Table of Contents: Chapter 2

List of Tables

1 Scientific Conceptual Foundation

A conceptual foundation is a set of scientific theories, principles, and assumptions which, in aggregate, describe how a system functions. The conceptual foundation determines how information is interpreted, what problems are identified and, as a consequence, it also determines the range of appropriate solutions to achieve desired management goals (Independent Scientific Group, 1996).

Stated differently, the merging of the science-based conceptual foundation with management goals and objectives permits the logical development of management strategies. In watershed/aquatic ecosystem management, these implementation strategies create the properly functioning ecosystem conditions necessary to achieve the management goals (NPPC 1997). The importance of explicitly defining this foundation is emphasized in the above citations, and is thoroughly discussed in *A Conceptual Foundation for the Management of Native Salmonids in the Deschutes River* (Lichatowich 1998). The latter forms the basis on which much of the conceptual foundation for the *Yakima Subbasin Plan* and, hopefully, subsequent planning efforts are based.

1.1 Definition and Purpose of a Scientific Conceptual Foundation

The conceptual foundation plays a powerful, albeit often unrecognized, role in fish and wildlife management and restoration programs. Because it describes both the workings and the limitations of the basin ecosystem, it forms the premise upon which the logical framework for management of the ecosystem (habitat, organisms, and population structure) and watershed is based. Management goals should be achievable within the logical framework of the conceptual foundation, conditions within the ecosystem should relate to each other as described in the logical framework, and strategies for management need to recognize the limits imposed by the logical framework.

If conceptual foundations play such an important role in the design, implementation, and success of fish and wildlife management plans, why are they not commonly stated at the beginning of most plans? Plans are usually developed based on scientific principles mixed with the policy directives of a given agency that is developing the management plan. Separating the scientific basis from the policy/legal basis is not usually a straightforward process, even for plan developers. In a multiparty and multi-jurisdictional effort such as subbasin planning, the scientific and policy -assumptions need to be obviously and openly stated, in contrast to plans developed by a single agency where the need for this may be less. Without a clearly articulated conceptual foundation, the underlying premises of a planning effort cannot be readily reviewed, evaluated, and debated -. False assumptions, outdated science or unsupported principles cannot be identified and corrected unless they are explicitly stated, reviewed, and publicly discussed.

The focus and organization of the assessment, inventory, and management strategies of a subbasin plan should directly reflect the conceptual foundation. The foundation should also consider the increasingly broader geographic scales within which other fish and wildlife management plans or actions operate. For example, in the Columbia Basin, this means that the way the conceptual foundation views events at the smallest scale—the individual fish and its surrounding habitat—should be consistent with and mirror how the fish communities and habitat characteristics are viewed at the river reach scale, subbasin tributary, entire subbasin, multiple subbasins or regional scale (e.g., ESU scale), and aggregate Columbia Basin anadromous fish stocks in the estuary and ocean environments. Ensuring conceptual consistency across multiple geographic scales in the management and recovery of fish, wildlife, and their habitats is a daunting challenge which has yet to be fully realized—primarily because the conceptual foundation at each geographic level is not explicitly stated and there has not been adequate communication and coordination regarding scientific principles and assumptions between the ever increasing numbers of management entities and governmental boundaries (i.e., local, state, and national) as geographic scale increases.

The conceptual foundation is defined at the largest geographic scale applicable to a planning effort. In this case, the Columbia Basin will usually be the largest geographic scale, although other out of basin scales may be appropriate for some migratory birds and the saltwater life stage of anadromous fish As the plan focuses with increasing detail on management strategies for smaller geographic areas, planners should then continue to check for conceptual consistency. The only current examples of an explicitly stated conceptual foundation are the “alternative conceptual foundations” of Return to the River (ISG, 1996) and the NPCC’s An Integrated Framework For Fish And Wildlife Management In The Columbia Basin (NPPC 1997), which are reviewed and synthesized in Lichatowich (1998).

1.2 Guiding Principles

Four sets of guiding principles derived from Lichatowich’s synthesized Columbia Basin Conceptual Foundation introduce principles and corollaries specific to the Yakima Subbasin. These four guiding principles (in bold) have been modified to make them applicable to both fish and wildlife. Following them, the principles of the Yakima Subbasin Conceptual Foundation (also in bold) are identified and discussed.

The Columbia River Basin is a natural-cultural system characterized by natural environmental variability and fluctuation in production. Restoration and management must consider the whole ecosystem, natural as well as cultural, in the terrestrial, freshwater, estuary, and ocean. Suitable ecosystem attributes can be achieved by managing human interference in the natural habitat forming processes and by use of technology to support those processes. The use of technology to circumvent natural ecological processes should be avoided, if possible.

> **Yakima Subbasin Conceptual Foundation - Principle 1. Strategies for recovery need to be evaluated within the context of the entire life history of the population.**

The Yakima Subbasin Plan can only identify, evaluate and prioritize alternative strategies for anadromous and migrating species recovery that can be fully implemented within the subbasin by authorized local, state, federal and tribal managers. The subbasin plan addresses strategies that can be implemented locally and that effect life stages that subbasin managers have complete control to influence through their decisions. However, planning and implementing actions for Fish and Wildlife recovery within the Yakima Subbasin must also consider out of basin affects, which will influence the success or failure of population recovery. Ideally, populations should be tracked or accounted for throughout the geographical range of their life history to ensure that differential survival/mortality rates specific to that population can be evaluated in preparation of recovery strategies.

For species whose entire life history is confined to the Yakima Subbasin, it is possible to make informed and logical decisions regarding all strategies necessary for recovery ("masters of our own destiny"). For example, only one native fish focal species is in this category---bull trout. Current bull trout life histories found in this basin, to the best of our knowledge, occur totally within the Yakima Subbasin. Bull Trout are highly dependent on the connectivity and maintenance of habitats suitable to complete their life history throughout the entire basin, and would make a good indicator of ecosystem health within the Yakima Subbasin

For Fish and Wildlife species that spend a portion of their life history outside of the subbasin boundaries, management goals, the desired ecosystem attributes, and restoration strategies should generally be universal and integrated across the subbasin, eco-region (ESU), Columbia Basin, and full life history (including estuary and marine) scales to be successful. Where differing parts of a population's life history or habitat are managed by different entities, those populations and their interactions with the environment, with other populations, and their responses to management actions should be monitored and communicated in a common language. The broader and more inclusive the management planning process becomes, the greater the potential that these common and integrated goals, attributes, strategies will be successful in recovering far-ranging migratory species.

Despite the need for universal and integrated strategies across regions, Yakima Subbasin planners/managers recognize that management of species with large migratory ranges is also analogous to a relay race. For anadromous salmonids, freshwater production phases of the life cycle occur totally within the boundaries of the subbasin, and thus objectives and implementation strategies that address adult pre-spawning survival, spawning, incubation, rearing and in-basin juvenile migration (fry, fingerlings and smolts) to maximize annual in-basin smolt production constitutes the subbasin manager's "lap holding the baton." During this portion of the race (life cycle), subbasin planners/managers can (or should) control their own destiny in terms of survival rates within their sphere of influence. When salmon and steelhead smolts leave the Yakima Basin, subbasin managers pass the baton to the next relay race participant, who become responsible for maximizing fish survival for the portion of the life cycle they have management control or influence over. This analogy holds true for the management of migratory wildlife species as well. For anadromous salmonids and migratory wildlife, recovery success depends on all relay race participants running a good race and not dropping the baton. Managers in each discrete sphere of influence should communicate their recovery efforts and expected results and limitations to managers outside their management spheres. In addition, they should evaluate and try to understand how results and limitations in other spheres influence overall survival and production rates for the populations throughout their life histories to determine at what point recovery efforts cease to increase production. However, it is clear that managers at each geographic scale should focus on maximizing fish and wildlife survival within their sphere of control.

Yakima Subbasin Conceptual Foundation - Principle 2. The Yakima Subbasin contains an evolving, natural-cultural system that will continue to change into the future.

Since Euro-American settlement, most of the watershed has been altered by the development (within and outside of the subbasin) of water resources and transportation systems, changes in land use and physical characteristics, fish and wildlife harvest, hatchery practices, and introduction of non-native species. In certain areas, this development has been less intense (e.g. Satus Creek), and the biologic productive capacity of those areas remains high. Development since 1850 has not produced a balance in the natural and cultural elements of the ecosystem; and the trend in native fish and wildlife abundance, especially naturally produced salmon, has been generally downward even in the face of repeated restoration and mitigation attempts.

The Yakima Subbasin's natural and cultural elements must be considered in any management planning. Unless a balance between the needs and constraints of the natural and cultural components of the ecosystem is achieved, the status of many of the native fish and wildlife populations in the basin will continue to decline. To move toward a balance, science and resource managers need to present the values and benefits of the natural elements and must show when their benefits outweigh the costs of protection and recovery. In addition, it must be made clear that healthy natural and cultural elements do not have to be mutually exclusive.

Yakima Subbasin Conceptual Foundation - Principle 3. Important environmental attributes that determine the distribution and productivity of fish and wildlife populations have been influenced by human activity in and outside the subbasin.

Cultural impacts have occurred at different rates and scales throughout the basin. For example, the USBR's Yakima Project constructed storage dams, without fish passage facilities, at the natural glacial lakes in the upper basin causing the rapid extirpation of the natural sockeye salmon populations (in one sockeye generation, i.e., 4 years) and likely several other populations of high elevation anadromous salmonids. Other changes also occurred in a relatively short time (30 years): The development of irrigation systems, many of which eventually became the USBR's Yakima Project, resulted in rapid changes in the linked habitat attributes of quantity of flow, rate and magnitude of flow fluctuations, stream energy, sediment loading and routing, channel complexity, and water temperature. Since then the physical and biological environments of the basin, both upstream and downstream of the dams, have continued to evolve on a trend largely determined by these changes. Other environmental changes, such as the presence of agricultural chemicals in the river, have been more varied. In the early years of development there was little change from previous conditions, followed by rapid increases in fertilizers, herbicides and pesticides starting in the 1920s (some of which will persist regardless of future action), and more recently a decrease in farm chemical concentrations due to environmental regulation beginning in the 1970s. These types of changes do not show clear trends and the effects can be variable into the future.

Many habitat attributes, now out of synch (timing) with the life history strategies that fish and wildlife populations had evolved prior to those alterations, are lethal to fish or wildlife for part of the year, or have directly resulted in habitat loss. These alterations have resulted in decreased abundance and productivity, and changes in the distribution of native fish and wildlife populations. The goal of Yakima Subbasin management should be to restore attributes (fish populations, fish access, flow regimes, stream energy or "power," sediment budget, temperature, and vegetative structure) that create properly functioning fish and wildlife habitat that is as close to the natural historic range as possible.

Fish and wildlife productivity requires a network of complex, interconnected habitats that are created, altered, and maintained by natural physical processes in terrestrial, freshwater, estuary, and ocean areas. Management and restoration goals depend on achieving suitable ecosystem attributes.

> **Yakima Subbasin Conceptual Foundation – Principle 4. Viable native fish and wildlife populations are dependent upon the natural environment and the natural processes that sustain them.**

The key is discovering what the important processes are. Usually the original conditions represent the best models we will ever have. Subbasin planners and managers must avoid a common tendency to become excessively (or exclusively) "salmo-centric" in developing management strategies. Instead, focusing on restoring terrestrial and aquatic/riparian ecosystem health and function will provide habitat attributes that will enable salmonid recovery together with other native biota.

> **Yakima Subbasin Conceptual Foundation – Principle 5. Changes to the physical characteristics and connectivity of the Yakima Subbasin have contributed to the decline of native fish and wildlife populations.**

Understanding the pre-development conditions, the current conditions, the trend in these conditions, and their effect on ecosystem attributes is crucial to formulation of recovery strategies.

Isolation and impoundment of the glacial headwater lakes had a large effect on the biological productivity of the basin, as did the radically altered hydrology resulting from storage reservoir operation. Flow management has altered ecosystem attributes to a large extent in the watershed as a whole. In the mainstem Yakima River, recovery of fish and wildlife productivity requires an emphasis on restoration of the natural range of hydrological attributes and fluvial processes, reconnection of isolated physical habitat, and protection or reintroduction of salmonid populations once reconnection has been achieved.

In Yakima River tributaries, loss of connectivity to the mainstem, blockage of upstream habitat at manmade fish passage barriers, and reductions in flow have occurred in numerous locations. These disturbances are usually located in physically similar locations, and are related to irrigation diversion location and design. Restoration in the tributaries should concentrate on increasing flow and improvement in design, location and management of irrigation diversions to reverse losses in connectivity. Where significant amounts of habitat have been unutilized or under-utilized for long periods of time, reintroduction of populations (hatchery supplementation) should take place as well.

> **Yakima Subbasin Conceptual Foundation – Principle 6. Changes to the physical characteristics of the alluvial valley and floodplains of the Yakima River have also resulted in changes in ecosystem attributes.**

Some of these changes are reversible from a societal perspective; some are not. Floodplain management and restoration where possible is a key to successful recovery of physical and biological characteristics that support native fish and wildlife species.

Isolation and impoundment of the glacial headwater lakes had a large effect on the biological productivity of the basin, as did the radically altered hydrology resulting from storage reservoir operation. Flow management has altered ecosystem attributes to a large extent in the watershed as a whole. In the mainstem Yakima River, recovery of fish and wildlife productivity requires an emphasis on restoration of the natural range of hydrological attributes and fluvial processes, reconnection of isolated physical habitat, and protection or reintroduction of salmonid populations once reconnection has been achieved.

In Yakima River tributaries, loss of connectivity to the mainstem, blockage of upstream habitat at manmade fish passage barriers, and reductions in flow have occurred in numerous locations. These disturbances are usually located in physically similar locations, and are related to irrigation diversion location and design. Restoration in the tributaries should concentrate on increasing flow, and improvement in design, location and management of irrigation diversions to reverse losses in connectivity, as well as reintroduction of populations (hatchery supplementation) where significant amounts of habitat have been unutilized or under-utilized for long periods of time.

Changes to the physical characteristics of the alluvial valley and floodplains of the Yakima River have also resulted in changes in ecosystem attributes. Some of these changes are reversible from a societal perspective; some are not. Floodplain management and restoration where possible is a key to successful recovery of physical and biological characteristics that support native fish and wildlife species.

> **Yakima Subbasin Conceptual Foundation – Principle 7. The historical distribution of fish and wildlife populations and species in the Yakima Subbasin was controlled by relatively abrupt changes in physical attributes, i.e. "steep" environmental gradients.**

In the Yakima Subbasin, these gradients existed at:

- Mouths of the glacial lakes (which delineated sockeye salmon populations)
- The confluence of certain cold (Teanaway R., American R.) or warm (Wenas Cr., Cowiche Cr., Satus Cr.,) tributaries with the mainstem
- The downstream geologic controls of the alluvial valleys (Gleed, Selah Gap, Prosser, Union Gap)
- Precipitation-based changes in vegetation zones (such as the forest/shrub steppe interface)

Changes to or elimination of the environmental gradients can be expected to affect the presence and distribution of species or populations. Not all species respond in the same way to a similar gradient. For instance, the steep temperature gradient (colder water) that occurs in the lower American River results in a distinct population of spring chinook with a very early spawning time, however, it is not known to ever have supported a steelhead population, (the temperature gradient forms population boundaries for Chinook and Steelhead), but the bull trout population is not distinct from the other upper Naches bull trout spawning aggregations. Nevertheless, reducing the temperature of the Upper Yakima year-round or increasing the summer temperature and lowering the winter temperature would have a powerful effect on species distribution and life history.

Species diversity and the biotic community are a reflection of the ecosystem attributes. The co-evolved assemblage of species share requirements for similar ecosystem attributes and those attributes can be estimated by intensive study of focal species.

> **Yakima Subbasin Conceptual Foundation - Principle 8. Selection of a broad range of focal species will cover most ecosystem attributes.**

Bull trout, sockeye, spring chinook, fall chinook, steelhead, and Pacific lamprey are the aquatic focal species for the Yakima Subbasin. Evaluation and planning for these species is expected to cover most of the important environments.

> **Yakima Subbasin Conceptual Foundation - Principle 9. It should be possible to divide the subbasin into geographic areas based on salmonid species or population distribution and the location of pre-settlement environmental gradients.**

These areas, called assessment units, should have similar native species assemblages and should provide a means for evaluation of the effect of the changes in physical and environmental processes on ecosystem attributes. Because wildlife use terrestrial and aquatic environments, they often inhabit multiple salmonid assessment units.

> **Yakima Subbasin Conceptual Foundation - Principle 10. For wildlife, the selection of focal habitats and their related focal species targets offer a basis for developing management strategies.**

This is done by considering ecological conditions necessary for *long term viability*, examining the planning area's current ecological states, and conducting coarse scale threats analyses. Where current habitat conditions or focal species population trends fail to meet assumptions about what constitutes target viability, protection or restoration efforts may be directed at abating threats and enhancing conditions supporting long term persistence of the focal targets.

Viability, a key concept in the context of conservation planning, refers to the ability of a species or a community/ecological system (referred to in this document as "focal habitats") to persist over some specified time period.

Species viability at the population level is affected by chance events that may dictate whether a species remains viable or goes extinct. Small populations can be affected by demographic or genetic uncertainty. Both large and small populations are affected by environmental uncertainty (e.g., unpredictable events related to weather and predator and competitor populations) and natural catastrophes.

Three general factors characterize community or ecological systems viability: demography of component species populations; internal processes and structures among these component species; and landscape-level processes that sustain the community or system. These factors are often referred to as "size," "condition," and "landscape context."

> **Yakima Subbasin Conceptual Foundation - Principle 11. A thorough threats assessment separates the stresses or factors impinging on target viability from the sources of stress or anthropogenic causes of impairment.**

For instance, in the case of a ponderosa pine matrix-forming system, stressors like altered fire regime, rapid spread of invasive species or pathogens, altered composition, lack of minimum dynamic area, can all be affecting the target. Stresses operate on the size, condition, or landscape attributes of targets. The sources of these stresses are human-caused factors. In the ponderosa pine example, the sources of stress may be coming from fire suppression and selective logging for high commercial value rather than from retention of structure, multiple use disturbances leading to invasions of exotic species, and so on. The combination of stresses and sources provides a deeper analysis of actual viability impairment, thus forming a basis for management strategies.

Suitable for larger planning areas, coarse-scale threats assessments identify the crosscutting threats operating across the landscape. Land conversions, both residential and agricultural, improper grazing practices, and uncontrolled spread of invasives are examples of the kinds of threats operating across the planning area. Critical threats are those threats likely to destroy or degrade conservation targets. Urgent threats are critical threats likely to occur in the near term. Among all threats assessed for a planning area, those that are most urgent can be prioritized for earlier management action.

> **Yakima Subbasin Conceptual Foundation - Principle 12. If the desired outcome for subbasin planning includes the persistence of representative regional biodiversity, these planning elements can structure a defensible and practicable result.**

Careful selection of focal targets, representing the breadth of spatial and biologic scales, can serve as the foundation for a detailed and rigorous assessment of current ecological states. The assessment is based on the precepts of focal target viability and detailed threats analyses. Focused acquisition and restoration strategies, bounded by the analysis structure, can then be directed at threat abatement and viability enhancement.

> **Yakima Subbasin Conceptual Foundation - Principle 13. Fish and wildlife are components of their own environment.**

Inter and intra-specific competition are the drivers for species and life history diversity within a given species assemblage. Restoration of individual populations may not be possible without restoration of other fish or wildlife populations with which they co-evolved. In addition to population dynamics, fish and wildlife can alter key habitat characteristics (e.g., nutrients, cleaned spawning beds, beaver ponds, forest understory, etc.).

Management of fish and wildlife resources should include management of species and life history assemblages (diversity) as well as population abundance. Management strategies that minimize intra-specific competition and variation will result in the loss of life history diversity as well as abundance, and over time will reduce the fitness of the population, especially for intensively managed populations such as hatchery supplemented stocks. Loss of intra-specific variability or the beneficial synergistic effects of sympatric salmonid populations on the ecosystem also decreases ecosystem stability and productivity. (Sympatric refers to species occupying the same habitat compatibly but not interbreeding.)

Life history, genetic diversity, and metapopulation organization are ways that fish and wildlife adapt to their habitat. Diversity and population structure are how fish and wildlife species cope with spatial and temporal environmental variations. Such diversity promotes production and long-term persistence at the species level.

> **Yakima Subbasin Conceptual Foundation – Principle 14. Most native fish and wildlife populations are linked across large areas; in pre-settlement times this**

distribution across a large area and the large size of the individual populations made extinctions a very remote possibility. The best way to recovery is to work within that framework and try to recreate it.

Attempting to restore populations outside of this framework will be difficult or impossible. Management of Yakima Subbasin fish and wildlife populations in the wild and in the hatchery environment should include strategies to maintain a close connection to the ecosystem attributes that influence and shape the population (i.e., environmental selective pressures), while also allowing for gene flow across populations.

Any program to restore fish and wildlife to the Yakima Subbasin must be capable of detecting and monitoring new, locally adapted life histories, if and when they occur in unique habitats.

Reintroduction or supplementation programs for fish or wildlife should concentrate on specific environments within the basin, selection of an appropriate stock for reintroduction to that environment or locally adapting a donor stock where a local stock no longer exists. When supplementing native populations, the facilities and programs should mimic the native environment as closely as possible. For example, in the hatchery environment, this includes maintenance of life history diversity such as spawn timing, matching hatchery incubation temperatures to the natural incubation environment, and simulating the natural rearing environment in the hatchery to the extent feasible.

Population management using supplementation must consider habitat quality and quantity to determine if existing habitat has the carrying capacity to support the number of fish or wildlife needed for genetic expression and to meet population goals.

Yakima Subbasin Conceptual Foundation – Principle 15. Populations with the least amount of change from their historical state are the easiest to protect and restore, and will have the best response to restoration actions.

The historical population structures and genetic diversity allowed populations to be resilient to disturbance, persist over evolutionary time, and expand into new habitats or reoccupy former habitats lost because of disturbance. Often blockages or land use changes result in areas of suitable habitat that are currently unoccupied. Reintroducing fish and wildlife to these areas is often appropriate because it may otherwise take a long time for populations to reseed themselves naturally.

The ability to predict population responses to changes in the environment is highest for those populations that are closest to their pre-settlement population structure. At some point along the scale from intact populations to former populations that have had entire metapopulation (groups of related populations that share genes at low rates over time) extirpated from the basin and adjacent basins, emphasis on recovery actions is better focused on rebuilding population structure than on habitat restoration. If the goal of cost- effective restoration is to be achieved, subbasin planners need to assess the optimal mix of habitat restoration and population structure restoration to achieve biological goals. In other words, in areas where some components of population structure or genetic integrity have been lost (as is the case with most wild populations of salmonids and other populations of wildlife or plant species in the Yakima Subbasin), it is likely that a coordinated restoration strategy will involve both restoration of habitat and population structural attributes such as abundance, growth rate, intra-population genetic and life history diversity, and genetic linkages to other populations.

Populations that have multiple life histories (e.g., multiple locations or times where rearing takes place, multiple ages/times of year when out-migration occurs, multiple ages at sexual maturity, multiple spawning areas) minimize risk to the population as a whole. These life history strategies are linked to population structure and genetics (Altukhov et. al. ISRP). Where a life history type has been eliminated (e.g., Yakima summer chinook or spring chinook that rear in the lower river in the summer downstream of Parker Dam) by changes or loss of habitat, restoration of that habitat will probably not result in an increase in abundance or productivity in the short term. If a life history type still exists in closely related populations, it may be necessary to artificially reintroduce this life history type to see a response to habitat restoration in the short term.

> **Yakima Subbasin Conceptual Foundation – Principle 16. All else being equal, small populations are at greater risk of extinction than large populations, primarily because several processes that affect population dynamics operate differently in small populations than they do in large populations.**

These processes are deterministic density effects, environmental variation, genetic processes, demographic stochasticity, ecological feedback, and catastrophes. In some cases, these small populations will need measures in addition to habitat restoration if they are to survive into the future. Such measures may include captive broodstock, artificial introduction of spawners from outside the population, or special consideration where habitat restoration modifies the only known sites where a particular life history is expressed.

2 Wildlife Habitat

2.1 Introduction

2.1.1 Overview Related to Wildlife

As humid air from the Washington coast is forced up and over the Cascade Mountains, most water vapor falls as precipitation on the western slope and crest of the mountain range. The crest of the Cascades forms the western border of the Yakima Subbasin, and accordingly, annual precipitation declines from west to east across the region (Figure 2-1 shows major vegetation zones, typical locations, its elevation (m), precipitation (mm), and mean annual temperature (C)). The rainshadow effect of declining precipitation and concurrent drop in elevation determines potential vegetation, resulting habitat types, and the distribution of wildlife species in the subbasin.

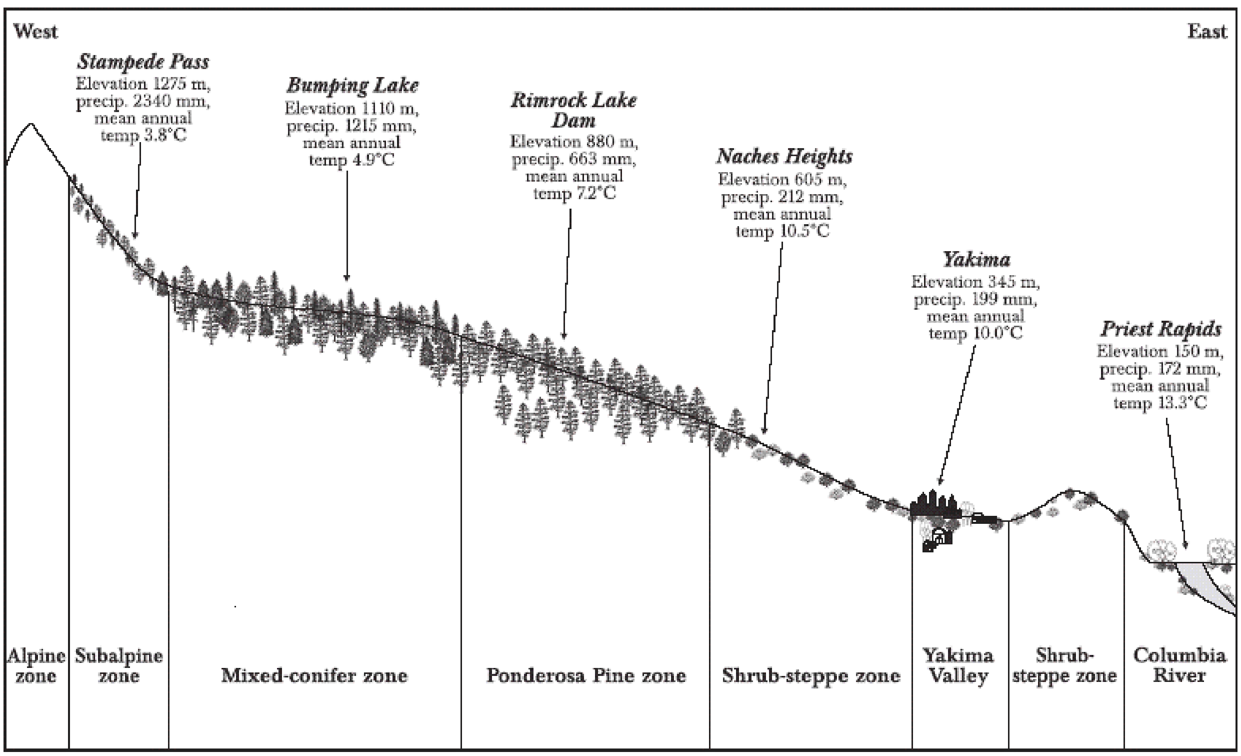


Figure 2-1. Transect west to east across Yakima County from Cascade Crest to Columbia River. Stampede pass 4183 feet, 92 inches of precipitation, 39ºF; Priest Rapids 492 feet, 7 inches of precipitation, 56ºF.(Stepniewski 1999)

Wildlife species are found in various habitats, which extend across and beyond subbasin "boundaries" (see Figure 1-1). Some wildlife species may spend their entire life in a 1sq mile area or smaller. Others, however, travel beyond subbasin boundaries, to other states and other countries. For example, some bird species are year-round residents, while others are migratory. It is especially important to recognize that how habitats are managed within subbasins affects species occurrence and viability over the long term.

2.1.2 Assessment Tools

The wildlife assessment was developed from a variety of tools including the Yakima Subbasin Summary from 2001, the Interactive Biodiversity Information System (IBIS), the WDFW Priority Habitats and Species (PHS) database, the Washington GAP Analysis database (GAP), Partners in Flight (PIF) information, National Wetland Inventory maps (NWI), and input from local, state, federal, and tribal wildlife managers. Specific information about these data sources is located in Appendix A

2.1.3 Interactive Biodiversity Information System

IBIS is an informational resource developed by the Northwest Habitat Institute (NHI) to promote the conservation of Northwest fish, wildlife, and their habitats through education and the distribution of timely, peer-reviewed scientific data. IBIS contains extensive information about Pacific Northwest fish, wildlife, and their habitats, but also, IBIS attempts to reveal and analyze the relationships among these species and their habitats. More information related to IBIS can be accessed at: http://www.nwhi.org/nhi/home/home.asp.

Although IBIS is a useful assessment tool, it should be noted that IBIS-generated historic habitat maps have a minimum polygon size of 1 km^2 while IBIS current habitat type maps have a minimum polygon size of 100 ha or 250 acres (T. O'Neil, NHI, pers.comm., 2003). In either case, linear aquatic, riparian, wetland, subalpine, and alpine habitats are under represented, as are small patchy habitats that occur at or near the canopy edge of forested habitats. It is also likely that microhabitats located in small patches or narrow corridors were not mapped at all. Another limitation of IBIS data is that they do not specifically rate habitat quality nor do they associate key ecological correlates (KEC) with specific areas. As a result, a given habitat type may be accurately depicted on IBIS maps, but may be lacking in functionality and quality. For example, IBIS data do not distinguish between shrub steppe habitat dominated by introduced weed species and native shrub steppe habitat.

2.1.4 Washington GAP Analysis Program

Gap Analysis is a process of identifying areas of high conservation priority. It is designed to be a proactive approach to conservation. Gap relies on information about current landcover and terrestrial vertebrates to identify habitat types and species that are poorly represented on reserves. Washington State GAP data was used extensively throughout the wildlife assessment. The GAP generated acreage figures may differ from IBIS acreage figures as an artifact of using two different data sources. The differences, however, are relatively small (less than 5 percent) and will not impact planning and/or management decisions. GAP analysis does not cover lands on the Yakama Nation Reservation. For a more detailed description of GAP refer to the National GAP homepage at http://www.gap.uidaho.edu.

2.2 Wildlife Habitats

IBIS 2003 describes 15 different habitat types for the Yakima Subbasin. These wildlife-habitat types update and expand the prior regional works of Thomas (1979), Maser (1984), and Brown (1985). Chapter 1 in *Wildlife-Habitat Relationships in Oregon and Washington* (Johnson and O'Neil, 2001) describes how these wildlife-habitat types were determined. Detailed descriptions of each habitats geographic distribution, physical setting, landscape setting, structure, and composition can be found in Appendix C as well as information that may possibly help managers, researchers, and others gain further insight into each habitat. The following table, Table 2-1, describes the habitat types encompassed by the IBIS data set. These are useful in a comparative sense. See Figure 2-3 for the locations of these habitat types within the subbasin.

Table 2-1. Wildlife habitat types within the Yakima Subbasin (IBIS 2003)

Habitat Type	Brief Description
Mesic Lowlands Conifer-Hardwood Forest	One or more of the following are dominant: Douglas-fir, western hemlock, western redcedar, Sitka spruce, red alder.
Montane Mixed Conifer Forest	Coniferous forest of mid-to upper montane sites with persistent snowpack; several species of conifer; understory typically shrub-dominated.
Interior Mixed Conifer Forest	Coniferous forests and woodlands; Douglas-fir commonly present, up to 8 other conifer species present; understory shrub and grass/forb layers typical; mid-montane.
Lodgepole Pine Forest and Woodlands	Lodgepole pine dominated woodlands and forests; understory various; mid- to high elevations.
Ponderosa Pine and Interior White Oak Forest and Woodland	Ponderosa pine dominated woodland or savannah, often with Douglas-fir; shrub, forb, or grass understory; lower elevation forest above steppe, shrub steppe.
Subalpine Parkland	Whitebark pine (P. albicaulis) is found primarily in the eastern Cascade mountains Okanogan Highlands, and Blue Mountains.
Alpine Grasslands and Shrubland	Grassland, dwarf-shrubland, or forb dominated, occasionally with patches of dwarfed trees.
Interior Grasslands	Dominated by short to medium height native bunchgrass with forbs, cryptogam crust.
Shrub steppe	Sagebrush and/or bitterbrush dominated; bunchgrass understory with forbs, cryptogam crust.
Agriculture, Pasture, and Mixed Environs	Cropland, orchards, vineyards, nurseries, pastures, and grasslands modified by heavy grazing; associated structures.
Urban and Mixed Environs	High, medium, and low (10-29 percent impervious ground) density development.
Lakes, Rivers, Ponds, and Reservoirs	Natural and human-made open water habitats.
Herbaceous Wetlands	Emergent herbaceous wetlands with grasses, sedges, bulrushes, or forbs; aquatic beds with pondweeds, pond lily, other aquatic plant species; sea level to upper montane.
Montane Coniferous Wetlands	Forest or woodland dominated by evergreen conifers; deciduous trees may be co-dominant; understory dominated by shrubs, forbs, or graminoids; mid- to upper montane.
Interior Riparian Wetlands	Shrublands, woodlands and forest, less commonly grasslands; often-multilayered canopy with shrubs, graminoids, forbs below.

Dramatic changes in wildlife habitat have occurred throughout the subbasin since circa 1850. The most significant habitat changes throughout the subbasin include the loss and/or alteration of shrub steppe, ponderosa pine, riparian, and wetlands (Figure 2-2 and Figure 2-3). Quantitative changes in subbasin wildlife habitat types are further described in Table 2-2.

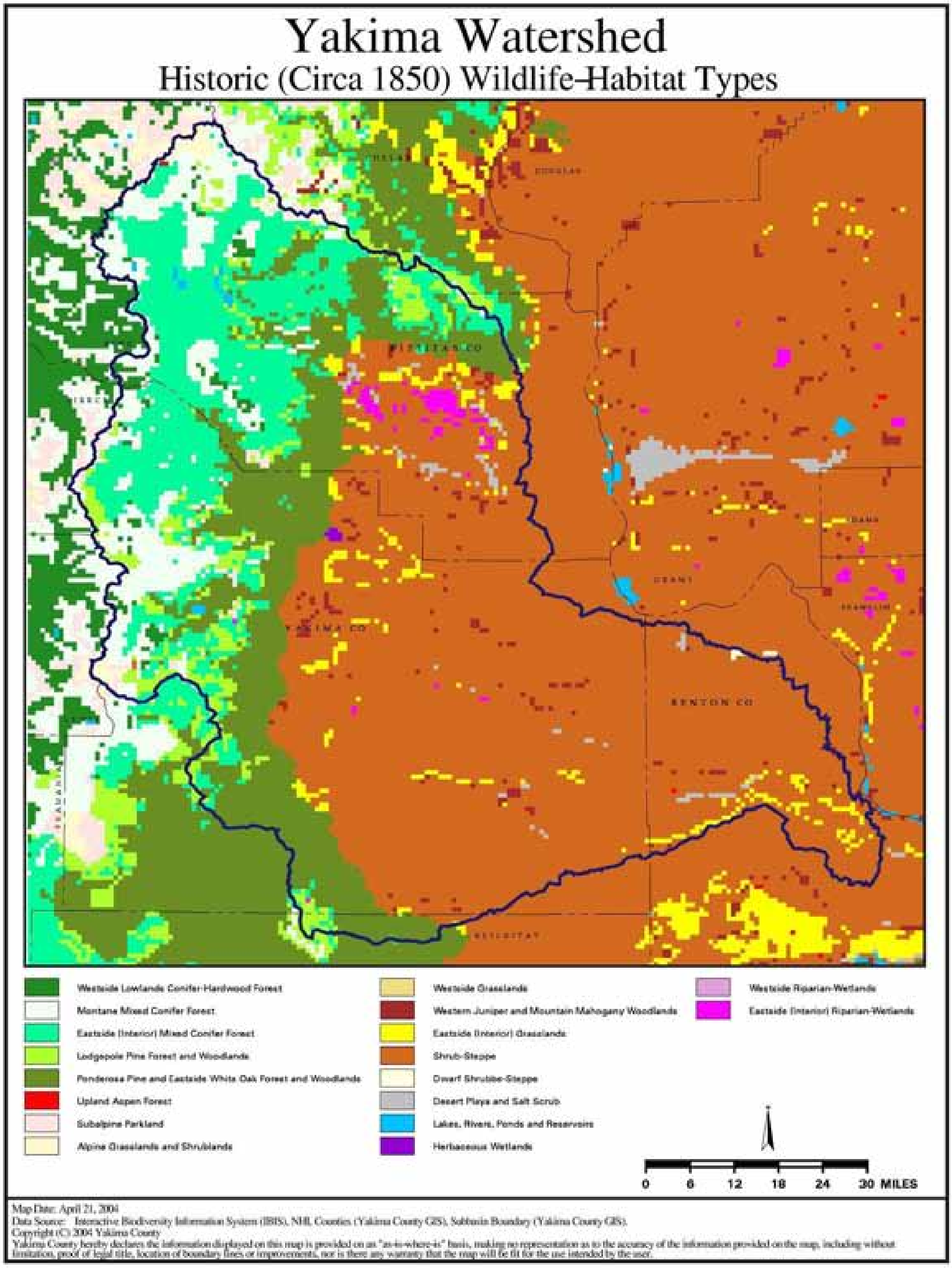


Figure 2-2. Historic wildlife habitat types of the Yakima Subbasin (IBIS 2001)

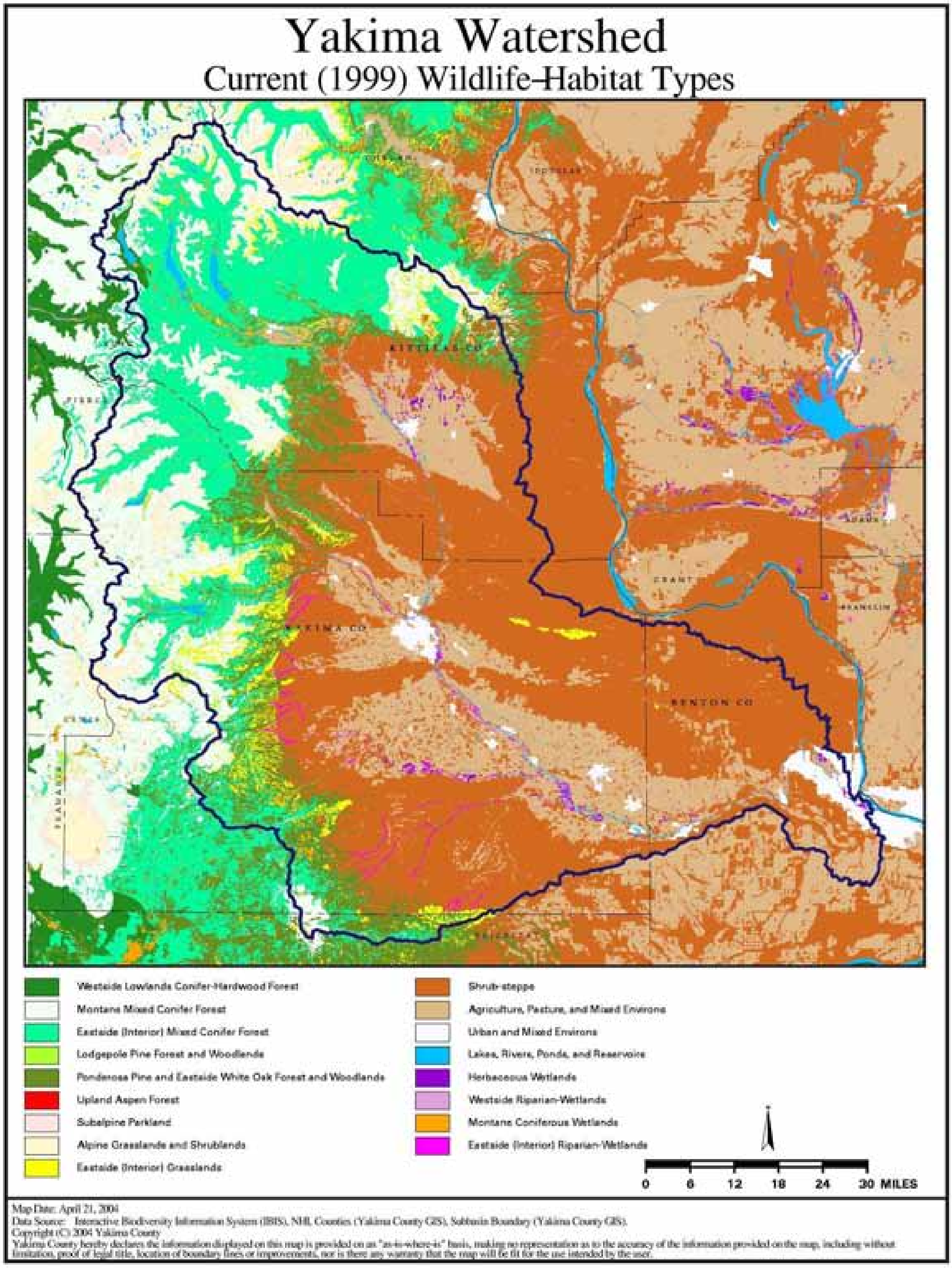


Figure 2-3. Current wildlife habitat types of the Yakima Subbasin (IBIS 2003)

2.3 Focal Wildlife Habitats

2.3.1 Habitat Selection and Rationale

To ensure that species dependent on given habitats remain viable, Haufler (2002) advocated comparing the current availability of the habitat against its historic availability. According to Haufler, this coarse filter habitat assessment can be used to quickly evaluate the relative status of a given habitat and its suite of obligate species. To ensure that "nothing drops through the cracks," Haufler also advocated combining the coarse filter habitat analysis with a single species or fine filter analysis of one or more obligate species to further ensure that species viability for the suite of species is maintained. The following three key principles/assumptions were used to guide selection of focal habitats (see Figure 2-4 for an illustration of the focal habitat/species selection process).

- Focal habitats can be used to evaluate ecosystem health and establish management priorities at the subbasin level (coarse filter).
- Focal species can be used to represent focal habitats and to infer and/or measure response to changing habitat conditions at the subbasin level (fine filter).
- Focal species were selected at the subbasin level. To identify focal macro habitat types within the Subbasin, Subbasin planners used the assessment tools to develop a habitat selection matrix based on various criteria, including ecological, spatial, and cultural factors. As a result, subbasin planners selected four focal wildlife habitat types of the fifteen that occur within the Subbasin as identified by IBIS (Table 2-4).
- Four IBIS habitats were combined into two focal habitat types for the Yakima Subbasin Plan. Shrub steppe has been combined with interior grasslands; montane coniferous wetlands were grouped with herbaceous wetlands in montane elevational zones. For an illustration of where the focal wildlife habitat types occur in the Subbasin, see Figure 2-1.

Therefore, subbasin focal habitats included are:

- Montane Coniferous Wetlands
- Ponderosa Pine/Oregon White Oak
- Shrub steppe/Interior Grasslands
- Interior Riparian Wetlands.

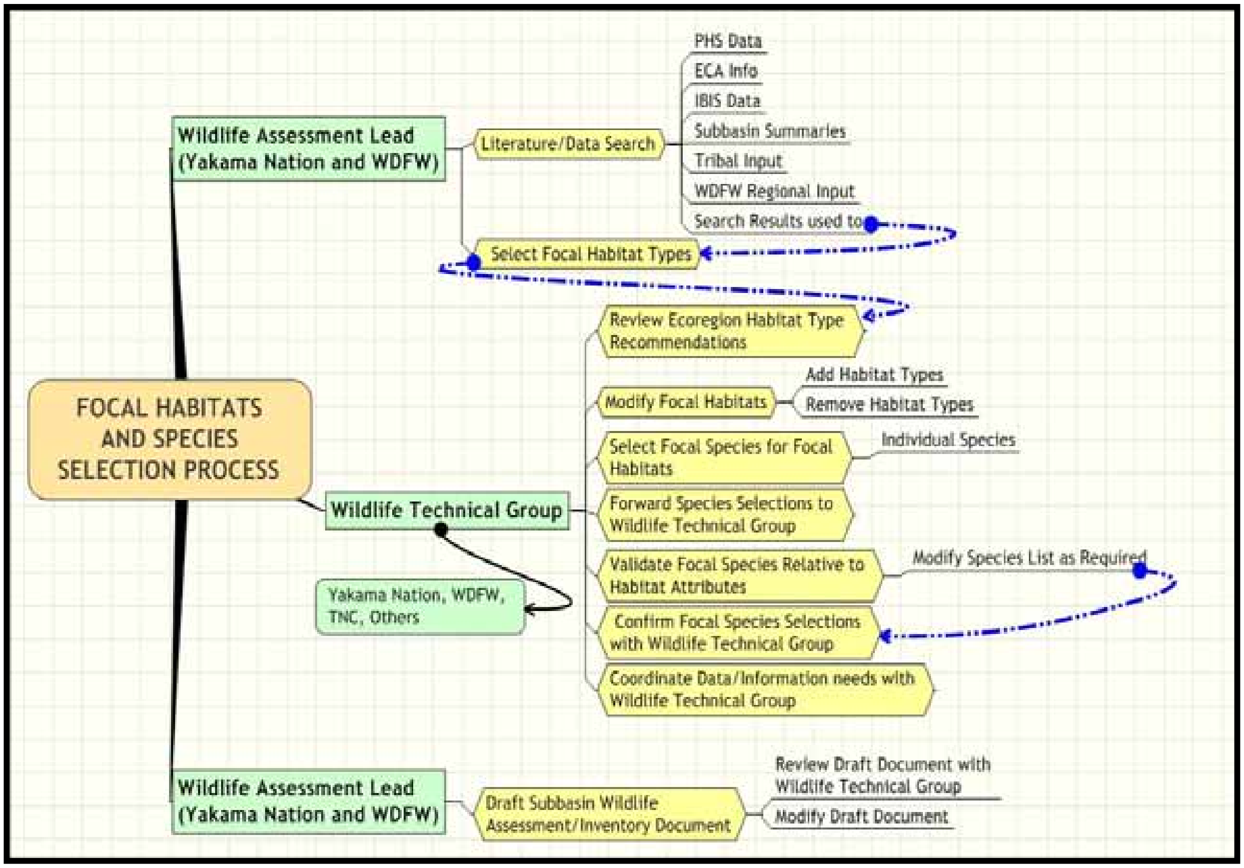


Figure 2-4. Focal habitat and species selection process summary

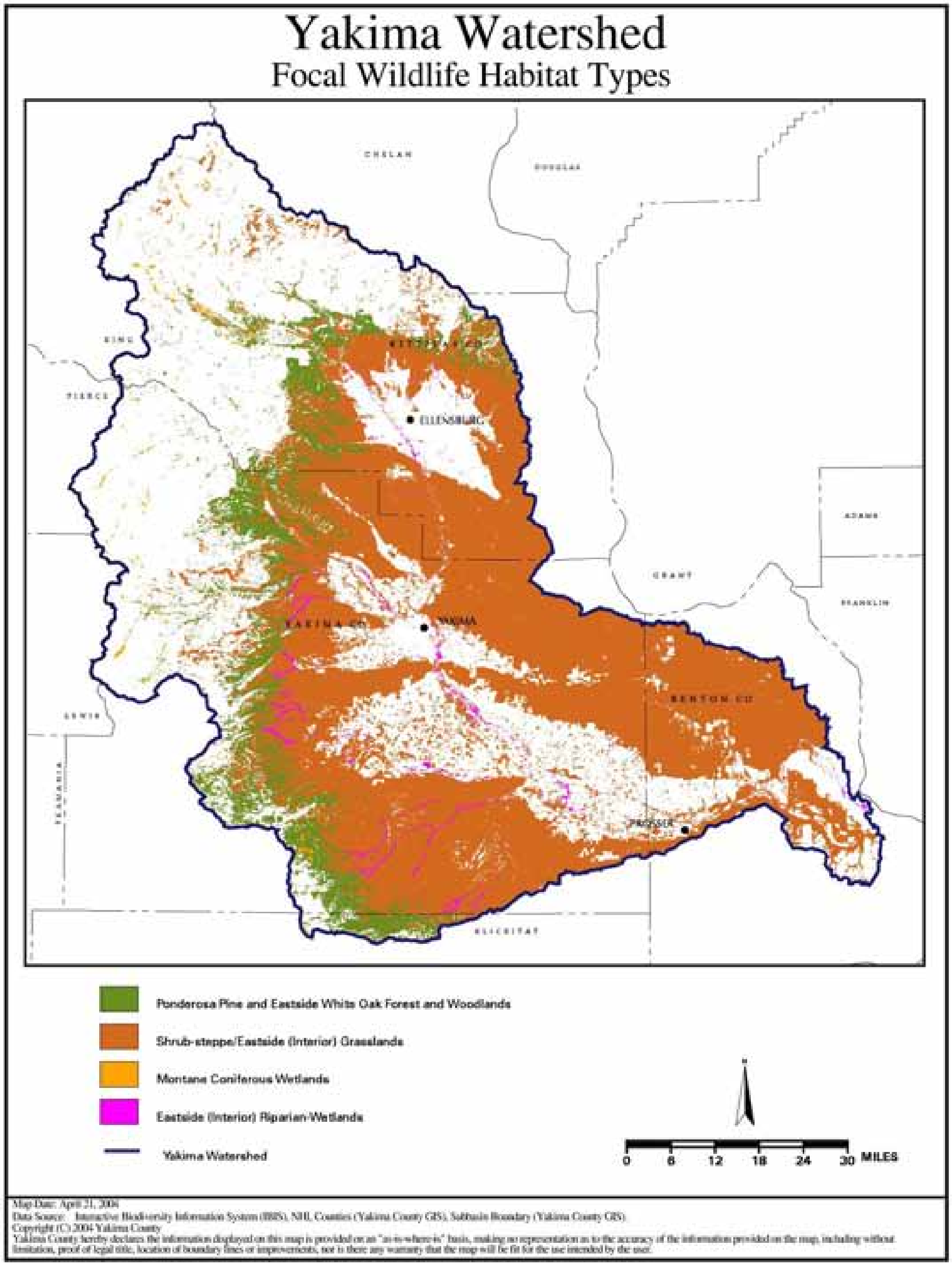


Figure 2-5. Focal wildlife habitat types of the Yakima Subbasin (IBIS 2003)

Broadly speaking, most of the major habitat types within the subbasin, from the interior riparian wetlands at the valley floor to the montane coniferous wetlands of the high country, were selected. Notable exceptions exist. Four coniferous forest types were not selected based on the assumption that federal forest management actions were adequately addressing issues related to these habitat types. Also, two alpine types were not selected because significant portions of these are protected as wilderness areas.

2.3.2 Montane Coniferous Wetlands

In the forest zone, montane coniferous wetlands provide important ecological and hydrologic function disproportionate to their size on the landscape. Montane coniferous wetlands are positioned at the headwaters of many important Yakima River tributaries. In addition, they provide critical habitats for specialized organisms as well as the collection and slow delivery of snowmelt. Habitat degradation and disturbance associated with human activities have impacted the functionality of many of these habitats in the Yakima Subbasin, thus justifying their selection as focal. The strong link to hydrologic function also played a role in selection. An effort was made to select all terrestrial habitat types that are connected ecologically to aquatic systems. This approach should provide for management consistency between aquatic and terrestrial systems.

2.3.3 Ponderosa Pine/Oregon White Oak

Ponderosa pine/Oregon white oak woodland habitats are unique dry forest ecosystems and have experienced extensive loss and degradation in the Yakima Subbasin. Several highly associated bird species are in declining populations and identified as species of concern. Old growth Ponderosa pine forests are experiencing declines in the Interior Columbia Basin (Wisdom et al. in press). In addition to the overall loss of this forest type, two features, snags and old-forest conditions, have diminished appreciably with resulting declines of bird species highly associated with these conditions or features (Hillis et al. 2001). The changes in fire cycles have greatly changed this focal habitat as well, resulting in dense, poor quality habitat for these dependant species. Oregon white oak woodlands exist to a lesser extent in the Yakima, but nevertheless are an important and unique habitat, thus it is included as a focal habitat.

2.3.4 Shrub Steppe/Interior Grasslands

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

(BBS) (Saab and Rich 1997). Historically, shrub steppe was the most abundant habitat type within the subbasin (Refer back to Figure 2-2) deserving high conservation priority.

Interior Grasslands were selected as a focal habitat type because land use practices in the past 100 years have reduced this habitat type by 97 percent. This significantly impacted grassland dependent species such as sharp-tailed grouse (IBIS 2003). Within the Subbasin, this habitat type historically occurred at the transition zone between shrub steppe and forest and where fires killed shrubs within the shrub steppe. Despite its importance as a wildlife habitat it was limited in distribution within the Subbasin historically. Modern altered fire intervals have converted large portions of remaining shrub steppe into grassland habitat. Adequate mapping data illustrating where these two types exist within the Subbasin does not exist. Therefore, the Interior Grassland type was included into the Shrub Steppe habitat type for this plan.

2.3.5 Interior Riparian Wetlands

Riparian wetlands was selected as a focal habitat because its protection, compared to other habitat types, may yield the greatest gains for fish and wildlife while involving the least amount of area (Knutson and Naef 1997). Riparian habitat covers a relatively small area yet it supports a higher diversity and abundance of fish and wildlife than any other habitat; it provides important fish and wildlife breeding habitat, seasonal ranges, and movement corridors; it is highly vulnerable to alteration; it has important social values, including water purification, flood control, recreation, and aesthetics; and, many species that primarily dwell in other habitat types, such as shrub steppe, depend on riparian areas during key portions of their life history.

2.4 Changes in Focal Wildlife Habitat Quantity and Distribution

The IBIS habitat data are incomplete. Therefore, focal habitats may not be well represented. In the Yakima Subbasin, significant physical and functional losses have occurred. IBIS was utilized to provide consistency and standardization within in the Columbia Basin. Where possible, other data sources are used in this assessment.

Table 2-2. Changes in focal wildlife habitat types in the Yakima Subbasin from circa 1850 (historic) to 1999 (current) (IBIS 2003)

HABITAT TYPE	STATUS			
	Historic	Current	Change (acres)	Change (%)
Ponderosa Pine/Oregon White Oak	593,000	293,000	-300,000	-51
Shrub Steppe/Interior Grasslands	2,063,000	1,537,000	-526,000	-25
Agriculture, Pastures, and Mixed Environs	0	656,000	656,000	NA
Urban and Mixed Environs	0	72,000	72,000	NA
Montane Coniferous Wetlands	**	**	**	**
Interior Riparian Wetlands	**	**	**	**
** montane coniferous and riparian wetlands do not appear adequately on historic maps.				

3 Focal Wildlife Species

3.1 Selection and Rationale

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

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

Subbasin planners consider focal species' life requirements representative of habitat conditions or features that are important within a properly functioning focal habitat type. In some instances, extirpated or nearly extirpated species (e.g., sage grouse) were included as focal species if subbasin planners believed they could potentially be reestablished and/or are highly indicative of some desirable habitat condition. Other species, Sandhill Crane and the Western Toad, were selected by planners because they were considered closely associated with a particularly significant habitat.

Subbasin planners identified a focal species assemblage for each focal habitat type (Table 2-4) and combined life requisite habitat attributes for each species assemblage within each focal habitat to form a recommended "range of management conditions." Wildlife habitat managers will use the recommended range of habitat conditions to identify and prioritize future habitat acquisition, protection, and management strategies and to develop specific habitat management actions/measures for focal habitats.

Subbasin planners emphasize ecosystem management through use of focal habitat types while including components of single-species, or indicator species assemblages. This approach is based on the following assumption: a conservation strategy that emphasizes focal habitats at the subbasin scale is more desirable than one that emphasizes individual species.

By combining the "coarse filter" (focal habitats) with the "fine filter" (focal wildlife species assemblage) approach, subbasin planners believe there is a much greater likelihood of maintaining, protecting and/or enhancing key focal habitat attributes and providing functioning ecosystems for wildlife. This approach not only identifies priority focal habitats, but also describes the most important habitat conditions and attributes needed to sustain obligate wildlife populations within these focal habitats. Although conservation and management is directed toward focal species, establishment of conditions favorable to focal species also will benefit a wider group of species with similar habitat requirements.

Focal species can also serve as performance measures to evaluate ecological sustainability and processes, species/ecosystem diversity, and results of management actions (USFS 2000). Monitoring of habitat attributes and focal species will provide a means of tracking progress towards conservation. Monitoring will provide essential feedback for demonstrating adequacy of conservation efforts on the ground, and guide the adaptive management component that is inherent in this approach.

Subbasin planners selected focal wildlife species using a combination of several factors including:

Primary association with focal habitats for breeding; Specialist species that are obligate or highly associated with key habitat elements/conditions important in functioning ecosystems
Declining population trends or reduction in their historic breeding range (may include extirpated species)
Cultural significance of the species from a tribal and non-tribal perspective
Special management concern or conservation status such as threatened, endangered, species of concern, management indicator species, etc.
Professional knowledge on species of local interest

3.2 Focal Wildlife Species Selected

A total of seven bird, three mammalian species and one amphibian species were chosen as focal species to represent four priority habitats in the Yakima Subbasin (**Table 2-3**). Focal species selection rationale and important habitat attributes for each species are described in further detail in Table 2-4.

