (2001) concluded that an average of 100 (i.e., 50/0.5 = 100) adults spawning each year would be required to minimize risks of inbreeding in a population and that 1,000 adults (i.e., 500/0.5 = 1,000) are necessary to prevent loss of genetic variation due to genetic drift. This later value of 1,000 spawners may also be reached with a collection of local populations among which gene flow occurs.

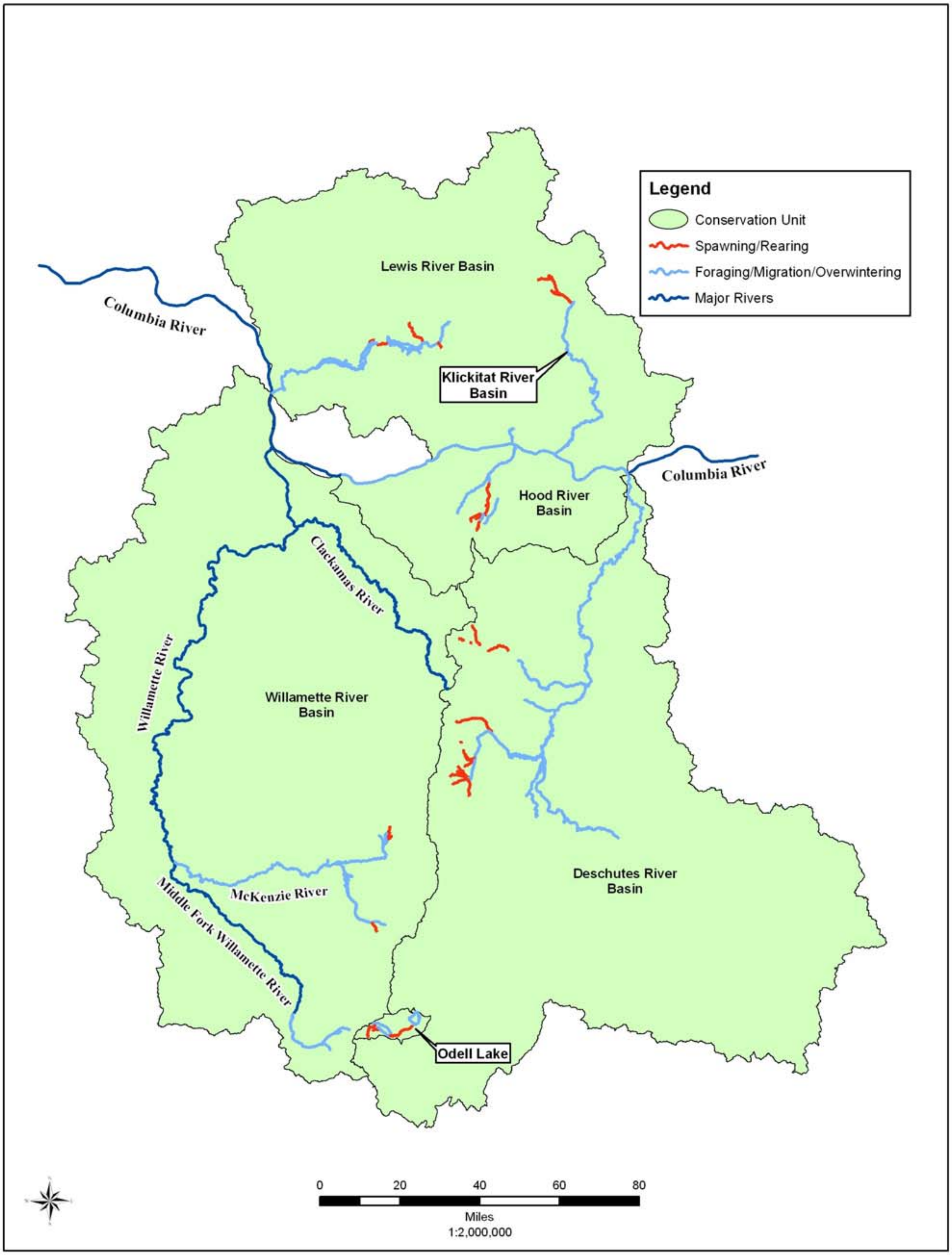

Figure 3.2. Possible Donor Populations for a Potential Reintroduction of Bull Trout to the Clackamas River.

3.3 Synthesis of Potential Donor Populations

This chapter has thus far described several parameters that may be used for the identification of a suitable donor stock of bull trout for reintroduction into the Clackamas River. These parameters can be thought of as “filters” for narrowing the options among available local populations across the species range. By exploring issues associated with life history strategy, metapopulation dynamics, biogeography, and genetic considerations, the CRBTWG has identified bull trout populations in the “coastal” lineage as the most likely source for a donor population (see Section 3.2). Any of the coastal lineage local bull trout populations are likely to carry the alleles to preserve and protect the coastal lineage regardless of localized and specific adaptations. Although these local adaptations are important, each of the local populations is likely to contain the evolutionary potential that is characteristic of the coastal evolutionary lineage. In a further refinement, local donor populations from Lower Columbia River tributaries would be most appropriate (Figure 3.2). The potential Lower Columbia River donor populations of bull trout include fish in five river basins, the Willamette River, Hood River, Lewis River, Deschutes River, Klickitat River basins.

Acknowledging that Lower Columbia River tributaries are the most likely candidates for further consideration, additional refinement includes considerations regarding the 50/500 rule. In order to utilize the 50/500 rule “filter,” an up-to-date synthesis of current information on the five potential donor populations was necessary (i.e., population status, abundance, trend, life history strategies, etc.). Appendix E provides a detailed summary of the donor populations being considered in the Lower Columbia River, and it summarizes information down to the local population level in each river basin where that level of detailed information is available. A summary of the detailed information in Appendix E is provided in Table 3.1. In Table 3.1, the best estimate is made for adult abundance of each local population along with a confidence rating for the data available to arrive at that estimate. Additionally, expected heterozygosity (from Spruell et al. 2003), and population trend (2000 to 2005) information are displayed. Table 3.1 presents data and information as it has been collected, and for several local populations data are refined at a much finer scale.

Table 3.1. Summary of Potential Local Donor Populations from Five River Basins in the Lower Columbia River Portion of the Coastal Evolutionary Group.

Local Population Name	Adult Abundance & Data Confidence Rating (A,B,C)*	Expected Heterozygosity (from Spruell et al. 2003)	Population Trend (2000 to 2005)	Comments **
Willamette River Basin (McKenzie River Subbasin) – three local populations				
Mainstem McKenzie River	130 (A)	.183	Slight Decline	Adult abundance estimate based on 3yr. average (2003 to 2005) generated by redd counts at 2.0 fish p/redd. 61 redds observed in 2005 (Anderson Creek, Olallie Creek and mainstem McKenzie River combined).
South Fork McKenzie River – above Cougar Dam	40 (A)	.106	Slight Increase	Adult abundance estimate based on 3yr. average (2003 to 2005) generated from Vaki Riverwatcher, video, & trapping. 35 redds & 50 individual spawners documented in 2005 (Roaring River).
Upper McKenzie River – above Trail Bridge Dam	38 (B)	Unknown	Slight Increase	Adult abundance estimate based on 3yr. average (2003 to 2005) generated by redd counts at 2.0 fish p/redd. 19 redds observed in 2005 (Sweetwater Creek and McKenzie River above Trail Bridge Dam combined). See Table E2 (and footnote) in Appendix E.
Hood River Basin – two local populations				
Clear Branch – upstream of Clear Branch Dam	42 (B)	.238	Slight Increase	Adult abundance estimate based on 3yr. average (2003 to 2005) generated by redd counts at 2.0 fish p/redd. 31 redds observed in 2005 (Pinnacle and Clear Branch creeks combined).
Hood River – downstream of Clear Branch Dam & tributaries	Unknown (C)	Unknown	Unknown	Bull trout detected in very low numbers, limited information and data available at the local population level.
Lewis River Basin – three local populations				
Pine and Rush Creek Local Populations Combined (Swift Reservoir)	996 (B)	.249	Increasing	Adult abundance estimate based on 3yr. average (2002 to 2004) generated by mark/recapture studies in Swift Reservoir. Adult population estimate combines Pine and Rush creek populations. Adult population size estimated at 1,287 individuals in 2004.
Cougar Creek (Yale Reservoir)	107 (B)	.211	Unknown	Adult abundance estimate based on 3yr. average (2003-2005). Counts generated by weekly snorkel counts in Cougar creek (July-Nov.).

Table 3.1 Summary of Potential Local Donor Populations from Five River Basins in the Lower Columbia River Portion of the Coastal Evolutionary Group (continued).

Local Population Name	Adult Abundance & Data Confidence Rating (A,B,C)*	Expected Heterozygosity (from Spruell et al. 2003)	Population Trend (2000 to 2005)	Comments**
Lower Deschutes River Basin – two local populations				
Warm Springs River	100 to 150 (A)	.256	Stable – but significant 2005 decline in redd #s.	Adult abundance estimate generated by redd counts, weir trapping & video. Though 5-year trend is stable, the 2005 redd count (n=56) was the lowest since surveys began in 1998. CTWSR biologists estimate the current adult population to be approximately 100 to 150 individuals.
Shitike Creek	200 to 250 (A)	.082	Stable – but significant 2005 decline in redd #s.	Adult abundance estimate generated by redd counts, weir trapping & video. Though 5-year trend is stable, the 2005 redd count (n=27) was the lowest since surveys began in 1998. Video recorded 238 adult fish entering Shitike Creek March-September 2005. However, 100 were recorded moving out of Shitike Creek prior to spawning perhaps due to artificial passage barriers) The 2005 redd count represents a decline of 86.8% from the 2002 high of 204 redds
Lower Deschutes River Basin (Metolius River Subbasin) – three interacting local populations				
Whitewater River	50 (B)	.106	Unknown	Whitewater Creek was not surveyed for redds in 2005 due to poor water clarity during spawning season. Last accurate redd counts occurred in 1998 (n=14) and 1999 (n=30). CTWSR biologists estimate the current adult population to be approximately 50 individuals.
Jefferson, Candle, and Abbot River Complex Jefferson Creek Candle Creek	299 (A)	.207	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 92 redds were observed in 2005.
	340 (A)	Unknown	Increasing	Adult abundance estimate for Candle Creek based on 5yr. average (2001-2005) generated by redds counts (2.3 fish p/redd). 124 redds were observed in 2005.
Canyon, Jack, Heising, and Mainstem Metolius River Complex Canyon Creek Roaring Creek Jack Creek Heising Cr./Spring Metolius River mainstem	374 (A)	Unknown	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 146 redds were observed in 2005.
	318 (A)	Unknown	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 196 redds were observed in 2005.
	508 (A)	.158	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 221 redds were observed in 2005.
	86 (A)	Unknown	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 65 redds were observed in 2005.
	34 (A)	Unknown	Stable	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 22 redds were observed in 2005.

Table 3.1 Summary of Potential Local Donor Populations from Five River Basins in the Lower Columbia River Portion of the Coastal Evolutionary Group (continued).

Local Population Name	Adult Abundance & Data Confidence Rating (A,B,C)*	Expected Heterozygosity (from Spruell et al. 2003)	Population Trend (2000 to 2005)	Comments**
Klickitat River Basin				
West Fork Klickitat River	Unknown (C)	Unknown	Unknown	Little data currently available. Bull trout juveniles have been observed in the West Fork of the Klickitat River as recently as 2001. Bull trout in the Klickitat Basin may exhibit resident behavior, rather than fluvial.

* A =High Confidence (comprehensive redd counts, weir/screw trap counts on spawning tributaries, use of PIT tagging, video and/or VAKI fish counters).

B = Moderate Confidence (redd counts on index reaches, mark/recapture studies, some extrapolation of data to reach estimated abundance.

C = Low Confidence (very little survey data or redd counts, few observations of adult fish, little or no documented spawning.

** Where possible, adult abundance estimates were generated from redd counts utilizing established fish per redd ratios (i.e., South Fork McKenzie and Metolius bull trout populations). However, if fish per redd data were not available, then a default of 2.0 fish per redd was used (Hood River, mainstem McKenzie River and Trail Bridge bull trout populations).

Although adult abundance is useful in examining population status, N_e is a more informative metric to consider. Recall from section 3.2 and Appendix D, the best estimate of N_e for most bull trout populations is thought to be between 0.5 and 1.0 times the mean number of adults returning to spawn (Rieman and Allendorf 2001). This correlates to adult spawning abundances of 100 and 1,000 (using the more conservative value of $N_e/0.5$). Thus, one hundred spawning adults are needed to reduce the risks of inbreeding and 1,000 spawning adults are needed to maintain genetic variation (i.e., reduce genetic drift). Unfortunately, little information exists to accurately determine N_e for Lower Columbia River bull trout populations. The best available information (i.e., spawning adult abundance as a function of redd count data) and how population abundances were determined is displayed in the comments column of Table 3.1.

The CRBTWG evaluated each local population and groups of interacting local populations of bull trout within the five river basins in the Lower Columbia River as a potential donor based on current status and trend (Table 3.1). Bull trout from two of the five river basins, Lewis River and Deschutes River, contain groups of interacting local populations that meet or exceed abundance criteria (approximately 1,000 spawning adults, see Table 3.1) and would confer a low level of genetic risk due to reduced effective population size (Ne). For the Lewis River Basin, this includes the combined Pine Creek and Rush Creek local populations that occur above Swift Dam. For the Deschutes River Basin, this includes the three interacting local populations present in the Metolius River Subbasin.

In a local population or group of interacting local populations that contain a total spawner abundance in excess of 1,000 individuals, there is lower “genetic” risk (i.e., loss of unique alleles or reduction in heterozygosity to the donor population) associated with removal of an appropriate number of individuals. In the case of the Pine Creek and Rush Creek local populations in the Lewis River Basin, this low risk assumes that the donor population is able to maintain its current abundance while serving as a donor stock. The Pine Creek and Rush Creek local populations display an abundance trend with a positive trajectory since 1994, increasing the CRBTWG’s confidence in the genetically low risk ranking for these two combined local populations. Furthermore, the expected heterozygosities observed in bull trout samples from the Lewis River Basin are comparable to values observed for bull trout elsewhere (Neraas & Spruell 2004, Spruell et al. 2003). That is, there are relatively low levels of intrapopulation variation, but high levels of interpopulation variation. In particular, the expected heterozygosity for the combined Pine Creek and Rush Creek local populations was found to be 0.249 (see Table 3.1) (Spruell et al. 2003) and in a more recent study, 0.330 (Neraas & Spruell 2004). For the loci examined, the expected heterozygosity is the highest of all the lower Columbia River tributaries for which there is data available. Although bull trout sampled from two different local populations, Pine Creek and Rush Creek, show differentiation (Fst = 0.188, Neraas & Spruell 2004), this level of discreteness is not unexpected given that Pine Creek experienced significant mudflows during the eruption of Mt. St. Helens in 1980. Bull trout in Pine creek likely experienced a severe genetic bottleneck due to extremely low numbers of individuals (i.e., the founder effect). In a population structure estimate using the program STRUCTURE, 11 to 18.5 percent of individuals were assigned to the opposite creek (i.e., bull trout collected in Pine Creek were assigned/grouped to individuals in Rush Creek and the converse) (Nerass & Spruell 2004). Even after this catastrophic event, the expected heterozygosity of bull trout sampled from Pine and Rush creeks were 0.277 and 0.240, respectively, and are still among the most genetically diverse and resilient local populations of bull trout in the Lower Columbia River Basin.

Having information regarding potential gene flow (i.e., migration and exchange of alleles between local populations) can significantly alter how to view the level of genetic risk associated with serving as a donor. Table 3.1, divides the Deschutes River Basin into Lower Deschutes River Basin and Lower Deschutes River Basin (Metolius Subbasin). The Metolius River Subbasin contains three interacting local populations, for which there is likely gene flow between these local populations given their close geographic proximity. Because bull trout typically display low levels of intrapopulation variation there is reason to expect that there is gene flow among the three Metolius River Subbasin local populations. As part of a larger study of Metolius River bull trout (Ratliff et al. 1996), a radio-tagging effort was implemented that revealed information regarding spawning fidelity. Of 127 recaptures of spawning adults tagged during previous spawning migrations, eight bull trout were documented changing spawning tributaries. Although spawning tributary fidelity was not the goal of the study, the results suggest that at least six percent of bull trout strayed during the study period (1993-1994). This straying provides additional support that there is gene flow among the three bull trout local populations in the Metolius River Subbasin even in the presence of high natal stream fidelity.

For the above reasons, it is likely the metapopulation dynamics of the Metolius River Subbasin bull trout result in an adult abundance value that is a combination of all three local populations (i.e., adult abundance of approximately 2,009 adults). Because there is likely significant connectivity among the Metolius River Subbasin local populations, the reproducing adult abundance value (higher than any other in the coastal lineage) suggests that the Metolius River Subbasin bull trout are the least "at risk" of the potential donors and would likely serve as an acceptable donor stock with a very low chance of adverse impacts genetically. To verify this conclusion, the USFWS along with other partners are implementing a study that will characterize the genetic discreteness of each of the Metolius River Subbasin local populations of bull trout. Study results are expected in the winter of 2007.

The majority of local populations examined for use as potential donor stock have a higher risk of reduced genetic fitness associated with the removal of individuals. Within these higher risk local populations there is a higher level of concern in regard to negatively impacting the genetic fitness of the donor population and there is greater uncertainty in regard to whether enough donors would be available to confer long-term persistence for the newly founded population in the Clackamas River (i.e., loss of fitness through inbreeding depression/founder effects). Local populations included in this higher risk category include: South Fork McKenzie River, Upper McKenzie River, Clear Branch, Hood River, Cougar Creek, and West Fork Klickitat River. Many of the potential local populations currently have a high level of risk for reduced genetic fitness and fail to meet the minimum criteria necessary to preclude the immediate negative effects of inbreeding depression (i.e., less than 100 spawning adults derived from the 50/500 rule).

As expected, there are also potential local populations that are intermediate to the low and high risk populations. Local populations included in this intermediate risk category include: Mainstem McKenzie River, Warm Springs River, and Shitike Creek. These local populations have adult abundance levels between 100 and 1,000. These intermediate-risk potential local populations require further consideration as there is much variability within the category. For example, the Mainstem McKenzie River Local Population is estimated at approximately 130 spawning adults, which is more than the 100 adult criteria that may be considered at an elevated risk for experiencing accelerated rates of inbreeding depression or loss of diversity as the result of removing individuals. On the other hand, the Shitike Creek Local Population is larger and estimated between 200 and 250 adults. In contrast, the Shitike Creek Local Population would be less likely to experience the loss of unique alleles or experience a reduction in heterozygosity as a result of removing a discrete number of individuals. There is a gradient of risk associated with each local population of bull trout that fall in the adult abundance category of 100 to 1,000 individuals, with risk decreasing as adult abundance approaches 1,000 individuals.

It is also important to consider factors other than reproducing adult abundance (100/1,000) or other surrogates of N_e. Adult abundance trends or trajectories observed for local populations are an important consideration. Keeping with the example above, the Mainstem McKenzie River Mainstem Local Population has been experiencing a slightly downward trend over the past five years. Trends in abundance help further refine the level of risk associated with use of a local population or groups of interacting local populations as a donor stock. Information regarding risk can also be informed by examining the expected levels of heterozygosity for each local population (Spruell et al. 2003) found in Table 3.1, or by other metrics such as F_{st} which is the reduction in heterozygosity of a local population due to genetic drift (Hartl 1988) and can be used as an indicator of relative levels of gene flow. This information can provide insight regarding the dynamics or interactions between local populations.

3.4 Summary and Conclusions

After considering the information regarding the evolutionary lineage of bull trout, current demographic trends, connectivity, potential for gene flow, and expected levels of heterozygosity within bull trout local populations, two river basins contain interacting local populations that likely contain the necessary characteristics and associated low level of risk (both demographically and genetically) to serve as donor stocks for a reintroduction into the Clackamas River. The purpose of this chapter is not to rank potential donor stocks for reintroduction into Clackamas River, but rather, highlight the theoretical basis and current synthesis of information in such a manner to identify relative levels of risk to each donor.

The two river basins containing local populations that likely have the lowest level of genetic risk (i.e., loss of unique alleles or reduction in heterozygosity) associated with serving as donors include bull trout from the Lewis River Basin (Pine Creek and Rush Creek local populations) and the Lower Deschutes River Basin, Metolius River Subbasin (Whitewater River; Jefferson, Candle, and Abbot River Complex; and Canyon, Jack, Heising, and Mainstem Metolius River Complex local populations). It is important to note that the Metolius River Subbasin local populations are considered at low risk for detrimental genetic effects only if they are grouped together, which appears to be appropriate as described in Section 3.4. As such, any efforts utilizing Metolius River Subbasin bull trout as a donor stock must include a carefully crafted implementation strategy that does not place a disproportionate amount of pressure (i.e., extraction) on a single local population. If a reintroduction effort into the Clackamas River is pursued, these options will need to be further evaluated depending on the specific strategy of implementation.

In addition to the low risk potential donor populations, the synthesis provided herein also suggests there are local populations of bull trout in the costal lineage that have an elevated level of risk associated with serving as donor stocks. At intermediate level of risk for harmful genetic drift are the following local populations: Mainstem McKenzie River, Warm Springs River, and Shitike Creek. At higher risk, and likely not suitable for serving as donor stocks include the following local populations: South Fork McKenzie River, Upper McKenzie River, Clear Branch, Hood River, Cougar Creek, and West Fork Klickitat River. Not only might there be an elevated level of concern in regard to negatively impacting the genetic fitness of these higher risk local populations, but it is likely that not enough individuals would be available to confer long-term persistence for the newly founded local population in the Clackamas River.

Chapter 4 – Ecological Interactions and Food Web Considerations

Chapter 4 considers food web dynamics and important ecological interactions in the Clackamas River Subbasin, and how these may relate to the reintroduction of bull trout. The key questions addressed in this chapter include:

- What are the potential interactions between bull trout and nonnative brook trout and their implications for reintroduction of bull trout into the Clackamas River?
- What are the potential interactions between bull trout and other native fish species present in the Clackamas River?
- What is the nature of the prey base in the Clackamas River that would be needed to support a bull trout reintroduction?
- What are the fish diseases and pathogens of concern regarding a translocation of bull trout from one or more potential donor stocks into the Clackamas River?

4.1 Potential Interactions Between Bull Trout and Nonnative Brook Trout and Implications to a Reintroduction of Bull Trout in the Clackamas River

Brook trout (*Salvelinus fontinalis*), a char native to eastern North America, have been introduced in cold water streams and lakes throughout western North America (MacCrimmon and Campbell 1969; Meehan and Bjornn 1991) and they have successfully invaded many waters beyond where they were intentionally stocked. The majority of these introductions were intended to provide recreational fisheries (Dunham et al. 2004), especially in high mountain lakes previously devoid of fish, many with outlets to downstream environments inhabited by native trout. A growing body of evidence suggests nonnative trout can substantially change aquatic ecosystems wherever they are present (Simon and Townsend 2003) as well as threaten native fish through competition, predation and hybridization. However, the popularity of recreational fisheries, and the difficulty of eradicating established populations of nonnative species, suggests nonnative trout will remain in many aquatic ecosystems into the foreseeable future (Dunham et al. 2004).

Brook trout are widespread throughout the native range of bull trout and are considered an important threat to the persistence of bull trout (Rieman et al. 1997). The influence of nonnative brook trout on bull trout may depend in part on local habitat features. Rich et al. (2003) examined the influence of habitat features on the distribution and co-occurrence of nonnative brook trout and bull trout. The study suggested that bull trout and brook trout may partition themselves naturally based on habitat type and stream temperature, and that bull trout may be more susceptible to brook trout invasion in small, low-gradient streams where brook trout may have a competitive advantage (Nagel 1991; Paul and Post 2001). Brook trout appear to adapt better to degraded habitats and higher water temperatures than bull trout (Clancy 1993, Dunsmoor 1997, Rich 1996). Yet in areas of clean, cold water with complex habitat, bull trout may successfully compete with brook trout (Paul and Post 2001; Dunham and Rieman 1999; Dunham et al. 1999).

Hybridization is most common where isolated or remnant bull trout populations overlap with brook trout (Cavender 1978; Leary et al. 1983, 1991; Markle 1992). Small resident populations are particularly susceptible to hybridization from co-occurring brook trout because individuals of spawning age are similar in size, and both spawn in the fall and utilize similar spawning habitat.

Stocking of nonnative brook trout for recreational angling began in the Clackamas River in the early 1900s, and continues today in high elevation lakes. Over time, some lakes have developed naturally reproducing populations of brook trout while others require regular stocking. Past stocking in lakes with outlet streams has resulted in self-sustaining populations of brook trout in some streams in the Clackamas River Subbasin.

Specific Areas of Concern with Brook Trout Present

Stream surveys and biological inventories completed by USFS fish biologists over the last two decades provide a reliable source for documenting observations of brook trout in particular river segments and streams. However, little to no quantitative data exists to characterize their abundance relative to that of native species. Given the lack of systematic, quantitative surveys for brook trout, the CRBTWG was only able to map brook trout presence by identifying the river and stream segments where they have been observed (Figure 4.1). Brook trout have been observed in one of the six patches containing suitable bull trout spawning and rearing habitat; Patch 3 Upper Clackamas River (above Cub Creek). Within Patch 3, brook trout have been observed in Squirrel and Ollalie creeks, and in the upper Clackamas River above its confluence with Squirrel Creek, representing approximately six of the 20 miles (30 percent) of suitable bull trout spawning and rearing habitat in this patch. This corresponds to less than 10 percent of the total available bull trout spawning and rearing habitat in the six habitat patches identified in Chapter 2.

Brook trout originated in the river segments and streams shown in Figure 4.1 from historic stocking in headwater, mountain lakes with tributary outlets. Brook trout were repeatedly stocked over many decades by ODFW in various lakes throughout the Ollalie Lakes complex and in other lakes that feed Ollalie and Squirrel creeks. Beginning in 2003, a coordinated effort was begun between ODFW and the USFS that led to a discontinuation of stocking brook trout into lakes with tributary outlets to the upper Clackamas River and its tributaries containing suitable bull trout spawning and rearing habitat.

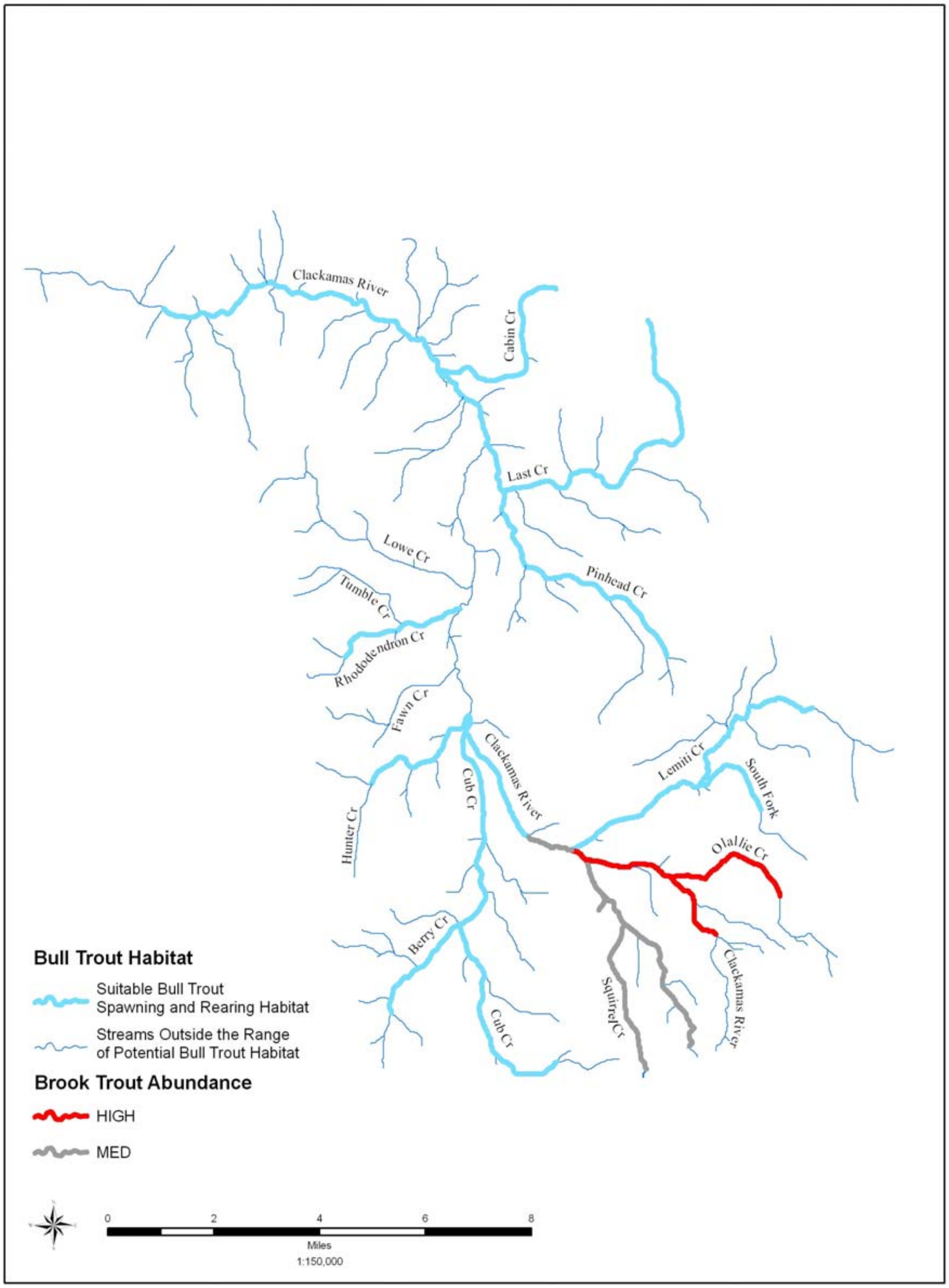

Figure 4.1. Brook Trout Presence in the Upper Clackamas River Subbasin.

4.2 Adequacy of Prey Base to Support a Reintroduced Bull Trout Population

Bull trout are opportunistic feeders and if reintroduced into the Clackamas River would likely prey on a variety of native and nonnative fish species. In many locations, mountain whitefish (*Prosopium williamsoni*) are a preferred bull trout prey species and in the Clackamas River watershed adult mountain whitefish are commonly found in large pool habitats of the Clackamas and Collawash rivers (Murtagh et al. 1992, Ratliff 2003, Beauchamp and Van Tassel 2001, Pratt 1992, Bergamini 2005). Largescale sucker (*Catostomus macrocheilus*) is also common in larger pool habitats in this watershed (Bergamini 2005). Large numbers of anadromous salmonids rear as pre-smolts in the upper Clackamas River. The five year average for smolt outmigrants annually passing North Fork Dam (all anadromous species 2001-2005) was 139,152 smolts (PGE 2001, 2002, 2003, 2004, 2005). Older juvenile and adult bull trout would be expected to prey upon rearing juvenile anadromous salmonids. Resident coastal cutthroat trout (*Oncorhynchus clarki clarki*), sculpin (genus *Cottus)*, and a diverse assemblage of aquatic macroinvertebrates are found in abundance in many of the smaller tributary streams within the Clackamas River Subbasin and also would likely be preyed upon by bull trout.

<u>Fish Species Found in the Clackamas River</u>

If reintroduced, bull trout would add to the already highly diverse assemblage of fish species, native and nonnative, found in the Clackamas River Subbasin. The Clackamas River supports naturally reproducing populations of early and late-run stocks of coho salmon (*O. kisutch*), spring Chinook salmon (*O. tshawytscha*), and winter steelhead (*O. mykiss*), all of which are federally listed as threatened under the ESA. A small, remnant run of fall Chinook salmon utilize the lower Clackamas River and a small population of sea-run coastal cutthroat trout also persists in this part of the subbasin. The upper subbasin, above PGE's North Fork Dam, is managed as a wild fish sanctuary and all anadromous salmonids identified as hatchery origin (i.e., those that are adipose fin clipped), are captured at the North Fork Dam fish trap and prevented from migrating past the dam. Pacific lamprey (*Lampetra tridentata*) also occur upstream of North Fork Dam.

Downstream of North Fork Dam, hatchery produced spring Chinook, coho, and winter and summer steelhead are released each year at a number of locations. Other fish species present throughout the subbasin include resident and fluvial cutthroat trout, rainbow trout, mountain whitefish, largescale sucker, Pacific lamprey, sculpin, mountain sucker (*C. platyrhynchus*), longnose dace (*Rhinichthys cataractae*), western brook lamprey (*L. richardsoni*), northern pikeminnow (*Pytchocheilus oregonensis*), chisel mouth (*Acrocheilus alutaceus*), redside shiner (*Richardsonius balteatus*), threespine stickleback (*Gasterosteus aculeatus*), and peamouth (*Mylocheilus caurinus*). Introduced exotic fish species, such as bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), brown bullhead (*Ameiurus nebulosus*), American shad (*Alosa sapidissima*), smallmouth bass (*Micropterus dolomieu*) and other species are encountered in some habitats in the lower watershed below Rivermill Dam (Murtagh et al. 1992).

Recovery of Anadromous Species in the Upper Clackamas River Subbasin During the Early 1900s After the Rebuilding of Cazadero Fish Ladder

Salmon and steelhead populations in the Clackamas River declined dramatically in the early 1900s as a result of intense pressure from commercial fisheries, egg-taking practices for hatchery supplementation, and hydropower development. The most significant declines resulted from failure of the fish ladder at Cazadero Dam in 1917, which resulted in a complete blockage of passage into the upper portion of the subbasin. The original fish ladder at Cazadero partially functioned to pass fish from 1905 to 1917, although it was racked by local hatchery managers for egg-taking purposes. Most of the egg-taking focused on Chinook, and it is not clear from records and documentation whether coho and steelhead were allowed to pass. It is possible that few, if any, fish passed into the upper Clackamas River Subbasin between 1905 and 1917, and there was no passage from 1917 to 1939 (Cramer and Cramer 1994).

In 1939, the fish ladders at Cazadero and Rivermill dams were re-built, restoring passage to historic spawning and rearing areas in the upper subbasin (Taylor 1999). Restoration of passage, combined with reductions in egg-taking for hatchery production, greatly increased the number of adult salmon and steelhead that successfully reached natural spawning habitat in the upper subbasin. Cazadero Dam failed in January 1965 and was rebuilt later in the year and renamed Faraday Diversion Dam (Cramer and Cramer 1994).

PGE constructed the North Fork Dam along with the 1.7 mile long North Fork fishway in 1958. The fishway allows fish to migrate past both the Faraday Diversion Dam and North Fork Dam. At North Fork Dam, downstream migrants are diverted into a juvenile bypass pipeline that provides passage around the North Fork, Faraday, and Rivermill dams. Downstream migrants that are not diverted into the bypass pipeline must pass through turbines or over the spillways at the dams. The construction of North Fork Dam and the associated fish ladder and downstream migrant pipeline substantially increased anadromous fish production in the upper portion of the subbasin (Cramer and Cramer 1994).

Despite modifications to hatchery operations and improvements implemented at the mainstem hydroelectric dams, a large amount of land development in the lower Clackamas and Willamette rivers began in the 1940s and is thought to have limited the recovery of anadromous fish due to habitat degradation. Increases in road construction and development in the upper portion of the subbasin also occurred during this timeframe, and also reduced the amount and quality of spawning and rearing habitat available. Development of new roads into the upper subbasin was coupled with large increases in the harvesting of timber. By 1954, timber harvest occurred on more than 29 percent of the upper subbasin and, combined with other development activities, reduced the quality and quantity of fish habitat (Taylor 1999).

By the 1950s, anadromous salmonid runs began to rebuild primarily through natural production in the upper subbasin. Coho salmon and steelhead recovered more quickly than spring Chinook since they were not the focus of hatchery production and had more opportunity to utilize habitat in the lower subbasin below hatchery egg racks and hydroelectric dams. The USFWS operated a fish trap at the exit of Rivermill Fish Ladder for five years beginning in 1950 and documented the improving fish runs (Taylor 1999). During the five-year period, coho counts numbered 416, 741, 1,378, 1,122, and 1,155, respectively; steelhead counts numbered 1,484, 1,954, 1,559, 1,616, and 950, respectively; and Chinook counts numbered 366, 496, 668, 533, and 407, respectively (Taylor 1999). Figure 4.2 shows counts of winter and summer steelhead from the period of 1963 through 2005. Figure 4.3 shows counts of spring Chinook and coho from the period of 1950 through 2005.

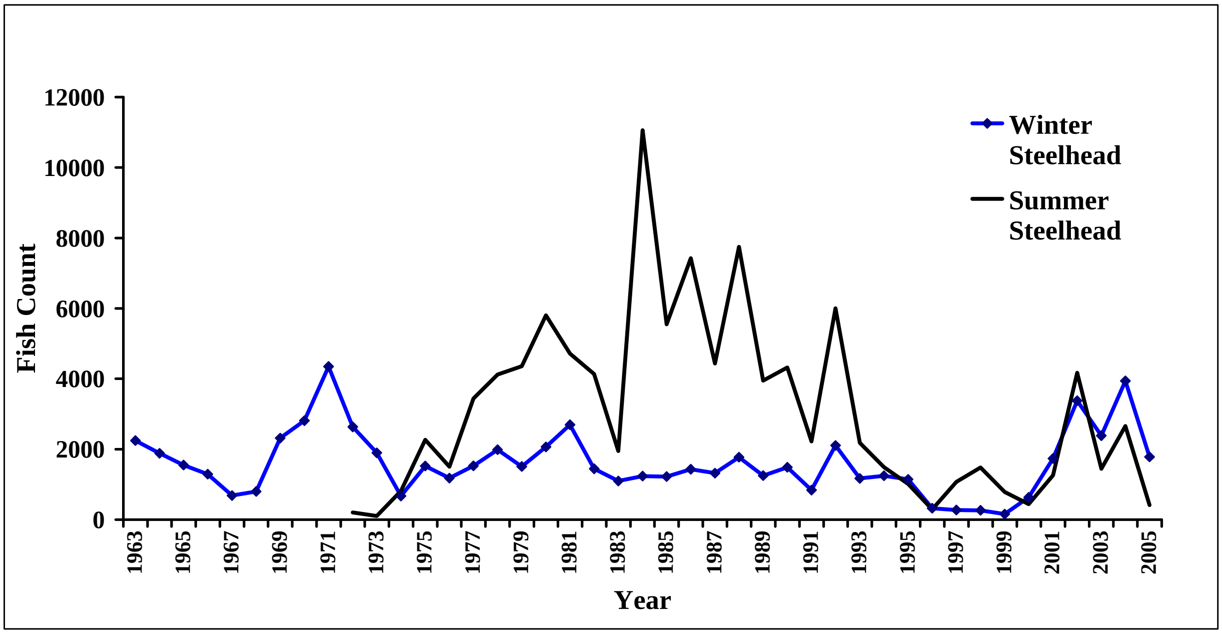

Figure 4.2. Adult Steelhead Fish Counts at North Fork Fish Ladder from 1963 to 2005. [Winter steelhead were counted by run year from November to October, and summer steelhead are counted by calendar year. Summer steelhead were not counted prior to 1972, since they were introduced in 1970.]

Winter Steelhead

The number of adult winter steelhead passing North Fork Dam peaked in the early 1970s with 4,349 fish passing in 1971. Winter steelhead numbers declined between 1971 and 1999 with a low of 156 winter steelhead passing in 1999. The dramatic decline in returning adults is likely due to a combination of harvest and freshwater habitat-related impacts combined with extremely poor ocean survival. Recent returns have rebounded in part due to protections afforded by the ESA listing of steelhead in 1998. Improved ocean survival also played a role in the increase of adult winter steelhead that passed North Fork Dam since 1999. Over the past five years, an average of 1,187 winter steelhead passed North Fork Dam with a maximum of 2,073 fish passing in 2004. Despite recent gains between 2001 and 2005, only 429 wild winter steelhead were seen at the North Fork fish trap in 2006.

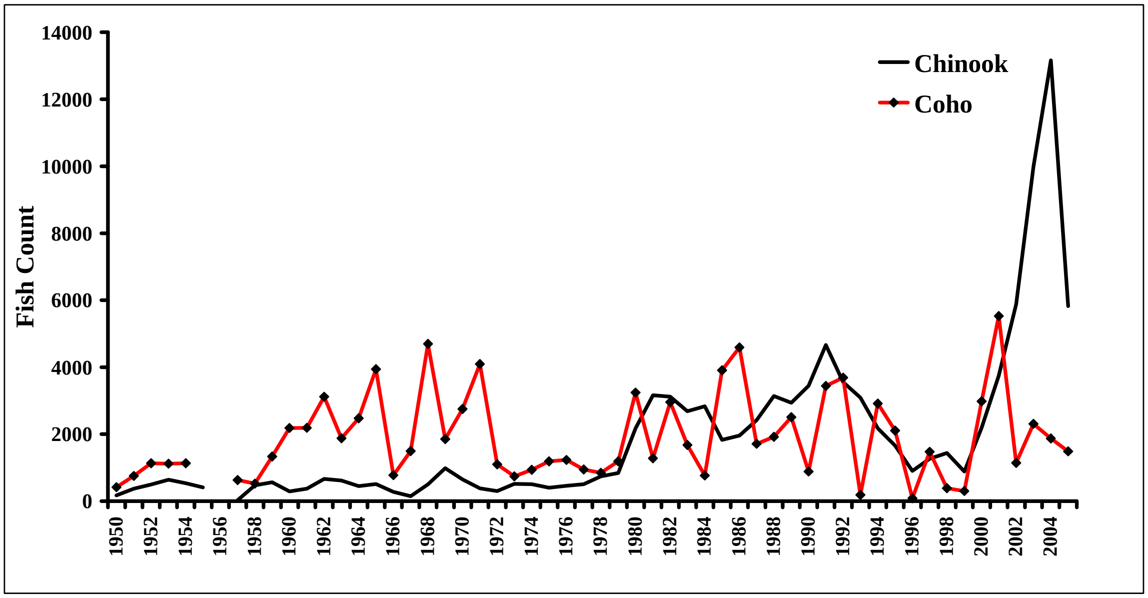

Figure 4.3. Adult Spring Chinook and Coho Fish Counts at North Fork Fish Ladder from 1950 to 2005. [Spring Chinook runs for each year are counted from August to July; coho are counted from March to April. No data available for 1956.]

Spring Chinook

Spring Chinook did not recover for a number of years after passage was restored to the upper Clackamas River Subbasin. Between 1950 and 1979, the number of spring Chinook passing North Fork Dam averaged 393 fish, with a low count of 25 adults in 1957 and a high count of 909 adults in 1969. The low escapement of spring Chinook was likely due to a number of reasons, including intense harvest pressure from commercial and sport fisheries, hatchery egg-taking procedures, degradation of habitat, and poor out-migrant survival.

Adult spring Chinook escapement began to increase substantially after 1980, when the first adult returns from the present-day Clackamas River fish hatchery returned to the subbasin. In 1980, the combination of hatchery and wild spring Chinook adults passing North Fork Dam was 2,188 fish. Hatchery and wild fish could not be distinguished from one another until 2002 due to the lack of external marking on all hatchery produced fish. Combined returns of hatchery and wild spring Chinook counted at North Fork Dam between 1980 and 2001 averaged 2,437 fish, with a low count of 888 adults in 1996 and a high count of 4,584 adults in 1991. Between 2002 and 2005, the number of wild spring Chinook averaged 3,447 fish, with a low count of 2,170 adults in 2002 and a high count of 5,236 adults in 2004. During the same time period, the number of hatchery origin spring Chinook counted at North Fork Dam averaged 5,088 fish, with a low count in 2005 and a high count in 2004.

Coho Salmon

Two separate stocks of coho salmon occur in the Clackamas River Subbasin. The early-run stock is present throughout the subbasin and is likely descended from hatchery releases primarily from the Eagle Creek National Fish Hatchery. The early-run stock spawns from October through November. Early-run coho juveniles or adults have not been released in the Clackamas River above North Fork Dam since 1980 and 1972, respectively (Murtagh 1992). The late-run, or wild stock, is separated spatially and temporally from the early-run stock. The late-run stock spawns in the upper portion of the subbasin above North Fork Reservoir from December through March.

The number of coho adults passing North Fork Dam from 1950 through 1958 averaged about 1,100 fish. Coho counts at North Fork Dam increased to an average of 2,088 adults after production from the Eagle Creek National Fish Hatchery began to return to the subbasin. The number of returning coho has been highly variable over the past 50 years, averaging 1,889 adults with a low count of 87 adults in 1996 and a high count of 5,530 adults in 2001. Adult coho counts reached an extremely low level in the late-1990s due to poor ocean survival combined with harvest effects from the commercial and sport fisheries. However, adult coho counts rebounded by 2001, reaching the highest recorded. One major change has been a shift in the overall contribution of the two coho stocks. The late-run coho stock used to be the stronger of the two stocks, dominating the overall returns. However, the early-run stock presently comprises a greater proportion of the overall return. It is believed the early-run stock takes advantage of an expanded spawning distribution in the Big Bottom area resulting from warmer water temperatures throughout the upper subbasin during mid-fall months.

Fall Chinook

Historically, the Clackamas River is believed to have had a substantial run of fall Chinook salmon (Fulton 1968). There are limited references to fall Chinook likely due to the overwhelming importance of spring Chinook salmon in the subbasin and confusion over identification of fall versus spring Chinook at hatcheries and counting stations (Murtagh 1992).

Fall Chinook are known to have spawned above the town of Estacada prior to development of the North Fork Hydroelectric Project (Fulton 1968). The impacts from loss of upstream fish passage at Cazadero Dam in the early 1900s, combined with extensive harvest in lower Columbia and Clackamas river terminal fisheries, likely reduced the fall Chinook population to very low numbers. Native fall Chinook in the Clackamas River Subbasin were likely extirpated during this time period but have since been replaced with a “tule” stock, first released in the subbasin in 1952 (Murtagh 1992). Currently, it is estimated that between 300 and 600 “tule” fall Chinook naturally reproduce in the lower subbasin below Rivermill Dam.

Cutthroat Trout

Very little is known about the status and life history of sea-run cutthroat trout in the Clackamas River Subbasin (Murtagh 1992). There is limited evidence of sea-run cutthroat trout passing upstream at Rivermill or North Fork dams according to historic documentation and trap counts by PGE staff. However, there is some evidence of sea-run cutthroat trout presence in tributaries to the lower subbbasin, based on smolt trap monitoring of Clear, Deep, and Eagle creeks by the USFS. Unfortunately, there has been little effort made to monitor the life history and population trends of cutthroat trout.

4.3 Potential Bull Trout Interactions with Native Fish Species, Predatory Behavior, Dietary Composition, and Consumption Rates of Bull Trout

<u>Bull Trout Interactions with Native Fish Species in the Clackamas River</u>

The intent of this section is to provide information on potential interactions between a reintroduced population of bull trout and other native fish species within the Clackamas River, with emphasis on interactions between bull trout and other salmonids (i.e., coastal cutthroat trout, rainbow trout, steelhead, Chinook, and coho). The focus on interactions between bull trout and other native salmonids in the Clackamas River is driven not only by the recreational and economic values put on these species by the general public, but also by concerns regarding recovery of other ESA listed fish species in the subbasin.

Unfortunately our current understanding of predator/prey relationships between bull trout and other species is limited, as is information on general interactions between bull trout and anadromous fish. Underwood (1995) examined interactions between Chinook, steelhead, and bull trout. However, the life history strategy utilized by the bull trout population studied was resident (piscivory was not the primary feeding strategy) and no predator/prey relationships were noted. Instead the study focused on examining and confirming habitat partitioning between the three species, a trait common among species that evolve together. Habitat partitioning among sympatric species allows the utilization of different resources thereby reducing direct competition. This strategy was documented in several studies investigating interactions between bull trout and cutthroat trout (Marnell 1985; Nakano et al. 1992) and bull trout and rainbow trout (McPhail and Baxter 1996).

Although few studies have attempted to quantify bull trout predation impacts on sympatric fish species, the reputation of bull trout as an apex predator is not undeserved as there is an abundance of literature noting the aggressive piscivorous nature of this species. This reputation led to fish management actions that for many years included bounties, rotenone treatments, and trap and removal that ultimately extirpated many populations and in part led to a federal ESA listing of the species as threatened. Despite these actions there were no attempts that the CRBTWG is aware of to quantify impacts of bull trout predation on anadromous or resident fish populations, relative to the array of other variables that determine population sizes such as predation by other piscivorous fish and birds, sport and commercial angling, habitat conditions, migratory conditions, water quality and ocean conditions to name a few.

Bull trout are opportunistic feeders and prey on whatever fish species or aquatic organisms (e.g., crayfish, aquatic macroinvertebrates, etc.) are present and in the most abundance. In many rivers within the native range of bull trout, juvenile anadromous salmonids historically, and in many cases currently, provide the most significant forage base for bull trout. Over the last century, the decline in abundance and distribution of anadromous salmonids in many rivers in the western United States precipitated a forage base shift for many bull trout populations to other fish species. The reduction, and in many cases complete loss of juvenile anadromous fish within portions of the range of bull trout has had unknown consequences. In some areas other species may have filled the niche previously occupied by anadromous fish and bull trout may not have been negatively affected. Conversely, the forage base in other areas may not have been replaced by other species and bull trout populations may have responded accordingly by reductions in abundance and distribution.

Within the native range of bull trout, many populations historically and currently overlap with the distribution of anadromous Pacific salmon. In Oregon, bull trout, Chinook salmon and steelhead trout co-occur in a number of rivers including the McKenzie (Willamette River Basin), Hood, John Day, Warm Springs (Deschutes River Basin), Wenaha, Minam, Lostine and other tributaries of the Grand Ronde River in northeast Oregon, and in the Walla Walla and Umatilla rivers. The status of Pacific salmon and bull trout in each of these river systems ranges from healthy to depressed. Although the CRBTWG is not aware of any studies assessing interactions between bull trout and anadromous fish in these watersheds, it likewise is unaware of any premise that bull trout within these watersheds are a limiting factor in anadromous fish production.

A reintroduction of bull trout to the Clackamas River would require a Section 7 ESA consultation between the USFWS and NMFS due to the presence of federally listed anadromous fish in the Clackamas River that may be impacted by the reintroduction. The biological assessment and biological opinion developed as part of the consultation process would provide a more in-depth analysis of potential effects to anadromous fish than is possible in this feasibility assessment. The CRBTWG anticipates that a biological opinion by NMFS would include recommendations and guidance for monitoring.

Predatory Behavior and Feeding of Bull Trout

Large bull trout are widely recognized as predators of fish but because of their diverse life history forms (resident, anadromous, fluvial, and adfluvial) and habitats that range from small mountain lakes to large turbid, northern Canadian rivers, it is best not to generalize too greatly about food preferences of these char (Budy et al. 2004; Goetz et al. 2004; Johnston 2005; McPhail and Baxter 1996; Post and Johnston 2002; Wilhelm et al. 1999). Bull trout appear to be opportunistic in their feeding behavior and prey items range from midges to small mammals. Another element in bull trout feeding behavior is their increased activity during periods of low light (Goetz et al. 2004, Muhlfeld et al. 2003). For example, hydro-acoustic surveys of Lake Chester Morse by the Seattle Water Department indicated peak activity on dark, moonless nights and little activity by bull trout during the day (McPhail and Baxter 1996). Bull trout generally appear to be most visible at night during snorkeling surveys and during day time far fewer bull trout are typically visible (Spangler and Scarnecchia 2001; Peterson et al. 2002).

Juvenile Diet and Feeding Behavior

During night snorkeling in Idaho, Spangler and Scarnecchia (2001) found age-0 bull trout rearing in shallow, low velocity stream margin habitats in the summer. A possible advantage listed for summer shallow water feeding by small juvenile bull trout (less than 66 mm) was avoiding encounters with larger piscivorous bull trout and other aquatic predators. Fraley and Shepard (1989) also found young-of-the-year bull trout distributed more often along stream margins and in side channel locations in the Flathead River Basin, feeding on *Diptera* and *Ephemeroptera* aquatic invertebrates. Another Idaho study reported juvenile bull trout (70-170 mm) using pools more frequently than riffle habitat. In this study, other bull trout were apparently not feeding during the day and could be found hiding in the substrate or resting on the bottom (Bonneau and Scarnecchia 1998).

Juvenile bull trout are generally consumers of aquatic insects (Goetz et al. 2004; Budy et al. 2004; Fraley and Shepard 1989). Fraley and Shepard (1989) found that bull trout greater than 110 mm in the upper Flathead River consumed small trout and sculpin. Underwood et al. (1995) found bull trout (less than 200 mm) from three southeast Washington streams feeding on a wide range of food sources including mayfly nymphs, midge larva, rainbow trout, and frogs.

Sub-adult Diet and Feeding Behavior

In general, juvenile and sub-adult fluvial and adfluvial bull trout start to migrate to larger river or lake habitats after age-2 or 3 and begin feeding on larger prey with fish becoming an increasing part of their diets (Pratt 1992; Ratliff and Howell 1992). Ratliff et al. (1996) found most Metolius River bull trout spawned for the first time at age 5 and were at least 450 mm long. Some Metolius River bull trout did not become adfluvial but reared in the river system in a fluvial life history pattern and spawned earlier at age-4. Some of the age-2 and older bull trout in the Metolius River system did not continue to disperse downstream from early juvenile rearing habitats but instead moved into adjacent warmer tributaries not utilized by bull trout for spawning. Ratliff et al. (1996) suggests that bull trout movement into these warmer tributaries is apparently for feeding opportunities on abundant sculpin.

In the upper Flathead River in winter, sub-adult bull trout (less than 400 mm) were observed concealed in deep pools and runs during daylight. At night these same fish were observed leaving the former habitats and utilizing shallow, low-velocity stream margin habitats during full darkness. The observers believed that these sub-adult bull trout were feeding on juvenile mountain whitefish or other small fish found in the shallow margin habitat (Muhlfeld et al. 2003). In the Flathead River, areas with concentrations of yearling whitefish often were the same locations where sub-adult bull trout were captured (Pratt 1992).

The opportunistic feeding behavior of sub-adult bull trout also apparently includes cannibalism of bull trout fry and juveniles (Goetz 1989, Post and Johnson 2002). Observations by Horner in 1978 of bull trout actually digging into the stream substrate to prey on juvenile bull trout and cutthroat was cited in Spangler and Scarnecchia (2001). In the South Fork Walla Walla and North Fork Umatilla rivers, the rate of bull trout cannibalism was found to be relatively high (Budy et al. 2004) despite information suggesting that bull trout in both systems feed on a high proportion of aquatic insects. In Lake Billy Chinook, as much as 10 percent of identifiable prey in sub-adult bull trout stomachs was cannibalized smaller bull trout (Beauchamp and Van Tassel 2001).

Adult Diet and Feeding Behavior

Goetz et al. (2004) considers large adult, migratory bull trout "apex predators" that feed opportunistically based on what food items are most available at any one time or location. This may include cannibalism of other bull trout by larger adults (Beauchamp and Van Tassel 2001, Spangler and Scarnecchia 2001). In northern Canada, large adult bull trout are found in big turbid rivers such as the mainstem Peace and Laird rivers, feeding as wandering fluvial migrants. McPhail and Baxter (1996) presumed that the small numbers of widely scattered, large bull trout (some exceeding 900 mm) in these northern mainstem rivers was attributable to their position as top predators in these riverine habitats, where their diet includes suckers, grayling, red backed voles and mice. Adult bull trout diets can differ greatly depending on the ecosystems and locations they are found in. In Alberta's Harrison Lake, where bull trout are the only fish present, their diet was primarily small insects and zooplankton, even for adults (Wilhelm et al. 1999).

Other evidence suggests that adult bull trout change their diet as prey abundance varies. The large adfluvial bull trout of Lake Billy Chinook Reservoir in Oregon, have a diet largely of fish, with kokanee salmon and other salmonids (including whitefish) showing the highest percentages as prey items. Longnose dace, sculpins, and suckers were also prey species regularly selected. Bull trout utilization of the above prey varied in abundance seasonally. For example, adult bull trout in autumn preyed heavily on age-2 and age-3 kokanee salmon, while in summer adult bull trout primarily consumed mountain whitefish (Beauchamp and Van Tassell 2001). Goetz et al. (2004) in studies of anadromous bull trout in Puget Sound reported, "…anadromous bull trout opportunistically utilize forage fish species (surf smelt, Pacific herring, and Pacific sand lance) almost exclusively when they are present in the nearshore marine environments." Goetz et al. (2004) further concluded that bull trout feeding habits vary according to prey abundance, season, size, and competition and that bull trout will adjust to utilize the prey sources that are available.

Piscivory By Other Native Fish Species

Although adult bull trout are known for a diet large on fish, it is also important to remember the context of the other fish they are cohabitating with. Bull trout consume other fish that are capable themselves of being piscivorous predators. Sculpin, rainbow/steelhead trout, cutthroat trout and other salmonid species of the Clackamas River are also piscivorous and are known to consume other fish, including anadromous salmon fry and juveniles. During USFS smolt trapping in the Clackamas in 2007, wild coho juveniles were documented cannabilizing coho fry. In addition, juvenile rainbow trout/steelhead smolts were documented foraging on coho fry (Tom Horning, biologist, USFS, personal comm., 2007). At the yearling stage, coho salmon are known in some rivers to supplement their insect diets by cannibalizing their own fry or fry of other species. In California, Chinook salmon fry have been known to be eaten in large numbers by yearling coho outmigrants. In some locations coho less than 30 mm were heavily preyed upon by torrent sculpins (Groot and Margolis 1991). Mobrand et al. (2005) in a review of hatchery effects on natural fish populations, determined that yearling hatchery coho, stream-type Chinook, and steelhead smolts are the most likely predators on wild salmonid fry because of their larger size when released.

4.4 Disease Considerations Associated with an Out-of-Basin Transfer of Bull Trout to the Clackamas River

Unwanted parasites and diseases frequently have been introduced through fish transfers (Hoffman and Schubert 1984). To avoid these unintended consequences, translocations of fishes between major river basins should be preceded by a thorough investigation into the potential transfer of pathogens from the donor source, as well as the resistance of the donor stock to any known pathogens present in the receiving habitat.

The development of a bull trout reintroduction plan for the Clackamas River would include a thorough investigation into the potential impact of pathogens on the success of the effort, as well as an assessment of risk to other fish species in the receiving watershed (Clackamas River). The USFWS' Lower Columbia Fish Health Center (LCFHC) has offered to provide assistance to the CRBTWG in addressing fish health concerns if a future reintroduction of bull trout to the Clackamas River were to occur (Susan Gutenberger, Lower Columbia Fish Health Center, personal communication, August 2006). In addition to working with the Lower Columbia Fish Health Center, the CRBTWG would work closely with fish pathologists from the states of Oregon and Washington to examine, and if necessary collect, relevant disease information.

In considering disease issues in a reintroduction, the transfer of wild stocks within their native ranges presents lower risks (Minckley 1995) due to previous exposure and resistance capabilities to potential pathogens. All potential donor stocks investigated in this assessment inhabit the lower Columbia River and thus historically were equally exposed to the same suite of pathogens. However, artificial propagation and widespread stocking of native and nonnative salmonids throughout the lower Columbia River over the last century have resulted in unintended introductions of nonnative pathogens.

In the lower Columbia River, a number of bull trout populations have been isolated for many years above impassable dams, including potential donor populations in the Deschutes (Metolius), Hood, and Lewis river basins. In many cases their isolation from anadromous fish and other stocked resident salmonids protected them from exposure to pathogens recently introduced, but not native, to the lower Columbia River and its tributaries. The isolation of bull trout in the Metolius River above the Pelton Round Butte Dam Complex provides an example of how fragmentation of the environment, combined with the biology of the fish pathogens, can influence the character of disease transmission within a watershed.

The Pelton Round Butte Dam Complex was completed in 1964, effectively cutting off migration of anadromous salmonids into the Metolius, Deschutes and Crooked rivers above the dam. After several years of failed efforts to move anadromous fish up and down over the two dams, transport was abandoned in 1968 in favor of operating a hatchery facility below the dams. In the late 1990s, studies were initiated to examine the possibility of reintroducing anadromous fish above the dams. As part of the effort, ODFW conducted a fish disease risk analysis to assess the risk to native resident fish from reintroducing anadromous fish and their associated organisms into waters above the Pelton Round Butte Dam Complex (Engelking 2003).

The study concluded that certain pathogens, in particular, Type 2 strain infectious hematopoietic cecrosis (IHN) and *M. cerebralis* (whirling disease) are now present in fish below the dams but not in fish sampled above them, and that if these pathogens were introduced above the dams native fish stocks may be at risk. The study noted additional evaluations are underway to further assess the risk of these pathogens to native fish above the dams.

The information presented in Engelking (2003) underscores the importance of a rigorous disease evaluation prior to implementing a fish reintroduction, even when returning fish to historic habitat. An abundance of information exists on fish pathogens in the Deschutes River Basin due to the ODFW analysis discussed above, as well as other disease studies associated with the federal relicensing of the Pelton Round Butte Project dams and the effort to restore anadromous fish production above the project. This level of information is not available in other basins inhabited by potential donor stocks for a Clackamas River bull trout reintroduction. However, before selection of a donor stock and moving forward with implementing a reintroduction, additional analysis would likely be needed to satisfy state and federal requirements, as well as to provide the best chance of a successful reintroduction and to ensure the least risk to other fish in the reintroduction area.

4.5 Summary and Conclusions

The evidence that nonnative brook trout can have significant negative effects on bull trout distribution and abundance is highly variable. In some places, brook trout appear to have a strong negative impact, whereas in others there is no apparent impact – a situation paralleling impacts of brook trout on native cutthroat trout (Dunham et al. 2002). The Clackamas River has abundant cold water, including water temperatures cold enough to potentially limit the success of brook trout relative to bull trout (Rieman et al. 2006; Benjamin et al. 2007). Although brook trout are found in the Upper Clackamas River, their distribution is limited to less than 10 percent of the identified bull trout spawning and rearing habitat where a reintroduction could take place. Brook trout presence in one of six bull trout habitat patches could influence where translocated bull trout would be stocked, but the CRBTWG does not believe the limited presence of brook trout would deter the success of an attempted bull trout reintroduction in the Clackamas River.

Bull trout coexisted with a many of other native fish species in the Clackamas River for thousands of years, likely feeding on a variety of different species. Historically, anadromous Pacific salmon were likely the most abundant fish in the subbasin and they probably comprised a significant portion of the bull trout diet. However, current abundance and distribution of anadromous salmon in the subbasin is reduced from historic levels. Bull trout, if reintroduced, may be more dependent upon other native species as a prey base, such as mountain whitefish and largescale sucker, both of which are present and abundant along with other potential prey such as dace, sculpin, northern pike minnow, and several species of trout. Available information on bull trout populations from other areas in the Lower Columbia River Basin suggest that, while possibly important, bull trout persistence is not dependent upon the presence of anadromous salmon.

Despite evidence that bull trout prey on juvenile anadromous salmonids when they are available, no data were found that suggests predation is a factor in the status of Pacific salmon across the hundreds of watersheds where they co-occur in the western United States. Although the distribution and abundance of Pacific salmon in the Clackamas River is reduced from historical levels, the remaining native fish assemblage is assumed to be healthy. For these reasons, the CRBTWG believes there is a sufficient forage base to support a bull trout reintroduction in the Clackamas River.

Review of available information on interactions between bull trout and other sympatric fish species suggests it will be exceedingly difficult to predict in advance the food web effects of a reintroduction of bull trout into the Clackamas River. The CRBTWG fully anticipates that if a reintroduction occurs and is successful, that some predation of juvenile anadromous fish by bull trout will occur. However, given that bull trout will also be eating other predators of juvenile anadromous fish (i.e. resident rainbow and cutthroat trout, pike minnow, and sculpin), it is uncertain whether the overall impact to anadromous fish will be negative or positive.

Other uncertainties also make predicting food web effects difficult. Although the amount of bull trout spawning and rearing habitat was quantified in Chapter 2, the carrying capacity of the system for bull trout (i.e., future abundance) cannot be predicted with any certainty. The actual abundance and distribution of bull trout within the Clackamas River Subbasin, if reintroduced, and its use of the watershed for rearing, foraging and overwintering also present additional uncertainty in regard to predicting food web effects. Finally, the expression of life history form (e.g., resident, fluvial, adfluvial, or combinations thereof) creates even further uncertainty.

Although the CRBTWG acknowledges a significant amount of uncertainty regarding the food web effects of a reintroduction of bull trout into the Clackamas River, the best available information suggests the impact to listed anadromous fish and other native fish in the subbasin is unlikely to be significant. Furthermore, we believe accurately measuring food web effects from a reintroduction of bull trout would be a difficult, if not impossible endeavor. However, should a means be identified to accurately measure food web effects, and in particular predation effects to listed anadromous fish, than the CRBTWG would further explore this type of monitoring. If a reintroduction of bull trout into the Clackamas River takes place and is later identified through monitoring as a limiting factor in the recovery of anadromous salmonids, the CRBTWG believes the reintroduction effort is reversible.

Chapter 5 – Summary

5.1 Overall Summary

Bull trout were an historic component of the fish assemblage in the Clackamas River Subbasin, a major tributary in the Willamette River Basin. Once abundant and widely distributed throughout the subbasin, bull trout are now locally extirpated. Bull trout were listed as threatened under the ESA by the USFWS in 1998. The 2002 draft bull trout recovery plan specifies completing an assessment to determine the feasibility of reintroducing bull trout into the Clackamas River Subbasin. This assessment investigated that feasibility. This assessment does not evaluate all of the various factors and issues involved in contemplating a potential reintroduction. Instead, it focuses specifically on whether or not a reintroduction is possible (i.e., “Can it be done?”). This assessment examines four questions that were adapted from Epifanio et al. (2003):

1. Is there a high level of confidence that bull trout are no longer present that would serve as a natural gene bank?

2. Is there suitable habitat remaining, what conditions or stressors currently prevent bull trout from occupying suitable habitats, and have these been corrected?

3. Is suitable habitat expected reasonably to be recolonized through natural processes if conditions are improved?

4. Is a suitable or compatible donor population(s) available that can itself tolerate some removal of individuals?

This assessment does not attempt to determine, “Should a reintroduction be done?” or, “How should it be done?” These two latter questions can be addressed after a proposed action is developed amongst multiple agencies and stakeholders with full public involvement.

Bull trout historically occurred throughout much of the Clackamas River Subbasin prior to the post-European settlement era beginning after the mid-1800s. The CRBTWG has a high confidence that bull trout have been extirpated from the Clackamas River Subbasin because extensive sampling targeting bull trout occurred from the 1990s to 2004. The factors leading to the decline of bull trout began in the early 20th Century and extended into the 1970s. The primary factors for their decline include migration barriers from hydroelectric and diversion dams, direct and incidental harvest in the sport and commercial fisheries, targeted eradication with bounty fisheries, and habitat and water quality degradation from forest management and agricultural activities. A more detailed explanation of bull trout extirpation in the Clackamas River Subbasin is provided in Appendix B. The causative factors responsible for the decline of bull trout in the Clackamas River Subbasin are believed to be sufficiently remedied so as not to impede or negatively influence the success of a reintroduction effort.

Suitable habitat for bull trout was examined using a tiered approach. Bull trout require very cold water for spawning and rearing. The portion of the Clackamas River Subbasin providing suitable bull trout spawning and rearing habitat today is located in the Clackamas River mainstem and its tributaries in the headwaters of the subbasin upstream of the Collawash River confluence. This portion of the subbasin contains approximately 70 miles of suitable spawning and rearing habitat configured into six separate habitat patches. Habitat patches range in size, configuration, and condition. The most downstream habitat patch occurs along the mainstem Clackamas River known as Big Bottom. This unique and complex reach of the river provides suitable spawning and rearing habitat, and would also likely serve as an important foraging area for migratory adult and sub-adult bull trout. Other habitat patches occur either adjacent to or up to a maximum distance of approximately six river miles upstream into the headwaters of the subbasin.

Three evolutionary lineages of bull trout are found in the Columbia River Basin: Coastal, Snake River, and Upper Columbia River. The CRBTWG refined its review of potential donor stocks to the Lower Columbia River portion of the Coastal evolutionary lineage. The nearest five donor stocks for consideration come from the Willamette, Lewis, Hood, Klickitat, and Deschutes river basins. Each nearby donor stock is located a considerable distance away from the Clackamas River Subbasin and in many cases the presence of migration barriers makes natural recolonization highly unlikely.

After considering the information regarding the evolutionary lineage of bull trout, current demographic trends, connectivity, potential for gene flow, and expected levels of heterozygosity within bull trout local populations, two river basins contain local populations that likely have the necessary characteristics and associated low level of risk (both demographically and genetically) to serve as a donor stock for a reintroduction into the Clackamas River:

- **Lewis River Basin –** Two interacting local populations: Pine Creek and Rush Creek.
- **Lower Deschutes River Basin (Metolius River Subbasin) –** Three interacting local populations: Whitewater River; Jefferson, Candle, and Abbot River Complex; and Canyon, Jack, Heising, and Mainstem Metolius River Complex.

In addition, the synthesis of available data revealed three intermediate risk local populations: 1) the Mainstem McKenzie River Local Population in the Willamette River Basin (McKenzie River Subbasin), 2) the Warm Springs River Local Population in the Lower Deschutes River Basin and 3) the Shitike Creek Local Population in the Lower Deschutes River Basin. At higher risk and likely not suitable for serving as donor stocks are the following local populations: South Fork McKenzie River, Upper McKenzie River, Clear Branch, Hood River, Cougar Creek, and West Fork Klickitat River. Not only might there be an elevated level of concern in regard to negatively impacting the genetic fitness of these higher risk local populations, but it is likely that not enough individuals would be available to confer long-term persistence for the newly founded local population in the Clackamas River.

This assessment also investigated ecological interactions between bull trout and native and nonnative fish species. Nonnative brook trout can have significant negative effects on bull trout distribution and abundance. However, recent studies suggest that certain habitat variables play a strong role in determining the level of effect. Brook trout distribution is limited to one of the six suitable habitat patches where a bull trout reintroduction could take place. Brook trout are present in low abundance. For several decades, ODFW stocked high mountain lakes within the habitat patch with brook trout. Brook trout escaped via outflow tributaries connected to downstream suitable bull trout habitat reaches. ODFW no longer stocks brook trout in headwater lakes within the Upper Clackamas River Subbasin that contain tributary outlets to streams determined as suitable bull trout spawning and rearing habitat. As such, brook trout is not considered to be a significant factor that would affect the success of a reintroduction of bull trout into the Clackamas River.

Bull trout coexisted with a multitude of other native fish species in the Clackamas River for thousands of years, likely feeding on a variety of different species. Historically, anadromous Pacific salmon were likely the most abundant fish in the subbasin and they probably comprised a significant portion of the bull trout diet. However, current abundance of anadromous salmon and steelhead in the subbasin is greatly reduced from historic levels. Bull trout, if reintroduced, may be more dependent upon other native species as a prey base, such as mountain whitefish and large-scaled suckers, both of which are present and abundant along with other potential prey such as dace, sculpin, northern pike minnow, and several species of trout. Available information on bull trout populations from other areas in the Lower Columbia River Basin suggest that, while possibly important, bull trout persistence is not dependent upon the presence of anadromous salmon.

Due to the multitude of variables that contribute to the mortality of juvenile Pacific salmon, including other fish and avian predators, the rate of bull trout predation on juvenile salmon and the potential effect of that predation are unquantifiable. Despite evidence that bull trout prey on juvenile anadromous salmonids when they are available, no data were found that suggests this predation is a factor in the status of salmon and steelhead across the hundreds of watersheds where they co-occur in the western United States. Although the abundance of Pacific salmon in the Clackamas River is reduced significantly from historical levels, the remaining native fish assemblage is assumed to be healthy. For these reasons, it is believed there is a sufficient forage base to support a bull trout reintroduction in the Clackamas River and further, that if reintroduced, predation on juvenile salmon would not likely negatively affect the status of salmon and steelhead populations in the subbasin.

In conclusion, the CRBTWG believes, based on this analysis, that a reintroduction of bull trout into the Clackamas River Subbasin is feasible because:

- There is a high level of confidence that bull trout have been locally extirpated.
- The causes for their decline have been sufficiently rectified.
- High quality habitat is available in sufficient amounts.
- Nearby donor stocks are unlikely to naturally recolonize the subbasin.
- Compatible donor stocks are available that can withstand extraction of individuals.

- Nonnative brook trout presence is restricted to a small portion of the suitable habitat and they occur in low abundance.

- A diverse and abundant fish assemblage would serve as a sufficient prey base.

5.2 Additional Areas for Consideration

Several other factors need to be considered in the next steps of developing a proposed action for reintroduction. These include:

- Establishment of specific bull trout reintroduction goals and objectives.
- Identification of specific donor stock(s) to be used.
- Age class, duration, and quantity of individuals to be extracted from the donor bull trout stock(s).
- Method(s) of translocation to the Clackamas River.
- Fish disease screening.
- Specific location(s), timing, and habitat patch(es) for release of individuals.
- Additional management actions needed in order to ensure bull trout reintroduction success.
- Specific monitoring and evaluation criteria for the recipient and donor populations.

Once a proposed action is developed collaboratively with multiple agencies and stakeholders including public review and input, several other analyses would need to be completed. These include:

- Socio-economic impacts.
- Ecological affects to other native fish species present.
- Evaluation of the potential donor stock hybridization with brook trout.
- Endangered Species Act compliance by affected agencies and parties.
- Evaluation of achieving recovery goals identified in the Draft Bull Trout Recovery Plan (USFWS 2002) in the absence of an active reintroduction effort.

5.3 Adaptive Management: Monitoring and Evaluation Considerations

Many translocations of fishes have occurred over the past several decades. Translocation success varies by species and location. Simons et al. (1989) reported an 18 percent translocation success rate for Gila topminnow (*Poeciliopsis o. occidentalis*) in southern Arizona. Hendrickson and Brooks (1991) reported a 35 percent translocation success rate for 39 taxa of desert fishes in southwest North American. Harig et al. (2000) reported a 38 percent translocation success rate in the case of greenback cutthroat trout (*Oncorhynchus clarki stomias*) in Colorado. An 80 percent translocation success rate was reported for Gila trout (*O. gilae gilae*) in New Mexico by Propst et al. (1992). Hepworth et al. (1997) reported an 83 percent translocation success rate for Bonneville cutthroat trout (*O. clarki utah*) in southwestern Utah. In every instance, fisheries managers and decision makers implemented these translocation efforts with the very best intention. However, any one of a number of factors may have contributed to the uncertainty around a particular situation and ultimately led to a failed translocation attempt.

If a reintroduction of bull trout into the Clackamas River is to be undertaken, there will be a number of uncertainties even with this assessment. Ludwig et al. (1993) acknowledge that a great deal of uncertainty often faces decision makers when confronted with natural resource and fisheries management decisions. Given this, they recommend managers and decision makers “consider a variety of plausible hypotheses …, (consider) a variety of possible strategies, favor actions that are robust to uncertainties, favor actions that are informative, probe and experiment, and monitor results …”

Following the guidance from Ludwig et al. (1993) and employing an adaptive management approach offers the highest likelihood for ensuring success should a bull trout reintroduction effort be initiated. Establishing realistic goals with measurable objectives and specific benchmarks for achievement is imperative in developing a proposed action. Identifying the key areas of uncertainty would also be imperative in order to develop a robust monitoring and evaluation strategy for both the donor and recipient populations. Key information obtained from monitoring would shed light on the uncertainties identified and allow for necessary adjustments during implementation to ensure success. The CRBTWG encourages that knowledge learned during a bull trout reintroduction effort, if implemented, is shared within the fisheries management and scientific communities.

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Appendix A – Causes for Decline of Bull Trout in the Western United States

Bull trout distribution, abundance, and habitat quality have declined range-wide (Bond 1992; McPhail and Baxter 1996; Newton and Pribyl 1994; Rieman and McIntyre 1993; Schill 1992; Thomas 1992; Ziller 1992). Several local extirpations have been documented, beginning in the 1950s (Berg and Priest 1995; Buchanan et al. 1997; Donald and Alger 1993; Goetz 1994; Light et al. 1996; Newton and Pribyl 1994; Ratliff and Howell 1992; Rode 1990; WDFW 1998). Bull trout were extirpated from the southernmost portion of their historic range, the McCloud River in California, around 1975 (Moyle 1976; Rode 1990). Bull trout have been functionally extirpated (i.e., few individuals may occur there but do not constitute a viable population) in the Coeur d'Alene River Basin in Idaho and in the Lake Chelan and Okanogan River basins in Washington (USFWS 1998b). These declines resulted from the combined effects of habitat degradation and fragmentation, blockage of migratory corridors, degradation of water quality, angler harvest and poaching, entrainment into diversion channels and dams, and introduced nonnative species. Specific land and water management activities that have depressed bull trout populations and degraded habitat include dams and other diversion structures, forest management practices, livestock grazing, agriculture, agricultural diversions, road construction and maintenance, mining, and urban and rural development (Beschta et al. 1987; Chamberlain et al. 1991; Craig and Wissmar 1993; Frissell 1993; Furniss et al. 1991; Henjum et al. 1994; Light et al. 1996; MBTSG 1995a, b, c, d, e, 1996b, c, d, e, f, h; McIntosh et al. 1994; Meehan 1991; Nehlsen et al. 1991; Sedell and Everest 1991; USDA and USDI 1995, 1996, 1997; Wissmar et al. 1994).

Dams

Dams affect bull trout by altering habitat; flow, sediment, and temperature regimes; migration corridors; and creating additional interspecific interactions, mainly between bull trout and nonnative species (Bodurtha 1995; Craig and Wissmar 1993; Rieman and McIntyre 1993; Rode 1990; USDA and USDI 1996, 1997; WDW 1992; Wissmar et al. 1994). Impassable dams have caused declines of bull trout by preventing migratory fish from reaching spawning and rearing areas in headwaters and recolonizing areas where bull trout have been extirpated (MBTSG 1998; Rieman and McIntyre 1993).

The extirpation of bull trout in the McCloud River Basin, California, has been attributed primarily to construction and operation of McCloud Dam, which began operation in 1965 (Rode 1990). The McCloud Dam flooded bull trout spawning, rearing, and migratory habitats. The dam also resulted in elevated water temperatures.

Although dams negatively affect bull trout (Gilpin 1997; Rieman and McIntyre 1993), some dams can benefit bull trout by blocking introduced nonnative species from upstream areas (MBTSG 1995d). Some dams also increase the potential forage base for bull trout by creating reservoirs that support prey species (Faler and Bair 1991; Pratt 1992).

Some of the major effects to bull trout resulting from the Federal Columbia River Power System and from operation of other hydropower, flood control, and irrigation diversion facilities include the following: (1) fish passage barriers, (2) entrainment of fish into turbine intakes and irrigation canals, (3) inundation of fish spawning and rearing habitat, (4) modification of streamflows and water temperature regimes, (5) dewatering of shallow water zones during power peaking operations, (6) reduced productivity in reservoirs, (7) periodic gas super-saturation of waters downstream of dams, (8) water level fluctuations interfering with retention of riparian vegetation along reaches affected by power peaking operations, (9) establishment of nonnative riparian vegetation along reaches affected by power peaking operations, and (10) severe reductions in reservoir levels to accommodate flood control operations.

Hungry Horse, Libby, Albeni Falls, Dworshak, Chief Joseph, Keechelus, Tieton, and Grand Coulee dams, as well as others in the Columbia River Basin and throughout the range of bull trout in the conterminous United States, were built without fish passage facilities and are barriers to bull trout migration. These barriers have contributed to the isolation of local populations of migratory bull trout. Bull trout have been observed using upstream fish passage facilities at many of the hydropower projects on the Snake and Columbia rivers. However, even dams with fish passage facilities may be a factor in isolating bull trout local populations if they are not readily passable by bull trout or if they do not provide an adult downstream migration route.

Entrainment of bull trout may also occur at various projects in the Columbia River Basin including Libby, Hungry Horse, Albeni Falls, Rocky Reach, Rock Island,Wells, Dworshak, Bonneville, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. Fish can be killed or injured when passing the dams. Potential passage routes include spill through the turbines or the juvenile bypass systems, but the relative passage success of these routes for adult salmonids has not been thoroughly investigated. However, one study of fish facilities at Foster and Green Peter dams on the South Santiam River, Oregon, conducted in the early 1970s revealed that passage through turbines resulted in a 22 to 41 percent mortality rate for adult steelhead (Wagner 1973). Additionally, a 40 to 50 percent injury rate for adult salmonids passing through the juvenile fish bypass system at McNary Dam has been noted (Wagner and Hinson 1993; Wagner 1991). Adult bull trout may experience similar mortality rates. In addition, those adult fish that survive downstream passage at dams without upstream passage facilities are isolated in downstream reaches away from their natal (native) streams. As indicated above, the loss of these larger, more fecund migratory fish is detrimental to their natal populations.

The creation of mainstem Columbia and Snake river reservoirs (i.e., the areas of slow moving water behind the dams) combined with introductions of piscivorous species [e.g., bass *(Micropterus spp)*, walleye (*Stizostedion vitreum*)] have also affected the habitat of bull trout and other salmonids. An increase in predator populations, both native [e.g., northern pikeminnow (*Ptychocheilus oregonensis*)] and nonnative, as a result of creating artificial habitat and concentrating prey may be a factor in the decline of listed Snake River salmon species (NMFS 1991a, b, c). Ideal predator foraging environments have been created in these pools, particularly for warmwater species in the summer. Smolts that pass through the projects are subjected to turbines, bypasses, and spillways that may result in disorientation and increased stress, conditions that reduce their ability to avoid predators below the dams. Creation of the pools above the dams has resulted in low water velocities that increase smolt travel time and increase predation opportunity. Increased water temperatures, also a result of the impoundment of the river, have also been shown to increase predation rates on salmonid smolts (Viggs and Burley 1991). Because bull trout are apex (top) predators of other fish, negative effects to the salmonid smolt prey base, and the resulting decline in adult returns, are likely to affect bull trout negatively as well. Additionally, increased water temperatures, influenced by the presence of dams, also decreases the suitability of the lower Snake and Columbia river pools for bull trout in the late spring through early fall.

Uncontrolled spill over dams, or even high levels of managed spill, at hydropower projects can produce extremely high levels of total dissolved gas that may impact bull trout and other species. These high levels of gas super-saturation can cause gas bubble disease trauma in fish. Gas bubble disease is caused by gas being absorbed into the bloodstream of fish during respiration. Effects can range from temporary debilitation to mortality, and super-saturation can persist for several miles below dams where spill occurs. The states of Oregon and Washington have established a 111 percent total dissolved gas level as State water quality standards. However, total dissolved gas levels of up to 120 percent have been experienced during recent years of managed spill in the Federal Columbia River Power System, with involuntary spill episodes resulting in total dissolved gas levels of as high as 140 percent at some sites (NMFS 2000). At levels near 140 percent, gas bubble disease may occur in over three percent of fish exposed. At levels of up to 120 percent the incidence of gas bubble disease decreases to a maximum of 0.7 percent of fish exposed (NMFS 2000).

Manipulated flow releases from storage projects alter the natural flow regime, affect water temperature, have the potential to destabilize downstream streambanks, alter the natural sediment and nutrient loads, and cause repeated and prolonged changes to the downstream wetted perimeter (MBTSG 1998). Power peaking operations, which change the downstream flow of the river on a frequent basis, cause large areas of the river margins to become alternately wet and then dry, adversely affecting aquatic insect survival and production. Changes in water depth and velocity as a result of rapid flow fluctuations, and physical loss or gain of wetted habitat, can cause juvenile trout to be displaced, thus increasing their vulnerability to predation. Additionally, rapid flow reductions can strand young fish if they are unable to escape over and through draining or dewatered substrate. These effects also indirectly adversely affect bull trout by degrading the habitat of their prey (small fish) and the food upon which they depend (aquatic insects).

Reservoirs created by dams have also inundated bull trout habitat. For example, reservoirs created by the construction of Libby and Hungry Horse dams have inundated miles of mainstem river and tributary habitat previously used by many local populations of bull trout. Reservoir water level manipulations can create migration barriers at the confluence of tributaries entering the reservoir, as well as negatively affecting littoral rearing habitats for prey species of bull trout. Reservoir levels are often drawn down substantially during drought years, or annually as operators evacuate flood control reservoirs to make room for spring snow melt runoff. Reduced volumes of water in reservoirs can affect their overall productivity that may ultimately reduce the food base of predators such as bull trout. Other reservoirs are unproductive and provide poor habitat for bull trout compared to natural riverine habitats (e.g., Noxon and Cabinet Gorge). However, reservoirs such as Libby, Hungry Horse, and Dworshak now provide suitable habitat for adfluvial populations of bull trout that was not available prior to dam construction.