Table 2-3. Focal species selection matrix for the Yakima Subbasin

Common Name	Focal Habitat	Status[1]		Native Species	PHS	Partners in Flight	Game Species
		Federal	State				
Western Toad	Montane Coniferous Wetlands	SC	C	Yes	Yes	No	No
Sandhill Crane		n/a	E	Yes	Yes	No	No
White-headed Woodpecker	Ponderosa Pine / Oregon White Oak	n/a	C	Yes	Yes	Yes	No
Lewis' Woodpecker		n/a	C	Yes	Yes	Yes	No
Western Gray Squirrel		SC	T	Yes	Yes	No	No
Mule Deer	Shrub steppe /Interior Grasslands	n/a	n/a	Yes	Yes	No	Yes
Brewer's Sparrow		n/a	n/a	Yes	No	Yes	No
Sage Grouse		C	T	Yes	Yes	No	No
Yellow Warbler	Interior Riparian Wetlands	n/a	n/a	Yes	No	No	No
Mallard		n/a	n/a	Yes	No	No	Yes
American Beaver		n/a	n/a	Yes	No	No	Yes

[1] C = Candidate; SC = Species of Concern; T = Threatened; E = Endangered

Table 2-4. Focal species selection rationale and habitat attributes for the Yakima Subbasin

Focal Species	Focal Habitat	Conservation Focus	Habitat Attribute (Vegetative Structure)	Comments	Life Requisite	Reason For Selection
Western Toad	Montane Coniferous Wetlands	Intact and functional montane wetland	Breeds in montane wetlands, needs standing water < .5 m. Terrestrial habitats include down logs and soft soils.	Widespread but possibly in significant decline. IUCN endangered	Reproduction	Dependent on montane wetlands for critical life stages
Sandhill Crane	Montane Coniferous Wetlands	Large montane wetlands with limited human disturbance	Breeds in montane wetlands with large open water component and high cover nearby for hiding of colts.	One known breeding site in Yakima, potential for others	Reproduction and migration	Dependent on large montane wetlands for critical life stages. WA state endangered
White-headed woodpecker	Ponderosa Pine /Oregon White Oak	Large patches of old growth forest with large trees and snags	> 10 trees/ac > 21" dbh w/ > 2 trees > 31" dbh, 10-40% canopy closure, > 1.4 snags/ac > 8" dbh w/ > 50% > 25"	Large high-cut stumps; patch size smaller for old-growth forest; need > 350 ac or > 700 ac	Reproduction	Obligate for large patches of healthy old-growth Ponderosa pine forest; WA Priority Species
Lewis's Woodpecker	Ponderosa Pine /Oregon White Oak	Large, Ponderosa Pine trees / snags	> .8 trees / acre > 21" dbh, canopy cover 10-40%, shrub cover 30-80%	Dependent on insect food supply; competition from E. starlings detrimental	Reproduction	High conservation importance, because of its relatively small and patchy distribution, low overall density, and association with mature montane forests.

Focal Species	Focal Habitat	Conservation Focus	Habitat Attribute (Vegetative Structure)	Comments	Life Requisite	Reason For Selection
Western Gray Squirrel	Ponderosa Pine /Oregon White Oak	Closely linked to oak p. pine woodlands	Mixed stands of oak and ponderosa pine preferred for nesting. Large pine considered essential for winter food in off acorn years.	Remnant populations on Yakama Nation Res., Extirpated from Tieton/ Naches	All life stages, non migratory	Obligate for oak pine woodlands habitat. WA PHS species
Mule deer	Shrub steppe/Interior grasslands	Big sagebrush, antelope bitterbrush	30-60% canopy cover of preferred shrubs < 5 ft., number of preferred shrub species > 3, mean height of shrubs > 3 ft., 30-70% canopy cover of all shrubs < 5 ft.	Important game species	Food	Indicator of healthy diverse shrub layer in shrub steppe habitat; WA Priority Species
Sage Grouse	Shrub steppe/Interior grasslands	Diverse herbaceous understory, sagebrush cover	Sagebrush cover 10-30%, forb cover > 10%, open ground cover > 10%, non-native herbaceous cover < 10%	Area sensitive; needs large blocks	Year around habitats	Indicator of healthy and complete shrub steppe ecosystems
Brewer's sparrow	Shrub steppe/Interior grasslands	Sagebrush cover	sagebrush cover 10-30%, sagebrush height > 60 cm, herbaceous cover > 10%, open ground > 20%, non-native herbaceous cover < 10%	Prefer patchy distribution of sagebrush	Food, Reproduction	Indicator of healthy sagebrush dominated shrub steppe habitat w/ native herbaceous cover
Yellow warbler	Interior Riparian wetlands	Subcanopy foliage	> 70% cover in shrub and subcanopy w/ subcanopy > 40% of that, > 70% cover native species	Highly vulnerable to cowbird parasitism; grazing reduces understory structure	Reproduction	Represents species which reproduce in riparian shrub habitat and make extensive use of adjacent wetlands.

Focal Species	Focal Habitat	Conservation Focus	Habitat Attribute (Vegetative Structure)	Comments	Life Requisite	Reason For Selection
Mallard	Interior Riparian wetlands	Wetland Quality	Ratio of emergent vegetation to open water 60:40 to 40:60	Wetland brood habitat must be near riparian or grassland nesting habitat	Food, Reproduction	Culturally important Life stages represent wetland, riparian grassland and agricultural habitats
Beaver	Interior Riparian wetlands and Montane Coniferous Wetlands	Canopy closure	40-60% tree/shrub canopy closure trees, < 6" dbh; shrub height 6.6 ft.	Wetland and riparian shrub/forest habitat	Food	Indicator of healthy regenerating cottonwood stands; important habitat manipulator
		Permanent water	stream channel gradient 6% with little to no fluctuation	Keystone species creating pools and standing water used by many species	Water (cover for food and reproductive requirements)	

4 Focal Habitat and Focal Species Discussion

4.1 Montane Coniferous Wetlands

4.1.1 Historic

Montane Coniferous Wetlands were chosen as a focal habitat due to the ecological and cultural importance. This habitat type is naturally limited in its extent and has probably declined little in area over time (Figure 2-3). Montane meadows are a part of this habitat type. Degradation of these habitats has been observed in the Yakima Subbasin. These wetlands are extremely important to the functioning of the surrounding riparian systems. They act as water storage reserves, providing water to streams well into the summer. They are also important for many wildlife species including the Yakima Subbasin focal species, American Beaver, Sandhill Crane and Western Toad.

Logging, fire suppression and grazing activities have over time compressed the soil, lowered the water table and allowed surrounding forests to encroach. This decreases the available water here for native plant and wildlife species, and results in some areas drying up. They are also important culturally, supporting many species of medicinal plants collected by tribal people.

Forest streams and ponds are another part of this habitat type and can also be degraded by logging and grazing. These activities can increase sedimentation and temperature and decrease in-stream woody debris and riparian vegetation. This can make the habitat unsuitable for species dependent on these areas for some or all of their life cycle.

4.1.2 Current

Montane coniferous wetlands occur in mountains throughout much of Washington and Oregon, except the Basin and Range of southeastern Oregon, the Klamath Mountains of southwestern Oregon, and the Coast Range of Oregon. This includes the Cascade Range, Olympic Mountains, Okanogan Highlands, Blue and Wallowa mountains (see Figure 2-6) for a location of this habitat in and surrounding the Yakima Subbasin).

This habitat is typified as forested wetlands or floodplains with a persistent winter snow pack, ranging from moderate to very deep. The climate varies from moderately cool and wet to moderately dry and very cold. Mean annual precipitation ranges from about 35 to >200 inches (89 to >508 cm). Elevation is mid- to upper montane, as low as 2,000 ft (610 m) in northern Washington, to as high as 9,500 ft (2,896 m) in eastern Oregon. Topography is generally mountainous and includes everything from steep mountain slopes to nearly flat valley bottoms. Gleyed or mottled mineral soils, organic soils, or alluvial soils are typical. Subsurface water flow within the rooting zone is common on slopes with impermeable soil layers. Flooding regimes include saturated, seasonally flooded, and temporarily flooded. Seeps and springs are common in this habitat.

These wetlands can occur along stream courses or as patches, typically small, within a matrix of montane mixed conifer forest, or less commonly, eastside mixed conifer forest or lodgepole Pine forest and woodlands. It also can occur adjacent and intermixed with other wetland habitats: particularly riparian-wetlands, and herbaceous wetlands. The primary land uses are forestry, recreation and watershed protection.

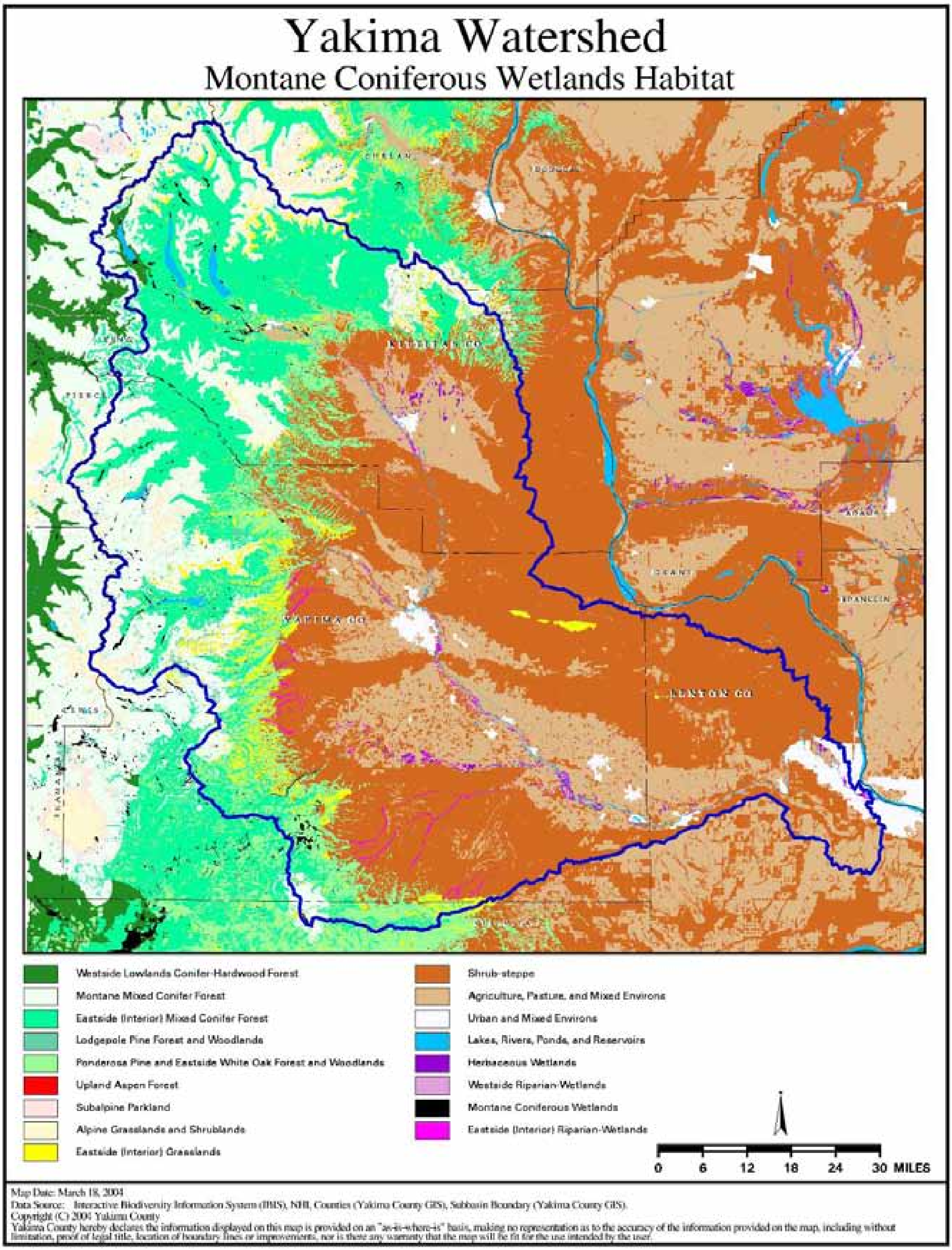


Figure 2-6. Montane coniferous wetlands in and surrounding the Yakima Subbasin

This habitat is within a forest or woodland dominated by evergreen conifer trees. Deciduous broadleaf trees are occasionally co-dominant. The understory is dominated by shrubs (most often deciduous and relatively tall), forbs, or graminoids. The forb layer is usually well developed even where a shrub layer is dominant. Canopy structure includes single-storied canopies and complex multi-layered ones. Typical tree sizes range from small to very large. Large woody debris is often a prominent feature, although it can be lacking on less productive sites. Areas of herbaceous vegetation may occur as a part of this focal habitat, often with conifers encroaching along the edges of these wet meadows and wetlands.

Indicator tree species for this habitat include Pacific silver fir, mountain hemlock, Alaska yellow-cedar Engelmann spruce, subalpine fir, lodgepole pine, western hemlock, and Western redcedar, Douglas-fir and grand fir also occur in the Yakima Subbasin. Quaking aspen and black cottonwood are also important occasional co-dominants. This habitat may extend down into the Abies grandis zone. It is not well represented by the Gap projects because of its relatively limited acreage and the difficulty of identification from satellite images.

Dominant or co-dominant shrubs include salmonberry, red-osier dogwood, Douglas spirea, common snowberry, mountain alder, Sitka alder, Cascade azalea, and glandular Labrador-tea. The dwarf shrub bog blueberry is an occasional understory dominant. Shrubs more typical of adjacent uplands are sometimes co-dominant, especially big huckleberry, oval-leaf huckleberry, grouseberry, and fools huckleberry.

Graminoids that may dominate the understory include bluejoint reedgrass, Holm's Rocky Mountain sedge, widefruit sedge, and fewflower spikerush. Some of the most abundant forbs and ferns are ladyfern, western oakfern, field horsetail, arrowleaf groundsel, two-flowered marshmarigold, false bugbane, skunk-cabbage, twinflower, western bunchberry, clasping-leaved twisted-stalk, singleleaf foamflower, and five-leaved bramble.

Flooding, debris flow, fire, and wind are the major natural disturbances. Many of these sites are seasonally or temporarily flooded. Floods vary greatly in frequency depending on fluvial position. Floods can deposit new sediments or create new surfaces for primary succession. Debris flows/torrents are major scouring events that reshape stream channels and riparian surfaces, and create opportunities for primary succession and redistribution of woody debris. Fire is perhaps the most significant influence in the Yakima Subbasin. Fires are typically high in severity and can replace entire stands, as most of these tree species have low fire resistance. Although fires have not been studied specifically in these wetlands, fire frequency is probably low. These wetland areas are less likely to burn than surrounding uplands, and so may sometimes escape extensive burns as old forest refugia (Agee 1993). Shallow rooting and wet soils are conducive to windthrow, which is a common small-scale disturbance that influences forest patterns. Snow avalanches probably disturb portions of this habitat in the high mountains as well. Fungal pathogens and insects also act as important small-scale natural disturbances.

Succession has not been well studied in this habitat. Following disturbance, tall shrubs may dominate for some time, especially mountain alder, currant, salmonberry, willows, or Sitka alder. Quaking aspen and black cottonwood in these habitats probably regenerate primarily after floods or fires, and decrease in importance as succession progresses. Pacific silver fir, subalpine fir, or Engelmann spruce would be expected to increase in importance with time since the last major disturbance. Western hemlock, western redcedar, and Alaska yellow-cedar typically maintain co-dominance as stand development progresses because of the frequency of small-scale disturbances and the longevity of these species. Tree size, large woody debris, and canopy layer complexity all increase for at least a few hundred years after fire or other major disturbance.

This habitat is naturally limited in its extent and has probably declined little in area over time. However, much has been degraded by road building, timber harvest, grazing and recreational use. Five of 32 plant associations representing this habitat listed in the National Vegetation Classification are considered imperiled or critically imperiled (Anderson et al. 1998).

Roads and clearcut logging practices can increase the frequency of landslides and resultant debris flows/torrents, as well as sediment loads in streams (Swanson et al.1987). This in turn alters hydrologic patterns and the composition and structure of montane riparian habitats. Logging typically reduces large woody debris and canopy structural complexity. Timber harvest on some sites can cause the water table to rise and subsequently prevent trees from establishing (Williams et al. 1995). Wind disturbance can be greatly increased by timber harvest in or adjacent to this habitat. Blowdown is common in buffers retained around such habitats. Road construction and placement can alter hydrologic regimes of wet meadow systems, directing flows into ditches and culverts and eliminating natural flows. Summer grazing can result in significant impact to herbaceous plant communities due to the continual presence of livestock. Recreational vehicular access can create ruts from “mudding”, thus diverting flows, and compaction in high use areas such as campsites.

These habitats in the Yakima Subbasin are largely on federal, industrial forest, or tribal lands. They fall roughly into two categories: 1) Well protected: High elevation locations on federal Wilderness designations are generally in excellent condition. The lack of roads and vehicular access allows natural processes to continue there, or 2) Routinely degraded: Many montane coniferous wetland habitats are in areas where substantial degradation occurs each year. For example, habitats near Darland Mountain on Washington Department of Natural Resource (DNR) lands are bisected by roads, and regularly impacted by summering cattle and Off Road Vehicles. Piscoe Meadow on the Yakama Reservation is heavily grazed each year. Meadows along the S. Fork Tieton River, on Forest Service lands, are heavily used for camping. Many small montane wetlands adjacent to streams in the Yakima Subbasin have been severely disrupted by the placement of road fill and associated ditches that completely disrupt hydrologic function. Human disturbance from recreational use probably limits use of these habitats by sensitive wildlife species. It may be significant that the only breeding site for sandhill cranes in the Yakima Subbasin is on the Yakama Nation Reservation, in a large wetland complex where human disturbance is limited.

4.1.3 Trends

Forestry, recreation and grazing activities have been consistently negative in their impacts to these accessible habitats for many years. Changes in grazing patterns, camping sites, vehicle access, road planning and this process offer hope that conditions on the montane wetlands near roads will improve. For example, Forest Service and non-federal “Green Dot” road management efforts have succeeded in removing degradation to some montane coniferous wetlands. Human use in the cascades continues to increase, however, and without conscious effort trends for these habitats will continue downward.

4.1.4 Key Attributes

Some of the key attributes of montane coniferous wetlands that are important to wildlife include: water storage, flood cycles, vegetation type, size of wetlands and lack of fragmentation, water quality, presence of large woody debris, level of human disturbance and vegetative complexity.

4.2 Focal Species for the Montane Coniferous Wetlands

4.2.1 Western Toad (*Bufo boreas*)

Introduction

Western toads are a unique and important species in the mid to higher elevations mountainous forests of the Yakima Subbasin. They use many different forest, meadow and wetland habitats. Adults are a variety of colors, with a creamy-colored background and green, brown, red or gray blotches, with dry and bumpy skin. Females are substantially larger than males, with large specimens reaching up to 6 inches in body length (snout to vent). When encountered on nocturnal forays in the mountains they seem surprisingly large.

This toad is now uncommon in the lowlands of western Washington and the mountain meadows of the north Cascades for unknown reasons. Populations that were once abundant are known to have become extinct in only a few years (Leonard et al. 1993).

Life History

Diet

Western toads adults consume a wide variety of invertebrates, including worms, spiders, and insects. Tadpoles swim along the margins of ponds or lakes feeding upon filamentous algae and organic detritus and scavenging carrion (Leonard et al. 1993).

Reproduction

Breeding may occur from February to April at low elevations west of the Cascades and from May to early July at higher elevations in the Cascade Mountains. The number of males at the breeding ponds may exceed females by 20 to 1. Each female deposits up to 12,000 eggs in two long strings that may extend 30 feet. Embryos develop and hatch in 3 to 10 days depending upon water temperatures (Leonard et al. 1993).

Migration or Home Range

Migration occurs between aquatic breeding and terrestrial non-breeding habitats. Toads move overland by climbing or crawling in contrast to the jumping habits of frogs. After metamorphosis (the change from tadpole to toadlet), large concentrations of tiny toadlets leave the ponds and may be encountered as they roam about the forest floor. They may wander great distances through dry forests or shrubby thickets. (Leonard et al. 1993).

Mortality

Garter snakes, coyotes, raccoons, and corvids such as crows and ravens prey upon western toads. In the Cascade Range of Oregon, persistent predation on adults by ravens during the breeding season appears to have contributed significantly to some population declines (Leonard et al. 1993, Olson 1989, 1992).

Sometimes large concentrations of tiny toadlets have been found crossing roads; this often leads to mortality by automobile.

Habitat Requirements

4.2.1.1.1.1 General

Western toads are found in many different types of mountain forests in the Yakima Subbasin, particularly in the mid elevation mixed conifer zones in areas where wetlands occur. These tend to be locations with areas of gentle topography allowing for the existence of critical wetland habitats for breeding and development of young toads. They are known to occur at altitudes up to 7000 feet in Oregon, and have been found near the Cascades Crest in the Yakima Subbasin (Dvornich 1997).

They are found in a wide variety of habitats such as riverine habitats (low gradient creeks and pools), lacustrine habitats (shallow water), palustrine habitats (herbaceous wetlands, riparian and temporary pools). They also occur in terrestrial habitats such as cropland / hedgerow, conifer forests, hardwood forests, mixed forests, herbaceous grasslands, and others. Other habitats include: desert springs and streams, meadows and woodlands, mountain wetlands, in and around ponds, lakes, reservoirs, and slow-moving rivers and streams.

Western toads are most common near marshes and small lakes, but they may wander great distances through dry forests or shrubby thickets (Leonard et al. 1993).

4.2.1.1.1.2 Breeding

Western Toads breed in shallow ponds, lakes, reservoirs, slow-moving streams or wetlands in water less than 18 inches deep (.5 m). Eggs are laid on the bottom (Cockran and Thoms 1996). Hatchlings and tadpoles remain in the shallow water as they grow. Tadpoles will swim in long lines around the perimeter of these shallow ponds. They appear solid black (Nussbaum et al 1983).

During daylight, male toads rest quietly upon logs, moss, or grasses along the edge of the breeding pool and at night actively swim in search of the few gravid females visiting the pond (Leonard et al. 1993).

4.2.1.1.1.3 Non-breeding

Western toads live in the forested habitats of mid to higher elevations of the Yakima Subbasin. They may occur in streams or springs during dry periods, especially east of the Cascade Range (Corkran and Thoms, 1996). Outside of the breeding season, western toads are nocturnal, spending the day buried in the soil concealed under woody debris, or in the burrows of other animals (Leonard et al. 1993). Toadlets often live under rocks near ponds or in brush. Young toads will live under rocks and logs near water, and adults live underground, or under logs, in areas often much further from water (Corkran and Thoms, 1996).

4.2.1.1.1.4 Foraging

These animals eat a wide variety of insect and other invertebrates.

4.2.1.1.1.5 Cover

Western toads dig their own burrow in loose soil or use those of small mammals. They also use shelters under logs or rocks. Adults live underground, under large debris, and in grass and brush (Corkran and Thoms, 1996).

Status and Abundance Trends

These animals are believed to be in significant decline in portions of their range for mostly unknown reasons. It is known that in western Washington populations of western toads have noticeably decreased over a relatively short period of time. (www.nps.gov/olym/amphibian/bufbor.htm). Corkran and Thoms (1996) wrote that increased exposure to ultraviolet radiation and the spread of an egg fungus are among the many theories to explain the observed reductions in western toad populations in many areas.

Carey (1993) hypothesized that some environmental factor or synergistic effects of more than one factor may stress toads, causing suppression of the immune system or indirectly causing immunosuppression by effecting elevated secretion of adrenal cortical hormones. Immuno-suppression, coupled with the apparent effect of cold body temperatures on the ability of the immune system to fight disease, may lead to infection by Aeromonas hydrophila bacteria (causes "red-leg") or other infectious agents and subsequently to death of individuals and possibly the extirpation of populations.

Increased exposure to ultraviolet radiation and the spread of an egg fungus may explain the observed reductions in their populations in many areas (Corkran and Thoms 1996). Declines are related to sensitivity of eggs to increased levels of ultraviolet radiation (Blaustein et al. 1994). Eggs are highly susceptible to the pathogenic fungus Saprolegnia ferax, which may be introduced during fish stocking (Kiesecker and Blaustein 1997, Kiesecker et al. 2001).

Decline may be prompted at least in part to habitat destruction and degradation, and water retention projects. Western toads, like many other amphibians, are sensitive to environmental changes caused by human development and disturbances to natural habitat, principally the loss of wetlands (Leonard et al. 1993).

Their decline may also be related to predation by and competition with native and non-native species, fishery management activities, or other factors that have not been adequately assessed.

Population and Distribution

4.2.1.1.1.6 Historic Population

Little is known of historic populations of western toads.

4.2.1.1.1.7 Current Population

Based upon trend information from other parts of Washington and the interior west, western toads may be experiencing population declines similar to other regions of Washington and the west. They may be already absent from areas in the Yakima Subbasin.

4.2.1.1.1.8 Historic Distribution

Historically western toads had a wider distribution in Washington than today. Known populations in western Washington have disappeared in recent years (Leonard et al. 1993), most probably due to the effects of urbanization and exotic species. Historic distribution in the Yakima Subbasin is unknown, but is likely to have been wider than at current based upon levels of suitable habitat lost.

4.2.1.1.1.9 Current Distribution

Distribution in Washington occurs across most of the western and northern part of the state as well as higher elevations in the eastern Cascades and in southeastern Washington (Figure 2-7).

Locations in the Washington's Natural Heritage database indicate a wide distribution. No rigorous population counts or monitoring programs exist in the Yakima Subbasin (D.Darda, Professor, Central Washington University, pers. comm). Figure 2-8 illustrates predicted current habitat for the western toad, which identifies core habitat and unsuitable habitat within the Yakima Subbasin.

The western toad can be found in all regions of Washington except for the driest portions of the Columbia Basin (Leonard et al. 1993).

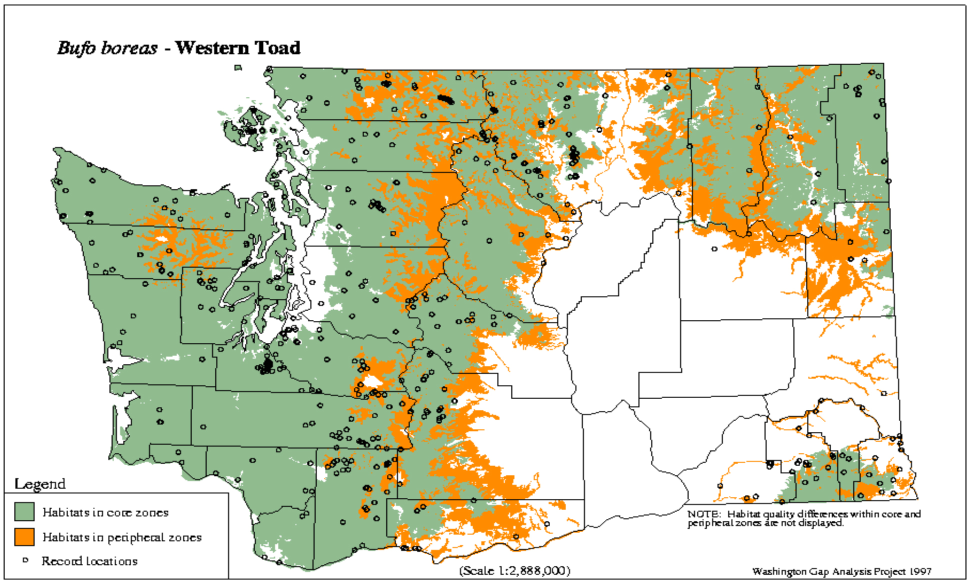


Figure 2-7. Distribution of habitat for western toad and record locations (Dvornich et al. 1997)

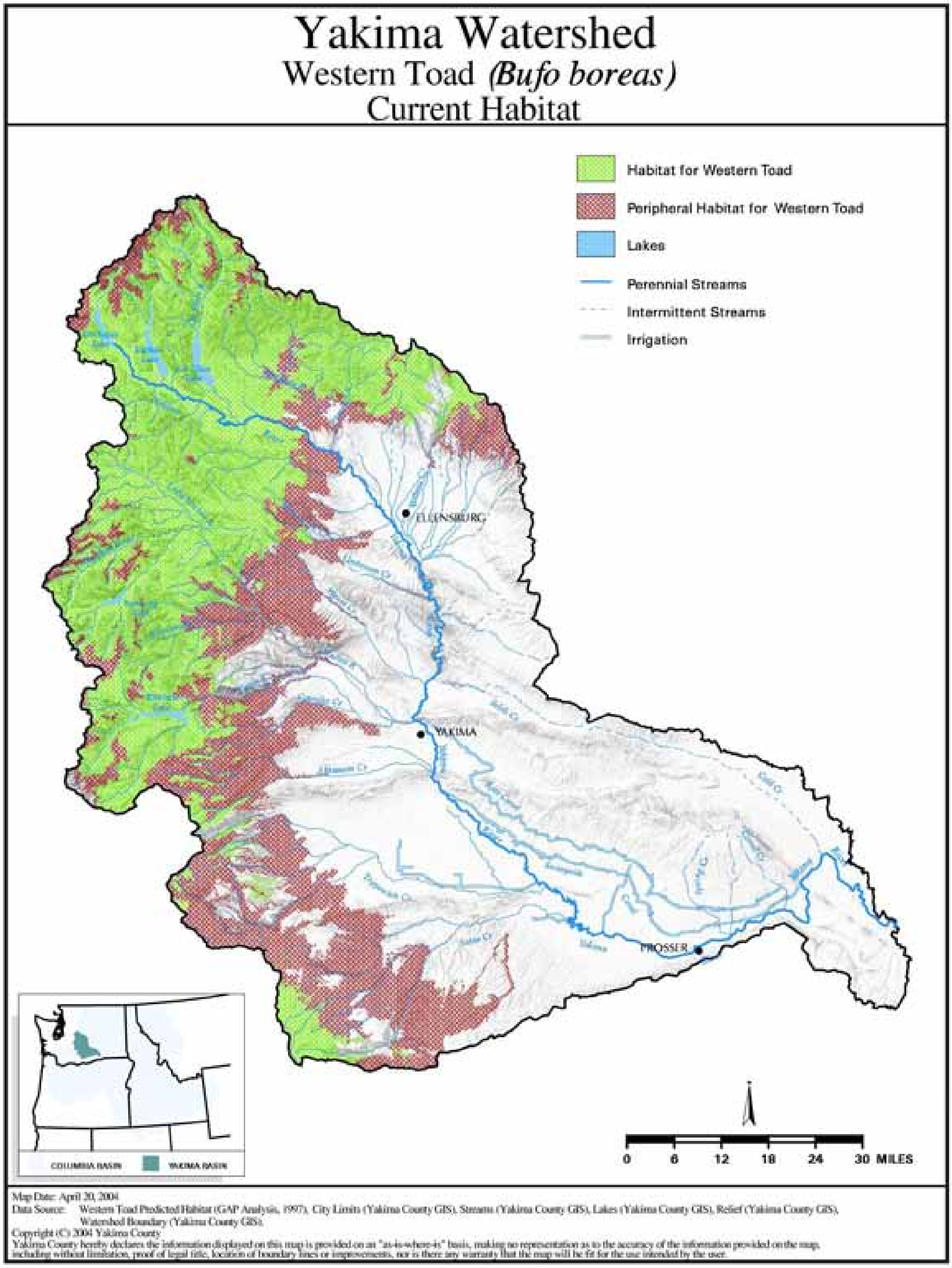


Figure 2-8. Western toad predicted habitat current habitat within the Yakima Subbasin

4.2.1.1.1.10 Out-of-Subbasin Effects and Assumptions

Loss of western toad populations in and adjacent to the Yakima Subbasin would mean a disruption in a population continuum of a once common species. Such a loss would indicate much larger problems for amphibians in general. In fact, this trend may already be occurring without our knowledge.

4.2.2 Sandhill Crane (*Grus canadensis*)

Introduction

The sandhill crane is the only member of the crane family in North America. Sandhill cranes are also the most numerous in total population of the 16 crane species on earth. This large and majestic bird has captured the imagination of people for centuries (Mathiessen 2001). They are a highly migratory species that breed and rear their young in northern wetlands, requiring limited human disturbance and an abundance of vertebrate and invertebrate prey. Migrations reach over many thousands of miles with major wintering populations in central California. They are separated into two sub species based upon size: Greater (Grus canadanensis tabida) and lesser (Grus canadensis canadensis). Intermediate forms exist in central Canada (Sibley 2000). The life histories of the greater and lesser Sandhill cranes are very similar; therefore, sub species distinctions are generally not mentioned here.

Life History

Diet

Sandhill cranes can be generally categorized as opportunistic omnivores (Armbruster 1987), feeding on a variety of food items including roots, bulbs, grains, berries, snails, earthworms, insects, amphibians, lizards, snakes, mice, and greens (Ridgway 1895, Barrows 1912, Bent 1926, Gabrielson and Jewett 1940, Brown 1942). Sandhill cranes have also been noted to consume eggs and young birds (Harvey et al. 1968, Littlefield 1976, Reynolds 1985).

Nesting and Reproduction

Sandhill cranes have a life history strategy that involves a low reproductive rate but high investment in the pair bond and defense of the breeding territory. Cranes usually take 3 or more years to mature, may nest for several years before successfully hatching eggs, then still may not be successful in raising a chick. When successful, cranes rarely raise more than 1 young. Sandhill cranes compensate for this low production with a relatively long life of up to 30 years or more (C. Littlefield and G. Ivey, 2001). Both pair members participate in nest building. Nests are composed of vegetation from the surrounding wetland left from the previous growing season. Cranes collect nesting material and pile it into a mound, usually in shallow water. The clutch is usually 2 eggs (Littlefield 1995).

Migration

Sandhill cranes stage long and spectacular migrations each year. Large flocks wheel in the sky, finding thermals and are sometimes soaring like great flocks of eagles. They can be detected miles before they are seen, by their haunting and pleasant “garooo-ah” calls. (Stepniewski 1999) Approximately 22,000 Lesser Sandhill cranes migrate over south central Washington twice each year; March through mid-April and again in September. These are thought to be the entire population of birds that nest in Bristol Bay of Western Alaska. Flocks will sometimes congregate during migration in wheat fields and rangeland of eastern Yakima County (Stepniewski, 1999).

Large concentrations of cranes regularly gather in similar habitats of the Columbia basin, particularly during spring migration. There is now an annual Sandhill crane festival held in Othello, Washington in late March that encourages people to enjoy this spectacle (Central Basin Audubon Society, 2004).

Historical records include notes from North Yakima County on 7 April 1915; late spring records include 10 May 1979 (Stepniewski 1999), and a late summer wanderer was wading in the Yakima River near Yakima on 15 August 1899 (Dawson 1902). Migrating cranes were spotted over eastern Yakima County in early March 2004 (D. Grandstrand, Yakima Audubon Society pers. comm.). A few autumn migrants have been noted in September, but concentrations such as occur in spring generally do not occur.

Mortality

Greater sandhill cranes can reach an age of at least 30 years in the wild (C. Littlefield and G. Ivey, unpubl. data). If young survive the brooding period, mortality rates decline dramatically once they develop sufficient flying skills. Primary causes of sandhill crane mortality are predation of young (occasional in adults) and collisions with powerlines. Other sources of fatality include entanglements in fences, disease, and illegal shooting. Cranes are still considered as game species in some states but not in Washington.

Habitat Requirements

Breeding and Nesting

Primary components of a breeding territory are the nest site, roosting area, feeding area, and to some degree, isolation (Armbruster 1987). In the West, greater sandhill cranes occupy breeding territories in wetlands adjacent to riverine systems, closed drainage basins at the base of desert mountain ranges, and isolated mountain meadows. Generally, sandhill cranes require wetlands for nesting, and will use a wide range of wetland classes and vegetation types, and occasionally will use uplands. Within the greater sandhill cranes' breeding range, nesting habitat varies from open meadows to deep-water bogs and marshes (Armbruster 1987).

At Conboy Lake National Wildlife Refuge (NWR), just 15 miles southwest of the Yakima Subbasin and home to the largest congregation of breeding cranes in Washington, 55 percent is comprised of wet meadows. Here, breeding territories include dry grass uplands, partially timbered uplands, emergent marshes, and wet meadows (Engler and Brady 2000).

Where cranes nest, the vegetation includes reed canarygrass, rushes, sedges, and spikerushes Peripheral areas of these meadows (11 percent) are slightly to heavily encroached upon by lodgepole pine, Douglas spirea, and willow, which crane pairs use for both nesting substrate and cover. Approximately half of the crane pairs nest in areas with some trees and shrubs, however, heavy encroachment by these species may preclude nesting cranes. Montane coniferous wetlands can be primary breeding habitats. It is thought that the historic wetland complexes of Toppenish Creek likely supported breeding cranes (T. Hames, YN, pers. comm, 2004).

Foraging and Migratory Stopovers

Cranes feed in a variety of habitats; security from disturbance and tradition are key factors in selection of areas during migration and wintering. Birds can concentrate in agricultural regions, which have extensive areas of small grain crops. However, associated wetlands are still used for some feeding, nighttime roosting and mid-day loafing (Littlefield and Ivey 2000). Cranes usually leave roosting locations in the early morning and fly to nearby grainfields, where they feed until mid-morning. In mid-day, birds occasionally feed in pastures, alfalfa fields, along canals, ditches, and dikes, or use shorelines and pond, lake, and other wetland shallows where they may obtain essential amino acids and minerals not present in grains (Reinecke and Krapu 1979). In mid-afternoon, most return to grainfields where they feed until early evening before returning to roost sites (Littlefield and Ivey 2000). Sandhill cranes therefore, utilize a variety of habitats for their life history needs, with emphasis on open country and key wetland features.

Status and Abundance Trends

Status

The sandhill crane was first granted federal legal protection under the Migratory Bird Act of 1916. Presently, the species, its nests, and its eggs are protected from unlawful direct persecution in Canada and the United States under the Migratory Birds Convention Act of 1994. This act prohibits the killing, capturing, injuring, taking, or disturbing of migratory birds, or damaging, destroying, removing, or disturbing of nests. It also prescribes protected areas for migratory birds and nests, and for the control and management of those areas. Although there is no federal protection for sandhill cranes, the populations that occur in the Yakima Subbasin, as well as several other sandhill crane populations, are not subject to legal harvest during hunting seasons. (Tacha et al. 1992).

The Washington Department of Game (the predecessor to WDFW) listed the sandhill crane as endangered in 1981. Sandhill cranes are also listed on the WDFW's PHS list as well as crane breeding areas, regular large concentrations, and migration staging areas. Under the Washington Forest Practices Act, sandhill cranes and their habitat are protected. In particular, timber harvest, road construction, aerial application of pesticides, and site preparation are restricted within 1/4 mile (0.4 km) of a known active nesting area (DNR Forest Practice Rules 2002).

On tribal lands, the Yakama Nation has listed the greater sandhill crane as a sensitive species in the Yakama Nation's Reservation Forest Management Plan (FMP) (BIA 1993), and it is considered a species of cultural importance (T. Hames,YN, pers. comm). In the Yakama Nation's habitat management guidelines (Leach et al. 1992), recommendations are to survey for cranes when activities are planned near large wet meadows. If they are found breeding, a 1/2 mile (0.8 km) no-entry buffer around the meadows should be designated during the breeding season (March-October), and road construction should be avoided within 1/2 mile (0.8 km) of the meadow.

Washington State has a recovery plan whose goal is to restore a healthy breeding population of cranes and to maintain the flocks that winter or stop in Washington. To reach this goal, this plan calls for expansion of the breeding range into former breeding areas in eastern Washington and protection of habitat for crane wintering and staging during migration. The Plan identifies recovery objectives that must be reached, and outlines strategies to use in meeting them before down listing of the species to threatened or sensitive status can occur.

Trends

Factors affecting Washington's breeding sandhills include predation, incompatible grazing and haying practices, water availability and management, and habitat loss. Crane habitat use is also affected by disturbance by human recreationists. Land use

practices, particularly conversion away from grassland or grain production, can affect migratory stopover use.

Productivity

Nest success in the Yakima Subbasin is extemely limited. The most recent record involves the pair at the Polo Field on Yakama Nation lands. They hatched 2 eggs and fledged 1 chick in 1997 (Stepniewski 1999). Another known pair attempted nesting at Camas Patch on Yakama Nation lands. They were not reproductively successful through 1997, apparently because of early drying and the presence of many cattle (G. King, YN, pers. comm.). Outside of Conboy Lake NWR, other Washington sites have rarely been monitored for nest success. No other monitoring of nesting sandhill cranes is known for the Yakima Subbasin. Reproductive success for this long-lived species is usually low. Generally, nesting success rates in the Pacific states are less than those reported elsewhere within the subspecies' breeding range. However, recruitment (percentage of fledged young in the population; calculated using known breeding pairs and counts of fledged young) in Washington has averaged 10 percent (range 0 to 27.3 percent) from 1990-2001 (Engler and McFall 2001).

Habitat Distribution

Sandhill crane breeding habitat is somewhat limited in Washington, when compared with the large wetland complexes found in southeastern and southcentral Oregon and northeastern California. The Glenwood Valley, slightly west of the Yakima, has the best potential for becoming a more important summer crane use area. In the Yakima Subbasin, there is habitat on private and federal lands available to accommodate an increasing and expanding population. However, there are current limitations on quality of habitat in many locations. In addition, breeding may be occurring on remote habitats on federal lands that has never been documented due to difficulty of early spring access.

Sandhill cranes use agricultural fields and wetlands for migratory staging and stopovers at several locations in eastern Washington, including wheatfields and rangeland east of Yakima (Stepniewski 1999).

Habitat Status

The availability of suitable nesting habitat in the Yakima Subbasin varies with conditions on these locations each year. Human disturbance may make otherwise suitable habitat unavailable. Migratory stopover locations are somewhat limited in the Yakima Subbasin as well, with the exception of areas in eastern Yakima County.

Factors Affecting Sandhill Crane Population Status

Predation

A major mortality factor, which confronts cranes on the breeding grounds, is predation on eggs and chicks. Ravens, minks, raccoons, and especially coyotes are the most destructive, and under certain conditions can be highly detrimental to sandhill crane productivity. For example, coyotes are thought to be the primary predator of crane chicks at Conboy Lake NWR (Engler and Brady 2000).

Grazing and Haying

In spring sandhill cranes generally prefer to forage in open, flooded meadows. Frequently, these sites are the result of mowing and livestock grazing practices which can be detrimental to nesting and fledging. Livestock grazing of wetlands in spring can be detrimental to nesting success (K.Bevis, WDFW pers. comm.).

Summer livestock grazing may pose a threat to breeding cranes (D. Anderson, WDFW pers. comm.). Potential threats also include drainage, trespass grazing, “mudding” by Off Road Vehicles, and property sales and subsequent development. No cranes were observed by helicopter at the Camas Patch site on 9 June 2000 and the area was dry and being grazed and may no longer be suitable breeding habitat (Engler and Brady 2000). The Polo Field site on Yakama Nation lands is located within a grazing unit, but cattle generally do not reach the site until after 15 July. Management of lands for cranes could be improved by excluding livestock from crane habitat during the spring breeding season, delaying hay harvest and grazing until after 10 August, and limiting human disturbance to nesting cranes.

Water Availability

Because cranes are dependent on wetlands, they are vulnerable to changes in hydrology. Water rights are an issue in some areas, and loss of irrigation rights could eliminate existing habitat for cranes (Ivey and Herziger 2000). Irrigation timing is also important, as cranes should have water applied to their territories by mid-March to prepare for April nesting; water should be maintained through the brooding period (early August). Historical sandhill crane pairs were absent from some sites surveyed in Oregon and California where irrigation was delayed (Ivey and Herziger 2000, 2001). Early drying of wetlands and irrigated fields can lead to increased chick mortality.

Habitat Loss

The majority of crane pair nesting territories in Washington is currently on protected lands, primarily those managed by the USFWS, but also by the Yakama Nation and the DNR. Potential nest territories occur in private and tribal lands, particularly in Toppenish Creek.

Threats exist for habitat loss from water development, residential development, and public recreational activity. Harmful management practices such as late irrigation and the presence of cattle on meadows until late spring could eliminate crane pairs. Loss of habitat through drainage of wetlands, replacement of flood-irrigated meadows with sprinkler or pivot irrigation, building construction, and conversion to row crops can also displace breeding pairs (Littlefield and Thompson 1979, Littlefield 1989, Ivey and Herziger 2000, 2001).

Black Rock Reservoir would eliminate some of the dry farmland currently being used by migrating cranes.

Population and Distribution

In the mid-1980s, the central California Valley population of greater sandhills was estimated to total 6,000 - 6,800; this included at least 839 Canadian sandhill cranes (Pogson and Lindstedt 1991). The Pacific Flyway population of lesser sandhill cranes is thought to be approximately 23,000 birds (Kramer et al. 1983). These lesser sandhills are thought to be the primary migratory cranes in the Yakima Subbasin, while nesting and summering birds are greater sandhills. After 1941, some 31 years lapsed before summering greater sandhill cranes were again found in Washington. In 1972 two cranes appeared at Conboy Lake NWR in September, remaining into late November. In 1979 nesting was finally confirmed, but fledged no young. Nesting was suspected but not verified from 1980 through 1983. In 1984 the first fledging was confirmed. Young were again produced in 1985, 1986, and 1988; the breeding population had increased to two pairs by 1988 and three in 1990, with successful reproduction by at least some pairs in 1989 and 1990.

In 1991 a pair was discovered at the Polo Fields on Yakama Nation lands north and east of Glenwood, and in the Yakima Subbasin (Figure 2-9 for predicted habitat). This is the only recently verified nest in the Yakima Subbasin, but two adults and a fledged juvenile were observed along wetlands adjacent to Toppenish Creek near White Swan on 26 September 1997 (T.Hames, YN, pers.comm.). Their origin is unknown. Fourteen pairs nested at Conboy Lake NWR in 1998 with a total state population of 44 (Engler and Anderson 1998). In 1999, 18 nesting pairs (including a new pair along Deer Creek on Department of Natural Resources [DNR] land) and 5 subadults were known Washington residents (Engler and Anderson 1999). In 2000, the state's known greater sandhill crane population was 53 birds, consisting of 19 pairs (15 known nesting), 9 subadults, and 6 fledged young (Engler and Brady 2000). Assuming there was 1 nesting pair on the Yakama Nation lands, there were 40 breeding adults and 10 known subadults for a total population of 50 in 2001.

For the period 1990 through 2001, Washington's breeding population fledged 30 chicks, with successful reproduction in all years except 1993, 1994, and perhaps 2001 (Table 2-5). The greatest number was 6 in 2000, while 5 chicks fledged annually during the 3 previous years.

Table 2-5. Greater sandhill crane pairs, productivity, and total population estimate in Washington, 1990-2001

Year	No. Breeding Pairs			Total Breeding Adults	Subadults (known)	No. Young Fledged	Recruitment[3] (%)	WA Population Estimate
	Conboy Lake NWR	YN[2]	Private DNR					
1990	3	--	--	6	--	1	14.3	7
1991	3	(1)[4]	--	8	--	1	11.1	9
1992	3	(1)[4]	--	8	--	3	27.3	11
1993	3	(1)[4]	--	8	--	0	0	8
1994	3	1	--	8	--	0	0	8
1995	7 (2)	1(1)	--	22	0	1	4.3	23
1996	8 (2)	2	(1)	26	0	3	10.3	29
1997	12	2	1	30	4	5	14.3	39
1998	14	(2)	(1)	34	5	5	12.8	44
1999	13 (1)	1(1)	2	36	4	5	12.2	45
2000	13 (3)	1	1 (1)	38	9	6	13.6	53
2001[5]	14 (2)	(1)	1(2)	40	10	0	0	50

[1] Data includes confirmed nesting pairs, unconfirmed pairs, and subadults. Data in parenthesis represent territorial pairs without confirmed nesting data; 1990-1994 data is based on incidental observations (*from* Engler and Brady 2000). Systematic surveys of breeding cranes began in 1995.

[2] YN = Yakama Nation lands – In Yakima Subbasin.

[3] Recruitment = no. fledged young / no. of breeding adults + fledged young X 100 (excludes subadults).

[4] Leach (1995).

[5] Drought conditions in 2001 negatively affected production; 1 pair was assumed to be present on the YIN which was not surveyed (Engler and McFall 2001).

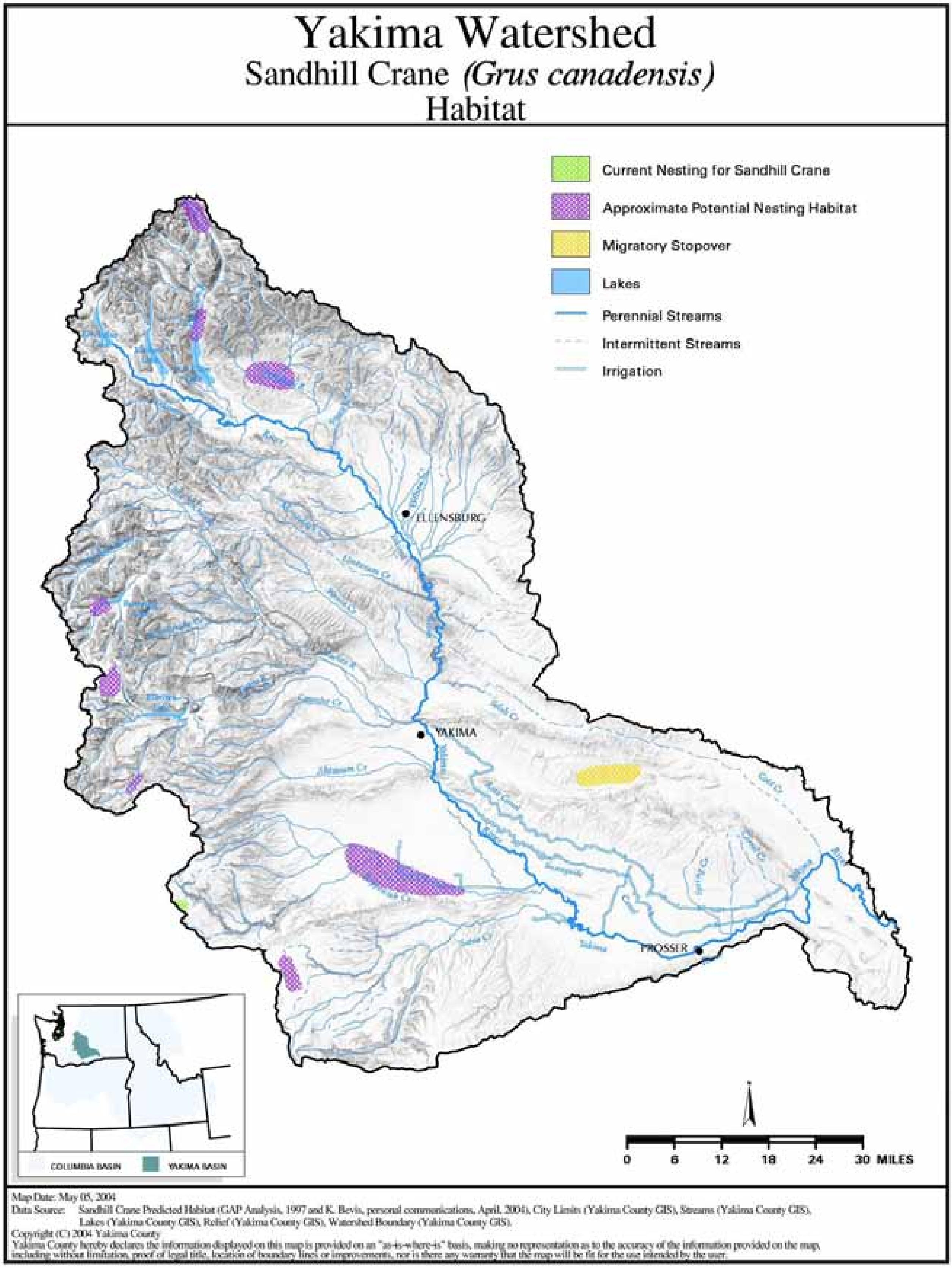


Figure 2-9. Sandhill crane predicted current habitat for the Yakima Subbasin

4.2.3 Key Findings for Montane Coniferous Wetlands and Focal Species

- Native vegetative composition of known wetland communities has been altered from historic conditions
- Montane coniferous wetland habitats remain unprotected in the watershed
- Hydrologic conditions (esp. flow) of known montane wetlands have been altered from historic conditions.
- Suitable nesting habitat for sandhill cranes in the Yakima Subbasin is unoccupied.

4.3 Ponderosa Pine/Oregon White Oak

4.3.1 Historic

Historically, in Washington, this habitat was very extensive. Prior to 1850, much of the ponderosa pine habitat in the Yakima Subbasin, and other parts of the inland northwest, was mostly open and park like with relatively few undergrowth trees. The ponderosa pine ecosystem has been heavily altered by past forest management. Specifically, the removal of overstory ponderosa pine since the early 1900s and nearly a century of fire suppression have led to the replacement of most old-growth ponderosa pine forests by younger forests with a greater proportion of Douglas-fir than ponderosa pine (Habeck 1990). Fire scar evidence in the Wenatchee Mountains of the upper Yakima Subbasin indicate that ponderosa pine forests burned approximately every 5-30 years prior to fire suppression, preventing contiguous understory development and, thus, maintaining relatively open ponderosa pine stands (Everett et al. 1999 and Camp et al. 1996). Similar forests in the Rockies burnt at 1-30 year intervals (Arno 1988; Habeck 1990).

The 1930s-era timber inventory data (Losensky 1993) suggests large diameter ponderosa pine-dominated stands occurred in very large stands, encompassing large landscapes. Such large stands were fairly homogeneous at the landscape scale (i.e. large trees, open stands), but were relatively heterogeneous at the acre scale, with “patchy” tree spacing, and multi-age trees (Hillis et al. 2001). Clear cut logging and subsequent reforestation have converted many older stands of ponderosa pine/Douglas-fir forest to young structurally simple ponderosa pine stands (Wright and Bailey 1982). Changes in the distribution of ponderosa pine habitat from circa 1850 (historic) to 1999 (current) are illustrated in Figure 2-3 and below in Figure 2-10.

The northern most occurrence of mixed or white oak/ponderosa pine habitat reaches the Tieton River midway north in the Yakima Subbasin. These habitats occupy portions of the lower elevation ponderosa pine zone indicated on the map.

4.3.2 Current

The ponderosa pine zone covers 3.7 million acres (1.5 million hectares) in Washington and is one of the most widespread zones of the western states. This dry forest zone between unforested steppe and higher-elevation, closed forests corresponds to Merriam’s Arid Transition zone.

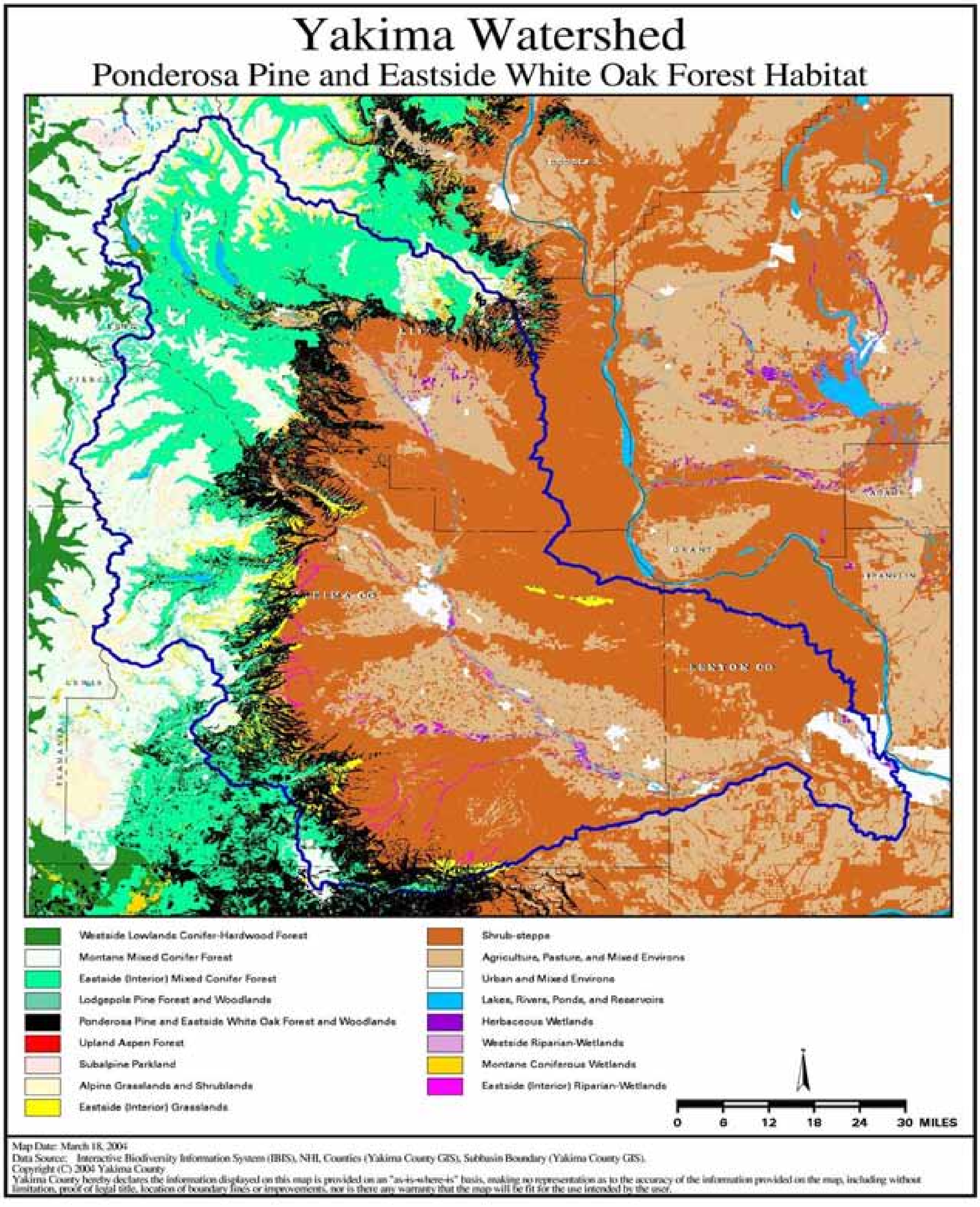


Figure 2-10. Current distribution of ponderosa pine/Oregon white oak in and surrounding the Yakima Subbasin

Ponderosa pine forms climax stands that border grasslands and is a common member in many other forested communities (Steele et al. 1981). Ponderosa pine is a drought tolerant tree that usually occupies the transition zone between grassland and forest. Climax stands are characteristically warm and dry, and occupy lower elevations throughout their range. Key understory associates in climax stands typically include grasses such as bluebunch wheatgrass and Idaho fescue, and shrubs such as bitterbrush and common snowberry. Daubenmire and Daubenmire (1984) recognize two more habitat types within the P. ponderosa series:

Stipa comata (needlegrass)
Purshia tridentata (bitterbrush)

Ponderosa pine has many fire resistant characteristics. Seedlings and saplings are often able to withstand fire. Pole-sized and larger trees are protected from the high temperatures of fire by thick, insulative bark, and meristems are protected by the surrounding needles and bud scales. Other aspects of the pine's growth patterns help in temperature resistance. Lower branches fall off the trunk of the tree, and fire caused by the fuels in the understory will usually not reach the upper branches. Ponderosa pine is more vulnerable to fire at more mesic sites where other conifers as Douglas-fir, and Grand fir form dense understories that can carry fire upward to the overstory. Ponderosa pine seedlings germinate more rapidly when a fire has cleared the grass and the forest floor of litter, leaving only mineral rich soil. (Fischer and Bradley 1987).