Forest Management Practices

Forest management activities, including timber extraction and road construction, affect stream habitats by altering recruitment of large wood, erosion and sedimentation rates, runoff patterns, the magnitude of peak and low flows, water temperature, and annual water yield (Cacek 1989; Furniss et al. 1991; Spence et al. 1996; Spencer and Schelske 1998; Swanson et al. 1998; Wissmar et al. 1994). Activities that promote excessive substrate movement reduce bull trout production by increasing egg and juvenile mortality, and reducing or eliminating habitat (e.g., pools filled with substrate) important to later life-history stages (Brown 1992a; Fraley and Shepard 1989). The length and timing of bull trout egg incubation and juvenile development (typically more than 200 days during winter and spring) and the strong association of juvenile fish with stream substrate make bull trout vulnerable to changes in peak flow alterations or disturbances to channels and substrates (Goetz 1989; MBTSG 1998; McPhail and Baxter 1996; Pratt 1992).

Roads constructed for forest management are a prevalent feature on managed forested and rangeland landscapes. Roads have the potential to adversely affect several habitat features, (e.g., water temperature, substrate composition and stability, sediment delivery, habitat complexity, and connectivity) (Baxter et al. 1999; Trombulak and Frissell 2000). Roads may also isolate streams from riparian areas, causing a loss in floodplain and riparian function. The aquatic assessment portion of the Interior Columbia Basin Ecosystem Management Project provided a detailed analysis of the relationship between road densities and bull trout status and distribution (Quigley and Arbelbide 1997). The assessment found that bull trout are less likely to use streams in highly roaded areas for spawning and rearing, and do not typically occur where average road densities exceed 1.1 kilometers per square kilometer (1.7 miles per square mile).

Although bull trout occur in watersheds where timber has been harvested, bull trout strongholds primarily occur in watersheds with little or no past timber harvest, such as the wilderness areas of central Idaho and the South Fork Flathead River drainage in Montana (Henjum et al. 1994; MBTSG 1995d; Rieman et al. 1997; USDA and USDI 1997). However, the Swan River Basin, Montana, has had extensive timber harvest and road construction, and is a bull trout stronghold (Watson and Hillman 1997). The overall effects of forestry practices on bull trout in parts of the Swan River Basin are difficult to assess because of the complex geomorphology and geology of the drainage (MBTSG 1996f).

Roads may affect aquatic habitats considerable distances away. For example, increases in sedimentation, debris flows, and peak flows affect streams longitudinally so that the area occupied by a road can be small compared to the entire downstream area subjected to its effects (Jones et al. 2000; Trombulak and Frissell 2000). Upstream from road crossings, large areas of suitable habitat may become inaccessible to bull trout due to fish passage barriers (e.g., culverts).

Forest management activities have also altered the frequency and duration of floods or high flows (USDA and USDI 1997). Roads and clear-cutting of forested areas tend to magnify the effects of floods, leading to higher flows, erosion, and bedload that scour channels (McIntosh et al. 1994; Spencer and Schelske 1998; Swanson et al. 1998; USDA and USDI 1997), and degrade bull trout habitat (Henjum et al. 1994). Erosion from road landslides increases bedload to stream flows (Furniss et al. 1991). Increased bedload increases the scouring effect of high stream flows, increasing channel width and instability and loss of habitat diversity, especially pools (Henjum et al. 1994; McIntosh et al. 1994). Bull trout eggs and fry in the gravels during scouring likely survive at low rates (Henjum et al. 1994), as do those with large sediment loading. For instance, hundreds of landslides associated with roads on the Clearwater and Panhandle national forests resulted from high flow events in 1995 (Patten and Penzkover 1996), likely reducing survival of bull trout eggs and fry. Habitat degradation has also reduced the number and size of bull trout spawning areas (USDA and USDI 1997).

Livestock Grazing

Improperly managed livestock grazing degrades bull trout habitat by removing riparian vegetation, destabilizing streambanks, widening stream channels, promoting incised channels and lowering water tables, reducing pool frequency, increasing soil erosion, and altering water quality (Henjum et al. 1994; Howell and Buchanan. 1992; MBTSG 1995a, b, e; Mullan et al. 1992; Overton et al. 1993; Platts et al. 1993; Uberuaga 1993; USDA and USDI 1996, 1997). These effects reduce cover, increase summer water temperatures, cause habitat degradation, and promote formation of anchor ice (e.g., ice attached to the bottom of an otherwise unfrozen stream, often covering stones, etc.) in winter, and increase sediment in spawning and rearing habitats.

Negative effects of livestock grazing on bull trout habitat may be minimized if grazing is managed appropriately for conditions at a specific site. Practices generally compatible with the preservation and restoration of bull trout habitat include fences to exclude livestock from riparian areas, rotation schemes, relocation of water and salting facilities away from riparian areas, and use of herders.

Agricultural Practices

Agricultural practices, such as cultivation, irrigation diversions, and chemical application, contribute to non-point source pollution (i.e., water quality impairment) and loss of instream flows in some areas within the range of bull trout (IDHW 1991; MDHES 1994; WDE 1992). These practices can release sediment, nutrients, pesticides, and herbicides into streams; increase water temperature; reduce riparian vegetation; and alter hydrologic regimes, typically by reducing flows in spring and summer. Irrigation diversions also affect bull trout by altering stream flow, dewatering streams, and entrainment. The effects of the myriad of small irrigation diversion projects throughout the range of bull trout may be an even greater significance than the large hydropower and flood control projects. Many of these diversions are located high in the watershed and either physically block fish passage by means of a structure (i.e., a dam), or effectively block passage by periodically dewatering a downstream reach (e.g., diversion of flows through a penstock to a powerhouse; diversion of flows for the purposes of irrigation). Reduced stream flows can also result in structural and thermal passage barriers. Additional effects include water quality degradation resulting from irrigation return flows and runoff from fields and entrainment of bull trout into canals and fields (MBTSG 1998). Some irrigation diversion structures are reconstituted annually with a bulldozer as “push up” dams and not only affect passage, but also significantly degrade the stream channel. Even though these “push up” dams are not legal, there is a prevalence of these structures throughout the range of bull trout which has resulted in the isolation of bull trout populations in the upper watersheds in many areas. Bull trout may enter unscreened irrigation diversions and become stranded in ditches and agricultural fields. Diversion dams without proper passage facilities prevent bull trout from migrating and may isolate groups of fish (Dorratcaque 1986; Light et al. 1996). Other effects of agricultural practices on aquatic habitat include stream channelization and large wood removal (Spence et al. 1996).

Transportation Networks

Roads degrade bull trout habitat by creating flow constraints in ephemeral, intermittent, and perennial channels; increasing erosion and sedimentation; creating passage barriers; channelizing stream reaches; and reducing riparian vegetation (Furniss et al. 1991; Ketcheson and Megahan 1996; Trombulak and Frissell 2000). In the Clearwater River Basin of Idaho, for example, Highway 12 is adjacent to much of the Clearwater River, and crosses the river at eight different bridge sites. The highway has constrained the river in some areas and highway maintenance may negatively affect bull trout and their habitats (CBBTTAT 1998). Moreover, the proximity of the highway to the Clearwater River increases the likelihood of hazardous materials or fuel spills entering the river. Similar situations exist along primary and secondary highways across the range of bull trout.

A dirt road is adjacent to much of the West Fork of the Jarbidge River in Nevada and Idaho. McNeill et al. (1997) determined that construction and maintenance of the Jarbidge Canyon Road has influenced the morphology and function of the river. Within a single 4.8 kilometer (3 mile) reach, there are seven bridge crossings, and the largest bridge spans only 62 percent of the average width of the river (McNeill et al. 1997). Maintenance of the road and bridges requires frequent channel and floodplain modifications that affect bull trout habitat, such as channelization; removal of riparian trees and beaver dams; and placement of rock, sediment, and concrete (Jay Frederick, U. S. Forest Service, personal communication, February 6, 1998; McNeill et al. 1997).

Transportation networks also affect bull trout habitat in protected areas such as National Parks. Roads have been constructed to provide access to the Hoh River and Quinault River basins, including areas within Olympic National Park. These roads were typically built following river valleys and often constrain the floodplains. As a result, these roads have been subjected to high flow events and shifts in river channels, forcing extensive streambank armoring to maintain them (Chad 1997; USNPS 2000). Bank armoring impairs bull trout habitat through reduced habitat complexity, stream channelization, reduced riparian vegetation, and bank erosion downstream. Within the Olympic National Park, about 1,770 meters (5,476feet) of rip-rap were documented along the Hoh River in 1997 (Chad 1997), and additional bank stabilization projects have occurred since then.

Mining

Mining degrades aquatic habitat used by bull trout by altering water chemistry (e.g., pH); altering stream morphology and flow; disturbing channel substrates; initiating channel incision and headcuts; and causing sediment, fuel, and heavy metals to enter streams (Martin and Platts 1981; Spence et al. 1996). The types of mining that occur within the range of bull trout include extraction of hard rock minerals, coal, gas, oil, and sand and gravel. Past and present mining activities have adversely affected bull trout and their habitat in Idaho, Oregon, Montana, Nevada, and Washington (Johnson and Schmidt 1988; MBTSG 1995b, e, 1996b, d; McNeill et al. 1997; Moore et al. 1991; Platts et al. 1993; Ramsey 1997; WDW 1992).

For example, it is thought that bull trout were widely distributed in the Coeur d'Alene River Drainage, Idaho (Maclay 1940). However, extensive mining and associated operations have modified and degraded stream channels and floodplains, created barriers to fish movement, and released toxic substances, especially in the South Fork Coeur d'Alene River (PBTTAT 1998). Portions of the system were essentially devoid of aquatic life during surveys conducted in the 1940s, and bull trout have been functionally extirpated in the Coeur d'Alene River Basin since 1992 (USFWS 1998b).

Residential Development and Urbanization

Residential development is rapidly increasing within many portions of the range of bull trout. Residential development alters stream and riparian habitats through building next to streams, contaminant inputs, and increased stormwater runoff, resulting in changes in flow regimes, streambank modification and destabilization, increased nutrient loads, and increased water temperatures (MBTSG 1995a). Indirectly, urbanization within floodplains alters groundwater recharge by rapidly routing water into streams through drains rather than through more gradual subsurface flow (Booth 1991).

Urbanization negatively affects the lower reaches of many of the large rivers and their associated side channels, wetlands, estuaries, and near-shore areas. Activities such as dredging; removing large wood (e.g., snags, log jams, drift wood); installing revetments, bulkheads, and dikes; and filling side channels, estuarine marshes, and mud flats have led to the reduction, simplification, and degradation of habitats (PSWQAT 2000; Spence et al. 1996; Thom et al. 1994). Pollutants associated with urban environments such as heavy metals, pesticides, fertilizers, bacteria, and organics (oil, grease) have contributed to the degradation of water quality in streams, lakes, and estuaries (NRC 1996; Spence et al. 1996).

Fisheries Management

Introductions of nonnative species by the Federal government, State fish and game departments, and private parties, across the range of bull trout have contributed to declines in abundance, local extirpations, and hybridization of bull trout (Bond 1992; Donald and Alger 1993; Howell and Buchanan. 1992; Leary et al. 1993; MBTSG 1995a, c, 1996a, g; Palmisano and Kaczynski 1997; Platts et al. 1995; Pratt and Huston 1993).

Introduced brook trout (*Salvelinus fontinalis*) threaten bull trout through hybridization, competition, and possibly predation (Clancy 1993; Leary et al. 1993; MBTSG 1996a; Rieman and McIntyre 1993; Thomas 1992; WDW 1992). Hybridization between brook trout and bull trout has been reported in Montana (Hansen and DosSantos. 1997; MBTSG 1995a, e, 1996d, e, f), Oregon (Markle 1992; Ratliff and Howell 1992), Washington (WDFW 1998), and Idaho (Adams 1996; Tim Burton, U. S. Forest Service, personal communication, July 1, 1997). Hybridization results in offspring that are frequently sterile (Leary et al. 1993), although recent genetic work has shown that reproduction by hybrid fish is occurring at a higher level than previously suspected (Kanda 1998). Hybrids may be competitors. Brook trout mature at an earlier age and have a higher reproductive rate than bull trout. This difference may favor brook trout over bull trout when they occur together, often leading to replacement of bull trout with brook trout (Clancy 1993; Leary et al. 1993; MBTSG 1995a). The magnitude of threats from nonnative fishes is highest for resident bull trout because they are typically isolated and exist in low abundance.

Brook trout apparently adapt better to degraded habitats than bull trout (Clancy 1993; Rich 1996), and brook trout also tend to occur in streams with higher water temperatures (Adams 1994; MBTSG 1996g). Because elevated water temperatures and sediments are often indicative of degraded habitat conditions, bull trout may be subject to stresses from both interactions with brook trout and degraded habitat (MBTSG 1996a). In laboratory tests, growth rates of brook trout were significantly greater than those for bull trout at higher water temperatures when the two species were tested alone, and growth rates of brook trout were greater than those for bull trout at all water temperatures when the species were tested together (McMahon et al. 1998, 1999).

Nonnative lake trout (*Salvelinus namaycush*) (i.e., west of the Continental Divide) also negatively affect bull trout (Donald and Alger 1993; Fredenberg 2000; MBTSG 1996a). A study of 34 lakes in Montana, Alberta, and British Columbia, Canada, found that lake trout likely limit foraging opportunities and reduce the distribution and abundance of migratory bull trout in mountain lakes (Donald and Alger 1993). Over 250 introductions of lake trout and other nonnative species have occurred in nearly 150 western Montana waters within the range of bull trout (Vashro 2000). The potential for introduction of lake trout into the Swan River Basin and Hungry Horse Reservoir on the South Fork Flathead River, both in Montana, is considered a threat to bull trout (MBTSG 1995d, 1996f). The presence of several lake trout has been recently documented in Swan Lake (MFWP 1999). In Idaho, lake trout and habitat degradation were factors in the decline of bull trout from Priest Lake (Mauser et al. 1988; Pratt and Huston 1993). Lake trout have invaded Upper Priest Lake and are a threat to the bull trout there (Fredericks 1999). Juvenile lake trout are also using some riverine habitats in Montana, possibly competing with bull trout (MBTSG 1996a).

Introduced brown trout (*Salmo trutta*) are established in several areas within the range of bull trout and likely compete for food and space and prey on bull trout (Platts et al. 1993; Pratt and Huston 1993; Ratliff and Howell 1992). In the Klamath River Basin, for example, brown trout occur with bull trout in three streams and have been observed preying on bull trout in one (Light et al. 1996). Brown trout may compete for spawning and rearing areas and superimpose redds on bull trout redds (Light et al. 1996; MBTSG 1996a; Pratt and Huston 1993). Elevated water temperatures may favor brown trout over bull trout in competitive interactions (MBTSG 1996a). Brown trout may have been a contributing factor in the decline and eventual extirpation of bull trout in the McCloud River, California, after dam construction altered bull trout habitat (Rode 1990).

Nonnative northern pike (*Esox lucius*) have the potential to negatively affect bull trout. Northern pike were introduced into Swan Lake in the 1970s (MFWP 1997), and predation on juvenile bull trout has been documented (MBTSG 1996f), but the bull trout population has not declined. Northern pike were also introduced into Salmon, Inez, Seeley, and Alva lakes in the Clearwater River Basin, and a tributary to the Blackfoot River, Montana (MBTSG 1996f). Northern pike numbers have increased in Salmon Lake and Lake Inez, having a negative effect on bull trout. Northern pike in Seeley Lake and Lake Alva are also expected to increase in numbers (Rod Berg; Montana Fish, Wildlife, and Parks; personal communication; November 13, 1997).

Introduced bass (*Micropterus spp*.) may negatively affect bull trout (MFWP 1997). In the Clark Fork River, Montana, Noxon Rapids Reservoir supports fisheries for both smallmouth bass (*M. dolomieui*) and largemouth bass (*M. salmoides*). Both have been high priority sport fish species in management of Noxon Rapids Reservoir. The Montana fishery management objective for Cabinet Gorge Reservoir, downstream of Noxon Rapids Reservoir, is to enhance bull trout while managing the existing bass fishery (MFWP 1997). However, a 1999 Federal Energy Regulatory Commission settlement with the Avista Corporation for dam relicensing makes recovery of bull trout a management priority (Kleinschmidt Associates and Pratt 1998).

Managers are now attempting to balance these potentially conflicting objectives. In the North Fork Skokomish River, Washington, Cushman Reservoir supports largemouth bass, that may prey on juvenile bull trout rearing in the reservoir and lower river above the reservoir (WDFW 1998).

Opossum shrimp (*Mysis relicta*), a crustacean native to the Canadian Shieldrea, was widely introduced in the 1970s as supplemental forage for kokanee salmon (*Oncorhynchus nerka*) and other salmonids in several lakes and reservoirs across the northwest (Nesler and Bergersen 1991). The introduction of opossum shrimp in Flathead Lake changed the lake's trophic dynamics resulting in expanding lake trout populations and causing increased competition and predation on bull trout (MBTSG 1995c; Weaver 1993). Conversely, in Swan Lake, Montana, introduced opossum shrimp and kokanee increased the availability of forage for bull trout, contributing to the significant increase in bull trout numbers in the Swan River Basin (MBTSG 1996f).

Nonnative fish threaten bull trout in relatively secure, unaltered habitats, including roadless areas, wildernesses, and national parks. For instance, brook trout occur in tributaries of the Middle Fork Salmon River within the Frank Church-River of No Return Wilderness, including Elk, Camas, Loon, and Big creeks (Thurow 1985) and Sun Creek in Crater Lake National Park (Light et al. 1996). Glacier National Park has self-sustaining populations of introduced nonnative species, including lake trout, brook trout, rainbow trout (*Oncorhynchus mykiss*), Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*), lake whitefish *(Coregonus clupeaformis*), and northern pike (MBTSG 1995c). Although stocking in Glacier National Park was terminated in 1971, only a few headwater lakes contain exclusively native species, including bull trout. The introduction and expansion of lake trout into the relatively pristine habitats of Kintla Lake, Bowman Lake, Logging Lake, and Lake McDonald in Glacier National Park has nearly extirpated the bull trout due to predation and competition (Fredenberg 2000; Marnell 1995; MBTSG 1995c).

Some introduced species, such as rainbow trout and kokanee, may benefit large adult bull trout by providing supplemental forage (Faler and Bair 1991; Pratt 1992; Vidergar 2000). However, introductions of nonnative game fish can be detrimental due to increased angling and subsequent incidental catch and harvest of bull trout (Bond 1992; MBTSG 1995c; Rode 1990; WDW 1992).

Isolation and Habitat Fragmentation

Although bull trout are widely distributed over a large geographic area, the effects of human activities over the past century have reduced their overall distribution and abundance, as well as fragmented their habitat. This fragmentation reduces the amount of available habitat and increases isolation from other populations of the same species (Saunders et al. 1991). Burkey (1989) concluded that when species are isolated by fragmented habitats, low rates of population growth are typical in local populations and their probability of extinction is directly related to the degree of isolation and fragmentation. Without sufficient immigration, growth for local populations may be low and probability of extinction high (Burkey 1989, 1995).

Metapopulation concepts of conservation biology theory have been applied to the distribution and characteristics of bull trout (Dunham and Rieman 1999; Rieman and McIntyre 1993). A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1997). Local populations may be extirpated, but can be reestablished by individuals from other local populations. Thus, multiple local populations distributed throughout a watershed provide a mechanism for spreading risk because the simultaneous loss of all local populations is unlikely. Habitat alteration, primarily through the construction of impoundments, dams, and water diversions, has fragmented habitats, eliminated migratory corridors, and isolated bull trout in the headwaters of tributaries (Dunham and Rieman 1999; Rieman and Dunham 2000; Rieman et al. 1997; Spruell et al. 1999). Based on population genetics, there is more divergence among bull trout than among salmon (Leary and Allendorf 1997), indicating less genetic exchange among bull trout populations. The recolonization rate for bull trout is very low and recolonization may require a very long time, especially in light of the man-made isolation of various bull trout populations.

Migratory corridors allow individuals access to unoccupied but suitable habitats, foraging areas, and refuges from disturbances (Saunders et al. 1991). Maintenance of migratory corridors for bull trout is essential to provide connectivity among local populations, and enables the reestablishment of extinct populations. Where migratory bull trout are not present, isolated populations cannot be replenished when a disturbance makes local habitats unsuitable (Rieman and McIntyre 1993; USDA and USDI 1997). Moreover, limited downstream movement was observed for resident bull trout in the Bitterroot River Basin (Nelson 1999) suggesting that reestablishment of migratory fish and potential re-founding of extinct bull trout populations may be a slow process, if it occurs at all.

Because isolation and habitat fragmentation resulting from migratory barriers have negatively affected bull trout by: (1) reducing geographical distribution; (2) increasing the probability of losing individual local populations (Rieman and McIntyre 1993); (3) increasing the probability of hybridization with introduced brook trout (Rieman and McIntyre 1993); (4) reducing the potential for movements in response to developmental, foraging, and seasonal habitat requirements (MBTSG 1998); and (5) reducing reproductive capability by eliminating the larger, more fecund migratory form from many local populations (MBTSG 1998; Rieman and McIntyre 1993), restoring connectivity and restoring the frequency of occurrence of the migratory form will be an important factor in providing for the recovery of bull trout. The manner and degree to which individual dams and diversions affect specific bull trout local populations is likely to vary depending on the specific physical factors at play and the demographic attributes of the local population in question.

Evidence suggests that landscape disturbances, such as floods and fires, have increased in frequency and magnitude within the range of bull trout (Henjum et al. 1994; USDA and USDI 1997). Passage barriers and unsuitable habitat that prevent recolonization, have resulted in bull trout extirpation through these landscape disturbances (USDA and USDI 1997). Also, isolated populations are typically small, and more likely to be extirpated by local events than larger populations (Rieman and McIntyre 1995), and can exhibit negative genetic effects.

Inadequacy of Existing Water Quality Standards

Temperature regime is one of the most important water quality factors affecting bull trout distribution (Adams and Bjornn 1997; Rieman and McIntyre 1995). Given the temperature requirements of bull trout (Buchanan and Gregory 1997), existing water quality criteria developed by the States under sections 303 and 304 of the Clean Water Act may not adequately support spawning, incubation, rearing, migration, or combinations of these life-history stages (62 FR 41162) (NDEP 1998; Oregon 1996; Washington 1997).

Elevated levels of contaminants may result in either lethal (e.g., mortality) or sublethal effects to bull trout. Sublethal impacts may include reduced egg production, reduced survival of any life stage, changes in behavior, reduced growth, impaired osmoregulation, and many subtle endocrine, immune, and cellular changes. Contaminants may also affect the food chain and indirectly harm bull trout by reducing prey availability due to reduced habitat suitability for prey species. Lethal impacts from contaminant inputs are most likely from spills, whereas sublethal impacts may occur from such land uses as agriculture, residential/urban, mining, grazing, and forestry.

Appendix B - Hypothesis for Local Extirpation

Introduction

Impacts to the bull trout population in the Clackamas River have been numerous and sometimes complex since large scale settlement began in the 1840s. The many threats responsible for the rangewide decline in bull trout discussed in Appendix A were also present in the Clackamas River Subbasin. The causes for decline described below on the Clackamas River bull trout population included hydroelectric dams, water diversion dams, timber harvest and forest management practices, conversion and elimination of riparian forest habitat, road building and transportation networks, livestock grazing, agricultural practices including irrigation and chemical applications, mining, residential development and urbanization, harvest of bull trout in the sport and commercial fisheries, fisheries management practices, habitat fragmentation and isolation, and overall water quality degradation.

Premise

The history of deleterious human impacts to anadromous salmonids in the Clackamas River over the last 150 years is parallel to that for bull trout. Most historical documentation of human effects to Clackamas River salmonids focuses on the economically important anadromous stocks; Chinook and coho salmon in particular. Bull trout, or “Dolly Varden” as they were commonly known, appear as footnotes in much of the historical documentation, if mentioned at all. As in many river systems, the presence of bull trout was recognized, but little else was known about them until recent investigations (Dodson and Brun, 2003). In examining the reasons for the decline of bull trout, the historic record and documented observations on other Clackamas River salmonids provide the best clues to what happened to bull trout in this river system. The evidence available indicates anadromous salmonids and bull trout encountered many direct and indirect impacts in the late 19th and early 20th centuries. These impacts were likely detrimental to bull trout, just as they were to the better documented salmon and steelhead populations. Yet, evidence suggests some bull trout persisted, despite major disruptions to their environment, until the 1970s (Murtagh et al. 1992).

A case can be made that increased public access to the upper Clackamas River Subbasin and rapidly expanding fishing pressure beginning in the late 1940s and continuing through the mid-1990s, was the final threat that drove the bull trout into an extinction vortex. The Clackamas River bull trout population, already severely depressed by many anthropogenic pressures, was especially vulnerable when tens of thousands of hatchery reared rainbow trout were stocked in the same rearing habitat during the mid-20th Century. Heavy rainbow trout stocking was followed by intense sport angling pressure accompanied by liberal bag limits (Whitt 1978). Bull trout, known to be exceptionally vulnerable to sport fishing, were subjected to this intense fishing pressure over several decades. In fact, bounty fisheries were offered to eradicate bull trout as reported by Murtagh et al. (1992): “An article in a 1914 edition of the Estacada Progress, a local newspaper, offered a prize for the largest ‘dollar-varden’ caught on the Clackamas River.” Earlier habitat destruction combined with overharvest is probably what finally eliminated bull trout from the Clackamas River.

Background

Commercial Fisheries

Bull trout in the Clackamas River were impacted directly and indirectly by commercial fisheries. Indirectly, bull trout were affected by the loss of large spawning populations of Chinook, coho, and steelhead that were intercepted in the fisheries. The juveniles and smolts from these anadromous fish populations are likely to have constituted a considerable part of the bull trout's prey base. Many bull trout were directly affected when caught in the nets themselves and most likely perished. There is strong evidence that sub-adult and/or adult fluvial bull trout were found historically in the same vicinity as areas of intense commercial fishing operations on the lower Clackamas and Columbia rivers. For instance, Livingston Stone established the first operating fish hatchery in the Columbia River Basin in 1877 at the confluence of Clear Creek and the Clackamas River (Cramer and Associates 2001). It is believed that near this location he secured the Clackamas River "Dolly Varden" (*Salvelinus confluentus*) specimen that is in the National Museum (Smithsonian Inst. 2005) during the winter of 1877-1878. Commercial fisheries in the vicinity were often a problem for the hatchery in securing enough adult Chinook salmon for spawning (Mattson 1950). In 1876, a trap near the mouth of the Clackamas River nearly closed off the entire river to upstream migrating salmon (U.S. Commission of Fish and Fisheries1877, cited in Taylor 1999). In 1877, more than 1,000 drift nets, many reaching 1,200 feet in length, were also being set on the Columbia River (Taylor 1999). In the Columbia River estuary, an area often exploited by the historic commercial fisheries, a recent USFWS review of old State of Oregon seining records for the head of the estuary shows bull trout being caught in seines while apparently foraging at that location (Yoshinaka 2002). Historically, Clackamas River bull trout may have been one of the bull trout populations that utilized the Columbia River estuary. Another historical record indicating heavy commercial fishing activity includes an 1893 report of approximately 12,000 adult spring Chinook salmon harvested by gill-netters in the lower Clackamas River (Smith 1974). By 1908, salmon numbers had declined to such a degree that only five or six commercial fisherman still operated on the Clackamas River itself. Until 1910, there no commercial fishing seasons designated on the Clackamas River (Taylor 1999).

Diversions and Dams

As with commercial fishing, there were direct and indirect effects to bull trout from dams and diversions. Bull trout and their associated prey base of other migratory and non-migratory fish species probably encountered similar threats due to dams and diversions. Likely impacts for bull trout and associated migratory salmonids included partial or complete barriers to migration, delays in migration, fragmentation of habitat, entrainment of fish and associated injury or death, greater exposure to predators, reduction in prey base, and degrading of water quality conditions. Historical records indicate well over 100 years of impacts from dams and diversions in the Clackamas River to fish populations, especially migratory fish.

On the Clackamas River as early as 1890, the State Fish Commission reported that a diversion dam across the Clackamas River near Gladstone impeded the passage of salmon. Although it is unclear from the reports, this dam may have been in existence for several years. Initially, the dam was a partial barrier and a year later became a complete barrier to adult salmon passage after the height was increased. H.D. McGuire, the Oregon Fish and Game Protector, filed a complaint against the mill owner which resulted in the installation of a fish ladder in 1895 (Wallis 1960 and Taylor 1999).

Diversion dams for a variety of purposes existed on many tributaries to the lower Clackamas River from the late 1840s and into the early 1900s. While it is not recorded whether these diversion structures impeded fish passage, most of them were built without fish passage provisions (Cramer and Associates 2001).

The first large hydroelectric facility and diversion dam on the mainstem Clackamas River was completed in 1907, named Cazadero Dam and now called Faraday Dam, which is less than two miles upstream of the town of Estacada (Taylor 1999). When construction began on the facilities in 1902, Oregon’s Master Fishwarden had communicated his concerns to the project owners about effects on Chinook salmon. Subsequently, a fish ladder was installed with cooperation of the dam’s owners upon completion in 1907. Historical Oregon Department of Fisheries reports indicate that construction of Cazadero Dam was responsible for the failure of the federal egg collecting facility in the upper Clackamas River Subbasin in 1905 and 1906. Thereafter, the state started an experimental egg collection facility at Cazadero Dam in an effort to remedy the problem (Report of the Master Fishwarden 1902, and 1907 and 1908; cited in Smith 1974). Additional impacts to bull trout were likely due to the fish ladder being blocked with a weir in order to capture Chinook salmon to collect eggs for hatchery propagation. Fish may have been allowed to climb the Cazadero fish ladder during some seasons, even though historical reports don’t provide much information. Additionally, after several flood events, which threatened the integrity of the dam and the fish ladder, a flood in 1917 damaged the Cazadero fish ladder and a decision was made to not repair or replace it until 1939. During that time, all Chinook salmon were intercepted downstream at River Mill Dam, the second mainstem dam on the Clackamas River located about one mile downstream of the town of Estacada and approximately three miles downstream of the Cazadero Dam site. Construction of the River Mill Dam begun in 1909 and was completed in 1911. Construction of a fish ladder on River Mill Dam was completed in 1912, but the ladder was racked to block fish passage during runs of Chinook salmon in order to collect eggs for fish propagation, thus influencing the decision not to repair the upstream fish ladder at Cazadero Dam. This continued until 1940, when fish passage was restored at Cazadero Dam (Taylor 1999).

The North Fork Dam; the third, furthest upstream, and largest of the Clackamas River dams at 207 feet high; was constructed by Portland General Electric in 1958. North Fork Dam provides upstream and downstream fish passage facilities.

Another diversion dam, the Lake Harriet Dam, on the Oak Grove Fork of the Clackamas River was built in 1924. While upstream of a natural, impassable waterfall on the Oak Grove Fork upstream of historic bull trout occurrence, Lake Harriet Dam likely impacted bull trout habitat in the lower 3.5 miles by diverting the entire river flow, except during high flow spill events. The Oak Grove Fork is a very cold tributary of the Clackamas River, and there are reports of bull trout in this tributary in the 1930s (Carrell 2003).

The early mainstem dams likely had significant impact on the Clackamas River bull trout population both during construction and operation. Upstream fish passage was either not available or not provided until ladders were constructed. These same, early twentieth century fish ladders, also would become damaged and inoperable after large flood events. Intermittently before 1917, and completely after that year for 22 years, all upstream fish passage was blocked at Cazadero Dam on the mainstem Clackamas River until 1939 (Murtagh et al. 1992). The 22 years of complete blockage of upstream fish passage effectively eliminated a large part of the potential food source for bull trout, specifically the large runs of spring Chinook salmon, steelhead, and coho salmon that utilized the upper portion of the subbasin before the early 1900s. Bull trout are a highly migratory, fluvial species in the Willamette River Basin, and were subjected to many of the same suppressing factors as anadromous steelhead and salmon when the dams were built (Buchanan et al. 1997). Early dam construction fragmented habitat and fish populations as they blocked adult migrants from their spawning habitat higher in the subbasin. By the time North Fork Dam was completed in 1958, many of the earlier fish passage problems had been ameliorated. Although fish passage and population connectivity problems still remained, especially for downstream juvenile migrants, naturally reproducing coho salmon and steelhead trout utilized the rebuilt ladders at the dams to build runs in excess of 1,500 fish during the 1950s and 1960s. Although to a lesser extent, spring Chinook salmon also began to re-populate the river above the dams, with runs averaging around 500 fish by the early 1960s (Murtagh et al. 1992).

Water Quality Impacts

In the 1870s, water quality was close to pristine conditions in much of the Clackamas River Subbasin. Much of the subbasin was forested with mature and old growth stands and human population was low and concentrated near the mouth of the Clackamas River. Before settlement, only the occasional large forest fire and rare natural events, such as large floods, volcanic eruptions, and earthquakes, had a negative effect on water quality for bull trout and other salmonids. Water quality changed rapidly in the lower Clackamas in the latter part of the 19^{th} Century, as increasing settlement resulted in land logged for timber and then developed for farming. No regulations inhibited early logging or land clearing. As streambanks and hillsides were stripped of their protective forest cover, instream habitat and water conditions declined. Instream sediment levels increased with the growing area of cleared land. Farmers and others began to divert water out of lower Clackamas River and its tributaries for irrigation and for mill development in the late 1800s. Gravel mining in and adjacent to the lower Clackamas River was also common (Cramer and Associates 2001). By the 1890s, sawdust and other mill byproducts were frequent pollutants in many Oregon streams. Further damage to water quality came from log drives that utilized the Clackamas River and tributaries for moving logs that resulted in scoured stream channels and damaged instream and riparian habitat (Oregon Fish Commission 1889-1890, cited in Taylor 1999).

Although almost no historical records are available, development in the lower portion of the subbasin negatively affected water temperatures in tributaries by the removal of large areas of riparian forest cover along low elevation stream areas. Land clearing; coupled with diversions, irrigation, and subsurface well withdrawals; only exacerbated a decline in water quality for lower elevation Clackamas River tributaries like Clear and Deep creeks. Deteriorating water quality conditions downstream in the lower Willamette River also impacted salmon, steelhead, and other fish including bull trout. By the early 1920s, untreated waste from growing municipalities, pulp and paper mills, and a host of other industries had reached high levels that contaminated the lower Willamette River and Portland Harbor areas. Fisheries authorities were concerned about the pollution impacting migrating salmonids headed for the upper subbasin (Gleeson 1972, cited in Taylor 1999 and Willis et al. 1960).

Hydroelectric dams and reservoirs constructed on the Clackamas River and upstream tributaries may affected water quality. At times, the reservoirs on the Clackamas River produce large algae blooms that sometimes include a noxious blue green algae that would not have concentrated in the historically, free-flowing waters of the river. Reservoirs can also be sinks for nutrients and solar energy. Past, present, and future impacts to Clackamas River fish resources from water quality changes caused by the reservoirs is generally unknown but under investigation by PGE as part of their FERC relicensing procedures.

More than three-quarters of the Clackamas River Subbasin is forested land (Murtagh et al. 1992). The bulk of this forested landscape is in the higher elevations of the middle and upper portions of the subbasin, primarily on National Forest lands with small blocks of Bureau of Land Management land. Substantial amounts of forested land are also held by private industrial forest owners in two tributaries to the Clackamas River; Clear and Eagle creeks. Most of the middle and upper portions of the subbasin were largely untouched by human activities until World War II. At that time and following the war, demand for timber products pushed road construction and timber harvest into many areas previously inaccessible except by trail. Clear-cut logging was the typical method of timber harvest, and removal of streamside vegetation was common (USFS 1994). Loss of streamside shade would have contributed to higher stream temperatures until vegetation could recover. Increased timber harvest led to an expansion of the road system into the middle and upper portions of the subbasin resulting in increased delivery of sediment. Roads generally contribute sediment to streams via road surfaces, cutslopes, and interception of surface and subsurface waters and may destabilize steep slopes depending on road construction methods (USFS and BLM 1995, USFS 1994). The relative impacts of roads, logging, and other human caused disturbances on the land and the effects to water quality can be directly tied to geologic differences in the subbasin.

The two underlying geologies of the Cascades determine how resilient each landscape is to activities such as road building and timber harvesting (Tague and Grant 2004). In watersheds of the Western Cascades, the landscape has undergone the processes of erosion for a longer period than the High Cascades and the rock strata are more deeply weathered, older volcanic rocks. The landscape is generally steep and well dissected by extensive networks of streams that deliver water quickly into the larger streams. Western Cascade streams receive much of their flow via surface and shallow subsurface runoff and generally have higher summer water temperatures. Winter flood runoff in large Willamette River Basin streams (including the Clackamas River) primarily comes from Western Cascade watersheds. High Cascade geology is younger, at higher elevation, less eroded, and usually a much more permeable geology to melting snow and rain. Water is more likely to percolate into this geologic material, rather than flow over it. With water infiltrating into the younger, permeable High Cascade geology, large cold springs fed by deep underground aquifers are common (Duncan 2002). Portions of the subbasin dominated by High Cascades geology (e.g., the upper Clackamas River above the confluence with the Collawash River and most of the Oak Grove Fork) are likely to be less impacted by road building and timber harvesting activities due to greater permeability, lower relief, and lower drainage density. In contrast, portions of the subbasin dominated by Western Cascades geology (i.e., Collawash River, Fish Creek, North Fork Clackamas River, and South Fork Clackamas River) are likely to be more impacted by these same activities. These portions of the subbasin tend to be more sensitive to land management activities.

Road building and logging in the upper portions of the subbasin throughout the 1940s to 1970s impacted fish habitat and populations. Removal of the forest cover to the edge of streams was common throughout the Pacific Northwest during this era (Cederholm et al. 1997, Murtagh et al. 1992). In some cases, tractor logging and skidding occurred directly through small tributaries on harvested blocks of timber in the 1950s and 1960s. Even after tractor logging through small streams was stopped, logging of all timber to the stream’s edge was common into the 1980s, via skyline yarder logging (Sue Helgeson, U. S. Forest Service, personal communication, 2005). Until about 1980, removal of large instream wood was also common and thought to be beneficial to fish for fish passage (USDA 1995, Oregon Chapter AFS 1990). Despite these negative impacts to water quality and riparian habitat, by the 1970s native salmon and steelhead populations were still common and were in some cases slowly recovering, although under mounting pressure with expanding hatchery programs and the ensuing sport and commercial fish harvest. During the 1970s, occasional bull trout were still being reported by anglers (Massey and Keeley 1996, cited in Zimmerman 1999, Nordlund 2005).

Fisheries Management and Sport Harvest

Early fisheries management (before 1940) in the Clackamas River Subbasin consisted largely of trapping salmon and steelhead runs to supply eggs to early hatchery operations, the designation of early sport harvest limits and enforcement, and the stocking of high mountain lakes with fingerling trout. Despite the blockage of all Clackamas River salmon and steelhead runs above Cazadero Dam (Faraday) prior to 1940, trout populations were abundant in these same waters and encounters with bull trout were sparse but not unusual. Jiggs Pederson, an early Forest Service employee who worked on trails and roads in the 1920s and 1930s, recalls anglers fishing for trout and bull trout using everything from red huckleberries to live mice floated on small pieces of wood (Pederson 2003, Carrell 2003). Access to much of the upper portion of the subbasin was limited to a few gravel roads or more commonly, foot trails which limited overall sport angling harvest. Gene McMullen, who fished the upper waters on the Collawash and Clackamas rivers in the late 1940s and early 1950s, recalled with some regret that he and two fellow anglers would come out of the roadless country with weekly limits amounting to 100 trout. This was probably commonplace for the time and era. Gene's understanding was, "that after the road penetrated this country, the fishing steadily declined" (McMullen 1994).

With the advance of the road system into the upper subbasin it was quickly recognized by fisheries authorities that the native trout populations would not meet the demand of a growing human population. It was also recognized that stocking fingerling trout would not provide a good return to the creel in streams. The 1947 annual report of the Oregon Fisheries Division recommended stocking catchable sized rainbow trout based on investigations completed on the Clackamas River (Lockwood 1948). By the 1950s, large numbers of hatchery rainbow trout were being stocked along the roads that paralleled the Clackamas and Collowash rivers. Expanding and sometimes booming human population growth in nearby communities helped fuel demand for fishing. Clackamas County's population grew by 45.7 percent between 1970 and 1980 alone (Oregon Employment Division 1992, cited in USFS 1993). By the 1970s, over 100,000 hatchery catchable trout were being stocked in the Clackamas River and its tributaries on an annual basis (Whitt 1978). The Clackamas River provided one of the largest trout fisheries in Oregon, with more than a quarter million angler days annually, supported by the stocking of tens of thousands of catchable sized, hatchery rainbow trout. This large, hatchery supported fishery also negatively affected steelhead production at the time. A 1988 survey documented nearly 10,000 hatchery and 800 wild steelhead smolts harvested in the fishery along with 1,000 coho smolts (Murtagh et al. 1992). Starting in 1968, an additional hatchery fishery was started in the Clackamas River with the first releases of Skamania/Foster summer steelhead pre-smolts and smolts. These steelhead were particularly popular with anglers because they have a long period of freshwater residency and bite well. This summer steelhead fishery was primarily in the Clackamas River above North Fork Dam, the same areas where bull trout were last reported. By 1979, summer steelhead harvests were averaging over 5,000 fish in the Clackamas River (Murtagh et al. 1992).

Summary and Conclusion

Based on available historical notes and records, the evidence indicates bull trout likely suffered many of the same impacts as did other Clackamas River salmonids (i.e., native spring Chinook salmon). In the 19th Century, spreading settlement with little or no regulations to protect natural resources impacted fish populations, including bull trout. Individual land owners could use the land and water for any purpose with no regulation or restriction. This included fish culture and trapping of Clackamas River salmon runs to collect eggs for hatchery rearing which also impacted salmon, steelhead, and the bull trout found. Since bull trout or "Dolly Varden" as they were known then, were recognized as predators of salmon, fisheries workers probably had a negatively biased view of any bull trout captured with salmon (Adams 1992, Holland 1962, Brown 1992b) and did little to conserve or protect them.

Increasing regulation of commercial and sport fisheries was offset by the construction of mainstem hydroelectric dams and diversions which impeded or blocked upstream and downstream fish passage. Hatchery weirs on fish ladders at the dams also expedited the decline of anadromous salmon runs in the upper portion of the subbasin. These passage barriers also affected migratory bull trout that utilized the lower Clackamas, Willamette, and Columbia rivers. From 1917 to 1939, there was no fish passage and during this period of migratory blockage, bull trout were able to persist in the upper portions of the subbasin without the benefit of a juvenile salmon prey base or access to lower mainstem foraging areas.

Road access into the upper portion of the subbasin was limited at this time, and as early anglers have reported, trout populations were abundant until road access became available. In the 1960s and 1970s, road and highway access expanded which aided in development of a large and popular hatchery trout fishery that may have been the final causative factor that sent the remaining bull trout population into an extinction vortex. The late 1960s stocking and development of a hatchery summer steelhead fishery in the upper subbasin contributed even more angling pressure as hundreds of anglers bait fished every deep hole in the river. Ratliff and Howell (1992) observed that bull trout are aggressive and can be readily caught by lures and bait and thus, are very susceptible to angler pressure. Bull trout can also be more vulnerable in mixed species fisheries because they usually don't sexually mature until they are four to six years old, in contrast to faster maturing species like rainbow trout (Adams 1992). In Oregon's Grand Ronde River Basin, overharvest was considered a limiting factor for bull trout in streams that were being stocked with hatchery, catchable rainbow trout (Buchanan et al. 1997). On the Wenatchee National Forest in Washington, increased fishing pressure was considered a "major contributor" to native bull trout mortality (Brown 1992b). In the Flathead River system in the late 1980s, it was felt that any increase in fishing pressure in any particular area or subbasin could cause a drop in the overall bull trout population in Flathead Lake (Fraley and Shepard 1989). The Metolius River Subbasin in Oregon is considered to be an example where overharvesting of bull trout apparently was one of the major limiting factors for the population. After a catch-and-release fishery was instituted for all trout in the Metolius River in 1983, the bull trout spawning population grew more than ten-fold in nine years (Buchanan et al. 1997). The USFWS documented in 1994, when considering the October 1992 petition to list the bull trout as an endangered species, that overharvest (both legal and illegal) can seriously threaten populations already reduced by other factors (USFWS 1994). Heavy angling pressure and barriers are thought to have caused the ultimate loss of the Clackamas River bull trout population (Don Ratliff, Portland General Electric, personal communication, January 1990).

By the 1980s, angler reports documenting bull trout in the Clackamas River ceased. In the early 1990s as interest and concern for bull trout increased, the first field surveys to locate remnant bull trout began. For over a decade, multiple surveys throughout the subbasin failed to document persistence of a remnant bull trout population. In hindsight, it is ironic that about the time bull trout were finally discerned to be a separate species in 1978, the Clackamas River bull trout was likely extirpated.

Appendix C - Overview of Reintroduction Strategies: Artificial Propagation, Captive Rearing, and Transplantation

Conservation efforts for imperiled fishes in the western United States have included numerous reintroductions (and introductions) utilizing a number of different strategies. The goal has generally been to increase population size and dispersion while maintaining genetic diversity, thus increasing probability of survival (Minckley 1995). Many of these efforts were called for in federal recovery plans as shown in a review by Williams et al. (1988) that indicated a majority (32 of 39) of recovery plans for threatened and endangered fishes in the United States called for one or more forms of introductions.

A decision to move forward with a reintroduction will require the development of an implementation plan, consistent with, and building from, this feasibility assessment. An implementation plan would provide a greater level of detail on the strategy and logistics of implementing the reintroduction than the level of analysis and investigation in this feasibility assessment. However, the CRBTWG believes it is appropriate to provide a brief summary of potential reintroduction strategies herein, as well as a brief review of known information on the propagation of bull trout and bull trout reintroductions that have occurred in Oregon.

The three strategies that would be considered as a precursor to developing a reintroduction proposal include:

1. **Artificial Propagation**, in which wild donor stock are moved into a hatchery environment for development of a captive broodstock program with resulting progeny released into the wild.

2. **Captive Rearing**, in which fertilized eggs, fry or juveniles are taken into a hatchery environment for short-term holding before translocation into the wild.

3. **Transplantation**, in which wild fish (fertilized eggs, fry, juveniles, sub-adults or adults) are taken from the wild and transported directly into the receiving habitat.

A reintroduction program may conceivably utilize more than one strategy, and any strategy that involves the transfer of fish from one basin to another would need to meet applicable State, Federal, and Tribal fish handling and disease policies. Also, inherent with any of the strategies outlined above is the need to address: 1) risk to the donor population; 2) life stage to introduce; 3) number to introduce to fully reflect the genetic composition and survival capabilities of donor stock; and 4) how long to conduct the transfer (i.e., over how many years or generations).

Artificial Propagation

Section 3(3) of the ESA lists artificial propagation as a method that may be used for the conservation of listed species. Hatcheries have been used in recovery efforts of other listed fish species (Rinne et al. 1986). The draft bull trout recovery plan (USFWS 2002) recognized that certain recovery units may require the use of artificial propagation techniques in order to meet recovery criteria. Artificial propagation could involve the use of Federal, State, or Tribal hatcheries to assist in recovery efforts (Buchanan et al. 1997; USFWS 1998a).

Any artificial propagation program instituted for bull trout would need to follow the joint policy of the USFWS and NMFS regarding controlled propagation of listed species (65 FR 56916). Defined in the context of the policy, controlled propagation refers to the production of individuals, generally within a managed environment, for the purpose of supplementing or augmenting a wild population(s), or reintroduction into the wild to establish new populations.

The overall guidance of this policy is that every effort should be made to recover a species in the wild before implementing an artificial propagation program. Because recovery for bull trout entails the identification and correction of threats affecting bull trout, artificial propagation programs should not be implemented until the reasons for decline have been addressed. The reasons for decline of bull trout in the Clackamas River Subbasin and the cessation of those threats are addressed in Chapter 1 of this assessment. The intent of the policy is to provide guidance and establish consistency for use of controlled propagation as a component of a listed species recovery strategy. The policy will help to ensure smooth transitions between various phases of conservation efforts such as propagation, reintroduction and monitoring, and foster efficient use of available funds. The policy's list of appropriate uses of artificial propagation includes supporting recovery related research, maintaining refugia populations, providing plants or animals for reintroduction or augmentation of existing populations, and conserving species or populations at risk of imminent extinction or extirpation.

The Montana Bull Trout Scientific Group (MBTSG 1996g) evaluated seven strategies for the potential use of artificial propagation in the recovery of bull trout. The report evaluated the use of hatcheries in establishing genetic reserves, restoration stocking, research activities, supplementation programs, introductions to expand distribution, and the establishment of "put, grow, and take" fisheries. The report concluded that the potential use of hatcheries in bull trout recovery should be limited to the establishment of genetic reserves for declining populations, restoration stocking (reestablishment of a self-sustaining bull trout populations in habitat where they have been extirpated), and some research activities including the evaluation of hybridization. The report concluded the use of hatcheries for bull trout supplementation programs, "put, grow, and take" stocking, and introductions outside historic range are not appropriate.

History of Bull Trout Propagation

Bull trout are probably the most geographically widespread char native to North America that has not been extensively cultured in hatcheries (MBTSG 1996). As a result, little information exists on bull trout propagation, especially in regards to stocking individuals in the wild. The most extensive information available originates from propagation efforts beginning in 1993 by Creston National Fish Hatchery in Montana. In addition to successfully propagating bull trout, experiments were undertaken to evaluate the effects of water temperature, diet, structure, cover, and rearing density on growth and behavior and to evaluate time of imprinting by juvenile bull trout via thyroid hormone analysis (Fredenberg et al. 1995). Due to various concerns, no progeny from these experiments have been stocked into the wild.

Other experiments in bull trout cultivation occurred by Montana Fish, Wildlife and Parks in the 1940s and 1950s within the Clark Fork and Kootenai River drainages. One effort in 1949 and 1950 involved the collection of 876,000 eggs from bull trout in the Clark Fork River drainage. Subsequently, during 1950 to 1952, about 10,000 of these fish were planted into Lake Pend Oreille and about 65,000 into Flathead Lake (Pratt and Huston 1993).

More recently, several experiments in bull trout cultivation occurred in Idaho and Canada. From 1989 to1991, Idaho Fish and Game conducted a small experimental hatchery program at Cabinet Gorge Hatchery to investigate techniques for egg taking, egg incubation and hatchery rearing (Pratt and Huston 1993). Canada's Kootenay Trout Hatchery in British Columbia conducted experimental work with bull trout in the early 1980s and that work continued at Hill Creek Hatchery in the headwaters of the Columbia River drainage as part of a mitigation program for loss of bull trout spawning habitat due to dam construction. Wild bull trout adults are captured annually, spawned, and then returned to the wild. Resulting juveniles are planted in tributaries as four-inch fingerlings in the fall. Post stocking evaluation of the program has been inadequate to assess its outcome, however, the program is continuing (MBTSG 1996).

History of Bull Trout Reintroductions in Oregon

In Oregon, several attempts have been made to propagate or translocate bull trout. In 1989, over 60 resident adult bull trout from the Sprague River in the Upper Klamath Basin were captured and spawned in the Klamath Hatchery for a reintroduction effort in the McCloud River, California. Pre-spawning mortality, combined with egg and juvenile mortality, ultimately resulted in only 270 juvenile bull trout available for stocking into the wild during the spring of 1990. After five years of monitoring in the McCloud River, the reintroduction was determined a failure and terminated (Buchanan et al. 1997). A contributing factor to this unsuccessful effort may have been the resurgence of brook trout overlapping in distribution with the introduced bull trout even though a previous rotenone treatment program was attempted to eradicate brook trout.

In Northeast Oregon, bull trout were thought to be extirpated from the watershed above Wallowa Lake by the 1950s (Buchanan et al. 1997). A reintroduction program using translocated bull trout and/or Dolly Varden from Alaska began in 1968 and ran through 1978 before being terminated. The program was determined to be unsuccessful after no bull trout or Dolly Varden were detected in creel surveys at Wallowa Lake from 1980 to 1996 (Buchanan et al. 1997). In 1997, 600 bull trout (age-1 to 15 inches) were taken from Big Sheep Creek (tributary of the Imnaha River) during a canal salvage, and translocated to Wallowa Lake. No funds were available to monitor this effort and the status of the translocated fish is generally unknown (Brad Smith, Oregon Department of Fish and Wildlife, personal communication, August 2006). Though no official creel surveys have been conducted in recent years, sporadic catches of bull trout are reported, and individual bull trout have been occasionally observed in the Wallowa River above Wallowa Lake. Limiting factors in this reintroduction may include limited spawning habitat, redd superimposition by kokanee, and the presence of lake trout, a known predator and competitor with bull trout (Brad Smith, Oregon Department of Fish and Wildlife, personal communication, August 2006).

In the Middle Fork Willamette River, a transplantation program has been implemented since 1997, as discussed earlier in this assessment. Bull trout were thought to be extirpated or in extremely low abundance at the time the program was initiated. Since 1998, over 10,000 fry have been captured from Anderson Creek in the McKenzie River (also a Willamette River tributary) and transported directly to multiple release sites in the Middle Fork Willamette River above Hills Creek Reservoir. Over time, annual monitoring has provided evidence of survival, and in 2005 spawning was documented for the first time from 11 adults. Successful recruitment was subsequently documented during the summer of 2006. Ultimately the success of this project will hinge on the ability of this population to rebound to a self-sustaining level.

Despite information and knowledge gained from the projects described above, there is still an obvious need to determine the effectiveness and feasibility of using artificial propagation for bull trout recovery. To that end, the draft bull trout recovery plan recommended a study be initiated to determine the effectiveness and feasibility of using artificial propagation in bull trout recovery (USFWS 2002). Specific goals and objectives for the use of hatcheries in the recovery and conservation of bull trout should be identified. Information gained from such a study would help guide proposed artificial propagation programs identified in individual recovery units.

The following briefly summarizes general advantages and disadvantages of the three reintroduction strategies when weighed against each other:

Artificial Propagation:

Advantages: 1) ability to potentially stock a large number of individuals thereby increasing the probability of a successful reintroduction; and 2) reduced risk to the donor population due to a reduced number of individuals needing to be removed.

Disadvantages: 1) high cost relative to other reintroduction strategies; 2) potential loss of genetic variability and ecological diversity; and 3) possible increase in the frequency of deleterious recessive alleles.

Captive Rearing:

Advantages: 1) better survival of wild eggs, fry and juveniles in a hatchery environment as compared to in the wild may result in greater numbers available for a reintroduction, and may reduce the number of individuals removed from the donor stock; 2) older age and larger size of captive reared individuals would result in better survival rates when stocked into the wild, relative to individuals translocated directly to the receiving habitat from the wild; 3) captive rearing may allow individuals to attain a size prior to release that would allow for implantation of PIT tags, greatly facilitating future monitoring of survival, growth, movement, distribution and other parameters; 4) captive rearing prior to release into the wild may facilitate disease testing.

Disadvantages: 1) moderate cost relative to other reintroduction strategies (i.e., lower cost relative to artificial propagation, but higher cost than direct transplantation); 2) higher potential for disease transmission relative to direct transplantation; 3) potential catastrophic loss of valuable wild individuals from hatchery malfunction (e.g., temperature, dissolved oxygen, disease); and 4) possible increase in the frequency of deleterious recessive alleles.

Transplantation:

Advantages: 1) lowest relative cost when compared to other reintroduction strategies; 2) assuming appropriate numbers of individuals transferred, least potential for loss of genetic variability and ecological diversity

Disadvantages: 1) highest risk to the donor population relative to the other reintroduction strategies due to the number of individuals needed to start a new population. Assuming a transplantation of eggs and/or fry, naturally high mortality suggests numbers of individuals transplanted may need to be high.

Appendix D – Genetic Conservation Considerations (excerpt taken from Whitesel et al. 2004)

Measures of genetic diversity within and between populations are principal attributes by which to infer population (breeding) structure. Genetic data can provide an indication of the extent of reproductive isolation among groups. Molecular genetic markers such as allozymes and nuclear or mitochondrial DNA can be used to statistically describe a species population structure based on measures of genetic similarity between groups. Although inference about population structure from data on genetic characters requires various assumptions, there is a growing body of literature from genetic studies of bull trout that allows for general conclusions to be made. Most research, using allozymes, mitochondrial DNA, and microsatellite DNA has found that bull trout exhibit relatively low levels of intrapopulation variation, but high levels of interpopulation variation (Costello et al. 2003; Kanda and Allendorf 2001; Neraas and Spruell 2001; Spruell et al. 1999; Taylor et al. 1999; Whiteley et al. 2003; Williams et al. 1995). Even in the case where bull trout populations are connected by suitable habitat, reproductive isolation appears to occur between adjacent drainages (Kanda and Allendorf 2001) and within the same tributary (Spruell et al. 1999).

In a study across a broad geographic range using mitochondrial DNA, Taylor et al. (1999) found that significant variation did exist within individual sample sites, but that most of the molecular variation resides at the inter-population and inter-region levels, with greater variation between regions considered at greater scales. Spruell et al. (2003) collected and examined data on four microsatellite loci from 65 bull trout populations in the northwest United States. Their findings concurred with previous work that bull trout have relatively low levels of genetic variation within populations compared to other salmonids. They found that population-specific levels of heterozygosity varied substantially among the different regions, perhaps reflecting historic isolation due to geography. Systems with large natural lakes were found to have above average heterozygosities. Spruell et al. (2003) also caution that genetic drift and low levels of variation appear to have influenced the relationships inferred from their data.

The degree of population differentiation in bull trout tends to be higher than among other salmonids. A commonly used indicator of degree of population subdivision is Wright's fixation index (F_{st}), which characterizes the reduction in heterozygosity of a subpopulation due to genetic drift (Hartl 1988), and can be used as an indicator of relative levels of gene flow in different species. It provides a measure of the proportion of genetic variation that lies between subpopulations within the total population. Values of F_{st} can range between 0 and 1, with higher values indicating greater genetic difference between populations. The mechanisms influencing genetic variation among and within populations include historical processes of glacial refugia, colonization and gene flow, natal stream fidelity, life history form, natural and anthropogenic barriers, patch occupancy, habitat complexity, spatial connectivity, and effective population size (Costello et al. 2003; McPhail and Baxter 1996; Neraas and Spruell 2001; Rieman and Allendorf 2001; Spruell et al. 2003; Spruell et al. 1999).

The genetic variation between and within bull trout populations represents their evolutionary potential (Laikre 1999). Their evolutionary lineages provide the basic genetic template for that to occur. Laikre (1999) concurs with the majority of authors who suggest that conservation efforts should focus on evolutionary lineages within the species. Doing so will preserve the genetic legacy from which bull trout evolved. When available, genetic data for bull trout is critical in trying to discern population structure and identify evolutionary lineages, however it is not necessarily sufficient.

Allendorf and Leary (1986) show that the evolutionary potential of any species depends upon the amount of genetic variation it contains. Once genetic variation is lost, it must be replaced by the slow process of genetic mutation, which can take many generations. Genetic variation needs to be preserved in order to increase the likelihood of a species survival. Genetic variation is the raw material from which populations adapt to changing environments and is critical to evolutionary change (Meffe and Carroll 1997). The concept that connects evolutionary potential to genetic variation was first formulated by Fisher (1930) in his ‘fundamental theorem of natural selection.’ Fisher (1949) rephrased this theorem as: ‘The rate of increase in average fitness of a population is equal to the genetic variance of fitness of that population.’ Loss of genetic variation may occur at low population levels through genetic drift and inbreeding depression (Fisher 1949). Wang et al. (2002) found that inbreeding in salmonids is often associated with a reduction in mean phenotypic value of one or more traits with respect to fitness. They believe that although experimental studies detected inbreeding depression in salmonids, its genetic basis has rarely been addressed or demonstrated in the wild (Wang et al. 2002).

Nevertheless, Wang et al. (2002) feel this reinforces the importance of maintaining genetic variation within populations as a primary goal of conservation and management. Loss of genetic variation can have deleterious effects on the development, growth, fertility, and disease resistance of fishes, among other processes important to survival and reproduction (Danzmann et al. 1985; Kincaid 1983; Kripichinikov 1981; Leary et al. 1985; Leary and Booke 1990). This loss of variation may also negatively affect fitness and preclude adaptive change in populations (Frankham 1995).

Deciding what needs to be conserved in order for a species to perpetuate is the basic issue for any conservation activity. Recognizing that there can be considerable biological diversity within a species, an approach that focuses on just conserving species is not enough. The evolutionary potential, represented by the genetic variability within and between populations of a species must also be conserved in order for the species to evolve in response to short-term and long-term environmental changes (Frankel and Soulé 1981). This is particularly important for a species like bull trout where distinct genetic differences have been observed between populations and where within population variation is low (Neraas and Spruell 2001; Spruell et al. 2003; Spruell et al. 1999; Taylor et al. 1999).

Since the 1998 ESA listing, DNA analyses have suggested that bull trout may be organized on a finer scale than previously thought. In the past 10 years a tremendous volume of genetic information about bull trout has been developed. Much of what is known about the evolutionary process and bull trout genetics has been developed in the last few years. Mitochondrial DNA data has revealed genetic differences between coastal populations of bull trout, including the lower Columbia and Fraser rivers, and inland populations in the upper Columbia and Fraser river drainages, east of the Cascade and Coast (Taylor et al. 1999; Williams et al. 1995). Nuclear DNA allele frequencies at microsatellite loci have revealed an apparent genetic differentiation between inland populations within the Columbia

River Basin. This differentiation occurs between (a) mid-Columbia (John Day, Umatilla, Walla Walla), lower Snake River (Clearwater, Grande Ronde, Imnaha rivers, etc) populations and (b) upper Columbia (Methow, Clark Fork, Flathead River, etc.), upper Snake River (Boise River, Malheur River, Jarbidge River, etc.) populations (Spruell et al. 2003). Allozyme, mtDNA, and nDNA data indicate bull trout inhabiting the Deschutes River drainage of Oregon are derived evolutionarily from coastal populations and not from inland populations in the Columbia River Basin (Leary et al. 1993; Spruell and Allendorf 1997; Taylor et al. 1999; Williams et al. 1995).

Although there are multiple resources that contribute to the subject, Spruell et al. (2003) best summarized genetic information on bull trout population structure. Spruell et al. (2003) analyzed 1,847 bull trout from 65 sampling locations, four located in three coastal drainages (Klamath, Queets, and Skagit Rivers), one in the Saskatchewan River drainage (Belly River), and 60 scattered throughout the Columbia River Basin. They concluded that there is a consistent pattern among genetic studies of bull trout, regardless of whether examining allozymes, mitochondrial DNA, or most recently microsatellite loci. Typically, the genetic pattern shows relatively little genetic variation within populations, but substantial divergence between populations. Microsatellite loci analysis supports the existence of at least three major genetically differentiated groups (or lineages) of bull trout (Spruell et al. 2003). They are characterized as:

- “Coastal,” including the Deschutes River and all of the Columbia River drainage downstream, as well as most coastal streams in Washington, Oregon, and British Columbia. A compelling case also exists that the Klamath River Basin represents a unique evolutionary lineage within the coastal group.

- “Snake River,” which includes the John Day, Umatilla, and Walla Walla rivers. Despite close proximity of the John Day and Deschutes rivers, a striking level of divergence between bull trout in these two systems was observed.

- “Upper Columbia River,” which includes the entire basin in Montana and northern Idaho. A tentative assignment was made by Spruell et al. (2003) of the Saskatchewan River drainage populations (east of the continental divide), grouping them with the Upper Columbia River group.

Spruell et al. (2003) noted that within the major assemblages, populations were further subdivided, primarily at the level of major river basins. Taylor et al. (1999) surveyed bull trout populations, primarily from Canada, and found a major divergence between inland and coastal populations. Costello et al. (2003) suggested the patterns reflect the existence of two glacial refugia, consistent with the conclusions of Spruell et al. (2003) and the biogeographic analysis of Haas and McPhail (2001). Both Taylor et al. (1999) and Spruell et al. (2003) concluded that the Deschutes River represented the most upstream limit of the Coastal lineage in the Columbia River Basin.

A number of different definitions and parameters have been used to describe populations and their size. From a theoretical perspective, an ideal population is a discrete population in which all adults mate randomly and reproduce at the same age, once in their life (Frankham 1995). Ideal populations also have an equal sex ratio and all individuals have an equal probability of contributing offspring to subsequent generations (Frankham 1995). Few, if any, natural populations conform to these ideal conditions. Thus, within a population, the census number of sexually mature individuals per generation (N) is not necessarily a measure of how many individuals reproduce effectively, and thus, the amount of genetic variation transmitted between parental and progeny generations (Allendorf and Ryman 1987). The effective population size (N_e) has been defined as the size of the ideal population that will result in the same amount of genetic drift as in the actual population being considered (Wright 1969) or as the number of individuals per generation that actually spawn and produce offspring in the next generation (Crow and Kimura 1970; Lynch 1990). The effective breeding population size (N_b) has been defined as the number of individuals per year that actually spawn and contribute offspring the next generation assuming the number of progeny per spawner follows a Poisson probability distribution (Waples 1990). For semelparous species, N_e can be estimated by multiplying N_b and generation length (g), or the average age of spawners (Waples 1990). Although the relationship is complicated by multiple spawning events, N_e for iteroparous species can also be approximated by the mean number of first time spawners multiplied by generation length (Hill 1972).

The likelihood that a population will persist (or go extinct) over time depends on both its demographic size and genetic effective size. The ability of a population to persist is, in part, a function of stochastic events as well as demographic and genetic risks. The impacts to a population of stochastic events are difficult to predict. For demographic risks to be minimized, it has been shown that the variance in population abundance over a time period covering two or more generations needs to be less than the mean abundance during that period. In general, however, unless population sizes are very small, demographic risks can be difficult to quantify. Alternatively, various size thresholds have been identified that are associated with the genetic risk to populations. Theoretical models of genetic characteristics have suggested that the effective size (N_e) of a population (or group of populations) needed to minimize genetic risk typically range from 50 (to prevent inbreeding depression in closed populations) to 5,000 (for entire species to have sufficient genetic variation to respond to changing, or stochastically variable, environmental conditions) (Allendorf et al. 1997; Lande 1995; Thompson 1991).

Genetic variation is the raw material that allows organisms to adapt evolutionarily to changing environments. Significant reductions and fragmentation of habitat and associated reductions in population sizes have the potential to rapidly change the genetic composition of populations due to both random genetic drift in isolates and altered selection regimes. The amount of genetic variation in a population is a balance between (a) losses due to random genetic drift and directed natural selection and (b) gains due to mutation and migration from other populations (Wright 1931). Loss of genetic variation can influence the dynamics and persistence of populations through three mechanisms: inbreeding depression, loss of phenotypic variation, and loss of evolutionary potential (Allendorf and Ryman 2002). The loss of genetic variation in a population is directly influenced by N_e (Ryman et al. 1995).

Effective population size is a parameter that incorporates relevant demographic information and influences the evolutionary consequences of members in a population (Wright 1931). When prioritizing populations for conservation, N_e is an important parameter. In a population that is finite but otherwise randomly mating, the rate of loss of genetic variation and the rate of increase in inbreeding is inversely related to N_e (Waples 2002). Within a population, N and N_e are the same when the following conditions are met: constant and large population size, variance in reproductive success is binomial (number of progeny per parent follows a Poisson distribution), and sex ratio is equal. Because most populations do not conform to these conditions, the N_e to N ratio is usually below 1.0 (Frankham 1995). For example, in a population that has 20 mature females and 30 mature males (i.e., differing sex ratios), N=50. Based on the formula $N_e = 4\ N_m\ N_f\ /\ N_m + N_f$ (where N_m = the number of males and N_f = the number of females) random mating among these individual would yield $N_e = 48$. In this case the N_e to N ratio would be 0.96 (48/50). The N_e to N ratio for most bull trout populations is thought to be between 0.15 and 0.27 (Rieman and Allendorf 2001).

Effective sizes of more than 50 have been considered a minimum requirement to ensure the short-term persistence of a local population (Allendorf and Ryman 2002). Effective population sizes smaller than 50 are subject to the effects of inbreeding (Franklin 1980). Over very few generations, inbreeding can reduce the amount of potentially adaptive genetic variation within local populations (Lande 1995). Increased homozygosity of deleterious recessive alleles is thought to be the main mechanism by which inbreeding depression decreases the fitness of individuals within local populations and viability of these populations (Allendorf and Ryman 2002). Deleterious recessive alleles are introduced into the genome via random mutations, and natural selection is slow to purge them because they are usually found in the heterozygous form where they are often not detrimental. When local populations become small, heterozygosity decreases at the rate of $0.5N_e$ per generation which in turn causes an increase in the frequency of homozygosity of all alleles, including those that are deleterious recessive (Lande 1995). Hedrick and Kalinowski (2000) provide a review of studies demonstrating inbreeding depression in wild populations (also see Wang et al. 2002).

By preventing significant loss of genetic variation from genetic drift, effective population sizes of 500 have been considered a minimum requirement to ensure the long-term persistence of local populations or metapopulations (Allendorf and Ryman 2002). Over ecological time scales, or centuries, effective populations larger than 500 may be necessary to avoid the risks from random genetic drift (Franklin 1980; Soulé 1980). In effective populations smaller than 500, the loss of genetic variation from drift is likely to exceed the increase in genetic variation from mutation (Lande 1995). When the lost genetic variation is associated with heritable traits (such as age at maturity), a population can also lose genetic variation for quantitative traits. Although phenotypic differences may have little effect on individual fitness, the loss of life-history variability among individuals may reduce the likelihood of a population being viable (Allendorf and Ryman 2002). Maintaining an effective population size large enough to prevent the erosion of quantitative traits may require gene flow from neighboring populations or within a metapopulation (Allendorf and Ryman 2002).

To be able to adapt over evolutionary time periods, N_e greater than 5,000 has been recommended for entire species or discrete groups that share an evolutionary legacy within a species (Lande 1995). When the persistence of a species, taxon, or phylogenetic lineage is of concern, it is important to consider the amount of genetic variation necessary to uphold the evolutionary potential that is needed for that taxon to adapt to a changing environment. A large amount of genetic variation may be selectively neutral under present environmental conditions (i.e., during the time when new mutations underlying that genetic variation arose). However, some of this variation may be at a selective advantage when environmental conditions change and a species must adapt to those changes or potentially face extinction. Thus, for retention of evolutionary potential, an N_e greater than 5,000 or (following from (Rieman and Allendorf 2001)) N greater than 10,000 (5,000/0.5) would apply to the largest grouping of fish that share an evolutionary trajectory (Franklin and Frankham 1998; Lynch and Lande 1998). Populations of this size are able to retain additive genetic variation for fitness-related traits gained via neutral-mutations at the time of their origin (Franklin 1980).

Population structure is often complicated and dynamic. Isolated local populations function autonomously, demographically independent of other local populations. Local populations that are not isolated may exchange genetic material on a regular basis and be structured as part of a larger metapopulation. In addition, relatively large groups of local populations or groups of metapopulations that share an evolutionary trajectory may be structured as evolutionary (or conservation) units. Effective population size is associated with the population unit being considered and has both a temporal and spatial element (Allendorf and Ryman 2002; Waples 2002). When N_e less than 50 for an isolated population, inbreeding depression may be expected to occur over relatively few generations (e.g., 2-5 generations). When N_e less than 500 for an isolated population or single metapopulation, loss of genetic variation due to genetic drift may be expected to occur over tens of generations. When N_e less than 5,000 for an entire species or evolutionary lineage within which some gene flow occurs, loss of evolutionary potential may be expected to occur over hundreds of generations.

Bull trout specific benchmarks have been developed concerning the minimum N_e necessary to maintain genetic variation important for short-term fitness and long-term evolutionary potential. These benchmarks are based on the results of a generalized, age structured, simulation model, VORTEX (Miller and Lacy 1999), used to relate N_e to the number of adult bull trout spawning annually under a range of life histories and environmental conditions (Rieman and Allendorf 2001). In this study, the authors estimated N_e for bull trout to be between 0.5 and 1.0 times the mean number of adults spawning annually. Rieman and Allendorf (2001) concluded that an average of 100 (i.e., 50/0.5 = 100) adults spawning each year would be required to minimize risks of inbreeding in a population and that 1,000 adults (i.e., 500/0.5 = 1,000) are necessary to prevent loss of genetic variation due to genetic drift. This later value of 1,000 spawners may also be reached with a collection of local populations among which gene flow occurs.

The combination of resident forms completing their entire life cycle within a stream and the homing behavior of the migratory forms returning to the streams where they hatched to spawn can promote reproductive isolation among local bull trout populations. This reproductive isolation creates the opportunity for genetic differentiation and local adaptations to occur. However, migratory behavior and straying from natal streams also provide a mechanism to maintain genetic continuity among breeding units (local populations) located in different streams or tributaries. This type of connection of local populations, linked by migration, is termed a metapopulation (Hanski and Gilpin 1997). Where local populations cannot support the minimum N_e necessary to maintain genetic variation important for long-term evolutionary potential, managers should attempt to conserve a metapopulation that is at least large enough to meet the minimum of 1,000 annual spawners.

Guidelines on effective population size appear to apply reasonably well to bull trout (Rieman and Allendorf 2001). The recommendation that N_e exceed 50 to avoid inbreeding depression appears to be most closely related to the short-term genetic viability of local bull trout populations. The recommendation that N_e exceed 500 to avoid the loss of genetic and phenotypic variation through drift appears to be most closely related to the long-term persistence of groups of local populations among which gene flow occurs to form a metapopulation of bull trout. Since few local populations may support a N_e greater than 500 (Rieman and Allendorf 2001), effective populations of this size may often require the possibility of gene flow between local populations. It also appears reasonable that effective population sizes that exceed 5,000 may be required to ensure the evolutionary persistence of bull trout conservation units.

The risk of extinction for a population is clearly related to its size and its variance in abundance relative to its mean size over time. More specifically, theoretical evidence suggests that inbreeding and genetic drift are likely to occur in populations when N_e less than 50 and 500, respectively. When detailed information is lacking for bull trout populations, these guidelines would be the most useful tool for managers to apply for avoiding loss of genetic variation and trying to ensure population persistence. These numbers represent relatively straightforward and defensible, theoretical minimums. While theoretical N_e can reflect the minimum number necessary to alleviate certain genetic risks, it does not necessarily reflect the most appropriate population size. Detailed information for a population may allow the justification of effective population sizes larger or smaller than 50 or 500. If possible, when estimating the population size necessary for persistence, managers should consider, for example, demographic risks and selective pressures as well as stochastic and historical events in addition to genetic risks.

It is clear that a sufficient N_e is a necessary consideration for conserving bull trout populations. Except for well-documented exceptions, the 50, 500, and 5,000 values should be considered necessary minimums and viewed as generalizations. For any given population the specific N_e necessary for conservation purposes will depend on characteristics of the population such as the ratio of $N:N_e$, the dominant life history form present, and the frequency of spawning.

Appendix E - Population Characteristics of Potential Donor Stocks

Recent studies of evolutionary lineages of bull trout suggest three major groupings: Coastal, Upper Columbia River, and Snake River (Spruell et al. 2003, Leary et al. 1993, Haas and McPhail 2001, Taylor et al. 1999, and Williams et al. 1997). Bull trout population genetic analyses further suggest bull trout inhabiting tributaries of the Lower Columbia River, including and downstream of the Deschutes River, are more closely related to the Coastal group than to populations in the Upper Columbia River tributaries (Spruell et al. 2001).

Chapter 3 of this assessment summarizes current knowledge of bull trout population genetic information for western North America with a focus on the Coastal evolutionary lineage and in particular bull trout populations in the Lower Columbia River. The CRBTWG limited its assessment of donor populations to the tributaries of the Lower Columbia River based on factors such as evolutionary history, geographic proximity, life history, and potential gene flow through migration. This appendix provides an overview of the status and life history of potential bull trout donor stocks from the Lower Columbia River, including populations from the Willamette, Lewis, Hood, and Deschutes river basins.

Bull Trout in the McKenzie River Subbasin (Willamette River Basin)

Bull trout were historically widespread in multiple tributaries of the Willamette River but are now limited to less than 300 adults in the McKenzie River. A translocation program to move bull trout fry from the McKenzie River to the Middle Fork Willamette River began in 1997. The program has occurred annually to augment the small, or perhaps extirpated, local population of bull trout last documented in the 1980s above Hills Creek Dam. Bull trout spawning has now been documented in the Middle Fork Willamette River in 2005, and 2006.

The bull trout population in the McKenzie River Subbasin was likely a single fluvial population prior to the construction of flood control and hydropower dams in the 1960s. Cougar Dam on the South Fork McKenzie River and Trail Bridge Dam on the upper mainstem McKenzie River effectively isolated bull trout above these dams, resulting in two adfluvial local populations that continue to exist today despite each numbering less than 100 spawning adults. The remaining mainstem, local population in the McKenzie River below these dams is the most viable of the three local populations, although abundance is depressed. The very low numbers, combined with isolation make these local populations highly vulnerable to extirpation and genetic depression. Bull trout in the McKenzie River Subbasin have been monitored since the mid-1990s.

Mainstem McKenzie River Local Population

The majority of spawning for the Mainstem McKenzie River local population occurs in Anderson Creek in approximately 3.8 kilometers (2.4 miles) of stream and to a lesser extent in Olallie Creek. Spawning by individuals from this local population has not been documented in other tributaries. Access to approximately 3.2 kilometers (2.0 miles) of spawning and rearing habitat in Olallie Creek upstream of Highway 126 was restored in 1995, when an additional culvert was installed to provide fish passage. Based on redd counts from 1995 through 1999, spawning in Anderson and Olallie creeks peaks during the third week of September (Taylor and Reasoner 2000).

Annual redd counts in the two spawning streams suggest an adult spawning abundance of approximately 130 bull trout. Most fry and juveniles rear in these two spawning streams or in the first eight miles of the McKenzie River below the confluence of the two spawning streams. Adults over-winter and forage in the mid to lower sections of the McKenzie River, some migrating as far as the McKenzie River's confluence with the Willamette River.

The ODFW and USFS have estimated juvenile bull trout abundance in Anderson Creek from data collected annually over the last decade by a downstream migrant fish trap (Table E1). The trap is located just below Highway 126, and thus the estimates exclude bull trout fry and juveniles that may result from spawning in the reach downstream from Highway 126.

Table E1. Number of Bull Trout Fry and Juveniles Captured in the Downstream Migrant Trap in Anderson Creek, 1994 through 2006, Julian weeks 6 through 22.

	Number of fry age 1 or less		Number equal to or greater than age 1	
Date	**Captured**	**Estimated [1]**	**Captured**	**Estimated[1]**
1994	1,745	5,827	183	753
1995	1,849	6,097	255	773
1996	1,995	5,700	178	475
1997	7,260	21,607	63	205
1998	7,869	23,053	124	417
1999	7,406	21,698	81	255
2000	6,127	17,750	152	455
2001[2]	3,247	9,853	82	238
2002	508	1,453	131	397
2003	3,142	8,460	167	500
2004	1,591	4,655	177	552
2005	281	1,642	107	628
2006	837	4,907	93	533

1 Estimated number of bull trout captured if the trap ran continuously and captured fish at a 60 percent rate of efficiency.
2 2001 was not a complete sample year for age 1+ bull trout due to trap repairs.

The trap is generally operated four days a week, from early February until the first week in June. In the decade since monitoring began, juvenile abundance peaked during the years 1997 through 2000, and dropped to the lowest count on record in 2002 (Table E1).

In 1999, densities of juvenile bull trout were estimated in 2.6 kilometers (1.62 miles) of Anderson Creek using a modified Hankin and Reeves protocol (Hankin and Reeves 1988). An average of 1.8 juvenile (age 1 year or more) bull trout per unit were observed in 60 habitat units sampled. Pocket units had the highest observed densities (9.7 per 100 m^2), while the lowest densities were observed in fast-water units (0.8 per 100 m^2) (Taylor and Reasoner 2000).

South Fork McKenzie Local Population above Cougar Dam

The local population of bull trout in the South Fork McKenzie River occurs upstream of Cougar Dam to approximately the Three Sisters Wilderness boundary and also the lower portions of French Pete Creek and Roaring River – a total of 29.3 kilometers (18.2 miles) of stream habitat. Spawning and juvenile rearing occurs in approximately five kilometers (three miles) of Roaring River, a large, spring-fed tributary of the South Fork McKenzie River (Ziller and Taylor 2000). Additional juvenile rearing has been documented in the South Fork McKenzie River downstream from the Roaring River confluence (ODFW 2003).

Intensive monitoring of the South Fork McKenzie River local population by ODFW, in association with the U.S. Army Corps of Engineers (USACE) Cougar Dam Water Temperature Control Project, began in 2001. Monitoring of this local population is being conducted by use of radio-telemetry and passive integrated transponder (PIT) tags, use of video and electronic fish counters, redd counts, snorkeling, and sampling by use of minnow traps and downstream migrant fish traps. Data collected to date, in conjunction with information from previous studies of bull trout in the South Fork McKenzie River, indicate Cougar Reservoir is utilized by adult and sub-adult bull trout for foraging from late fall through early spring. Adult and sub-adult bull trout move into the South Fork McKenzie River upstream from Cougar Reservoir in April and May, remaining in the South Fork until migrating into Roaring River to spawn in late-August through early-October (ODFW 2003).

Monitoring the timing and numbers of adult bull trout ascending and descending Roaring River has been accomplished by use of a remote passive integrated transponder tag antenna, radio telemetry, an electronic fish counter, redd counts, and in 2004, a video camera. Fry and juvenile out-migrations are monitored using a downstream migrant fish trap. Together these methods have provided an abundance of information not available for the other two local populations in the McKenzie River Subbasin.

In 2001 and 2002, a downstream migrant trap was operated in Roaring River about 550 feet above its confluence with the South Fork McKenzie River. Peak out-migration of bull trout fry occurred in March and April, and peak out-migration of age 1 and older juvenile bull trout occurred from May through July (ODFW 2003).

The number of redds counted in Roaring River steadily increased from 1998 to 2001, peaking at 34 in 2001. In 2002, total redd counts dipped to 25, but then climbed to 27 in 2003, and 32 in 2004, and 35 in 2005 (USFS 2004). The electronic fish counter utilized in Roaring River in 2003 and 2004, combined with PIT tag monitoring, and trapping of downstream migrating, post-spawning bull trout, has allowed for precise estimations of spawner abundance in the South Fork McKenzie River local population. The number of adult bull trout that entered Roaring River in 2003 was approximately 37. The following year, 38 unique spawners were detected entering Roaring River. Trapping of downstream migrating (post spawning) adults revealed that 23 were female and 15 were male. The 32 redds observed in 2004, compared with the known number of spawning individuals, results in a ratio of redds to female bull trout of 1.4:1. There could be several explanations for more redds counted than females spawning: female bull trout deposit eggs in more than one redd, females dig without depositing eggs, and features are sometimes counted as redds that were not constructed by bull trout (ODFW 2003, 2004).

Current abundance of the South Fork McKenzie River local population may be adversely affected by the entrainment of bull trout through Cougar Dam. Entrainment through the dam may cause injury or mortality. Individuals that survive entrainment through the project may be lost to the local population above. The 38 bull trout spawning in Roaring River in 2004 included nine fish (eight female and one male) that had been entrained through Cougar Dam and subsequently captured below the dam in the spring of 2003 and 2004, and released back in Cougar Reservoir (ODFW 2004).

Upper McKenzie River Local Population above Trail Bridge Dam

This bull trout local population occurs in Trail Bridge Reservoir, Sweetwater Creek (a direct tributary to Trail Bridge Reservoir), the McKenzie River above Trail Bridge Reservoir to Tamolitch Falls, and Smith River upstream to Smith Dam. There is no information to suggest bull trout historically occupied the McKenzie River above Tamolich Falls, which is a natural barrier to upstream fish migration. However, bull trout historically utilized habitat in Smith River above Smith Dam, because individuals were observed in Smith Reservoir following completion of Smith Dam in 1963.

The Upper McKenzie River local population spawns in two locations: 1) the McKenzie River upstream of Trail Bridge Reservoir which provides approximately 1.1 kilometers (0.68 miles) of available spawning and rearing habitat and 2) Sweetwater Creek, which following a 1992 culvert project that restored passage, provides 2.4 kilometers (1.49 miles) of spawning and rearing habitat (Ziller and Taylor 2000). A program to transfer fry from Anderson Creek to Sweetwater Creek to reestablish spawning was implemented from 1993 to 1999, with the annual number of fry transferred ranging from 308 to 1,889 (6,384 fry in total from 1993 to 1999). The first adult bull trout to be documented ascending Sweetwater Creek occurred in 1999, when five adults were video-recorded moving through the culvert. In 2000 and 2001, two redds were counted, and in 2002, one redd was observed. In 2003 and 2004, four and nine redds were observed, respectively.