Fire suppression has lead to a buildup of fuels that, in turn, increase the likelihood of stand-replacing fires. Heavy grazing, in contrast to fire, removes the grass cover, reduce fine fuels that carry low intensity fires, and tend to favor shrub and conifer species. Fire suppression combined with grazing creates conditions that support cloning of oak and invasion by young conifers, including shade tolerant species such as grand fir.

Ponderosa pine is shade intolerant and grows most rapidly in near full sunlight (Franklin and Dyrness 1973; Atzet and Wheeler 1984). Logging is usually done by a selection-cut method. Older trees are taken first, leaving younger, more vigorous trees as growing stock. This effectively returns succession to earlier seral stages and eliminates climax, or old growth, conditions. Logging also impacts understory species by machine trampling or burial under slash. Clearcutting generally results in dominance by understory species present before logging, with invading species playing only a minor role in post logging succession (Atzet and Wheeler 1984).

Currently, much of this habitat has a younger tree cohort of more shade-tolerant species that gives the habitat a more closed, multi-layered canopy. For example, this habitat includes previously natural fire-maintained stands in which grand fir can eventually become the canopy dominant. Large late-seral ponderosa pine, and Douglas-fir are harvested for timber in much of this habitat. Oregon white oak is frequently cut for fuelwood, or removed during thinning as competition with desired timber species. Under most management regimes, typical tree size decreases and tree density increases in this habitat. Ponderosa pine-Oregon white oak habitats are now denser than in the past and may contain more shrubs than in pre-settlement habitats.

Annual precipitation in this vegetation zone is between 14 and 30 inches (35 and 76 centimeters). Wide seasonal and diurnal temperature fluctuations are the rule. In Washington, the ponderosa pine zone generally lies between 2,000 and 5,000 feet (600 and 1500 meters), but its occurrence at any particular location is strongly influenced by aspect and soil type (Cassidy 1997).

In the Yakima Subbasin, it is possible to find ponderosa pine woodlands at nearly 5,000 feet (1,500 meters) on southern aspects and subalpine fir (Abies lasiocarpa) communities at the same elevation on opposite northern aspects (K.Bevis, WDFW, pers. comm.). In some places, the change from steppe to closed forest occurs without the transitional ponderosa pine zone, for example, at locations along the east slopes of the north and central Cascades. More commonly, the aspect dependence of this zone creates a complex inter-digitization between the steppe and ponderosa pine stands, so that disjunct steep zone fragments occur on south-facing slopes deep within forest while ponderosa pine woodlands reach well into the steppe along drainages and north slopes. This pattern is typical in the Yakima Subbasin.

A similar process occurs between the ponderosa pine zone and the higher-elevation closed forest zones. At higher elevations, Pacific ponderosa pine is seral to trees more shade tolerant and moisture demanding. In the Pacific Northwest, this generally includes Douglas-fir, grand fir, and white fir (Howard 2001). Also common are mosaics created by soil type in which ponderosa pine stands on coarse-textured soil are interspersed with steppe communities on finer soil. The ponderosa pine habitat in the Yakima Subbasin is thus a broad, complex transition zone above shrub steppe and interspersed within more mesic forest types at higher elevations.

4.3.3 Climax Vegetation

The successional status of ponderosa pine can be best expressed by its successional role, which ranges from seral to climax depending on specific site conditions. It plays a climax role on sites toward the extreme limits of its environmental range and becomes increasingly seral with conditions that are more favorable. On more mesic sites, ponderosa pine encounters greater competition and must establish itself opportunistically, and is usually seral to Douglas-fir and true firs (mainly grand fir and white fir). On severe sites, it is climax by default because other species cannot establish. On such sites, establishment is likely to be highly dependent upon the cyclical nature of large seed crops and favorable weather conditions (Steele 1988).

Successional and climax tree communities are inseparable in this zone because frequent disturbance by fire is necessary for the maintenance of open woodlands and savanna. Natural fire frequency is very high, with cool ground fires believed to normally occur at 8 to 20 year intervals by one estimate and 5 to 30 year intervals by another. Ponderosa pine trees are killed by fire when young, but older trees survive cool ground fires. Fire suppression favors the replacement of the fire-resistant ponderosa pine by the less tolerant Douglas-fir and grand fir.

The high fire frequency maintains an arrested seral stage in which the major seral tree, ponderosa pine, is the “climax” dominant because other trees are unable to reach maturity. The ponderosa pine zone is most narrowly defined as the zone in which ponderosa pine is virtually the only tree. As defined in this document, the ponderosa pine zone encompasses most warm, open-canopy forests between steppe and closed forest, thus it includes stands where other trees, particularly Douglas-fir, may be co-dominant with ponderosa pine (Daubenmire and Daubenmire 1968).

Throughout most of the zone, ponderosa pine is the sole dominant in all successional stages. At the upper elevation limits of the zone, on north-facing slopes in locally mesic sites, or after long-term fire suppression, other tree species Douglas-fir, grand fir , western larch, or lodgepole pine may occur. At the upper-elevation limits of the zone, in areas where the ponderosa pine belt is highly discontinuous, and in cooler parts of the zone, Douglas-fir, and occasionally western larch, lodgepole pine, and grand fir become increasingly significant. In Yakima and Klickitat Counties, Oregon white Oak may be present, especially in drainages

The major defining structural feature of this zone is open-canopy forest or a patchy mix of open forest, closed forest, and meadows. On flat terrain, trees may be evenly spaced. On hilly terrain, the more common pattern is a mix of dry meadows and hillsides, tree clumps, closed forest in sheltered canyons and north-facing slopes, shrub patches, open forest with an understory of grass and open forest with an understory of shrubs. Without fire suppression, the common belief is that the forest would be less heterogeneous and more savanna-like with larger, more widely spaced trees and fewer shrubs (see Daubenmire and Daubenmire 1968 for a dissenting opinion).

Understory associations in Washington are broadly differentiated into a mesic shrub group and a xeric grass/shrub group. Soil type appears to be the major determining factor separating these groups. The mesic shrub group usually occurs on deeper heavier-textured, more fertile soils than the xeric grass/shrub group. Understories of the mesic shrub associations are usually dominated by snowberry or ninebark. The snowberry association is widespread. (Daubenmire and Daubenmire 1968).

The xeric grass/shrub associations usually occur on stony, coarse-textured or rocky soils. They have an understory dominated by bluebunch wheatgrass, Idaho fescue, needle and thread grass, bitterbrush, or combinations of these species. Bluebunch wheatgrass and Idaho fescue associations are common throughout Washington. The bitterbrush association, which has a shrub layer dominated by bitterbrush over a xeric grass layer, is most common along the east slope of the Cascades (Daubenmire and Daubenmire 1968), and is common in the Yakima Subbasin.

4.3.4 Disturbance

In addition to timber harvest as a disturbance factor, heavy grazing of ponderosa pine stands in the mesic shrub habitat type tends to lead to swards of Kentucky bluegrass and Canada bluegrass. Native herbaceous understory species are replaced by introduced annuals, especially cheatgrass, and invading shrubs under heavy grazing pressure (Agee 1993). In addition, four exotic knapweed species are spreading rapidly through the ponderosa pine zone and can replace cheatgrass as the dominant increaser after grazing (Roche and Roche 1988). Dense cheatgrass stands eventually change the fire regime of these stands.

Ponderosa pine and oak zones, the major transition zones between steppe and closed forest in Washington, are poorly protected in the east-side forest zones (Cassidy 1997).

The pattern of land ownership of the ponderosa pine zone varies considerably across the State of Washington. In the Yakima Subbasin, primary landowners of the ponderosa pine zone include the Yakama Nation, the Washington DNR, and the Boise Cascade Corporation.

Management strategies for the ponderosa pine zone in these regions must consider the needs of all of these landowners. Potential improvement of biodiversity protection on public lands in this zone depends primarily on management policies of the National Forests, The Yakama Nation, private landowners, and the DNR.

4.3.5 Status and Trends

Quigley and Arbelbide (1997) concluded that the interior ponderosa pine habitat type is significantly less in extent than pre-1900 and that the Oregon white oak habitat type is greater in extent than pre-1900. They included much of this habitat in their dry forest potential vegetation group, which they concluded has departed from natural succession and disturbance conditions. The greatest structural change in this habitat is the reduced extent of the late-seral, single-layer condition. This habitat is generally degraded because of increased exotic plants, decreased overstory canopy, and decreased native bunchgrasses. One third of Pacific Northwest Oregon white oak, ponderosa pine, and dry Douglas-fir or grand fir community types listed in the National Vegetation Classification are considered imperiled or critically imperiled.

A DNR assessment of forest inventory data on DNR lands across eastern Washington, found very little of the largest diameter ponderosa pine type remaining (R. Crawford, DNR, pers.comm.). These forest stands have been repeatedly logged over many decades, with associated loss of large pine overstory. Stephenson in 2001 did an informal review of old growth pine locations based upon extensive fieldwork in the Yakima Subbasin. He presented his work to the Ponderosa Pine Habitats Workshop in Ellensburg, WA, in March 2004. His report identifies only a handful of locations with remaining old growth pine on state and private lands (Stephenson 2004).

Reagen (2002) performed a systematic survey of DNR lands in the Wenatchee Mountains north of Ellensburg, looking for old growth ponderosa pine habitats based on the published needs for white-headed woodpeckers. At the end of her two-year effort, she found very little old ponderosa pine habitat in her research area in the Naneum basin (Reagan 2002).

4.3.6 Recommended Future Conditions

Recognizing that extant ponderosa pine habitat within the subbasin currently covers a wide range of seral conditions; subbasin wildlife habitat managers have identified a general ecological/management condition that, if met, will provide suitable habitat for multiple wildlife species at the subbasin scale within the ponderosa pine habitat type. This ecological condition corresponds to life requisites represented by a species assemblage that includes white-headed woodpecker (J. Stephenson YN, pers. comm., 2004). This species may also serve as a performance measure to monitor and evaluate the impacts future management strategies and actions.

Subbasin wildlife/land managers will review the condition described below to plan and, where appropriate, guide future enhancement/protection actions in ponderosa pine habitats. Specific desired future conditions will also be identified and developed within the context of individual management plans at the habitat type level.

Oregon white oak is Washington's only native oak. Although limited and declining, oaks and their associated floras comprise distinct woodland ecosystems. The various plant communities and stand age mixtures within oak forests provide valuable habitat that contributes to wildlife diversity statewide. In conjunction with other forest types, oak woodlands provide a mix of feeding, resting, and breeding habitat for many wildlife species. More than 200 vertebrate and a profusion of invertebrate species use Washington's oak woodlands. Some species occur in especially high densities, whereas others are not typically found in Washington (Larsen and Morgan 1998).

Oregon white oak is considered a state priority habitat that is determined to be of significance because it is used by an abundance of mammals, birds, reptiles and amphibians. Many invertebrates, including various moths, butterflies, gall wasps and spiders are found exclusively in association with this oak species. Oak/conifer associations provide contiguous aerial pathways for animals such as the state threatened western gray squirrel and they provide important roosting, nesting and feeding habitat for wild turkeys and other birds and mammals. Dead oaks and dead portions of live oaks harbor insect populations and provide nesting cavities. Acorns, oak leaves, fungi and insects provide food. Some birds, such as the Nashville warbler, exhibit unusually high breeding densities in oak. Oaks in Washington may play a critical role in the conservation of neotropical migrant birds that migrate through or nest in Oregon.

Oregon white oak stands in the subbasin are being lost and degraded by conversion to urban development and agricultural and range lands. Other factors that negatively affect white oak stands are fuelwood cutting, cattle grazing, and conifer encroachment caused by fire suppression (Larsen and Morgan 1998). Condition and extent of this habitat type has been examined little in the Yakima Subbasin.

4.4 Focal Species for Oregon White Oak/Ponderosa Pine Forest

4.4.1 White-Headed Woodpecker (*Picoides albolarvatus*)

Introduction

The white-headed woodpecker is a native species exclusive to the ponderosa pine forest. They are dependent on large, old growth (or late seral) ponderosa pines for nesting and food. White-headed woodpeckers are a Washington State candidate species, a PIF species and PHS species. For these reasons, they were chosen as a focal species for the ponderosa pine / Oregon white oak focal wildlife habitat.

The white-headed woodpecker is a year round resident in the ponderosa pine forests found at the lower elevations (generally below 3117 feet or 950m). Nesting and foraging requirements are the two critical habitat attributes limiting the population of this species of woodpecker. Both of these limiting factors are very closely linked to the habitat attributes contained within mature open stands of ponderosa pine. Land use practices, including logging and fire suppression, have resulted in significant changes to the forest structure in the ponderosa pine habitat within the Yakima Subbasin. White-headed woodpeckers are particularly vulnerable to habitat modifications in the ponderosa Pine habitats, due to their highly specialized winter diet of ponderosa pine seeds and the lack of alternate, large cone producing, pine species.

Life History

General Habitat Requirements

White-headed woodpeckers prefer a ponderosa pine conifer forest with a relatively open canopy (30-50 percent cover) and an availability of large snags. The understory vegetation is usually very sparse within the preferred habitat and local populations are abundant in burned or cut forest where residual large diameter live and dead trees are present. The openness however, is not as important as the presence of mature or veteran cone producing pines within a stand (Milne and Hejl 1989).

Diet

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

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

Reproduction

White-headed woodpeckers are monogamous and may remain associated with their mate throughout the year. They build their nests in old trees, snags or fallen logs but always in dead wood. Every year the pair bond constructs a new nest. This may take three to four weeks. The nests are, on average 10 feet (3m) off the ground. The old nests are used for overnight roosting by the birds.

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

The woodpeckers are not very territorial except during the breeding season. They are not especially social birds outside of family groups and pair bonds and generally do not have very dense populations (about 1 pair bond per 20 acres or 8 ha).

Nesting

Generally large ponderosa pine snags consisting of hard outer wood with soft heartwood are preferred by nesting white-headed woodpeckers. In British Columbia 80 percent of reported nests have been in ponderosa pine snags, while the remaining 20 percent have been recorded in Douglas-fir snags. Excavation activities have also been recorded in Quaking Aspen, live ponderosa pine trees and fence posts (Cannings et al. 1987). A large majority of known nests in the Yakima Subbasin were found in large ponderosa pine snags. Nests have been observed in stubs and large stumps in the Yakima Subbasin as well (K. Bevis, WDFW, pers. Comm.)

Nesting locations in Southern British Columbia ranged between 1476 to 1969 feet (450 - 600m) in elevation (Blood 1997), with large diameter snags being the preferred nesting tree. Their nesting cavities range from 8 to 29 feet (2.4 to 9 m) above ground, with the average being about 16.4 feet (5m). New nests are excavated each year and only rarely are previous cavities re-used (Garrett et al. 1996).

Migration

The white-headed woodpecker is a non-migratory bird, but may move seasonally to areas of large, seed producing ponderosa pine in winter.

Mortality

Average life span of white headed woodpeckers is unknown. Mortality sources are likely to include avian predators, such as the northern goshawk.

Habitat Requirements

Breeding

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

Highest abundances of white-headed woodpeckers occur in old-growth stands, particularly ones with a mix of two or more pine species. They are uncommon or absent stands dominated by small-coned or closed-cone conifers, such as lodgepole pine.

Where food availability is at a maximum such as in the Sierra Nevadas, breeding territories may be as low as 247 acres (10ha) (Milne and Hejl 1989). Breeding territories in Oregon are 257 acres (104 ha) in continuous forest and 793 acres (321 ha) in fragmented forests (Dixon 1995). In general, open ponderosa pine stands with canopy closures between 30 - 50 percent are preferred. The openness however, is not as important as the presence of mature or veteran cone producing pines within a stand (Milne and Hejl 1989). Older Ponderosa pine stands are considered optimal for white-headed woodpeckers (K. Bevis, WDFW, pers.comm.). Milne and Hejl (1989) found 68 percent of nest trees to be on southern aspects. These attributes are thought to be consistent with habitat use in the Yakima Subbasin.

Status and Abundance Trends

Status

This species is of conservation concern because of its specialized, relatively small and patchy year-round range and its dependence on mature coniferous forests. Knowledge of this woodpecker’s tolerance of forest fragmentation and silvicultural practices is poorly understood and will be important in conserving future populations.

Factors Affecting White-Headed Woodpecker Population Status

Logging

Logging has removed much of the old cone producing pines throughout the Yakima Subbasin. Very few stands of old ponderosa pine exist, and those that still exist often are targeted for future harvest (J.Stephenson, YN, pers. Comm.). Impacts from the decrease in old, large diameter ponderosa pines are even more exaggerated in the Yakima Subbasin, because there are no alternate pine species for the white-headed woodpecker to utilize. This is especially true over the winter when other major food sources such as insects are not available. Suitable snags (dbh>2feet or>60cm) are in short supply in the Yakima Subbasin (Stephenson, 2004 and Reagan 2002).

Fire Suppression

Fire suppression has altered the stand structure in many of the forests in the Yakima Subbasin. Lack of fire has allowed dense stands of immature ponderosa pine as well as the more shade tolerant Douglas-fir to establish. This has led to increased fuel loads resulting in more severe stand replacing fires where both the mature cone producing trees and the large suitable snags are destroyed. These dense stands of immature trees has also led to increased competition for nutrients as well as a slow change from a ponderosa pine climax forest to a Douglas-fir dominated climax forest (Agee 1993).

Predation

Chipmunks are known to prey on the eggs and nestlings of white-headed woodpeckers. There is also predation by great horned owls, on adult white-headed woodpeckers. However, predation likely does not appreciably affect the woodpecker population.

Habitat Loss

Logging and fire suppression has altered the stand structure in many of the forests. Logging has removed much of the old growth cone producing pines throughout this species' range, which provide winter food and large snags for nesting. The impact from the decrease in old growth cone producing pines is even more significant in areas where no alternate pine species exist for the white-headed woodpecker to utilize, such as the Yakima Subbasin.

Population and Distribution

Current Population

White-headed woodpeckers are considered a rare, local resident of ponderosa pine dominated forests in the Yakima Subbasin (Stepniewski, 1999). Populations are thought to be reduced from historic occurrences based upon recent data from surveys on a research project with some sites in the basin. Few systematic surveys for this species, however, have ever occurred, and population trends are strictly conjectural, particularly based upon habitat associations with old ponderosa pine, which is largely gone from the Yakima Subbasin. White-headed woodpeckers may be a species in critical trouble in the Yakima Subbasin due to loss of its principle habitat feature, large diameter ponderosa pine.

This species is of increasing conservation importance because of its relatively small and patchy year-round range, and its dependence on mature ponderosa pine forests. The high commercial value of ponderosa pine and continued aggressive harvest of large specimens in the Yakima Subbasin increase this concern. Knowledge of this species' tolerance of forest fragmentation and silvicultural practices will be important in conserving future populations.

Historic Population

Historically, white-headed woodpeckers were likely widespread and patchy across the lower elevation forests dominated by large ponderosa pine in the Yakima Basin. Bird watchers records from the Wenas Valley, site of an annual Audubon Society campout since the 1950s, indicate substantially reduced observations of this species over the years. The area has been logged for large diameter overstory trees several times during this period, most recently in 2002.

Current Distribution

Woodpecker abundance appears to decrease north of California. They are uncommon in Washington (Figure 2-11) and Idaho, and rare in British Columbia. Core habitat and unsuitable habitat for the white-headed woodpecker have been identified in Figure 2-12 using Washington State GAP data.

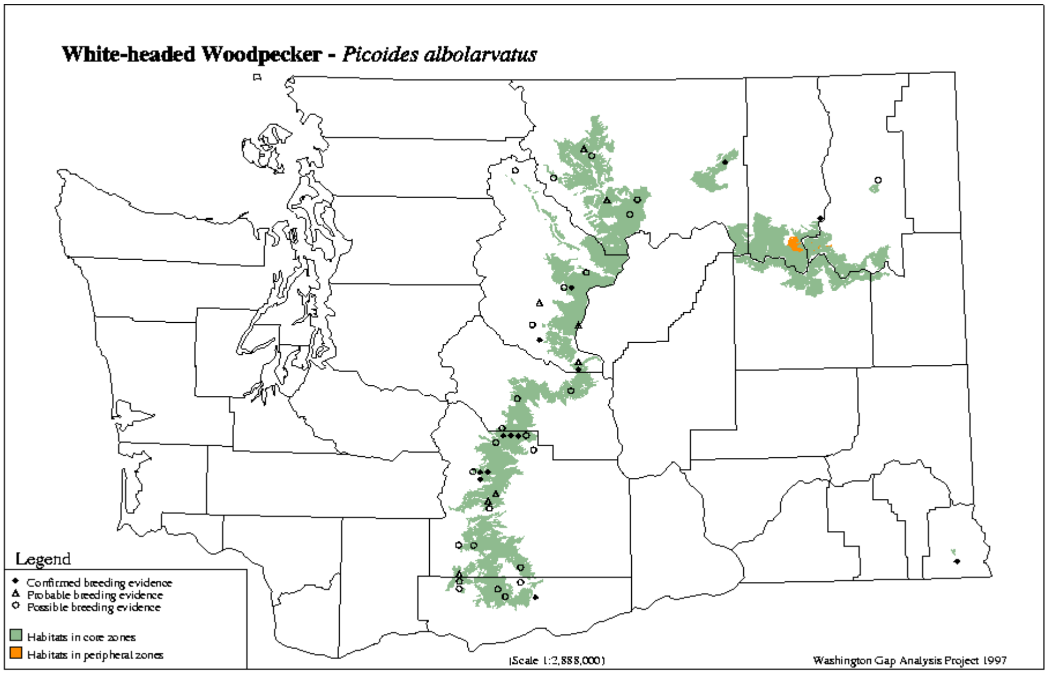


Figure 2-11. Breeding bird atlas data (1987-1995) and species distribution for white-headed woodpecker (Smith et al. 1997)

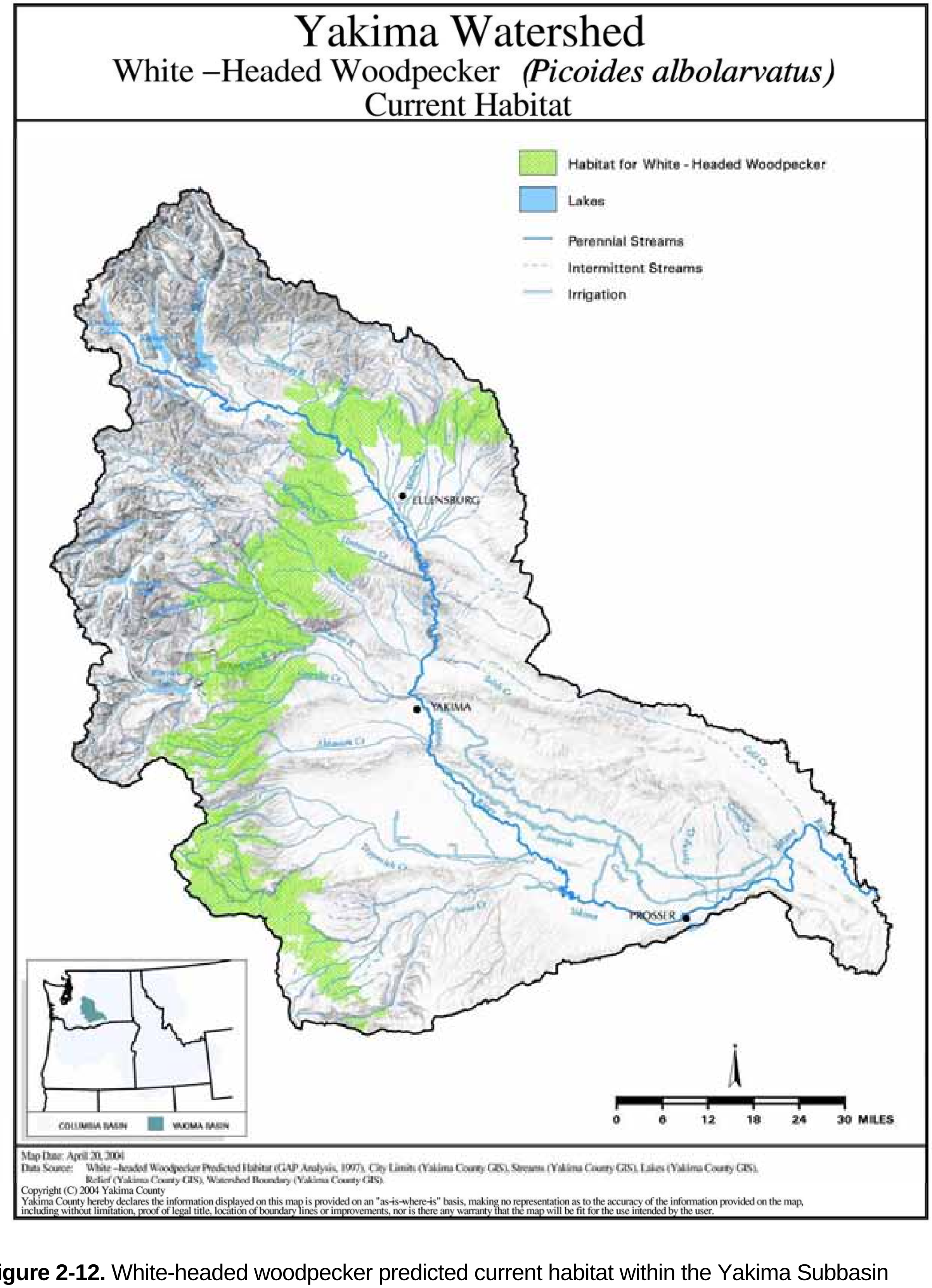


Figure 2-12. White-headed woodpecker predicted current habitat within the Yakima Subbasin

4.4.2 Lewis' Woodpecker (*Melanerpes lewis*)

Introduction

The Lewis' woodpecker is considered a potential sensitive environmental indicator in forest communities dominated by ponderosa pine (Diem and Zeveloff 1980). Lewis' woodpecker populations tend to be scattered and irregular and are considered rare, uncommon, or irregularly common throughout their range (Tobalske 1997). For these reasons, and their being an indicator of healthy ponderosa pine systems, they are a focal species for the ponderosa pine / Oregon white oak habitat.

Life History

Diet

The most common foraging method during the breeding season is flycatching, which requires open scanning perches such as snags, trees, power poles, etc. Other commonly used foraging methods include foraging on the ground or shrubs, and gleaning. Lewis' woodpeckers also feed heavily on fruits and berries during late summer and fall. The winter diet of the Lewis' woodpecker consists primarily of available acorn mast or corn. Mast is stored in caches and is occasionally used early in the breeding season. It is assumed that potential mast production (and winter food suitability) in the shrub stratum increases with increased canopy cover of mast-producing shrubs. Lewis' woodpeckers require mast storage sites in the form of trees or utility poles with desiccation cracks.

Acorn production in Oregon white oaks tends to cycle between heavy and very little mast, generally on a 2-3 year cycle. Lewis' woodpecker seasonal movements and reproductive success may be dependent upon this.

Reproduction

Lewis' woodpeckers are cavity nesters. Clutches usually include six or seven eggs. Males incubate eggs and brood young at night; both sexes do so during daylight. Multiple Lewis' woodpecker pairs sometimes nest in very close proximity to each other, even in the same tree. In a single case, five adult Lewis' woodpeckers have been observed at a single nest, with most of them feeding young. This case suggests the possibility that the species may engage in cooperative breeding, a behavior well documented among acorn woodpeckers but very rare among birds in general.

Nesting

Trees selected for nest sites in the Yakima Subbasin are generally Oregon white oak, ponderosa pine or cottonwood. Snags are often selected, but live oak trees often possess excellent rot characteristics and make good cavity sites. Fort Simcoe, on the Yakama Nation Reservation near White Swan, has a large colony of nesting Lewis' woodpeckers due to the presence of large, old oaks providing excellent nesting locations. This is a favored destination for bird watchers in Yakima County (Stepniewski, 1999).

Migration

The Lewis's woodpecker is mostly a seasonal visitor to the Yakima Subbasin, although some birds may stay all year then the weather is mild and food (acorn mast) is available. They are consider to be highly migratory often flocking in large groups in search of more plentiful sources of food.

Mortality

No information is available.

Habitat Requirements

Nesting

The Lewis' woodpecker is restricted, as a breeding species, to areas below the upper montane life zone (Bock et al 1971). Park-like ponderosa pine stands provide the major breeding habitat of the Lewis’ woodpecker throughout its range (Bock 1970). The combination of an open canopy, a brushy understory, and an abundance of insects describes breeding habitat for the Lewis’ woodpecker in ponderosa pine forests. Logged or burned coniferous forests that are structurally similar to park-like pine stands also provide suitable breeding habitat. At lower elevations, breeding habitat is provided by riparian cottonwood groves, fencerows in agricultural areas, and oak woodlands (Bock et al 1971). Suitable conditions for breeding in these habitats are provided by the same structural features important in ponderosa pine forests, except that shrub cover is apparently not a critical habitat feature. Lewis’ woodpeckers may use areas dominated by agricultural lands if sufficient nest trees are available in fencerows, along roads, or around buildings (Bock et al. 1971).

Lewis’ woodpeckers are cavity nesters but are not well suited for excavating their own cavities except in dead or dying trees (Bock 1970). Comprehensive information on Lewis’ woodpecker nesting requirements were not identified for this report.

It is assumed that canopy conditions will be optimal if tree canopy closure is less than 30 percent and will be unsuitable if canopy closure exceeds 75 percent. Optimal understory conditions are assumed to exist if shrub crown cover exceeds 50 percent. Both understory and canopy conditions must be optimal in order to have optimal conditions in ponderosa pine stands. If tree canopy closure exceeds 75 percent or if no shrubs occur in the understory, then it is assumed that the habitat is not suitable for Lewis’ woodpecker. The same habitat features may be used to describe foraging habitat during the breeding season in deciduous cover types, although a dense shrub stratum is apparently unnecessary. In deciduous cover types, the presence of shrubs is considered to add to the food value, but will not be limiting to food suitability.

Cavity nesters generally face a shortage of nesting sites where trees occur in clumps (Jackman 1975). In areas of high demand for sites, Lewis’ woodpeckers may nest within a short distance of each other. Currier (1928) reported three holes that were occupied by Lewis’ woodpeckers in each of two trees less than 0.25 miles (402 meters) apart. Managed forests generally have fewer available nesting sites than do natural forests, because snags and diseased and damaged trees are usually removed (Jackman 1975). Lewis’ woodpeckers exhibit a strong pair bond and high nest fidelity, returning to nest in the same cavity in consecutive years (Bock 1970).

Cover

Habitats used by Lewis' woodpeckers are characterized by their openness (Bock 1970). Open forests allow sufficient visibility and movement for the Lewis' woodpecker to flycatch effectively and also allow the development of a shrubby understory that supports terrestrial insects. Vertical interspersion of vegetative strata is important in evergreen forests and in burned areas, in meeting habitat requirements for breeding and, to a lesser degree, for winter habitat. Although logged or burned habitats may provide suitable habitat for 10 to 30 years following the disturbance, the habitat will be unsuitable if it does not contain a shrub stratum (as a result, for example, of overgrazing or intensive forest management). However, the presence of a shrubby understory is apparently of less importance in riparian groves, and oak woodlands (Bock 1970). Although the reasons for such a difference in the importance of shrubs is unclear, it may be due to different feeding strategies in coniferous and burned habitats compared to riparian and oak habitats.

Status and Abundance Trends

Status

The Lewis' woodpecker has been included in the Audubon Society's Blue List[1] since 1975 (Tate 1981). The list is intended as an early warning list of species exhibiting non-cyclical population declines or range contractions. Competition for nest sites from starlings may be a possible cause of the decline. However, evidence also exists that the Lewis' woodpecker has expanded its range into plains habitat in response to maturation of cottonwoods around rural residences and the availability of a mast source in the form of irrigated corn (Hadow 1973). The Lewis' woodpecker is considered a potential sensitive environmental indicator in forest communities dominated by ponderosa pine (Diem and Zeveloff 1980).

Trends

According to the Interior Columbia Basin Ecosystem Management Plan (ICBEMP) (Wisdom et al. 2000) terrestrial vertebrate habitat analyses, historical source habitats for Lewis' woodpecker occurred in most watersheds of the three Ecological Reporting Units (ERUs)[2] within our planning unit (Wisdom et al. in press). Habitats have declined from historic to current levels here, including 97 percent in the Columbia Plateau and 95 percent in the Owyhee Uplands. Within the entire Interior Columbia Basin, overall decline in source habitats for this species was the greatest among 91 species of vertebrates analyzed (Wisdom et al. in press).

Lewis' woodpecker populations tend to be scattered and irregular and are considered rare, uncommon, or irregularly common throughout their range; local abundance may be cyclical or irregular (Tobalske 1997). In the past century, populations have apparently declined in British Columbia by more than 50 percent and decreased in Oregon, California, and Utah (DeSante and George 1994). Based on North American BBS data, numbers may have declined more than 60 percent overall between the 1960s and mid-1990s (Tobalske 1997). BBS data indicate a significant decline in the United States for the period 1966-1996 (-3.3 percent average annual decrease; $P = 0.01$; $N = 62$ survey routes) and non-significant declining trend between 1980 and 1996 (-1.7 percent; $P = 0.22$; $N = 53$). Thirty-year trends were negative but not statistically significant survey-wide and for the Western BBS Region and California; likewise trends were positive but not statistically significant for these analysis areas from 1980 to 1996. Mapped trends for 1966-1996 show steep declines throughout their range (Sauer et al. 1997). Declines

---

[1] The Audubon Blue List was an early warning system that called attention to species that were declining or of conservation concern, but that were not already listed by the Endangered Species Act, and were not receiving any special attention. This system has been improved upon and is now referred to as the Audubon WatchList.

[2] Ecological Reporting Units (ERUs) were developed by the Science Integration Team (SIT) of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) to use as an ecologically based subdivision of the ICBEMP area for grouping and reporting assessment data, described by Brewer and others [In press] in; Description of the geoclimatic and hydrologic properties of ecological reporting units within the Interior Columbia Basin Ecosystem Management Project Assessment Area.

have occurred in coastal areas of British Columbia and Washington (S. Cannings, D. Paulson pers. comm. WDFW PHS).

Christmas Bird Count (CBC) data show non-significant declining trends survey-wide and in California, Colorado, and Oregon, and a non-significant increase in Arizona, for the period from 1959 to 1988 (Sauer et al. 1996). Ehrlich et al. (1992) suggest that populations appear to have stabilized recently, but those in riparian habitats in arid regions continue to be vulnerable to drought, overgrazing, and other habitat degradations.

Factors Affecting Lewis's Woodpecker Population Status

Destruction of Foraging Habitat

Although preferred habitat types for breeding and wintering remain structurally similar from year to year, the presence of Lewis' woodpeckers in any given preferred habitat depends heavily on the food supply, either insects or mast (Bock 1970). Because the habitat needs of Lewis' woodpeckers are more specialized in winter than during the breeding season, destruction of winter range represents a greater potential threat to the species than loss of breeding habitat (Bock, pers. comm.)

Lewis' woodpecker habitat may be adversely affected by grazing, which eliminates brushy undergrowth (Jackman 1975). Forest management practices that provide snags, a brushy understory, and slash provide suitable Lewis' woodpecker habitat.

Population and Distribution

Historic Population

Lewis' woodpeckers were formerly more abundant in the lower Yakima valley than today. They were considered an agricultural pest in the early 20th century (Stepniewski 1999) in some places.

Current Population

Today, Lewis' woodpeckers are a fairly common species during the breeding season along the streams and in the pine/ oak woodlands of the mountain edges in Yakima County. Birdwatchers regularly sight them in Umtanum, Cowiche Creek, Oak Creek Wildlife Area and particularly at Fort Simcoe State Park (Stepniewski, pers. Comm). They are, however, thought to be in decline across Western North America, and are listed as WA state species of concern, and on the PIF WatchList.

Historic Distribution

Historic distribution is not known, but based upon the continued presence of most suitable habitat types, is likely similar to current conditions in the Yakima Subbasin, with local exceptions where habitat conditions have deteriorated due to human activities (i.e. removal of nesting trees).

Current Distribution

Lewis' woodpeckers are found throughout the Columbia Basin as far north as Revelstoke and Golden, British Columbia. Lewis' woodpecker breeds in North America from interior British Columbia and southwestern Alberta, south to Arizona and New Mexico, and from coastal California east to Colorado. Virtually the entire Canadian population occurs in British Columbia. The birds winter from interior British Columbia (casually) south through the western states to northern Mexico, but mainly in the southwestern United States (Cannings et al. in prep.). Figure

2-13 illustrates the core habitat that has been identified for the Lewis's woodpecker in the Yakima Subbasin. According to Stepniewski (1999) in his book, "*The Birds of Yakima County*", the Lewis' woodpecker is known to be fairly common in oak woodlands adjacent to the base of the cascades during the summer months.

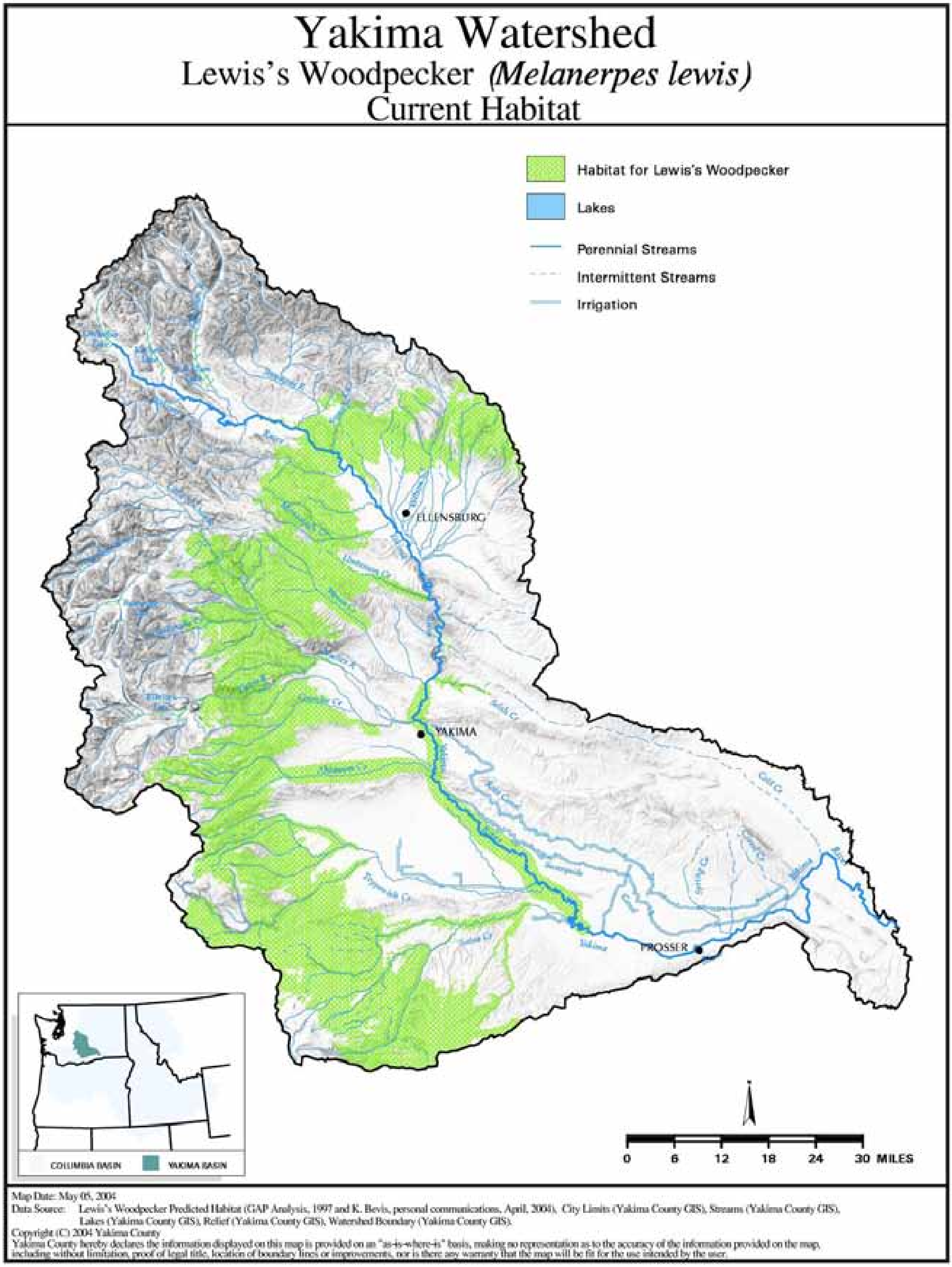


Figure 2-13. Lewis' woodpecker predicted current habitat in the Yakima Subbasin

4.4.3 Western Gray Squirrel (*Sciurus griseus*)

Introduction

The Western gray squirrel is the largest tree squirrel native to the Pacific Northwest. The species range extends along the West Coast from Washington to southern California. Although once abundant and widespread throughout oak-conifer forests, its range in Washington State has contracted to three disjunct populations largely due to habitat loss and degradation. A 1993 status review by the Washington Department of Wildlife (WDW) found that the species was "in danger of extirpation from most of its range in Washington" (WDW 1993), resulting in its listing as state Threatened. The western gray squirrel is a Federal Species of Concern, and the Washington population was petitioned for listing under the ESA in 2001. However, the USFWS' status review and 12-month finding concluded that this population does not qualify as a distinct population segment, and is therefore not a listable entity (68 FR 34682). Persistence of this species in the state of Washington will therefore likely depend on state-level protections of oak-conifer habitats and voluntary efforts by federal entities.

Life History

Diet

Preferred foods for western gray squirrels in California are hypogeous fungi, acorns, pine nuts, California bay fruit, and green vegetation (Cross 1969, Steinecker and Browning 1970, Steinecker 1977). California bay fruit are not found in Washington, but hazelnuts may be an additional important food source here (Rodrick 1986). Walnuts from trees planted by early settlers may be the principle mast source where western gray squirrels inhabit atypical (non-oak) habitats in Chelan and Okanogan Counties (Barnum 1975). In Oregon acorns were preferred in winter and spring, fungi in late spring through fall, with pine seeds also favored in late summer through fall (Foster 1992). The oak native to the northern portions of the squirrel's range (Oregon white oak) is prone to acorn crop failures (Foster 1992, Ryan and Carey 1995). Although hypogeous fungi have been found to constitute over half of squirrels' diets in California (Steinecker and Browning 1970, Steinecker 1977), and may therefore serve to buffer variability in mast supply, availability of tree seeds may be very important as a high-energy food source enabling winter survival and initiation of breeding (Steinecker and Browning 1970).

Reproduction

Western gray squirrels generally produce one litter of 1-5 young (averaging about 3 young) per year. Females rear the young. Males reach sexual maturity at 1 year and females at about 10-11 months of age. Males come into breeding condition in December or January and remain in breeding condition until early summer (Cross 1969). Any individual female is in estrous for only a single day generally in December or January, although some may apparently come into estrous in June (Foster 1992). The gestation period is believed to be about 43 days (Ingles 1947, Swift 1977), with lactation lasting about 75 days (Gurnell 1987). Thus, lactating females have been observed from May to August in Washington (M. Linders unpubl. data) and from March to October in northern Oregon (Foster 1992).

Nesting

Nests are used both by females rearing young and by all squirrels for year-round shelter. Western gray squirrels build stick nests, although cavities may be important for parturition and initial rearing of young (Cross 1969, Barnum 1975, Ingles 1947). Squirrels use multiple nests, with as many as 14.3 nests per squirrel reported in Washington (Linders 2000). Squirrels also build multiple loose stick and leaf platforms for resting.

Home Range

A radio telemetry study of 25 western gray squirrels in Klickitat County, Washington, found 95 percent MCP year-round home ranges from 10-187 ha (mean 73 ha) for males and 3-44 ha (mean 21 ha) for females (Linders 2000). This study found that breeding females used smaller areas than non-breeding females, which in turn used smaller areas than males (Linders 2000). A northern Oregon study estimated home ranges at only 1.7-6.5 ha, but was based on only 8 individuals (Foster 1992).

Mortality

Mortality rates for western gray squirrels are not well-known, although a Klickitat County study estimated about 61 percent mortality of squirrels trapped over a 16-month period (Linders unpubl. data). For tree squirrels in general, only 15-25 percent of young generally survive the first year, with perhaps 50-70 percent adult survival in average food years (Gurnell 1987). Major mortality factors for western gray squirrels include starvation, predation by a variety of avian and mammalian predators, parasites, disease, and automobiles (H. Simmons-Rigdon, YN, pers.comm.). Of the diseases affecting western gray squirrels, Notoedric mange[3] has taken a particularly large toll, with major outbreaks in Washington noted in the 1930s, 1940s, 1950s (WDW 1993) and 1998-99 (Cornish et al. 2001). The disease may have been introduced to the Washington population by California ground squirrels upon expansion of their range into Washington in 1912. Hunting was a major source of mortality in Washington until 1943, and continues to be a mortality factor in Oregon.

Habitat Requirements

General

Western gray squirrels need a variety of mast-producing trees for food, cover and nesting sites (WDW 1993). The squirrels are found primarily in three regions of Washington, the southern Puget Trough, Chelan and Okanagan counties, and the Columbia River Gorge of south-central Washington.

In the Columbia River Gorge, ponderosa pine forests /Oregon white oak prevail. These forests follow stream drainages northward toward Goldendale and into Yakima County (Franklin and Dyrness 1973). Other tree species of importance to the western gray squirrel are Douglas-fir, which appears as elevation increases, and introduced nut trees which were planted in agricultural areas (Barnum 1975).

The quality of the habitat is influenced by the number of mast-bearing tree species in and near the nest tree sites, the age and size of the trees, and proximity to permanent water (Cross 1969, Gilman 1986, Foster 1992). The western gray squirrel seems to be associated with late successional forests, which provide the above-mentioned characteristics (WDW 1993).

---

[3] Notoedric mange is a serious disease of squirrels, especially during the winter. Large areas of the body or entire body become denuded with hair and the animal may die of exposure because of the loss of insulating fur.

Nesting

Most squirrels build round stick nests, approximately 60 cm (2 ft) in diameter, in pole to saw timber-sized conifers, about one third of distance from the top of the tree and next to the trunk. The nests are lined with lichen, moss, and bark shavings Western gray squirrels need a variety of mast-producing trees for food, cover and nesting sites (WDW 1993).

Foster (1992) found that the most important components of nest tree sites in north-central Oregon, were contiguous canopy cover (mean = 60 percent) to allow aerial travel, and being within 180 m (600 ft) of water. Nest tree age (69-275 yr, mean = 108 yr) and diameter at breast height (21-58 cm, mean = 40 cm; 8.2-22.6 in, mean = 15.7 in) appeared to be the most important determinants of the tree chosen. All nest trees in the study area were ponderosa pine, except one Douglas-fir.

Breeding

Long-term studies of the eastern gray squirrel show years of acorn mast failure followed by cessation of reproduction (WDW 1993). Eastern gray squirrels are capable of compensatory breeding at high rates, with two litters per year, in times of low population density and food abundance (WDW 1993). Western grays do not appear to be capable of higher rates of reproduction (Byrne 1979). When other factors like disease or competition are present, the western gray is more vulnerable to population crashes.

Non-breeding

Maser et al. 1981 suggested that during wet coastal winters this squirrel probably takes shelter in cavities or hollows.

Foraging

Acorns are an important food source in winter and early spring. In oak dominated habitats, acorn production is very important. Pinecones and seeds become important late summer through fall (WDW 1993).

Cover

Generally, western gray squirrels require trees of sufficient size to produce an interconnected canopy for arboreal travel (WDW 1993). Barum (1975) observed no use of a lone pine tree that was full of green cones, conceivably because there was no travel cover The western gray squirrel was listed as State Threatened in 1993, and as a Federal Species of Concern in western Washington. In a 2003 Status Review and 12-month finding for a petition to list the Washington population of the western gray squirrel (68 FR 34682), the USFWS concluded that listing was not warranted because although the Washington populations are discrete from the Oregon and California populations and are declining, they are not "significant to the remainder of the taxon". The USFS considers the squirrel to be a sensitive species, and uses it as an oak-pine community management indicator species in the Columbia River Gorge National Scenic Area and on the Mt. Hood National Forest.

Status and Abundance Trends

Status

Long-term trends in the south Cascades population are unclear, although researchers did observe a decline and rebound in response to a widespread mange outbreak in 1998-1999 (Cornish et al. 1991).

Habitat Status

Since extinction or extirpation rates are partly area-dependent, the size of reserves, spacing of reserves, and dispersal corridors are important. Individual reserves must be large enough to ensure stability of the ecosystem and to provide a buffer from disturbance (Frankel and Soulé 1981).

Oak was more common in Washington 10,000 years ago, before a long-term climatic change (Kertis 1986). The western gray squirrel was probably more widely distributed in prehistoric times and has diminished recently along with the oak woodlands (Rodrick 1986). Presently, both the oak and the squirrel are at the northern extent of their ranges in potentially marginal habitat.

In Washington, western gray squirrels and their habitat are found primarily in three regions of Washington, the southern Puget Trough, Chelan and Okanagan counties, and the Columbia River Gorge of the south-central Cascades (Source: Johnson and Cassidy 1997

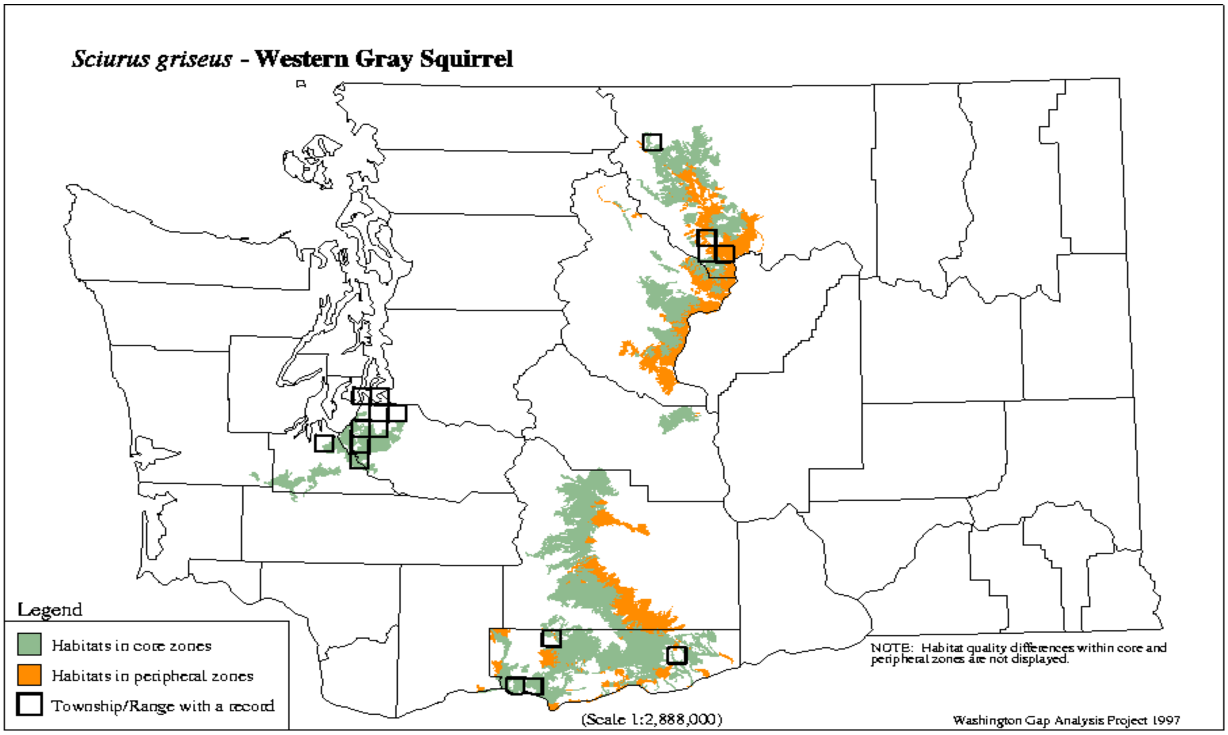
Figure 2-14).

In the south Cascades, western gray squirrels are unevenly distributed from Underwood in Skamania county, east through Klickitat County, and into the Yakama Nation reservation to the north. They occur in oak-conifer communities along the tributaries of the Columbia River (WDW 1993, WDFW, unpub. data). There is a remnant group of squirrels occurring in the White Salmon watershed. The highest concentration of squirrels occurs along the Klickitat River and its tributaries. A western gray squirrel was recently observed in this area, just south of the Yakama Nation Reservation in April 2004 (H. Simmons-Rigdon, YN, pers.comm.) The last live sighting on the reservation was in 2003 (L. James, YN, pers.comm.) In the Rock Creek subbasin, there are scattered occurrences distributed throughout. Figure 2-15 shows the predicted current habitat of the western gray squirrel in the Yakima Subbasin.

Historic records indicate western gray squirrels occurred in the Oak Creek Wildlife Area until the 1980’s (WDW 1993). Historic sightings are documented for Cowiche Creek and the Ahtanum basin (WDW 1993).

Factors contributing to the Washington population’s decline and threats to its persistence include habitat loss and degradation, disease, competition with introduced and native species, variability in annual mast crops, and mortality from road-kill and (now illegal) hunting (WDW 1993, Ryan and Carey 1995). Factors contributing to habitat loss and degradation include climate change (reducing distribution of oak-conifer forests), habitat conversion to non-forest, fire suppression, logging, firewood cutting, grazing, forest pathogens, and stand-replacement fires (WDW 1993).

The species’ state and federal status affords its habitat little protection. Washington’s RCW 77.15.130 protects the squirrels from malicious killing and malicious destruction of nests, but few habitat protections have been implemented on federal lands and protections on state and private lands are voluntary (M.Linders, WDFW, pers com.) Conservation efforts for this species in Washington State will require better survey and monitoring and identification of limiting factors for each subpopulation. Landscape-level habitat assessments and plans for improving habitat quality and connectivity are likely to be essential to sustaining and recovering populations. Measures may include removing Douglas-fir and true firs encroaching on pine-oak stands (using fire or mechanical means), retaining or developing canopy closure, protecting oak regeneration from grazing



Source: Johnson and Cassidy 1997

Figure 2-14. Distribution of western gray squirrel habitat in Washington

Trends

This species has been extirpated across much of its former range in Washington. Comparison of detection rates of surveys conducted on Fort Lewis in 1992-1993 to those conducted in 1998 indicate that the Southern Puget Trough population has declined precipitously, with only five western gray squirrels detected in 538 foot-survey hours in 1998 and none detected by intensive surveys the following year (Bayrakci 1999). Trends in the North Cascades population are unclear due to lack of repeated surveys. If numbers of nests detected are a reliable index of population size, the Okanogan population appears to have declined between initial surveys in 1995-1997 and revisits to previously occupied sites in 2000.

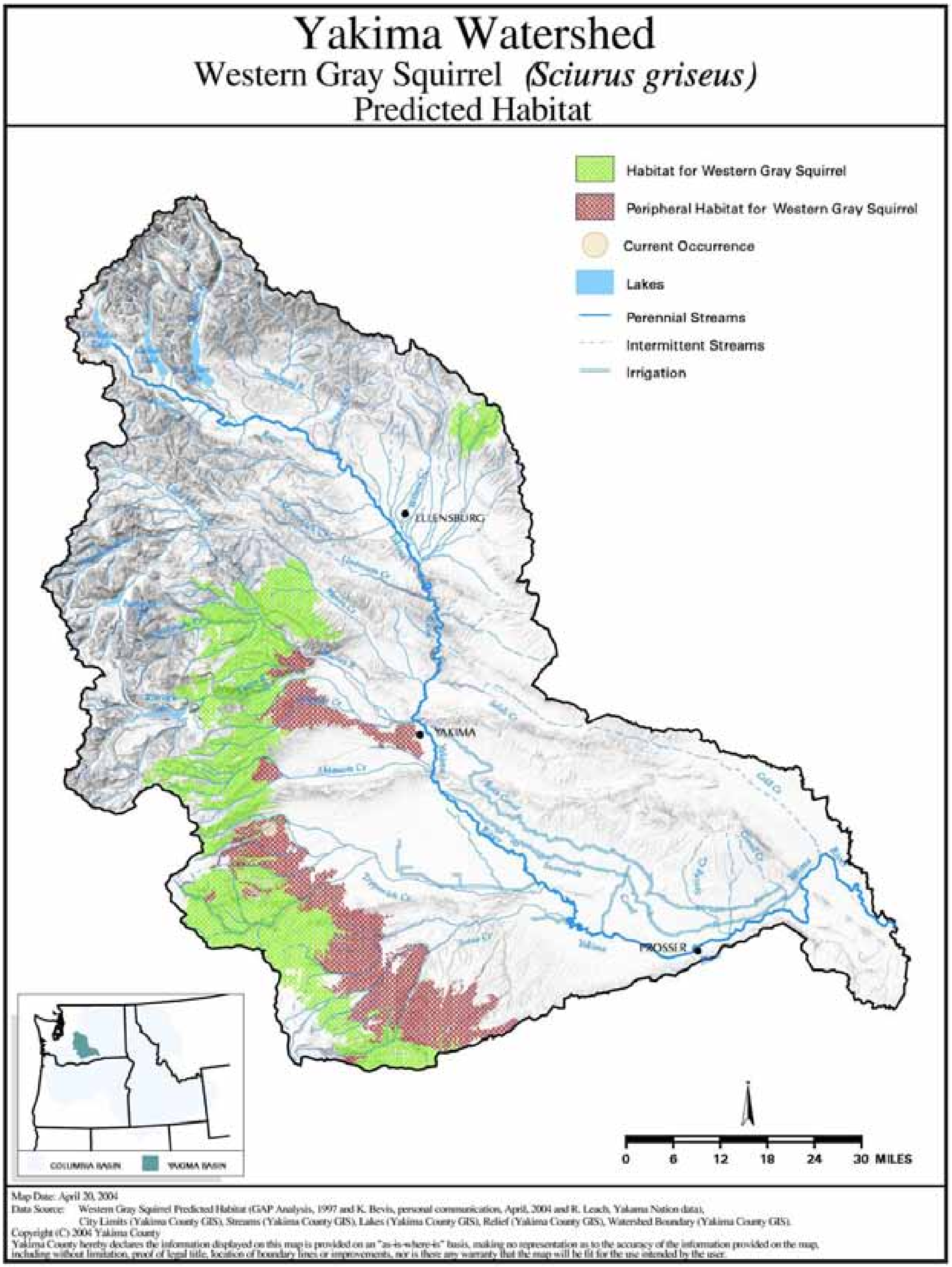


Figure 2-15. Predicted current habitat for the western gray squirrel in the Yakima Subbasin

4.4.4 Key Findings for Ponderosa Pine/Oregon White Oak Habitat and Focal Species

- Forest structures have been altered towards smaller diameter trees
- Habitat connectivity has been lost across landscape
- Dense mixed species stands have replaced characteristic focal habitat

4.5 Shrub Steppe/Interior Grasslands

4.5.1 Historic

Shrub steppe was the most abundant wildlife habitat within the subbasin. No systematic vegetation survey data is available from the pre-European settlement period. Therefore, historic vegetation patterns can only be inferred from sites thought to resemble historic conditions. Several shrub and grass associations were commonly interspersed with one another forming a diverse floral mosaic. The combination of elevation, aspect, soil type, and proximity to surface and/or ground water contributed to the vegetation potential of a site. Fire was likely the primary disturbance factor with intervals ranging between 50 and 100 years (Stinson et al. 2003); large mammals such as elk, small mammals such as ground squirrels, and flooding in perennial and ephemeral streams probably contributed secondary localized disturbance roles. Shrubs and perennial bunchgrasses co-dominated with a micro-biotic crust of lichens, mosses, green algae, and micro-fungi on the surface of the soil (Belnap et al. 2001). Biotic crusts are critical for binding soil particles together protecting the soil from wind and water erosion, fixing nitrogen, accumulating nutrients used by vascular plants, and out competing invasive species (Stinson et al. 2003). Estimates for historic shrub cover at undisturbed sites vary between 5 and 30 percent (Daubenmire 1970, Dobler et al. 1996, Crawford and Kagan 2001). Perennial bunchgrass cover was estimated to vary between 69-100 percent (Daubenmire 1970).

The dominant shrub-grass association was Wyoming big sagebrush and bluebunch wheatgrass (Daubenmire 1970). Scattered throughout this dominant cover type were many other bunchgrasses including Sandberg’s bluegrass, needle and thread, Thurber’s needle grass, Idaho fescue, Indian rice grass, squirreltail, and Cusick’s bluegrass. Scattered shrubs also included two rabbitbrush species and, short-spine horsebrush, Antelope bitterbrush, spiny hopsage, rigid sagebrush, basin sagebrush and three-tip sagebrush (Crawford and Kagan 2001).

Most of these shrub species had their own unique association with one or more bunchgrasses and dominated a portion of the landscape. For example, at higher elevations and north facing slopes three-tip sagebrush and Idaho fescue was the dominant association. On ridge tops where shallow soils (i.e., basaltic lithosols) were common, rigid sagebrush and Sandberg’s bluegrass and/or bluebunch wheatgrass dominated. Rabbitbrush was common in areas where fires had recently burned. Within the shrub steppe landscape there also were alkaline adapted community types, usually associated with drainage bottoms, perennial and ephemeral streams, or seeps and springs. This vegetation association, more common to the Great Basin, included black greasewood, basin wildrye, and inland saltgrass (Daubenmire 1970). The lower Yakima River Valley bottom likely had, and still does in some areas, extensive stands of this community type.

4.5.2 Current

An estimated 10.4 million acres of shrub steppe existed in Washington prior to the 1800's of which approximately 40 percent remains (Dobler et al. 1996). Changes in the distribution and abundance of shrub steppe habitat from circa 1850 (historic) to 1999 (current) are illustrated in (Figure 2-16 and Figure 2-17). The National Biological Division of the U.S. Geological Service (USGS) has identified native shrub and grassland steppe in Washington as an endangered ecosystem (Noss et al. 1995). The most significant direct cause of shrub steppe loss in the subbasin was creation of the Yakima Basin Irrigation Projects. Some shrub steppe was converted to non-irrigated wheat production especially in western Benton County. The pattern of agricultural conversion has resulted in a disproportionate loss of deep soil communities not reflected in typical measures given for habitat loss (Vander Haegen et al. 2000). Domestic plants and animals that are dependent on irrigated agriculture have replaced native shrub steppe plants and animals. Indirectly, invasive alien species have competed with and replaced natives.

Three relatively large shrub steppe properties remain within the subbasin; the US Army's Yakima Training Center (YTC), the Yakama Nation's Reservation, and Department of Energy's Hanford Nuclear Reservation. The WDFW owns and manages several smaller, but key parcels as well. The YTC contains 327,242 acres in Kittitas and Yakima Counties; approximately 199,000 acres are in the Yakima Subbasin. It supports one of two remaining sage grouse populations left in Washington (Hays et al. 1998). High habitat quality on YTC is largely due to its complex topography precluding early agricultural endeavors and historic low intensity livestock-grazing program (Schroeder et al. 2000). Grazing by livestock was completely eliminated in 1995. The complex topography of the site has resulted in a diversity of plant associations. YTC was determined to be critical in contributing to conservation of biological diversity within the region (The Nature Conservancy [TNC] 1999).

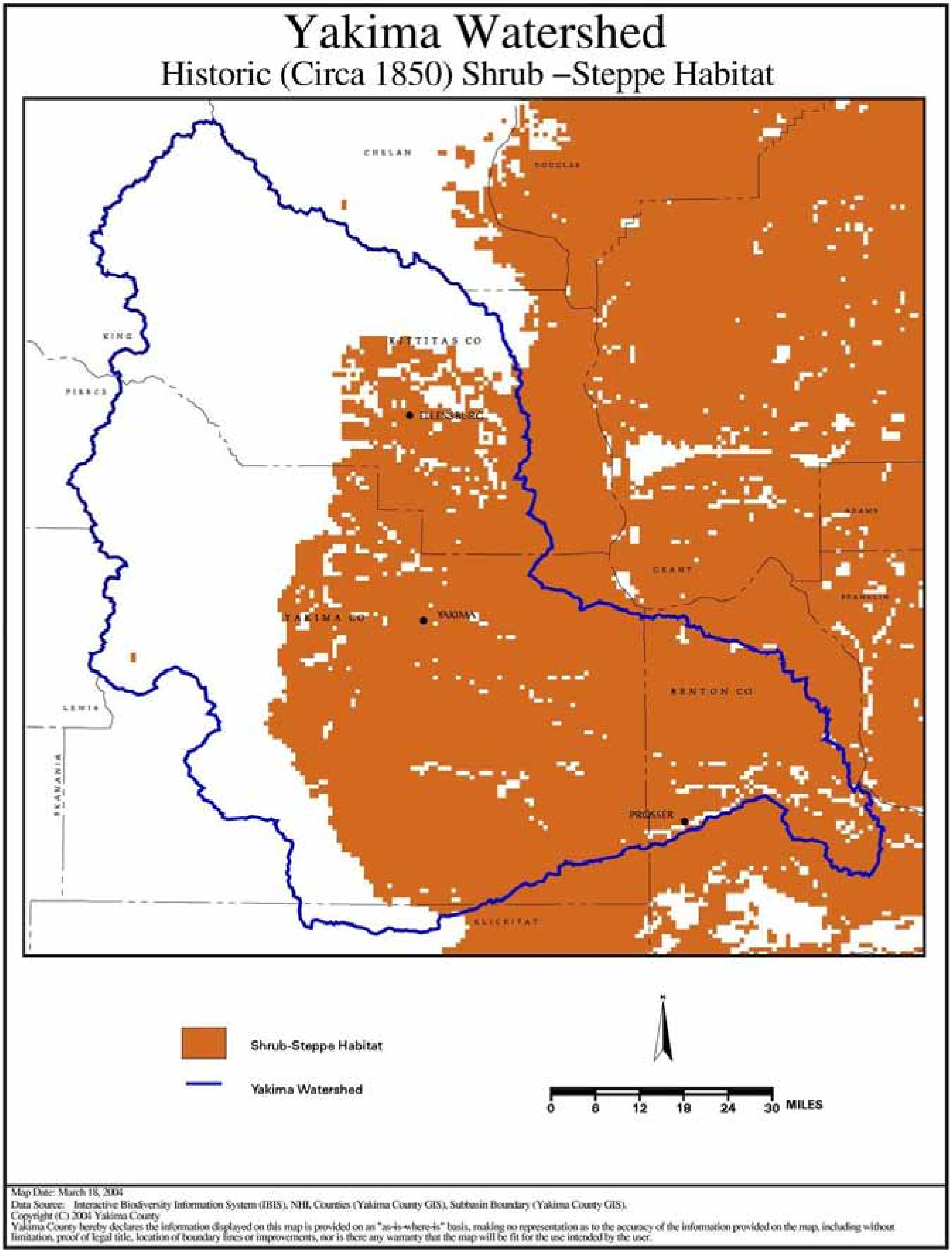


Figure 2-16. Historic shrub steppe habitat in the Yakima Subbasin

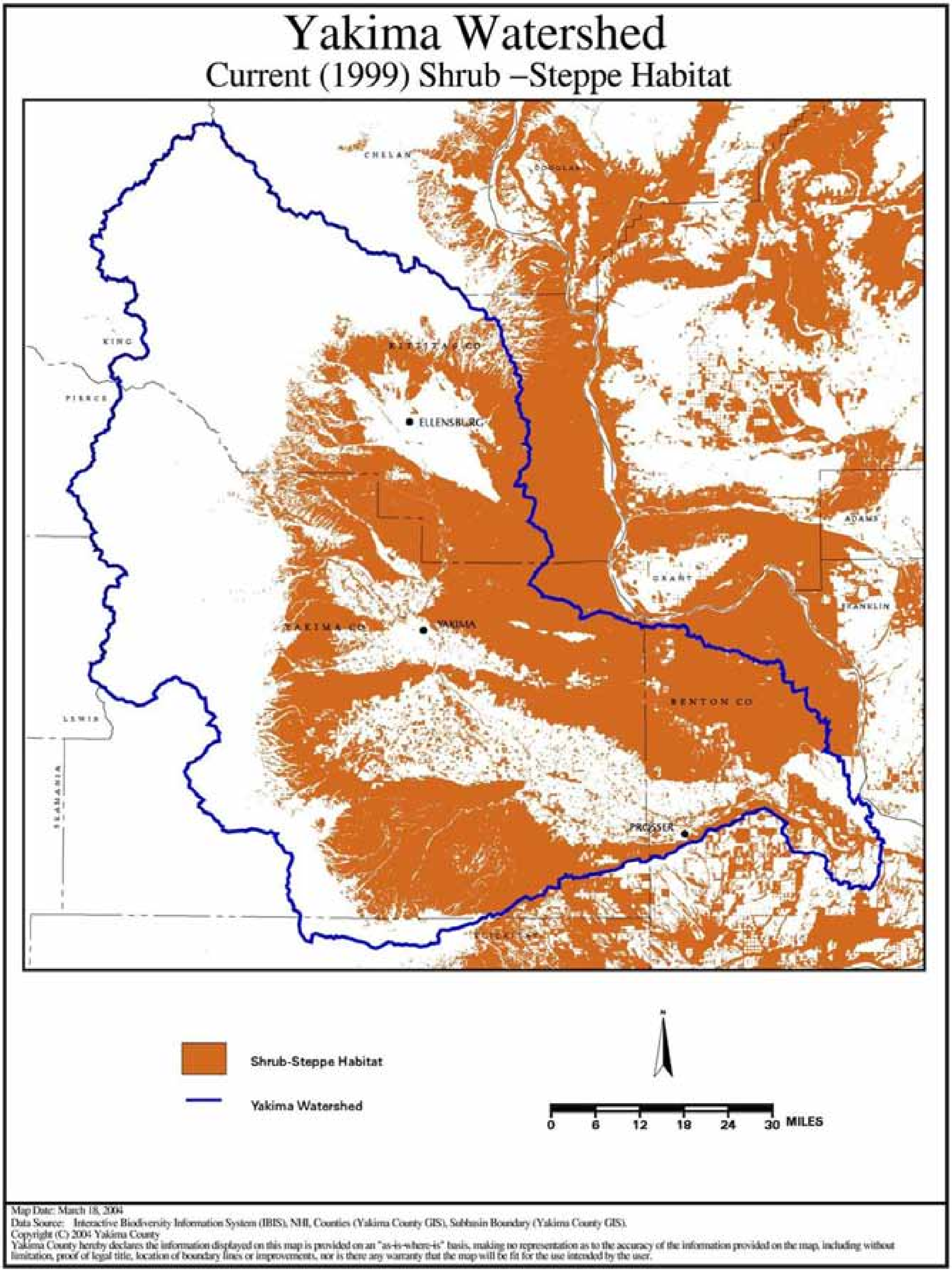


Figure 2-17. Current shrub steppe in the Yakima Subbasin

Military training poses the greatest threat to habitat security. Cross-country maneuvers with military vehicles decrease habitat quality through sagebrush mortality (Cadwell et al. 1996, Stephan et al. 1996) and disturbance to understory communities (Cadwell et al. 2001). Training ignited wildfires are a significant threat and could potentially eliminate large portions of existing habitat (Livingston 1998). In 1996, and again in 2003, approximately 40,000 acres were consumed in the east central portion of YTC. Several smaller fires have burnt in the last 10 years in the Selah Creek and Cold Creek Valleys. In response, the Army restricts training in many core sage grouse areas, and implements aggressive fire prevention and fighting techniques. The Army plants tens of thousands of sagebrush seedlings each year in an attempt to restore lost shrubs (YTC-ENRD 2002).

The Yakama Nation possesses approximately 410,000 acres of shrub steppe in Yakima County. Shrub steppe on the Reservation broadly remains in four areas; Ahtanum Ridge, Medicine Valley and the two areas west (West Satus) and east (East Satus) of Satus Creek and US 97 and south of Toppenish Ridge. Tart et al. (1987) ranked the shrub steppe quality on the reservation using the Natural Resources Conservation Service's Range Condition rankings of excellent, good, fair and poor. These rankings were based on current condition combined with ecological potential of the site. The Ahtanum Ridge area (56,000 acres) had a mixture of good to excellent habitat on the north facing slope and a mixture of poor to good habitat condition on the south-facing slope (Tart et al. 1987). This area is threatened by irrigated agriculture on the south side and suburban development on the north side. Medicine Valley (56,000 acres) between Ahtanum and Toppenish Ridges had a ranking between poor to good (Tart et al. 1987). A large portion of this area is dominated by lithosolic soils and therefore; it's use by wildlife is primarily restricted to spring foraging by mule deer, elk and horses.

West Satus (124,000 acres) has a mixture of poor to good habitat condition. There are large expanses of lithosols in this area with rigid sagebrush being the dominant shrub and some Sandberg's bluegrass and cheatgrass. This plant community provides very little cover for wildlife, but does supply an important forage source in winter and spring for mule deer and elk. Within the West Satus area, the south slope of Toppenish Ridge has had a long history up to present of over grazing and wildfires. Consequently, this area is dominated by cheatgrass and largely devoid of sagebrush. Range condition improves with increasing elevation towards the forested zone.

East Satus (175,000 acres) has a mixture of poor to excellent habitat condition (Tart et al. 1987). A sage grouse habitat evaluation study has recently been conducted within this area. Approximately 50,000 acres were identified as high habitat quality for sage grouse (B. Jamison, YN, Upland Gamebird Biologist, pers. comm.). Wild fires in 2000 consumed approximately 10,000 acres on the north and south slopes of Toppenish Ridge and 40,000 acres in the Mule-Dry Canyon and Horse Heaven Hills of East Satus. The YN is currently developing plans for the management of wild horses and the restoration of other culturally important species including sage grouse (B. Jamison, YN, pers.comm.).

Approximately 160,000 acres of Department of Energy (DOE) land is within the subbasin. Since the early 1940's, DOE has owned the property for operation of the Hanford Nuclear Reservation. The USFWS currently manages several of the lands surrounding it including the 75,000-acre Fitzner/Eberhardt Arid Lands Ecology Reserve (FEALE). Livestock grazing was eliminated when DOE acquired the land. During a biodiversity inventory of the site, over 1,000 species of insects, 3 species of reptiles and amphibians, 44 species of fish, 214 species of birds, and 39 species of mammals have been found on the Hanford Site (Soll 1999). Habitat condition at low elevations is a mixture of good to fair quality owing to its sandy soils, which has yet to recover from overgrazing. Healthy bluebunch wheatgrass and Idaho fescue associations prevail at higher elevations on the north slopes of the Rattlesnake hills. Large wild fires in 1984 and 2000 removed virtually all upland shrubs (USDI 2000). Riparian areas have recovered more rapidly. The USFWS has initiated aggressive revegetation efforts throughout the FEALE (H. Newsome, USFWS, pers. comm.). Since 1998, 1.1 million sagebrush seedlings on approximately 2,865 acres have been planted. This figure represents only 3.2 percent of the landmass that burned in 2000 (Stinson et al. 2004). Several years will be required to determine if efforts are successful at restoring native bunchgrasses and shrubs throughout the property.

WDFW owns and manages approximately 94,000 acres of shrub steppe habitat on six separate properties within the Subbasin (see Chapter 1, Figure 1-3). East of FEALE, the 3,600-acre Rattlesnake Slope Unit of WDFW's Sunnyside Wildlife Area contains a medium to high quality bluebunch wheatgrass community. Wildfires in 1984 and 2000 eliminated most sagebrush similar to the FEALE. Approximately, 1,000 acres were seeded in fall of 2000 with a mixture of native shrubs and grasses. Recent monitoring indicates that the seeding of sagebrush and winterfat was successful over many acres (R. Ross, WDFW, pers. comm.).

WDFW's Wenas Wildlife Area contains approximately 64,950 acres of shrub steppe. Agricultural fields located on both sides of Wenas Creek were historically used for hay production and/or livestock pasture. When acquired by WDFW in the late 1960s, hay production was maintained for WDFW's winter elk feeding program. These agricultural fields, however, were seeded to native grasses, forbs, and shrubs in late fall of 1998. These plantings have had mixed results and unsuccessful areas are being reseeded (C. Confer, WDFW Wildlife Area Manager, pers. comm.). Prior to WDFW ownership, the Umtanum Creek Unit of the Wenas Wildlife Area was used for livestock grazing. With the exception of riparian sites, grazing impacts were not as pronounced as on other units due to the steep topography that exist on much of the area (Confer – the Wenas Management Plan).

WDFW's Oak Creek Wildlife Area contains approximately 12,800 acres of shrub steppe. Scattered throughout this property are 1-mile sections owned by Washington DNR. Several of these sections are leased by WDFW and managed as part of the Wildlife Area. This property encompasses some high quality shrub steppe and steppe communities that transitions into the Ponderosa Pine forest (J. McGowan, WDFW, pers. comm.).

The Cowiche Wildlife Area (CWA) owned and managed by WDFW contains approximately 4,480 acres of shrub steppe. This Wildlife Area is nested within an important habitat corridor linking shrub steppe to the north with the Yakama Reservation shrub steppe (Stinson et al. 2004). Lands surrounding the CWA are rapidly being lost to suburban sprawl.

Remaining shrub steppe on private land tends to be fragmented into relatively small patches that have been degraded in quality (Dobler et al. 1996). There are a few exceptions where relatively large (<12,000 acres) shrub steppe parcels exist in close proximity to public land (Refer to Chapter 1, Figure1-3). They are usually associated with steep topography such as on ridges that were historically not productive for cultivation. These lands are mostly working ranches, and therefore, have issues related to overgrazing, fragmentation, and invasive species. A redeeming quality is they remain mostly intact and, at a minimum, act, or could potentially act, as wildlife (e.g., sage grouse, elk, mule deer) corridors for dispersal between public lands. The Rattlesnake Hills from Union Gap to the FEALE, has scattered tracts of private land amongst Washington DNR and BLM land. The private land between YTC and the Yakima River Canyon and between YTC and the Hanford Reach National Monument are key wildlife corridors. Sage grouse, Brewer's sparrows, elk, golden eagles, and other high priority species are regularly observed on these private lands.

There is a narrow band of remaining shrub steppe on the north slope of the Horse Heaven Hills. This area has been encroached by dryland wheat cultivation to the south and urban and irrigation development to the north. Most of the valley portions of the subbasin around Ellensburg, Yakima, and the Lower Valley between Union Gap and Richland have been converted to irrigated agriculture (Figure 2-18**).** The majority of areas with suitable soils throughout the Rattlesnake Hills north of Sunnyside, Prosser, and Benton City have been converted to both irrigated and non-irrigated agriculture. Deep soils remaining in shrub steppe habitat in the Yakima Subbasin are relatively rare because productive agriculture is associated with deep soils. Shrub steppe with deep soils is required for burrowing or burrow-using wildlife such as badgers, ground squirrels, and burrowing owls.

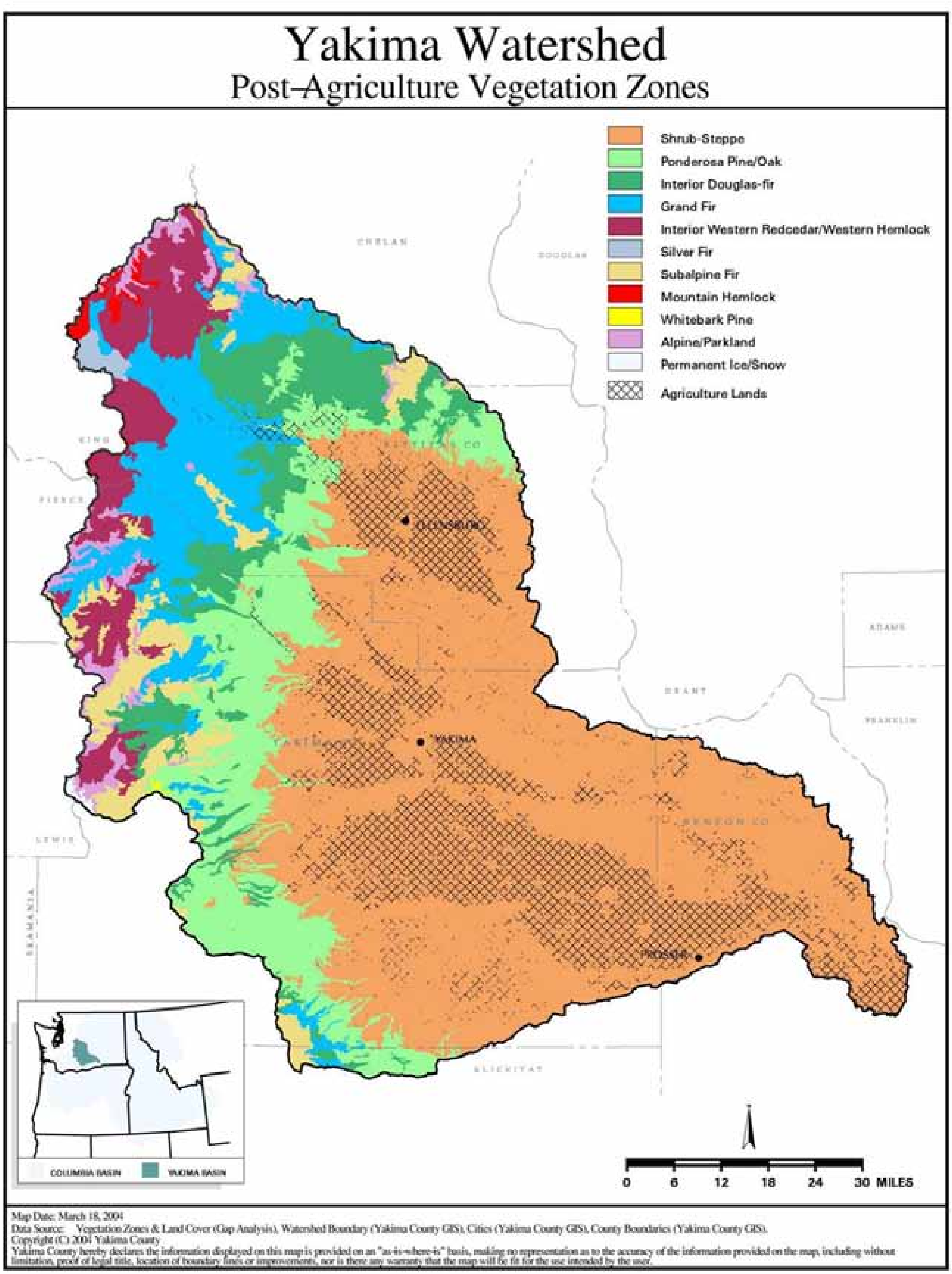


Figure 2-18. Location of agricultural lands in the Yakima Subbasin

4.5.3 Key Findings for Shrub Steppe Habitat

The limiting factors discussed here refer to large-scale forces that threaten the viability of the shrub steppe ecosystem as a whole. The concepts discussed were developed by Chuck Warner of TNC to describe conditions of the Moses Coulee portfolio site in northern Washington. His framework was modified to describe the condition of shrub steppe within the Yakima Subbasin. Proximal limiting factors to the biota of the various shrub steppe communities take the form of reductions in the composition (species richness), structural complexity, or spatial extent and distribution of the communities. Although these losses are expressed in myriad ways, they are summarized into the general categories of 1) reduced plant diversity, 2) reduced extent and diversity of the microbiotic crust, 3) increase, decline or loss of shrubs, 4) reduced faunal diversity, and 5) isolation of species populations. These, in turn, are closely related to, or are the direct result of, several ultimate limiting factors, including introduction of cheatgrass and other invasive species, soil disturbance, too frequent or too infrequent fire, habitat fragmentation, and drought.

- ***Reduced plant diversity**:* Declines in shrub steppe species diversity frequently are the direct result of overgrazing by livestock (Knick et al. 2003), with the consequent elimination of many species by foraging or trampling. It may also come about indirectly when cheatgrass and other invasive alien species out compete native taxa. Introduction and spread of many of these invasive species can occur as direct or indirect effects of grazing. This process may be accelerated when grazing occurs in combination with droughts, frequent fires, and soil disturbance. Inappropriate grazing regimes embrace a multitude of practices that exacerbate various stresses, and which ultimately results in the degradation of shrub steppe floristic composition. These may include numbers of grazing animals in excess of what the vegetation can support, grazing at times of year that are particularly stressful to vegetation, and various permutations and combinations of these problems. It is particularly important to recognize that the degraded condition of many shrub steppe habitats within the Subbasin is the result of historical grazing practices (see Sheller 1959 for account of early grazing practices within the subbasin). Even where grazing regimes have been modified to be less damaging to native plants, or where livestock have been removed entirely, full recovery of the system is unlikely to occur unassisted (Knick et al. 2003). Native plant species often are no longer present to seed back into habitats, microbiotic crusts may have been degraded or eliminated, and invasive species may have become well established. For this reason, active recovery strategies should be a very high priority in many areas, even where the current threats from inappropriate grazing or human use may be small.
- ***Reduced microbiotic crust***: The causal chain resulting in degradation of the microbiotic crust is closely linked to that just described for vascular plants. However, since livestock do not graze directly on cyptogamic species, their loss generally comes about through soil disturbance (e.g., trampling, vehicular traffic including military vehicles), or destruction by fire (Stinson et al. 2004). Once degraded, full crust recovery is slow, or may even be precluded; research is needed. A degraded or absent crust also is an important factor in allowing cheatgrass and some other annual alien species to become established more easily. Cheatgrass increases the likelihood of frequent fires where it provides an abundance of continuous, dry fuels in a heavily infested site. The ability of this species to significantly alter the nature of this important ecosystem process warrants its recognition

as the primary alien species limiting factor. Other invasive species may compete with native taxa, but none alter fire and soil processes to the extent that cheatgrass does.

- ***Changes in shrub cover***: Shrubs are an important structural component of steppe vegetation. They provide critical habitat for many species of wildlife. Big sagebrush does not resprout after fire (Crawford and Kagan 2001). Hence, fire intervals more frequent than every 20 years or so can result in the loss of this species (Crawford et al. 2004). If this occurs over a large enough area, sagebrush seed sources may be too remote to permit re-establishment. Shrubs may also be removed by land managers (through chaining, fire, or herbicide) who seek to promote more grass for livestock. Excessive grazing can also increase cover of sagebrush through soil disturbance and preferential grazing (Stinson et al. 2004).
- ***Reductions in faunal diversity***: Losses in faunal diversity frequently result in shrub steppe communities where the shrub component has been eliminated. Many bird species use sagebrush for nesting, cover, or forage (Paige and Ritter 1999). Presumably, many insects are obligates on these shrubs as well. Less certain is how losses in other plant species may impact faunal diversity. However, it seems likely that as forb and grass species disappear, many pollinators, granivores, and other herbivores, as well as animals that prey or feed upon them, are likely to vanish as well. Sage grouse, especially chicks, are dependent upon forbs for forage (Crawford et al. 2004).
- ***Population isolation and reduced viability***: In addition to the loss of individual species and organisms described above, the shrub steppe community is degraded as the habitat itself is broken up into smaller fragments. This results in the isolation of populations, with possible reductions in effective breeding numbers, genetic isolation and impoverishment, increased likelihood of stochastic extinctions, and an overall loss of species and community viability. Vander Hagen et al. (2002) documented that nest success for shrub steppe dependent birds decreases in more-fragmented landscapes. Most of these effects are only hypothesized for species within the Subbasin, as data for particular taxa are difficult to gather. However, there are indications that sage grouse are experiencing loss of genetic diversity possibly as a result of isolation (see Sage Grouse Species Account). Effects are perhaps likely to be evident first for shrub steppe obligate birds, some mammals, and perhaps some herpetofauna. Historically, this habitat fragmentation came about largely as a result of conversion of shrub steppe to agriculture. Road construction contributed to this as well. Currently, residential subdivision is a fragmentation threat in some areas and agricultural breakout is still occurring within the irrigated zone of the Subbasin especially for vineyard development. This threat also increases other threats as well, including an increased likelihood of fire ignitions, and increased sources for invasive species. Other features on the landscape, including wind power generators, water storage reservoirs, and transmission lines, may provide barriers to movement of some species.

4.5.4 Ranking of Limiting Factors

- ***Altered fire regimes* (High)**: Wildfires are a significant problem on all remaining public and private shrub steppe lands within the subbasin. Within the last 10 years, roughly 500,000 acres of shrub steppe have burned within the Subbasin. Some of these fires were very large such as the 2000 Hanford fire that consumed 160,000 acres. Fire alone could eliminate many sagebrush-steppe dependent species from the Subbasin. Not only does wildfire kill sagebrush it also encourages expansion of invasive alien species such as cheatgrass, Russian thistle and knapweeds, especially on south facing slopes. North facing slopes of ridges appear to be more resilient to invasion following fire probably because of cooler micro-climates. Cheatgrass can germinate when native bunchgrasses are dormant during the cold season. South facing slopes tend to be warmer with less snow accumulation. Warmer soil temperatures permit cheatgrass to germinate. As a result, many remaining shrub steppe areas in the Subbasin have significant cheatgrass problems on south facing slopes. Restoration techniques for restoring Wyoming big sagebrush into healthy bunchgrass stands need further development. Sagebrush restoration efforts, however, will merely be a waste of resources if a significant reduction in fire intervals is not accomplished.

- ***Inappropriate grazing practices* (High)**: Inappropriate grazing can directly result in an increase in invasive species (such as cheatgrass) that alter ecosystem properties such as fire frequency, degrade the composition of floral and faunal communities, disturb soils and eliminate microbiotic crusts. Furthermore, these changes may be relatively permanent, that is, they push the system into another state from which it will not return to its original composition without outside inputs of resources. Such restoration activities are extremely costly and it has not yet been demonstrated that it is possible to return a degraded shrub steppe site to its original condition at a large scale. Grazing has been eliminated from the YTC, WDFW Wildlife Areas and Hanford Reach National Monument. The remaining larger parcels of shrub steppe have various levels of grazing and probably will into the future. Because alterations resulting from inappropriate grazing are so closely linked to a cascade of medium and highly ranked stresses, it stands out as a highly ranked source.
- ***Military Training Direct and Indirect Impacts* (Med):** Military impacts are unique to the YTC, however, because it supports the only sage grouse population within the Subbasin it received a medium ranking. Direct negative impacts to shrub steppe condition include shrub and understory species mortality and microbiotic crust and soil disturbance from wheeled and tracked vehicle maneuvers. Indirect impacts result from training ignited wildfire that reduces shrub cover and exacerbates alien plant invasion.
- ***Increased habitat fragmentation* (Med)**: Many sources contribute to increased fragmentation. Collectively, these comprise a significant threat to the ecological integrity of shrub steppe biota. Agriculture and residential development are the two most significant sources of fragmentation across the Subbasin. Urbanization continues to contribute to permanent shrub steppe loss. Land around the Cities of Yakima, Ellensburg, and Richland is rapidly being developed for housing. The construction of roads and other infrastructure completely change the nature of the landscape. Many of these lands were formerly under cultivation and are just taking the last step toward complete loss. However, in some areas such as west of Richland and Yakima, suburban sprawl is reaching into uncultivated shrub steppe, further increasing the fragmentation of remaining habitat. Suburban sprawl is not limited to the larger cities within the subbasin. A nighttime view from the Horse Heaven Hills reveals that human occupation of the lower Yakima valley between Union Gap and Richland is extensive as well. Restoring native vegetation to agricultural land in key areas may offer valuable opportunities for

reducing fragmentation in important habitats. Wind farm and water storage development may pose future fragmentation threats in the Subbasin.

- ***Invasive alien species* (Med - High):** While linked in many areas to inappropriate grazing practices, other sources also exacerbate this stress, including recreational use, residential development, and frequent fire. As with habitat fragmentation, we cannot point to a single highly ranked source for this limiting factor across the site. However, in selected locales throughout the Subbasin, invasive alien species pose a serious threat to biotic integrity of the shrub steppe. The abundance of such locations, the diversity of sources, and the continued or increasing nature of this threat, combines to yield a medium-high rank for this limiting factor.

4.6 Focal Species for Shrub Steppe

4.6.1 Rocky Mountain Mule Deer (Odocoileus hemionus hemionus)

Introduction

Mule deer have been an important member of eastern Washington’s landscape, serving as a food and clothing source for Native Americans prior to settlement by Euro-Americans. Today mule deer remain an important component of the landscape, providing food for Native Americans, recreational opportunities for hunters and wildlife watchers, and tremendous economic benefits to local communities and the state of Washington. Mule deer range throughout the Yakima Subbasin, occupying various habitats from alpine areas in the Cascades, to the farmlands and shrub steppe/grassland habitats along the Yakima and Naches Rivers and their tributaries.

Life History

Mule deer fawns are born from late May through mid June following a gestation of approximately 203 days, with does having 1 to 2 fawns. Does require nutritious forage and water while nursing fawns. Fawns need good hiding cover to protect them from predators. The breeding season occurs in the late fall and early winter (November –early December) across eastern Washington, with mule deer becoming sexually mature as yearlings. During the fall season, high quality forage should be available to allow does to recover from the rigors of nursing fawns and prepare for the leaner winter months. In the Yakima Subbasin late summer/fall rains may create a green-up that is very important for mule deer. The fall green-up provides the nutrition necessary to improve body condition for the coming winter, and maintain the fertility of does that breed in late fall. A drought can result in increased mortality of adults and fawns, lower fertility rates for does, and poor fawn production and survival. Good spring range conditions are important because they provide the first opportunity for mule deer to reverse the energy deficits created by low quality forage and winter weather. Winter can be a difficult time for mule deer; forage quality and availability maybe limited, and does that are carrying developing fetuses are under significant stress. Ideally, mule deer winter range should be free of disturbance and contain abundant, high quality forage. Poor winter range conditions and severe winter weather in the form of deep snow and cold temperatures can result in high mortality, especially among the old and young.

Diet

Mule deer diets are as varied as the landscapes they inhabit. Kufeld et al. (1973) have identified 788 plant species that have been eaten by mule deer; this list includes 202 trees and shrubs, 484 forbs, and 84 grasses, rushes, and sedges. Diets vary by season, age, and sex. Mule deer wintering in the Yakima Subbasin rely heavily on the fall green-up of Sandbergs' bluegrass and cheatgrass to improve body condition for the winter months. Antelope bitterbrush and buckbrush also provide important forage where available.

Reproduction

Mule deer in eastern Washington typically mate between late October and December with the peak of the rut occurring in mid November. Bucks are polygamous. Following a gestation of approximately 203 days, single or twin fawns are born (Zeigler 1978). Mule deer become sexually mature as yearlings. In 1997, a 3-point regulation and nine day season was implemented in an effort to improve post-season buck/doe ratios and increase the number of adult bucks available for breeding. From 1996 to 2002, the post-season ratio of bucks per100 does increased from 2-3 to 13-30 (WDFW 2002).

Migration

Most mule deer summering at high elevation in the Cascades migrate to lower elevations to winter. Some mule deer have been observed to migrate considerable distances (up to 50 miles or 80 km) between summer and winter ranges. Most mule deer in the Yakima Subbasin migrate long distances to winter range. However, those east of the Yakima River are probably resident.

Mortality

Observed deaths of mule deer have resulted from a variety of sources. These include legal hunting, poaching, predation by cougars, bobcats, coyotes, and black bears, disease and parasites, starvation, automobiles, and other accidents (Zeigler 1978).

Harvest

Mule deer are managed using Game Management Units (GMU's) across Washington State. Within the Yakima Subbasin, three GMU's are restricted to permit only. All other units are open during the general modern firearm season for 3-point minimum bucks. The late archery season is open in two GMU's and in the north portions of three others. Three GMU's are open for muzzleloader.

Deer hunter numbers in the Yakima Subbasin in 2002 were at an all time low, down 39 percent from the 10-year average. The severe winter of 1996-97 reduced deer numbers. The 3-point restriction and subsequent low success rate further decreased hunter interest. The deer populations appear to be rebounding, but hunters have not returned to the region.

Harvest has increased since 1997, but remains well below average. Total harvest was 50 percent below the 1991-96 (pre-3 point minimum) average in 2002. Hunter success has been above average the last 2 years (WDFW 2003).

Habitat Requirements

General

Mule deer need the same basic elements for life as other organisms. However, mule deer occupy a variety of cover types across eastern Washington. Consequently, habitat requirements vary with vegetative and landscape components contained within each herd range. Forested habitats provide mule deer with forage as well as snow intercept, thermal, and escape cover. Mule deer occupying mountain-foothill habitats live within a broad range of elevations, climates, and topography, which includes a wide range of vegetation; many of the deer using these habitats are migratory. Mule deer are found in the deep canyon complexes along the major rivers and in the shrub steppe of eastern Washington; native bunch grasses and sagebrush and other shrubs dominate these areas. Mule deer also occupy the margins of agricultural areas, which were formerly shrub steppe.

Status and Abundance Trends

Mule deer and their habitats are being impacted in a negatively by urban and suburban development, road and highway construction, over-grazing by livestock, inappropriate logging operations, competition by other ungulates, drought, fire, over-harvest by hunters, predation, disease and parasites.

Weather

Weather conditions can play a major role in the productivity and abundance of mule deer. Drought conditions can have a severe impact on mule deer because forage does not replenish itself on summer or winter range, and nutritional quality is low. Drought conditions during the summer and fall can result in low fecundity in does, and poor physical condition going into the winter months. Severe winter weather can result in high mortality depending on severity. Severe weather can result in mortality of all age classes, but the young, old, and mature bucks usually sustain the highest mortality. If mule deer are subjected to drought conditions in the summer and fall, followed by a severe winter, the result can be high mortality rates and low productivity the following year.

Habitat

The conversion of shrub steppe habitat to agricultural croplands has resulted in the loss of hundreds of thousands of acres of deer habitat in the Yakima Subbasin Factors that have contributed to the loss and degradation of shrub steppe as discussed within the shrub steppe section have negatively impacted mule deer. Agriculture conversion, overgrazing, too frequent wildfires in shrub steppe, and urbanization have all contributed to mule deer population declines. Fire suppression has resulted in a decline of habitat conditions in the mountain and foothills of the Cascades. Browse species need to be regenerated by fire in order to maintain availability and nutritional value to big game. Lack of fire has allowed many browse species to grow out of reach for mule deer (Leege 1968; 1969; Young and Robinette 1939).

Predation

Cougar predation on mule deer in the mountains could be a major factor contributing to the population decline in that area. Coyote predation on fawns can have a significant impact on the deer population when coyote populations are high, and fawn productivity is low.

Hunter Harvest

The deer harvest by licensed hunters is restricted to bucks with a minimum of three points, while the antlerless harvest is generally regulated by special permit. This system allows for harvesting deer at optimum levels, while preventing over harvest. However, in order to maintain buck survival at management objective, hunting opportunity needs to be strictly regulated.

Population and Distribution

Mule deer are distributed throughout the Yakima River Subbasin, from higher elevations (7000 feet, 1219 meters) in the mountains to the east in the remaining shrub steppe habitats. Current deer populations are probably below the long-term average. Harvest peaked in the early 1990s after seven relatively mild winters. Severe winters in 1992-1993 and 1996-1997 caused the population to fall dramatically. The lack of harvest and mild winters since 1996-1997 should have resulted in a rebound in deer numbers. The 3-point minimum regulation clouds comparison of recent harvest to historic.

Historic Population

Historic population levels are unknown but are generally thought to be higher than current mule deer numbers.

Current Population

No current population estimates are available for the entire Subbasin.

Historic Distribution

Mule deer where generally thought to have occupied most of eastern Washington.

Current Distribution

Mule deer can be found in every county within eastern Washington. They are found in varying abundances across the Subbasin where habitat is suitable (Figure 2-19).

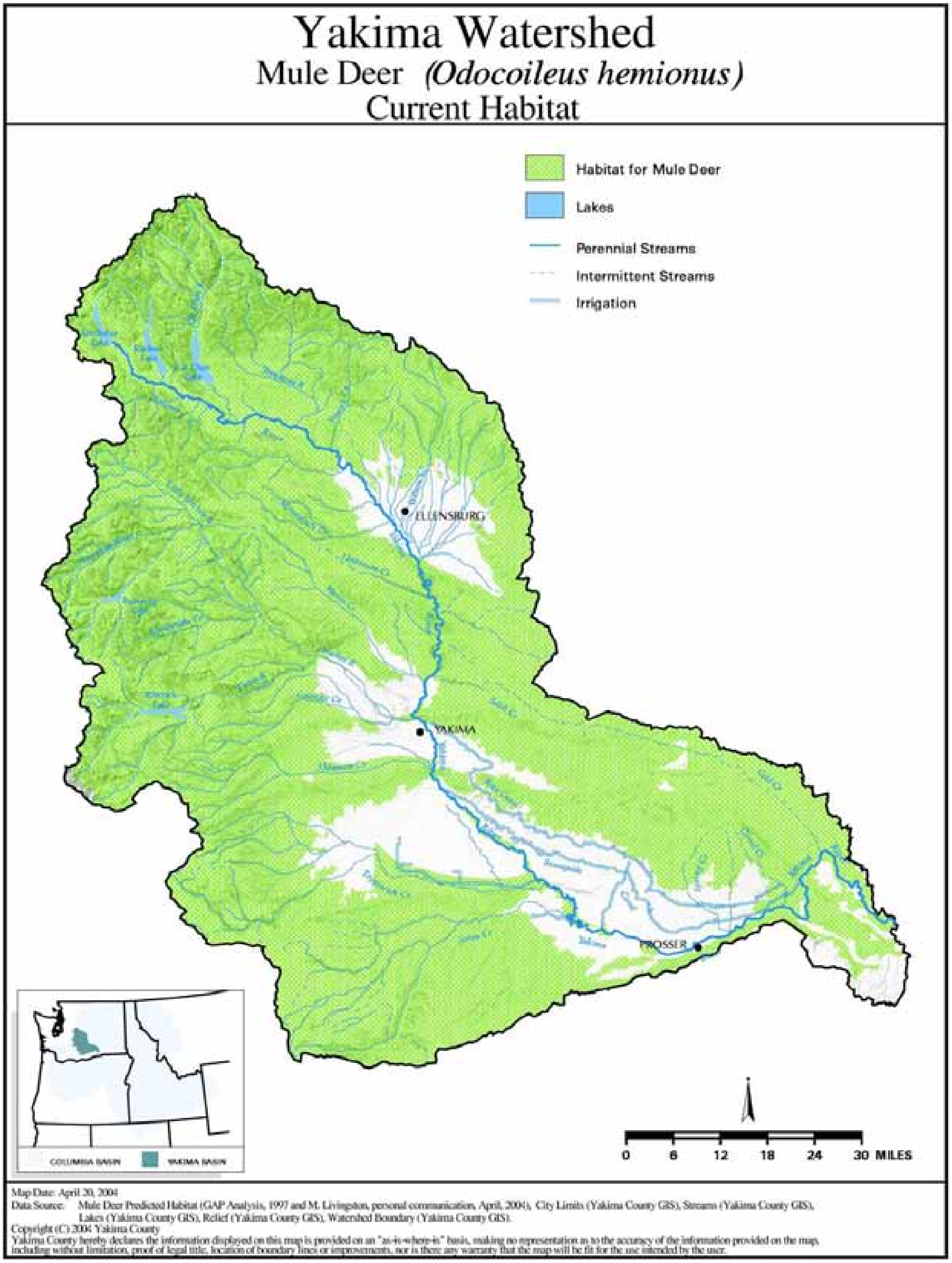


Figure 2-19. Mule deer predicted current habitat within the Yakima Subbasin

4.6.2 Brewer's Sparrow (*Spizella breweri*)

Introduction

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

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

Life History

Diet

Brewer's sparrows forage by gleaning a wide variety of small insects from the foliage and bark of shrubs. Occasionally, seeds are taken from the ground. They will drink free-standing water when available but are physiologically able to derive adequate water from food and oxidative metabolism (Rotenberry et al. 1999). Lepidopterans (butterflies and moths, 90 percent larvae), araneans (spiders), hemipterans (bugs), and homopterans (hoppers, aphids, etc.) make up 72 percent of the nestling diet (Petersen and Best 1986).

Reproduction

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

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

Nesting

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

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

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

Migration

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

Mortality

Nest predators include gopher snake, western rattlesnake, common raven, black-billed magpie, loggerhead shrike, long-tailed weasel, Townsend's ground squirrel, and least chipmunk. Predators of juvenile and adult birds include loggerhead shrike, American kestrel, sharp-shinned and Cooper's hawks (Rotenberry et al. 1999).

Habitat Requirements

General

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

Nesting

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

Breeding

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

The average canopy height is usually < 5 feet (1.5 meters) (Rotenberry et al. 1999). Brewer's sparrow is positively correlated with shrub cover, above-average vegetation height, bare ground, and horizontal habitat heterogeneity (patchiness). They are negatively correlated with grass cover, spiny hopsage, and budsage (Larson and Bock 1986; Rotenberry and Wiens 1980; Wiens 1985; Wiens and Rotenberry 1981). Brewer's sparrows prefer areas dominated by shrubs rather than grass. They prefer sites with high shrub cover and large patch size, but thresholds for these values are not quantified (Knick and Rotenberry 1995). In Montana, preferred sagebrush sites average 13 percent sagebrush cover (Bock and Bock 1987). In eastern Washington, Brewer's sparrow abundance significantly increased on sites as sagebrush cover approached the historic10 percent level (Dobler et al. 1996). Brewer's sparrows are strongly associated throughout their range with high sagebrush vigor (Knopf et al. 1990).

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

Non-breeding

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

Status and Abundance Trends

Status

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

Considered a shrub steppe obligate, the Brewer's sparrow is one of several species closely associated with landscapes dominated by big sagebrush (Rotenberry et al. 1999, Paige and Ritter 1999). Historically, the Brewer's sparrow may have been the most abundant bird in the

Intermountain West (Paige and Ritter 1999) but BBS trend estimates indicate a range-wide population decline during the last twenty-five years (Peterjohn *et al.* 1995). Brewer's sparrows are not currently listed as threatened or endangered on any state or federal list. Oregon-Washington PIF consider the Brewer's sparrow a focal species for conservation strategies for the Columbia Plateau (Altman and Holmes 2000).

Trends

Within the entire Interior Columbia Basin, over 48 percent of watersheds show moderately or strongly declining trends in source habitats for this species (from Altman and Holmes 2000). BBS data for 1966-1996 show significant and strong survey-wide declines averaging -3.7 percent per year (n = 397 survey routes). The BBS data (1966-1996) for the Columbia Plateau are illustrated in Figure 2-20. Significant declines in Brewer's sparrow are evident in California, Colorado, Montana, Nevada, Oregon, and Wyoming, with the steepest significant decline evident in Idaho (-6.0 percent average per year; n = 39). These negative trends appear to be consistent throughout the 30-year survey period. Only Utah shows an apparently stable population. Sample sizes for Washington are too small for an accurate estimate. Mapped BBS data show centers of summer abundance in the Great Basin and Wyoming Basin (Sauer *et al.* 2003).

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

Note that although positively correlated with presence of sage thrashers, probably due to similarities in habitat relations (Wiens and Rotenberry 1981), thrashers are not exhibiting the same steep and widespread declines evident in BBS data (see Sauer *et al.* 2003).

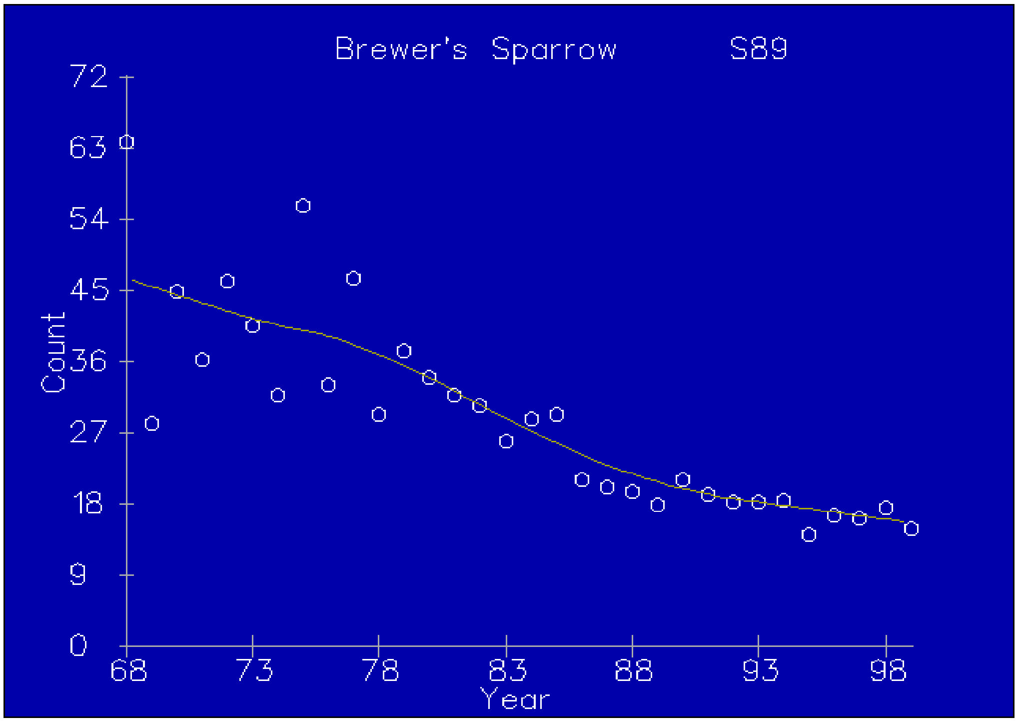


Figure 2-20. Brewer's sparrow trend results for the Columbia Plateau (from BBS data) (Sauer et al. 2003)

Factors Affecting Brewer's Sparrow Population Status

Habitat Loss and Fragmentation

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

Grazing

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

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

Invasive Grasses

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

Fire

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

Brood Parasitism

Brewer’s sparrow nests are an occasional host for brown-headed cowbird; nests are usually abandoned, resulting in loss of clutch (Rotenberry et al. 1999). Prior to European-American settlement, Brewer’s sparrows were probably largely isolated from cowbird parasitism, but are now vulnerable as cowbird populations increase throughout the West and where the presence of livestock and pastures, land conversion to agriculture, and fragmentation of shrublands creates a contact zone between the species (Rich 1978, Rothstein 1994). Frequency of parasitism varies geographically; the extent of impact on productivity is unknown (Rotenberry et al. 1999). In Alberta, in patchy sagebrush habitat interspersed with pastures and riparian habitats, a high rate of brood parasitism is reported. Usually abandoned parasitized nests and cowbird productivity was lower than Brewer's (Biermann et al. 1987). Rich (1978) also observed cowbird parasitism on two nests in Idaho, both of which were abandoned.

Predators

Nest predation is a significant cause of nest failure. Documented nest predators (of eggs and nestlings) include gopher snake, Townsend's ground squirrel; other suspected predators include loggerhead shrike, common raven, black-billed magpie, long-tailed weasel, least chipmunk, western rattlesnake, and other snake species. American kestrel, prairie falcon, coachwhip reported preying on adults (Rotenberry *et al.* 1999). Wiens and Rotenberry (1981) observed significant negative correlation between loggerhead shrike and Brewer's sparrow density.

Pesticides/Herbicides

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

Population and Distribution

Historic Population

No data are available.

Current Population

Brewer's sparrows can be abundant in sagebrush habitat and will breed in high densities (Great Basin and Pacific slopes), but densities may vary greatly from year to year (Rotenberry *et al.* 1999). Dobler *et al.* (1996) reported densities of 50-80 individuals/km^2 in eastern Washington. In the Great Basin, density usually ranged from 150-300/km^2, sometimes exceeding 500/km^2 (Rotenberry and Wiens 1989). Brewer's sparrow breeding density ranges from 0.08 to 0.10 individuals/ha in shadscale habitat in eastern Nevada (Medin 1990). Breeding territory usually averages between 0.6-1.25 hectares and will contract as densities of breeding birds increase (Wiens *et al.* 1985). In southeastern Oregon, densities have ranged from 150-300 birds/km^2 (390-780/mi^2), but can exceed 500/km^2 (Wiens and Rotenberry 1981, Rotenberry and Wiens 1989). Keaney et al. (1996) found that Brewer's sparrows were among the highest in abundance in high elevation sagebrush habitat on the YTC; they were only second to western meadowlarks in abundance in high elevation drainage habitat on YTC. Stepniewski (1999) described Brewer's sparrow as being very common on the north slopes of Yakima, Umtanum, and Horse Heaven Ridges.

Historic Distribution

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

Undoubtedly, the Brewer's sparrow was widely distributed throughout the lowlands of south central Washington when it consisted of vast expanses of shrubsteppe habitat. Large-scale conversion of shrubsteppe habitat to agriculture has resulted in populations becoming localized in the last vestiges of available habitat (Smith *et al.* 1997).

Current Distribution

Washington is near the northwestern limit of breeding range for Brewer's sparrows. Birds occur primarily in Okanogan, Douglas, Grant, Lincoln, Kittitas, Yakima, Benton and Adams counties Figure 2-21). Brewer's sparrows are still common within the subbasin on the YTC, Yakama Reservation, Hanford Reach National Monument, and other places where healthy sagebrush and bunchgrass communities remain (Figure 2-22).