Counting bull trout redds in the McKenzie River upstream of Trail Bridge Reservoir is complicated by the presence of redds created by spawning Chinook salmon out-planted above Trail Bridge Dam. Biologists confirmed less than 10 redds annually in spawning surveys spanning a 10-year period beginning in 1994. However, in 2004, intensive spawning surveys occurred in the McKenzie River above Trail Bridge Reservoir in association with Eugene Water and Electric Boards' relicensing of the Carmen-Smith Hydroelectric Project. These surveys, which combined direct fish observations with redd counts, resulted in the verification of 16 bull trout redds, as compared to nine redds observed the previous year (USFS 2004).

Table E2. Summary of Bull Trout Redd Counts in the McKenzie River from Spawning Surveys by the Oregon Department of Fish and Wildlife, Stillwater Sciences and the U.S. Forest Service; 1989-2005.

	Mainstem McKenzie River Local Population									Upper McKenzie River Local Population			South Fork McKenzie River Local Population
	Anderson Creek				Olallie Creek								
Year	Below Culvert	USFS Index Reach	Above Culvert	Total Stream	Below Culvert	Above Culvert	Total Stream	McKenzie River Below Trail Bridge Dam	Total Mainstem McKenzie River Local Population	McKenzie River above Trail Bridge Dam	Sweetwater Creek	Total Upper McKenzie River Local Population	Roaring River Total South Fork River McKenzie Local Population
1989	-	7	-	7	-	-	-	-	7	-	-	-	-
1990	-	9	-	9	-	-	-	-	9	-	-	-	-
1991	0	8	8	8	-	-	-	-	8	-	-	-	-
1992	4	13	9	13	-	-	-	-	13	-	-	-	-
1993	4	15	11	15	-	-	-	-	15	-	-	-	1
1994	7	22	23	30	3	-	3	-	33	0	0	0	1
1995	3	30	70	73	1	9	10	-	83	7	0	7	2
1996	1	26	81	82	0	7	7	-	89	7	0	7	0
1997	-	18	-	85	0	9	9	-	94	3	0	3	0
1998	4	29	75	79	0	7	7	-	86	2	0	2	6
1999	13	47	64	77	0	6	6	-	83	0	0	0	13
2000	15	44	68	83	0	9	9	-	92	0	2	2	25
2001	6	23	66	72	2	4	6	-	78	1	2	3	34
2002	9	31	51	60	5	5	10	-	70	3	1	4	25
2003	6	23	50	56	7	10	17	0	73	9	4	13	27
2004	6	24	43	49	7	5	12	1	62	16	9	25*	32
2005	7	24	40	47	7	5	12	2	61	10	9	19	35
2006	-	-	-	59	-	-	8	1	68	12	21	33	33
2007	-	-	-	58	-	-	15	4	77	15	22	37	54

*The number of redds counted in 2004 may be disproportionately high compared to prior year counts in part because of an intensive survey effort that occurred in 2004, associated with the relicensing of the Carmen Smith Hydroelectric Project. See Stillwater Sciences 2006, pg. 67 for additional abundance estimates.

Middle Fork Willamette River Bull Trout Rehabilitation Program

A plan to rehabilitate the small or perhaps extirpated bull trout in the upper Middle Fork Willamette River was completed by the Willamette Basin Bull Trout Working Group in 1997 (ODFW and USFS 1998). Beginning in 1997 and continuing through 2005, bull trout fry from Anderson Creek in the McKenzie River Subbasin were reintroduced by ODFW and USFS to four coldwater springs and four creeks above Hills Creek Reservoir as part of the rehabilitation plan (ODFW and USFS 1998) (Table E3). Information on survival and dispersal of the 10,408 fry is limited, although distribution in 2001, was documented to be at least 5.5 miles in the Middle Fork Willamette River from approximately Chuckle Springs downstream to Sacandaga Campground (ODFW 2001a). ODFW and USFS personnel observed 28 bull trout and sampled approximately 25 percent of available habitat in the survey reach.

Table E3. Bull Trout Fry Transferred from Anderson Creek, a McKenzie River Tributary, to the Middle Fork Willamette River Basin above Hills Creek Reservoir.

	Coldwater Springs				Creeks						
Year	Chuckle	Iko	Indigo	Shadow	Bear	Upper Swift	Swift Side	Found	Skunk	Echo	Totals
1997	96		26						56		178
1998	411	938		150							1,499
1999	302	1,000		148			526				1,978
2000	349	1,075	204	53		522	300	285			2,788
2001	269	418			673	96					1,456
2002	177	75			38						290
2003	365	439	242		388					28	1,462
2004	149	129	109		75	155					617
2005		81	61								142
2006	---None--										0
Totals	**2,018**	**4,155**	**642**	**351**	**1,174**	**773**	**826**	**285**	**56**	**28**	**10,408**

Assuming an observation probability of 50 percent for night snorkeling, an estimate was made of approximately 230 bull trout present in the survey reach. Of these 230 estimated individuals, it is further estimated that 40 were greater than 10 inches (25 cm) in length. For the second consecutive year, juvenile bull trout were observed eating young-of-the-year Chinook salmon during snorkel surveys, underscoring the importance of this historic and recently reintroduced prey base for bull trout (ODFW 2001a).

A single sub-adult bull trout was captured by an angler in the Middle Fork Willamette River below Hills Creek Dam in June 2000. The origin of this fish is unknown, although it is possible it originated from the fry releases to the coldwater springs and creeks that are tributaries to the Middle Fork Willamette River above Hills Creek Reservoir during the first few years of the rehabilitation program. If this individual sub-adult bull trout originated from the rehabilitation program that began in 1997, it most likely migrated downstream through Hills Creek Reservoir and was entrained through the dam.

Additional evidence suggests introduced bull trout fry are surviving to sub-adult age and moving downstream to rearing habitat in Hills Creek Reservoir. In the spring of 2003, four sub-adult bull trout were reportedly caught and released by anglers in Hills Creek Reservoir, one of which was photographed and measured by USFS personnel (Dave Bickford, U. S. Forest Service, personal communication, 2003). In 2005, 11 post-spawning adult bull trout were captured in a screw trap in the Middle Fork Willamette River above Hills Creek Reservoir. Their precise spawning locations are unknown but in the summer of 2006, bull trout fry were observed in Iko Spring. The observation of fry represented the first known reproduction in the Middle Fork Willamette River since the rehabilitation program began in 1997 (Mark Wade, Oregon Department of Fish and Wildlife, personal communication, August 2006).

None of the four USACE dams in the Middle Fork Willamette River Subbasin are designed to minimize fish mortality; therefore, fish survival through the turbines and regulating outlets, especially for larger sized fish, is expected to be low. However, data collected from ODFW's radio-tagging studies in the South Fork McKenzie River Subbasin above Cougar Dam have provided evidence that adult bull trout can survive entrainment through these large dams.

The current abundance of adult and sub-adult bull trout in the Middle Fork Willamette River is believed to be approximately 20 to 30 fish. Spawning and successful reproduction was first documented by ODFW and the USFS in 2005 and again in 2006. PIT tag monitoring and trapping of adult bull trout documented at least 12 adults spawning in 2005 and 2006 (ODFW 2007). The bull trout carrying capacity of the Middle Fork Willamette River is not known, but local biologists believe the potential is similar to that of the South Fork McKenzie River (ODFW and USFS 1998).

Bull Trout in the Deschutes River Basin

Two core areas are identified in the Deschutes River Basin: Lower Deschutes River and Upper Deschutes River. The Lower Deschutes River Core Area contains current and historic bull trout habitat from Big Falls downstream to the mouth where it enters the Columbia River. The Deschutes River population of bull trout within the Lower Deschutes River Core Area, among the healthiest in Oregon, is approaching recovery status as set forth in the Deschutes Chapter of the Draft Bull Trout Recovery Plan (USFWS 2002). This population's increase in abundance over the last two decades is attributed largely to changes in angling regulations combined with an abundance of forage (kokanee) in Lake Billy Chinook. In contrast, bull trout in the Upper Deschutes River Core Area have been extirpated since the 1950s due to increased water temperatures, altered stream flow regimes, inundation of some juvenile rearing areas, blockage of passage to adult spawning areas, fisheries management, competition with nonnative trout, and overharvest (USFWS 2002).

The Pelton Round Butte Hydroelectric Project (Project) is owned by PGE, and is located just below the confluence of the Deschutes, Metolius, and Crooked rivers. Although there are a small number of bull trout that migrate downstream through the Project, the three dams associated with the Project do not currently provide fish passage and thus functionally split the bull trout population in the Lower Deschutes River Core Area into two groups with five local populations:

1. the Metolius River Subbasin above the Project (includes three local populations), and
2. Shitike Creek and Warm Springs River below the Project (includes two local populations).

The five local populations within the Lower Deschutes River Core Area are:

1. Whitewater River (Metolius River Subbasin above the Project)
2. Jefferson, Candle, and Abbot River Complex (Metolius River Subbasin above the Project)
3. Canyon, Jack, Heising, and Mainstem Metolius River Complex (Metolius River Subbasin above the Project)
4. Shitike Creek (Shitike Creek and Warm Springs River below the Project)
5. Warm Springs River (Shitike Creek and Warms Springs River below the Project)

Bull trout residing above the Project are primarily adfluvial, spawning and rearing in the Metolius River Subbasin, with sub-adult and adult rearing, overwintering, and foraging in Lake Billy Chinook. There are also resident bull trout in the Metolius River but they comprise a small component of the overall population. Bull trout below the Project spawn and rear in Shitike Creek and Warm Springs River, and use the lower Deschutes River for foraging.

There is an abundance of data over a long time series for bull trout in the Deschutes River Basin due primarily to studies initiated in the 1980s by PGE, in cooperation with the Confederated Tribes of the Warm Springs Reservation and ODFW. Bull trout in the Metolius River have been monitored for approximately 20 years, while bull trout in Shitike Creek and the Warm Springs River have been monitored since 1998. Data on bull trout in the Whitewater River, a Metolius tributary, cannot be collected consistently because of its remoteness and the presence of turbid glacially-influenced water most years (Brun and Dodson 2002). All five local populations in the Deschutes River Basin appear to be stable or increasing over the period from 1998 to 2005 (USFWS 2002).

Bull trout in the Metolius River Subbasin are grouped into three local populations that interact and form spawning complexes based on geography and other limited data. As stated above, these include the Whitewater River complex, Jefferson/Candle/Abbot Creek complex, and Canyon/Jack/Heising/mainstem Metolius River complex. Life history studies have shown that there is considerable straying between the latter two local populations (Ratliff et al. 1996). A comprehensive genetic analysis of Metolius River bull trout is underway with results expected from the USFWS in late 2007. The analysis will provide information on the relatedness of bull trout from the various spawning tributaries of the Metolius River. Since regular monitoring began in the 1980s, redd counts in the Metolius River Subbasin have risen steadily from 27 in 1986 to a high of over a 1,000 in 2004 (Figures. E1a and E1b). Figures E1a and E1b do not include counts from Whitewater River on the Warm Springs Reservation. Current redd counts suggest an adult population of over 2,000 individuals in the Metolius River Subbasin.

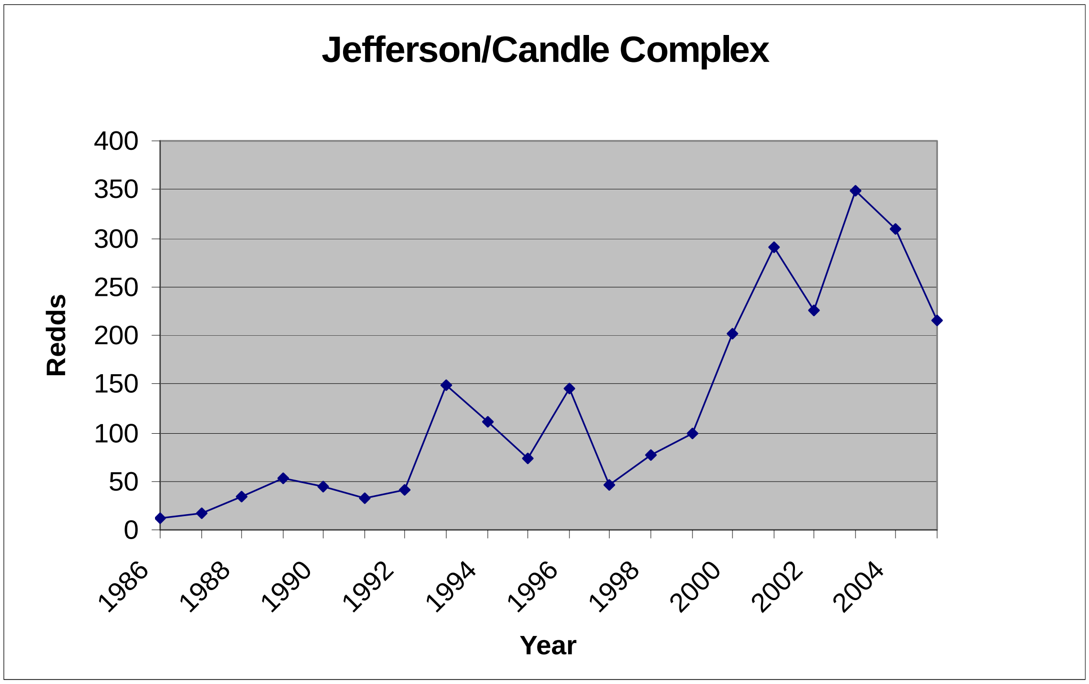

Figure E1a. Redd counts from the Metolius River Subbasin, 1986 – 2005: Jefferson/Candle Complex.

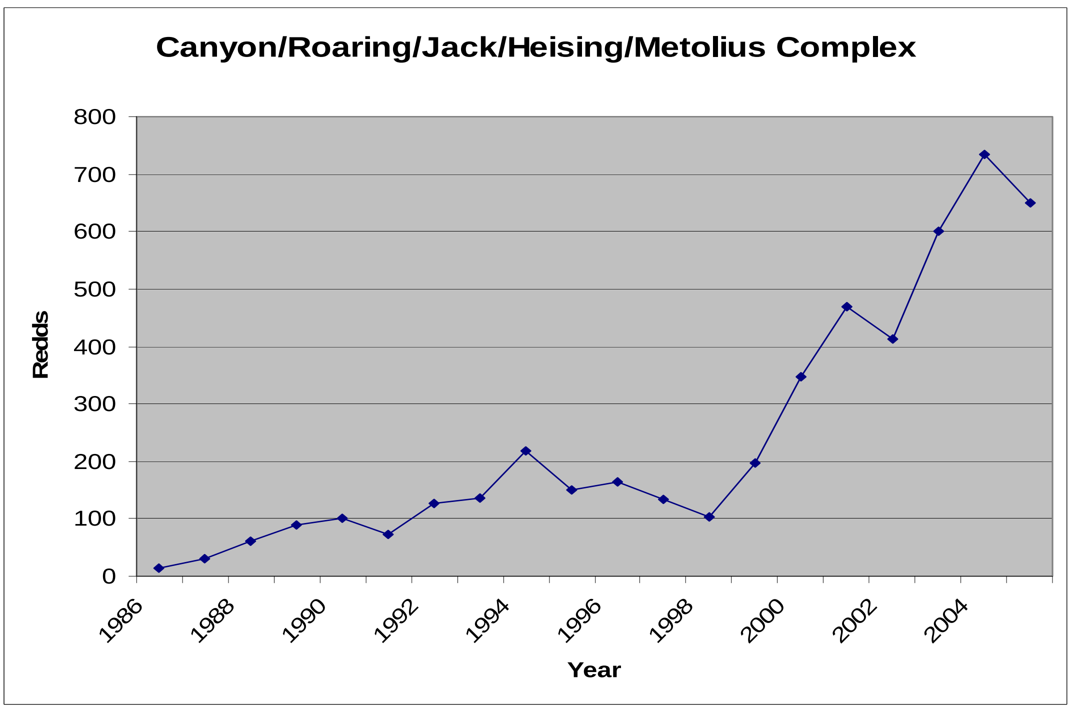

Figure E1b. Redd counts from the Metolius River Subbasin, 1986 – 2005: Canyon/Roaring/Jack/Heising/Metolius Complex.

Bull trout local populations in Shitike Creek and the Warm Springs River averaged 232 and 202 spawners, respectively between 1998 and 2001 (Brun and Dodson 2001). Redd counts peaked in Shitike Creek in 2002 and in Warm Springs River in 2003, and have declined since (Figures. E2a and E2b).

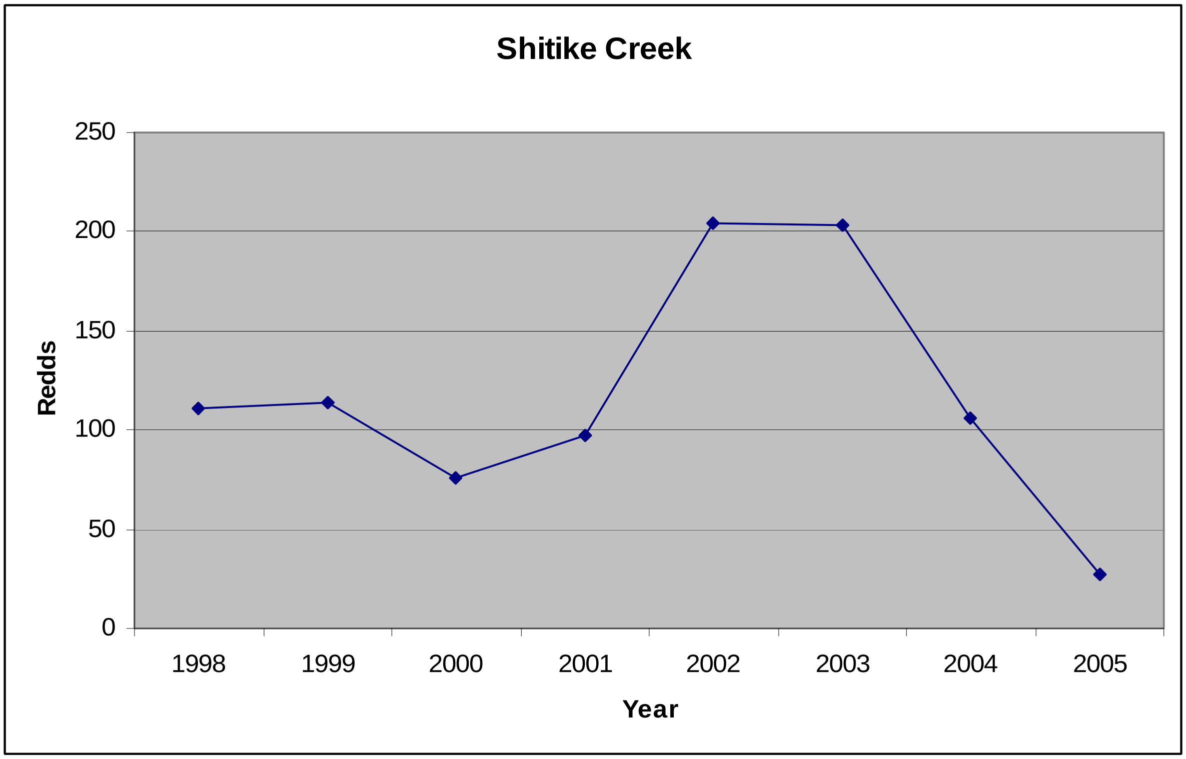

Figure E2b. Redd counts in Shitike Creek, 1998 – 2005 (adapted from Burchell and Brun 2005).

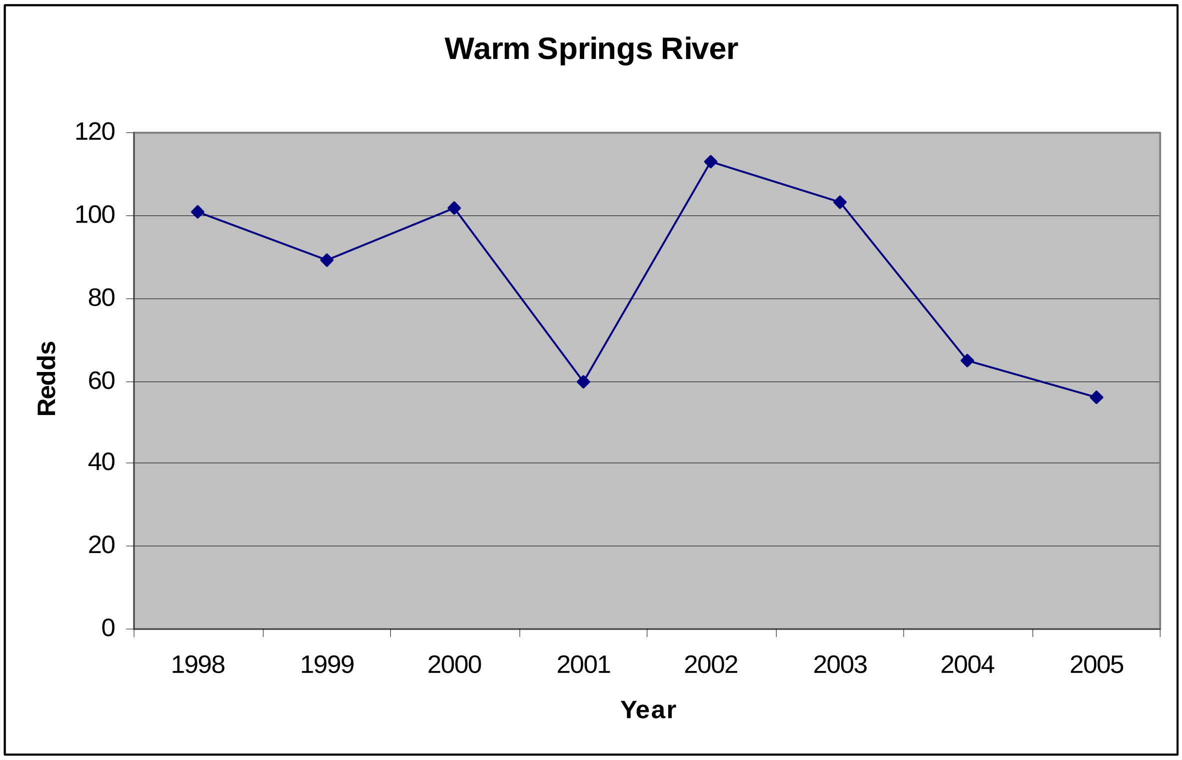

Figure E2b. Redd counts in Warm Springs River, 1998 – 2005 (adapted from Burchell and Brun 2005).

The reason for the recent decline in redd counts in Shitike Creek and Warm Springs River is unknown, but could be related to warmer than average water conditions during the fall of 2005, an increase in the numbers of seasonal passage barriers created by recreational swimmers, or a shift in spawning distribution to areas outside index reaches (Burchell and Brun 2005).

In the Metolius River, most bull trout spawning occurs between August 15 and October 1. However, spawning has been observed as early as July 13 and as late as mid-October (Ratliff et al. 1996). In Shitike Creek, spawning was observed from August 20 through early November, when water temperature averaged 6.1 degrees Celsius (43 degrees Fahrenheit) between RM 18 to 27 [note: this was the mean 7-day average from thermographs]. In the Warm Springs River, temperatures averaged 6.6 degrees Celsius (44 degrees Fahrenheit) between RM 31 to 35 during the late-August to early November spawning period (Brun 1999).

Deschutes River Basin bull trout exhibit both fluvial and adfluvial life histories. Fluvial bull trout migrate from their smaller natal stream to a larger river to rear, and then back to their natal stream to spawn. Adfluvial bull trout migrate from their smaller natal stream eventually entering a lake or reservoir to rear. After several years of growth, and with the onset of maturity, adfluvial bull trout retrace their earlier migration back to their natal stream to spawn. In one recent study conducted by Brun and Dodson (2000), radio-tagged adults began their migration in mid-May. They initially made short migrations into and out of spawning streams. Later, one individual moved upstream 73 kilometers (44 miles) in Shitike Creek to reach spawning areas and then moved quickly downstream after spawning. Other tagged fish showed similar behavior. In the Metolius River, maturing bull trout migrating from Lake Billy Chinook were captured from May through August. Peak upstream movement occurred between August 20 and September 15.

All bull trout local populations in the Lower Deschutes River Basin contain the migratory life history form as observed by radio-tag studies (Brun 2000; Brun and Dodson 2001); and upstream migrant traps (Ratliff et al. 1996, Brun and Dodson 2001, Brun and Dodson 2002). However, the three local populations in the Metolius River Subbasin are currently separated by the Project from the two local populations downstream in Shitike Creek and the Warm Springs River. The Project does not have operational fish passage facilities at this time. However, PGE has proposed renewing passage thru trap and haul as a major mitigation goal during the new Federal license term (Ratliff et al. 2001). Renewed passage is planned to commence within the next ten years. Having successful passage through or around the Project is considered important to the recovery of the bull trout in the Deschutes River Basin (USFWS 2002).

Bull Trout in the Lewis River Basin

The Lewis River Basin is located on the western flanks of the Cascade Mountains in southwest Washington. The Lewis River is segregated by three dams (Merwin, Yale, and Swift), none of which have upstream passage. Limited downstream passage via spill over these dams is assumed and explains bull trout adults observed in the most downstream reservoir (Merwin). The Lewis River Basin is one of two core areas identified in the Lower Columbia River Recovery Unit and it contains three local populations (USFWS 2002): Pine Creek, Rush Creek, and Cougar Creek. The first two local populations, Pine Creek and Rush Creek, occur highest in the basin above Swift Dam. The Cougar Creek Local Population occurs above Yale Dam, a tributary to Yale Lake. Fish passage on the Lewis River is blocked approximately 10 miles above Swift Reservoir by a series of three natural barrier waterfalls. Fluvial bull trout entrained through or spilled over the three dams could migrate to and use the Columbia River, but whether they do is currently unknown. Bull trout in the Lewis River where once fluvial but now are adfluvial due to the existence of reservoirs. Anecdotal records indicate that the Lewis River may have had anadromous bull trout prior to the construction of Merwin Dam. “Dollies” were reportedly routinely netted in Woodland, Washington prior to the construction of Merwin Dam. There have also been several records of silvery bull trout captured in the fish trap at the base of Merwin Dam and at the Lewis River Hatchery (Jim Byrne, Biologist,Washington Department of Fish and Wildlife, personal communication, 2007).

Only two verified bull trout sightings have occurred below Merwin Dam, and their presence is likely a result of water spilled over Yale Dam. No known spawning areas exist in Lake Merwin. Bull trout have been observed in the Yale Dam tailrace apparently attempting to migrate upstream. The one local population of bull trout in Yale Lake spawns and rears in Cougar Creek. Spawning bull trout have been observed in Cougar Creek since 1979, and the local population spawner abundance has ranged from zero to 40 individuals. Spawning adfluvial bull trout in Yale Lake migrate into Cougar Creek from the middle of August through early September. Spawning occurs from late September through early October. In 2001, the count of adult spawners in Cougar Creek was nine adults.

Swift Dam was constructed in 1958. The reservoir formed by the dam is approximately 18.5 km (11.5 miles) long with a surface area of approximately 1, 895 hectares (4,680 acres) at full pool. The two local populations occurring within Swift Reservoir occur in Pine and Rush creeks. These two local populations are assumed to interact with one another and the adults are enumerated together in abundance estimates made for bull trout spawners above Swift Dam. Surveys of adult spawners have been conducted since 1994. Bull trout spawners above Swift Dam have steadily increased from 101 spawners estimated in 1994 to 1,181 spawners estimated in 2005. In the spring of 2001, the Washington Department of Fisheries and Wildlife (WDFW) operated a screw trap in the Lewis River just above Swift Reservoir. Juvenile bull trout caught in the trap ranged in size from 120 millimeters to just over 200 millimeters (PacifiCorp 2002).

The WDFW, USFS, and PacifiCorp have been cooperatively conducting bull trout research on the Lewis River since 1989. Spawner abundance above Swift Dam is estimated utilizing a modified Peterson's mark-recapture population estimate for bull trout over 360 mm long. Table E4 below indicates bull trout netted for the marking portion of the adult spawner estimate from 1995 through 2004. There has been an increasing trend, and over 100 fish have been captured during the last four years.

Table E4. Swift Reservoir Bull Trout Net Captures, 1995 – 2004.

Year	Timeframe	No. Tagged	No. Captured	No. Recaptured	No. Mortalities
2004	May 19- July 14	128	141	19	0
2003	May 14- July 9	85	100	17	1
2002	May 30-July 24	100	114	13	0
2001	May 24-July 12	88	126	28	0
2000	May 18-July 13	69	87	16	1
1999	May 27-July 15	32	36	3	0
1998	May 7-June 11	58	67	14	0
1997	May 8-June 26	75	56	20	1
1996	May 10-June 18	15	18	2	1
1995	May 9-May 25	46	48	2	0

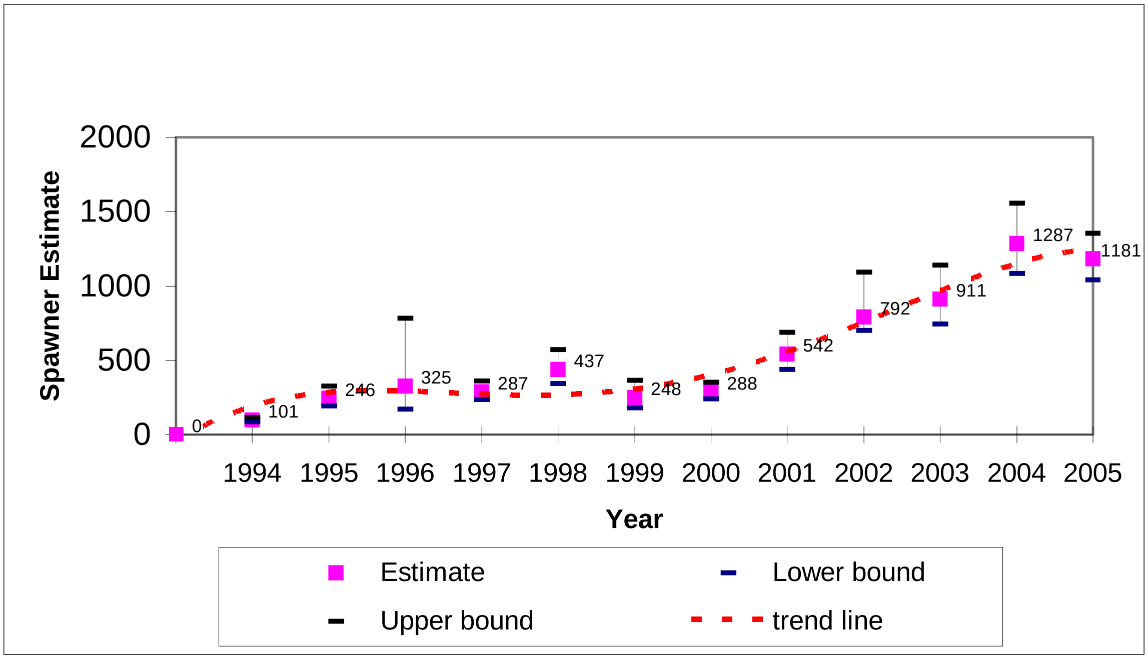

Figure E3. Swift Reservoir Bull Trout Adult (greater than 360 mm) Estimates, 1994-2005. Upper and lower bounds are indicated at the 95 percent confidence levels.

Bull trout residing in Swift Reservoir migrate into tributary streams from late May through early August, and spawn from early August through the middle of September. Emigration of juveniles from the tributaries to Swift Reservoir and Yale Lake is believed to occur from the middle of May through June.

Lack of passage at Lewis River hydroelectric facilities has fragmented the bull trout population and prevented migration into the lower Lewis and Columbia rivers. By adopting an adfluvial life history, bull trout persist at relatively moderate numbers in the Lewis River. The Lower Columbia Recovery Team considers upstream and downstream passage at Yale Dam and Swift Dam to be essential for recovery. An additional concern is the low instream flow levels in the Swift bypass reach which may affect potential spawning and rearing habitat for bull trout present in Yale Lake. Additional entrainment studies are necessary to evaluate the impacts of current operations at Yale and Swift dams on bull trout. Upstream passage for salmon at Merwin Dam currently exists in the form of trap and haul. Studies designed to assess whether or not bull trout from the upper watershed would benefit from volitional or trap and haul passage at Merwin Dam need to be conducted.

Kokanee were introduced into the reservoirs in the late 1950s and early 1960s and now spawn in tributaries of Lake Merwin and Yale Lake. Nonnative brook trout have been stocked in the upper Lewis River Basin and in some tributaries of Pine Creek.

Bull trout in the Lewis River persist at moderate numbers in fragmented local populations. Adult abundance estimates for bull trout above Swift Dam (Pine and Rush creeks combined) ranged from 101 in 1994 to 1,181 in 2005, peaking in 2004 at an estimated 1,287 adults (Figure E3). In recent years, the majority of spawning has shifted from Rush Creek to Pine Creek. Based on guidance in Rieman and Allendorf (2001), bull trout in Rush and Pine creeks are not at risk from inbreeding depression. Conversely, the local population in Cougar Creek is significantly below 100 individuals and is considered at risk.

Bull Trout in the Hood River Basin

Bull trout in the Hood River Basin are split into two local populations due to the presence of Clear Branch Dam: the Clear Branch Local Population and the Hood River Local Population. There is little connectivity between the two local populations above and below the dam because it has no operational upstream passage. Downstream passage can only occur when water is spilled over the dam during high water events. Although both local populations are very small, the Clear Branch Local Population above the dam appears to have higher numbers of adult spawners compared to the Hood River Local Population below the dam.

Information on bull trout distribution and abundance in the Hood River Basin is from a variety of sources, and includes a number of sampling methods. Fish trap data are available from fish collections at the Powerdale Dam trap, a trap on the Punchbowl Falls fish ladder (discontinued following the 1964 flood), floating screw traps at several locations throughout the basin, and a trap at the base of Clear Branch Dam. Other information includes individual observations, snorkel, and electrofishing surveys (Pribyl et al. 1996).

Current bull trout distribution in the Hood River Basin occurs in three major areas: mainstem Hood River, Middle Fork Hood River, and Clear Branch of Hood River (USFWS 2002). Bull trout distribution in the East and West Forks of Hood River are based on isolated, infrequent sightings. Historical distribution is believed to approximate current distribution based on existing knowledge. A comprehensive population assessment is not available. Buchanan et al. (1997) reported the total number of adult bull trout in the recovery unit is believed to be less than 300 individuals. Recent spawning surveys for bull trout upstream of Clear Branch Dam, where the majority of bull trout occur within the recovery unit, indicate an adult abundance less than 50 individuals.

Clear Branch Local Population

Table E5 shows annual high counts of bull trout above Clear Branch Dam. Snorkel surveys conducted in a portion of the habitat in Clear Branch above the dam found a total of 51 to 200 bull trout (all life stages) between 1996 and 2003, while surveys below the dam found a total of zero to three bull trout between 1996 and 2003. Figure E4 displays the same data graphically. Abundance studies conducted by the USFS and ODFW in 2005 and 2006 estimated the total local population (primarily juveniles) in Clear Branch above the dam to range between 233 to 849 individuals (2005 estimate) and 200 to 826 individuals (2006 estimate) (USFS 2006).

Table E5. Annual High Count of Adult and Juvenile Bull Trout in Clear Branch Above Laurance Lake from 1996-2003. All counts were made by snorkeling at night in established monitoring reaches that make up approximately 30 percent of the total available habitat above the lake (USFS 2003).

Year	Adults	Juveniles	Total
1996	23	64	87
1997	44	52	96
1998	16	53	69
1999	20	114	134
2000	9	42	51
2001	16	94	110
2002	29	171	200
2003	26	135	161

[**Note on Table E5 above:** Counts for 2001-2003 do not include the newly opened "old growth" channel that adds approximately 0.3 miles of habitat. Beginning in 1996 the USFS snorkeled the same subreaches at least two times per year. High counts in any given year vary but usually fall within the month of August.]

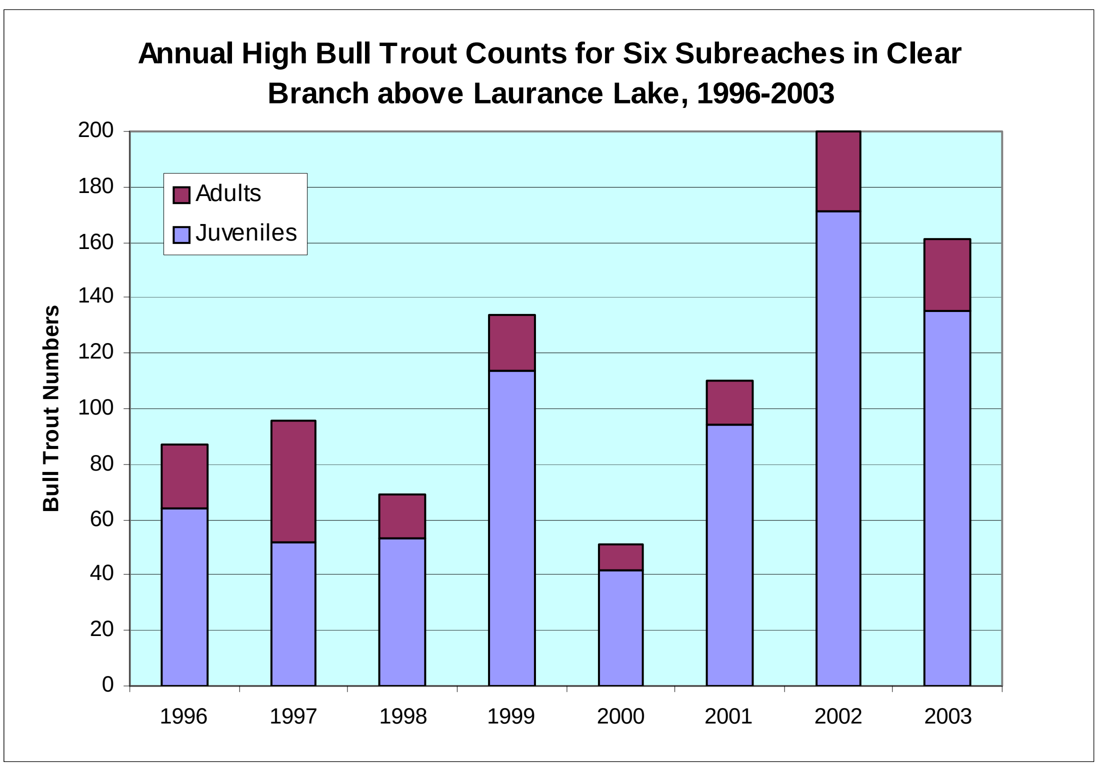

Figure E4. Annual High Counts 1996 to 2003 of Bull Trout Above Clear Branch Dam.

Bull trout forage and overwinter in the reservoir and spawn in the tributaries. Spawning has been confirmed in Pinnacle Creek and Clear Branch above the reservoir. Bull trout observations in Pinnacle Creek include three juveniles and one adult from 1996 to 1998, one adult and one juvenile in 1999 (USFS 1999), four adults and two juveniles in 2001, one adult and 12 juveniles in 2002 and two adults and eight juveniles in 2003 (USFS 2003). See Table E6 for annual counts of adult and juvenile bull trout in Pinnacle Creek 2002 and 2003, and see Table E7 for annual total counts of bull trout redds in Clear Branch and Pinnacle Creek, 2001-2005 (USFS 2003).

Table E6. Annual High Count of Adult and Juvenile Bull Trout in Pinnacle Creek in 2002 and 2003. All counts were made by snorkeling at night in established monitoring reaches that make up approximately 13 percent of the total available habitat. (USFS 2003).

Year	Adults	Juveniles	Total
2002	1	12	13
2003	2	8	10

Table E7. Annual Total Counts of Bull Trout Redds in Clear Branch, Pinnacle Creek, and Compass Creek 2001 to 2005. Clear Branch has two separate channels (reaches 2 and 5) that flow into Laurance Lake, thus both reaches start at RM 1.5. (USFS 2003 and 2005).

Stream and Reach No.	River Mile	Distance (RM)	Redds Counted				
			2001	2002	2003	2004	2005
Clear Branch							
Reach 1	0.0 – 0.6	0.6	0	1	2	0	0
Reach 2	1.5 – 2.2	0.7	6	1	5	6	13
Reach 3	2.2 – 3.0	0.8	8	5	7	4	7
Reach 4	3.0 – 3.5	0.5	NS	4	2	NS	0
Reach 5	1.5 – 1.85	0.35	NS	0	0	NS	0
Pinnacle Creek							
Reach 1	0.0 – 1.25	1.25	1	2	4	3	11
Compass Creek							
Reach 1	0.0 – 1.00	1.00	NS	NS	NS	NS	0
Total Redds			15	13	20	13	31

NS = Not Surveyed

Hood River Local Population

The distribution of the Hood River local population includes: Clear Branch downstream of the Clear Branch Dam; Bear, Coe, Compass, and Tony creeks; Eliot Branch; mainstem and Middle Fork of the Hood River; and perhaps Evans Creek and the East Fork Hood River. Bull trout captures in the Columbia River suggest that the Columbia River is used as foraging habitat for Hood River bull trout (Buchanan et al. 1997). Records from the Powerdale Dam upstream fish trap provide some adult bull trout abundance data for two time periods: from 1963 to 1971 and from 1992 to present. Adult bull trout counts were not made from 1972 to 1991. During the first time period (1963 to 1971), trap counts at Powerdale Dam were not consistent due to counting at only one of the two ladders or the ladders themselves being inoperable (USFS 1996a). Numbers of bull trout counted during this time period range from a high of 12 in 1967, to a low of zero in 1970, and average five fish annually over the nine year period (USFS 1996a). Bull trout have been trapped at the Powerdale Dam fish trap continuously since 1992. Adult bull trout counts range from a high of 28 fish in 1999 to two fish in 1993. Figure E5 displays the adult bull trout counts at the Powerdale Dam fish trap for both time periods.