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

Breeding Range

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

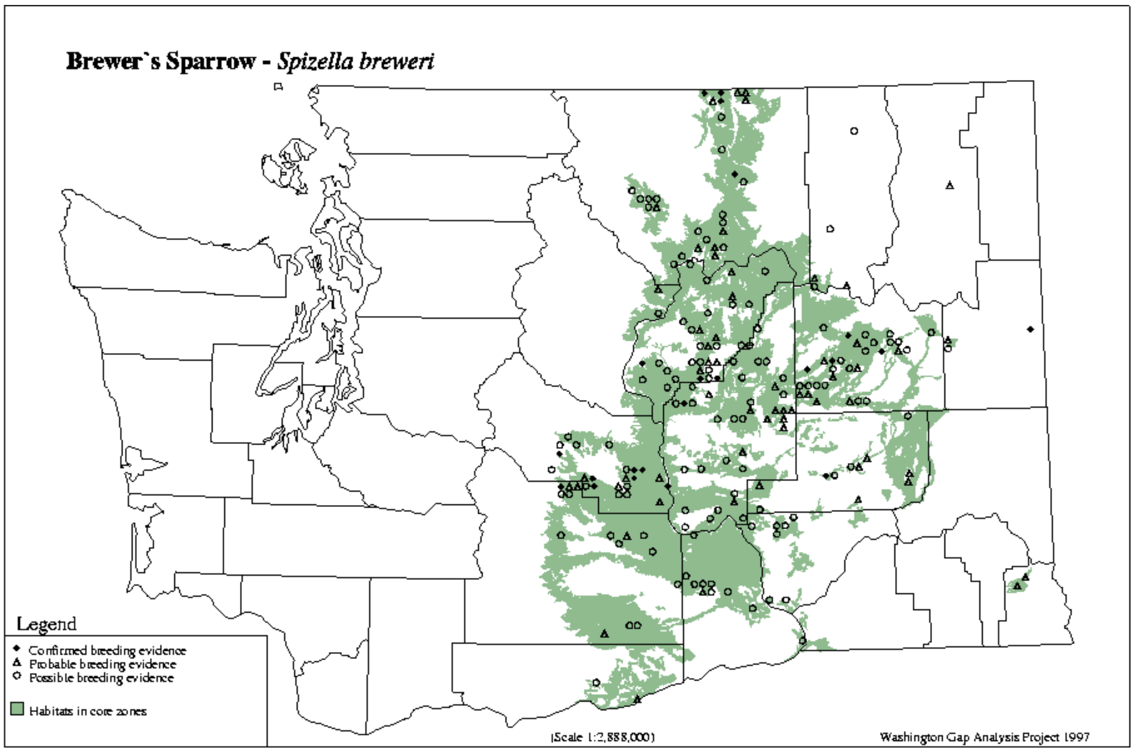


Figure 2-21. Brewer's sparrow breeding range and distribution in Washington (Smith et al 1997)

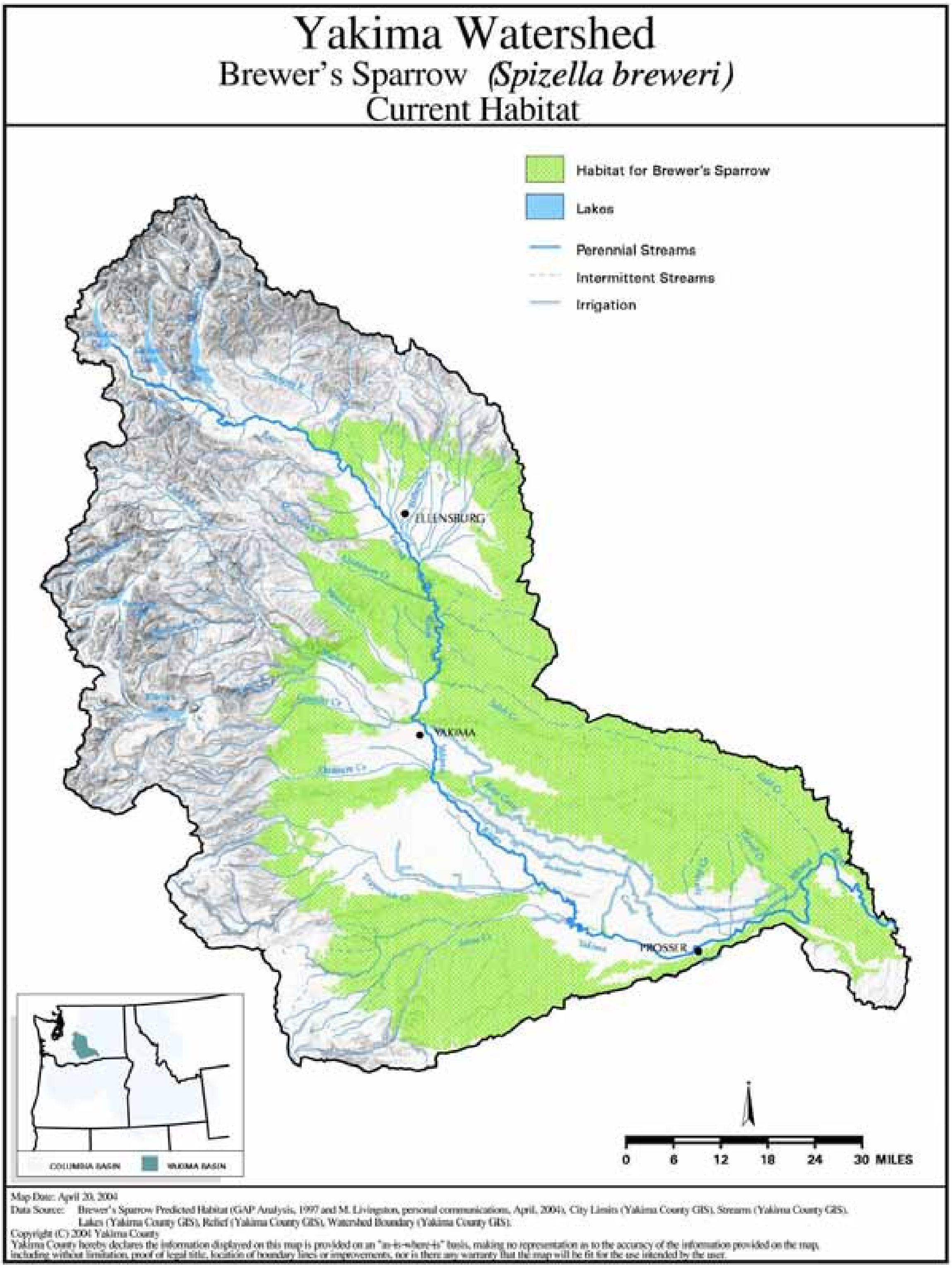


Figure 2-22. Brewer's sparrow predicted current habitat within the Yakima Subbasin

Non-breeding Range

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

Out-of-Subbasin Effects and Assumptions

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

4.6.3 Greater Sage-Grouse (Centrocercus urophasianus)

Introduction

The greater sage-grouse (sage grouse) was selected as a focal species for the shrub steppe focal habitat for several reasons. Specific selection criteria are listed in Table 2-3. Generally, this species is an excellent umbrella species (Rich and Altman 2002). It uses numerous vegetation associations (cover types) within the shrub steppe community (Crawford et al. 2004). For example, in fall and winter sage grouse utilize areas dominated by sagebrush (*Artemesia sp.).* In spring, they use areas with abundant sagebrush of varying heights along with native bunch grasses and forbs. As the summer progresses and the plant communities desiccate at lower elevations, sage grouse seek out wet meadows and/or plant communities at higher elevations. This species therefore requires a native landscape diverse in floral structure and composition. It is assumed that many other shrub steppe obligates will be found where a viable sage grouse population exists.

Life History

Diet

The tips of sagebrush leaves dominate the diet during late fall, winter, and early spring (Remington and Braun 1985, Schroeder et al. 1999). Studies have documented the preference for big sagebrush over other species of sagebrush during winter (Welch et al. 1991). Moreover, preference has been documented for Wyoming big sagebrush over mountain big sagebrush (A. t. vaseyana) (Remington and Braun 1985). Of the sage species determined to be preferred in other states (Wallestad et al. 1975, Remington and Braun 1985, Welch et al. 1988, 1991), only Wyoming big sagebrush is common in Washington. Hoffman (1991) identified, through fecal analysis, Artemisia sp. as a key food item on the Army's Yakima Training Center, but did not differentiate between species or subspecies. It is likely that Wyoming big sage was the subspecies in the fecal samples given its dominance on YTC.

Grasshoppers (Orthoptera), beetles (Coleoptera), ants (Hymenoptera), and other insects are consumed, especially by juveniles less than three weeks of age, in the spring and summer. Adults and aging juveniles forage on forbs and sagebrush (Schroeder et al. 1999). Forbs are especially important to pre-egg laying hens (Barnett and Crawford 1994). Forbs preferred by sage grouse in other states (Klebenow and Gray 1968, Drut et al. 1994) and have been documented in sage grouse use areas on YTC include desert parsley (*Lomatium sp*.), common yarrow (*Achillea millefolium*), mountain dandelion (*Agoseris sp.),* hawksbeard (*Crepis sp.),* fleabane daisy (*Erigeron sp.),* prickly lettuce (*Lactuca serriola*), common dandelion (*Taraxacum officinale*), yellow salsify (*Tragopogon dubius*), *Astragalus sp.*, microsteris (*Microsteris gracilis*), Phlox sp., and Thompson's paintbrush (*Castilleja thompsonii*) (Sveum et al. 1998b, M. Livingston, unpublished data).

Reproduction

Sage grouse use a lek mating system in which the males do not provide food or help during the rearing of young. In the spring the males gather at display sites (i.e., leks) to compete with each other for the opportunity to breed with females. Very few males breed with the majority of females (Gibson et al. 1991). Research has shown that as few as two dominant males have obtained between 54 percent and 86 percent of all copulations on a lek (Schroeder et al. 1999). In Washington, male lek attendance generally begins in February and continues through April. Female attendance at leks to breed with males tends to be concentrated during a brief few days each year. On the YTC, this period generally occurs in mid-March.

Nesting

Hens that lose their first nest and/or eggs early in the season often rebreed and/or renest a second time (Hanf et al. 1994, Gregg et al. 1994, Sveum 1996, Schroeder 1997). Average clutch size for three studies in Washington was 6.2 (M. Livingston, unpublished data), 6.6 (Sveum 1996), and 9.1 (Schroeder 1997). Chicks hatch between 6 - 7 weeks after females copulate (Patterson 1952). In 1999 on the YTC, the median hatch date for successful hens was 9 May and ranged between 28 April and 19 May (M. Livingston, unpublished data). Eggs are laid within a nest bowl, which is dug or scratched typically below a sagebrush shrub just before egg laying (Schroeder et al. 1999).

Migration

Some populations migrate others do not. The YTC sage grouse population as a whole does not display seasonal migrations. In contrast, sage grouse in Grant and Douglas Counties nest in remnant patches of shrub steppe and in lands enrolled in the federal Conservation Reserve Program (CRP). These preferred nesting cover types are surrounded by dryland wheat fields. In the winter, this population largely migrates from the wheat country to the dry coulees of the Columbia Basin. Sagebrush in these areas is dense and provides sufficient forage and cover for wintering sage grouse (M. Schroeder, WDFW, pers. comm.).

Mortality

Few studies have been conducted on life span and causes of mortality. Sage grouse mortality is possibly highest among adult males during lek attendance, for females during nesting, and for all age classes in winter. Golden eagles (Aquila chrysaetos) harass and can kill male sage grouse at leks. Ferruginous hawks, red-tailed hawks, gyrfalcons, northern goshawks, Cooper's hawks, coyotes, red foxes, and bobcats have been observed killing and/or eating sage grouse; nest predators include small mammals, badgers, and corvids (Schroeder et al. 1999).

Harvest

Hunting in Washington was first closed from 1933 through 1949 in response to population declines (Schroeder et al. 2000). The sage grouse hunting season was again closed and remains so since 1988. The one bird daily bag limit during the period of 1950 through 1987 (WDFW 1995) displays the long-term nature of these declines. Total harvest from 1950 through 1969 averaged 2,016 birds annually (WDFW 1995). Approximately 900 sage grouse were harvested annually during the period 1967 through 1972 in Yakima, Benton, and Kittitas Counties (Hays et al. 1998).

Habitat Requirements

Sage grouse habitat requirements can be broadly divided into four categories; 1) breeding (lek sites), 2) nesting and early brood rearing, 3) late summer and fall, and 4) winter.

Breeding.

Lek sites are typically located on flat areas with minimum cover. On YTC, leks are located on tertiary roads, low-lying ridge tops where shallow soils predominate, and burned areas. In northern Washington, leks occasionally are in wheat fields. Escape cover in the form of sagebrush areas and draws with heavy cover are usually nearby. Lek areas are not limited on the landscape. It appears that males select lek sites within suitable nest areas, because females select nest sites independent of lek sites (Bradbury et al. 1989).

Nesting and Early Brood Rearing

Sage grouse nesting and early brood rearing habitats are similar in structure and composition. Hens typically build their nests under a sagebrush shrub (Wallestad and Pyrah 1974, Connelly et al. 1991, Gregg et al. 1994, Sveum 1998a). On YTC and elsewhere, successful nests have been found under other shrub and non-shrub species including three-tip sagebrush, rabbitbrush, and basin wildrye (Klebenow 1969, Connelly et al. 1991, Sveum 1995, M. Livingston, unpublished data). Height of shrubs selected for nest placement range from 29 to 80 cm and tends to be the tallest shrub within a stand (Connelly et al. 2000). Shrub cover around nests tends to be greater at successful nests than at unsuccessful nests. Connelly et al. (2000) recommended maintaining 15-25 percent canopy cover of sagebrush, perennial herbaceous cover averaging ≥ 18 cm in height with ≥ 15 percent canopy cover for grasses and ≥ 10 percent for forbs and a diversity of forbs. On YTC, primary vegetation cover types selected for nesting and raising young include an overstory of big sagebrush and/or three-tip sagebrush and an understory of bunchgrasses including bluebunch wheatgrass, Idaho fescue and Sandberg’s bluegrass (Sveum et al. 1998a and 1998b).

Late Summer and Fall

Habitat for males, females and broods is generally similar in structure and composition during late summer and fall. Vegetation begins to desiccate at lower elevations and in uplands as the summer progresses. Sage grouse shift their habitat use to higher elevation and more mesic (e.g., around seeps and springs) or wet meadow areas in response (Klebenow 1969, Peterson 1970, Wallestad 1971). Sagebrush cover in sage grouse use areas varies more so during this period than any other in the year and is less important compared to forb cover (Connelly et al. 2000).

Winter

Few studies of winter habitat use have been conducted for sage grouse. Hupp and Braun (1989) reported that when snow depths were ≥30 cm sage grouse became more restricted in their habitat selection. During the 1999 winter on YTC before snowfall, sage grouse used areas with less Wyoming big sagebrush cover and shorter height than appeared to be available at random locations (M. Livingston, unpublished data). After snowfall, the use of areas with Wyoming big sagebrush increased, while the use of areas with three-tip sagebrush decreased. The height and cover of shrubs increased at use patches after snowfall. In addition, sage grouse used areas with varied aspects when snow was absent, but ceased using north aspects after snowfall. Connelly et al. (2000) recommended the following for winter habitat management; maintain sagebrush stands with canopy cover of 10 - 30 percent and heights at least 25 – 35 cm above snow cover. Winter areas should be managed at the landscape scale and should be given high priority for fire suppression.

Status and Abundance Trends

Factors Affecting Population Status

Factors that have contributed to loss and degradation of sage grouse habitat are very similar to those discussed for shrub steppe (section 4.5.4). Sage grouse declines have largely resulted from habitat loss due to agriculture, degradation of habitat quality associated with livestock management (Dobler et al. 1996, Hays et al. 1998), and more recently, large-scale wildfires. The single most contributing factor to habitat loss was probably cultivation of native shrub steppe communities (WDFW 1995, Dobler et al. 1996). Cultivation impacted vast acreage during the 1800's and 1900's. Dryland wheat farming was responsible for loss of millions of acres. Many remaining shrub steppe areas in the basin were cultivated for irrigated crops after the Yakima River Irrigation projects were completed. Recently, the Washington DNR has been leasing scattered shrub steppe parcels for conversion to Irrigated crops. This action not only results in a net loss of habitat, but also eliminates key linkages between larger publicly owned shrub steppe properties.

Second in importance, and possibly more relevant today, is the degradation of existing habitat. Overgrazing, military training, and wildfires contribute to degradation of shrub steppe quality on remaining lands. Monitoring in sage grouse areas indicates that habitat quality has improved since livestock grazing on the YTC was eliminated in 1995. However, cross-country maneuvers with military vehicles continue to decrease habitat quality through sagebrush mortality (Cadwell et al. 1996, Stephan et al. 1996) and disturbance to understory communities (Cadwell et al. 2001). Training ignited wildfires are a significant threat and could potentially degrade large portions of existing occupied habitat. The military restricts training in many core sage grouse areas, and implements aggressive fire prevention and fighting techniques.

Urban and suburban sprawl is contributing to the loss of habitat connectivity. Expansion of development in the Cowiche area west of the city of Yakima is decreasing the likelihood of connecting habitat on the Yakama Reservation with that on WDFW wildlife areas and the YTC. Similarly, development in the Moxee Valley east of the city of Yakima is decreasing the likelihood of sage grouse expansion south of YTC. The Tri-Cities, on the eastern edge of the subbasin, have experienced significant suburban expansion in the last decade. Sage grouse have been extirpated from the area for a number of years. However, as the suburban area expands shrub steppe areas on the edge, such as the Horse Heaven Hills, are being permanently lost. These areas will not be able to function as corridors for migrating wildlife.

Loss of genetic diversity may be contributing to sage grouse population declines in the state. Fewer individuals are contributing to the gene pool as the two remaining populations have become isolated from each other and peripheral populations have been extirpated. Given current information, it is assumed that interbreeding between the Douglas/Grant and YTC populations does not occur. Lack of suitable habitat and major obstacles presented by Interstate Highways 90 to the north and 82 to the west are possibly the reasons sage grouse do not occupy more land surrounding YTC. Isolation and declining trends have heightened the concern for a population bottleneck further developing. Recent genetic work by Benedict et al. (2003) has indicated that both populations have experienced similar loss of genetic diversity. This is especially true for the YTC population where only 1 of 38 haplotypes identified was present. The Douglas/Grant population had 3 of 38 haplotypes present. Habitat loss, fragmentation, and degradation on lands surrounding YTC will decrease the likelihood of connecting this population with the Douglas/Grant population. Similarly, opportunities for expanding the YTC population beyond the installation boundaries onto lands such as the Hanford Reach National Monument will be lost if key parcels are not protected. The proposed Black Rock Reservoir, at the boundaries of Yakima and Benton Counties, poses a potential obstacle to accomplishing this conservation objective.

Population and Distribution

The distribution of sage grouse has dramatically decreased across its range. Historically they occurred in 16 western states and 3 Canadian provinces (Aldrich 1963, Schroeder et al. 1999). They have been extirpated from British Columbia, Arizona, New Mexico, Oklahoma, Kansas, and Nebraska (Connelly and Braun 1977, Braun 1998, Schroeder et al. 1999). They historically occupied 57,741 km^2 within 16 counties in eastern Washington (Schroeder et al. 2000). Today they are restricted to two relatively isolated populations roughly separated by 50 km; one in Douglas and Grant Counties and the other in Yakima and Kittitas Counties (Schroeder et al. 2000) (Figure 2-23). The Yakima/Kittitas population resides on the Army's Yakima Training Center (Figure 2-24 and Figure 2-25). Within the Yakima Subbasin, the last known active lek in Benton County was in 1991 on the FEALE reserve, currently managed by the USFWS as part of the Hanford Reach National Monument (HRNM). Wildfires during the 1980's that eliminated sagebrush are likely responsible for sage grouse extirpation from this property (Hays et al. 1998). Extirpation of other local populations occurred on the Yakama Reservation (YR), and WDFW's Wenas, LT Murray, and Quilomene Wildlife Areas during the 1960's, 1970's, and 1980's (L. Stream, WDFW, pers. comm).

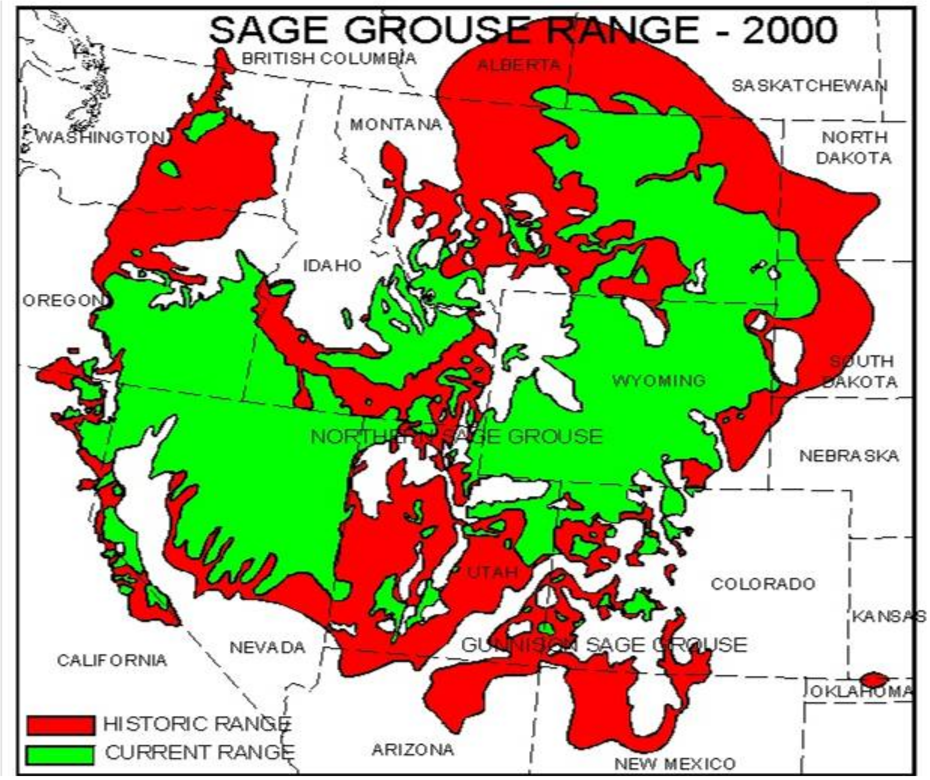


Figure 2-23. Greater gage grouse historic and current range

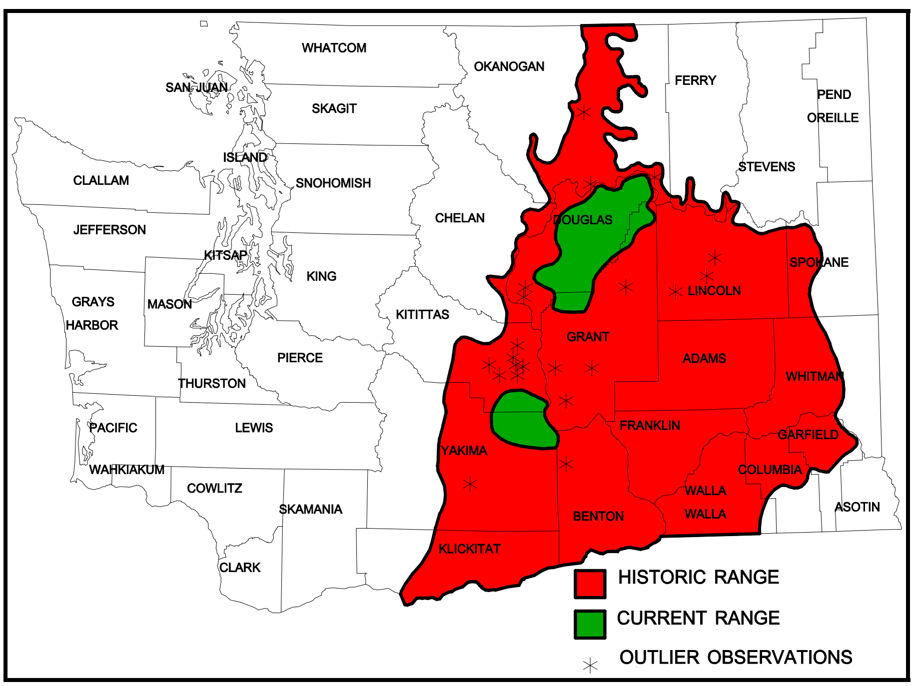


Figure 2-24. Greater sage grouse historic and current range in Washington

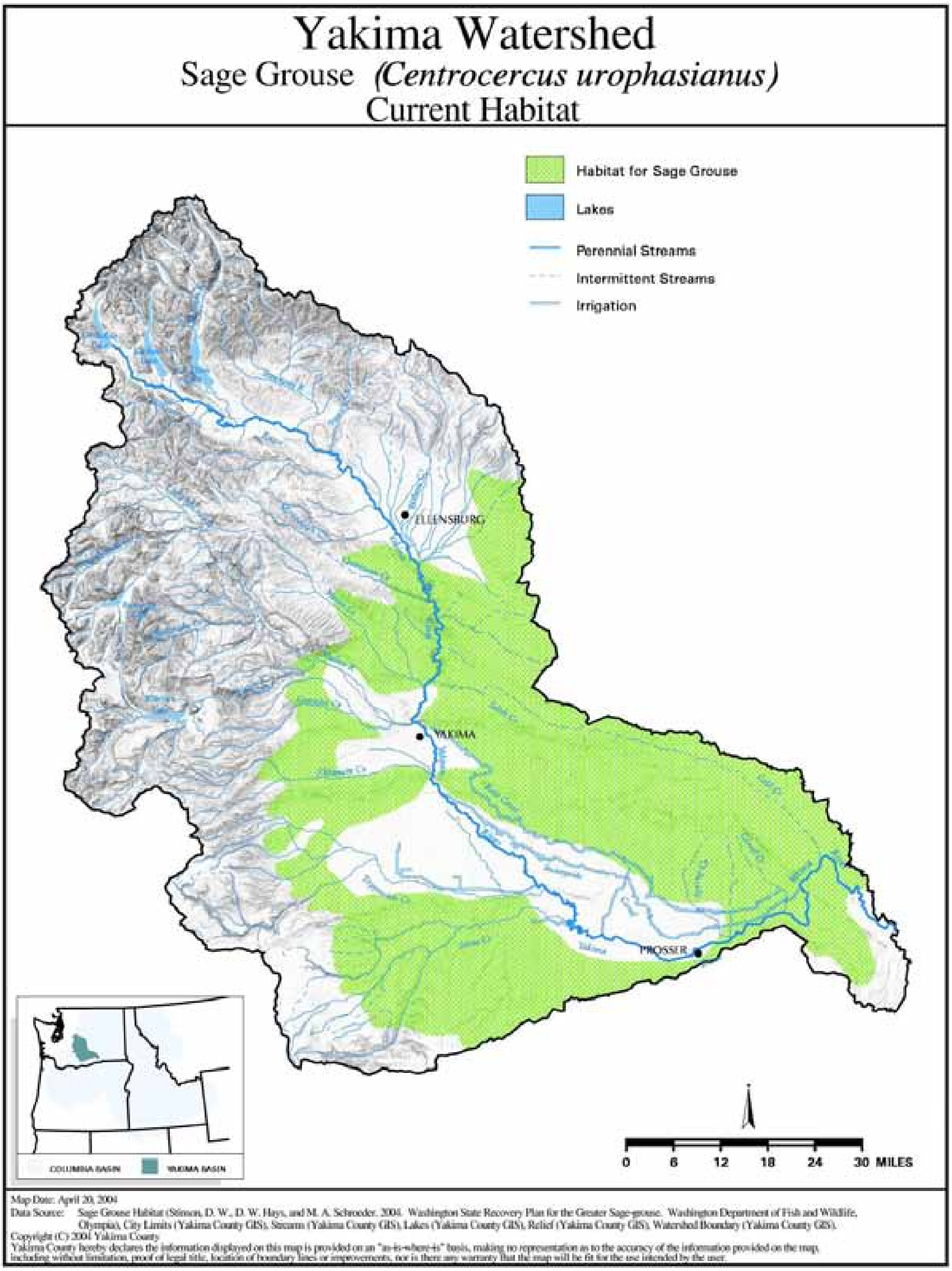


Figure 2-25. Greater sage grouse predicted current habitat in the Yakima Subbasin

Population trends have followed a similar pattern as distribution. Given the significant range contraction within Washington, population declines since European settlement likely approach 95 percent (Schroeder et al. 2000). However, incomplete data prior to 1960 prevent solid estimates. The earliest reliable estimates of past abundance are 4,682 in 1960 (Schroeder et al. 2000). In 2003, the population was estimated to be 1,009; 627 in Douglas and Grant Counties (M. Schroeder, unpublished data) and 382 on YTC (US Army 2003); representing a 78 percent decline since 1960.

Out-of-Subbasin Effects and Assumptions

The YTC sage grouse population inhabits portions of the Yakima Subbasin, the Columbia Lower Middle Subbasin, and the Columbia Upper Middle Subbasin. Factors that negatively affect shrub steppe in anyone of these subbasins will likely impact this population. Wildfires in shrub steppe often burn over the top of ridges. So fires ignited in one subbasin can easily affect another.

4.6.4 Key Findings of Shrub Steppe/Interior Grasslands Habitat and Focal Species

- Fragmentation of shrub steppe has led to isolated wildlife populations, species extirpations, and reduced viability
- Sage Grouse population viability is threatened
- Sagebrush and other shrubs have been eliminated over large acreages of remaining shrub steppe
- Cheatgrass and other invasive species have been given a competitive advantage
- Native plant diversity has been reduced
- The viability of existing shrub steppe is threatened
- Microbiotic crust is reduced across the landscape

4.7 Interior Riparian Wetlands

4.7.1 Historic

Since the arrival of settlers in the early 1800's, 50 to 90 percent of riparian wetland habitat in Washington State has been lost or extensively modified (Buss 1965). Prior to 1850, riparian habitats were found at all elevations and on all stream gradients; they were the lifeblood for most wildlife species with up to 80 percent of all wildlife species dependent upon these areas at some time in their lifecycle (Thomas 1979).

These habitats are strongly influenced by stream dynamics and hydrology. The normative hydrologic conditions which supported the historic riparian wetland habitats in the Yakima Subbasin are discussed in chapter 1. Riparian forests require various flooding regimes and specific substrate conditions for reestablishment. Annual flood cycles occurred in most riparian wetland areas, although flood regimes varied among stream types. Hyporheic hydrology supported riparian wetland conditions considerable distances from perennial creek and river channels. Upwelling and down-welling groundwater dynamics created thermal conditions in wetland and spring brook areas conducive to wildlife use throughout the seasons. Fire typically influenced habitat structure in most areas, but was nearly absent in colder regions or on topographically protected streams. River meander patterns, ice and log jams, sediment dynamics and flood debris deposits provided spatial and temporal changes in habitat condition. Abundant beaver activity cropped younger cottonwoods and willows, damming side channels. This activity influenced the vegetative, sediment, hyporheic and surface water dynamics creating diverse and complex habitat interactions.

In the Yakima Subbasin, the density and diversity of wildlife in riparian wetland areas is also high relative to other habitat types (Figure 2-26). Riparian forest habitats are critical to the structure and function of rivers and to the fish and wildlife populations dependent upon them (Rood and Mahoney 1990). Healthy forested riparian wetland habitat has an abundance of snags and downed logs that are critical to many cavity nesting birds, mammals, reptiles and amphibians. Cottonwood, alder and willow are commonly dominant tree species in riparian wetland areas from the Cascades down through the valley portion of the subbasin. This habitat is often characterized by relatively dense understory and overstory vegetation. Riparian wetland habitats also function as travel corridors between, and provide connectivity to, other essential habitats (e.g., breeding, feeding, seasonal ranges).

Though riparian wetland habitats are often forested, they also contain important sub-components such as marshes and ponds that provide critical habitat for a number of wildlife species. Broad floodplain mosaics consisting of cottonwood gallery forests, shrub lands, marshes, side channels, and upland grass areas contain diverse wildlife assemblages. The importance of riparian wetland habitats is increased when adjacent habitats are of sufficient quality and quantity to provide cover for nesting, roosting, and foraging. In the Lower Yakima Valley, Larsen (1999) found higher mallard brood survival in wetlands associated with floodplain areas than those located outside of floodplains.

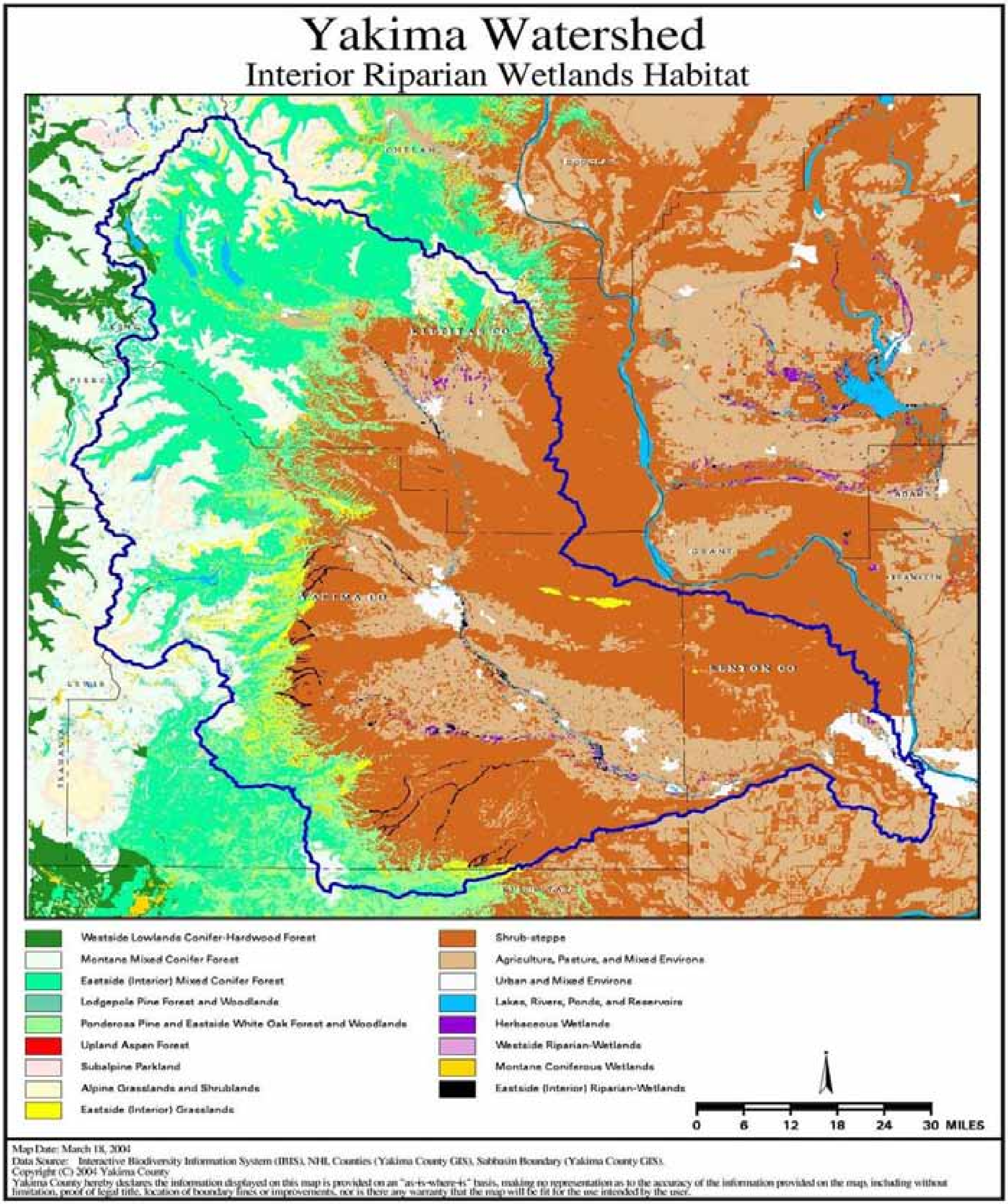


Figure 2-26. Current interior riparian habitat as described (IBIS 2003)

Riparian vegetation was restricted in the arid Intermountain West, but was nonetheless diverse. It was characterized by a mosaic of plant communities occurring at irregular intervals along streams and dominated singularly or in some combination by marshes, side channels, grass-forb associations, shrub thickets, and mature forests with tall deciduous trees. Common shrubs and trees in riparian zones included several species of willows, red-osier dogwood, alder, Wood's rose, snowberry, currant, black cottonwood, water birch, aspen, and peachleaf willow. Herbaceous understories were very diverse, but typically included several species of sedges along with many dicot species. Marsh habitats contained tule, cattail, burreed, wapato, water plantain, many species of submersed macrophytes (including sago, coontail, and bladderwort), yellow water lily, and water cress. Lower elevation wet meadows contained much of the vegetation found in their montane counterparts; including sedges, smartweeds, spike rushes, camas, and wild onion. Floodplain grasslands were dominated by Great Basin wild rye, greasewood, and dogbane.

Riparian areas have been extensively impacted within the Columbia Plateau such that undisturbed riparian systems are rare (Knutson and Naef 1997). In the Yakima Subbasin, altered flow regimes along with other effects discussed below have lead to severe reductions in alluvial floodplains, channel simplification and impared ecosystem function (Ring and Watson 1999). Losses in lower elevations include large areas once dominated by cottonwoods that contributed considerable structure to riparian habitats. In higher elevations, stream degradation occurred with the trapping of beaver in the early 1800s, which began the gradual unraveling of stream function that was greatly accelerated with the introduction of livestock grazing. Woody vegetation has been extensively suppressed by grazing in some areas, many of which continue to be grazed. Herbaceous vegetation has also been highly altered with the introduction of Kentucky bluegrass that has spread to many riparian areas, forming a sod at the exclusion of other herbaceous species. The implications of riparian area degradation and alteration are wide ranging for bird populations, which utilize these habitats for nesting, foraging and resting. Secondary effects that have affected insect fauna have reduced or altered potential foods for birds as well.

Historic wetland acreage in the Yakima Subbasin is difficult to measure. The IBIS riparian habitat data are incomplete; therefore riparian floodplain habitats are not well represented on IBIS maps. These sources point to extensive riparian wetland complexes in the Kittitas Valley and Lower Yakima Basin between Union Gap and Prosser. Using hydrologic and landscape information, Eitemiller et al. (2000) estimated the extent of Holocene floodplain acreage in several mainstem and tributary Yakima River reaches; the Easton – 2,679 ha, Cle Elum - 1,750 ha, Kittitas – 5,420 ha, Selah – 1,182 ha, Naches – 3,310 ha, Union Gap – 2,325 ha, and Upper Wapato – 24,854 ha. This analysis showed that the Wapato floodplain was by far the most extensive. This is also illustrated by a map of the Wapato alluvial reach developed in 1909 (during irrigation development) by the Indian Irrigation Service (Figure 2-27). (The tributary entering from the left is Toppenish Creek.) Tributaries with extensive historic riparian wetland habitats included the Teanaway and Naches Rivers, Ahtanum, Toppenish and Satus Creeks. Localized riparian wetland information, including historic and current hydrographs, is provided in more detail in the Assessment Unit descriptions provided in the fisheries assessment of this chapter.

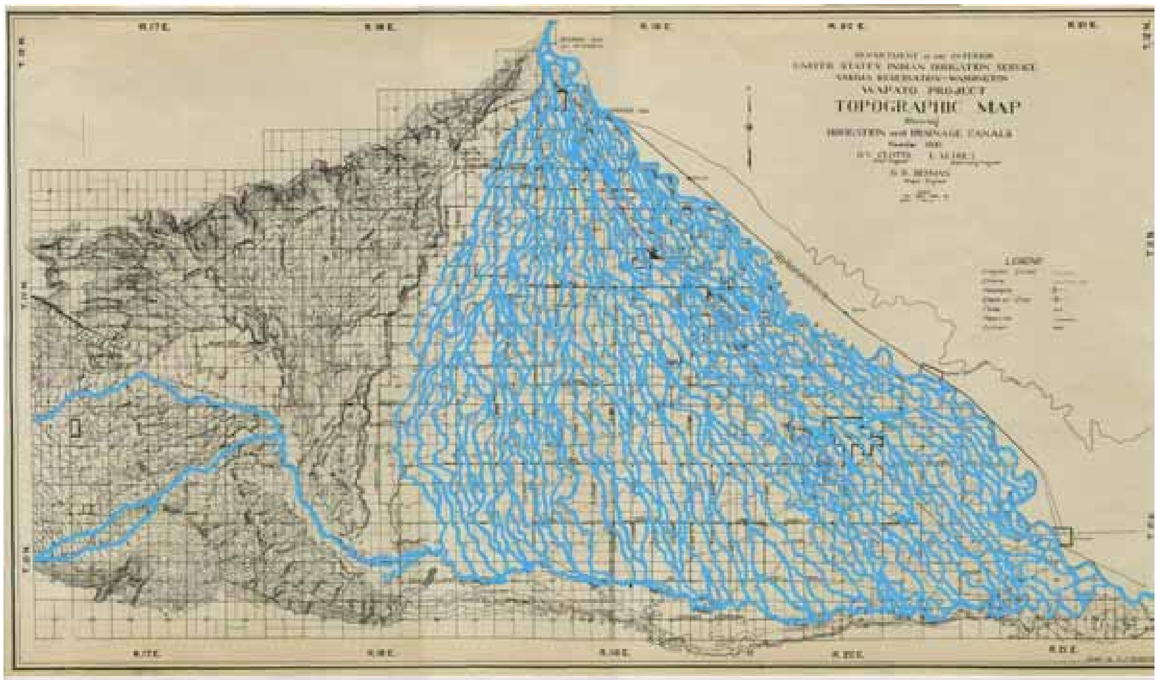


Figure 2-27. Wapato alluvial reach in 1909 (Indian Irrigation Service:USBR Yakima Project)

4.7.2 Current

Quigley and Arbelbide (1997) concluded that the cottonwood-willow cover type covers significantly less in area now than before 1900 in the Inland Pacific Northwest. The authors concluded that although riparian shrub land occupied only 2 percent of the landscape, they estimated it to have declined to 0.5 percent of the landscape.

Approximately 40 percent of riparian shrublands occurred above 3,280 ft. in elevation pre-1900; now nearly 80 percent is found above that elevation. In the Yakima Subbasin, Braatne and Jamieson (2001) documented declines in cottonwood recruitment related to alterations in the natural flow regimes. They conclude that prescribed flow regimes, such as those used in Alberta and Nevada (Mahoney and Rood 1998), could be very cost-effective mechanisms for addressing the needs of cottonwood recruitment in the Yakima Subbasin.

Riparian and wetland conditions in the Yakima Subbasin range from severely degraded to high quality depending on the level of impact by activities such as hydrologic alteration, land use conversion, agricultural practices, and grazing. Levee and urban development projects have constricted floodplains throughout the subbasin and reduced riparian wetland habitats. Natural stream side-channels and distributaries have been converted to canals and drains. Timing of flow in these channels has been highly altered, causing loss of natural function. Hydrologic alteration has caused loss of native vegetation and replacement by non-native species. The long history of intensive year-around livestock grazing results in extensive damage to many riparian plant communities throughout the shrub steppe and valley portions of the subbasin. Riparian habitats are degraded along Toppenish and Satus Creeks because of levee development, channelization and excessive livestock grazing. Lacking vegetation to slow water run-off and to reduce stream velocity, Roza Creek's stream channel has incised as much as 20 feet in places. Irrigation canals, drains, and rights-of-way act as conduits delivering noxious weeds such as purple loosestrife to riparian wetland habitats.

Within the past 100 years, a large amount of Yakima Subbasin riparian wetland habitat has been altered, degraded, or destroyed (Figure 2-3). As in other areas of the Columbia Basin, impacts have been greatest at low elevations and in valleys where reservoir development, agricultural conversion, levee and road development, altered stream channel morphology, and water withdrawal have played significant roles in changing the character of streams and associated riparian areas. Eitemiller et al. (2000) and Braatne and Jamieson (2001) estimated floodplain losses of 77 percent in the Cle Elum Reach, 82 percent in the Union Gap Reach, and 95 percent in the Upper Wapato Reach. Hauer et al. (2002) described hydrologic processes, floodplain complexity and ecological interactions related to riparian wetland abundance and health in the Yakima Subbasin. They recognized significant potentials for riparian wetland restoration in all reaches of the Yakima Subbasin. They identified the Wapato and Union Gap reaches, respectively, as being the most complex and physically intact, and as being the most restorable.

Stresses

Natural systems evolve and become adapted to a particular rate of natural disturbances over long periods. Land uses alter stream channel processes and disturbance regimes that affect aquatic and riparian habitat (Montgomery and Buffington 1993). Anthropogenic-induced disturbances are often of greater magnitude and/or frequency compared to natural disturbances. These higher rates may reduce the ability of riparian and stream systems and the fish and wildlife populations to sustain themselves at the same productive level as in areas with natural rates of disturbance.

Other characteristics also make riparian wetland habitats vulnerable to degradation by human-induced disturbances. Their small size, topographic location, and linear shape make them prone to disturbances when adjacent uplands are altered. The unique microclimate of riparian and associated aquatic areas supports some vegetation, fish, and wildlife that have relatively narrow environmental tolerances. This microclimate is easily affected by vegetation removal within or adjacent to the riparian area, thereby changing the habitat suitability for sensitive species (Thomas *et al.* 1979, O'Connell *et al.* 1993).

Factors affecting riparian wetlands in the Yakima Subbasin are summarized in the paragraphs below and in Table 2-7 at the end of the stresses section. Riparian wetland habitat conditions throughout the subbasin have been influenced by one or all of these factors in different ways depending on their location. Restoration plans for these habitats must take in to consideration the location of the habitats, the historic conditions under which they operated, the alterations which have occurred to impact their function, and the possibilities which currently exist to adequately address the stresses in a cost-effective manner. Many of the stress mechanisms outlined below were adapted from those identified by Hauer et al. (2002) in their long-term ecological and geomorphic studies relating to normative flow conditions in the Yakima Subbasin.

Alteration of the Hydrograph

The development of irrigated agriculture in the Yakima Subbasin has altered the river's hydrograph in fundamental and profound ways. A discussion of this alteration is given in general in Chapter 1 and locally in the Assessment Unit portions of the fisheries section of this assessment. Reservoir development and water release for irrigation has increased river flow during portions of the year and decreased river flow during other portions of the year. Flow alterations impact the time and duration of flooding. Irrigation diversions have greatly reduced the flows in the lower portion of the subbasin. Agricultural drains have altered the hyporheic flows in the waterways adjacent to irrigation districts. These factors must be addressed first and foremost for successful riparian wetland restoration to occur in a meaningful way throughout the Yakima Subbasin. Restoration priority should be given to those areas that have experienced fewer impacts due to hydrologic alteration or to areas within which normative hydrologic conditions can be mimicked through management.

Exclusion of River from Floodplain

Agricultural development has altered the hydrograph of the subbasin such that flood events have been greatly reduced. Road and levee development has further restricted the floodplain in many areas. Land conversion from riparian wetland habitat to agricultural, residential, gravel mining, or recreational uses has also occurred behind the levees and roads. Riparian wetland restoration must take in to consideration the effects of restoration on lands that have been converted away from flooded habitats. Landscapes behind levees that have been physically altered by leveling or residential development may be much more difficult to restore than landscapes that have not been altered. Restoration priority should be given to protecting those areas that have not experienced floodplain exclusion and to areas within which floodplain reconnection is economically and culturally possible.

Alteration of Sediment Dynamics

Riparian wetland habitats are spatially and temporally dynamic. Floodplain processes creating and altering these habitats are largely dependent on cut and fill alluviation. The activities creating the altered hydrograph, the floodplain restrictions, the irrigation dams across waterways, the agricultural drainage of sediment-laden water into the waterways, the loss of green vegetation, and the reduction in woody debris have disrupted the sediment processes necessary for healthy riparian wetland conditions. Certain watersheds are experiencing increased sedimentation, filling riparian wetland habitats. Other areas, such as those below irrigation dams, are experiencing a reduction in sediment, causing channel incision and lowered groundwater levels. Management actions often can correct alterations in sediment dynamics in localized areas. Priority should be given to projects that include the restoration of sediment processes.

Loss Or Alteration Of Riparian Wetland Vegetation

Vegetation loss and alteration is caused by multiple factors. All of the impacts listed above result in loss and alteration of riparian wetland vegetation communities. In areas unaffected or receiving little alteration by the factors listed above, vegetation alteration can also occur through heavy grazing or clearing. In areas that have experienced little hydrologic and landscape alteration, vegetation restoration may be as simple as reducing the grazing or vegetation removal practices. In situations where the hydrology or landscape has been altered in a significant manner, these impacts must be addressed if vegetation restoration is to be successful. Many riparian wetland vegetation reintroduction projects fail because the hydrologic impacts have not adequately been addressed. Priority should be given to projects that adequately address the reasons for vegetation loss or alteration.

Reduction In Large Woody Debris

Healthy riparian wetland habitats create large amounts of dead woody materials. Cottonwood gallery forests are famous for their ability to provide standing and downed snags. The processes mentioned above interact with this dead woody material to supply nesting and feeding opportunities for many fish and wildlife species. This material is responsible, as well, for influencing the floodplain dynamics, especially cut and fill alluviation, necessary for riparian wetland and cottonwood forest health. As cottonwood stands age, the large dead material produced will collect sediment, block side channels, and force the establishment of new channels. The new channels will create exposed gravel and sediment conditions upon which new cottonwood trees will become established. The result is a diverse mosaic of cottonwood stands of different ages within a floodplain area. Restoration of large woody debris, then, is dependent on the restoration of healthy cottonwood stands. This activity requires floodplain areas large enough to provide space for cottonwood stands of various ages. Restoration areas too small may experience declines in the health of the cottonwood forests as they age and are not replaced with new stands. Restoration priority should be given to projects large enough to provide sufficient floodplain conditions conducive to the continued development of healthy cottonwood forests.

Reduction Of Beaver Activity

Beaver were central to the maintenance of healthy riparian wetland habitats. Their abundant activity created flooded conditions throughout the subbasin. A testimony to their abundance is reflected in the fact that the Pacific Northwest was revered for its fur trade. Extensive trapping is routinely listed as a major factor in their decline. Healthy beaver populations, however, are returning to many restoration areas in the lower portions of Yakima Subbasin. As restoration projects move up the watersheds, there is a possibilty that beaver populations will move upstream with them. Beaver damage complaints often will increase in areas adjacent to restoration projects. Restoration managers must be prepared to address these affects if projects are to succeed in the long term. Priority should be given to projects that address the factors necessary to support healthy populations of beavers and to address the unintended impacts to adjacent lands.

Increase In Exotic Vegetation

The Yakima Subbasin is in no means an isolated area. Global markets and economies cause human interactions unheard of a century ago. Because of this, the introduction of vegetation from exotic locals increases every year. Habitat conversion in the intensively developed irrigated agricultural portions of the subbasin compounds the effects of these introductions. Weed management is becoming an increasingly important component of riparian wetland restoration and management. A list of weed species occurring in the riparian wetland habitats of the Yakima Subbasin is included in Table 2-6. To combat these invasive species, techniques must be used that fit the situation within which they are arising. A comprehensive, integrated approach to pest management involves many tools. An important tool is in the restoration of conditions as close as possible to those that existed historically. The re-creation of native conditions conducive to the needs of the native plants which evolved in these conditions will often allow the best defense against infestation by exotic vegetation. Intensive weed control, however, may be necessary to reestablish these native communities in the first place. Many times, the removal of grazing on a heavily disturbed area will result in large weed infestations. Weed issues are much more important in the lower portions of the subbasin, but are increasing in the upper basin as well. Restoration projects must include plans to address weed infestations. Priority should be given to projects that include credible, integrated plans to address exotic vegetation issues.

Table 2-6. Riparian weeds in the Yakima Subbasin and their origin (adapted from Callihan and Miller 1994)

Common Name	Scientific Name	Origin
Field bindweed	*Convolvulus arvensis*	Eurasia
Hoary cress	*Cardaria draba*	Europe
Meadow hawkweed	*Hieracium caespitosum*	Europe
Orange hawkweed	*Hieracium aurantiacum*	Europe
Poison hemlock	*Conium maculatum*	Europe
Johnsongrass	*Sorghum halepense*	Mediterranean
Diffuse knapweed	*Centaurea diffusa*	Eurasia
Russian knapweed	*Acroptilon repens*	Southern Russia and Asia
Spotted knapweed	*Centaurea bibersteinii*	Europe
Purple loosestrife	*Lythrum salicaria*	Europe
Puncturevine	*Tribulus terrestris*	Europe
Tansy ragwort	*Senecio jacobaea*	Eurasia
Rush skeletonweed	*Chondrilla juncea*	Eurasia
Yellow star thistle	*Centaurea solstitialis*	Mediterranean and Asia
Canadian thistle	*Cirsium arvense*	Eurasia
Musk thistle	*Carduus nutans*	Eurasia
Scotch thistle	*Onopordum acanthium*	Europe
Dalmatian toadflax	*Linaria dalmatica*	Mediterranean
Yellow toadflax	*Linaria vulgaris*	Europe
Yellow Iris	*Iris pseudacorus*	Europe
Parrotfeather	*Myriophyllum aquaticum*	South America
Japanese Knotweed	*Polygonum cuspidatum*	Asia
Perennial pepperweed	*Lepidium latifolium*	Europe
Meadow Knapweed	*Centaurea pratensis*	Europe
White Water Lily	*Mymphaea tuberosa*	Eastern United States
Phragmites	*Phragmites australis*	Florida (United States)
Common St. Johnswort	*Hypericum perforatum*	Europe
Houndstongue	*Cynoglossum officianale*	Europe
Eurasian watermilfoil	*Myriophyllum spicatum*	Europe and Asia

Human Disturbance

As the Yakima Subbasin becomes increasingly populated, human disturbance issues will also increase (see Figure 1-4). Fish and wildlife populations need habitats relatively free of human activity. The best habitat will not provide the needs of wildlife if the level of human disturbance is high. Restoration areas must balance the needs of the fish and wildlife with the needs of the local communities. Restoration projects away from large population centers will require less effort to minimize human disturbance than projects near or adjacent to urban areas. Priority should be given to projects adequately addressing human disturbance issues.

Reduction In Anadromous Fish Populations

Many native wildlife species and habitats in the Yakima Subbasin were dependent on the constant energy sources brought up from the ocean by the large anadromous fish runs. The loss of these fish runs caused a large reduction in energy entering the system, altering wildlife population dynamics. This resulted in less vegetation, lower invertebrate numbers, and thus reduced numbers of wildlife dependent on eating salmon. Priority should be given to riparian wetland restoration activities that emphasize anadromous fish as well as wildlife benefits which promote an increase in the inter-specific interactions.

Table 2-7. Summary of potential effects of various land uses on riparian wetland habitat elements needed by fish and wildlife (Knutson and Naef 1997)

Potential Changes in Riparian Elements Needed by Fish and Wildlife	Land Use						
	Forest Practices	**Agriculture**	**Unmanaged Grazing**	**Urban-ization**	**Dams**	**Recreat ion**	**Roads**
Riparian Habitat							
Altered microclimate	X	X	X	X		X	X
Reduction of large woody debris	X	X	X	X	X	X	X
Habitat loss/fragmentation	X	X	X	X	X	X	X
Removal of riparian vegetation	X	X	X	X	X	X	X
Reduction of vegetation regeneration	X	X	X	X	X	X	X
Soil compaction/ deformation	X	X	X	X		X	X
Loss of habitat connectivity	X	X	X	X		X	X
Reduction of structural and functional diversity	X	X	X	X		X	X
Stream Banks and Channel							
Stream channel scouring	X	X	X	X		X	X
Increased stream bank erosion	X	X	X	X	X	X	X
Stream channel changes (e.g., width and depth)	X	X	X	X	X	X	X
Stream channelization (straightening)	X	X		X			
Loss of fish passage	X	X	X	X	X		X
Loss of large woody debris	X	X	X	X	X	X	X
Reduction of structural and functional diversity	X	X	X	X	X		X
Hydrology and Water Quality							
Changes in basin hydrology	X	X		X	X		X
Reduced water velocity	X	X	X	X	X		
Increased surface water flows	X	X	X	X		X	X

Potential Changes in Riparian Elements Needed by Fish and Wildlife	Land Use						
	Forest Practices	Agriculture	Unmanaged Grazing	Urban-ization	Dams	Recreat ion	Roads
Reduction of water storage capacity	X	X	X	X			X
Water withdrawal		X		X	X	X	
Increased sedimentation	X	X	X	X	X	X	X
Increased stream temperatures	X	X	X	X	X	X	X
Water contamination	X	X	X	X		X	X

4.8 Focal Species of Riparian Wetland Habitat

4.8.1 Yellow Warbler (*Dendroica petechia*)

Introduction

The yellow warbler is a common species strongly associated with riparian and wet deciduous habitats throughout its North American range. In Washington, it is found in many areas, generally at lower elevations. It occurs along most riverine systems, including the Yakima and Naches Rivers, where appropriate riparian habitats remain. The yellow warbler is a good indicator of functional subcanopy/shrub habitats in riparian areas.

Life History

Diet

Yellow warblers capture and consume a variety of insect and arthropod species. They consume insects and occasionally wild berries (Lowther et al. 1999). Food is obtained by gleaning from subcanopy vegetation; the species also sallies and hovers to a much lesser extent (Lowther et al. 1999) capturing a variety of flying insects.

Reproduction

Although little is known about yellow warbler breeding behavior in Washington, substantial information is available from other parts of its range. Pair formation and nest construction may begin within a few days of arrival at the breeding site (Lowther et al. 1999). The reproductive process begins with a fairly elaborate courtship performed by the male who may sing up to 3,240 songs in a day to attract a mate. The female does nest construction, incubation and most feeding of the young, while the male contributes more as the young develop.

Nesting

In most cases only one clutch of eggs is laid; renesting may occur following nest failure or nest parasitism by brown-headed cowbirds (Lowther et al. 1999). The typical clutch size ranges between 4 and 5 eggs in most research studies of the species (Lowther et al. 1999). Egg dates have been reported from British Columbia, and range between 10 May and 16 August; the peak period of activity there was between 7 and 23 June (Campbell et al. 2001). The incubation period lasts about 11 days and young birds fledge 8-10 days after hatching (Lowther et al. 1999). Young of the year may associate with the parents for up to 3 weeks following fledging (Lowther et al.

1999). Results of research on breeding activities indicate variable rates of hatching and fledging. Two studies cited by Lowther et al. (1999) had hatching rates of 56 percent and 67 percent. Of the eggs that hatched, 62 percent and 81 percent fledged; this represented 35 percent and 54 percent, respectively, of all eggs laid. Two other studies found that 42 percent and 72 percent of nests fledged at least one young (Lowther et al. 1999); the latter study was from British Columbia (Campbell et al. 2001).

Migration

The yellow warbler is a long-distance neotropical migrant. Spring migrants begin to arrive in the region in April. Early dates of 2 April and 10 April have been reported from Oregon and British Columbia, respectively (Gilligan et al. 1994, Campbell et al. 2001). Average arrival dates are somewhat later, the average for south-central British Columbia being 11 May (Campbell et al. 2001). The peak of spring migration in the region is in late May (Gilligan et al. 1994). Southward migration begins in late July, and peaks in late August to early September; very few migrants remain in the region in October (Lowther et al. 1999). In Yakima County, earliest arrival dates are in late April with most breeders present by mid- to late-May; by late July/early August numbers begin to decline and by early September most yellow warblers have migrated out of the County (Stepniewski 1999).

Mortality

Little has been published on annual survival rates. Roberts (1971) estimated annual survival rates of adults at 0.526 ±0.077 SE, although Lowther et al. (1999) felt this value underestimated survival because it did not account for dispersal. The oldest yellow warbler on record lived to be nearly 9 years old (Klimkiewicz et al. 1983).

Yellow warblers have developed effective responses to nest parasitism by the brown-headed cowbird (*Molothrus ater*). The brown-headed cowbird is an obligate nest brood parasite that does not build a nest and instead lays eggs in the nests of other species. When cowbird eggs are recognized in the nest the yellow warbler female will often build a new nest directly on top of the original. In some cases, particularly early in the incubation phase, the female yellow warbler will bury the cowbird egg within the nest. Some nests are completely abandoned after a cowbird egg is laid (Lowther et al. 1999). Up to 40 percent of yellow warbler nests in some studies have been parasitized (Lowther et al. 1999).

Habitat Requirements

General

The yellow warbler is a riparian obligate species most strongly associated with wetland habitats and deciduous tree cover. Yellow warbler abundance is positively associated with deciduous tree basal area, and bare ground; abundance is negatively associated with mean canopy cover, and cover of Douglas-fir, Oregon grape, mosses, swordfern, blackberry, hazel, and oceanspray (Rolph 1998).

PIF have established biological objectives for this species in the lowlands of eastern Oregon and eastern Washington. These include providing habitats that meet the following definition: >70 percent cover in shrub layer (<3 m) and subcanopy layer (>3 m and below the canopy foliage) with subcanopy layer contributing >40 percent of the total; shrub layer cover 30-60 percent (includes shrubs and small saplings); and a shrub layer height >2 m. At the landscape level, the biological objectives for habitat included high degree of deciduous riparian heterogeneity within or among wetland, shrub, and woodland patches; and a low percentage of agricultural land use (Altman and Holmes 2000).

Nesting

Radke (1984) found that nesting yellow warblers occurred more in isolated patches or small areas of willows adjacent to open habitats or large, dense thickets (i.e., scattered cover) rather than in the dense thickets themselves. At Malheur National Wildlife Refuge, in the northern Great Basin, nest success was 44 percent (n = 27), however, cowbird eggs and young were removed; cowbird parasitism was 33 percent (n = 9) (Radke 1984).

Breeding

Breeding yellow warblers are closely associated with riparian trees, specifically willows, alders, or cottonwoods. They are most abundant in riparian areas in the lowlands of eastern Washington, but also occur in west-side riparian zones, in the lowlands of the western Olympic Peninsula, where high rainfall limits hardwood riparian habitat. Yellow warblers are less common (Sharpe 1993). There are no BBA records at the probable or confirmed level from subalpine habitats in the Cascades, but Sharpe (1993) reports them nesting at 4000 feet in the Olympics. Numbers decline in the center of the Columbia Basin, but this species can be found commonly along most rivers and creeks at the margins of the Basin. A local breeding population exists in the Potholes area. Stepniewski (1999) described them as a fairly common summer resident of riparian woodlands in Yakima County. He also mentioned that yellow warblers have likely suffered along the Yakima River lowlands due to cowbird parasitism. Habitat loss and fragmentation and the extensive cattle operations within the Lower Yakima River Valley have contributed to high brown-headed cowbird densities.

Non-breeding

Fall migration is somewhat inconspicuous for the yellow warbler. It most probably begins to migrate the first of August and is generally finished by the end of September. The yellow warbler winters south to the Bahamas, northern Mexico, south to Peru, Bolivia and the Brazilian Amazon.

Status and Abundance Trends

Status

Yellow warblers are demonstrably secure globally. Within the state of Washington, yellow warblers are apparently secure and are not of conservation concern (Altman 1999).

Trends

Yellow warbler is one of the more common warblers in North America (Lowther et al. 1999). Information from BBS indicates that the population is stable in most areas. Some subspecies, particularly in southwestern North America, have been impacted by degradation or destruction of riparian habitats (Lowther et al. 1999). Because the BBS dates back only about 30 years, population declines in Washington resulting from habitat loss dating prior to the survey would not be accounted for by that effort (Figure 2-28).

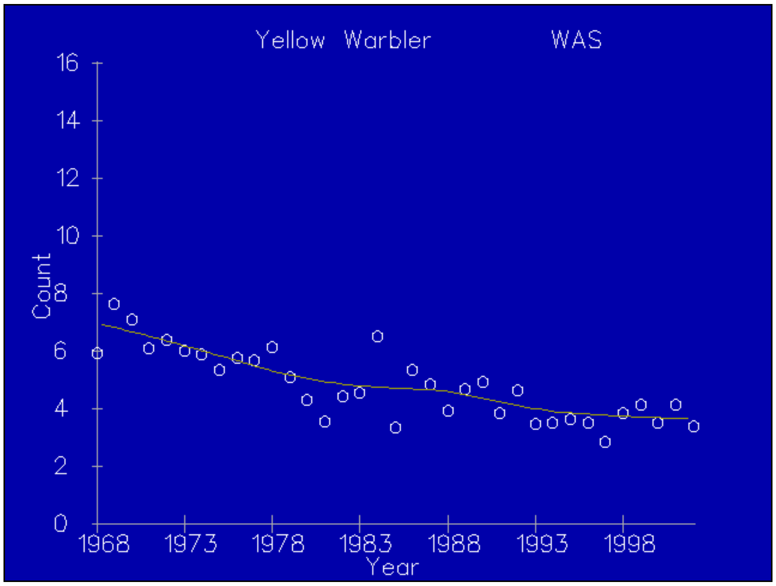


Figure 2-28. BBS data for Washington show a significant population decline of 2.9 percent per year ($p < 0.10$) from 1966 to 1991 (Peterjohn 1991)

Factors Affecting Yellow Warbler Population Status

Habitat losses have been largely due to hydrological diversions and control of natural flooding regimes (e.g., dams) resulting in reduction of overall area of riparian habitat, conversion of riparian habitats, inundation from impoundments, cutting and spraying for ease of access to water courses, gravel mining, etc. Habitat degradation has been caused by: loss of vertical stratification in riparian vegetation, lack of recruitment of young cottonwoods, ash, willows, and other subcanopy species; stream bank stabilization (e.g., riprap) which narrows stream channel, reduces the flood zone, and reduces extent of riparian vegetation; invasion of exotic species such as reed canary grass and blackberry; overgrazing which can reduce understory cover; reductions in riparian corridor widths which may decrease suitability of the habitat and may increase encroachment of nest predators and nest parasites to the interior of the stand. Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of brown-headed cowbirds and domestic predators (e.g., cats), and be subject to high levels of human disturbance. Recreational disturbances, especially during nesting season, and particularly in high-use recreation areas may be a significant factor in population declines. Pesticide and herbicide use as part of agricultural practices may reduce insect food base or nesting substrate.

Population and Distribution

Historic Population

No historic data could be found for this species.

Current Population

No current data could be found for this species.

Historic Distribution

Jewett et al. (1953) described the distribution of the yellow warbler as a common migrant and summer resident from April 30 to September 20 in the deciduous growth of Upper Sonoran and

Transition Zones in eastern Washington. Jewett et al. (1953) also note that the yellow warbler was common in the willows and alders along the streams of southeastern Washington and occurs also in brushy thickets. They state that its breeding range follows the deciduous timber into the mountains, where it probably nests in suitable habitat to 3,500 or perhaps even to 4,000 feet.

Current

The yellow warbler breeds across much of the North American continent, from Alaska to Newfoundland, south to western South Carolina and northern Georgia, and west through parts of the southwest to the Pacific coast (AOU 1998). Browning (1994) recognized 43 subspecies; two of these occur in Washington. This species is a long-distance migrant and has a winter range extending from western Mexico south to the Amazon lowlands in Brazil (AOU 1998). Neither the breeding nor winter ranges appear to have changed (Lowther et al. 1999).

The yellow warbler is a common breeder in riparian habitats with hardwood trees throughout the state at lower elevations. It is a locally common breeder along rivers and creeks in the Columbia Basin, where it is declining in some areas. Core zones of distribution in Washington are the forested zones below the subalpine fir and mountain hemlock zones, plus steppe zones other than the central arid steppe and canyon grassland zones, which are peripheral. Figure 2-29 shows the distribution of the yellow warbler in Washington (Smith et al. 1997) and Figure 2-30 shows predicted habitat for yellow warblers in the Yakima River Subbasin.

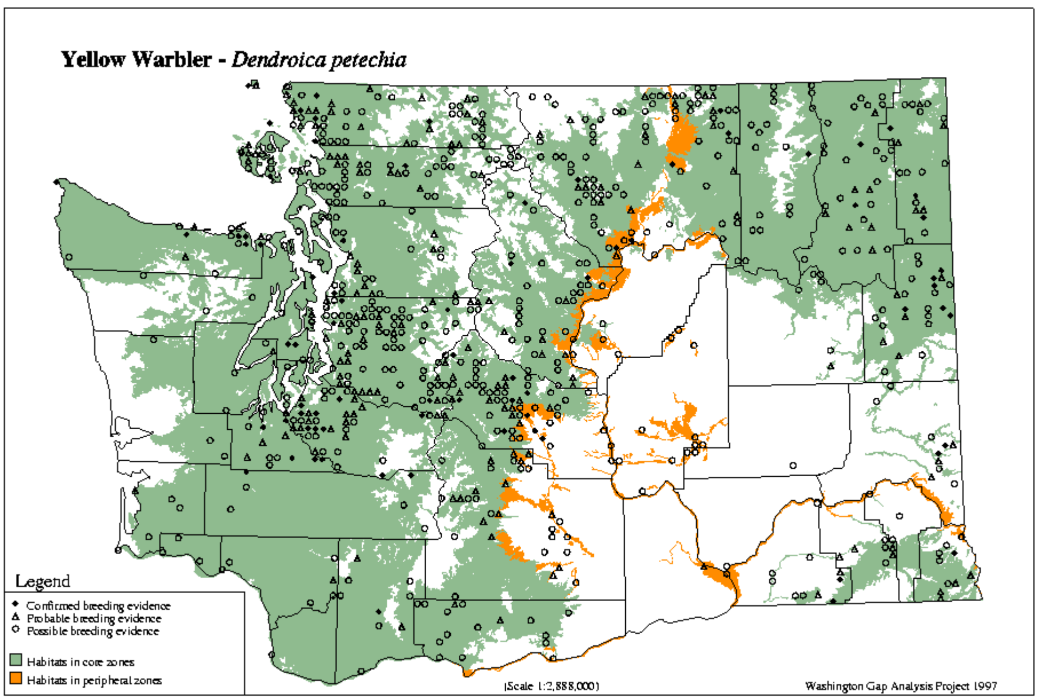


Figure 2-29. Breeding bird atlas data (1987-1995) and species distribution for yellow warbler (Smith et al. 1997)

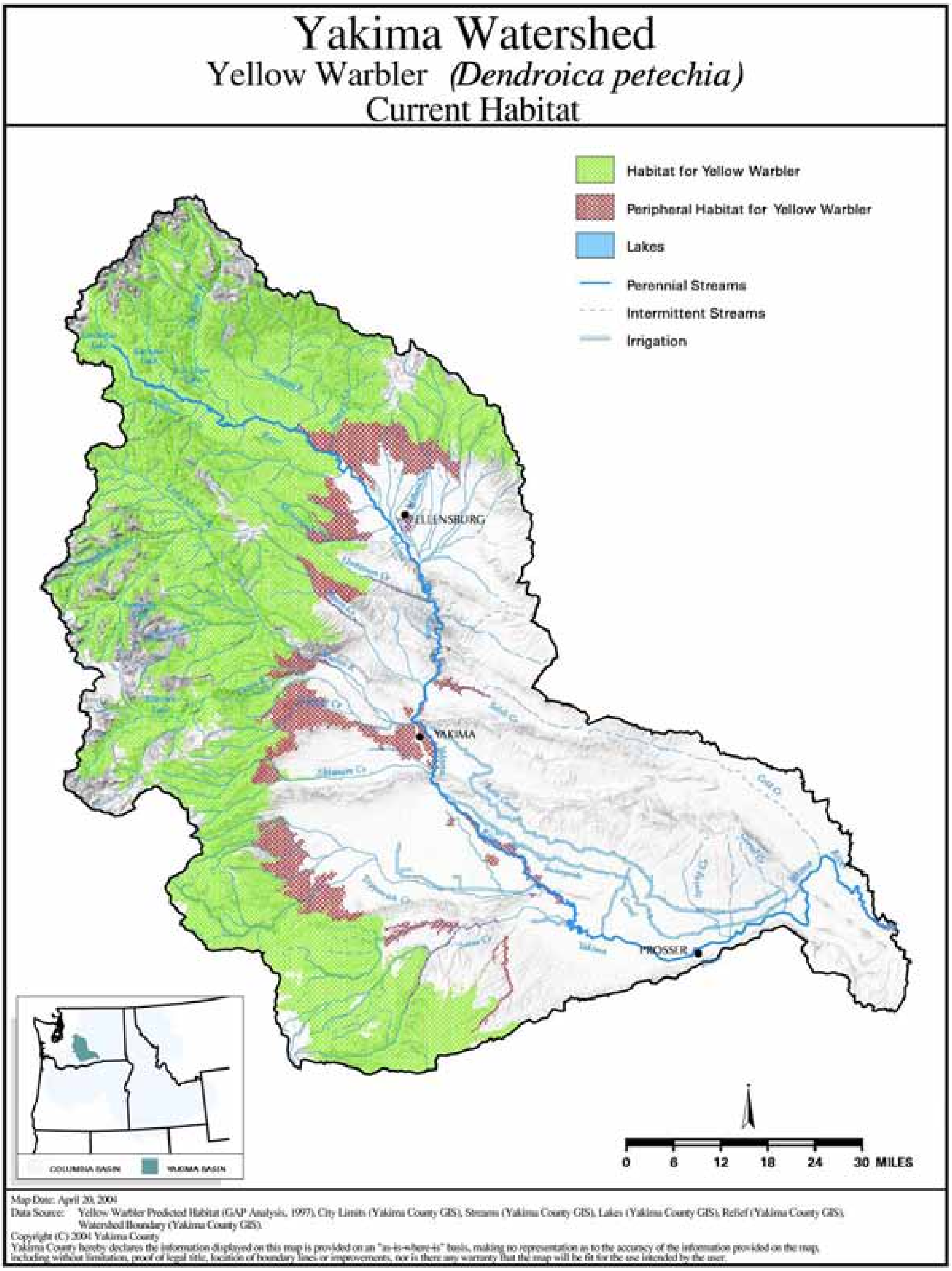


Figure 2-30. Yellow warbler predicted current habitat within the Yakima Subbasin

Breeding

The yellow warbler breeds across much of the North American continent, from Alaska to Newfoundland, south to western South Carolina and northern Georgia, and west through parts of the southwest to the Pacific coast (AOU 1998) (Figure 2-31).

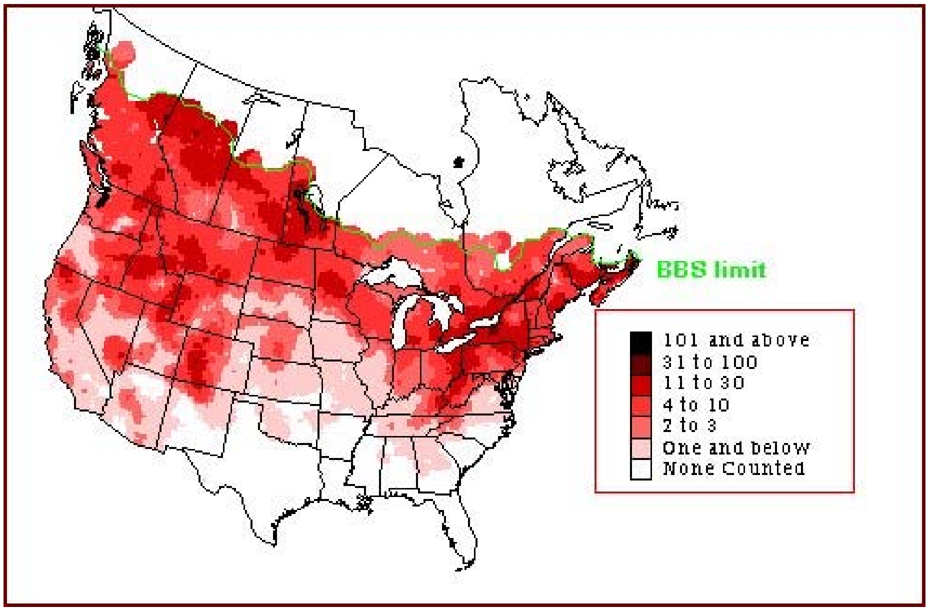


Figure 2-31. Yellow warbler breeding season abundance (from BBS data) (Sauer et al. 2003)

Non-Breeding

This data is not readily available; however, the yellow warbler is a long-range neotropical migrant. Its winter range is from Northern Mexico south to Northern Peru.

Out-of-Subbasin Effects and Assumptions and Assumptions

No data could be found on the migration and wintering grounds of the yellow warbler. It is a long-distance migrant and as a result faces a complex set of potential effects during its annual cycle. Habitat loss or conversions is likely happening along its entire migration route (H. Ferguson, WDFW, pers. comm. 2003). Riparian management requires the protection of riparian shrubs and understory and the elimination of noxious weeds. Migration routes, corridors and wintering grounds need to be identified and protected just as its breeding areas. In addition to loss of habitat, the yellow warbler, like many wetland or riparian associated birds, faces increased pesticide use in the metropolitan areas, especially with the outbreak of mosquito born viruses like West Nile Virus.

4.8.2 Mallard (*Anas platyrhynchos*)

Introduction

The mallard is one of the most important game birds in North America. It is the most abundant duck species in the Pacific Northwest. The Yakima Subbasin contains some of the most productive mallard habitat in eastern Washington. Though the mallard is widespread, its habitat requirements are specific enough to warrant its inclusion as a focal species in the Yakima Subbasin[4].

Life History

Diet

Mallard dietary requirements vary according to season and age of the individual. Ducklings feed nearly exclusively on aquatic invertebrates for the first weeks after hatching. Aquatic vegetation becomes increasingly more important in their diet up until fledging. Adult mallards eat mostly vegetative matter. Aquatic invertebrates become important during molting periods and in preparation for nesting and egg laying. Winter foods often consist of agricultural waste grains and moist soil plant seeds.

Reproduction

Mate selection usually begins in late winter, and may proceed throughout the spring. Because unpaired males will commonly attempt to copulate with paired females, paired drakes will defend a small territory in a wetland near the location they have chosen for their nest. The male will remain with the female well into incubation, but rarely remains once the eggs hatch. When the drake eventually abandons the female, he will usually migrate to a large wetland area to enter his summer flightless molt period. These drake molting areas occur mostly outside of the Yakima Basin.

Nesting

Nest initiation in the Yakima Basin begins as early as the last week of February and may continue through August. The peak period of nest initiation is usually April, but may be earlier or later depending on spring weather conditions. Nests contain 8-10 olive-green eggs (Ransom 1981). The nest is a soft hollow built in grass or shrubs, not always near water. In the case of nest depredation, a hen will re-nest several times, if necessary. Hatching begins the first week of April, but peaks in May or early June. In certain irrigated agricultural valleys of the Yakima Basin, nesting may occur as far as five miles from brood rearing habitat. In these situations the hen will use the canal/drain systems to lead the broods to the appropriate rearing wetlands where they will remain until fledging. Fledging occurs from early June until late September. When the young are near the age of fledging, the hen will leave them to begin her summer flightless molt. These molts take place in similar habitats as those where brood rearing occurred.

Migration

The Yakima Basin contains breeding, migration and wintering habitats for mallard populations. Mallards migrating from northern breeding grounds (Alaska, British Columbia and western Alberta) may begin as early as August. Peak migration from the north usually occurs after mid-November. Peak wintering numbers in the Yakima Basin occur from December through February. Winter severity, the availability of winter food, and ice conditions influence the amount and timing of migrating mallard numbers in the Yakima Basin. Adult drakes breeding in the Basin will migrate to molting areas beginning in early spring and continuing until mid-summer. These molting areas occur mostly out of the subbasin to the east and south. Fledged

[4] Much of the Yakima Subbasin-specific information contained in this section is based on unpublished breeding, migration, wintering, and banding data compiled and collected by YN Wildlife Biologists since 1990 (Hames 2004).

young will migrate soon after they fledge, from July through September. Banding data has shown that these young birds will commonly migrate in the summer throughout eastern Washington and Oregon. Fall migration of “local” (breeding adults or fledged young) continues from late summer throughout the fall and winter depending on weather conditions. A large amount of the local mallards migrate to areas within eastern Washington, eastern Oregon, and the central and southern basins of California. Summer banding activities, however, have detected individuals migrating as far away as Kentucky. A large segment of these “local” mallards also remain in the Yakima Basin throughout the year.

Mortality

Nest depredation is an important source of mortality for mallards. Nest success rates in North Dakota are often measured to be less than 15 percent. In the lower Yakima valley, however, nest success rates have been documented to be much higher than in other parts of North America. Larsen (1998) measured mallard nest success rates between 30 and 60 percent. Similar mallard nest success rates have been independently documented by Yakama Nation and Toppenish NWR staff (T. Hames, YN pers. comm., 2004; H. Browers, USFWS, pers. comm., 2004). Nest predators include magpies, American crows, hawks, coyotes, skunks, raccoons, badgers, California ground squirrels, mink, feral cats, and feral dogs.

Mortality of pre-fledged young is another important source of annual mortality. Larsen (1999) showed brood survival rates of 75 percent in riparian wetlands, 50 percent in irrigation canals and drains, and 23 percent in flooded pastures. Predators include those listed above and otters. There is no evidence that predation is an important component of adult mortality in the Yakima Basin.

Mallard disease epizootics have been not been documented in the Yakima Basin.

Harvest

Hunting seems to be the largest factor affecting mallard mortality in the Yakima Basin. Mallard harvest numbers in Yakima County are the second largest of any county in the state (WDFW 2003). This holds true even though basin wintering numbers have declined substantially since the late 1970’s (Fig 2-32). Banding studies have been conducted each summer in the lower Yakima valley since 1990. Hunting mortality rates of Yakima Basin summer banded mallards has been estimated from 6 percent to slightly over 10 percent, depending on season length and daily bag limit. Approximately 50 percent of this mortality occurs within the Yakima Basin. Nearly all of the rest of the harvest occurs in other areas of eastern Washington, eastern Oregon, and the central and southern basins of California.

Habitat Requirements

Nesting

Mallard nest placement occurs on the ground in grass, forb or shrub cover. Because nesting occurs early in the spring, mallards must rely on residual vegetation much more than new growth. The structure of the vegetation is more important than the vegetative species providing the cover. Adequate nesting habitat consists of vegetation that will cover the nest on all sides and over the top. Ideal cover provides Robel pole measurements of 3-4 dm on at least three sides. Large nesting fields (>20 acres) afford more protection against predators than do thin strips or isolated small parcels of vegetation. Nesting habitats should be adjacent or within 1/4 mile of water. In the irrigated valleys of the Yakima Basin, canal and drain watercourses provide safe transport of broods to rearing habitat.

High quality rearing habitat consists of emergent wetlands with a ratio of 40:60 – 60:40 of open water to emergent vegetation (Rassmussen and Wright 1990). The wetlands must have healthy beds of submersed vegetation. The submersed vegetation hosts populations of aquatic invertebrates upon which the duckling feed. As the young birds grow, they consume more and more vegetative matter. Predator avoidance is achieved by young ducklings through hiding in emergent cover or diving under water. Larsen (1998) found that duckling survival was much greater in wetlands that contained adequate depth for diving predator avoidance. These wetlands occurred more frequently in riparian areas associated with creek and river floodplains. Inadequate brood wetlands occurred in shallowly flooded pasturelands even when emergent cover was deemed adequate.

Breeding

Mallard breeding habitat consists of wetlands similar to those used in brood rearing. Large wetlands and flooded riparian areas are also important for mallard pairing activities. When the pairing is established between a male and female mallard, the male will defend the wetland territory within which the two are spending their time feeding and loafing. They will then seek out an appropriate nesting location together. The drake will remain with the hen well into the nesting period, awaiting the hen at on the nearby wetland where pairing occurred. Pairing and brood rearing areas ideally should be in close proximity to adequate nesting cover. If not, they should be linked by a canal or drain system.

Non-Breeding

Non-breeding habitats consist of wetland or riverine areas used for loafing and feeding. These areas should be relatively free of human disturbance. Preferred areas also contain structure such as trees, logs, mud or gravel bars. These areas are used for loafing, preening, sleeping or sunning.

Foraging

Requirements change seasonally as is discussed in the diet requirements section above. Emergent wetland and riverine areas are used year round for access to aquatic vegetation and invertebrates. During winter months access to waste grain is important. These are obtained by feeding in corn, wheat or barley crop fields post-harvest. Mallards will fly 5- 30 miles from loafing areas to reach fields with adequate waste grain during the colder months of the year. Feeding occurs mostly crepuscularly, but may occur diurnally or nocturnally depending on weather and disturbance conditions. Cattle feed lots and waste treatment plants also provide winter feeding opportunities.

Cover

Cover needs are discussed in the nesting habitat requirements section.

Status and Abundance Trends

Historic

Mallard breeding, migration and wintering population numbers are unknown. Clues to the mallard's abundance in the Yakima Basin come from Yakama legends' references to mallards assisting in bringing warm weather patterns after extreme cold spells. Flood flows associated with precipitation events historically occurred from late October through March each year. These events in the lower elevation valleys provided large protected wintering habitats for migrating mallards and other waterfowl. Migrating mallards would enter the subbasin as wetlands froze in the north. This typically occurs in mid-November. Migration would continue out of or into the subbasin as the wetland areas would freeze and thaw.

Breeding abundance can be inferred by the large amounts of riparian, wetland, and floodplain grassland habitats shown to exist pre-development. Most pre-irrigation mallard production probably occurred in the broad, flat landscapes of the Kittitas and Yakima valleys. These areas contained multiple wetland, riparian and grassland habitats conducive to mallard nesting and rearing. Mallard production likely also occurred in beaver-inhabited mountain streams.

Population and Distribution

Current

Yakima Subbasin mallard wintering surveys began in the late 1940's (Figure 2-32). This was well after irrigation development in the Yakima Basin. These surveys have been confined to the area of the basin below Union Gap and above Prosser because there are too few wintering mallards elsewhere to justify the expense in conducting the surveys. These surveys show that peaks in wintering mallard numbers along Toppenish Creek and the Yakima River between Union Gap and Prosser ranged from 150,000 to nearly 300,000 in the 1950's through 1970's. Mallard numbers dropped substantially in the 1980's due to expanded diurnal loafing habitat created by the Columbia river hydropower system (Thompson et al. 1988), local crop conversion away from grain production (Lloyd, et al. 1983), and increased irrigation development south of the Yakima Basin (Ball et al. 1989) Today wintering mallard numbers rarely exceed 40,000.

Breeding surveys started in the Lower Yakima Valley in 1955 (Figure 2-33). The Yakima Valley was nationally known as an important waterfowl breeding area (Linduska 1964). Production surveys today use the same methods and survey sections as those used since the start of the surveys. Within the agricultural valleys on the Yakama Reservation, mallard production is as strong as it has been since these surveys began. These surveys show that mallard production within riparian and wetland areas is much greater than those areas converted to irrigated agriculture. Current production numbers of mallards on the Yakama Reservation are estimated at between 10,000 and 20,000. Production is less in the rest of the basin due to much more intensive land use practices. Figure 2-34 shows the predicted current habitat for mallards in the Yakima River Subbasin.

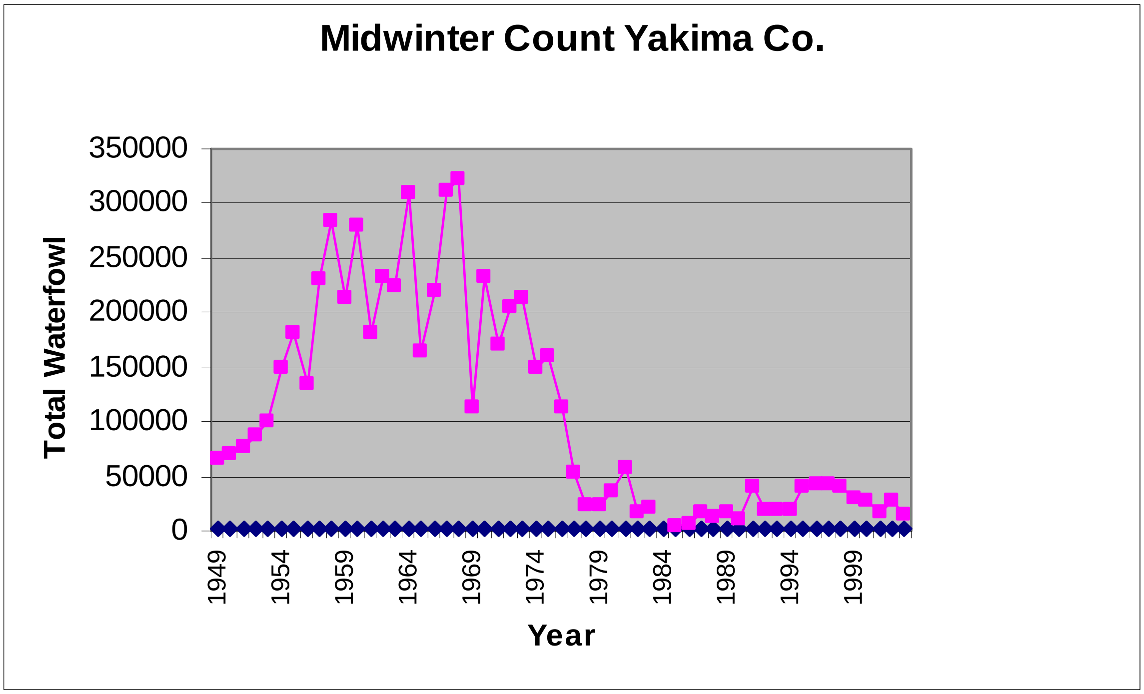


Figure 2-32. Midwinter waterfowl counts in Yakima County 1949-2003 (Hames 2004).

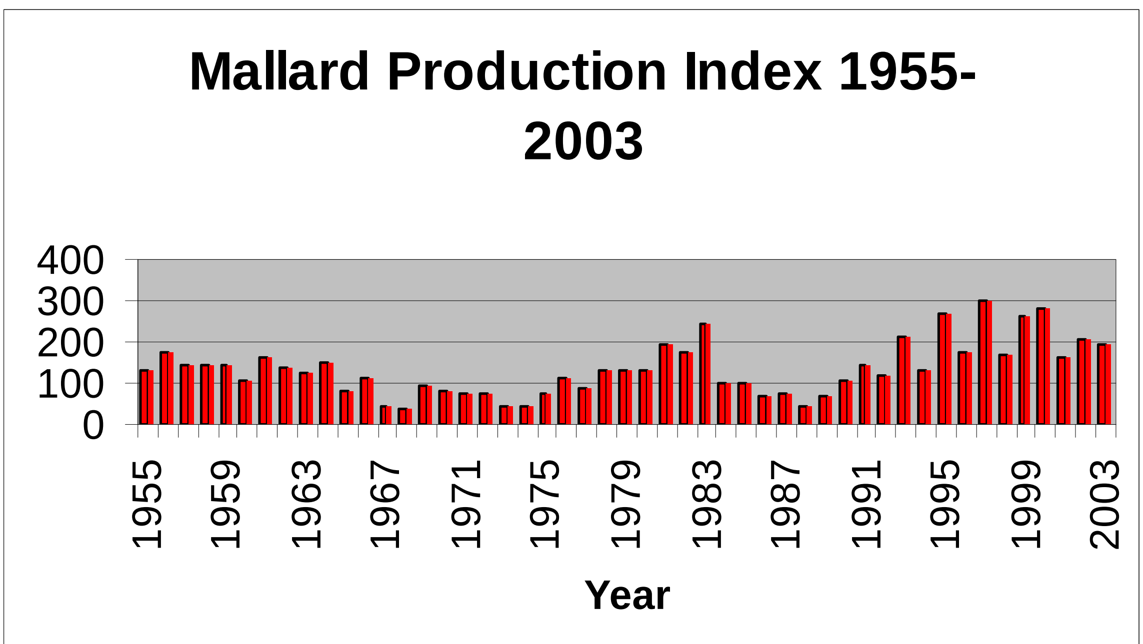


Figure 2-33. Mallard production index for agricultural portion of Yakama Reservation 1955-2003 (Hames 2004).

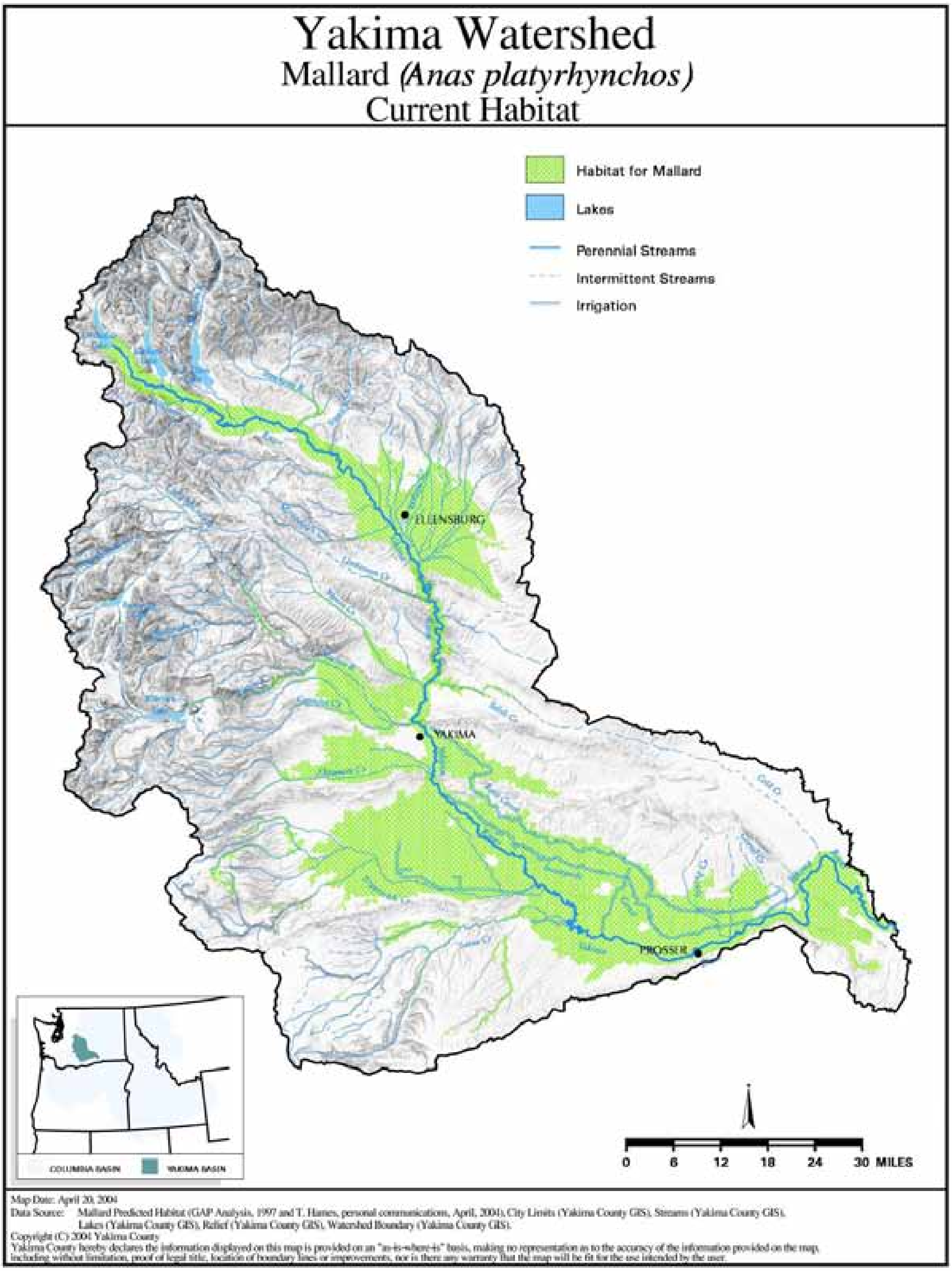


Figure 2-34. Mallard predicted current habitat in the Yakima Subbasin

Out-of-Subbasin Effects and Assumptions and Assumptions

Wintering mallard numbers are influenced by local and out of basin conditions. Surveys during mild winters, when there is abundant open water and foraging conditions to the north, will show lower mallard numbers than during colder winters. Most of the mallard refuge areas (where no hunting is allowed) were establish before wintering mallard numbers declined. Unfrozen wetland and river loafing habitats are also currently as abundant as they were before the numbers declined. Winter feeding opportunities, in the form of available grains in agricultural fields, have declined substantially since the 1970's. Natural foods available to wintering mallards in the form of wetland plant seeds have also likely declined due to riparian wetland conversion. The amount of forage available to wintering mallards is the most important factor limiting their increase to historic population numbers. Minimum tillage agricultural practices are becoming more and more accepted in the basin because these methods now are becoming economically preferable. Grain production is also on the rise in the basin due to an increase in the number of dairy feedlot operations in the area. These two factors may increase the amount of winter forage available at least in the short term. Restoration of wetland areas to native conditions, however, will be necessary to provide consistent forage production independent of current agricultural scenarios.

Mallard production, though some of the strongest in the state, has been greatly reduced by wetland, riparian and grassland conversion to agriculture. As irrigation delivery systems become more efficient, this production will likely be reduced. To counteract these anticipated reductions, native wetland, riparian and grassland floodplain habitats should be protected and restored in these historic mallard-producing valleys. Native habitats in the Yakima Basin have been shown to be 10 to 20 times more productive than agricultural habitats.

4.8.3 American Beaver (*Castor canadensis*)

Introduction

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

Life History

Diet

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

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

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

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

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

Reproduction

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

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

Home Range

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

Mortality

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

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

Harvest

4.8.3.1.1.1 Historic

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

4.8.3.1.1.2 Current

Beaver harvest in the Yakima Subbasin occurs at levels much lower than those reported historically. According to harvest figures from the WDFW and the Yakama Nation Wildlife Resource Management Program (WRMP), total numbers taken basin-wide in the last 5 years rarely exceed 200 annually. Much of the beaver harvest activities in the subbasin occur in response to property damage reports.

Habitat Requirements

General

All wetland cover types (e.g., herbaceous wetland and deciduous forested wetland) must have a permanent source of surface water with little or no fluctuation in order to provide suitable beaver habitat (Slough and Sadleir 1977). Water provides cover for the feeding and reproductive activities of the beaver. Lakes and reservoirs that have extreme annual or seasonal fluctuations in the water level will be unsuitable habitat for beaver. Similarly, intermittent streams, or streams that have major fluctuations in discharge (e.g., high spring runoff) or a stream channel gradient of 15 percent or more, will have little year-round value as beaver habitat. Assuming that there is an adequate food source available, small lakes [< 8 ha (20 acres) in surface area] are assumed to provide suitable habitat. Large lakes and reservoirs [> 8 ha (20 acres) in surface area] must have irregular shorelines (e.g., bays, coves, and inlets) in order to provide optimum habitat for beaver. Lind (2002) developed a beaver habitat model for Umptanum Creek, a tributary to the Yakima River. Verification of this model showed that the most important predictors of beaver habitat suitability were related to water regime, vegetation type, stream gradient, and geologic substrate.

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

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

Foraging

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

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

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

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

Cover

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

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

Status and Abundance Trends

Status

No current data is available

Trends

No current data is available

Factors Affecting Population Status

Though excessive trapping is thought to be the cause of original beaver declines in the 1800’s, trapping pressure is nearly non-existent today. Beaver seem to be thriving in many locations within which adequate habitat remains or has been restored. These areas occur predominately in the agricultural portions of the subbasin. Many areas containing adequate habitat in higher elevation locations suffer from a lack of beavers. These areas are isolated from the agricultural zones where beaver are present. In these instances, relocation of animals to areas containing sufficient quality and quantity of beaver habitat is likely a viable alternative.

Habitat loss is also a major factor affecting beaver distribution throughout the subbasin. Hydrologic alteration, vegetation removal, and channel disturbance have occurred to limit the abilities of many areas to be recolonated by beavers. In areas containing potential habitat as described in Lind (2002), restoration efforts addressing the local limiting factors should occur. When adequate habitat quality and quantity is achieved, beavers should be reintroduced to these areas if they do not colonize on their own.

Population and Distribution

Historic

No beaver population data exists for the Yakima Subbasin. Landscape, hydrologic and habitat information, however, suggest that beavers were not only plentiful, but important components of riparian function and health.

Current

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

Though little information exists pertaining to current beaver populations, biologists believe their numbers to be much lower than those which occurred historically. In Washington State, beavers have been recorded from the west to the eastern portion of the state (Figure 2-35). An increase in beaver numbers in response to restoration projects in the agricultural portion of the Yakama Reservation is occurring (T. Hames, Yakama Nation, pers. comm., 2004). Damage complaints due to beaver activity in this area are also on the rise. Attempts to move nuisance beavers to montane areas are occurring on the Yakama Reservation. The success of these relocations is not monitored at this time.

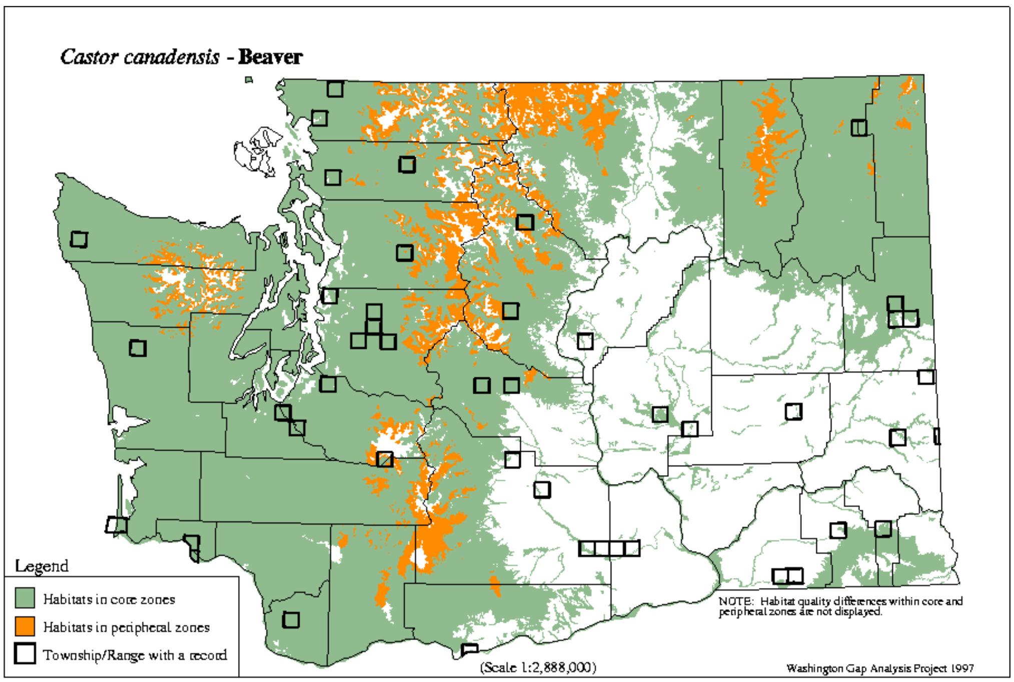


Figure 2-35. American beaver distribution and core habitat zones in Washington

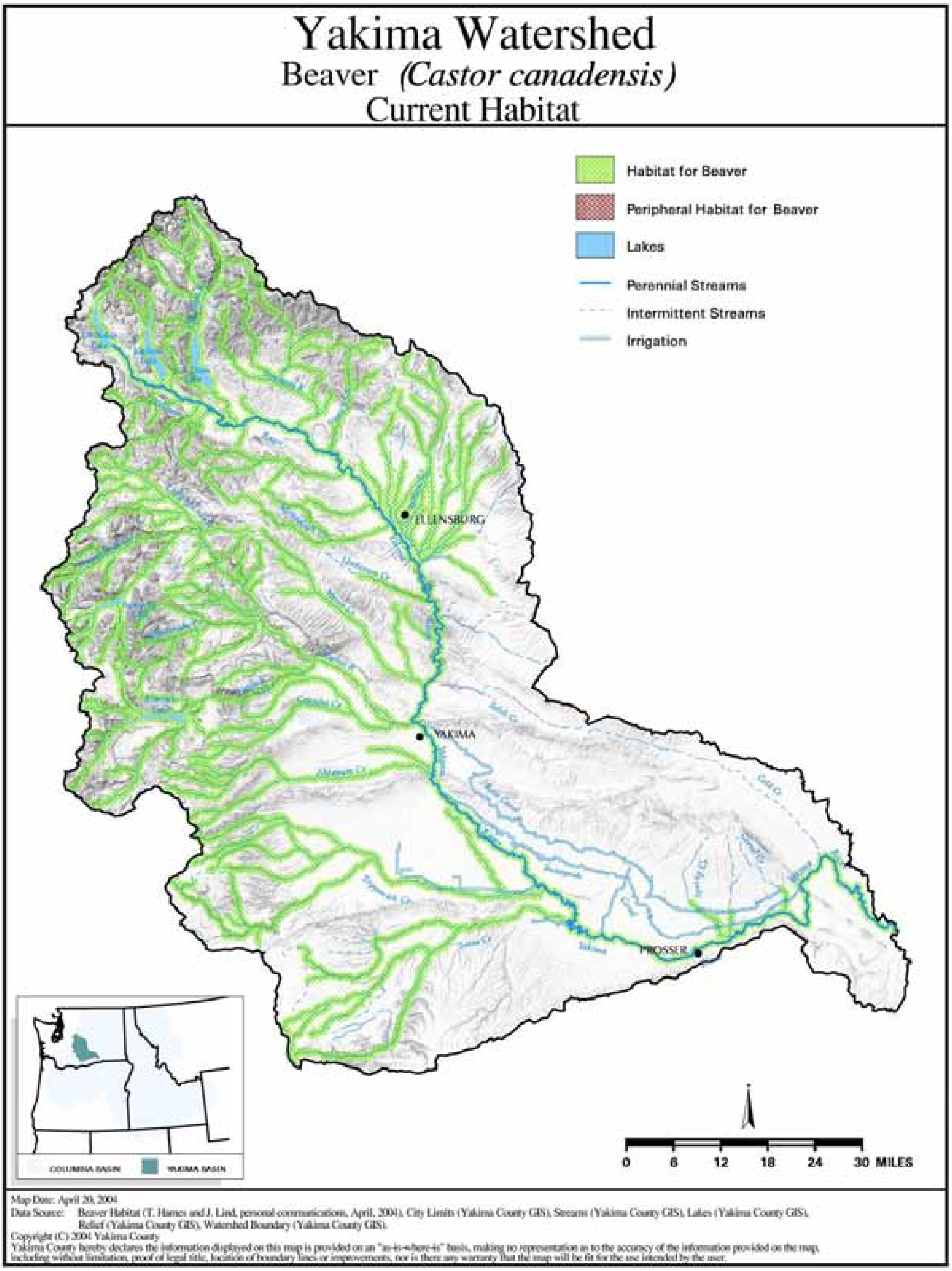


Figure 2-36. American beaver predicted current habitat in the Yakima Subbasin

Out-of-Subbasin Effects and Assumptions

There are no out-of-subbasin effects and assumptions for the American Beaver as this species is non-migratory.

4.8.4 Key Findings for Interior Riparian and Focal species

- Riparian Wetland structure and composition has been lost or degraded
- Extensive loss of Riparian Wetland habitat has occurred

5 Aquatic-Terrestrial Ecosytem Linkages

5.1 Salmonid Associations

Anadramous salmon provide a rich, seasonal food resource that directly affects the ecology of both aquatic and terrestrial consumers, and indirectly affects the entire food web that knits the water and land together. Wildlife species and salmon have likely had a very long, and co-evolutionary relationship with salmon in the Pacific Northwest.

Out of the 390 wildlife species in the Yakima Subbasin, 88 were characterized as having a relationship with salmon at various life stages. These life stages range from egg to its role as a carcass. Table 2-8 defines the life stages. The relationship is classified by whether it is Strong, Consistent, Recurrent, or Indirect (Table 2-9). Of these 88 species 27 were mammals, 57 were birds, 2 were amphibians, and 2 were reptiles. (Cederhom et al.2000). See Table F1 in Appendix F for a full list of wildlife species identified as having an association with salmonids.

Table 2-8. Salmon life stages from egg to carcass and their definitions (Johnson, NWHI cd-rom)

LIFE STAGE	DEFINITION
Egg	One of the female reproductive cells consisting of an embryo surrounded by nutrient material and protective covering
Alevin	Larval salmonid that has hatched but has not yet emerged from the spawning gravel
Fry	Life stage of trout or salmon between full absorption of the yolk sac and fingerling or parr stage, which generally is reached by the end of the first summer
Fingerling/Parr	Young salmonid, usually in its first or second year and generally between 2 and 25 cm long, in the stage between alevin and smolt that has developed distinctive dark "parr marks" on its sides and is actively feeding in fresh water
Smolt	Juvenile salmonid one or more years old that has undergone physiological changes to cope with a marine environment; the seaward migrant stage of an anadromous salmonid
Spawner	Sexually mature salmonid migrating to or at its natal spawning grounds
Carcass	Dead body of salmonid

Table 2-9. Salmon-wildlife relationships and their definitions (Johnson, NWHI cd-rom)

STRONG, CONSISTENT RELATIONSHIP
Salmon play (or historically played) an important role in this species distribution, viability, abundance, and/or population status. The ecology of this wildlife species is supported by salmon, especially at particular life stages or during specific seasons. Timing of reproductive activities, and daily or seasonal movements often reflect salmon life stages. Relationship with salmon is direct (e.g., feeds on salmon, or salmon eggs) and routine. The relationship may be regional or localized to one or more watersheds. Examples: A significant portion of the diet of killer whales is adult salmon (Saltwater stage); common mergansers may congregate to feed on salmon fry (Freshwater Rearing stage) when they are available.
RECURRENT RELATIONSHIP
The relationship between salmon and this species is characterized as routine, albeit occasional, and often tends to be in localized areas (thus affecting only a small portion of this species population). While the species may benefit from this relationship, it is generally not considered to affect the distribution, abundance, viability, or population status of this species. The percent of salmon in the diet of these wildlife species may vary from 5 percent to over 50 percent, depending on the location and time of year. Example: turkey vultures routinely feed on salmon carcasses, but feed on many other items as well.
INDIRECT RELATIONSHIP
Salmon play an important routine, but indirect link to this species. The relationship could be viewed as one of a secondary consumer of salmon; for example, salmon support other wildlife that are prey of this species. This includes aspects such as salmon carcasses that support insect populations that are a food item for this species. Example: American dippers feed on aquatic insects that are affected by salmon-derived nutrients. The hypothesis of an indirect relationship between an aerial insectivore and salmon was supported by the presence of two or more of the following characteristics of the insectivore: (1) riparian obligate or associate, (2) feeds below or near the canopy layer of riparian trees, (3) known or perceived to feed on midges, blackflies, caddisflies, stoneflies, or other aquatic insects that benefit from salmon-derived nutrients, and/or (4) feeds near the water surface. While this category includes general aspects of salmon nutrient cycling in stream/river systems, we are not including or examining the role of carcass-derived nutrient cycling on lentic system riparian and wetlands vegetation, and subsequent links to wildlife.
RARE RELATIONSHIP
Salmon play a very minor role in the diet of these species, often amounting to less than 1 percent of the diet. Typically, salmon are consumed only on rare occasions, during a shortage of the usual food and may be especially evident during El Niño events. As salmon are often present in large quantities, they may be consumed on rare occasions by species that normally do not consume them. Examples: red-tailed hawks are known to consume salmon carcasses in times of distress; trumpeter swans are primarily vegetarians, but on rare occasions will consume eggs, parr, as well as salmon carcass tissue.
UNKNOWN RELATIONSHIP
A relationship between this species and salmon may exist, but there is not enough information to determine the scope or scale of the relationship at this time. Example: while it is logical to speculate that riparian feeding bats may feed on salmon-derived insects, aspects of seasonality of both bats and salmon carcasses are relevant, as is the nocturnal flight behavior of the insects. Do bats and salmon carcasses coincide seasonally, and if so, are salmon-derived insects actually available to feeding bats? At this time, the evidence for this relationship is inconclusive and remains to be examined.
NO RELATIONSHIP
There is no recognized or apparent relationship between salmon and this species.

5.2 Ecological Processes and Functions

Every ecosystem has structure and function. An ecosystem is an arrangement of its three components – the physical habitat, energy and material resources, and the biological community– in relation to one another. An ecosystem functions to direct the flow of energy and material through the ecosystem. An ecosystem's function is governed by its physical, chemical and biological components with the physical and chemical features providing the framework for development of the biological community and its resources.

The aquatic and terrestrial ecosystems are closely linked. The flow of water, sediment, nutrients, and organic matter from the watershed surrounding the stream shapes physical habitats and supplies energy and nutrient resources for the aquatic ecosystem. Organic matter that supports the trophic system of freshwater ecosystems is provided from both autochthonous and allochthonous sources. Common types of autochthonous sources are: algae, mosses, vascular plants, and phytoplankton. All of these factors are found in freshwater, and generate organic matter though the process of photosynthesis. Common types of allochthonous input include leaves, needles, wood and insects from the terrestrial environment, and dissolved organic matter carried in groundwater that enters the water body. Salmon provide an important source of allochthonous organic matter for Pacific Northwest freshwater ecosystems. The stream's physical and chemical environment, organic matter and nutrients, and biological community interact as a dynamic system closely linked to riparian vegetation and changing from headwaters to river mouth. Energy from sunlight and organic matter flows into, through, and out of the ecosystem. By processing these inputs, the stream community obtains energy for activity, growth, and reproduction (Cedarholm et al. 2000).

Anadromous salmon play an important role in maintaining an ecosystem's productivity by contributing to the overall biodiversity. For example, the seasonal migrations of millions of salmon between Pacific rim streams and the subarctic Pacific Ocean appear to increase overall terrestrial productivity. The numerical response of predators to salmon congregations is often substantial, sometimes spectacularly so. The ability of wildlife species to concentrate at salmon sites is more than just opportunistic foraging, it has significant biological importance. Anadromous fishes (including their eggs) are a major source of high-energy food that allows for successful reproduction and enhanced survival of adults and juveniles of many wildlife species, and support for long-distance migrant birds (Cedarholm et al. 2000).

Depending on the species run size and subbasin, returning wild spawning salmon run sizes can significantly increase nitrogen and phosphorus levels and stream biomass. In Kamchatka, Alaska, returning sockeye salmon transported 35-40 percent of the yearly total phosphorus input to a lake as well as much of the nitrogen input to the system (Krokhin 1975). In the Puget Sound Basin, based on calculations using recent peak wild spawning escapement numbers, from 0.9 percent (Puyallup watershed) to 46.8 percent (South Puget Sound watershed) of total nitrogen and from 0.1 percent (Puyallup watershed) to 5.5 percent (South Puget Sound watershed) of total phosphorus was imported into the freshwater environments from returning salmon spawners (Cedarholm et al. 2000). Macroinvertebrate communities in streams receiving salmon runs can also change in response to spawning activity and nutrient enrichment (Piorkowski 1995, Bilby et al. 1996, and Nicola 1996). In Kennedy Creek, Washington, Minakawa (1997) found the presence of salmon carcasses and eggs produced a two-fold or greater increase in total insect densities and biomass compared to control reaches. Terrestrial insects also,(fly maggots [Diptera] and hornets), have been observed feeding heavily on salmon carcasses in steams but generally little work has been done to systematically document these activities (Cedarholm et al. 2000). Quantitative measurements of salmon carcass consumption in the terrestrial environment has focused on their utilization by high profile species like bald eagles and grizzly bears, but Cederholm et al (1989) recorded 43 taxa of mammals and birds present on small Olympic Peninsula streams at a time when coho salmon carcasses were present, and found that 51 percent of those taxa had fed on carcasses.

A system's productivity depends not only upon the nutrient inputs but also on the system's ability to retain those nutrients (Cederholm et al. 2000). The capacity of a streamto retain organic matter is a function of both hydrologic and biotic features. Interstices in the streambed and roughness elements (i.e., boulders and woody debris) in the channel promote retention, as do macrophytes and filter-feeding invertebrates (Meehan and Bjorn 1991). Woody debris complexes, an important component of habitat complexity, have been identified as important for increasing salmon carcass retention (Cedarholm and Peterson 1985 and Cedarholm et al. 1989). The transport of salmonid organic matter and nutrients across mosaics of in-channel, riparian, and floodplain habitats in a watershed may then occur as water, sediments, and organic debris are redistributed, as in freshets.

6 Aquatic Focal Species and Habitat Assessment

6.1 Overview

The Yakima Subbasin, like the other river basins of the Middle and Lower Columbia, was not overrun by the continental glaciations of the last 4 million years. The salmonid species that inhabit the Yakima Subbasin thus were able to continuously inhabit portions of the watershed during this time. While the lower portions of the basin escaped glaciations, the upper portions of the basin were subjected to repeated episodes of alpine glaciations, resulting in the formation of the glacial valleys glacial lakes in the upper basins, and driving riverine habitat formation by contributing coarse and fine sediments to the alluvial floodplains below.

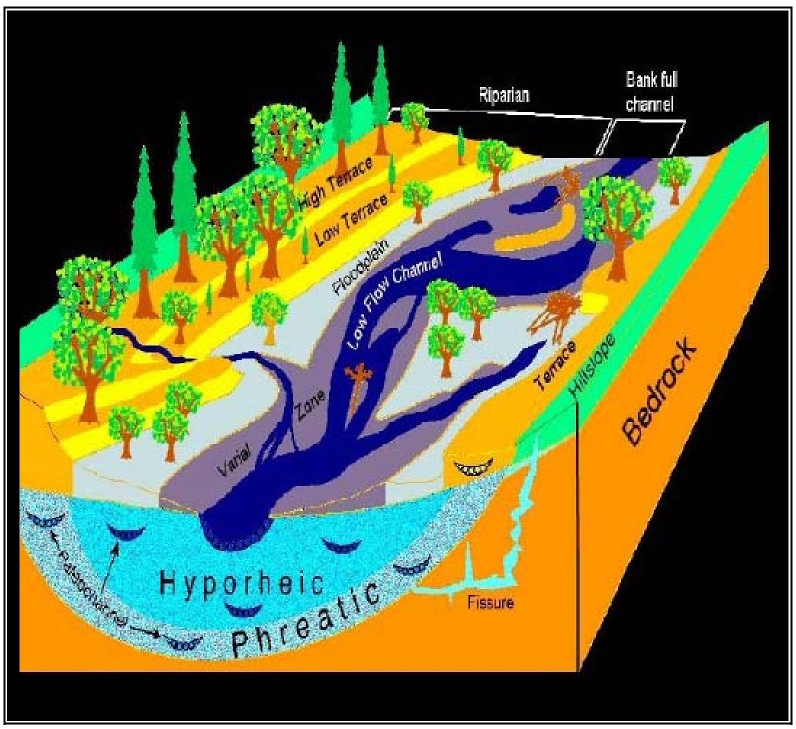


Figure 2-37. Idealized view of natural river ecosystem structure emphasizing dynamic longitudinal, lateral and vertical dimensions, and the role of large woody debris eroded from the riparian zone. This landscape is produced by the legacy of cut and fill alleviation, which is linked to the natural-cultural setting of the catchment (from Stanford 1998)

The long residence time of salmonid species in the basin driven by intraspecific competition; genetic exchange with salmonid populations in similar basins such as the Walla Walla, Umatilla and lower Snake Rivers; and the types of disturbance regimes that occurred have allowed the salmonids in the basin to tailor their life histories to the conditions in this watershed – the shape of the annual hydrograph, the annual temperature regime, and the available habitats (collectively the ecosystem attributes) - and to alter conditions in the watershed itself – the nutrient and energy regime from the import of marine-derived nutrients, fats and proteins in salmon carcasses, eggs, sperm, and fry, and the physical changes in the stream and lake environment due to the act of spawning – to maximize exploitation of available habitats in the Yakima Subbasin and the Middle and Lower Columbia River.