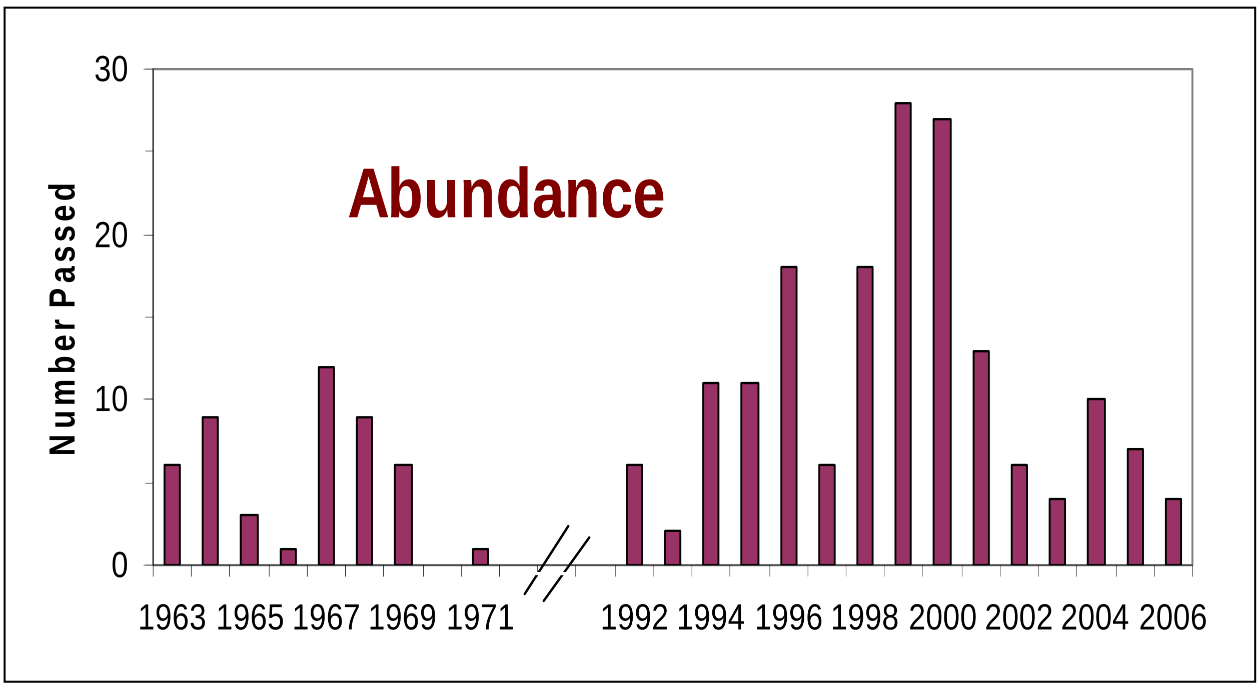

Figure E5. Adult Bull Trout Counts at the Powerdale Dam Fish Trap, 1963 - 2006.

As shown in Figure E6 below, bull trout migrate upstream in the Hood River from the Columbia River through the trap from early May to early October. The primary movement period appears to be from mid-May to mid-July.

The mainstem Hood River is formed by the confluence of the Middle Fork and the East Fork of the Hood River. At present, the mainstem Hood River, is believed to be used primarily for foraging, migration, and overwintering by bull trout. Migrations include journeys into the Columbia River of unknown extent, however, at least two bull trout tagged at the Powerdale Dam trap have been recovered in 1994 and 2000, at or near Drano Lake on the opposite side of the Columbia River in Washington State (Pribyl et al. 1996, ODFW 2001b). Another fish tagged in 1994 was recaptured in 1995, 6.8 miles downstream of the confluence of the Hood and Columbia rivers (Buchanan et al. 1997). Overwintering in the mainstem Hood River is suspected because untagged adult bull trout have been observed at several locations within the Hood River Basin (USFS 1996a) indicating they have not crossed the Powerdale Dam and upstream trap. There are no confirmed spawning locations on the mainstem Hood River, and information on bull trout use of the mainstem is mostly from trap data collected at Powerdale Dam.

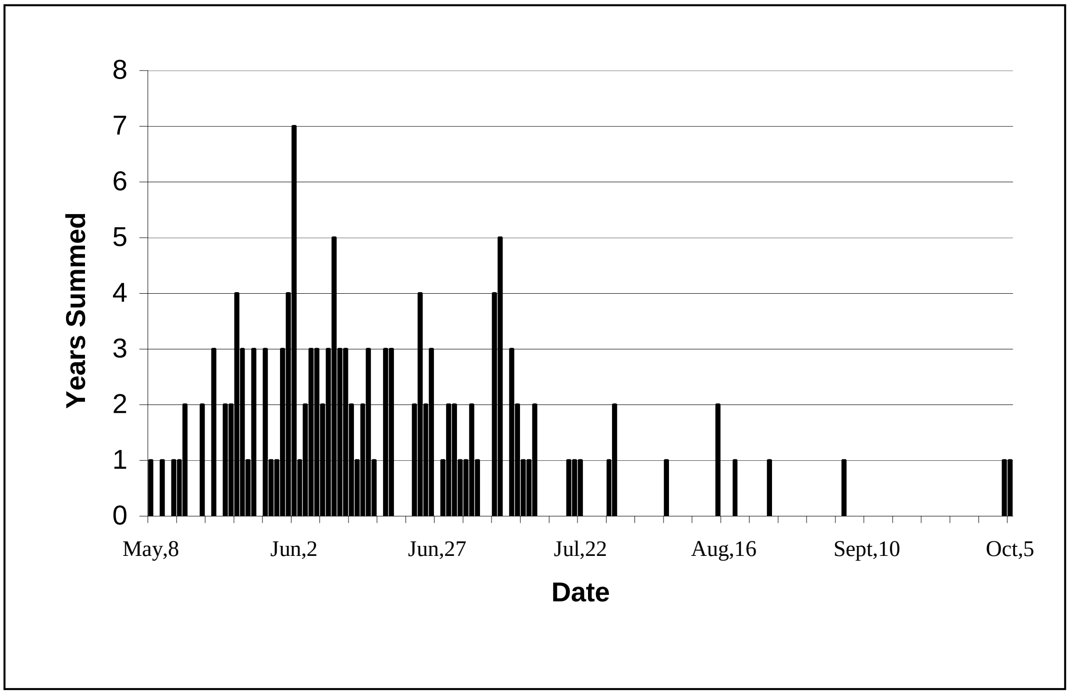

Figure E6. Frequency of Bull Trout Trapped in the Upstream Fish Trap at the Powerdale Dam, May – October, all years summed.

Two redds were detected in Bear Creek in 1999, by personnel from the USFS (USFS 1999). These redds were located approximately 325 feet upstream of the confluence with the Middle Fork Hood River. This suggested that rearing bull trout occur in the vicinity, including the Middle Fork Hood River, which was later verified by surveys (USFS 1999). A radio-tagged bull trout was tracked into Tony Creek, a Middle Fork Hood River tributary in 1998. Rearing bull trout were observed in 1995, in Coe Branch and Compass Creek by ODFW personnel (Buchanan et al. 1997), and one redd was found in Coe Branch in 1999. At the Coe Branch diversion, six adult bull trout were passed manually above the diversion in 1995 (Pribyl et al. 1996), and two adults that were tagged at Powerdale Dam in 2005 were observed at the Coe Branch diversion later that year. Bull trout have also been observed in Eliot Branch, where river conditions inhibit sampling above this diversion (USFS 1999).

No abundance estimates are available for the Middle Fork Hood River and tributaries. Surveys in 1995, found 19 bull trout (all life stages) in Compass Creek (Buchanan et al. 1997). Snorkel surveys conducted in Compass Creek from 1995 through 1998, detected a high of 19 fish in 1995, two fish in 1996, zero fish in 1997, and one fish in 1998 (USFS 1999), however these surveys were presence/absence surveys, not abundance estimates.

ODFW has operated rotary-screw traps (i.e., migrant traps) to capture downstream migrant anadromous salmonids in the Hood River Basin since 1992. The traps are located in the West (RM 4.0), Middle (RM 1.3), and East (RM 1.0) forks of the Hood River; and in Lake Branch (RM 0.1), which is a tributary to the West Fork of the Hood River. Sampling periods for all traps is generally from late March to July 31 annually. The traps are operated to monitor steelhead, coho, and Chinook salmon outmigration, however bull trout were also found in the traps, particularly in the Middle Fork trap, and results are summarized in Table E8 (Olsen 2004; Steve Starcevich, Oregon Department of Fish and Wildlife, personal communication, 2006).

Table E8. Bull Trout Captures in Screw Traps Operated in all Three Forks of the Hood River from 1992 to 2006.

Trap location	Number of Bull Trout Captured	Mean Fork Length (mm)
West Fork	0	NA
Lake Branch (West Fork)	1	>300
East Fork	1	375
Middle Fork	63	169

The number of bull trout observations for the West Fork of Hood River is limited. However, bull trout would not have been precluded from using the West Fork Hood River historically, at least on a seasonal basis. There are two records of bull trout occurrences in the West Fork of Hood River. The earliest available documentation is a single fish capture in 1963 at the fish trap at Punchbowl Falls fish ladder (USFS 1996b, Buchanan et al. 1997). Another bull trout was captured at the mouth of Lake Branch, a tributary to the West Fork of Hood River, in the fall of 1997 by the ODFW. Based on temperature data collected by USFS fish biologists (USFS1996b) suitable bull trout habitat is present in the West Fork Hood River mainstem and tributaries. Bull trout use of the West Fork Hood River is thought to be primarily for foraging, migration, and overwintering.

Although bull trout may have occurred in the East Fork Hood River historically (USFS 1996a), confirmation is lacking. According to Buchanan et al. (1997), William Stanley from the Middle Fork Irrigation District observed a bull trout in Evans Creek, a tributary to the East Fork Hood River, in the early 1990s. A subsequent survey of the area by a fisheries biologist did not yield any further detections (Buchanan et al. 1997). The bull trout in Evans Creek likely ended up there via the Eliot Branch irrigation ditch or moved in from downstream because it was attracted to Eliot Branch water. One bull trout was seen in the mouth of Wisehart Creek (USFS 1996a). However, due to the lack of bull trout observations during snorkeling and electrofishing surveys and the current water quality and habitat conditions, it was determined that use of the East Fork Hood River by bull trout is limited. An analysis of East Fork Hood River tributary stream temperatures indicate that Cold and Crystal Spring creeks, and some headwater East Fork Hood River stream segments may be suitable for bull trout, however, compared to the West Fork Hood River, the habitat is limited (Gary Asbridge, U. S. Forest Service, personal communication, 2003). Recovery efforts may also be directed to include the East Fork Hood River as habitat for an additional local population if information gathered in future efforts indicate that bull trout are occupying the East Fork Hood River or the habitat has the potential to support a bull trout local population.

At the time of listing, the USFWS considered bull trout in the Hood River Basin to be threatened by isolation (from dams and seasonally impaired water quality) and impacts to stream systems from past and ongoing forest management and agricultural activities. Bull trout above Laurance Lake in the Clear Branch of Hood River are considered to be at high risk of a random extinction event due to low numbers, isolation, and restriction to a single confirmed spawning area (USFWS 1998b, Buchanan et al. 1997).

Appendix F – Authors' Responses to State of Oregon Independent Multidisciplinary Science Team (IMST) Review of Draft Clackamas River Bull Trout Reintroduction Feasibility Assessment (November 2006)

[Note to Reader: the numbering of appendices changed between draft and final reports.]

At the request of the Oregon Department of Fish and Wildlife (ODFW, letter from Chris Wheaton dated September 18, 2006), the State of Oregon Independent Multidisciplinary Science Team (IMST) completed a review of *Draft Clackamas River Bull Trout Reintroduction Feasibility Assessment* (hereafter referred to as "draft Assessment"). The draft Assessment was prepared for the Clackamas River Bull Trout Working Group (CRBTWG) by seven authors representing the U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and ODFW. ODFW asked that the IMST evaluate the document with respect to the following questions:

- Is the Assessment credible?
- Are the tools employed appropriate for addressing the questions posed in the Assessment?
- Are there tools more appropriate for addressing the questions posed in the Assessment?
- With respect to the feasibility of a bull trout reintroduction in the Clackamas River, are there other issues that should be addressed in the Assessment?

The IMST addressed these four questions from ODFW within the framework of its review, completed January 30, 2007.

The authors of the draft Assessment held two meetings in February and March 2007 to review the comments provided by the IMST. This document provides the authors' responses to each general and specific comment made by the IMST. This document is organized in the same sequence as the IMST Review, outlining the particular IMST comment in italics followed by the authors' response indented below.

Scope of the Assessment

The authors believe it is important to restate the scope established for the draft Assessment since many of the IMST comments extend beyond its original scope. As stated on Page 11 of the draft Assessment:

> *This assessment represents a collaborative, comprehensive examination of the various factors involved in determining whether or not a bull trout reintroduction into the Clackamas River is feasible. Inevitably, it is easy to quickly jump ahead to all of the various factors and issues involved in contemplating a potential reintroduction of bull trout into the Clackamas River. Some of these factors and issues include which is the best donor stock, where should bull trout be released, what method of translocation should be used, what are the ecological impacts of reintroduction, etc. The authors have focused this assessment very specifically on the feasibility of reintroduction – that is, "Can a reintroduction of bull trout into the Clackamas River be done?" This specific focus thereby determines the scope of the feasibility assessment. The assessment, itself, does not attempt to determine "Should a reintroduction be done?" or "How should it be done?" Once the feasibility of determining whether or not a reintroduction can be done is established, only then can a proposed action be developed in coordination with multi-agency policy and decision-makers to investigate the later two questions further through formal administrative and regulatory procedures. It is imperative that reviewers of this assessment understand its breadth and scope. The authors of this assessment explore, in detail, all of the facets of the first and most fundamental question: "Can a reintroduction of bull trout into the Clackamas River be done?" The assessment answers this question and goes even further to provide valuable baseline information that would be useful in addressing the later two questions should a reintroduction effort be pursued.*

General Comments

IMST Comment: *Throughout, IMST advises CRBTWG to examine original documents to reduce the possibility of error (e.g., see the Murtagh et al. 1992 citation on p. 7 of the Assessment). … For example, on page 46 of the Assessment, the authors have miss cited Tague and Grant (2004) on the relative ages of the High Cascades and Western Cascades.*

> **Authors' Response:**
> The authors appreciate this advice and will make an effort to examine original documents referenced to reduce the possibility of error. A correction to the Tague and Grant (2004) reference will be made (e.g., High Cascades geology is younger than the Western Cascades geology, not conversely as stated incorrectly on page 46 of the Assessment).

IMST Comment: *Given that the USFWS bull trout recovery plan (USFWS 2002) remains a draft after four years, it would be helpful to provide assurance that a reintroduction plan could be approved in fewer than the four years it has taken for approval of the recovery plan. It would also be helpful to indicate how the lack of a final USFWS recovery plan may affect the conclusions reached in the Assessment and in subsequent actions by the CRBTWG.*

> **Authors' Response:**
> This comment extends beyond the original scope set for the draft Assessment. The timeframes for completion of these two efforts are independent from one another and involve separate administrative processes. The draft recovery plan for bull trout has been published, and the authors are working within that guidance. The lack of a final recovery plan does not influence the conclusions reached in the draft Assessment. The draft Assessment is specifically focused on a determination as to whether or not a reintroduction is biologically feasible. Evaluating potential subsequent actions by the CRBTWG is also outside the scope of the draft Assessment. At the time when a final bull trout recovery plan is issued, any subsequent actions undertaken by a particular entity would have to be assessed to ensure consistency with the final plan.

IMST Comment: *… explain why effective population size (Ne) recovery goals differ for coho salmon versus bull trout.*

> **Authors' Response:**
> Effective population size (Ne) for bull trout is not presented in the draft Assessment within the context of recovery goals identified in the draft recovery plan (USFWS 2002). The draft recovery plan goals and objective cited for the Willamette Recovery Unit (page 24 of the Assessment) do not specify Ne, nor was that done in the draft recovery plan. Ne is introduced in Chapter 3 of the draft Assessment only as it pertains to the 50-500 rule. Since the draft Assessment is focused on bull trout, the authors do not see the need or relevance of relating considerations for bull trout to coho salmon. Doing so may, in fact, create confusion.

Chapter 1 – History, Status, and Draft Recovery Plan Guidance for Bull Trout in the Clackamas River Subbasin

IMST Comment: *Prioritization and Risk Assessment. The Assessment does not address if, why, or how the Clackamas River basin was prioritized for bull trout reintroduction in Oregon. … it seems necessary to demonstrate that reintroduction to the Clackamas River basin is both feasible and is preferable to reintroduction and/or stock rebuilding in other parts of the Willamette River drainage… why should reintroduction into the Clackamas system be preferred to increased introduction efforts on the Middle Fork Willamette River or efforts to stabilize the declining McKenzie River population? An explanation of how the Clackamas River system compares to other areas where bull trout have been extirpated or reintroduced and whether it is the only (or one of several) area(s) under consideration for bull trout reintroduction would create a useful context that will help readers understand how this action fits within the larger recovery plan for bull trout in Oregon. What will the reintroduction of bull trout in the upper Clackamas basin contribute to the persistence of bull trout in the larger Willamette basin (other than spreading risks associated with catastrophic events)?*

Authors' Response:
The authors of the draft Assessment were charged with developing a reintroduction feasibility assessment for the Clackamas River Subbasin. The authors were not charged with prioritizing subbasins within the Willamette River Basin or Lower Columbia River Basin where a bull trout reintroduction could be considered. Given the long standing history of the CRBTWG, there was a large amount of local interest and collaborative effort that enabled the completion of such an assessment for the Clackamas River Subbasin. In fact, the initial effort to pursue this effort came from the guidance provided in the draft bull trout recovery plan. By focusing the draft Assessment on the Clackamas River Subbasin, the authors are in no way inferring there is a lesser importance for considering bull trout reintroductions in other subbasins of the Willamette or Lower Columbia River basins. The fact that the Clackamas River Subbasin happens to be somewhat centrally located to other extant bull trout populations within the Lower Columbia River Basin does make it an appealing location for reintroduction from a recovery standpoint; however, this was not a factor taken into consideration when the authors began developing the draft Assessment.

The authors did not attempt to evaluate all areas within the State of Oregon and to prioritize them for consideration of bull trout reintroduction. Again, this extends beyond the scope established for the draft Assessment. Every recovery unit likely has the opportunity for and may in fact require reintroduction in order to achieve the number of recovered populations to meet delisting. The authors' focus was on the Clackamas River Subbasin, and they did not undertake an effort to evaluate or prioritize the need for bull trout reintroductions within the Willamette Recovery Unit as a whole or for that matter other recovery units within the State of Oregon. The two subbasins within the Willamette River Basin identified as "core habitat" within the draft bull recovery plan are the Clackamas and Middle Fork Willamette. Core habitat is contained in areas where bull trout were historically present, have been locally extirpated, and currently contain suitable habitat. An active bull trout reintroduction effort was begun in the 1990s for the Middle Fork Willamette. This effort is described in the draft Assessment. Page 25 of the draft Assessment provides the necessary background and information giving context for the Clackamas River Subbasin within the larger Willamette River Basin.

A bull trout reintroduction effort in the Clackamas River Subbasin, if undertaken, would pursue the longer range goals for achieving recovery within the Willamette River Recovery Unit. If a reintroduction is pursued in the Clackamas River Subbasin and population connectivity reestablished within the recovery unit, then recovery goals and objectives would be much closer to attainment. The authors of the draft Assessment did not attempt to evaluate the contribution of a reintroduction in the Clackamas River Subbasin within the context of recovery planning for the Willamette River Recovery Unit as a whole. Again, the scope for the draft Assessment is identified very clearly in the Introduction on Page 1: "Can a reintroduction of bull trout into the Clackamas River be done?" The draft Assessment does not attempt to address the questions of "Should a reintroduction be done?" or "How should it be done?" The authors also defined the scope of the draft Assessment with members of the IMST at its October 16, 2006 public meeting.

IMST Comment: *Prioritization and Risk Assessment. If this information exists in the federal bull trout draft recovery plan (USFWS 2002)* [i.e., information that would provide the answers to the questions/comments listed in the previous IMST comment], *it would be helpful if it were summarized in Chapter 1 of the Assessment, if it does not, it would be wise to address these questions so that the Assessment can stand alone.*

Authors' Response:
Given the stated scope of the draft Assessment, the authors believe sufficient background information and discussion is provided in Chapter 1 to give the reader enough context for the Clackamas River Subbasin.

Chapter 2 – Habitat

IMST Comment: *Definitions. Although the authors may be clear about what constitutes a patch, a population, a population patch, a sustainable population, a river segment, a catchment/watershed/basin, or a subcatchment/subwatershed/subbasin, the meanings these terms are intended to impart is not sufficiently clear in the Assessment. Also in the habitat chapter, one comes across "critical habitat", "core habitat", "core area", and "patch" or "patch habitat". Perhaps the Glossary in the federal draft recovery plan (USFWS 2002) could be augmented and used in the Assessment to quantitatively define and describe these terms to aid the reader, provide consistent usage, and reduce contradictions.*

Authors' Response:
The authors appreciate this suggestion and will review sections of text where all such terms referenced above are used and make necessary edits to avoid confusion and ensure consistent usage. Additionally, a glossary of terms will be developed for the final Assessment.

IMST Comment: *Definitions. … what exactly is meant by the phrase 'self-sustaining local population' versus a sustainable population? Is this a minimum number of individuals or a minimum area, or both? How many bull trout adults per square kilometer constitute a self-sustaining population? What are minimum and maximum river segment lengths, patch sizes, or population areas for sustainable bull trout populations?*

Authors' Response:
The authors did not attempt to define or categorize differences between a "self-sustaining local population" and a "sustainable population." This, in fact, is likely where some confusion developed within the draft Assessment over the usage of different terms. The authors used the term "self-sustaining local population" in Chapter 2 of the draft Assessment to refer to a potential or hypothetical group of bull trout individuals within a local area of suitable habitat that would interbreed and persist over the long-term. The authors did not intend to equate this term with a "population" as might be defined in the draft bull trout recovery plan, since they are unaware of any data or published literature that would be used to answer the more specific questions raised by the IMST (i.e., How many bull trout adults per square kilometer constitute a self-sustaining population?, etc.). Given the amounts of habitat in spawning and rearing areas for nearby extant populations in the Lower Columbia River Basin, the authors are confident the habitat patches as defined in the Upper Clackamas either equal or exceed those (e.g., Anderson Creek in the McKenzie River, Pine and Rush creeks in the Lewis River, Clear Branch in the Middle Fork Hood River, etc.). In order to clear up any confusion, the authors intent to adopt the following terms in the final Assessment: "population" and "local population" as defined in the draft bull trout recovery plan and "sub-population" in parts of Chapter 3 only were its use pertains to the general discussion on population-level genetics.

IMST Comment: *Definitions. … How are self-sustaining populations related to the 7th field hydrologic unit code (HUC)? The geographic divisions appear to be based on hydrologic units, not true catchments or drainages. Such artificial units are unlikely to be perceived by bull trout, and may be misleading to aquatic ecologists.*

Authors' Response:
Somewhat similar to the last response, the authors did not draw a specific link to habitat areas and a "population" as is defined in the draft bull trout recovery planning sense. Chapter 2 assesses currently suitable habitat for bull trout spawning and rearing in the Upper Clackamas River (Figure 2.7 on Page 44 of the draft Assessment). The authors next segregated the total available suitable spawning and rearing habitat into areas termed "patches" which do in fact conform to watershed boundaries, except for Patch 1 Clackamas River Mainstem (Big Bottom) which does not qualify as a watershed. The authors' defined "patches" simply as a means to better describe and differentiate the characteristics and conditions of the available suitable spawning and rearing habitat across the Upper Clackamas River landscape. The authors are not certain as to how introduced bull trout would specifically organize themselves into local, interbreeding groups within the various patches. Only through reintroduction and monitoring could this be determined. Unfortunately, the authors created confusion by their use of terminology in linking "self-sustaining local populations" to individual "patches." This will be clarified in the final Assessment.

IMST Comment: *Definitions. …What constitutes suitable habitat (or critical habitat, core habitat, core area, patch size, or patch habitat) quality and quantity, and over what catchment area and stream size (volume, length, area) is it evaluated?*

Authors' Response:
The authors define suitable spawning and rearing habitat in a three-step process depicted in Figure 2.6 on Page 43 of the draft Assessment. Step 1 considered all streams accessible to bull trout as defined by the range of historical habitat accessible to anadromous fish (i.e., this is consistent with where historic and extant populations of bull trout have been/are found within the western Cascades portion of the Lower Columbia River Basin). Step 2 considered only those streams assumed to be large enough (i.e., watershed area greater than 1,700 acres) to sustain a group of interbreeding adult bull trout. Step 3 considered streams and rivers with water temperatures cold enough (less than 15 degrees Celsius) to support spawning, incubation, emergence, and rearing life stages. For reasons provided at the bottom of Page 38, the authors did not include two small tributaries (Farm and Dickey creeks) in the Collawash River in their further evaluation of suitable spawning and rearing habitat. The result from this three-step process yields the total available suitable spawning and rearing habitat (Figure 2.7 on Page 44). As stated in the previous response, the authors categorized the available suitable spawning and rearing habitat into patches for a more detailed characterization. The total amount of suitable spawning and rearing habitat is 70.1 miles as listed in Table 2.5 on Page 58 of the draft Assessment. For purposes of more detailed watershed and habitat characterizations, the authors used the "patch" boundaries (which largely conform to 7th field HUC boundaries) to display and contrast data and information pertaining to the quantity and quality of suitable habitat. The range of catchment areas for which this evaluation was conducted is presented in Table 2.2 on Page 47 of the draft Assessment (catchment size range = 4,104 to 25,572 acres). The range in stream size for this evaluation was not presented; however they range from a minimum summer low flow width of 10 feet to over 100 feet (Clackamas River mainstem at Big Bottom). The range in stream lengths is given in Table 2.5 on Page 58 of the draft Assessment (stream length range = 2.1 to 9.4 miles). More importantly, stream habitat surveys conducted on the majority of streams deemed as suitable for spawning and rearing further refine and breakdown each stream into smaller geomorphic reach segments for the purpose of a more detailed and meaningful analysis of stream channel and fish habitat conditions. The total lineal stream distance represented as suitable spawning and rearing habitat in Figure 2.7 on Page 44 of the draft Assessment is broken into several dozen individual geomorphic stream reaches. In order to aggregate stream survey data for a wide range of stream sizes in a given patch, fish habitat and stream characteristics (Pages 57 – 63 of the draft Assessment) are presented in terms of the total habitat area (square meters) available within a patch. The authors did not attempt to relate suitable spawning and rearing habitat with other components such as critical habitat, core habitat, core area, patch size, or patch habitat. See the Authors' Response above on Page 7 explaining why patches were delineated.

IMST Comment: *Delineation of Suitable Habitat Patches. It would be very helpful to explain the rationale for assuming that bull trout perceive patch boundaries along the same variables used to delineate them in the Assessment. Depending on how one defines a patch, there may be only three patches (one small (Rhododendron) and two large (Big Bottom/Pinhead, Upper Clackamas/Cub/Hunter patches), which are hydrologically linked just as tightly as the proposed six patches. Is there any evidence that the proposed patches would produce 6 distinct populations vs. 1–3 populations (e.g., Whiteley et al. 2006)? In other words, are the patches sufficiently interconnected to facilitate panmiximal or indistinct populations, versus distinct populations? If Rieman and McIntyre (1993) are correct and fewer than five local populations are at increased risk of extirpation, it may be important whether one defines the Clackamas recovery unit as having one, three, or six populations.*

Authors' Response:
Patch boundaries in this case represent discontinuities in either flow regime or temperature that would likely be recognized by bull trout. The Upper Clackamas, Cub Creek, and Hunter Creek patches, for instance, differ from one another in both flow regimes and temperature regimes, as discussed in Chapter 2 of the draft Assessment. Each patch is separated from the other by a portion of the mainstem Clackamas River that did not meet the temperature requirement. Pinhead contributes to but has a distinct flow regime from the Big Bottom patch, which, in turn differs in temperature regime from the Clackamas River upstream of the Pinhead confluence. There is no reason to suspect that these discontinuities would impede bull trout movements between patches, but the purpose of the patch delineation is explained above on Page 7. In this context, the discontinuities between patches become meaningful.

The authors are aware of the source of this confusion with regard to linking "patches" to "self-sustaining local populations" and they intend to provide necessary clarifications in the final Assessment. Within the context of recovery planning, had the Clackamas Recovery Unit been inhabited, then the entire recovery unit would constitute a "population" derived from one or more "local population(s)." The authors do not intend to correlate "patches" to areas of habitat capable of supporting distinct populations as the IMST suggests. The authors are unaware of any existing data or available information to undertake such an analysis.

IMST Comment: *Delineation of Suitable Habitat Patches. The transparency of how habitat patches were delineated would be significantly increased if the criteria used to delineate patch boundaries were explicitly stated and explained. The authors identify six suitable habitat patches distributed within the upper Clackamas River basin. These patches differ dramatically in size and are superimposed on a highly interconnected river network. Are the patches identified in the Assessment evaluated by some comparison with habitat patches in other basins known to support stable bull trout populations? In the absence of explicit criteria used to delineate these patches it is difficult to understand why they vary so dramatically in size. Patch 3 is six times larger than patches 4 and 5. If these smallest patches are capable of supporting a 'self-sustaining local population' it would be helpful to explain why so much area is required to support a population in patch 3. Also, patches 1 and 2 and patches 3, 4 and 5 appear to be fully connected by suitable habitat (i.e., not separated by warmer stream reaches). It would aid the reader if the criteria used to determine the boundaries among these patches were explained. This section contains considerable descriptive information on fish habitat in the six delineated patches (pgs. 57–63 of the Assessment). Perhaps this information can be used to better describe how the patches differ and to justify boundary placements.*

Authors' Response:
The authors believe the description of this process is quite transparent. Patch boundaries that largely conform to 7th field HUC boundaries were developed for the total available suitable spawning and rearing habitat displayed in Figure 2.7 on Page 44 of the draft Assessment. The authors understand the confusion in the draft Assessment making the link between "patches" and "self-sustaining local populations" as addressed in response to a similar IMST comment above on Page 7. This confusion will be rectified in the final Assessment. Given such, the authors do intend to organize the total available suitable spawning and rearing habitat into the patches identified for the purpose of characterizing and describing the conditions of particular suitable habitat areas within the Upper Clackamas River landscape.

IMST Comment: *Delineation of Suitable Habitat Patches. The justification for the CRBTWG determination that there is sufficient habitat available in the Clackamas River basin to warrant a bull trout reintroduction would be better supported if the authors provided additional discussion addressing: 1) the probability that all six patches can be recolonized, 2) why an intermediate extinction risk is acceptable, and 3) what constitutes, in a probability range, an intermediate extinction risk.*

Authors' Response:
The probability that any of the suitable habitat areas within the Upper Clackamas River can be naturally recolonized is extremely low as the authors state in Chapter 1. Approximately 70 miles of suitable spawning and rearing habitat are available in the Upper Clackamas River. This amount of suitable habitat exceeds those amounts present in other neighboring river basins where extant bull trout populations are found in the Lower Columbia River Basin. Since the authors are not making a link between patches and populations per Rieman and McIntyre (1993), they are not attempting to assess the potential for patch colonization with range of extinction risk.

IMST Comment: *Bull Trout Dispersal and Migration. The amount of movement (if any) by bull trout between the upper Clackamas and the lower Clackamas, Willamette, and Columbia that is expected by the CRBTWG is unclear. The IMST recommends that the CRBTWG determine whether ladders designed for upstream passage of adult salmon are effective for upstream passage of smaller, weaker-swimming bull trout. IMST suspects that flow velocities in the ladders may be too high for bull trout. Also adult bull trout tend to move downriver during high fall flows. It would be useful to provide quantitative estimates of the effectiveness of migration of adult steelhead through the ladders and reservoirs as a possible model for bull trout.*

Authors' Response:
As described on Page 21 of the draft Assessment, the authors briefly describe the fish passage facility improvements for the mainstem dams on the Clackamas River owned and operated by Portland General Electric (PGE). Since the completion of the draft Assessment, PGE has finished construction of the new Rivermill Dam Fish Ladder to current NMFS fish passage standards and criteria for salmon and steelhead. Many fish passage studies and evaluations were completed during the process of Federal Energy Regulatory Commission (FERC) re-licensing of the PGE hydroelectric facilities and operations. Operational and facility improvements have been identified in the pending PGE license application to FERC to address upstream and downstream fish passage needs for all fish species evaluated. As stated on Page 21 of the draft Assessment: "The USFWS has not finalized passage and screening criteria specific to bull trout. In the interim, the criteria developed by the National Marine Fisheries Service (NMFS) for anadromous salmonids have guided fish passage facility improvements for the Clackamas River mainstem hydroelectric dams, and it is believed they should be effective for bull trout as well." Since this evaluation and determination was made by other state and federal agency fish biologists involved in the FERC re-licensing proceeding, the authors do not believe it is warranted to repeat such an evaluation for the reintroduction feasibility assessment.

IMST Comment: *Sufficiency of Present and Future Bull Trout Habitat. IMST questions whether sufficient high quality habitat is available in the upper Clackamas now and will be in the future. It would be very useful for the authors to indicate precisely what constitutes a sufficient amount of high quality habitat for a successful reintroduction. This would include data and information on whether or not winter water temperatures are low enough in all the catchments to allow successful reproduction and juvenile rearing.*

Authors' Response:
As stated above on Page 8, there are approximately 70 miles of suitable spawning and rearing habitat in the Upper Clackamas River. This is a larger amount of suitable habitat than exists in other neighboring basins containing extant populations of bull trout in the Lower Columbia River Basin. All of the available suitable habitat is contained on U.S. Forest Service lands which are managed under the Mt. Hood National Forest Land and Resource Management Plan as amended by the Northwest Forest Plan described on Pages 54-56 of the draft Assessment. The authors believe these management standards and guidelines (i.e., protective measures) are the most protective of any land management regulations in the State of Oregon pertaining to forest management related activities (including recreational and other related activities) and believe they are sufficient to

maintain high quality habitat conditions in the future. The authors are unaware of any available data or information that would suggest how much suitable habitat is required to ensure a successful bull trout reintroduction.

IMST Comment: *Sufficiency of Present and Future Bull Trout Habitat. Given the importance of an accessible large lentic water body to apparently sustainable bull trout populations in the Metolius and Lewis River systems, it would be helpful to estimate the likelihood of similar success in the upper Clackamas, which lacks such access. Inadequate lake or large river access and egress may be a limiting factor to a sustainable Clackamas bull trout population. The two identified donor stocks are associated with large reservoirs containing kokanee and rainbow trout that may serve as bull trout prey. The North Fork reservoir within the Clackamas River basin is smaller, lacks kokanee, and probably differs significantly in water residence time, stratification, nutrient regime, and primary and secondary productivity. It seems important to explain how these prey and limnological differences might affect potential reintroduction success. Given the requirement of bull trout for lakes or very large complex pools (e.g., Rieman and McIntyre 1993) and the frequent translocation failure of cutthroat trout due to insufficient habitat space (Harig and Fausch 2002), this issue would benefit from further explanation in the Assessment.*

Authors' Response:
The Clackamas River system does differ from others being considered as potential donor populations in its connection to a large water body. Not all of the potential donor populations come from river systems that have a connection to a large water body. However, the two most likely sources do (e.g., Metolius and Lewis rivers). The authors are unaware of any available data or information upon which could be drawn to make a correlation between a river system's lentic water body connection attributes and the success of bull trout reintroduction. In fact, the authors believe the life history plasticity of bull trout across the specie's rang is broad enough for a reintroduced population in the Clackamas River to express itself however it might based on the river's specific physical and ecological characteristics. While the authors hypothesize the historic bull trout present in the Clackamas River maintained a dominant fluvial life history type (Page 9 in the draft Assessment), they do not attempt to hypothesize what the dominant life history type of a re-introduced population might be nor what the controlling factors could be. Furthermore, it is important to realize that many of the river systems containing both historical and extant populations of bull trout did not historically contain lentic habitat connections. It was only after substantial hydroelectric dam developments in several river systems that such connections were artificially created. Additionally, other strong populations of bull trout exist in river systems without human-created reservoirs and nonnative fish (i.e., kokanee salmon). Two such examples are the bull trout populations in the Skagit and Middle Fork Salmon rivers.

IMST Comment: *Sufficiency of Present and Future Bull Trout Habitat. Given that upper Clackamas road densities exceed those associated with bull trout decline and extirpation elsewhere, the scientific credibility of the Assessment would increase if the authors provided scientific support for the likelihood of successful reintroduction in the upper Clackamas in the context of current road density. A brief discussion of stream crossings by roads is needed, especially the potential for barriers to upstream and downstream migrations by adult and juvenile bull trout. For example, Heller and Sanchez (2005) found that 90% of culverts in Oregon and Washington national forests impaired fish passage. It would aid this Assessment if scientific documentation were provided for why this is not a limiting factor in the upper Clackamas or the Mt. Hood National Forest.*

Authors' Response:
The authors did not intend to correlate the results of Quigley and Arbelbide (1997), an assessment conducted in the interior Columbia River Basin, with the current road densities in the Upper Clackamas River. Admittedly, the current road densities in most of the suitable spawning and rearing habitat patches within the Upper Clackamas River are higher than 1.7 miles/square mile. Quigley and Arbelbide (1997) did not conclude that road densities greater than 1.7 miles/square mile excluded bull trout, but that the probability of their presence declined. Road densities are associated with weaker bull trout populations in many areas; however, the mechanisms are not clear. In the case of the Metolius River which has a very strong and robust population of bull trout, the road network does not appear to have much of an influence in this stable, spring-fed dominated hydrologic setting. In a more sensitive watershed, a similar road density and network may have a more deleterious impact on the bull trout population. The authors believe the controlling suitable habitat attribute for the Upper Clackamas River is cold water. As stated in Chapter 2 of the draft Assessment, the geologic conditions of the Upper Clackamas River are quite stable and the negative impacts often associated with roads (i.e., landslides, surface erosion, interception of sub-surface flow, etc.) have not been detected through the detailed assessment completed as part of the watershed analysis procedure. The authors will provide a stronger basis and rational for this conclusion in the final Assessment with appropriate citations to the 1995 Upper Clackamas River Watershed Analysis. The authors will elaborate on this further in the final Assessment.

The authors are familiar with all road-fish passage surveys completed in recent years by Mt. Hood National Forest staff, and surveys of all suitable streams found no road-related barriers that would affect potential bull trout fish passage in the Upper Clackamas River. The authors will disclose this finding and provide a reference to the source of that information in the final Assessment.

IMST Comment: *Sufficiency of Present and Future Bull Trout Habitat. The Assessment would profit from a discussion on the degree to which current habitat and catchment conditions differ from those occurring when bull trout were extirpated from the Clackamas, and how they compare with those in other basins where bull trout populations are healthy and increasing. It would be especially useful to document and compare habitat, landscape, and riverscape conditions in basins with increasing populations against those in the Clackamas.*

Authors' Response:
The authors believe the 1995 Upper Clackamas River Watershed Analysis provides a sufficient assessment of changing watershed conditions from pre-European settlement (late 1800s) to the mid-1990s. In fact, the watershed analysis contains a complete chronology of management activities during this timeframe. While it may be informative to compare and contrast current conditions in the Clackamas River to other basins with increasing populations of bull trout, the authors do not believe this additional analysis is warranted or necessary.

IMST Comment: *Sufficiency of Present and Future Bull Trout Habitat. It would be valuable to provide more information about why bull trout populations in other basins are decreasing and to indicate the degree to which these problems have been addressed in the Clackamas. The authors' argument that negative effects stemming from forest management have been ameliorated is not convincing. The Assessment would benefit from an evaluation of possible forest wildfire and forest disease risks that may alter water quality in the upper Clackamas. New and more conservative riparian protection regulations will improve forest conditions in the future but do not address landscape alterations that still exist and may hinder the near-term success of a bull trout reintroduction. Riparian and upland forests in the upper Clackamas have been significantly altered by past forest practices. The current condition of the basin and the percentage managed as 'matrix' and subject to future road construction and timber harvest are well documented in Tables 2.3 and 2.4 of the Assessment. Quigley and Arbeldibe (1997) reported that bull trout are less likely to spawn and rear in streams where road densities exceed 1.1 km/ km^2. Yet the lowest densities in the upper Clackamas are in this range. This conflicts with the Assessment statement that there is sufficient high quality habitat in the upper Clackamas. Road densities in the basin are higher than, and range up to double, those observed to limit the distribution of bull trout elsewhere. This contradiction could be clarified if the Assessment provided scientific evidence that, in the absence of fisheries management practices that facilitated bull trout eradication, continued timber harvest and road construction would not have produced the same result. In addition, inclusion of scientific evidence supporting the contention that future timber harvest, road building, and stream crossing activities on 'matrix' land in the basin will not inhibit successful bull trout reintroduction would strengthen the Assessment.*

Authors' Response:
The authors will provide additional information and details from the 1995 Upper Clackamas River Watershed Analysis that assesses both anthropogenic and natural disturbances at the landscape scale as recommended by Diaz and Apostol (1992) in their "Forest Landscape Analysis and Design: A Process for Developing and Implementing Land Management Objectives for Landscape Patterns" U.S. Forest Service Technical Publication (R6 ECO-TP-043-92). Tiering to the watershed analysis will provide insight into where watershed, riparian, and aquatic habitat conditions are mostly likely to trend in the future under current management direction as prescribed for the Upper Clackamas River under the Mt. Hood National Forest Land and Resource Management Plan as amended by the Northwest Forest Plan. While there is still a legacy of past timber harvest and road building impacts observable today across the watershed when viewed from a landscape perspective, the authors have concluded that approximately 70 miles of suitable spawning and rearing habitat currently exist that would support a bull trout reintroduction effort.

The IMST comment pertaining to current road densities in the Upper Clackamas as they relate to Quigley and Arbeldibe (1997) was addressed above on Page 13.

Since the Riparian Reserve land allocation under the Northwest Forest Plan occurs along all streams and water bodies throughout the Upper Clackamas River (even on lands designated as "Matrix"), the authors believe sufficient protections will be provided for future timber harvest and road building activities so as not to degrade currently suitable bull trout spawning and rearing habitat. There is little scientific evidence upon which to base this conclusion other than the general improving trend observed in watershed and riparian conditions in the Upper Clackamas River over the last decade during the implementation of the Northwest Forest Plan. As stated above on Page 11, the authors believe the management standards and guidelines (i.e., protective measures) contained in the Mt. Hood National Forest Land and Resource Management Plan as amended by the Northwest Forest Plan are the most protective of any land management regulations in the State of Oregon pertaining to forest management related activities. The authors believe these protections are sufficient to maintain high quality habitat conditions in the future.

IMST Comment: *Sufficiency of Present and Future Bull Trout Habitat. The federal draft recovery plan states that "to protect and recover bull trout, lands with the most influence on streams must be managed primarily for bull trout and the riparian-dependent resources that bull trout depend upon." (page 111, USFWS 2002) It would be useful if the Assessment presented evidence that this is feasible in the upper Clackamas.*

Authors' Response:
The authors will include a reference to this draft recovery plan guidance in the final Assessment, and will point out that the Mt. Hood National Forest Land and Resource Management Plan as amended by the Northwest Forest Plan contains management direction and guidance consistent with this guidance.

IMST Comment: *Climate Change. IMST sees a need for the Assessment to explicitly address how predicted changes in temperature and precipitation regimes during the period 2010 to 2040 (e.g., increased rain-on-snow events, lower snow packs in the Cascades, changes in high and low stream flows) might influence the likelihood of a successful bull trout reintroduction. A comprehensive analysis would also address how these factors might influence the status of potential donor populations. Specifically, it would be wise to evaluate the effect of a potential 1–2º C (33.8–35.6º F) increase in temperature due to global warming on the long-term success of a bull trout reintroduction. Preston (2006), modeling the loss of cold water fish habitat, predicted median impacts associated with different temperature distributions suggested habitat loss in years 2025, 2050, and 2100 of approximately 10, 20, and 30%, respectively, for the US and 20, 35, and 50%, respectively, in the Rocky Mountains. Because bull trout require very cold water for spawning and rearing and much of the Clackamas River system has water temperatures that approach or exceed summer temperature tolerances, climate change could be a major factor in the success or failure of bull trout reintroduction.*

The Climate Impacts Group at the University of Washington has produced warming and precipitation predictions for the Pacific Northwest based on the latest available climate models. These can be found at http://cses.washington.edu/cig/fpt/ccscenarios.shtml. Table 1, below, summarizes these forecasts. Evaluation of how projected annual and seasonal precipitation and temperature changes, increased rain-on-snow events, and lower snow packs in the Cascades may affect critical temperatures and high and low flows for Clackamas bull trout is needed. Another useful analysis would be to forecast what the upper Clackamas landscape and the lower Clackamas riverscape will likely look like in 10, 50 and100 years, and to assess how those conditions might affect sustainable bull trout populations (e.g. Van Sickle et al. 2004).

Authors' Response:
The majority of suitable bull trout spawning and rearing streams in the Upper Clackamas River are ground-water fed or spring-fed. As such, these streams are likely to be less susceptible to potential water temperature increases that may occur due to anticipated global warming effects. Patches 2, 3, 4, and 5 (Figure 2.9 on Page 49 of the draft Assessment) occur entirely within the High Cascades geology and contain streams that are ground-water fed and spring-fed. Suitable bull trout spawning and rearing habitat in these patches is less likely to be affected should global warming effects become realized in future decades. Patches 1 and 6 are dominated by Western Cascades geology. Streams within these two patches tend to contain streamflows largely derived from surface-land flow, and therefore are more likely to be susceptible to potential water temperature increases should global warming effects be realized in the future. The authors will provide a discussion on potential affects from anticipated global warming in the final Assessment.

Chapter 3 – Conservation Genetic Considerations and Donor Stock Suitability

IMST Comment: *Vortex Modeling. The value and usefulness of the VORTEX simulation model would be significantly increased by showing and describing the VORTEX model, discussing how it was validated, and listing its assumptions. Also, an explicit description of the direction and magnitude with which these assumptions might bias the results (perhaps in a summary table) would be useful. For example, the strict order of life history events used by VORTEX (p. 80 of the Assessment) represents one such assumption that is identified but not completely addressed in the document. How does the assumption that introduced individuals are advanced to the next age class without any mortality bias the modeled probability of population persistence? Other assumptions inherent but not explicitly stated or discussed in this chapter include (but are not limited to) the absence of mortality associated with removal and translocation of propagules, absence of female mortality with the removal of eggs, the biological relevance of demographic schedules A and B as they apply to real bull trout populations, and the assumption that all propagules have unique genotypes. The substantial loss of heterozygosity and allelic diversity from donor populations when eggs are removed (compared to adults or juveniles; Figure 3.5, p. 86 in the Assessment) is not intuitive but would probably be more transparent if the assumptions underlying these models were more explicitly described.*

Authors' Response:
It is beyond the scope of the assessment to fully describe the theory and use of the VORTEX stochastic simulation model. The reader is referred to Miller, P.S., and R.C. Lacy. 2005. VORTEX: A Stochastic Simulation of the Extinction Process. Version 9.50 User's Manual. Apple Valley, MN: Conservation Breeding Specialist Group (SSC/IUCN). Appendix A contains "An Overview of Population Viability Analysis Using VORTEX" for model validation, assumptions, etc. and to Rieman and Allendorf 2001, for an example of the application of the model.

Because many of the results in Section 3.4 of the draft Assessment (Vortex Simulation Modeling) are derived from a manuscript that is still in preparation (Tallmon et al.), the authors recognize that it is somewhat premature to fully utilize this information. The VORTEX modeling exercise was performed to help provide insight into potential risks to donor populations, but these risks were explored by several other means as well. As such, conclusions made in the draft Assessment are supported by the VORTEX modeling results, but are not dependent on them.

Comments received from other reviewers of the draft Assessment have stated the VORTEX modeling exercise did not meet the stated intent or purpose because the modeling results were specific to implementation planning (i.e., numbers of fish to be used in reintroduction) and was not appropriate given the scope established by the authors.

For the above reasons, much of section 3.4 in the draft Assessment will be removed in the final version, with only brief mention of the preliminary results. As the manuscript by Tallmon et al. is peer reviewed and if the reintroduction effort moves into a planning stage, then it may then be appropriate to revisit the modeling exercise to provide an additional methodology to aid in specifying the number of propagules to be used in a reintroduction effort.

IMST Comment: *Vortex Modeling. … further elaboration of the genetic considerations would be helpful given that the genetic variation between bull trout stocks appears to be quite site-specific and not driven by drift and gene flow as commonly assumed (Whiteley et al. 2006). These insights would also relate to determining adequate patch size for sustainable populations, the adequate Ne needed for the reintroduced populations, and probable effects on donor stocks.*

Authors' Response:
As the IMST comment states, Whiteley et al. (2006) found low genetic variation within and significant differentiation among sample sites within the Boise River. Two groups of fish were associated with the two major subbasins in the system, which the authors attributed to long-term reduction of gene flow or distinct sources of colonization. They also observed a significant pattern of isolation by distance in one subbasin and not in the other; suggesting that the relative influences of gene flow and drift have differed between the two subbasins. Whiteley et al. (2006) hypothesized that the geometry and size of habitats may be important controls on the patterns of genetic variation within the subbasins sampled. The results provided little evidence of a patch-size effect, despite geographic isolation imposed by the discontinuity of thermally suitable habitats. Ecologically defined patches of suitable habitat were not good predictors of genetic variation among samples, hence the difficulty in relating adequate patch size or abundance to genetic population structure. Whiteley et al. (2006) did not presume that the physical and ecological processes influencing the genetic population structure of bull trout in one region will accurately reflect those in another region, thus they were reluctant to specify what constitutes an adequate patch as a function of genetic considerations, nor do they believe there is a rigorous or reliable way of predicting adequate population size for a given patch other than to specify the necessary genetically derived minimums (i.e., 50/500 rule). In relation to the Clackamas River, an attempt to address these questions could be made through implementation and monitoring if a reintroduction were to occur.

IMST Comment: *Vortex Modeling. The VORTEX modeling exercise is useful in that it allows the exploration of the range of donor population risk and reintroduction success under a restrictive set of assumptions and demographic schedules applied to the modeled population. However, the IMST believes that extreme caution should be exercised when using the results of these simulations to set absolute thresholds for propagule requirements or donor population size. Population viability analysis is more appropriately used to provide relative outcomes, not to predict absolute results (i.e., a minimum threshold for donor population size).*

Authors' Response:
The authors agree. VORTEX simulation results helped delineate broad risk categories for potential donor populations, but population viability analysis was not used as the sole source of information that defined potential donor populations or categories of risk. As detailed on Page 90 of the draft Assessment, broad risk categories were defined utilizing both Tallmon et al. model simulation results, the 50/500 rule, and the summation of the current status and trends of the five potential donor populations. The synthesis of these independent sources of information resulted in the three broad categories of risk to donor populations (i.e., low, intermediate and high). The authors also recognize that it is important to consider factors other than reproducing adult abundance or other surrogates of Ne. Adult abundance trends or trajectories observed for local populations are an important consideration. Trends in abundance help further refine the level of risk associated with the potential use as a donor stock. Information regarding risk can also be informed by examining the expected levels of heterozygosity for each local population (Spruell et al. 2003) found in Table 3.2 of the assessment, or by other metrics such as F_{st} (the reduction in heterozygosity of a local population due to genetic drift (Hartl 1988)), and can be used as an indicator of relative levels of gene flow. The use of this type of information can provide insight regarding the dynamics or interactions between local populations. The authors believe that this strategy is consistent with predicting relative outcomes and does not define absolute thresholds. As cautioned on Page 85 of the draft Assessment, the results from these simulations should be interpreted only as a means to compare the relative risks and benefits of the scenarios simulated.

IMST Comment: *Vortex Modeling. Using demographic schedule A on page 80 in the Assessment, 2500 eggs results in 1.1 adults in age class 4+. Over 5 years of stocking, this would result in 5.5 adults. Using schedule B, 2500 eggs results in 3.9 adults in age class 4+, and 19.5 adults in 5 years. This implies low probability of introduction success when using 2500 eggs, the need to use more donor eggs, the necessity of using another life stage, or to somehow increase survival rate. In any event it weakens the case for reintroduction and indicates a need to better estimate stocking needs and strategies. Although large numbers of eggs could provide the most alleles, with 99% mortality it will require a very large number, which is one reason few fishery agencies currently stock eggs in streams.*

Authors' Response:
The authors agree that the modeled results suggest that using life stages other than eggs will increase the probability of success. As stated above on Page 2, the draft Assessment only addresses the biological feasibility of a reintroduction and makes no attempt to specify strategies for implementation. When drafting an implementation plan should reintroduction be pursued, it may be determined that using a variety of different life stages would result in a high success rate. It may be determined that rearing fish in a captive environment to increase survival would be a valid strategy. There are likely a number of strategies that would be explored in an implementation plan. Chapter 3 on the draft Assessment only addresses the genetic criteria necessary to reduce genetic risk associated with small population sizes; it does not attempt to resolve demographic or abundance criteria. An implementation plan may specify significantly more fish be introduced than the necessary genetic criteria minimum.

As stated above on Page 17, much of Section 3.4 in the draft Assessment will be removed from the final version, with only brief mention of the preliminary results. As the manuscript is peer reviewed and if the reintroduction effort moves into a planning stage, it may then be appropriate to revisit the modeling exercise to provide an additional methodology to aid in specifying the number of propagules to be used in a reintroduction effort.

IMST Comment: *Vortex Modeling. It would be wise for the CRBTWG to determine if 5 years of stocking are enough, and whether the introduced bull trout populations can survive on their own without improbable immigrations from another population. Similarly, it is advisable that the CRBTWG determine whether stocking must be continuous, creating a dependent bull trout population. Also, it would be helpful to briefly explain why it was assumed that 2,500 eggs were added (and presumably that all survived to age 1). Would not 25–100 surviving eggs be more likely? Likewise, it might clarify the issue to briefly explain why it was assumed that 25 introduced adults would all survive and reproduce in year one, versus, for example, half that many.*

Authors' Response:
Based on VORTEX modeling results, five years of stocking is sufficient to meet the necessary minimum genetic criteria to confer population persistence of the newly founded population. The authors are not aware of another way of determining whether five years of stocking will be enough. This issue is likely better addressed through a rigorous monitoring program and adaptive management strategies that adjust accordingly should reintroduction be pursued. The modeling effort provided relative outcomes based on a defined set of assumptions while attempting to maintain minimum genetic criteria. Similarly, the authors are unaware of a methodology which could be utilized to determine whether the newly founded population will be dependent on continual stocking. The authors believe that careful monitoring (both demographically and genetically) would reveal whether continued stocking must occur (to either boost abundance or increase genetic diversity) should reintroduction be pursued.

In regard to the IMST questions concerning the mechanics of the model, because many of the results in Section 3.4 (Vortex Simulation Modeling) of the draft Assessment are derived from a manuscript that is still in preparation (Tallmon et al.), the authors recognize that it is somewhat premature to fully utilize the information. The VORTEX modeling exercise was performed to help provide insight into potential risks to donor populations, but these risks were explored by several other means as well. As such, conclusions made in the draft Assessment are supported by the VORTEX results, but are not dependent on them.

IMST Comment: *Vortex Modeling. Given the stream lengths, widths, gradients, and habitat complexities of the 6 patches, it would be useful for CRBTWG to estimate the potential carrying capacities for bull trout in each of the 6 patches. This could help evaluate the survival potential of this metapopulation if the transplants are successful. Also, it might improve estimates of the stocking sizes and propagule types needed. Using the Assessment's genetic risk information, are 50 or 100 adults in each of 6 patches a reasonable and sufficient target? If habitat is limiting for some unknown reason, the number of fish stocked to create a desired Ne might create an unrealistic drain on donor populations. On the other hand, if half the propagules die because of unaddressed compensatory or density independent limiting factors, the CRBTWG might wish to stock twice as many. This also could have a serious negative effect on the donor populations without increasing the Ne in the Clackamas, or it could create the need for the reintroduction attempt to be abandoned midway.*

Authors' Response:
Given that bull trout have been extirpated from the Clackamas River Subbasin, the authors are unaware of any reliable methodology to predict the carrying capacity of the habitat patches described in Chapter 2 of the draft Assessment. The authors described the supporting evidence to suggest the necessary habitat elements are present within the Clackamas River Subbasin to support a bull trout reintroduction. The authors do not view the habitat patches as distinct, isolated, independently functioning habitats, but rather as a loosely defined series of interconnected habitats that can all support bull trout. Although the habitat elements are present in the patches, the authors have no reliable way of predicting which patches are most likely to be utilized by reintroduced bull trout. The authors make no prediction that 50 or 100 adults will utilize each of the six patches. Further, the authors do not assert that 50 or 100 adults are sufficient abundance targets. The authors do not specify abundance targets as it is not germane to answering the question of biological feasibility as the defined scope for the draft Assessment described above on Page 2. Fifty adult bull trout is the necessary minimum effective population size (Ne) to confer a lower risk of the immediate effects of inbreeding depression or genetic drift. This criterion is solely a genetic risk parameter and in no way is to be considered demographic or abundance criteria.

The authors agree that if habitat is limiting for some unknown reason, the number of fish stocked to create a desired Ne might create a significant drain on donor populations. The authors also agree that if half the propagules die because of unaddressed compensatory or density independent limiting factors, there may be a necessity to stock twice as many. These situations are most appropriately addressed in a proposed action or an implementation plan and as a central component of the monitoring and adaptive management strategies.

IMST Comment: *Bull Trout Donor Stocks. Like the CRBTWG, the IMST is concerned about donor stocks. The Lewis River stock may be more suitable than the Metolius stocks because no individual Metolius stream appears to have greater than 500 bull trout. Also the Metolius stocks are unlikely to have been exposed to whirling disease or Type 2 strain infectious hematopoietic cecrosis (IHN) and will be vulnerable when introduced to the Clackamas where the pathogens for these diseases exist. The Lewis River system has a large bull trout population that has not been bottlenecked and possibly has had exposure to these two pathogens. On the other hand, it would seem wise to evaluate the likelihood of introducing diseases and parasites from the Metolius or Lewis to the Clackamas. In general, it is best that disease and parasite issues such as these be carefully examined before implementing any introductions.*

Authors' Response:
In terms of suitability of donor stock based on population size, the authors believe the Metolius River bull trout population is as suitable as the Lewis River population. There is evidence that bull trout in the Metolius River function as complexes, or intermingling spawning aggregates, and there are several that exceed 500 adults. The authors could have made this information more evident in the draft Assessment, and will do so in the final version. In addition, there is currently a genetic analysis underway conducted by the U.S. Fish and Wildlife Service (expected to be completed in 2008) that will further clarify the level of discreteness between populations of bull trout in the Metolius River. Relevant new information from this study should be taken into consideration should a reintroduction effort be pursued.

The authors agree with the IMST that the issue of disease susceptibility and transfer is significant. To that end, the authors have engaged the U. S. Fish and Wildlife Service's Lower Columbia Fish Health Center to provide a disease analysis for further assessment. The primary objective of the analysis will be to assemble known information on disease presence in the Clackamas, Lewis and Deschutes rivers. Information gaps will be addressed by field surveys and subsequent lab analysis by Fish Health Center staff. Their analysis and report are expected to be completed and submitted to the CRBTWG in 2007.

IMST Comment: *Bull Trout Donor Stocks. It would be helpful for the CRBTWG to evaluate the degree to which Metolius bull trout that are locally adapted to east side conditions will do well on the west side. The Assessment does not resolve whether the Metolius patches are interconnected in such a way as to allow substantial genetic mixing (p. 91). A detailed map showing the Metolius catchments would be helpful, as would discussion of genetic analyses on the putative populations (with citations). It would also be helpful if the number of donors required to establish a viable population were reexamined and clearly supported in a scientifically rigorous manner. Lastly, we caution the CRBTWG to confirm and quantify the bull trout metapopulation dynamics of the Metolius River basin before removing bull trout from these populations.*

Authors' Response:
The authors agree that there are likely differences between East-side Cascade and West-side Cascade bull trout populations based on environmental conditions. However, the headwaters of the Clackamas River and Metolius River, despite being situated on opposite sides of the Cascade Crest, share the same parent geology (New Cascade) and their close proximity to each other likely results in similar hydrologic conditions. In the absence of a more detailed analysis, the authors believe the environmental differences between the upper basins of these two watersheds are not so great as to negate the consideration of Metolius River bull trout for consideration in a Clackamas River reintroduction.

The draft Assessment provided little analysis regarding the interconnectedness of bull trout from the various spawning streams in the Metolius River because there is little information available. The bull trout spawning "complexes" described in the draft recovery plan for the Deschutes River Basin are based on very limited data collected in a radio-tagging study conduced in 1993 and 1994. As noted above, there is a genetic analysis underway conducted by the U.S. Fish and Wildlife Service (expected to be completed in 2008) that will further clarify the level of discreteness between populations of bull trout in the Metolius River. Relevant new information from this study should be taken into consideration should a reintroduction effort be pursued.

The authors are unaware of any scientifically rigorous manner or any translocation/reintroduction example that specifically attempts to determine the number of individuals required to successfully found a new population. Section 3.3 of the draft Assessment, provides a comprehensive discussion of the genetic considerations that should be addressed in an reintroduction attempt. Rather than specify a number of individuals required for translocation, the authors believe it is more appropriate to define goals in the context of minimum genetic criteria, namely the 50/500 criteria. The minimum number of individuals that would be required must be sufficient to found a new population (over a given number of years) that would result in an effective population size (Ne) of 50 so as to substantially reduce the effects of genetic drift and/or inbreeding depression. This may be 50 adults or any number/combination of other life stage individuals that would be equivalent to 50 adults (with specified mortality rates for selected life stage). This approach is consistent with taking a risk-adverse approach in regard to affects to the donor stock. Monitoring and adaptively managing a reintroduction effort would be paramount to successful reintroduction and ameliorating any potential adverse impacts to the donor population as a result of unnecessarily over-extracting donor stock. Additionally, the VORTEX stochastic simulation model was employed to help elucidate the number of individuals of different age classes that would be required to found a new population in the Clackamas River Subbasin and confer long-term persistence and high levels of heterozygosity. As explained above, due to the preliminary nature of the VORTEX modeling effort, the authors believe that the modeled results lend support to the conclusion of biological feasibility, but are likely more appropriately presented in an implementation plan should a reintroduction effort be pursued.

Chapter 4 – Ecological Interactions and Food Web Considerations

IMST Comment: *Brook Trout Interactions. The assessment too easily dismisses brook trout predation, competition, hybridization, and potential dispersal to other catchments. Oregon bull trout have been outcompeted by other salmonids in warmer water temperatures (Ratliff 1992; Dambacher et al. 1992). An explanation of why or why not the same might have occurred in the past and its likelihood of reoccurring in the upper Clackamas would be useful. One conservative approach would be to eliminate patch 3 or cut it in half and not stock bull trout where brook trout are apparently self sustaining. Another option might be a brook trout eradication program.*

Authors' Response:
Brook trout are localized in a portion of Patch 3 only (Figure 4.1 on Page 95 of the draft Assessment). Efforts to curtail high lake stocking in those lakes with tributary outlets began in 2003. The authors believe the brook trout present in Squirrel Creek may be self-reproducing. A more detailed response and explanation is provided under the second IMST question below for Chapter 4.

IMST Comment: *Brook Trout Interactions. IMST suggests that the CRBTWG evaluate brook trout introgression in the potential bull trout donor stocks.*

Authors' Response:
The authors agree that brook trout introgression with potential bull trout donor stocks is an important consideration. However, no information exists on introgression for the two most likely donor populations (Metolius River and Lewis River). Information exists suggesting brook trout are present in several of the spawning streams in the Metolius River (Abbot, Brush, Canyon creeks), and they have been documented in tributaries of Pine Creek, a primary spawning tributary in the Lewis River. However, presence of brook trout does not necessarily mean the two species are hybridizing.

Several studies have shown that bull trout and brook trout partition themselves in a watershed based on water temperature and stream gradient, with brook trout preferring warmer water temperatures and lower gradient stream reaches than bull trout (Rich et al. 1997, Paul and Post 2001, Dunham and Rieman 1999, Dunham et al. 1999).

Other studies suggest hybridization is most common where isolated or remnant bull trout populations overlap with brook trout (Cavender 1978; Leary et al. 1983, 1991; Markle 1992). Small resident bull trout populations are particularly susceptible to hybridization from co-occurring brook trout because individuals of spawning age are similar in size, and both spawn in the fall utilizing similar spawning habitat.

Although brook trout distribution overlaps some areas within the two most likely donor populations, available information suggests introgression is likely occurring at a low level, if at all. Both the Metolius and the Lewis rivers contain an abundance of cold water spawning habitat as well as large, healthy, fluvial populations of bull trout.

IMST Comment: *Brook Trout Interactions. Is there any evidence of recent range extension or population increases by brook trout in the upper Clackamas? If such evidence does not exist, has it been evaluated? Providing explicit scientific reasons why brook trout in the upper Clackamas will not threaten bull trout through competition, predation, and hybridization as it has elsewhere would help convince readers that brook trout would not affect success of the plan in the Clackamas system. In comparing successful and failed greenback cutthroat trout reintroductions, Harig et al. (2000) determined that 48% were reinvaded by nonnative salmonids and 43% had unsuitable habitat.*

Authors' Response:
From interviews with early U.S. Forest Service employees, it is known that high lake stocking goes back to at least the 1920s and perhaps earlier in some locations. Brook trout were often a favored species (Murtagh et al. 1992). Many lakes in the Olallie Lakes Scenic Area and lakes feeding Squirrel Creek in the uppermost headwaters of the Clackamas River have been stocked with brook trout for many decades. Other high lake areas in the Clackamas River Subbasin that also had long histories of brook trout stocking were the numerous lakes of Bull of the Woods Wilderness Area, Round Lake in the Collawash River Watershed, and Hideaway Lake in the Oak Grove Fork Watershed (Pederson 2003; USFS 1995). In some of these lakes, naturally reproducing populations of brook trout exist, have apparently been in existence for some time, and have often been bolstered with additional aerial stocking of brook trout. Despite this, naturally reproducing brook trout populations appear to be restricted to the same foothold areas such as Round Lake and Hideaway Lake areas that they have been populated for years and do not appear to be pioneering additional habitat away from these areas (Zimmerman 1999; Strobel 2005; USFS 1995).

For instance, during bull trout validation snorkel surveys performed in 1992 in the Collawash River, no brook trout were observed during the effort, despite many adjacent high lakes upstream within the Bull of the Woods Wilderness or from nearby Round Lake that could have supplied numerous, straying brook trout. A similar situation exists in the Upper Clackamas River headwaters where many lakes containing brook trout or stocked heavily with brook trout could have facilitated an expansion of brook trout. Despite this opportunity, during presence/absence bull trout night snorkel surveys in 2004, brook trout were only observed in the very uppermost reaches of the Clackamas River and in Squirrel Creek. These distributions of brook trout are very similar to those observed during snorkel surveys in the early and mid-1990s (Eberl and Kamakawa 1992; Strobel 2005; USFS 1995; Zimmerman 1995). Many nearby and accessible streams in this area support coastal cutthroat but not brook trout (Strobel 2005, USFS 1995). In 1994, a large scale survey effort of 111 streams using electroshockers in the Clackamas River Subbasin was initiated to verify resident fish distribution against earlier "best guess" mapped fish distributions in 1990. The original 1990 "best guess" brook trout distributions were found to be overestimated. Only five out of 111 streams sampled were found to have brook trout – Sluice, Fish, Shellrock, Bump, and Squirrel creeks. Bump Creek is a tributary to Squirrel in the Upper Clackamas River headwaters (Baker et al. 1994). On the mainstem Clackamas River, about two miles downstream of Patch 1, a rotary smolt trap was operated for a number of years (1999 -2002) by the U.S. Forest Service, Pacific Northwest Research Station for the Clackamas River Fisheries Working Group. This smolt trap captured large numbers of steelhead and coho smolts, as well as lesser numbers of rainbow and cutthroat trout, mountain whitefish, and sculpin. Brook trout were never captured (Clackamas River Fisheries Working Group 1999-2002).

From most observations, naturally reproducing brook trout populations in the Clackamas River Subbasin typically appear to be limited to low gradient streams, often with beaver dam habitat, or habitat that was originally fishless (above barriers) and/or with little or no competition from native fish (Strobel 2005, USFS 1995; SWCA Environmental Consultants 2004). Very few lakes in the Clackamas River Subbasin originally supported coastal cutthroat trout and where brook trout have been introduced into high lake and pond habitat they have thrived. Are brook trout better adapted to lake habitat in this subbasin but less adapted to higher gradient stream environments, where native cutthroat and rainbow trout dominate? In Patch 3, brook trout were observed in low abundance only in the uppermost reaches of the Clackamas River, often where the gradient was low, and August/September temperatures were very cold (4 - 6 degrees C.). Much of this low gradient, very cold stream habitat appeared structurally ideal for trout but large sections had no evidence of any fish species when it was night snorkeled in 2004, except for three reaches with brook trout (Strobel 2005; SWCA 2004). Even in the reaches with brook trout present, apparently ideal complex habitat was often void of fish. A short distance downstream of this reach, where temperatures were somewhat warmer, native cutthroat were numerically dominant with only one brook trout observed (Strobel 2005; SWCA 2004). Strobel (2005) speculated that the apparent lack of overlap between brook trout and cutthroat trout in the headwaters of the Clackamas River above RKm 125, may be an example of interspecific competitive exclusion of one species by another with the brook trout taking refuge in less hospitable frigid headwaters.

Where brook trout are found in potential spawning and rearing habitat for bull trout in the upper Clackamas River, competition, predation, and hybridization cannot be ruled out. Since night snorkel surveys and earlier daylight surveys found low numbers of brook trout in suitable spawning and rearing habitat for bull trout, the threat from potential brook trout competition and predation would appear to be at low risk but would not be entirely absent. Juvenile bull trout would likely encounter higher predation risk from the more abundant coastal cutthroat and rainbow trout found in these stream reaches. The brook trout encountered were also small in size (usually under 200 mm) which also may greatly limit but not rule out hybridization with bull trout (SWCA 2004). The authors will include pertinent components of this more robust discussion contained herein within the final Assessment.

IMST Comment: *Bull Trout Transfers. More concern seems warranted about the effect of introducing bull trout on top of existing salmon populations. Specifically, IMST suggests that CRBTWG evaluate the potential maximum loss of anadromous salmonids to predation and competition by bull trout. Similarly, IMST advises the CRBTWG to consider how it will educate stakeholders who might view bull trout as a scapegoat for declining salmon populations. The CRBTWG would be wise to explain how it plans to approach federal Endangered Species Act concerns and permitting issues related to the reintroduction of one threatened species regulated by the USFWS on top of another that may serve as prey and that is regulated by the NMFS.*

Authors' Response:
The IMST suggests inclusion of a more detailed analysis of potential effects to anadromous salmonids from predation and competition. While the authors agree this issue is an important one, especially from a socio/economic perspective, they do not believe it is necessary to further address this issue in the Assessment as the scope for it is specifically spelled out above on Page 2. The authors' intent in the draft Assessment was to focus on the biological feasibility of reintroduction, while only touching on related subjects such as potential effects of reintroduction on other species.

Should a reintroduction proposal be pursued, consideration would have to be given by the appropriate state and federal management agencies to potential interactions between bull trout and anadromous salmonids in the Clackamas River. This would likely be done as part of the environmental analysis and regulatory/procedural requirements. Such consideration would need to occur in a Section 7 ESA consultation between the U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS) to assess effects to listed salmon and steelhead under the jurisdiction of NMFS.

While the authors believe it is necessary to explore the means of assessing impacts to anadromous salmonids from competition and predation, a meaningful analysis may be exceedingly difficult to conduct. Food web interactions can dramatically alter the net effect of a predator on prey. For example, bull trout eat not only salmon, but predators of salmon, including northern pikeminnow, resident trout, and sculpins. Given that bull trout eat these fish, as well as salmon, what is their net effect on salmon? It is hard to tell with a simplistic modeling exercise that addresses only a limited number of species in the ecosystem. By consuming other predators of salmon, or in changing their behavior, bull trout could have a net positive effect on juvenile salmon survival. Regardless of the method used to assess potential predation/competition effects on anadromous salmonids, there would have to be further assessment of this subject in consultation with NMFS if a reintroduction effort is proposed.

The IMST advises the authors of the importance of education and outreach on the issue of bull trout competition and predation with salmon and steelhead. The authors acknowledge outreach on this issue will be paramount to moving forward with implementation of a reintroduction should it be pursued. However, it is not the intent of the authors to address outreach and education within the Assessment since that would best be undertaken at the time a proposed action for reintroduction is developed.

Along the same line, the authors did not intend to address ESA and permitting concerns in the Assessment. At the time when a proposed action is developed, these issues would be dealt with and coordinated by the appropriate state and federal management agencies.

IMST Comment: *Bull Trout Prey. The assumption that the native fish assemblage in the Clackamas River is healthy, diverse and abundant is testable and it would make sense to test that assumption. At the very least it is advisable to monitor it before and after reintroduction should it occur. In addition, the CRBTWG appears to assume that there are ample prey fish, particularly non-salmonids, to support adult bull trout in the upper Clackamas. However there are insufficient data presented to support this assumption. It would be useful for the CRBTWG to provide scientific survey evidence that the Clackamas and upper Clackamas fish assemblages are healthy. That would include how the CRBTWG defines a healthy versus an unhealthy fish assemblage. An additional valuable piece of information is to determine the size and composition of a fish forage base required for adult and sub-adult bull trout in a healthy bull trout population. An adequate prey base to support bull trout maturation and successful reproduction is best evaluated rather than assumed.*

Authors' Response:
The authors agree that the assumption – the native fish assemblage in the Clackamas is healthy, diverse and abundant – is a testable one. However, data are not currently available to test this. Instead, the authors believe information available on the relative health and current management of the Upper Clackamas River, combined with first-hand knowledge from local biologists, provides enough evidence that the native fish assemblage is likely healthy. The IMST advises monitoring the health of the native fish assemblage before and following a possible reintroduction. While the authors support the notion of monitoring, the collection of pre- and post-project information on forage base is outside the scope of the Assessment and would be more appropriately addressed in an implementation plan.

The IMST also suggests the authors determine the size and composition of a fish forage base required for adult and sub-adult bull trout in a healthy bull trout population. The authors are unaware of any available information, published or unpublished, to help address this comment.

IMST Comment: *Bull Trout Prey. If the lower Clackamas and Willamette are expected to provide prey for adult bull trout, an evaluation of their ability to freely pass the mainstem dam complexes is called for.*

Authors' Response:
The authors addressed the potential for bull trout passage impediment at the mainstem Clackamas River dams in Section 1.7 of the draft Assessment. This comment was addressed previously on Page 11 above.

Depending on the success of a potential reintroduction, some bull trout may migrate through the dams into the lower Clackamas and mainstem Willamette River. However, based on the migratory habitats of other lower Columbia River bull trout populations that exist above dams (e.g., McKenzie, Lewis, and Metolius rivers), the authors would not expect a significant portion of the adults to do so.

IMST Comment: *Bull Trout Prey. … IMST advises an evaluation of the degree to which the high levels of toxic chemicals in the lower Willamette River might reduce the fitness of bull trout that feed there.*

Authors' Response:
As noted in the response to the comment above, the authors do not expect a significant portion of a re-established bull trout population in the Clackamas River to migrate below PGE's dams into the lower Willamette River. In addition, based on age of maturity and probable low population size at the onset of a reintroduction program, potential use of the lower Willamette River by bull trout from the Clackamas would likely not occur for over a decade. Given this combined with the fact that the lower Willamette River constitutes such a relatively small portion of potential habitat for bull trout associated with a potential reintroduction into the Clackamas River Subbasin, the authors do not see the utility of conducting a lower Willamette River water quality evaluation at this time.

General Conclusions

IMST Comment: *General Conclusions. In conclusion, the IMST believes the Assessment is a serious, well considered review of the feasibility of reintroducing bull trout into the Clackamas basin that addresses the pros and cons associated with such an activity. In our review, we have stressed areas where we believe it would be wise to increase the Assessment's scientific credibility. However, our review should not be taken to imply that the IMST does, or does not, endorse bull trout reintroduction into this system; IMST does not express an opinion on this point, nor was it asked to. If the precautionary principle is followed and no or minimal harm to local species or donor stocks are probable, then a reintroduction may make sense. In any case, it would be wise to view a reintroduction as a scientific experiment that would include adequate pre- and post-introduction effectiveness monitoring of both target and non-target species and their immediate and landscape-scale environments.*

Authors' Response:
The authors agree with the IMST that a reintroduction effort should be accompanied by adequate pre- and post-introduction effectiveness monitoring of both target and non-target species and their immediate and landscape-scale environments. The authors emphasize the need for monitoring within an adaptive management framework in Section 5.3 of the draft Assessment. The development of monitoring and adaptive management strategies would be most appropriate at the time a reintroduction proposal is developed should it be pursued.

IMST Comment: *General Conclusions. IMST strongly endorses the intention articulated in the Assessment to use an adaptive management approach if a reintroduction is attempted. There are three scenarios that warrant consideration for adaptive management if a reintroduction plan is developed. 1) The reintroduction is successful with no harm to donor or resident fish assemblages. What near-field and far-field factors insured or aided that success and how can they be continued? 2) The reintroduction failed and the donor stock was harmed. What are the possible adaptive management scenarios to avoid its extirpation? 3) The bull trout reintroduction was successful but negatively affected the native fish assemblage. What is the adaptive management recourse? Another consideration for a reintroduction plan is a thorough review of the trout reintroduction literature (e.g. Harig et al. 2000; Harig and Fausch 2002) which documents variables associated with successes and failures.*

Authors' Response:
The authors appreciate the IMST's effort in framing three potential scenarios that warrant consideration for adaptive management if a reintroduction proposal is developed. These scenarios and questions posed would be further evaluated at a later date should a reintroduction plan be developed and could be tailored specific to the donor population(s) used in a reintroduction effort. With regard to determining the biological feasibility of reintroduction (i.e., Can a reintroduction of bull trout into the Clackamas River be done?), the authors believe there are no major uncertainties. The three scenarios identified for adaptive management have to do with potential ecological interactions and donor stock impacts.

Specific Comments

Executive Summary

IMST Comment: *Bullet three might read: "Is suitable habitat reasonably expected to be recolonized through natural processes if conditions are improved?"*

> **Authors' Response:**
> This editorial correction will be made in the final Assessment.

IMST Comment: *Question in quotes at bottom of page might be expanded to include "successfully and without harm to current resident fish and donor stocks".*

> **Authors' Response:**
> The authors will consider making this suggested editorial change.

IMST Comment: *Is fishing pressure included in socio-economic impacts? Explain why or why not changes in fishing regulations must be considered prior to bull trout reintroduction.*

> **Authors' Response:**
> The authors have not yet identified all of the potential socio-economic impacts to be considered for evaluation should a proposed action for reintroduction be developed. A review of existing fishing regulations might be warranted during evaluation of a reintroduction proposal; however, the authors do not consider such a review as essential prior to an actual reintroduction. The Oregon Department of Fish and Wildlife reviews sport angling regulations throughout the state, including the Clackamas River, on a regular basis and frequently makes changes or adjustments as deemed necessary and based on public input and review.

IMST Comment: *p. 1. Specify here how many bull trout adults and how many per square kilometer constitute a self-sustaining population.*

> **Authors' Response:**
> As stated above on Page 6, the authors are unaware of any available data or information that could be used to help answer this question. To their knowledge, no such data or information exists.

IMST Comment: *p. 2. Multiple reintroduction strategies are worthy, versus "may be" worthy of consideration.*

> **Authors' Response:**
> This editorial correction will be made in the final Assessment.

IMST Comment: *p. 3 & 110. The fact that no data were found indicating that bull trout predation limited anadromous salmonids does not indicate whether it does or not, or even if it was studied. Such statements raise the specter of type-2 error.*

Authors' Response:
This statement will be clarified in the final Assessment.

Chapter 1 – History, Status, and Draft Recovery Plan Guidance for Bull Trout in the Clackamas River Subbasin

IMST Comment: *p.1. The CRBTWG states that the Assessment is focused "very specifically" on the feasibility of reintroduction, yet the document is more than that. There are four main questions addressed in the document as listed on p. 3 and two relate to reintroduction.*

Authors' Response:
Although two of the four main questions do not specifically address "biological feasibility of reintroduction," the authors believe they naturally fit into the assessment and serve an important role in providing background information justifying the development of feasibility study. The authors acknowledge that other sections of the document also address issues beyond the primary intent of addressing "biological feasibility of reintroduction." For example, Section 5 on monitoring was developed to highlight the authors' belief in the importance of monitoring and to acknowledge that it should be a significant component of a future reintroduction. The authors' intent was to introduce important subjects that will be addressed in more detail in a future proposal for reintroduction or an implementation plan should reintroduction be pursued.

IMST Comment: *p. 3. Specify the percents of BLM, USFS, and private lands in the upper basin, and indicate their locations.*

Authors' Response:
The entire Clackamas River Subbasin encompasses 243,103 hectares (607,758 acres). Approximately 71 % of the total watershed is in U.S. Forest Service or Bureau of Land Management (BLM) federal ownership. Approximately 2.8 % is in tribal ownership on the extreme eastern edge of the watershed (Confederated Tribes of Warm Springs ownership).

In the Clackamas River Subbasin within the National Forest boundary (171,051 hectares), there are 165,540 hectares (413,850 acres) of National Forest ownership or 96.8 % of the land base, 1,602 hectares (4006 acres) BLM or 1 % of the land base, and 3,909 hectares (9,772 acres) of private or 2.2 % of the land base approximately.

The Upper Clackamas River which consists of the entire watershed upstream of the river's confluence with Collawash River and where all suitable bull trout spawning and rearing habitat is located, encompasses 40,624 hectares (101,560 acres). This 5th field watershed is largely Forest Service ownership at 38,105 hectares (95,263 acres) or 93.8 % Forest Service. Private land encompasses 64.4 hectares (161 acres) or 0.2% and 2,240 hectares (5,600 acres) or 6% are tribal ownership (outside of the Forest boundary).

IMST Comment: *p. 9, half way down. If possible, provide a citation for the statement beginning "This assumption is consistent with…."*

Authors' Response:
A review of current distribution and presence/absence survey information on bull trout populations in tributaries of the Lower Columbia River Basin on the western side of the Cascades Range suggests there are no known populations outside the zone of anadromy (upstream of known fish barriers). If above barrier habitat was occupied by bull trout in the past, there is a high likelihood it would be occupied at present (at least in moderate to low abundances) since these areas are often high in the watershed and offer protection from land management activities, angling, and nonnative species. Based on this information it is logical for the authors to assume bull trout did not occupy above barrier habitat in the Clackamas River Subbasin. No citation necessary.

IMST Comment: *The CRBTWG confirmed the historical presence of bull trout in entire river segments if 'enough' confirmed sightings were documented within close proximity. How many confirmed sightings constitute 'enough' to determine historical presence throughout a river segment and what length of river constitutes a segment to which this index was applied?*

Authors' Response:
As shown in Figure 1.4 on Page 11 of the draft Assessment, the authors developed a map depicting the historical distribution of bull trout in the Clackamas River Subbasin from available data and information. The authors state on Page 9 of the draft Assessment: "In the upper portion of the subbassin, enough confirmed sightings within close proximity of one another were determined to be sufficient … to map entire segments of river as confirmed for historical bull trout presence." The authors relied only upon one confirmed sighting as a point source of data. If the confirmed sightings were within close proximity of one another (within four to five miles), then the authors mapped the adjoining segment of river as "confirmed presence" instead of "probable historic distribution."

IMST Comment: *p.10. Indicate the causes of warmer water temperatures since 1850, as well as steps being taken to reverse the trend.*

Authors' Response:
The "Tier Four" streams and sections of streams were mapped as within the probable historic distribution of bull trout. It was assumed that these streams and segments of streams were in better condition for bull trout rearing in the mid to late 19th Century before large scale settlement and development occurred. Warmer water temperatures are just one example of less desirable conditions that may have impacted their suitability for bull trout today.

In the lower Clackamas River Subbasin, downstream of the National Forest, elevated summer water temperatures from removal of riparian vegetation for farms, house sites, sewage treatment plants, golf courses, etc. have greatly contributed to loss of shade and greater solar warming of tributary streams. Other impacts from these human developments to some of these same streams include increased sedimentation, increased nutrient inputs, pesticide residue in runoff, water withdrawals, etc. Historically, these same areas mostly had intact riparian forests or native prairie vegetation and in many cases probably better water quality compared to the present. They may not have been cold enough even historically to provide bull trout spawning or early rearing habitat but during the cooler months these same streams may have provided sub-adult and adult rearing habitat. On the National Forest lands in the Clackamas River Subbasin, riparian reserves protect remaining forested riparian areas from clearing activities. Previously harvested riparian areas on the National Forest are recovering and providing increasing shade to stream habitat and lowering thermal inputs. These riparian forests are managed for late seral forest development. "Tier Four" streams that are still largely forested land, have good water quality, and with mostly intact riparian zones, may still provide good quality habitat for bull trout. This is a reasonable assumption since migratory bull trout currently rear in the mainstem Snake River and bull trout have been occasionally reported from the mainstem Columbia River, even though these major rivers support large human population centers and receive their runoff (Buchanan et al. 1997).