The historic distribution of fall, summer, and spring chinook, coho, steelhead, sockeye, bull trout and other native fish and wildlife were closely tied to the pattern of ecological attributes of the watershed. The distribution of species and their life histories was an interconnected web of nutrient, energy, and habitat pathways that resulted in the tremendous productive potential (for salmonids) of the Yakima Watershed. The areas of the basin that today provide very high levels of agricultural production formerly provided a high degree of natural productivity for the same reasons – long growing season, highly diverse habitats (diverse and rich alluvial, glacial and loessal soil commuities), stability of the water regime in the alluvial valleys and glacial lakes, and abundant nutrient base. These alluvial valleys and the productive main channel and side channel habitats, that today form the basis of the agricultural economy of the valley, remain the primary production areas for the salmonid populations that remain in this basin.

Sockeye salmon populations were historically the most abundant species in the basin. The loss of sockeye, due to conversion of the glacial lakes to reservoirs without fish passage, has resulted in a tremendous loss in species diversity and importation of marine-derived nutrients, and thus the conversion of these once-stable and productive upper watershed habitats to relatively nutrient-poor, unproductive, and biologically disconnected features of the current Subbasin. Naturally reproducing coho have been extirpated from the basin due to a combination of habitat degradation and overharvest of these stocks in the Columbia mainstem and in the subbasin, and the distribution of steelhead has been drastically reduced for similar reasons. The loss of these populations from tributary habitats represented not only a loss in productivity for anadromous fish, but also for the many species dependent upon them, such as predators, aquatic and terrestrial vegetation, and resident fisheries.

6.2 General Approach to Plan Preparation:

The Yakima Subbasin has been the subject of numerous reports, studies, and management activities related to fish and wildlife resources. This Subbasin Plan is simply the latest in a long line of documents that attempt to synthesize these reports into a coherent whole, and goes beyond most of these reports to provide a management direction for expenditure of BPA mitigation funds as required under the Northwest Power Act. Recent publication of several management plans and studies (Watershed Plan, Limiting Factors Analysis, YSS, Reaches Report, etc) have come to mostly similar conclusions regarding the functioning of the subbasin, with some notable exceptions. The approach taken in the formulation of the Assessment was to attempt to find areas of agreement, disagreement, or gaps in the current understanding of the subbasin, and to put that understanding to work in a context specific to fisheries and fish habitat management in the subbasin, the Columbia Basin, and the Pacific Northwest. Additionally, we used the EDT model in collaboration with the Aquatic Technical Committee to assist in comparison of the documents and to update habitat conditions within the subbasin. Below is a list and short summary of the documents, which were most important in the composition of the Subbasin Plan.

6.2.1 General Approach to Fisheries and Habitat Management

Upstream (National Research Council, 1996)

Reference: Upstream – Salmon and Society in the Pacific Northwest. 1996. National Research Council, National Academy Press. Washington, D.C.
Short Summary: Analysis of regional salmon decline by National Research Council of National Academy of Science. It emphasizes habitat degradation, genetic problems associated with hatchery production, over harvest, and institutional constraints as problems and provides generalized restoration mechanisms.
Electronic Tag: http://www.nap.edu/readingroom/books/salmon/index.html

Viable Salmonid Populations (VSP) and the recovery of evolutionarily significant units.

Reference: McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.
Short Summary: This document introduces the viable salmonid population (VSP) concept, identifies VSP attributes, and provides guidance for determining the conservation status of populations and larger-scale groupings of Pacific salmonids. The concepts outlined here are intended to serve as the basis for a general approach to performing salmonid conservation assessments. As a specific application, the VSP approach is intended to help in the establishment of Endangered Species Act (ESA) delisting goals. This will aid in the formulation of recovery plans and can serve as interim guidance until such plans are completed.
Electronic Tag: http://www.nwfsc.noaa.gov/publications/techmemos/tm42/tm42.pdf

Clean Water Act

Reference: 33 United States Code 1251 et. Seq.
Short Summary: Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. It gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry.

The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water or with water quantity issues.) The statute employs a variety of regulatory and nonregulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Electronic Tag: http://www.epa.gov/region5/water/cwa.htm

6.2.2 Fish and Wildlife Management at the Columbia Basin Scale

"WY-KAN-USH-MI WA-KISH-WIT Spirit of the Salmon"

Reference: Columbia River Inter-Tribal Fish Commission 1995. WY-KAN-USH-MI-WY-KISH-WIT Spirit of the Salmon. The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes. Volume 1.

Short Summary: The plan's objectives are to halt the decline of salmon, lamprey and sturgeon populations above Bonneville Dam within seven years, to rebuild salmon populations to annual run sizes of four million above Bonneville Dam within 25 years in a manner that supports tribal ceremonial, subsistence and commercial harvests, and to increase lamprey and sturgeon to naturally sustaining levels within 25 years in a manner that supports tribal harvests. To achieve these objectives, the plan emphasizes strategies and principles that rely on natural production and healthy river systems. Simply stated, the plan's purpose is to put fish back in the rivers and protect the watersheds where fish live.

Electronic Tag: http://www.critfc.org/text/trp.html

Return to the River

Reference: Independent Scientific Group. 2000. Return to the River 2000: Restoration of Salmonid Fishes in the Columbia River Ecosystem. Northwest Power Planning Council Document 2000-12, Northwest Power Planning Council. Portland, OR. 536 pp.

Short Summary: This report examines the scientific basis for fish and wildlife recovery in the Columbia River and, in the light of continued declines of salmon and other species, has developed an alternative conceptual foundation that is grounded in modern scientific thought.

The report is organized into three sections:

Part I. An introduction and background to the salmon problem (Chapter 1), followed by a description of the current conceptual foundation directing salmon restoration and an analysis of the scientific basis for the assumptions and beliefs implied by measures in the Council's Fish and Wildlife Program (Chapter 2), and finally, an explicit description of an alternative ecologically based conceptual foundation for fish and wildlife management (Chapter 3).

Part II. A technical review and documentation of major scientific issues and topics supporting the conceptual foundation (Chapters 4-9).

Part III. A review of the role of monitoring and evaluation in salmon restoration (Chapter 10), and the Independent Scientific Group's conclusions and strategies for restoration from the overall review (Chapter 11).

Electronic Tag: http://www.nwppc.org/library/return/2000-12.htm

Population structure of Columbia River Basin chinook salmon and steelhead trout

Reference: Brannon, E., M. Powell, T. Quinn, and A. Talbot. 2002. Population structure of Columbia River Basin chinook salmon and steelhead trout. Final report to National Science

Foundation and Bonneville Power Administration. Center for Salmonid and Freshwater Species at Risk, Univ. of ID, Moscow, ID. 178 pp

Short Summary: The population structure of chinook salmon and steelhead trout is presented as an assimilation of the life history forms that have evolved in synchrony with diverse and complex environments over their Pacific range. As poikilotherms, temperature is described as the overwhelming environmental influence that determines what life history options occur and where they are distributed.

Electronic Tag: http://www.efw.bpa.gov/Environment/EW/EWP/DOCS/REPORTS/HATCHERY/A08319-1.pdf

6.2.3 ESA listing documents

Bull Trout interim recovery plan

Reference: U.S. Fish and Wildlife Service. 2002. U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon.

Short Summary: The goal of this recovery plan is to describe the actions needed to achieve the recovery of bull trout, that is, to ensure the long-term persistence of self-sustaining, complex interacting groups (or multiple local populations that may have overlapping spawning and rearing areas) of bull trout distributed across the species' native range. Recovery of bull trout will require reducing threats to the long-term persistence of populations, maintaining multiple interconnected populations of bull trout across the diverse habitats of their native range, and preserving the diversity of bull trout life-history strategies (*e.g.*, resident or migratory forms, emigration age, spawning frequency, local habitat adaptations).

To recover bull trout, the following four objectives have been identified:

- Maintain current distribution of bull trout within core areas as described in recovery unit chapters and restore distribution where recommended in recovery unit chapters.
- Maintain stable or increasing trend in abundance of bull trout.
- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies.
- Conserve genetic diversity and provide opportunity for genetic exchange.

Electronic Tag: http://pacific.fws.gov/bulltrout/recovery/Default.htm

6.2.4 Yakima Subbasin Specific Documents

Bull Trout interim recovery plan – Yakima Basin

Reference: U.S. Fish and Wildlife Service. 2002. Chapter 21, Middle Columbia Recovery Unit, Washington. 86 p. *In*: U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon.

Short Summary: The goal of the bull trout recovery plan is to ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout across the species' native range, so that the species can be delisted. To achieve this goal the following objectives have been identified for bull trout in the Middle Columbia Recovery Unit:

- Maintain current distribution of bull trout and restore distribution in previously occupied areas within the Middle Columbia Recovery Unit.
- Maintain stable or increasing trends in abundance of adult bull trout.
- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies.
- Conserve genetic diversity and provide opportunity for genetic exchange.

Electronic Tag: http://pacific.fws.gov/bulltrout/recovery/Chapter_21.htm

Yakima Subbasin Plan 1990

Reference: Yakama Indian Nation. 1990. Yakima River Subbasin Salmon and Steelhead Production Plan. Prepared by the Confederated Tribes of the Yakima Nation, Washington Department of Fisheries and Washington Department of Wildlife for the Northwest Power Planning Council and Indian Tribes of the Columbia Basin Fish and Wildlife Authority. 282pp.

Short Summary. The Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program called for long-term planning for salmon and steelhead production. The main goal of the planning process was to develop option or strategies for doubling salmon and steelhead production the in Columbia River. This is one of 31 subbasin plans that comprise the system planning effort. The Yakima plan describes the subbasin, habitat protection needs, constraints and opportunities for establishing production objectives, anadromous fish production plans, and objectives and implementation strategies.

Electronic Tag: http://www.streamnet.org/subbasin/Yakapp17.pdf

2001 Subbasin Summary

Reference: Fast, D. and L. Berg (eds.). 2001 Yakima Subbasin Summary (Draft). Northwest Power Planning Council, Portland, OR.

Short Summary: A detailed summary of fish and wildlife habitat conditions, population status, and management programs within the Yakima Subbasin. The initial step in subbasin planning, it forms the majority of the basis and analysis for this Subbasin plan.

Electronic Tag: http://www.cbfwa.org/cfsite/documents.cfm

Limiting Factors Analysis for Yakima Watershed, WRIA 37, 38, and 39

Reference: Washington State Conservation Commission. 2001. Habitat Limiting Factors Yakima River Watershed Water Resource Inventory Areas 37 – 39 Final Report.

Short Summary: Section 10 of Engrossed Substitute House Bill 2496 (Salmon Recovery Act of 1998), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes, to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." Although the report is titled as a habitat limiting factors analysis (per the legislation), it is important to note that the charge to the Conservation Commission in ESHB 2496 does not constitute a full limiting factors analysis in the true scientific sense. Analysis of hatchery, hydro, and harvest impacts would also be part of a comprehensive limiting factors analysis. These elements are not addressed in this report, but are being considered in other forums.

Electronic Tag: http://salmon.scc.wa.gov/LFInquiry.html

Watershed Management Plan for the Yakima River Basin

Reference: Yakima River Basin Watershed Planning Unit and Tri-County Water Resources Agency. 2003. Watershed Management Plan Yakima River Basin

Short Summary: The Plan reviews alternatives for improving water resource management in the Yakima Basin, and recommends a preferred alternative for implementation. Goals of the Plan include:

- Improve the reliability of surface water supply for irrigation use;
- Provide for growth in municipal, rural domestic and industrial demand;
- Improve instream flows for all uses with emphasis on improving fish habitat;
- Maintain properly functioning habitat and enhance degraded habitat;
- Protect, improve and sustain ground water quantity and pumping levels of aquifers for the benefit of current and future use;
- Protect surface and ground water from contamination;
- Maintain economic prosperity by providing an adequate water supply for all uses.

Electronic Tag: http://www.co.yakima.wa.us/tricnty/watershedplan.htm

Ecosystem Diagnostic and Treatment (EDT) Model for Yakima Subbasin

Reference: Registered datasets reside at Mobrand Biometrics and are available on their website. EDT overview is located at www.edthome.org.

Short Summary: The EDT model is used as a framework for organization of habitat and population data and as a tool for generation of hypotheses regarding the relationships between habitat and populations in the Subbasin Plan. EDT relates environmental attributes to performance (abundance, productivity, diversity) of certain salmonid populations for which the model has been developed. In certain instances, as discussed in the Assessment, the EDT model predicts certain conditions in the watershed (such as increased susceptibility to pathogens or hatchery fish competing with natural origin fish) as a result of other environmental conditions or existing management practices in the subbasin.

Electronic Tag: Describing the environment and habitat

Interim Operating Plan (IOP)

Reference: U.S. Department of the Interior; U.S. Bureau of Reclamation. 2002. Interim Comprehensive Basin Operating Plan for the Yakima Project, Washington.

Short Summary: This Interim Comprehensive Basin Operating Plan (IOP) provides a frame work within which the Field Office Manager for the Bureau of Reclamation (Reclamation) will operate the Yakima Project to meet the multiple use objectives of the project and the directives of Title XII of the October 31, 1994, Public Law 103-434, Section 1210 (Title XII). Title XII legislation is known as the Yakima River Basin Water Enhancement Project (YRBWEP). The stated goals of Title XII are to: 1) protect, mitigate, and enhance fish and wildlife through various means; and 2) to improve the reliability of water supply for irrigation. In addition to the IOP, Title XII includes directives to develop water conservation, water acquisition, habitat enhancement, improved fish passage and screening, and other means to enhance water supplies in the basin.

Electronic Tag: http://www.usbr.gov/pn/programs/yrbwep/opsindex.html

Review and Synthesis of River Ecological Studies In the Yakima River, Washington, with Emphasis on Flow and Salmon Habitat Interactions

Reference: Snyder, Eric and Jack Stanford. 2001. Review and synthesis of river ecological studies in the Yakima River, Washington, with emphasis on flow and salmon habitat interactions. Prepared for Bureau of Reclamation, Yakima Washington. Open File Report 163-01. Flathead lake biological Station, The University of Montana, Polson, Montana. 118pp.

Short Summary: The US Bureau of Reclamation commissioned an analysis of factors contributing to the decline of salmon and steelhead in the Yakima River in response to a recommendation by the Systems Operations Advisory Committee. Specific objectives were: 1) to review the Yakima literature and data; 2) to determine factors that limit the restoration of anadromous fish; and, 3) to identify data gaps that may be problematic for restoration of salmonids in light of finding under the first two objectives. The report shows that “normative flow” and enhancement of salmonid habitat are needed for long term salmonid restoration.

Electronic Tag: None currently available

Reaches Study Report

Reference: Stanford, Jack, Eric Snyder, Mark Lorang, Diane Whited, Phillip Matson and Jake Chaffin. 2002. The reaches project: ecological and geomorphic studies supporting normative flows in the Yakima River Basin, Washington. Prepared for Bureau of Reclamation, Yakima Washington and Yakima Nation, Toppenish Washington. Flathead Lake Biological Station, The University of Montana, Polson, MT 152pp

Short Summary: An examination of the geomorphology, habitat conditions, bethic production, and temperature conditions that currently exist in the major alluvial floodplains of the Yakima Subbasin, and their relationship to overall ecosystem productivity and salmonid abundance and life history.

Electronic Tag:
http://www.efw.bpa.gov/Environment/EW/EWP/DOCS/REPORTS/YAKIMA/P00005854-1.pdf

Yakima Klickitat Fisheries Project Research and Management Plan and Data

Reference: The Confederated Tribes and Bands of the Yakama Nation. 2003. Yakima Klickitat Fisheries Project Research and Management, Data and Habitat.

Short Summary: The Yakima/Klickitat Fisheries Project (YKFP or Project) is an initiative that is responding to the need for scientific knowledge for rebuilding and maintaining naturally spawning anadromous fish stocks in both basins. The Yakama Nation is pursuing this as the Lead Agency, in coordination with the other co-manager, the Washington Department of Fish and Wildlife, and in cooperation with the Bonneville Power Administration as the funding agency. The project is testing the principles of supplementation as a means to rebuild fish populations through the use of locally adapted broodstock in an artificial production program. Also, the goal is to increase the numbers of naturally spawning fish, while maintaining the long-term genetic fitness of the fish population being supplemented. This concept is being utilized on spring chinook within the Yakima River Basin.

Electronic Tag:
http://www.efw.bpa.gov/Environment/EW/EWP/DOCS/REPORTS/YAKIMA/P00004822-2.pdf

6.3 Focal Fish Species

6.3.1 Introduction

Selection criteria for potential focal fish species included: 1) current status under the Endangered Species Act; 2) ecological significance; 3) cultural significance; 4) life history form and; 5) utilization of key habitats in the basin. The aquatic technical committee identified a number of fish species and stocks that potentially warranted further consideration as focal species for subbasin planning purposes. An initial list of eight species/stocks was evaluated by the Yakima Subbasin Fish and Wildlife Planning Board and later narrowed to six species (Table 2-10).

Table 2-10. Focal species and criteria used for their selection.

Focal Species Criteria	Bull trout	Steelhead/ Rainbow trout	Spring Chinook	Fall Chinook	Sockeye	Pacific Lamprey
ESA Status	Threatened	Threatened	None	None	None - Extirpated	None
Has Ecological Significance	Yes	Yes	Yes	Yes	Yes	Yes
Has Cultural Significance		Yes	Yes	Yes	Yes	Yes
Anadromous and/or Resident	R	A and R	A	A	A	A

Additional rationale used in the evaluation of focal species include:

- Spring chinook – fall spawner, primarily upper basin mainstem and large tributary, and relatively long fresh water residence.
- Fall chinook – fall spawner in lower basin
- Steelhead – spring spawner, utilize upper mainstem and mid/high elevation tributaries, and have a long fresh water residence.
- Bull trout – very specific habitat requirements, yet diverse range of life history strategies, with very long fresh water residence.
- Sockeye – rear in lake environment and have a summer upstream migration, have a relatively long fresh water residence.
- Pacific lamprey – initially a secondary focal species with summer chinook and cutthroat but after public comments, Pacific lamprey is now a primary focal species with the other five focal species listed above. Of great cultural significance.

Each of the six focal species is reviewed in more detail in the sections that follow. In particular, for each focal species this document examines:

- Life history forms observed in the Yakima Subbasin relative to those observed throughout the entire range of the species;
- The historic and current distribution and abundance;
- Important characteristics of individual stocks within the subbasin;
- Behavioral characteristic of the focal species at each major life stage;
- Influence of hatcheries and harvesting on distribution and abundance;
- These factors will then be considered in light of the environmental conditions in each of seven Assessment Units (described in Fish Habitat Conditions).

6.3.2 Spring Chinook

Overview

Life History Forms

Spring chinook are differentiated from other chinook runs (or races) by the timing of their return to freshwater as adults. Adult spring chinook destined for areas upstream of Bonneville Dam (upriver runs) enter the Columbia River beginning in March and reach peak abundance (in the lower river) in April and early May (WDF and ODFW 1994). Chinook salmon may be further classified by the length of time young fish reside in streams prior to migration to the ocean environment. The two dominant behavioral patterns are generally characterized as stream-type or ocean-type (Gilbert 1913). Stream-type chinook spend usually one year (sometimes more) in freshwater as fry or parr before entry into the ocean, whereas ocean-type chinook generally migrate to the ocean in their first year of life (Healy 1991). Spring chinook in the Yakima Subbasin exhibit the stream-type life history form that is typical of northern populations and more southern populations that inhabit headwater tributaries. Occasionally, males mature in freshwater without ever migrating to the sea (Robertson 1957; Burck 1965; Mullan et al. (1992CPa).

Historical Distribution and Abundance

Spring chinook salmon were widely distributed in the Yakima basin prior to Euro-American settlement (Figure 2-38). The historic abundance of spring chinook in the Yakima Basin is poorly known due to the paucity of quantitative data. Therefore estimates of abundance rely on indirect methods rather than capture and release data. Consequently, estimates of spring chinook abundance may vary with methodology and information source. Bryant and Parkhurst (1950) and Davidson (1953) concluded that the Yakima Subbasin could support as many as 500,000 spawning adults. These estimates were based on the quantity of gravel in the basin that was of sufficient size for spring chinook spawning. The NPPC (1989) estimated that returning adult spring chinook could number as high as 200,000 individuals.

While considerable uncertainty exists for estimates of abundance under “reference conditions”, it is clear that populations decreased markedly throughout the upper Columbia Basin as a whole with the construction of mainstem dams. For example, the number of adult spring chinook that entered the Columbia River averaged less than 102,000 in the first eight years after construction of the Bonneville Dam (1938) a decline from previous years.

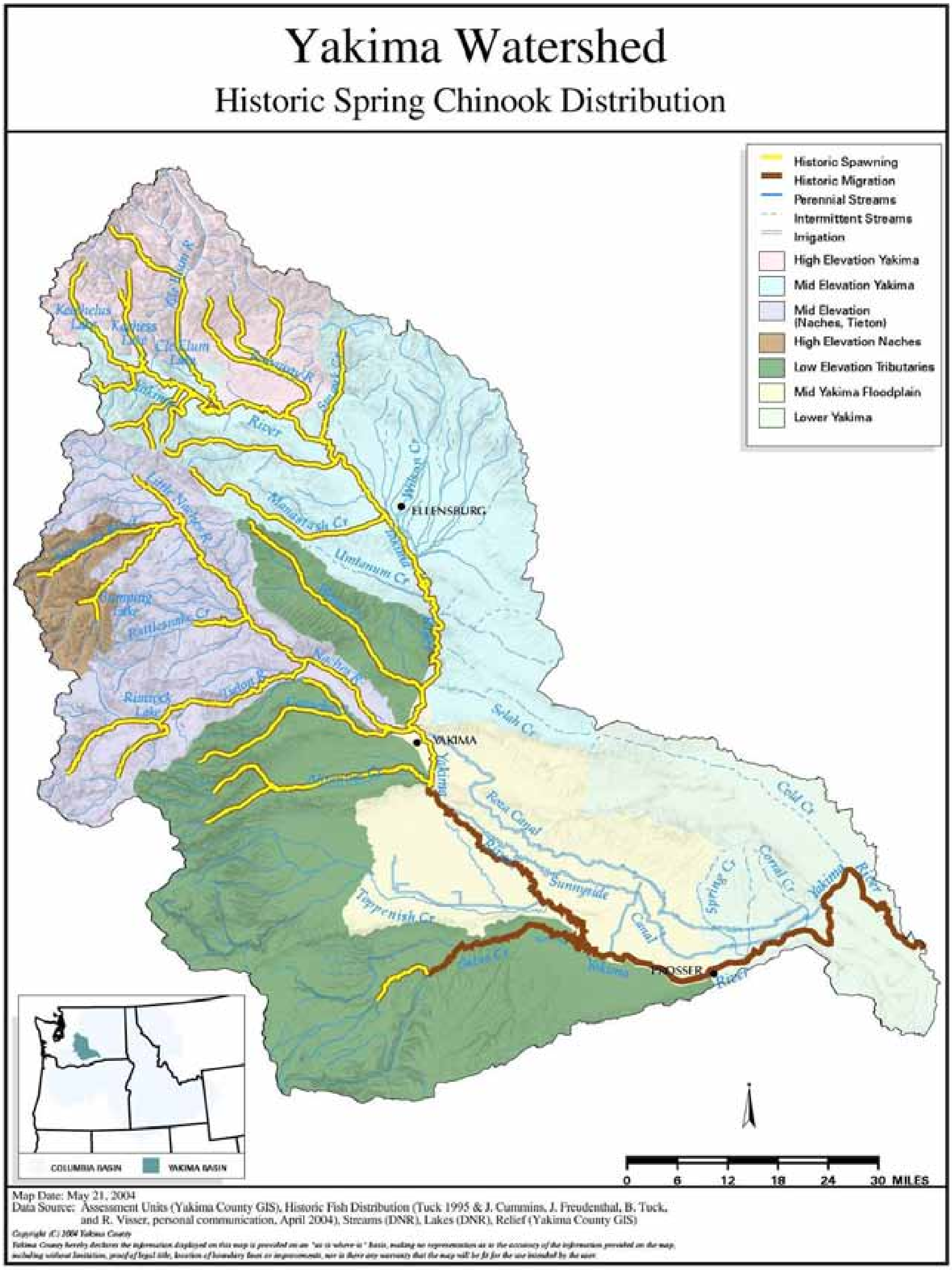


Figure 2-38. Historic spring chinook spawning distribution in the Yakima Subbasin

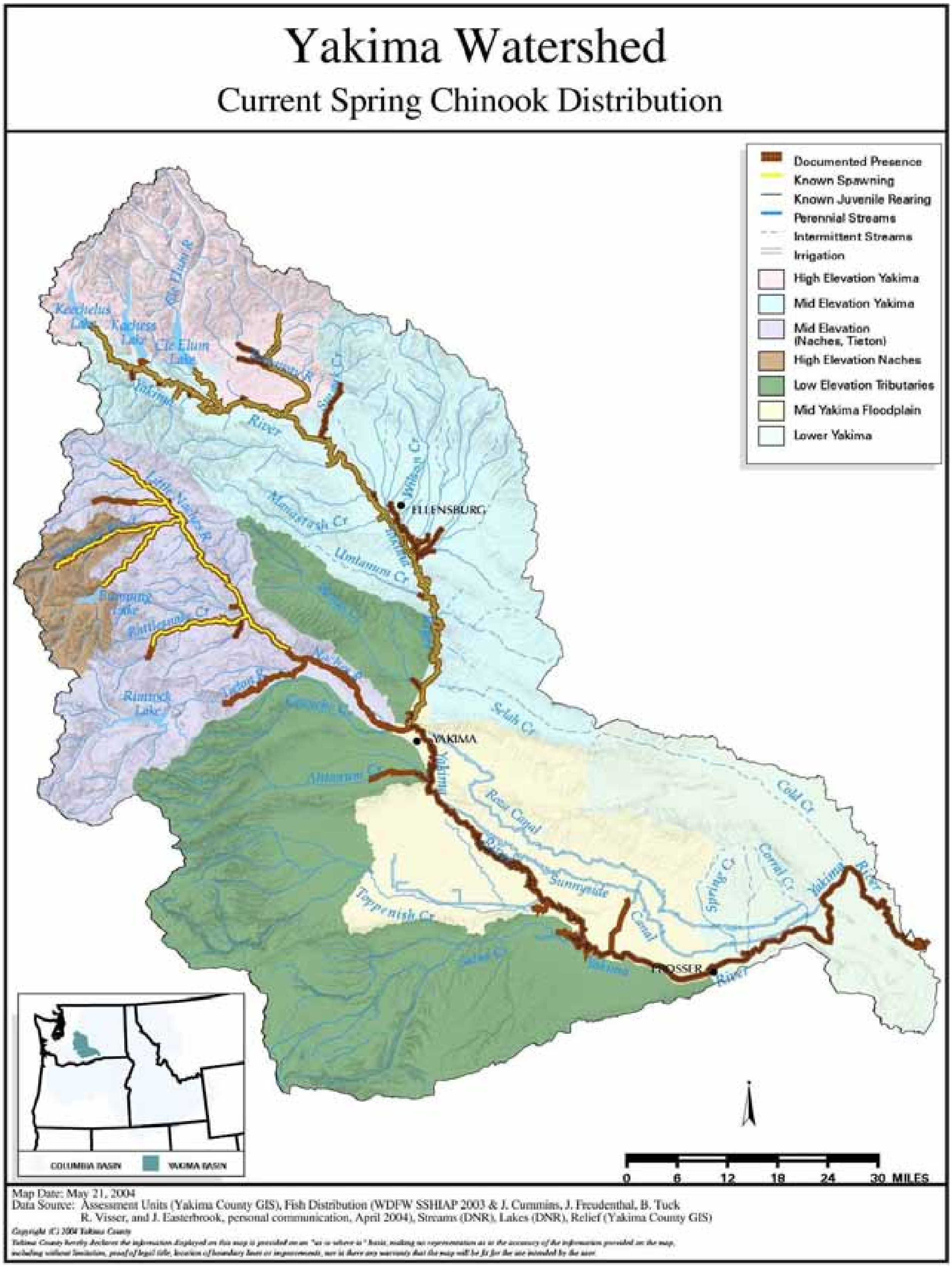


Figure 2-39. Current spring chinook distribution in the Yakima Subbasin. The current distribution figures are based on the most recent GIS data available from WDFW

Current Distribution and Abundance

The current distribution of spring chinook salmon in the Yakima Subbasin has been reduced, but is still relatively similar to historic distribution (Figures 2-38 and 2-39). Notable exceptions include streams rendered inaccessible or unusable by unladdered dams (the upper Cle Elum River, possibly the upper Kachess, and the North and South Forks of the Tieton River) or by excessive irrigation diversions or releases (Taneum, Manastash and Wenas Creeks; the lower Tieton River) (YSS, 2001). The Upper Yakima stock spawns in the Yakima mainstem from Roza Dam (RM 128) to Keechelus Dam (RM 215), as well as the lower Cle Elum River and the North Fork of the Teanaway River. The Naches stock spawns in the Bumping River, the Little Naches River, Rattlesnake Creek, and in the mainstem Naches above the Tieton confluence. The American River stock spawns exclusively in the American River. Although the overall distribution of spring chinook in the Yakima Subbasin has changed little, far fewer fish utilize the remaining areas than did so prior to 1850 (YSS, 2001). Spring chinook abundance is commonly monitored by counting the number of fish passing through dams.

Spring chinook adult passage at Prosser and Roza Dams was observed between 2000 and 2003. Between 4,000 and 22,000 fish successfully passed Prosser and between 6400 and 13,000 successfully passed Roza (Table 2-11, YKFP 2003). Another indicator of spring chinook abundance is the number of redds, or nests, constructed by salmon in the course of spawning. Based on the number of redds observed between 1986 and 2003, the upper Yakima stock is the most numerous of the three stocks. The number of observed redds ranged from the high of 3,836 to a low of 117. The number of redds constructed by fish affiliated with the Naches stock ranged from a high of 849 to a low of 58 during that same time period. Observed redds in the American River were even less common and ranged from a high of 464 to a low of 27.

Table 2-11. Spring chinook counts (Adults and jacks combined) at Prosser and Roza dams, 1982 - 2003. Data source: Yakama Nation Fisheries.

Year	Prosser Dam	Roza Dam
1982	1,499	1,146
1983	867	1,007
1984	2,539	1,619
1985	4,239	2,428
1986	8,909	3,267
1987	4,084	1,928
1988	3,913	1,575
1989	4,354	2,515
1990	2,255	2,047
1991	2,879	no count
1992	4,415	3,027
1993	3,873	1,869
1994	1,302	563
1995	666	326
1996	3,079	1,562
1997	3,173	1,445
1998	1,903	795
1999	2,773	1,704
2000	19,011	12,327
2001	21,472	12,516

2002	14,771	8,922
2003	6,898	3,842

6.3.2.1.1.1

The Upper Yakima population has been the focus of a supplementation program located at the Cle Elum Supplementation and Research Facility (CESRF). Returns since 2000 have included jacks from this program, and hatchery origin fish have made a significant contribution to abundance of this stock since that time (Table 2-12). The stability of the population if supplementation were to cease is not well understood, and much more study is needed

Table 2-12. Wild versus hatchery adult chinook counts at Roza Dam

Year	Hatchery	Wild
2000	663	18257
2001	7170	5346
2002	6384	2538
2003	2284	1558

Probably as a result of the location of an acclimation facility in the Teanaway River, spawner returns and redds in the Teanaway river have increased from near zero to 110 redds in 2002, and 31 in 2003. The long-term success of the introduced spring Chinook population in the Teanaway is also not well understood. The environmental conditions in the Teanaway, specifically the temperature regime, is significantly different from the mainstem Yakima, where the broodstock for the CESRF is collected.

Important stock characteristics

Three genetically distinct stocks of spring chinook have been identified in the Yakima Basin: the upper Yakima, the Naches, and the American River stocks (Marshall et al 1995). The Upper Yakima stock is a native stock with composite production, and the Naches and American River stocks are native stocks with wild production (WDFW, 2002). The Upper Yakima Stock includes the Yakima River, the Teanaway River, and Swauk Creek. The Naches River stock inlcudes the Naches River, the Tieton River, and Rattlesnake Creek. The American River stock resides exclusively in the American River. Besides the genetic (neutral markers) distinctions among them, other biological characteristics show differentiation as well (Marshall et al 1995). The stocks have some similarities in the timing of spawning runs and smolt outmigration and emergence, as well as in pre-smolt migration patterns and smolt age. However each stock has pronounced differences in terms of ocean age, mean fecundity, the spawning timing, and perhaps sex ratio. Although all stocks of Yakima spring chinook smolt as yearlings, adult ages do differ among stocks. For example, 77.5 percent of the spring chinook males and 88.8 percent of adult females in the upper Yakima stock return from the ocean at age 4 (Table 2-13). In contrast, only 58.8 percent of the males and 45.7 percent of the females in the Naches stock return at age 4 while 35.1 percent of the males and 52.7 percent females return at age 5. An even greater proportion of the American River stock adults return at age 5, with 52.8 percent males and 61.4 percent females. Age 4 adults comprise only 41.1 percent and 36.3 percent of the total for the American River stock. A greater proportion of the returning adults in the Upper Yakima stock were jacks (17.1 percent) than in the Naches Basin and American Basin stocks include (~11 percent). Conservation of the genetic diversity and the unique life history traits of each individual stock is an important objective of the Yakima Subbasin plan.

Table 2-13. Sex-specific age distribution of Yakima spring chinook spawners by stock based on mean data from 1986 to 2003 spawning ground carcass surveys. Data source: Yakama Nation Fisheries.

Stock and Age		FRACTION OF MALES THAT ARE AGE x	FRACTION OF FEMALES THAT ARE AGE x	FRACTION OF ALL FISH THAT ARE AGE x MALES	FRACTION OF ALL FISH THAT ARE AGE x FEMALES
UPPER YAKIMA	Age III =	14.4%	3.4%	6.8%	1.9%
	Age IV =	77.5%	88.8%	25.8%	57.9%
	Age V =	8.1%	7.8%	2.8%	4.9%
	Age VI =	0.0%	0.0%	0.0%	0.0%
	Sum	100.0%	100.0%	35.3%	64.7%
NACHES	Age III =	5.0%	1.0%	2.1%	0.3%
	Age IV =	58.8%	45.7%	23.4%	27.1%
	Age V =	35.1%	52.7%	12.7%	33.6%
	Age VI =	1.1%	0.6%	0.4%	0.3%
	Sum	100.0%	100.0%	38.6%	61.3%
AMERICAN RIVER	Age III =	5.6%	0.0%	1.6%	0.0%
	Age IV =	41.1%	36.3%	16.8%	21.0%
	Age V =	52.8%	61.4%	20.1%	39.9%
	Age VI =	0.5%	2.3%	0.3%	0.3%
	Sum	100.0%	100.0%	38.8%	61.2%

Spawning

Run-Timing

Most Columbia River adult spring chinook spend two years in the ocean and, on average, return to their natal streams at four years of age (Mullan 1987; Fryer et al. 1992; Tonseth 2003) (Table 2-13). However, as mentioned previously, the age of migrating adults varies somewhat within and among the Yakima Subbasin stocks. Radio-tagged spring chinook adults were released below Prosser Dam in 1991-92 and monitored through spawning in an effort to determine inter-stock differences in run-timing and delays associated with various dams and fish ladders (Hockersmith et al. 1994). Perhaps the most significant finding of this study was that there was no inter-stock difference in the temporal distribution of fish as they arrived at Prosser Dam. This is true even though there are clear inter-stock differences in the onset and duration of spawning. On average, the dates of 10, 50 and 90 percent cumulative passage are April 10, May 13 and June 3, respectively (Figures 2-40 and 2-41).

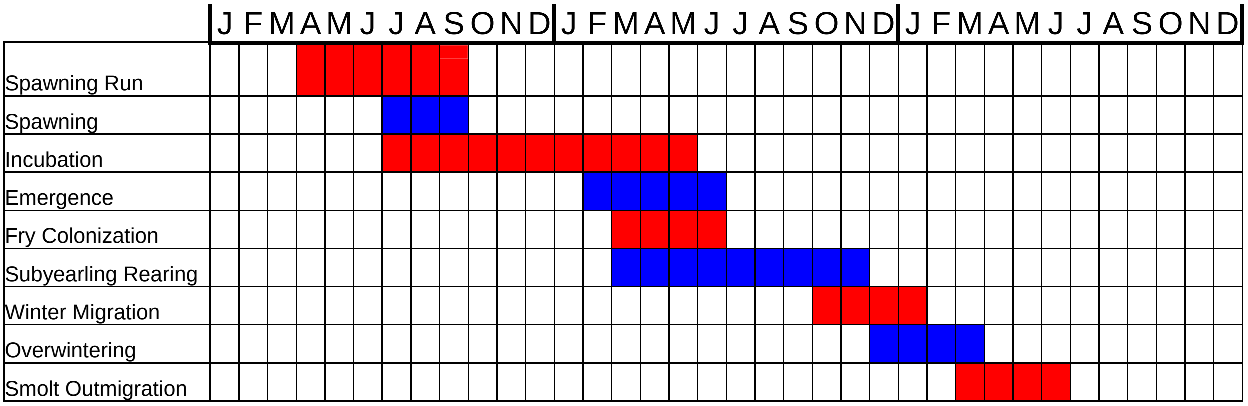


Figure 2-40. Mean timing of successive freshwater life stages of Yakima Basin spring chinook

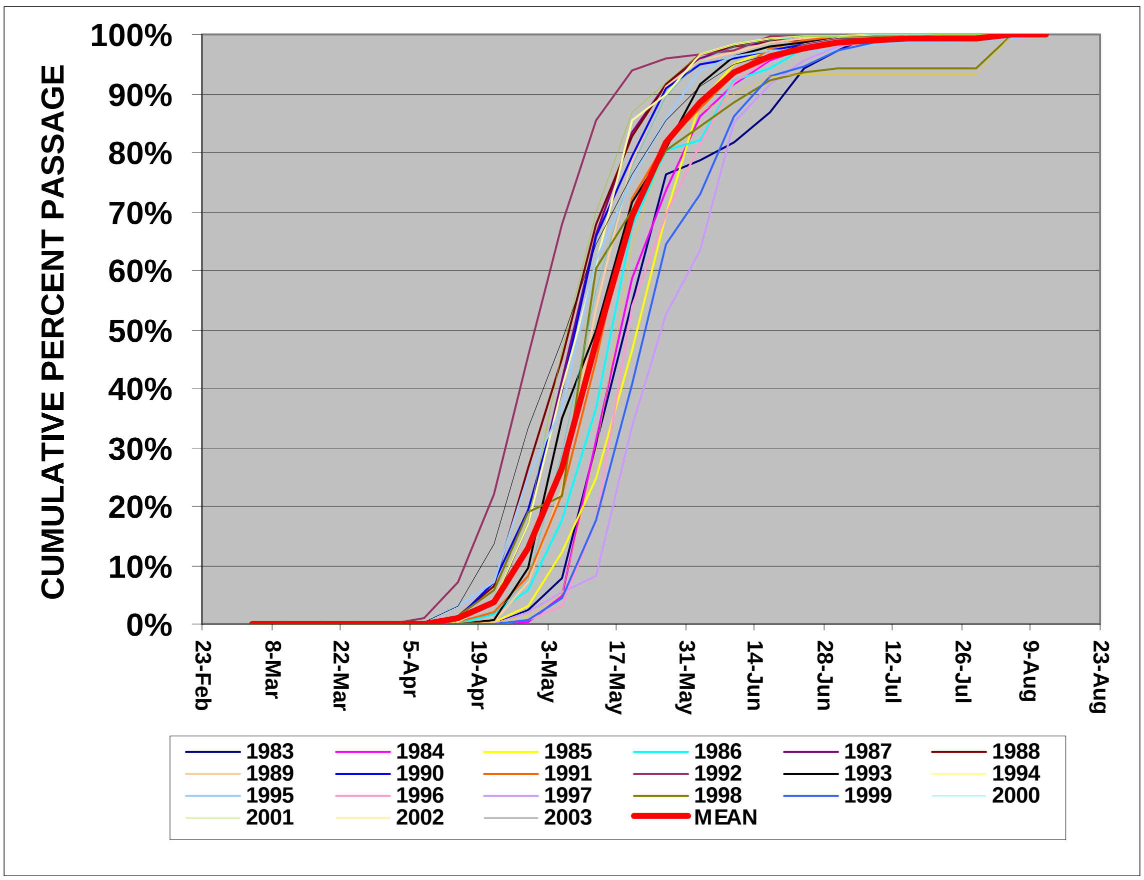


Figure 2-41. Cumulative passage of Yakima spring chinook spawning run at Prosser Dam, 1983-2004

There is, however, considerable variability from year to year, as the run has been 90 percent complete as early as May 20 and as late as June 24, a range of 35 days. The main reason for the interannual variability in run timing is the impact of high and low flows on the migration speed of spring chinook spawners (Figure 2-42). In an average year, the run is half complete 21 days later at Roza than at Prosser. Therefore, given the 81-mile distance between dams, the average fish is traveling at a rate of about 3.8 miles per day. In 1992, a year of unusually low flows, the median fish passed Roza only seven days after it passed Prosser, indicating a migration rate of more than 11 miles per day.

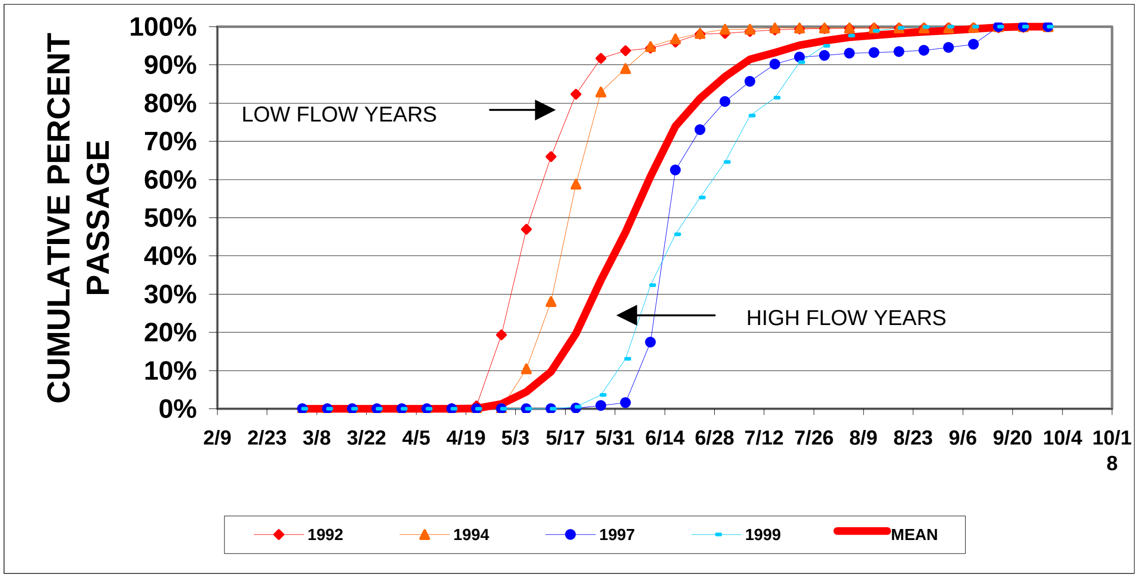


Figure 2-42. Impact of high and low flows on run-timing of spring chinook spawners at Roza Dam

Conversely, in years of high flow, like 1997, fish move considerably more slowly. This is a pattern observed for the spawning runs of all salmon and steelhead monitored in the Yakima Basin: run-timing is delayed during years of high flow and accelerated in years of low flow. Spring chinook enter the mainstem portions of tributaries from late April through July, and hold in deeper pools and under cover until onset of spawning. The spawning population typically includes of a small number of individuals that do not migrate to sea (Healey 1991; Mullan et al. 1992CPb). When male chinook salmon reach sexual maturity without an ocean phase they are known as "precocious". This is known to occur in both wild and hatchery stocks. The largest males are most likely to show evidence of early maturity (Rich 1920), and since hatchery fish reach larger sizes earlier in their development than wild fish this may be the reason why large numbers of hatchery fish mature precociously.

Spawning

Upper Yakima spring chinook spawn in the last 3 weeks of September, and Naches spring chinook generally begin spawning a few days earlier. American River fish spawn in late July through early August. Spring chinook in the Yakima Subbasin may spawn near holding areas or move upstream into smaller tributaries. Spawning activity may be delayed by elevated water temperature but generally peaks between August 8 and August 15 for American River fish, between September 8th and September 18 for the Naches stock and between September 15 and October 1st for the Upper Yakima stock.

While the ocean-type or stream-type life history forms do not differ in average fecundity, most high fecundity populations are stream-type (Healey and Heard 1984). Fecundity also appears to increase in populations that are farther upstream from the mouth of the Columbia River. These factors could be an evolutionary response to the probable higher mortality of migrants (both upstream and downstream).

Incubation and Emergence

Fertilized eggs incubate in the substrate from the time of redd construction in the late fall and winter until emergence as alevins in the spring. Natural spawn timing is related to incubation temperature, earliest in the cold temperatures such as the American, later in warmer temperatures such as the mainstem Upper Yakima. Emergence appears to be quite closely synchronized across stocks despite five to seven week differences in spawning timing. Fry traps were installed below most redds in the American River and in the upper Yakima River in the late winter of 1984 to estimate emergence timing. In the American River, fry were captured between March 20 and June 4, with a median capture date of April 17. In the upper Yakima, fry were captured between March 8 and June 13, with a median capture date of April 16. This range of emergence timing—from early March through mid June with a peak in mid April—was also seen in the capture dates of fry collected in mesh traps (“redd caps”) that were fitted over spring chinook redds in the upper Yakima in 1984, 1985 and 1986 (Fast et al 1991). The mean egg-to-fry survival for the redds capped in these years was 60 percent, a figure assumed representative for upper Yakima spring chinook.

Rearing

Juvenile spring chinook in the Yakima Subbasin generally spend one year in fresh water before they enter the sea. Healey (1991) reported that some populations in more northern rivers produce smolts that spend an additional year in fresh water, but the vast majority of stream-type chinook spend no more than one winter in fresh water before they enter the sea. Juveniles from all three Yakima Subbasin stocks redistribute themselves downstream the spring and summer after emergence, with highest densities in summer being found well below the major spawning areas, but above Sunnyside Dam. The lack of fish in the lower Yakima mainstem (below Sunnyside Dam) is attributed to excessive summertime water temperatures (Fast et al. 1991). Water temperatures of 70^{o}F or more are actively avoided by juvenile salmonids, and temperatures in excess of 77^{o}F are lethal

Smolt Outmigration

Smoltification is the term that describes the physiological transformation that juvenile salmon undertake in preparation for life in the marine environment. Another characteristic common to all stocks of spring chinook is an extensive downstream migration of pre-smolts in the late fall and early winter. Various observations over recent years have led to the conclusion that most spring chinook pre-smolts migrate to the lower Yakima mainstem when water temperatures fall sharply in the late fall. This thermal trigger occurs earlier in the upper reaches of the basin. Subyearling migrants begin appearing at the Wapatox Dam smolt trap on the lower Naches (RM 17.1) and at Roza Dam trap on the mid Yakima (RM 127.9) in October and November, and usually during December at the Chandler smolt trap at Prosser Dam on the lower Yakima (Fast et al 1991). Most wild Yakima spring chinook overwinter in the deep, slackwater portion of the mainstem Yakima between Marion Drain (RM 82.6) and Prosser Dam (Fast et al.1991), and begin their smolt outmigration from the lower river the following spring. This is commonly referred to as the “winter migrant” life history pattern. In contrast, 10-35 percent of the juveniles from a given brood year begin outmigration much nearer natal areas in the Naches and upper Yakima drainage and move below Prosser Dam during the winter. This behavior is known as the "upriver smolt" pattern.

The outmigration timing of Yakima spring chinook smolts is quite variable. Although the average dates of 10, 50 and 90 percent cumulative passage at Chandler are April 6, April 23 and May 20, respectively, the outmigration can be 90 percent complete as early as April 28 or as late as June 1 (Figure 2-43). The overall timing of the outmigration does not appear to be shifted earlier or later by flow, although the migration rate of actively migrating smolts is positively correlated with flow. The gross timing of the outmigration seems instead to be a function of water temperature the winter preceding smoltification. Specifically, there is an inverse relationship between the mean outmigration date and the thermal units accumulated over the months of December through March: the more degree-days in the Yakima through the coldest part of winter, the earlier the outmigration.

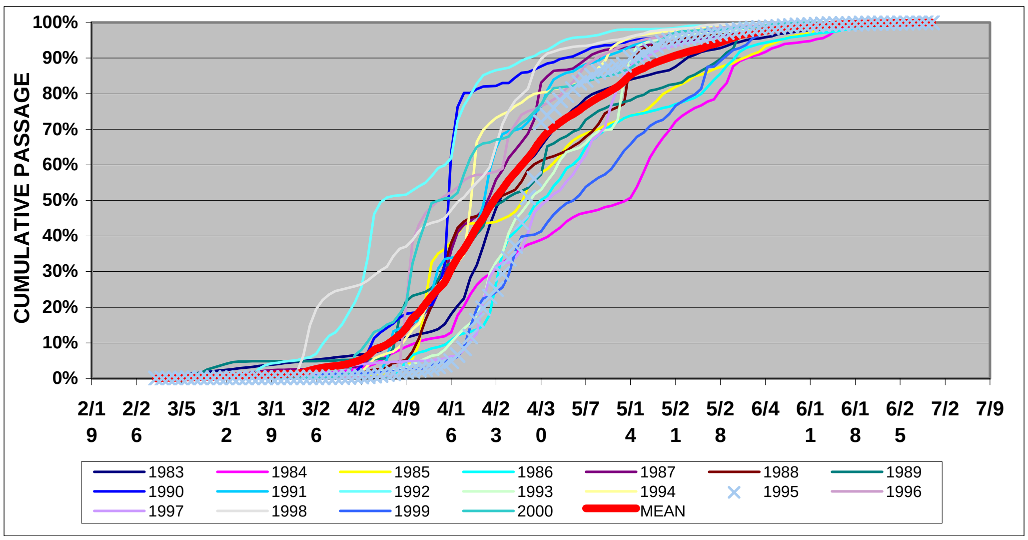


Figure 2-43. Outmigration timing of spring chinook smolts at Chandler trap, 1983-2000

Hatcheries

The Yakima/Klickitat Fisheries Project (YKFP) began artificial production of spring chinook in 1997 with the completion of the Cle Elum Supplementation and Research Facility (CESRF). This facility was designed to conduct research on hatchery supplementation. The Northwest Power Planning Council stated, "the purpose of the Yakima/Klickitat Production Project is to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining genetic resources. It also emphasized that careful evaluation of supplementation and employment of adaptive management methods will be needed to accomplish this purpose. Such an approach should add the benefits of learning about supplementation and hatchery systems while contributing to the Council's goal of increasing salmon and steelhead runs in the Columbia River Basin" (YSP 1990). Genetic impacts are monitored in terms of domestication and within and between population variability. Ecological impacts on nontarget stocks are be monitored by comparing abundance, size structure, geographic distribution and interaction indices before and after supplementation. Impacts of nontarget species on project fish are assessed by indices of predation, competition, prey abundance, mutualism and disease. The ongoing research and monitoring activities associated with the CESRF provide information on the effectiveness of restoration, hatchery supplementation technology and effectiveness, and other population management strategies that can benefit fisheries and habitat management in the Yakima Subbasin and in the Columbia Basin as a whole.

Adult spring chinook salmon are collected at the Adult Collection and Monitoring Facility located at Roza dam. Adults are randomly collected throughout the duration of the spawning migration. Initially it was decided that no hatchery-returning adults would be used for brood stock. Some experimental crosses between hatchery and wild fish will be done to evaluate domestication selection. It was also determined that no more than fifty percent of the total wild run could be taken into the hatchery for broodstock. This will insure that there will always be natural spawning occurring in the river.

Upon selection for brood stock, the adult salmon are measured, weighed, PIT tagged and transported by truck to the supplementation facility at Cle Elum. The adults are held in ponds through the summer. Spawning is done in September and early October. All adults are identified by their PIT tag code, DNA samples are taken, fish health samples are collected by USFWS, and the female's eggs are collected. Each females egg complement is divided into three equal components, and each of these is fertilized with the sperm from a separate male. The eggs are mixed together and incubated. At the eyed stage the eggs are divided into two groups, the control and treatment, for experimental purposes.

The fry are ponded in March and reared in the control or Optimum Conventional Treatment (OCT) group or the Semi Natural Treatment (SNT) group. OCT consists of juvenile hatchery rearing conditions that have been shown to be successful at various state tribal and federal hatcheries in the Northwest. The SNT treatment has the same densities, flows, etc as the OCT but also has raceway walls painted to resemble natural stream conditions, overhead cover, instream cover (submerged Christmas trees), and underwater feeders. There are nine raceways that are designated as OCT and nine are for the SNT fish, with about 45,000 juveniles reared in each raceway. The experiment is designed to determine if these more natural rearing conditions can improve survival and behavior of the juveniles. The juveniles are marked in the fall, with about 10 percent receiving PIT tags and all fish receiving coded-wire tags (CWT) that are placed in different body locations. These CWT fish can then be identified without sacrificing the experimental fish to recover the tags. The CWTs are coded so that each group (raceway) has its own code for identification of carcasses on spawning grounds. The juveniles are transported to three acclimation sites in late January or early February. Each of the acclimation sites has six raceways, with three OCT and three SNT. The fish are confined in the acclimation raceways for six weeks and then allowed to volitionally release for migration out of the subbasin. The smolts are monitored for PIT tags at various dams on their migration corridor to the ocean. Post release survival is calculated from these various detections. All adults returning to the upper Yakima can be identified at the Roza adult monitoring facility. Thus survival rates of returning adults can be determined at that facility. There is monitoring of harvest in the Yakima to collect any tag information of fish caught below Roza dam. YKFP managers are also requesting that other harvest monitors (in ocean and Columbia River) report tag information to the project. For more information on the CESRF and YKFP see the Inventory section.

Details on operations and practices employed at the hatchery are available at the Artificial Production Review and Evaluation (APRE) report on the CESRF at APRE Summary. After review of both the APRE and draft HGMPs for this facility there are no significant concerns with its operation or management that are not directly addressed in the experimental design and purpose of the facility.

Harvest

The State of Washington, the Yakama Nation and the Confederated Tribes of the Umatilla Indian Reservation regularly schedule fisheries in the Yakima River Basin. Each jurisdiction has retained the authority to regulate its fisheries upon approval of its respective governing bodies. Fishing regulations authorize fisheries and describe lawful gear, fishing area, notice restrictions, and other miscellaneous regulations for fisheries enforcement purposes. All fisheries are monitored and enforced by agencies of the respective jurisdictions to ensure compliance and to provide accurate in-season accounting of harvest. Fisheries are routinely coordinated and fishery data shared between the co-management authorities via the United States v. Oregon harvest management process.

Tribal Fisheries

The majority of tribal fishing effort occurs during a fishery typically open from early April through mid-June from the mouth of the Yakima River upstream to the Wapato irrigation dam just south of Union Gap. Weekly fishing periods are set annually and generally vary from 2.5 to 4.5 days per week depending on expected run size and can be adjusted based on in-season run size and harvest data. With the implementation of the CESRF, monitoring of tribal spring chinook fisheries in the Yakima River Basin has been increased with harvest monitors observing the fishery for an average of nearly 1,500 hours annually since 1999. The spring chinook fishery has also been sampled for biological and stock composition purposes since 1999. A tribal fishery is also open on the Yakima River during the fall with tribal monitors typically recording over 100 hours of observation of the fishing effort and harvest. However, very little effort and virtually no harvests have been observed in these fall fisheries in recent years.

At other times of the year, the Yakima River and selected tributaries within the Yakama Reservation are open to fishing by tribal (and sometimes by non-tribal) members. Regulations are promulgated annually specifying closures at times and places where steelhead spawning is known to occur. Since fishing effort and success in these fisheries are very sporadic, there is no routine monitoring program. Harvest is assumed to be minimal in these fisheries.

Harvest Estimates

Estimated annual harvests of spring chinook in tribal and non-tribal fisheries in the Yakima River Basin in recent years are given in Table 2-14.

Table 2-14. Spring Chinook Harvest in the Yakima River Basin, 1982-Present

	Tribal		Non-Tribal		River Totals			Harvest
Year	Adults	Jacks	Adults	Jacks	Adults	Jacks	Total	Rate[1]
1982	434	0	0	0	434	0	434	23.8%
1983	84	0	0	0	84	0	84	5.8%
1984	289	0	0	0	289	0	289	10.9%
1985	865	0	0	0	865	0	865	19.0%
1986	1,340	0	0	0	1,340	0	1,340	14.2%
1987	517	0	0	0	517	0	517	11.6%
1988	444	0	0	0	444	0	444	10.5%
1989	747	0	0	0	747	0	747	15.2%
1990	663	0	0	0	663	0	663	15.2%
1991	32	0	0	0	32	0	32	1.1%
1992	309	36	0	0	309	36	345	7.5%
1993	129	0	0	0	129	0	129	3.3%
1994	25	0	0	0	25	0	25	1.9%
1995	66	13	0	0	66	13	79	11.9%
1996	450	25	0	0	450	25	475	14.9%
1997	575	0	0	0	575	0	575	19.2%
1998	188	0	0	0	188	0	188	9.9%
1999	321	283	0	0	321	283	604	21.7%
2000	2,271	87	92	8	2,363	95	2,458	12.8%
2001	2,510	96	1,908	116	4,418	212	4,630	19.9%
2002	2,507	73	523[2]	5	3,030	78	3,108	20.6%
2003	352	88	0	0	352	88	440	6.3%

1. Harvest rate is the Yakima River Basin harvest as a percentage of the Yakima River mouth run size.
2. Includes estimate of post-release mortality of unmarked fish.

Recreational Fisheries

A spring chinook salmon “test” fishery in the upper Yakima River in Kittitas County, the first in approximately 40 years, was open 8 weekend days from June 10 - July 2, 2000. The fact that this reach of the Yakima was open year-round for catch and release trout fishing and selective gear rules (no bait, single barbless hook), caused some concern among trout fly fishers.