IMST Comment: *Clarify the apparent contradiction in bull trout distribution described here with that on page 3.*

Authors' Response:
The authors were unable to find the stated contradiction based on the detail provided in this comment.

IMST Comment: *pp.12-17. With one cottid exception, all the fish survey results reported indicate that only cutthroat and rainbow trout and coho and Chinook salmon are likely present in the upper basin. Yet elsewhere it is implied that healthy populations of cyprinids and catostomids are present and potential bull trout prey. Clarify this contradiction.*

Authors' Response:
The authors do not believe there is a contradiction. The surveys noted on Pages 12-17 of the draft Assessment occurred in areas thought to be potential bull trout spawning and early juvenile rearing habitat. Typically these areas are too cold and unproductive to produce abundant and diverse fish fauna. These are good areas for egg laying, incubation, and early juvenile rearing where the primary forage is invertebrates. In the case of fluvial bull trout populations, older juveniles and adults depend on larger, warmer, more productive areas lower in the watershed to produce the abundant and diverse forage base necessary to grow large and fecund.

IMST Comment: *p.14. It is best to confirm presence above barriers as well as below barriers via surveys.*

Authors' Response:
See the authors' response to a similar IMST comment above on Page 34.

IMST Comment: *p. 15. The IMST applauds the CRBTWG for recognizing that surveys conducted before 2004 lacked the statistical rigor required to confirm the absence of bull trout and for conducting additional surveys in 2004. The conclusion reached from the analysis of this survey effort would be better supported if the implications of survey methods and assumptions for bull trout detection were discussed. Specifically, the authors state that streams 'too large' to snorkel safely at night were not sampled. Briefly indicate what constitutes 'too large' and estimate the likelihood that these larger stream harbor undetected bull trout that would be detected in the smaller, sampled streams.*

Authors' Response:
The Peterson et al. (2002) sampling protocol employs a probabilistic sampling framework to determine the probability of bull trout presence (or absence). Large river segments that were too large, swift, and hazardous to snorkel at night were not sampled for safety reasons. The determination of "too large" was not associated with a particular, predetermined width or velocity, but rather with the surveyors' familiarity with the selected river segments and their personal judgment. Excluded segments, however, tended to be greater than 10 meters wide with current too swift to swim against or easily withstand by clinging to the substrate. Approximately less than 10 percent of the stratified random samples drawn from the total population of 200-meter stream segments within the area of Upper Clackamas River surveyed were determined "too large" and hazardous. These random draws were chosen again until a desired number of 200-meter stream segments could be safely sampled to achieve the desired high level of probability of detection in accordance with the protocol.

It is true that this method could inject a level of unavoidable bias, but this bias would tend to make the conclusions of the survey more conservative. The likelihood of finding members of a resident local population of bull trout in very large, swift riffles is undoubtedly less than in habitats with lower water velocities.

IMST Comment: *p. 17. Estimate or at least discuss the detection efficiencies for bull trout in deep pools and large streams, and for electrofishing versus snorkeling and how these efficiencies influence the habitat analysis.*

Authors' Response:
The surveys and sampling conducted to determine bull trout presence are not related to how the authors conducted their suitable habitat analysis in Chapter 2 of the draft Assessment. These two efforts are unrelated.

IMST Comment: *p. 20. Provide information about the extent of forest disease or unhealthy forests, and the likelihood of catastrophic wildfire in the upper Clackamas.*

Authors' Response:
Most of the Clackamas River Subbasin on National Forest lands appears to support healthy forests with only localized pockets and scattered mortality from native disease and pests. In the Olallie Lakes Scenic Area and north of that location along the Cascade Crest, greater mortality is being seen in these high elevation forests. Much of the wide spread browning evidenced in these forests is from pine beetle attacks on older lodgepole pine stands (approximately 100 years old). This area has a history of large fires and may explain the greater abundance of the fire adapted lodgepole pine. This area is also known as "lightning

alley" since it attracts greater summer storm patterns that generate lightning strikes. Large scale or catastrophic fire is always a potential depending on year to year climate conditions. Historic evidence points to large scale stand replacement fires occurring on an infrequent basis in the western hemlock-Douglas fir forest that makes up most of the Upper Clackamas River Subbasin. The high elevation forests with an abundance of lodgepole pine have a more frequent fire regime and may be experiencing stand replacement by fire every 100 years or so. (Goodwyne 2006, personal communication with Clackamas River Ranger District silviculturalist)

IMST Comment: *p. 25. Clarify whether adult bull trout abundance criteria are met with 900 individuals in the entire Willamette River Unit. This could mean very few individuals in each of the basins (upper Willamette, McKenzie, Santiam, Clackamas), which are fundamentally fragmented by mainstem dams.*

Authors' Response:
At this time, current abundance criteria in the draft recovery plan are 900 to 1,500 adults in the Willamette River Basin. It is expected that these numbers will be refined prior to finalization of the recovery plan and as new information becomes available through monitoring and research.

Chapter 2 – Habitat

IMST Comment: *p. 25, first sentence. Briefly explain why 3 patches will meet the distribution criteria. Also, justify the 900-1,500 abundance criterion.*

Authors' Response:
The distribution criteria in the draft bull trout recovery plan for the Willamette Recovery Unit will be met when "bull trout are distributed among three or more local populations in the recovery unit: two in the Upper Willamette River core area and one in the Clackamas River core habitat." The authors highlighted pertinent recommendations and guidance contained in the draft recovery plan for the Willamette Recovery Unit in the draft Assessment. They did not provide an explanation for these recommendations or guidance, nor do they believe it is necessary or relevant to the Assessment. The IMST comment pertaining to the 900 – 1,500 abundance criterion is addressed in the previous response above on Page 37.

IMST Comment: *p. 28. Given the 5-9 degrees Celsius required for bull trout spawning and juvenile preference, explain why 15 degrees was set as a temperature criterion for suitable habitat. Also indicate the suitability of winter habitat requirements.*

Authors' Response:
The authors conferred with members of the CRBTWG in establishing the 15 degrees Celsius temperature criterion for determining suitable bull trout spawning and rearing habitat. The authors recognize there is a range of water temperatures (from less than 9 degrees Celsius to greater than 15 degrees Celsius) in which bull trout spawning, egg incubation/emergence, and rearing take place. In order to err more on the conservative side of not underestimating potential suitable habitat, the CRBTWG selected the higher criterion of 15 degrees Celsius. It is important to remember; however, that this applies strictly to the period of summer temperature record (June through September) when the daily maximum temperature for a single hourly temperature reading is reached. This metric is much more discriminating towards delineating colder water streams than is the Oregon Department of Environmental Quality bull trout spawning temperature criterion which uses the rolling seven-day average of maximum daily temperatures. Winter water temperatures in the predominantly ground-water and spring-fed streams identified as suitable bull trout spawning and rearing habitat in the Upper Clackamas River are quite low (lower than for the period from June through September) during the fall, winter, and spring months based on a review of year-round water temperature data collected in past years at one site located along the Clackamas River near Big Bottom at Forest Service Road 4650 (Patch 1). Based on review of these data, the authors do not believe winter water temperatures are relevant to determining bull trout spawning and rearing habitat suitability.

IMST Comment: *p. 27. Add a bullet: 'What is the likelihood that the habitat will persist and improve?'*

Authors' Response:
This question is answered above under "General IMST Comments" for Chapter 2.

IMST Comment: *p. 29. There are an infinite number of watersheds and patches in a basin. Use quantitative areas versus "watershed scale" and "patches". The same goes for basin and subbasin. p. 30, first line. Bull trout are actually distributed over a small proportion of the conterminous USA. Perhaps modify to Pacific Northwest, USA.*

Authors' Response:
This comment is noted and editorial corrections as suggested will be made in the final Assessment.

IMST Comment: *There is usually an inverse correlation between slope and roads, and a positive one between roads and temperature. The site-scale stressors (e.g., sediment, temperature, prey, pool volume, wood) should be evaluated as well as the landscape-scale disturbances.*

Authors' Response:
The authors evaluated the following stressors: temperature, three pool metrics, and large wood; on Pages 57 – 62 of the draft Assessment. These are the primary stressors for which a consistent data set from U.S. Forest Service Level II stream surveys is available for analysis.

IMST Comment: *Briefly describe the floodplain and riparian functions and how roads decrease them.*

Authors' Response:
A brief discussion of the influence of roads on floodplains and riparian functions will be added in Section 2.1 of Chapter 2 under "Road Density" on Page 30 of the draft Assessment.

IMST Comment: *p. 31. In the sentence, "Survival of bull trout embryos planted in stream areas of groundwater upwelling used by bull trout for spawning were significantly higher than embryos planted in areas of surface-water recharge not used by bull trout for spawning (Baxter and McPhail 1999)." clarify that this statement is comparing springs to hyporheic flows.*

Authors' Response:
The authors will clarify this statement in the final Assessment.

IMST Comment: *A patch is defined here and on p. 42 differently, but neither definition is sufficient.*

Authors' Response:
As stated earlier on Page 7, the authors will more clearly define the term "patch" and will review all such references to this term throughout the final Assessment to ensure its consistent usage.

IMST Comment: *p. 32. The Assessment focus on spawning and rearing habitat includes insufficient analysis of cover, volume, and prey for several hundred bull trout to mature and achieve sufficient size to produce high numbers of eggs.*

Authors' Response:
The authors believe the analysis of large wood provides the necessary level of analysis for cover. Additional data on cover are lacking. The authors also believe the analysis of pool habitat (based on the three metrics investigated in Chapter 2 of the draft Assessment) sufficiently assesses the volume of habitat. Again, the authors are limited to relying upon available data for analysis. The IMST comment pertaining to sufficiency of analysis for prey is addressed above on Page 29.

IMST Comment: *Specify that the 15° C criterion is for summer water temperatures. What are fall and winter water temperatures in the proposed catchments? What was the study design for temperature recorders (number, placement)? (also p. 38).*

Authors' Response:
The authors state the 15 degrees Celsius criterion does apply to the period of time during which streams are their warmest – i.e., the summer months (see Page 38 in the draft Assessment). The authors will review other sections of text referring to this temperature criterion to provide clarification as needed in the final Assessment. The IMST comment pertaining to fall and winter temperatures is addressed above on Page 38. Additional text will be provided in the final Assessment to explain the approach (i.e., study design) for analyzing available water temperature data collected prior to 2004 and collecting additional data in 2004 where gaps were identified.

IMST Comment: *p. 36, figure 2.3. Indicate whether the line presented is the best fit for the data or simple linear regression. Briefly explain why pooling the data across basins is appropriate. Units should be shown on axes for clarity. Provide the R value to indicate the significance of this regression. Since the X-axis is a log, a slight difference in slope can result is a large change in the predicted Y value. Also, the figure title is missing an f from (summer low-flow width).*

Authors' Response:
The line in question is the result of simple linear regression. The data were pooled across neighboring basins, subjected to similar climate and, in many cases, similar geology. Differences in both of these factors likely contributed to the observed variability in the relationship. Because the relationship was still a very strong one, it was considered useful for the purpose of prediction of summer low-flow widths. Although a small change in slope can result in large changes in Y, when the X value is a log, this is much less true at the lower end of the relationship, which is the portion considered by the authors.

IMST Comment: *Solving the regression equation for a stream width of 10 feet yields a catchment area of 2199 (and a log of 3.34), not 1742 acres. The log of 1742 is 3.24, which multiplied by 29.8 is 96.58, if 89.6 is then subtracted, that yields 6.98 feet for stream width—not 10 feet. Because exclusion of streams and stream segments from consideration as suitable habitat was based on the assumption, of 1742 acres, it is critical to resolve the discrepancy between the text and Fig. 3 with respect to stream width vs. watershed size. IMST recommends that the CRBTWG evaluate exclusions based on a critical watershed size of 2199 acres if streams less than 10 feet wide are limiting.*

Authors' Response:
An error was made in stating that 10 feet was the desired minimum summer low flow width. In fact, a minimum width of 2 meters was used. This error will be corrected in the final Assessment.

IMST Comment: *p. 38. Are there no cold water refugia? Explain the methods behind temperature data collection and how these might bias delineation of habitat.*

Authors' Response:
Local areas of cold water refugia may exist; however, the authors do not believe these areas comprise large enough quantities of suitable spawning and rearing bull trout habitat to have biased the delineation of suitable habitat as shown in Figure 2.7 on Page 44 of the draft Assessment.

IMST Comment: *p. 42. It seems preferable to list patches as water bodies vs. catchments. Fish occupy water bodies, and patches are defined as stream segments.*

Authors' Response:
This comment is noted, and the authors will consider re-titling specific patches in the final Assessment.

IMST Comment: *p. 43. Although the captions use greater than 1700 acres for an apparently incorrect catchment size of 1742 acres, this process should be corrected based on a critical watershed size of 2199 acres.*

Authors' Response:
This comment is addressed above on Page 41. The authors made an error in stating that 10 feet was the desired minimum summer low flow width, when in fact it is two meters. This will be corrected in the final Assessment.

IMST Comment: *p. 45-46. The patches appear arbitrary and based on HUC mapping conventions, versus ecology, biology, or hydrology.*

Authors' Response:
As stated above on Page 7, the authors did not attempt to presuppose how reintroduced bull trout might actually utilize different stream segments or patches for that matter. In an attempt to provide a more detailed analysis of watershed, riparian, and fish habitat conditions throughout the Upper Clackamas River area mapped as suitable bull trout spawning and rearing habitat, the authors relied primarily on 7th field HUC boundaries to delineate patches. Doing so is not arbitrary, but in fact the most logical way to define watershed, riparian, and fish habitat conditions across the landscape.

IMST Comment: *p. 46. Tague and Grant (2004) are miss cited; their paper indicates that the High Cascades are geologically younger not older than the Western Cascades. Also check the other attributes listed for both. Also see p. 127 of the Assessment for accuracy and needs a reference to Tague and Grant (2004). The citation for Tague and Grant (2004) is also incomplete in the reference section.*

Authors' Response:
Corrections will be made in the final Assessment.

IMST Comment: *If possible, the Assessment should elaborate on the legacy effects of the 1996 storm event relative to these differing geological types.*

Authors' Response:
The authors do not believe this is necessary or relevant to the Assessment.

IMST Comment: *p. 47. Some numbers are incorrect. For example, Upper Clack Austin acreage should probably be 7488, not 748.8. Acreage numbers and square miles are not always consistent; i.e. Olallie Creek. Check all entries and column sums. Right, or decimal, justifications of numbers makes tables easier to read. Some column headings are redundant; i.e., acres/acres, Sq. miles/mi2*

Authors' Response:
All data contained in the summary tables for the Patch Characterization section in Chapter 2 of the draft Assessment will be proofed. Corrections will be made in the final Assessment.

IMST Comment: *p.48. Although it is stated here that Patches 3 and 4 are the most geologically stable, Table 2.2 indicates that patches 3 (92%) and 5 (86%) have the highest % of low landslide potential, rather than patches 3 and 4 (81%).*

Authors' Response:
A correction will be made in the final Assessment.

IMST Comment: *p. 49. Although parent geology is related to flow regime, this figure depicts geology not flow regime. If it does depict flow regime, it would be preferable for the Assessment to indicate flow regime is in terms of flow, runoff, or base flow to bank full flow ratio.*

Authors' Response:
Figure 2.9 on Page 49 of the draft Assessment does indeed depict parent geology and will be re-titled accordingly in the final Assessment.

IMST Comment: *p. 51. Only one catchment in Table 2.3 has road density less than 1.1km/km2. This indicates widespread disturbance and potentially many migration barriers. Indicate how the lack of migration barriers was determined, in terms of study design and indicators.*

Authors' Response:
This comment was addressed above on Page 13.

IMST Comment: *Some criteria used to select suitable habitat patches may not be as discriminating as the CRBTWG would have readers believe (Table 2.3). For example, Aggregate Recovery Percentage (ARP) seems more procedural than scientifically based. Use of ARP may be required in this Assessment by the Draft FWS Recovery Plan, but it and the Equivalent Clearcut Area (ECA) methodology produce indices, rather than actual changes in peak flows. The Assessment considers ARP an indicator of "hydrologic impairment", but there is little explanation provided for why that is the case. Explain how it is related to changes in peak flow quantity or timing, preferably with biplots, and provide correlations between bull trout habitat suitability and these indices, road density, and stand structure.*

Authors' Response:
The authors did not rely on Aggregate Recovery Percentage (ARP) results as a criterion used to select suitable habitat patches. ARP was used as one of several watershed condition metrics to characterize the current conditions of each patch. A further explanation of ARP is not necessary.

IMST Comment: *pp. 52 & 55. The column headings are redundant, as are units in cells if provided in headings.*

Authors' Response:
The authors will consider re-titling the column headings in the final Assessment.

IMST Comment: *p. 55. The percentages of catchments classified as matrix suggest widespread disturbance in all but the upper Clackamas. In Lemiti, S.F. Lemiti, Olallie, and Patch 3, the sums are far less than 100%.*

Authors' Response:
The percent of watershed in matrix is not an indicator of widespread disturbance. The percentage of watershed in various Northwest Forest Plan land allocation categories for each watershed listed in Table 2.4 on Page 55 of the draft Assessment will be reviewed and corrected if necessary.

IMST Comment: *p. 57. What design and indicators were used in the habitat surveys? Define the reach scale at which data were collected. Reach is an undefined term that can vary by several orders of magnitude.*

Authors' Response:
Data from U.S. Forest Service Level II stream surveys were collected in accordance with an inventory and data collection protocol originally developed for the USDA Forest Service Pacific Northwest Region in 1989. The original 1989 protocol has been reviewed annually and updated as necessary. The latest version is: Stream Inventory Handbook, Level I and II, Pacific Northwest Region, Region 6, 2006, ~Version 2.6. A reach is a unique segment of stream channel that differs from that just downstream or upstream based on stream size or flow, change in channel type or geomorphology, or biotic assemblage. The minimum stream reach length recommended is 0.5 miles. No maximum reach length is suggested.

IMST Comment: *Explain how and how many individual reaches were selected for assessment in each catchment. Explain whether the unlabeled bars in figures 2.13 – 2.18 represent only the sampled reaches or all reaches in each catchment. Unless the reaches were randomly selected, they can only represent the limited number of reaches actually surveyed—not entire catchments.*

Authors' Response:
The number of individual reaches identified in the draft Assessment for each watershed is based solely on those that have been surveyed to date and how a particular stream channel was categorized into reaches during the survey effort. The survey coverage for most suitable bull trout spawning and rearing streams within each patch is quite thorough; however, is lacking on the mainstem Clackamas River along Big Bottom and Ollalie Creek as indicated in Table 2.5 on Page 58 of the draft Assessment.

As explained on Page 57 of the draft Assessment, "Survey data are collected at the reach scale for individual streams; however, the habitat summaries and comparisons aggregate all data for the various reaches and streams surveyed within each patch and are reported as a function of the total habitat area (meters^2) available within the patch. The bars shown in Figures 2.13 – 2.18 represent the total square meters of habitat surveyed within a particular patch by habitat metric category. For example, the first graph presented in this section of Chapter 2; Figure 2.13 "Channel Gradients;" roughly 81,000 square meters of the total habitat that was surveyed in the Pinhead Patch is in the 2.5 – 4.9% channel gradient category.

IMST Comment: *p. 59. Briefly explain (in figure titles) the origin of the multiple bars for each catchment. Briefly explain in the text what each of the metrics measured means to bull trout.*

Authors' Response:
This issue is explained in the response the preceding comment. As explained on Page 57 of the draft Assessment, "Survey data are collected at the reach scale for individual streams; however, the habitat summaries and comparisons aggregate all data for the various reaches and streams surveyed within each patch and are reported as a function of the total habitat area (meters^2) available within the patch."

IMST Comment: *p. 63. Cub and upper Clackamas have more area than Pinhead in the stable flow categories.*

Authors' Response:
The conclusion as stated on Page 63 of the draft Assessment is correct. There was likely some confusion in interpreting this graph and the others like it (Figures 2.13 – 2.18) based on what the individual bars represent for each patch. The Pinhead Creek patch has less habitat overall by surface area than either the Upper Clackamas or Cub Creek patches. It has less area in the most stable flow category, but has more as a percent of the total (72% compared to 67% for the Cub Creek patch and 53% for the Upper Clackamas patch). Additional clarification will be provided in the final Assessment in order to avoid confusion in interpreting these figures.

IMST Comment: *p. 64. The Assessment need not give miles in each box if already provided in the table title, nor must it provide redundant values above the diagonal.*

Authors' Response:
The authors will consider revising the table title and format in the final Assessment.

IMST Comment: *p. 65. Briefly explain why each selected patch can support a self-sustaining bull trout population. Indicate whether each patch also includes over wintering habitat for large adults, or whether this must be provided in the lower Clackamas. Support these explanations with data or references.*

Authors' Response:
The issue of relating each individual patch to a self-sustaining population has already been addressed by the authors under IMST General Comments for Chapter 2. Each patch does contain habitat for over-wintering adult bull trout, and the authors stated earlier in response to a separate IMST comment that they are uncertain as to what dominant life history pattern a reintroduced population would exhibit despite the particular donor stock used. The authors expect large over-wintering adult bull trout could occupy habitat within the identified suitable spawning and rearing patches as well as areas downriver in the middle reaches of the Clackamas River downstream from the Collawash River confluence to North Fork Reservoir.

IMST Comment: *p. 66. Add a fourth bullet beginning with "What is the appropriate. ."*

Authors' Response:
This formatting correction will be made in the final Assessment.

Chapter 3 – Conservation Genetic Considerations and Donor Stock Suitability

IMST Comment: *p. 70. Based on the evidence herein, donor stocks from the lower Columbia River portion of the coastal evolutionary group appear appropriate and scientifically defensible.*

Authors' Response:
The authors will make a text revision in the final Assessment.

IMST Comment: *p. 72. Briefly explain why bull trout populations are highly isolated within catchments. Define highly isolated and what it means in terms of watershed/basin structure. Provide scientific reasons why four microsatellite loci are sufficient to determine the substructure of bull trout populations in the Pacific Northwest. That is, indicate what phenotypic characteristics those loci represent and how they relate to bull trout fitness.*

Authors' Response:
Taylor et al. (2001) concluded that bull trout populations are highly isolated from each other genetically and demographically within watersheds. This conclusion is made in part because "These microsatellite data are consistent with earlier studies of allozymes (Leary et al. 1993) and mtDNA (Taylor et al. 1999) that reported relatively low levels of within-population variation at these independent loci." "Low variability may stem from demographic processes that have reduced effective population sizes in bull trout historically

during and following postglacial dispersal (e.g., Hewitt 1996). Reduced population sizes through bottlenecks or founder events would have eliminated considerable allelic variation which has not yet recovered via mutation (Schug et al. 1997)." A more thorough and rigorous examination of the topic can be found in Taylor et al. 2001 and is beyond the scope of this Assessment.

The authors relied, in part, on Spruell et al. (2003) to provide information regarding the substructure of bull trout populations. The authors do not have a position in regard to whether four microsatellite loci are sufficient to determine sub-population structure. The reader is referred to Spruell et al. (2003) for an examination of the topic. The findings are consistent with a growing body of evidence (see references contained in Spruell et al. 2003) that explore the topics of evolutionary lineage or bull trout sub-population structure.

Microsatellite loci are by definition, non-coding sequences of DNA that are composed of two to five base pair repeats. As such, no gene products are encoded by microsatellites. Therefore, no phenotypic traits or performance/fitness related characteristics are the result of the transcription and translation of DNA found at microsatellite loci. Microsatellite regions tend to be highly variable and thus useful in population genetic studies as the repeated sequences are often mismatched and deleted during DNA replication. These mutations are selectively neutral because the random repeated DNA sequences are "junk" DNA (i.e., non-coding sequence). It is the high variability of the sequence that often allows microsatellite analysis to assign individuals to certain populations and even parents.

IMST Comment: *p. 75. Briefly explain why 5,000 individuals are sufficient for a species as completely, and potentially permanently, fragmented as bull trout. Does this many individuals suffice for other salmonid species to be viable over evolutionary time frames? Also explain why 50 is a sufficient population size.*

Authors' Response:
The authors do not advocate that abundance criteria of 50 or 5000 adult bull trout in a population is either sufficient or insufficient. As stated on Page 78 of the draft Assessment, guidelines on effective population size appear to apply reasonably well to bull trout (Rieman and Allendorf 2001). The recommendation that Ne exceed 50 to avoid inbreeding depression appears to be most closely related to the short-term genetic viability of local bull trout populations. The recommendation that Ne exceed 500 to avoid the loss of genetic and phenotypic variation through drift appears to be most closely related to the long-term persistence of groups of local populations among which gene flow occurs to form a metapopulation of bull trout. Since few local populations may support a Ne greater than 500 (Rieman and Allendorf 2001), effective populations of this size may often require the possibility of gene flow between local populations. It also appears reasonable that effective population sizes that exceed 5,000 may be required to ensure the evolutionary persistence of bull trout conservation units. The risk of extinction for a population is clearly related to its size and its variance in abundance relative to its mean size over time. More specifically, theoretical evidence suggests that inbreeding and genetic drift are likely to occur in populations when Ne less than 50 and 500, respectively. When detailed information is lacking for bull trout populations, these guidelines would be the most useful tool for managers to apply for avoiding loss of genetic variation and trying to ensure population persistence. These numbers represent relatively straightforward and defensible, theoretical

minimums. While theoretical Ne can reflect the minimum number necessary to alleviate certain genetic risks, it does not necessarily reflect the most appropriate population size. Detailed information for a population may allow the justification of effective population sizes larger or smaller than 50 or 500. If possible, when estimating the population size necessary for persistence, managers should consider, for example, demographic risks and selective pressures as well as stochastic and historical events in addition to genetic risks.

It is clear that a sufficient Ne is a necessary consideration for conserving bull trout populations. Except for well-documented exceptions, the 50, 500, and 5,000 values should be considered necessary minimums and viewed as generalizations. For any given population the specific Ne necessary for conservation purposes will depend on characteristics of the population such as the ratio of N:Ne, the dominant life history form present, and the frequency of spawning.

IMST Comment: *p. 75-79. Reducing the length of section 3.3 would increase the clarity of the overall document. This could be achieved by limiting this discussion to issues of immediate relevance to the proposed bull trout reintroduction.*

Authors' Response:
This comment will be considered in preparing the final Assessment.

IMST Comment: *p. 80. Justify the necessity of setting K at 30,000. This seems very high for small catchments.*

Authors' Response:
The carrying capacity of each population was set at 30,000 individuals, because 30,000 is the maximum parameter that can be entered into the simulation program, thus 30,000 is a large enough population to result in little loss of genetic variation or increased risk of extinction over 50 years. Because the authors are assessing relative outcomes and not attempting to model specific populations (i.e., there is no information available in regard to the carrying capacity of any potential donor population or the Clackamas River Subbasin), the authors did not want the carrying capacity to be so low as too result in additional modeled deaths or loss of alleles.

IMST Comment: *p. 81. The two point scenarios in Table 3.1 produce straight lines. Is VORTEX a linear model, even though few populations show linear trends? Employ various propagule numbers and types to yield more realistic patterns and options.*

Authors' Response:
VORTEX models population dynamics as discrete, sequential events (e.g., births, deaths, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or as random variables that follow specified distributions. Since the growth or decline of a simulated population is strongly influenced by these random events, separate model iterations or "runs" using the exact same input parameters will produce different results. Consequently, the model is repeated many times to reveal the distribution of fates that the population might experience under a given set of input conditions.

The results from these simulations should be interpreted only as a means to compare the relative risks and benefits of the scenarios simulated. With 500 or 1,000 adults in the donor population, none of the modeled scenarios reduced genetic variation or persistence of the donor population. It is not until the donor population adult abundance was dropped to approximately 200 that the modeled scenarios result in potential affects (these are the figures presented in the draft Assessment). Because the authors concluded that the most appropriate populations to use as donor populations are larger than 1,000 adults, there is little value added by modeling additional propagule numbers at the 200 adult abundance level, as any patterns observed will not be entertained as a viable option for implementation should a reintroduction be pursued. Stated another way, the authors believe the only biologically feasible outcome is one in which no affects can be modeled in VORTEX, because the donor population is sufficiently large.

IMST Comment: *p. 82-86. Presentation of the modeling results may be misleading for some readers. Two propagule sizes were modeled for each propagule age class. Plotting the results for the two propagule sizes and drawing a line between them indicates that the shape of the relationship between propagule size and heterozygosity, allelic diversity, or population persistence is understood, but this has not been modeled. p. 84. Indicate which plots are from demographic schedules A versus B, and add Probability to the y-axis of the second plot.*

Authors' Response:
The authors agree that the graphs may be misleading for some readers. The authors intend to significantly modify Section 3.4 in Chapter 3 of the draft Assessment to provide increased clarity and highlight that scenarios in which 500 or 1,000 adults are present in the donor population, none of the modeled scenarios reduced genetic variation or persistence of the donor population. Because many of the results in Section 3.4 (Vortex Simulation Modeling) are derived from a manuscript that is still in preparation (Tallmon et al.), the authors recognizes that it is somewhat premature to fully utilize the information in the Assessment as explained above.

IMST Comment: *p. 88-89. Provide the areas and discharges of these potential donor catchments, and their connectivity to over-wintering water bodies for adults. Provide means and ranges of adult abundance so that the reader has some notion of variability. Is there any evidence that the populations are independent or dependent?*

Authors' Response:
Data on area and discharge of potential donor catchments are not readily available for incorporation into the Assessment. Ranges, trends, and additional information regarding potential bull trout donor stock abundance is contained within Appendix C - Population Characteristics of Potential Donor Stocks of the draft Assessment. Table 3.2 on Pages 88-89 of the draft Assessment is only a summary of the available information.

IMST Comment: *It is misleading to specify that Jack Creek has 466 adults without some estimate of variability.*

Authors' Response:
As suggested, it would be more appropriate to provide the number generated in Table 3.2, which provided adult abundance estimates based on a five year average (2001 to 2005), rather than a one year estimate. The authors will make this revision in the final Assessment. Additionally, trends and variability for each of the potential donor stocks can be found in Appendix C - Population Characteristics of Potential Donor Stocks of the draft Assessment.

IMST Comment: *p. 91. Provide a large scale figure sufficiently detailed to indicate stream (population) proximity and the possibility that the populations listed in Table 3.2 are interbreeding and dependent. Provide evidence that the populations are independent or dependent.*

Authors' Response:
The authors do not believe a detailed map showing all the individual populations is necessary to address the question of whether populations are independent from each other. To the degree that information is available, it is included in the narrative of the draft Assessment, and included in Table 3.2. The majority of information on population designations (i.e., local populations, spawning complexes) was derived from the draft recovery plan. At this time there is no additional information on population discreteness beyond that presented in the draft Assessment.

IMST Comment: *p. 92. Indicate the current protective measures provided for persisting bull trout populations, and whether these measures are appropriate or ineffective for reintroduced populations.*

Authors' Response:
The causes for decline of bull trout in the Clackamas River Subbasin (Section 1.6 of the draft Assessment) and the curtailment of the causes for decline explore the effectiveness of the protective measures currently implemented. Results of the protective measures are exemplified in Chapter 2, which details the current habitat conditions of the upper Clackamas River and major tributaries.

Bull trout are listed threatened under the federal ESA and as such fall under the protections afforded listed species (primarily Section 7 and Section 9 of the ESA).

It is unknown at this time what the "listing status" will be of a reintroduced bull trout population in the Clackamas River. Bull trout could be reintroduced under Section 10(j) of the ESA, whereby the reintroduced population would be deemed "experimental, non-essential." Under this designation, the fish would have less ESA protections than provided under the designation threatened or endangered. However, federally listed anadromous salmonids are present in the Clackamas River and land and resource management activities designed to be protective of these species would also be protective of reintroduced bull trout and bull trout habitat.

Chapter 4 – Ecological Interactions and Food Web Considerations

IMST Comment: *p. 96, 106 & 110. The survey results on pp. 12–17 provide no support for warmwater fish populations in the upper Clackamas. Provide survey results here indicating the fish species and their abundances and size ranges in the upper Clackamas. Two sucker species does not equate with "several" sucker species. Explain why several sucker species are expected in the upper Clackamas, if they are, i.e., indicate which suckers besides C. macrocheilus and C. platyrhynchus might exist there. List the sculpin species occupying the upper Clackamas. Explain the importance to the upper Clackamas of a diverse warm water fish assemblage in the lower Clackamas. Such an assemblage seems unlikely in the upper Clackamas at water temperatures less than 15$_o$ C. and mainstem dams may preclude seasonal bull trout migrations.*

> **Authors' Response:**
> The survey results on Pages 12 – 17 of the draft Assessment dealt largely with surveys for bull trout or other cold water species higher in the watershed. Few surveys have been completed on the mainstem Clackamas River above North Fork reservoir because of the large size of the river. Long-nosed dace, sculpin species and suckers appear to be common in some locations above North Fork Reservoir. Approximately 32% (7,963) of all fish counted in a snorkel survey of the mainstem Clackamas River funded by PGE in 2000, were suckers (Cramer S.P. and Associates 2001). The survey reports did not indicate size ranges for the non-salmonids. Since the surveys have not usually identified fish to the species level, the assumption was these were large scale sucker, C. macrocheilus. The ODFW Clackamas River Subbasin Fish Management Plan also identifies mountain sucker, C. platyrhnchus as present in the Clackamas River (Murtagh et al. 1992) but this wasn't determined in the surveys. The use of "several" in the report for sucker species is incorrect and will be dropped in the final Assessment.

IMST Comment: *Use official AFS/ASIH fish names throughout (Nelson et al. 2004). Catostomus not Catastomus, pikeminnow not pike minnow, P. oregonensis not P. aregonensis, chiselmouth not chisel mouth, redside shiner not red-sided shiners, threespine stickleback not three-spine stickleback, L. tridentata not L. tridentate, pumpkinseed not pumpkinseed sunfish, brown bullhead not brown bull head catfish.*

> **Authors' Response:**
> The authors will make these suggested edits in the final Assessment.

IMST Comment: *In terms of disease, competition, prey, etc. discuss how hatcheries present in the basin may be expected to have, or not have, negative effects that might compromise the success of the reintroduction effort.*

> **Authors' Response:**
> In recent years, the upper Clackamas River above North Fork Reservoir is managed for wild fish only, except for the annual release of catchable rainbow trout in the North Fork Reservoir. The fishery surrounding planted trout in North Fork Reservoir could increase the mortality of adult bull trout using the reservoir for foraging, even if caught and released. Hatchery trout could also serve as an additional food source for bull trout. There is no longer a riverine hatchery trout stocking program in the primary portion of the watershed in which the authors expect bull trout to spawn and rear. In addition, no hatchery anadromous

salmonids are passed above North Fork Reservoir into the upper Subbasin. In short, the authors do not believe that hatchery operations in the Clackamas will have any measurable negative effects on a bull trout reintroduction effort. Potential disease issues were addressed above on Page 22 under a previous comment.

Chapter 5 – Summary

IMST Comment: *p. 108. Add another bullet: Indicate whether or not there is sufficient habitat to support one or more populations of 500 adult bull trout.*

Authors' Response:
The authors are not aware of any information quantifying the amount of habitat needed to support a population of 500 bull trout. While the authors believe there is a substantial amount of suitable spawning and rearing habitat available in the Upper Clackamas River, they do not know whether it is enough to support a population of 500 adults.

IMST Comment: *p. 109. Briefly and precisely describe what constitutes a self-sustaining local population of bull trout. Provide number of adults, key habitat complexes, catchment area, and drainage volume.*

Authors' Response:
The authors agree that the Assessment needs to better define a self-sustaining local population of bull trout. This issue was discussed above on Page 6. Again, the authors' intent is to be consistent with the usage of "population" and "local population" in the U.S. Fish and Wildlife Service's Draft Bull Trout Recovery Plan. The authors are unaware of information quantifying the amount of habitat, catchment area, and drainage volume needed to support a bull trout population.

IMST Comment: *p. 110. If brook trout are already established in the upper Clackamas, briefly explain why they are assumed to be an insignificant factor for bull trout, given that they are a significant factor elsewhere.*

Authors' Response:
This comment was addressed earlier under a General IMST Comment made on Chapter 4.

IMST Comment: *p. 111. Adaptive management and the success of past reintroductions have been discussed, but the negative impacts on donor stocks have not been thoroughly addressed. For example, see tables on bull trout population status and the apparent reduction in Anderson Creek (McKenzie) stocks associated with Middle Fork Willamette introductions (pp. 135 & 136).*

Authors' Response:
The authors dedicated a significant portion of the draft Assessment (Chapter 3) to addressing donor risk and thus they do not believe it needs to be addressed further in Section 5.3. In the case of the McKenzie River bull trout population, there are no data to support or refute the notion that fry removal (to the Middle Fork Willamette) is or is not contributing to a decline in adult spawners in the McKenzie.

IMST Comment: *The potentially limiting factors are believed to be remedied. Indicate precisely what has been remedied in the upper Clackamas as regards harvest, habitat, brook trout, and dam/road barriers.*

Authors' Response:
The Clackamas River above North Fork Dam is now managed by ODFW as a catch and release fishery only and with a limited fishing season to protect native fish species from harvest. Also, all hatchery salmonids (fin clipped) are sorted at North Fork Fish Ladder and are not allowed to pass upstream. The upper subbasin is managed as a wild fish sanctuary.

With the advent of the Northwest Forest Plan in 1994, riparian reserve protections were implemented on all intermittent and perennial streams on National Forest land in the Clackamas River Subbasin. Riparian reserves are managed for late successional old growth development and enhancement and to protect all fish habitat. Where earlier decades sometimes saw complete harvest of riparian tree cover in harvest units, such activity is now prohibited. Existing older riparian forest is protected under the Northwest Forest Plan and younger previously harvested riparian forest is managed for promotion of late seral forest characteristics. With less emphasis on regeneration harvesting of timber stands, many existing roads are now superfluous and are being obliterated and returned to a vegetated condition. In the late 1990s, over 100 miles of logging road were obliterated and revegetated in the Fish Creek drainage alone. This work continues today.

Regarding dam/road barriers, PGE just recently completed a new, state-of-the-art fish ladder on its River Mill Dam on the Clackamas River as stated previously. This replaced an antiquated, 1911 era fish ladder that was believed to delay anadromous fish passage. Additional upstream and downstream fish passage improvements have been identified in the current relicensing effort underway with PGE for its Clackamas River hydroelectric facilities. The U.S. Forest Service has also replaced most of the anadromous fish passage barriers on Forest roads in the last decade with fish-friendly culverts (e.g., open-bottom arch culverts). Perhaps four additional anadromous range culverts need replacing and these are lesser priority sites that are planned for replacement – all of which occur on streams in other portions of the Subbasin different from those identified as suitable bull trout spawning and rearing habitat.

The IMST comments pertaining to brook trout competition and hybridization were addressed previously under the authors' responses to General IMST Comments for Chapter 4.

IMST Comment: *Add a ninth factor to the first list of bullets: Quantitatively determine the fish prey base and compare it with the prey base sustaining putatively healthy bull trout populations such as those in the Metolius and Lewis systems.*

Authors' Response:
See the authors' previous response above on Page 29 regarding prey base. The authors do not believe it necessary to conduct a comprehensive "prey base" analysis in the Clackamas River should a reintroduction be pursued. The authors are aware of the prey base information that has been collected in Lake Billy Chinook (Metolius bull trout), but are unaware of any such information for the Lewis River system.

IMST Comment: *Alter the third bullet in the second list: Evaluate the possibility of hybridization, competition, and predation with brook trout, as well as the extirpation of brook trout.*

> **Authors' Response:**
> IMST comments pertaining to brook trout competition and hybridization were addressed previously under the authors' responses to General IMST Comments for Chapter 4.

IMST Comment: *p. 112. For emphasis, list the reintroduction plan phases as bullets versus paragraph text. IMST supports expanding and detailing this information should a recovery plan result from this Assessment.*

> **Authors' Response:**
> The authors will make the suggested revision in the final Assessment.

IMST Comment: *Add explicit mechanisms for sharing knowledge learned about proposed bull trout reintroductions in the Clackamas with scientists planning or conducting bull trout reintroductions elsewhere.*

> **Authors' Response:**
> The authors will add a paragraph stating their intent and desire to share "knowledge learned," as they strongly hope this effort can be used as a future template for appropriate investigation of reintroduction. However, the authors believe the explicit "sharing" mechanisms would be better suited in a future reintroduction proposal or implementation plan should the effort be pursued.

Appendix A – A Decline of Bull Trout in the Western United States: Causes for Decline of Bull Trout

IMST Comment: *p. 113. Retitle to: Causes for Decline of Bull Trout in the Western United States*

> **Authors' Response:**
> This comment will be incorporated into final Assessment.

IMST Comment: *p. 114. It is very important to assess upriver and downriver adult passage past dams multiple times.*

> Authors' Response:
> This comment is addressed above on Page 11.

IMST Comment: *p. 116. Provide the road density of the Swan River basin.*

> **Authors' Response:**
> The authors do not understand the relevance of including this information in the final Assessment.

Appendix B – Hypothesis for Local Extirpation

IMST Comment: *p. 127. Indicate the amount and location of private forest land on the appropriate tables and figures.*

Authors' Response:
The authors cannot find the above reference tables and figures on or close to Page 127 of the draft Assessment. A breakdown of land ownership within the Clackamas River Subbasin is provided in the authors' response to an IMST Comment above on Page33.

Appendix C – Population Characteristics of Potential Donor Stocks

IMST Comment: *p. 135-136. Emphasize that propagule removal was associated with marked declines in the number of redds of the donor population.*

Authors' Response:
There are no data to support or refute the notion that fry removal (to the Middle Fork Willamette) is or is not contributing to a decline in adult spawners in the McKenzie.

Appendix D – Overview of Reintroduction Strategies: Artificial Propagation, Captive Rearing, and Transplantation.

IMST Comment: *p. 153. Emphasize that propagule removal was associated with marked declines in the number of redds of the donor population.*

Authors' Response:
See authors' response to preceding IMST comment.

Editorial Comments

Authors' Response to all IMST Editorial Comments:
The authors appreciate the extra time IMST members took to note suggested editorial changes. The authors will take these into consideration when finalizing the Assessment to improve its overall clarity and presentation.