The second spring chinook season in recent history was open April 21, 2001 in the middle Yakima River from State Route 223 Bridge at Granger to 3,500 feet below Roza Dam Anglers were allowed to harvest two salmon per day (hatchery or wild) with a season limit of ten salmon per person. The fishery was originally planned to close on June 15, but due to higher than expected harvest rates and a slightly lower run size than forecast, the season was closed on May 28. Opening this fishery in the reach from Granger to Roza Dam reduced the conflict between salmon and trout anglers, and also avoided the problem that hatchery fish are anesthetized at Roza Dam, and cannot be used for human consumption for at least 21 days after being anesthetized.

A spring chinook season was again open April 20 - June 16, 2002 from State Route 223 Bridge at Granger to 3,500 feet below Roza Dam. Anglers were allowed to harvest two adipose-clipped hatchery salmon per day (wild fish had to be released) with a season limit of ten salmon per person. In 2002, for the first time, the spring chinook run included three age classes (age 3, 4 and 5) of Yakima/Klickitat Fisheries Project (YKFP) hatchery supplementation fish (brood years ‘97, ‘98 and ‘99). The pre-season forecast predicted an adult return of 12,300 hatchery and 9,500 wild fish for a total river mouth return of 21,800. During co-manager discussions with the YN, WDFW agreed to limit non-tribal sport harvest to YKFP hatchery fish in 2002 (and in most future years unless a very large (unspecified) wild run of Naches Basin chinook return). This was done to reduce “mixed stock” fishery impacts to the un-supplemented, “weak stock” of wild fish returning to the Naches Basin. In 2001, the sport fishery was permitted to harvest both wild and hatchery fish, but the wild component was substantially larger (2001 forecast: 16,100 wild; 10,000 hatchery).

There was no fishery in 2003, again due to low run size. A fishery is scheduled for 2004, from April 16 – June 15, again for hatchery chinook. Wild chinook must be released. The run size forecast is similar to 2002, so expectations are high for a very successful fishery.

Table 2-15. A summary of recent spring chinook sport fishing seasons and regulations

Season	River Reach Open to Fishing	Daily Limit	Additional Restrictions
June 10 – July 2, 2000*	Roza Dam to Teanaway Access	1	Bait prohibited, non-buoyant lure
April 20 – June 16, 2002	3500 ft below Roza to Granger	2	Wild release, 10 fish season limit
April 21 – May 28, 2001	3500 ft below Roza to Granger	2	10 fish season limit
No season in 2003			
April 16 – June 15, 2004	3500 ft below Roza to Granger	2	Wild release

*Weekend days only

Although wild spring chinook salmon production has increased significantly, beginning with the 2000 return, a significant part of the increase in adult production and returns is the result of experimental hatchery smolt supplementation from the YKFP.

Recreational fisheries for Yakima River spring chinook salmon will be conducted annually when the run size exceeds spawning requirements and a significant adult surplus is available for tribal and non-tribal harvest. Spring chinook fisheries typically commence in late April and continue into June, well before adult steelhead begin their migration into the Yakima River, which usually begins in late September. Fishery timing and locations provide temporal and spatial separation between spring chinook salmon anglers and wild adult steelhead and the encounter rate is virtually zero. Those steelhead caught and released are generally spawned out kelts. The 2002 Yakima spring chinook sport fishery was “biologically conservative” with a modest adult exploitation rate (3.6 percent) comparable to harvest rates on more threatened stocks. This conservative approach will continue into the future. The sport fishery was very popular and generated considerable support from both local and out-of-basin anglers, professional guides and bait/tackle retailers. The spring chinook fishery generates significant direct and indirect benefits to the local economy, as well as less measurable, but equally important "quality of life" benefits. The WDFW in cooperation with Yakama Nation will continue to provide biologically sound, fishing seasons for salmon in the Yakima Basin, consistent with resource stewardship obligations.

Sport Fishery Monitoring

A creel census was condusted on all eight days of the "test" spring chinook season of 2000, which was open on June 10-11, 17-18, 24-25, and July 1-2, 2000 (Table 2-16). Interviews were done with 320 salmon anglers who fished 941 hours, and caught and kept 29 adult and 2 jack spring chinook. Although good estimates of total fishing effort were not obtained, the product of a crude estimate of effort and catch per unit effort results in estimated harvest of 100 salmon during 780 angler days of fishing effort.

In 2001 a total of 1,516 bank anglers and 354 boat anglers (1,870 combined) were interviewed. Interviewed bank anglers fished 4,060 hours and caught 118 adults, 68 jacks, and released 1 steelhead. Interviewed boat anglers fished 2,714 hours and caught 99 adults, 3 jacks and did not release any steelhead. Estimated harvest was 1,918 adults and 105 jacks

A total of 485 bank anglers and 217 boat anglers were interviewed during the 2002 fishery. Interviewed bank anglers fished 892 hours, harvested 7 hatchery adults, and released 3 wild adults. Interviewed boat anglers fished 1,523 hours, harvested 51 hatchery adults, one jack and released 32 wild adults. The expanded season estimate for harvest of hatchery fish was 487 adults and 5 jacks; an estimated 357 wild adults and 0 jacks were released.

Table 2-16. Yakima spring chinook harvest 2000 to 2003.

Year	Adult	Jack
2003	No Fishery	
2002[1]	487	5
2001	1,918	105
2000	92	8

[1]2002 spring chinook fishery was open for retention of hatchery chinook only

Key Findings for Spring Chinook:

- Spring chinook populations have been dramatically reduced from pre-1850 abundance levels.
- Range of Spring Chinook has been reduced.
- Yakima Subbasin stocks redistribute themselves downstream the spring and summer after emergence, with highest densities in summer being found well below the major spawning areas, but above Sunnyside Dam.
- Increases in abundance of spring chinook as a result of the supplementation of the population at the Cle Elum Supplementation and Research Facility have allowed in Subbasin Tribal and Sport harvest for the first time in over 40 years.

Key Uncertainties for Spring Chinook:

- Ongoing activities associated with the Cle Elum Supplementation and Research Facility provide information on the effectiveness of restoration, supplementation technology and effectiveness, and other population management strategies that can benefit fisheries and habitat management in the Yakima Subbasin and in the Columbia Basin as a whole. The stability of the population if supplementation were to cease is not well understood and much more study is needed.
- As a result of the location of an acclimation facility in the Teanaway River, spawner returns and redds in the Teanaway river have increased from near zero to 110 redds in 2002, and 31 in 2003. The long-term success of the introduced spring Chinook population in the Teanaway is also not well understood. The environmental conditions in the Teanaway, specifically the temperature regime, is significantly different from the mainstem Yakima, where the broodstock for the CESRF is collected.
- The purpose of the Yakima/Klickitat Production Project is to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining genetic resources.

6.3.3 Fall Chinook

Overview

Life History Forms

Fall chinook are generally recognized as runs that return to natal streams for spawning during periods within the latter months of the year. This life history type is also referred to as Ocean Type. In the Yakima Basin, the timing of the spawning run is specifically in the September-November timeframe, with actual spawning taking place in October and November. Incubation extends throughout the winter and spring and is followed by emergence/fry growth/outmigration in the February-July period (Figure 2-44). This comparatively short instream development, followed by outmigration to saltwater prior to reaching a full year in age, which places fall chinook in the “ocean-type” life history category.

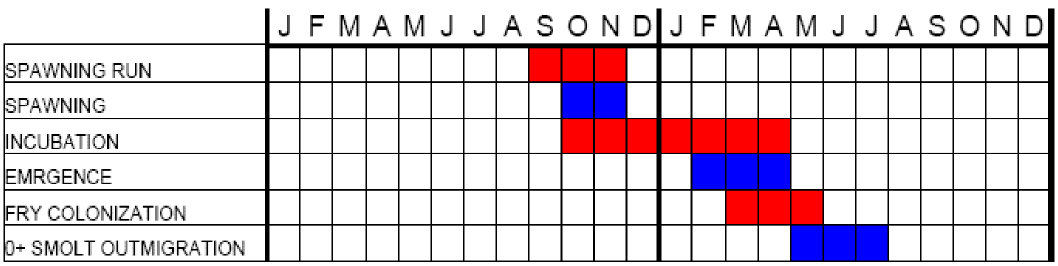


Figure 2-44. Mean timing of successive life stages of Yakima basin fall chinook

Historical Distribution and Abundance

As noted in the Yakima Subbasin Summary (2001), “Little is known about the historical distribution of fall chinook, although [fisheries] managers generally believe the primary production area was the same as it is today: the lower ~100 miles of the Yakima mainstem, from the current site of the Sunnyside Dam to the Columbia confluence (Figure 2-45).” The YSS (NPPC 2001) goes on to speculate that the historic distribution may have been somewhat broader, especially that there might have been some additional upstream extent as well as more successful utilization of the upper portions of the range.

There has also been the relatively recent (early 20th century) development of a separate, self-sustaining population of fall chinook in the Marion Drain. Some researchers speculate that this is the remnant endemic Yakima fall chinook strain**.** Similarly, there is limited information regarding historic abundance of fall chinook. The YSS (NPPC 2001) states that “[t]he scant literature on the subject suggests that historical abundance probably ranged from about 38,000 to 100,000” (based on two studies, using significantly different methods, from the early 1990s). In a recent master’s thesis, Tuck (1995) summarized the findings of various researchers and agencies from 1953 forward. These several older sources all arrived at estimates in the same range as noted in the YSS (NPPC 2001), above, with a tendency toward the high end of that range. By any estimation, the abundance of Fall Chinook has been significantly reduced from historic levels**.**

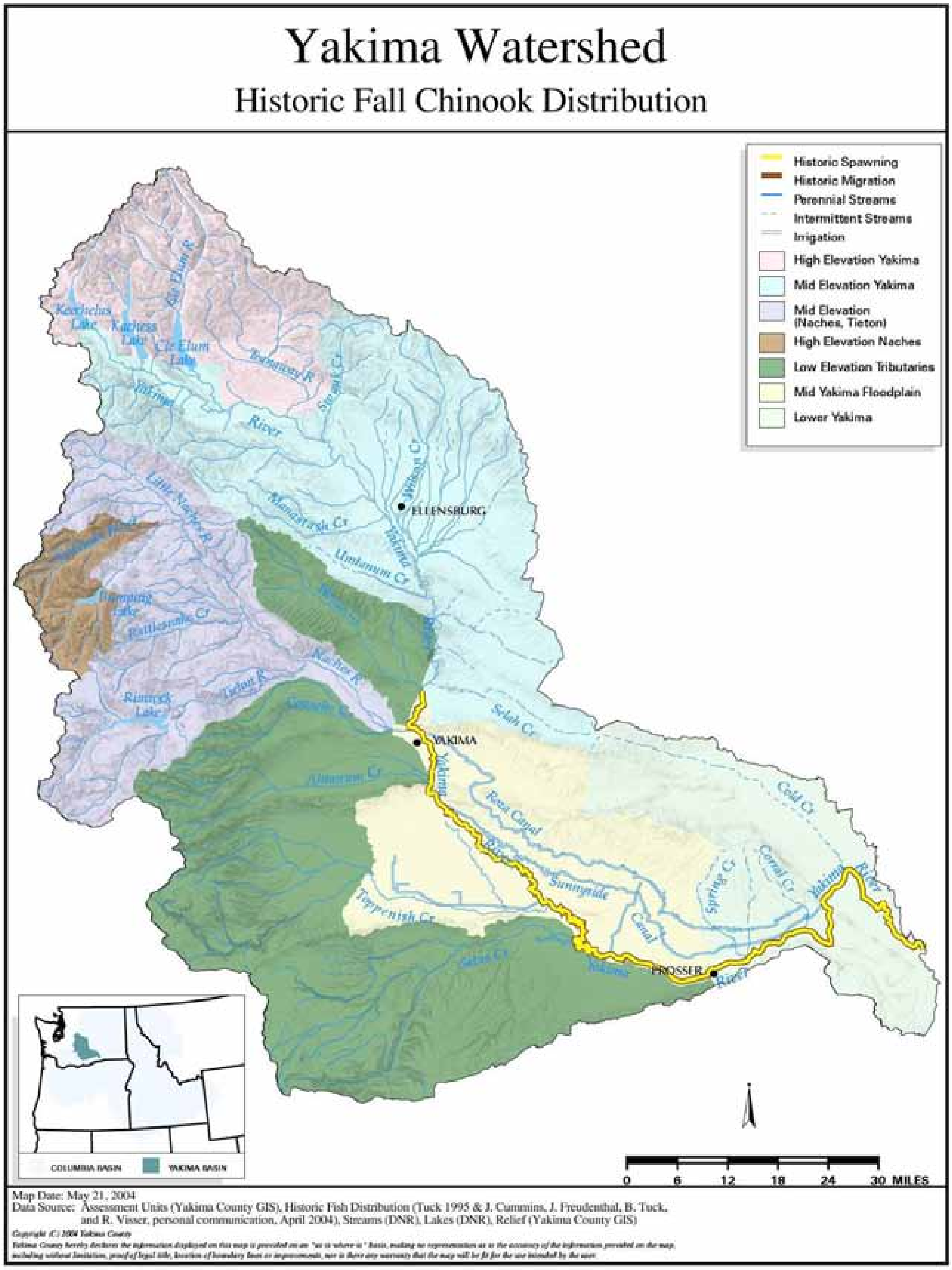


Figure 2-45. Historical spawning distribution of fall chinook in the Yakima Subbasin

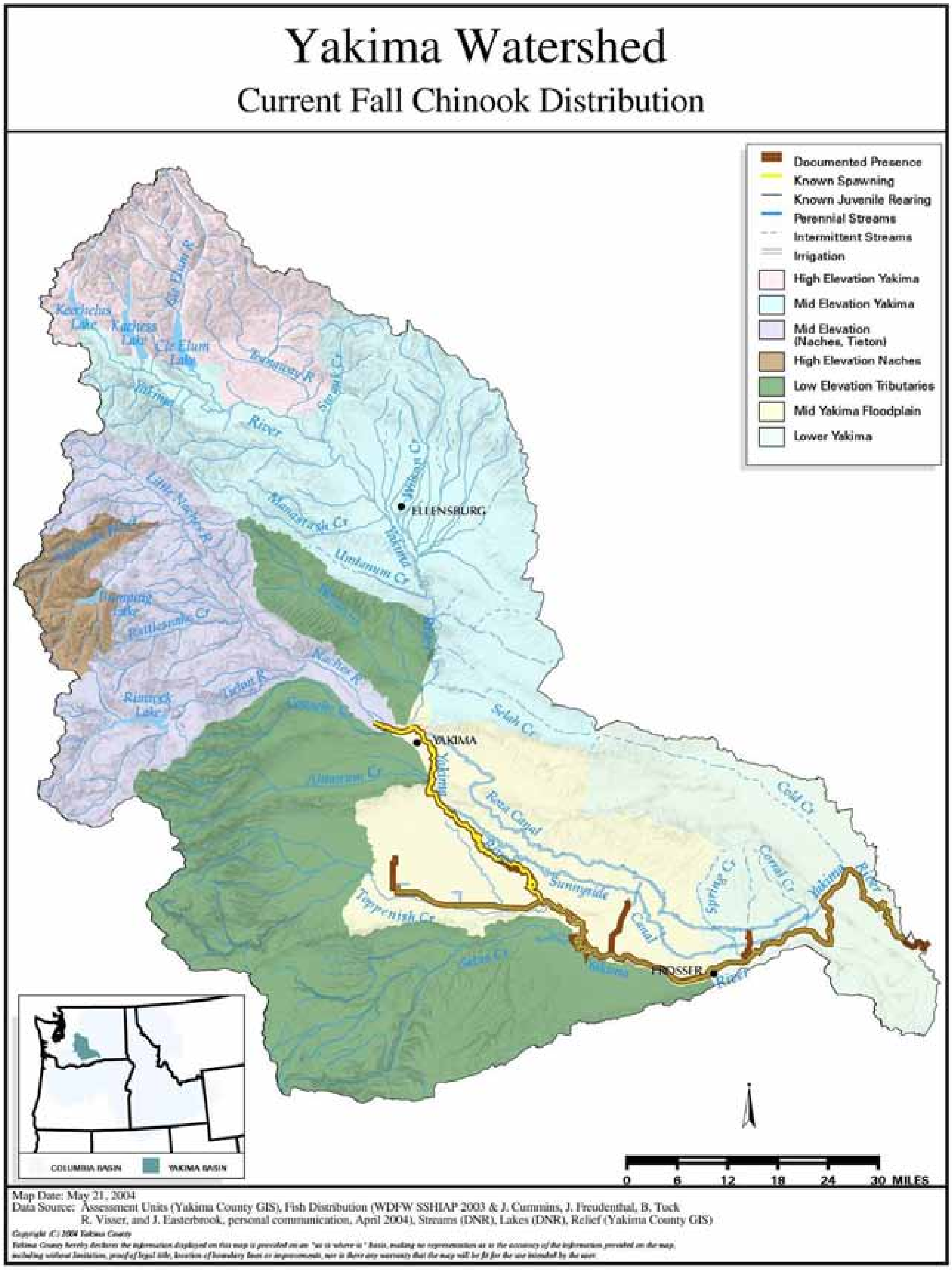


Figure 2-46. Current distribution of fall chinook in the Yakima Subbasin

Current Distribution and Abundance

There are two genetically distinct stocks of fall chinook recognized in the Yakima Basin. The mainstem stock is found throughout the lower mainstem (roughly the lower 100 miles), and the Marion Drain stock is endemic to the Marion Drain (Figure 2-46). Marion Drain is a unique, man-made feature of the watershed, consisting of a 19-mile-long drainage ditch for the Wapato Irrigation Project (WIP). The original ditch was dug early in the 20th century to drain wetlands and was enlarged over the years to serve as a major delivery canal for WIP. It discharges into the Yakima River at RM 82.6, 2.2 miles upstream of the mouth of Toppenish Creek.

As noted in the discussion of historic distribution, current distribution is thought to be similar to the historic (Figures 2-44 and 2-45). Current distribution continues to be along the lower mainstem of the Yakima up to approximately RM 100, and includes the Marion Drain "tributary".

Fall chinook abundance has been measured for many years. Figure 2-47 (NPPC 2001) illustrates the escapement through the Prosser Dam and the estimated redd counts from the Marion Drain during the 18-year period of 1983-2000. These suggest a fairly wide fluctuating abundance, with the Prosser escapement ranging from as low as 232 in 1988 to as high as 1,612 only 4 years later.

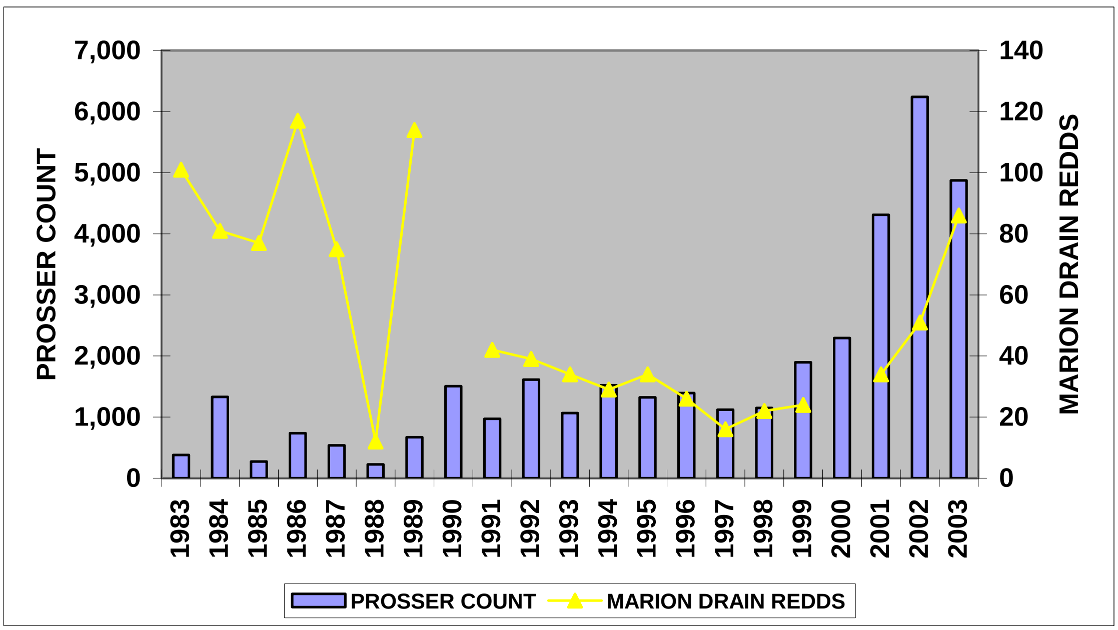
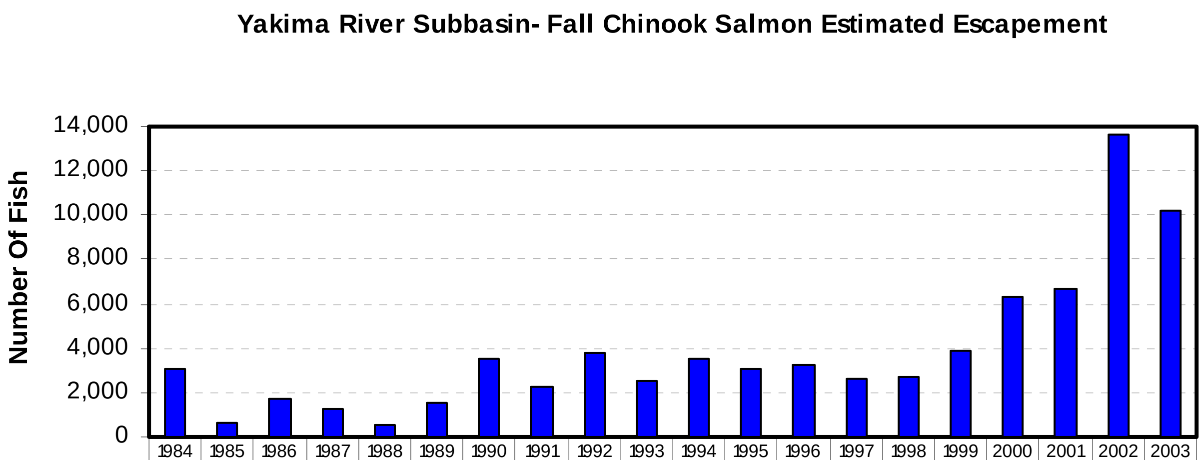


Figure 2-47. Prosser Dam counts of all chinook (adults + jacks) and Marion Drain

Because fall chinook utilize the river below Prosser Dam (the lower 47 miles of the mainstem), estimates of abundance must include the addition of escapement from below Prosser Dam to the figures noted above. The YSS (NPPC 2001) provides WDFW estimates of below-Prosser escapement for 1998-2000. The 1998 estimate was a range between 667 and 1203 (differences derive from different estimating methods); in 1999 they estimated 2069 (only one method was successfully used); and in 2000 the estimate was 3125 (again the just the "area under the curve" model was used).

Yakima basin fall chinook abundance has been supplemented with hatchery production for many years. This supplementation has been from both above and below the Prosser Dam. Yakima River Mainstem fall chinook are not a distinct population from the Hanford Reach fall chinook, genetic introgression or damage to the Hanford Reach Fall Chinook or Lower Yakima fall chinook from Prosser hatchery releases is low due to the small proportion of this combined stock that is currently of hatchery origin**.** Figure 2-48 presents estimates of total fall chinook escapement (natural plus hatchery) from the Yakima basin from 1984 through 2000. These estimates range from a low of 523 fish in 1988 to a high of 5133 in 2000.



	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
fall chinook	3106	637	1715	1251	523	1563	3509	2266	3761	2485	3547	3085	3248	2613	2679	3905	6341	6711	13672	10251

Figure 2-48. The estimated fall chinook run to the Yakima Basin (includes below Prosser Dam), 1984-2000

Important stock characteristics

The YSS (NPPC 2001) notes that "the genetic status of the historical fall chinook population is unknown" and goes on to identify the two current, genetically-distinct stocks (mainstem/ Hanford Reach and Marion Drain). It also makes the important point that "[b]ased on existing electrophoretic and life history data, the genetic variability within the Marion Drain population represents a substantial portion of the genetic variability found in mid-Columbia summer and fall chinook. … the Marion Drain population may prove to be an important part of the effort to rebuild fall chinook in the Yakima Basin."

In addition to these genetic differences, the YSS (NPPC 2001) reports that "[t]here are striking differences in age distributions and sex ratios between the two fall chinook stocks. Curt Knudsen (WDFW, pers.comm., 1992) estimated that the mean proportion of fish that were ocean age 1 through 4 in the mainstem stock was, respectively, 12 percent, 12 percent, 66 percent and 11 percent. By contrast, the age distribution for Marion Drain fish for the same ages was 48 percent, 46 percent, 6 percent and 0 percent. These figures represent the mean values observed in spawner/GSI surveys in 1989-1991, and incorporate corrections for sex- and size-related biases known to skew spawner survey data. Half of the Marion Drain population consists of jacks (ocean age 1). Not surprisingly, sex ratios between stocks are equally divergent. The mean sex ratio in Marion Drain is 73 percent males and 27 percent females. By contrast, the sex ratio for the mainstem stock is 46 percent males and 54 percent females."

The highly skewed sex ratio in Marion Drain implies correspondingly high spawners per redd ratio. The mean ratio observed in 1991 and 1992 was 9.3 spawners per redd. More importantly, the Marion Drain sex ratio implies a low reproductive potential and therefore, absent unusually high egg-to-adult survival rates or fecundity, low productivity. The fecundity of Marion fish has been estimated at 4,728 eggs/female. By contrast, the mean fecundity for mainstem females estimated at 6,106." Given the potential genetic diversity importance of the Marion Drain stock noted above, this reduced productivity/fecundity may suggest giving particular attention to the protection and restoration of this stock.

Spawning

Run-Timing

Adult fall chinook typically return to the Yakima Basin from the ocean as 3, 4, or 5 year olds, from September through November. The YSS (NPPC 2001) reports that "[t]he average dates of 10 percent, 50 percent and 90 percent passage are May 9, June 6 and July 1, but there is a very large amount of [year-to-year] variability

According to the YSS (NPPC 2001) "[t]he spawning run at Prosser begins in early September, peaks in late September, and is almost always totally finished by the second week of November. The variability in run-timing is related to flow, but not water temperature, and the flow/passage relationship is the opposite of that seen for spring chinook: [in this case,] higher flows accelerate passage."

Spawning

The YSS (NPPC 2001) explains that "[s]pawning …begins about the middle of October, peaks the first week of November, and is complete by the third week of November. Spawning in the lower mainstem, however, apparently includes some fish that spawn much later than the norm. WDFW biologists operated a screw trap in the lower river in 1990 and captured 35 mm newly emergent fry in May, when most fall chinook were 80-100 mm smolts (Busack et al., 1991). A spawning timing of late December or early January would be consistent with a May emergence."

Incubation and Emergence

Incubation of fall chinook eggs in the Yakima basin starts as early as October and can extend as late as late April. There is a typical incubation period of 4 to 5 months, followed by emergence of the fry. Emergence occurs earliest for Marion Drain fish, ranging from mid-February for eggs deposited by early spawners (mid October) to late March for late spawners (mid November). In the mainstem, emergence does not occur before late March and extends into the third week of April."

Rearing

Fall chinook rear a very short time in freshwater. Smolts begin migration almost immediately after fry colonization. This brief freshwater residence is critical to the survival of the population, even though rearing on the Yakima Subbasin is generally less than two months.

Smolt Outmigration

One important life history difference between present-day and historical fall chinook populations is known: smolt outmigration timing. In intact habitats, many populations of ocean-type chinook begin their smolt outmigration in May, reach a peak in June or July, and continue migrating through September (Groot and Margolis, 1991). Just such an outmigration of subyearling chinook was observed in the Yakima in 1928, 1929 and 1930 (Lichatowich, 1992). This timing contrasts sharply with the current outmigration, which typically ends in early July as stream temperatures in the lower reaches of the Yakima begin to approach lethal levels. This truncation in the outmigration "window" has likely had a significant negative effect on the suitability of the entire lower Yakima River for natural production of fall chinook.

As noted above in the run timing discussion, there is significant variation in the timing of outmigration. The YSS (NPPC 2001) suggests that "[i]t is possible that much of this variability is due to temperature – to a temporary "stalling" of the outmigration by a short period of high temperatures, or to a premature truncation of the entire run by a prolonged period of high temperatures which directly or indirectly kills the later portion of the outmigration. This hypothesis is supported by two observations. One observation is the strong inverse relationship between the date of 90 percent passage and mean Chandler water temperature from June 15 – July 15 [Figure 8 of the YSS (NPPC 2001)]. This data shows that the outmigration ends considerably earlier during hot years, and that an increase of 10^0 F in late spring water temperatures usually means the outmigration will end nearly a month earlier. "

"The other observation is the disparity between simultaneous passage estimates at Chandler and in a screw trap fished near Richland in the lower Yakima (RM 8) in the spring of 1992. The estimated passage of fall chinook smolts at Chandler and at the Richland screw trap lagged three days to adjust for travel time. Between May 26 and June 10, passage at Chandler averaged 10,538 fish per day, and totaled 174,624 fish. Comparable figures for the trap at Richland, 40 miles downstream, were 1,246 and 19,929[5], respectively. This loss of fish is all the more remarkable in light of the fact about 70 percent of Yakima fall chinook spawn below Chandler. During this period, mean daily water temperatures at Richland averaged 76^0 F, and ranged from 72 to 81^0 F. Temperatures at Chandler averaged 71^0 F, ranging from 69 to 73^0 F. Evidently the smolts were able to cope with the temperatures at Chandler, but not those further downstream."

Hatcheries

In 1996 the Yakama Nation constructed the Lower Yakima Supplementation and Research Facility at Prosser dam. Three ponds were constructed for acclimation and release of fall chinook at that facility. From 1996 on, the Yakama Nation has collected adult broodstock at Prosser dam and used their progeny for smolt releases. Details on operations and practices employed at the hatchery itself see the Artificial Production Review and Evaluation (APRE) report on the CESRF at **APRE Summary**

[5] Note that the figures for the Richland screw trap are estimates of *passage*, not raw catch. They were generated by dividing daily catches by 0.045, the mean entrainment rate estimated from the recapture of marked fish.

Harvest

Fall Chinook Sport Fishery Seasons

After being closed from 1965 through 1997, a fall chinook salmon sport fishery was opened on the Yakima River September 1, 1998. Since that time fall sport fishing salmon seasons have opened annually. The seasons, reaches open, daily catch limit, and some of the additional rules are recorded in Table 2-17 below.

Table 2-17. A summary of recent fall chinook sport fishing seasons and regulations.

Season	River Reach Open to Fishing	Daily Limit	Additional Restrictions
Sept 1 – Oct 31, 1998	Hwy 240 to Chandler Pwr House	2	Selective gear rules
Sept 25 – Oct 31, 1999	Hwy 240 to Prosser Dam	2	AD or Ventral fin clipped salmon
Sept 16 – Oct 31, 2000	Hwy 240 to Prosser Dam	2	
Sept 16 – Oct 31, 2001	Hwy 240 to Prosser Dam	6	no more than 2 adults
Sept 16 – Oct 31, 2002	Hwy 240 to Prosser Dam	6	no more than 2 adults
Sept 16 – Oct 31, 2003	Hwy 240 to Prosser Dam	6	no more than 2 adults
Sept 1 – Oct 22, 2004	Hwy 240 to Prosser Dam	6	no more than 2 adults

Selective gear rules (no bait, single barbless hook, no boats with motors) were adopted in 1998 to reduce potential steelhead hooking mortality. Steelhead, which are listed as threatened under ESA, are required to be released if caught. Monitoring in 1998 and since that time revealed that few steelhead are caught during the fall fishery, therefore starting in 1999 there have been no selective gear rules. The majority of the annual steelhead run enters the river after the fall fishery is closed.

A permanent regulation was implemented and published in the fishing regulation pamphlet in 2002. Yakima salmon seasons can be closed by emergency rule if in-season run size estimates indicate insufficient numbers of fish to support a fishery and meet hatchery/natural escapement needs. The regulation establishes a permanent season for salmon in the lower Yakima River from Prosser Dam to Hwy 240 bridge from September 16 through October 31, daily limit of 6 fish, no more than 2 adults (salmon $\geq$ 24 inches), non-buoyant lure restrictions, and night closure. The rule was modified slightly for the fall 2004 season because in recent years spawning fish have been harvested from redds. Starting in 2004, the season will close October 22nd to avoid fishing on spawning fish. Except in 1998, both coho and fall chinook could be retained during the fall salmon fisheries described above.

The fall Yakima River salmon fisheries are not the result of increased wild runs, but the product of Yakima/Klickitat Fisheries Project (YKFP) fall chinook and coho hatchery production. The co-managers hope to continue to provide these important sport fishing opportunities in future years. An agreement was reached in early 1999 with the Yakama Nation Fishery Resource Division to open both fall chinook and coho fisheries starting fall1999 based on favorable pre-season run size predictions.

Fall Sport Fishery Monitoring

The fall fishery has been and will continue to be monitored to estimate fishing effort, estimate harvest, and monitor catch and release of steelhead, which may not be harvested (Table 2-18). This monitoring is a required commitment by WDFW to NOAA Fisheries because steelhead are listed as threatened under ESA.

The first (1998) Yakima River fall chinook sport fishery in many years proved to be “low key” and not very successful. Since the river was opened by emergency regulation for the first time in decades, few anglers were prepared for the fishery even though an agency news release was published in several regional newspapers. The results were slightly better in 1999, and the fishery expanded dramatically in terms of fishing effort and harvest starting in 2000.

Table 2-18. 1998 - 2003 fall chinook/coho fisheries monitoring.

Year	Effort (total hours)			Anglers Interviewed	Estimated Harvest		
	Total	Sampled	%		Chinook (Adult)	Chinook (Jacks)	Coho
2003	32,225	5,045	15.7	2,341	1,422	41	0
2002	22,796	1,697	7.4	711	2,300	0	55
2001	13,193	2,159	16.4	861	942	58	54
2000	12,556	1,933	15.4	712	255	22	69
1999	6,412	1,139	17.8	408	134	0	54
1998	791	-	-	-	28	0	0

Protection Key Findings for Fall Chinook:

- There has also been the relatively recent (early 20th century) development of a separate, self-sustaining population of fall chinook in the Marion Drain. Some researchers speculate that this is the remnant endemic Yakima fall chinook strain.
- By any estimation, the abundance of Fall Chinook has been significantly reduced from historic levels.
- "[b]ased on existing electrophoretic and life history data, the genetic variability within the Marion Drain population represents a substantial portion of the genetic variability found in mid-Columbia summer and fall chinook. … the Marion Drain population may prove to be an important part of the effort to rebuild fall chinook in the Yakima Basin."

Restoration Key Findings for Fall Chinook:

- Yakima River Mainstem fall chinook are not a distinct population from the Hanford Reach fall chinook, genetic introgression or damage to the Hanford Reach Fall Chinook or Lower Yakima fall chinook from Prosser hatchery releases is low due to the small proportion of this combined stock that is currently of hatchery origin.
- One important life history difference between present-day and historical fall chinook populations is known: smolt outmigration timing. This truncation in the outmigration "window" has likely had a significant negative effect on the suitability of the entire lower Yakima River for natural production of fall chinook.
- The first (1998) Yakima River fall chinook sport fishery in many years proved to be "low key" and not very successful. Since the river was opened by emergency regulation for the first time in decades, few anglers were prepared for the fishery even though an agency news release was published in several regional newspapers. The results were slightly better in 1999, and the fishery expanded dramatically in terms of fishing effort and harvest starting in 2000.

6.3.4 Steelhead

Overview

Life History Forms

The species *Oncorhynchus mykiss*, of which steelhead and rainbow trout are members, displays an astonishing array of life history strategies, meristic traits, and genetic variation (Behnke 1992). Most taxonomists recognize the existence of a number of subspecies and steelhead trout that occur in the Yakima Subbasin are classified as *O. mykiss gairdneri*. Two forms of *O. mykiss gairdneri* occur in the Yakima Subbasin, the anadromous form known as the steelhead trout and the resident form known as the rainbow trout. Anadromy is not obligatory in *O. mykiss* (Rounsefell 1958, Mullan et al. (1992Cpa). Progeny of anadromous steelhead can spend their entire life in freshwater, while progeny of rainbow trout can migrate seaward. We consider *O. mykiss* as one complex for this review.

Steelhead may be further classified into two distinct races, or runs (Smith 1960; Withler 1966; Everest 1973; Chilcote et al. 1980). Winter-run fish ascend streams between November and April, while summer-run fish enter rivers between May and October. Steelhead in the Yakima Subbasin are all classified as summer-run.

Steelhead, unlike Pacific salmon, do not all die after spawning. A small proportion of spawners (known as kelts) may return to the ocean for a short period and repeat the spawning migration. Spawning adults typically range between three and seven years of age.

Young steelhead typically rear in streams for some time prior to migrating to the ocean as smolts. Steelhead smolts have been shown to migrate at ages ranging from 1-5 years, with most populations smolting at ages 2 or 3 (Shapovalov and Taft 1954; Withler; 1966; Loch et al. 1988). Steelhead grow rapidly after reaching the ocean, where they feed on crustaceans, squid, herring, and other fishes (Wydoski and Whitney 1979; Pauley et al. 1986). The majority of steelhead spend 2 years in the ocean (range 1 - 4) before migrating back to their natal stream (Shapovalov and Taft 1954; Narver 1969; Ward and Slaney 1988). Once in the river, steelhead apparently rarely eat and grow little if at all (Maher and Larkin 1954). These various behaviors produce fish that range between three and seven years of age at the time of spawning.

Historical Distribution and Abundance

Steelhead trout were widely distributed in the Yakima basin prior to 1850 (Figure 2-48) and were known to utilize virtually all of the major streams and tributaries for some aspect of their life history. It is probable that the historical spawning distribution of summer steelhead included virtually all accessible portions of Yakima Basin, with highest spawning densities occurring in complex, multi-channel reaches of the mainstem Yakima and Naches, and in third and fourth order tributaries with moderate (1-4 percent) gradients (YSS, 2001). The historic abundance of steelhead trout is poorly known. Howell et al., (1985) estimated that over 80,000 adult steelhead trout might have returned to spawn in the Yakima Subbasin.

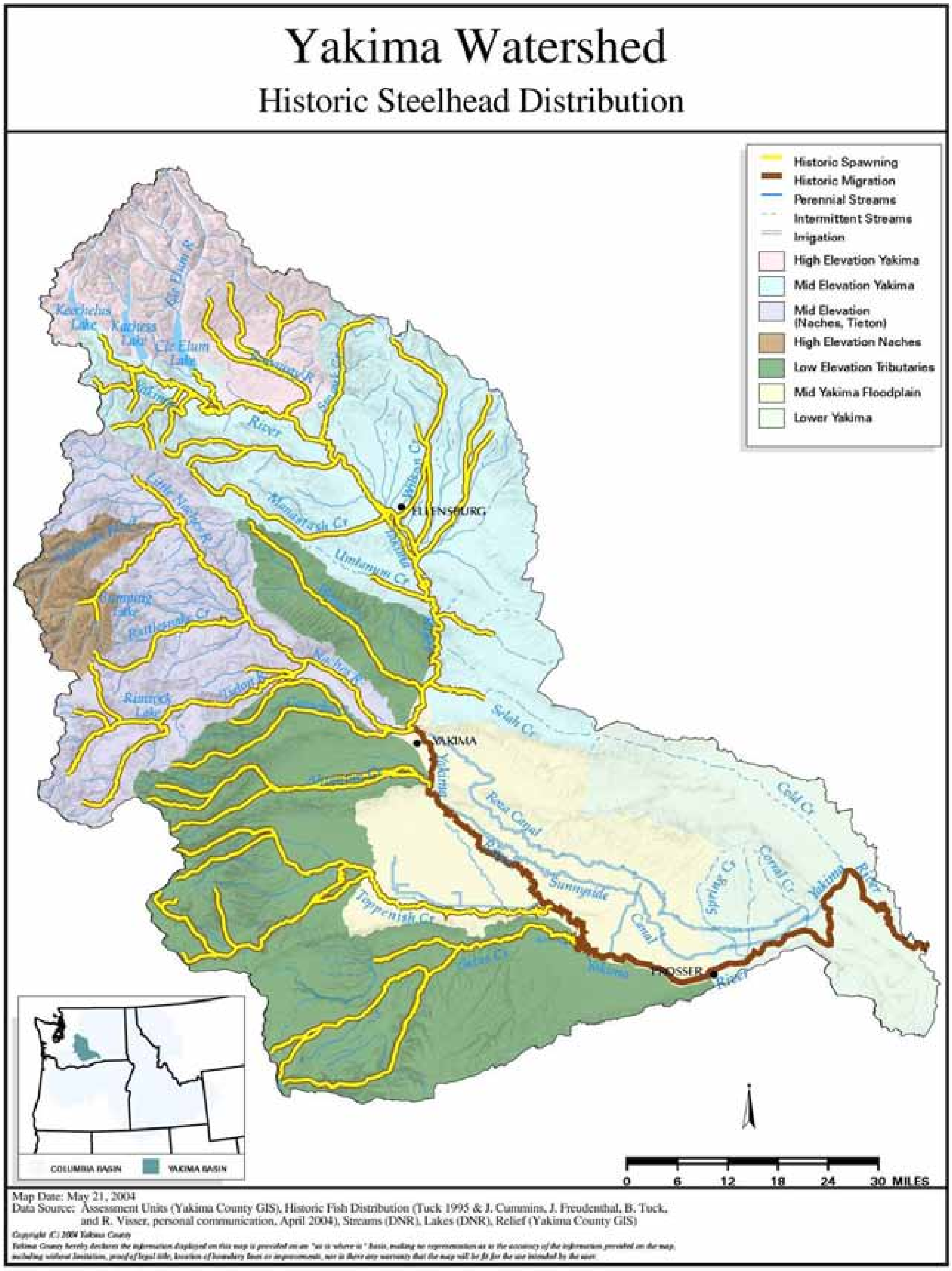


Figure 2-48. Historical steelhead spawning distribution in the Yakima Subbasin

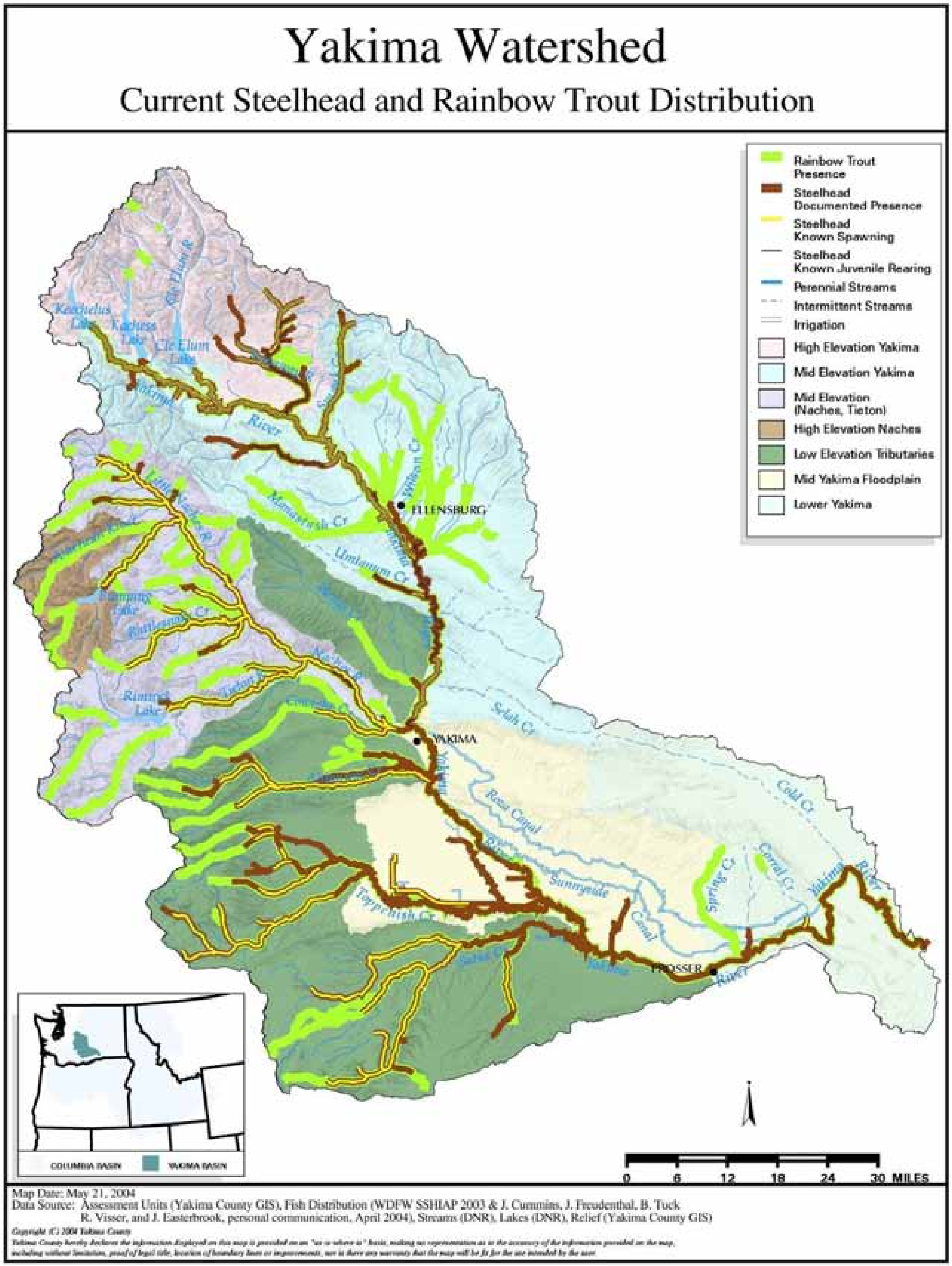


Figure 2-49. Current distribution of steelhead/rainbow trout in the Yakima Subbasin

Current Distribution and Abundance

The current range of the steelhead/rainbow trout complex in the Yakima Subbasin is slightly smaller than under historic conditions (Figure 2-49). However, the range of anadromous steelhead is significantly reduced from 1850. Fewer tributaries are utilized for spawning and rearing than were historically. Relevant examples include Tieton River and Wenas Creek. Sections of many streams thought to formerly support spawning and rearing are now utilized only as migration corridors due to habitat degradation.

When compared to other river sytems with similar elevations the proportion of the steelhead/rainbow trout population that exhibits anadromy is significantly reduced. There are several theories that attempt to reconcile this difference in rates of anadromy – current environmental conditions favor residency; interbreeding with introduced resident rainbow; and loss of anadromy due to reduced access caused by early operations of Roza Dam. It is also known that growth of juvenile rainbow trout is well below growth rates in similar Columbia Basin systems, reinforcing the hypothesis that the young of the year life stage is limiting rainbow/steelhead trout production in Upper Yakima. The population of resident *O. mykiss* in the Upper Yakima Basin is substantially less productive than red-bands in the Deschutes and rainbow trout in rivers of southwestern Montana. Age-classes are highly skewed to older fish. Significant mortality before year one affects these fish, and Pearsons *et al.* have hypothesized that the high-energy environment, coupled with a profound lack of habitat for small-bodied fish and an altered food base, is creating a body-size threshold that limits recruitment into the population.

Precise counts of steelhead abundance over time are not available because adult steelhead returns have been monitored for only a short period of time, while redd counts have been monitored since the 1980s. Between 1999 and 2004, roughly 1,300 to 4,500 adults were observed passing Prosser. Between 130 and 220 adults passed Roza Dam between 2001 and 2003 (Figure 2-19). In the period between 1986 and 2000 between 430 and 2,900 steelhead were observed in the Yakima Subbasin (Tables 2-17, 2-18). According to 2002 WDFW data, current steelhead stock abundance in the Yakima River basin is believed to be less than 5 percent of its historical level in most years and as low as 1 percent in some years.

The Toppenish and Satus Creek populations are currently healthy, and abundance of steelhead in the Yakima Subbasin is weighted heavily toward those stocks. Improvements in the abundance and distribution of other stocks in the subbasin will increase the stability and resiliency of steelhead populations within the subbasin as a whole. Within the subbasin, there are several areas where existing data suggest density-dependence is a significant depressing factor on steelhead productivity as observed at Prosser Dam. It is likely that this relationship reflects the fact that the majority of production under current conditions is restricted to Satus and Toppenish Creeks, which obviously have a limited carrying capacity. In some years, the relatively healthy Toppenish and Satus steelhead populations (along with reconditioned kelts) are habitat-limited and could provide a source of broodstock for this supplementation effort with minimal effect on population viability. There are several streams in the subbasin, notably Ahtanum, Cowiche, Manastash, Wilson/Naneum, Taneum Creeks, and others that currently have areas of suitable habitat that are unoccupied or have extremely low populations levels of anadromous fish. These areas are currently or have been in the recent past blocked to access by low flow or diversion dams, but these problems have been or soon will be rectified. Existing and anticipated future levels of abundance and straying indicate that natural colonization of suitable habitats (after removal of obstructions to passage) would be very slow or non-existent in this Assessment Unit. Supplementation into newly re-opened habitats (through the use of hatchery broodstock, adult collection and involuntary spawning or other means) could accelerate/greatly improve the success rate of population reestablishment.

Table 2-19. Steelhead wild adult counts at Prosser Dam in the Yakima Subbasin

Year	Yakima Total Escapement
1986	1822
1987	2365
1988	864
1989	539
1990	721
1991	1986
1992	1068
1993	540
1994	838
1995	436
1996	816
1997	948
1998	1018
1999	1345
2000	2879

Table 2-20. Steelhead Passage (Wild and hatchery strays) at Prosser and Roza Dam (based on Yakima Klickitat Fisheries Project Daily Counts Online data 2003)

Year	Total Steelhead Prosser	Total Steelhead Roza
1999/2000	1380	
2000/2001	2942	
2001/2002	4525	135
2002/2003	2201	216
2003/2004 (to 11/18/03)	1596	133

6.3.4.1.1.1

Important stock characteristics

Allozyme analysis of specimens collected from several locations in the basin between 1991 and 1994 show that multiple steelhead stocks are present in the Yakima system (Phelps et al. 1997). Until recently fisheries researchers generally recognized four distinct steelhead trout populations in the Yakima Subbasin; the Satus, Naches, Toppenish, and Upper Yakima. Recent research by Loxterman and Young (2003) indicates that the previously recognized populations are genetically differentiated with little or no gene flow among them. They also concluded that, based on a limited number of samples, that Ahtanum Creek steelhead should be recognized as a fifth population. These indications of genetic differentiation among populations should be verified using larger sample sizes, and also considered in the light of some populations, including the Ahtanum, having been at very low population levels (much less than 50 individuals in most years) for several generations. Rapid genetic divergence under these conditions can be expected due to the founder effect and genetic drift. Differentiation of populations into distinct units is important, especially for these populations that are listed under ESA, as it directs future management and restoration activities such as the ability to supplement existing populations, to allow/encourage genetic exchange between populations, and the need to take emergency actions to conserves unique genetic attributes of populations that are at critically low levels of abundance. These stocks also exhibit behavioral differences that will be discussed in later sections of this chapter.

Another important characteristic that merits consideration is the degree to which genetic material exchange occurs between steelhead trout and resident rainbow trout. The WDFW Ecological Interactions Team (2001) utilized a variety of observational and genetic techniques to analyze this phenomenon. Although individual stocks in the basin were not evaluated, this research may have important implications for the management of stocks. The important findings of this research are as follows.

- The distribution of steelhead is smaller than rainbow trout and streams utilized by steelhead for spawning fall within the range of rainbow trout spawning areas.
- Spawn timing for steelhead trout and rainbow trout overlap.
- Several instances of steelhead and rainbow trout interbreeding were documented.
- Sympatric steelhead and rainbow trout in the North Fork of the Teanaway River were genetically indistinguishable.
- Genetic evidence indicates that hatchery rainbow trout had previously spawned with wild steelhead; and hatchery steelhead had previously spawned with wild rainbow trout.

Spawning

Run-Timing

Yakima Subbasin steelhead typically spend between one and three years in the ocean before returning to natal streams to spawn (Table 2-21). Analysis of scales collected from fish captured at Prosser Dam revealed that 52 percent of steelhead trout spent one year in the ocean, 44 percent spent two years, and 3 percent spent three years (NPPC 2001).

Table 2-21. Length of time spent in ocean, Yakima Basin summer steelhead collected at Prosser Dam, brood years 1990 – 1992 (all stocks)

Brood Year And Ages		Fraction Of Males That Are Age X	Fraction Of Females That Are Age X	Fraction Of All Fish That Are Age X Males	Fraction Of All Fish That Are Age X Females	Fraction Of All Fish That Are Age X
1990	1 year	66.7%	62.5%	18.2%	45.5%	63.6%
	2 years	16.7%	37.5%	4.5%	27.3%	31.8%
	3 years	16.7%	0.0%	4.5%	0.0%	4.5%
	Total	100.0%	100.0%	27.3%	72.7%	100.0%
1991	1 year	50.0%	30.0%	10.5%	23.7%	34.2%
	2 years	50.0%	63.3%	10.5%	50.0%	60.5%
	3 years	0.0%	6.7%	0.0%	5.3%	5.3%
	Total	100.0%	100.0%	21.1%	78.9%	100.0%
1992	1 year	74.4%	56.5%	26.9%	36.1%	63.0%
	2 years	23.1%	40.6%	8.3%	25.9%	34.3%
	3 years	2.6%	2.9%	0.9%	1.9%	2.8%
	Total	100.0%	100.0%	36.1%	63.9%	100.0%

Steelhead adults begin passing Prosser Dam in September, cease movement during the colder parts of December and January, and resume migration from February through June. The run has two peaks, one in late October, and one in late February or early March. The relative numbers of wild fish returning during the fall and winter-spring migration periods varies from year to year, perhaps depending on the duration of a “thermal window” in the fall. Studies of steelhead radio tagged and released at Prosser Dam over the years 1990 - 1993 (Hockersmith et al. 1995) indicate that most “fall-run” steelhead spawners overwinter in the mainstem Yakima, in reaches with deep holes and low velocity. About 25 percent hold below Prosser Dam, 60 percent between Prosser Dam and Sunnyside Dam (many in the vicinity of the Satus Creek confluence) and 6 percent between Sunnyside Dam and Roza Dam. Only about ten percent of the fish hold in Satus Creek, Toppenish Creek, Marion Drain the lower Naches River, or the upper Yakima combined.

The final migration to the spawning grounds begins between January and May, with fish that will spawn in lower elevation tributaries generally beginning to move earlier. There is some evidence that the cue triggering this final run is thermal, because very few fish ascended Satus Creek during mid-winter floods, and virtually none of the eventual Naches spawners began moving until water temperatures reached 3^{o} C (Hockersmith et al. 1995).

Roughly 8.0 percent of returning adults are age-3, 49 percent age-4, 38 percent age-5, 4 percent age-5 and less than 1 percent are age-7 respectively (Table 2-22). The mean sex ratio over the 1990-1992 brood years (the only dataset in which both sexes were counted) was 68.5 percent female and 31.5 percent male.

Table 2-22. Sex-specific total ages, Yakima Basin summer steelhead collected at Prosser Dam, brood years 1990 – 1992 (all stocks)

Brood Year And Ages		Fraction Of Males That Are Age X	Fraction Of Females That Are Age X	Fraction Of All Fish That Are Age X Males	Fraction Of All Fish That Are Age X Females	Fraction Of All Fish That Are Age X
1990	Total age 3	0.0%	6.3%	0.0%	4.5%	4.5%
	Total age 4	66.7%	56.3%	18.2%	40.9%	59.1%
	Total age 5	16.7%	37.5%	4.5%	27.3%	31.8%
	Total age 6	16.7%	0.0%	4.5%	0.0%	4.5%
	Total age 7	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	100.0%	100.0%	27.3%	72.7%	100.0%
1991	Total age 3	25.0%	13.3%	5.3%	10.5%	15.8%
	Total age 4	25.0%	23.3%	5.3%	18.4%	23.7%
	Total age 5	50.0%	56.7%	10.5%	44.7%	55.3%
	Total age 6	0.0%	3.3%	0.0%	2.6%	2.6%
	Total age 7	0.0%	3.3%	0.0%	2.6%	2.6%
	Total	100.0%	100.0%	21.1%	78.9%	100.0%
1992	Total age 3	15.4%	7.2%	5.6%	4.6%	10.2%
	Total age 4	66.7%	63.8%	24.1%	40.7%	64.8%
	Total age 5	15.4%	26.1%	5.6%	16.7%	22.2%
	Total age 6	2.6%	2.9%	0.9%	1.9%	2.8%
	Total age 7	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	100.0%	100.0%	36.1%	63.9%	100.0%

6.3.4.1.1.2

Spawning

Spawn timing throughout the basin is highly variable and is likely triggered by a combination environmental cues including flow and temperature. Rainbow trout normally spawn in the spring between February and June, depending on temperature and location. In Umtanum Creek spawning occurred from mid-March until early May. In the mainstem Yakima and tributaries spawning peaks about mid-April (late March to mid-May), with a patchy distribution of redds . Spawning occurred earlier at the lower reaches of the river and later at the higher reaches (Wydoski and Whitney 2003). The overall distribution of spawning in the subbasin is 40-50 percent in the Satus/Toppensish creek systems, 35-40 percent in the Naches system, and 5-10 percent in the Upper Yakima (Hockersmith et al 1995)

Rainbow and steelhead trout spawn at similar times and locations in the upper Yakima River basin but steelhead trout spawned in a more restricted geographic area (Wydoski and Whitney 2003). Most Yakima steelhead are tributary spawners although the distribution of redd locations throughout a basin is highly variable from year to year. For example, 2002 spawning data from Toppenish creek watershed indicated 64 percent of spawning occurred above the confluence of Willy Dick, but 2003 data indicated 38 percent of spawning occurred between Willy Dick (RM 48.5) and Panther Creek (RM 69.2). The remainder of the 2002 and 2003 redds occurred in the major tributaries of Toppenish Creek, and in Simcoe Creek (which is a relatively high elevation tributary of Toppenish Creek that enters at RM 32.7) (Figure 2-50). It should be noted that high flows greatly affected spawning ground surveys in the Toppenish/Simcoe watersheds because water and turbidity was often too high to complete accurate surveys. Thus observed redd numbers fluctuated significantly (S. Adams, YN, pers.comm.). With the exception of the

Satus/Toppensish system few spawning surveys have been conducted in the subbasin because high flows, water turbidity and low number of fish make surveys difficult.

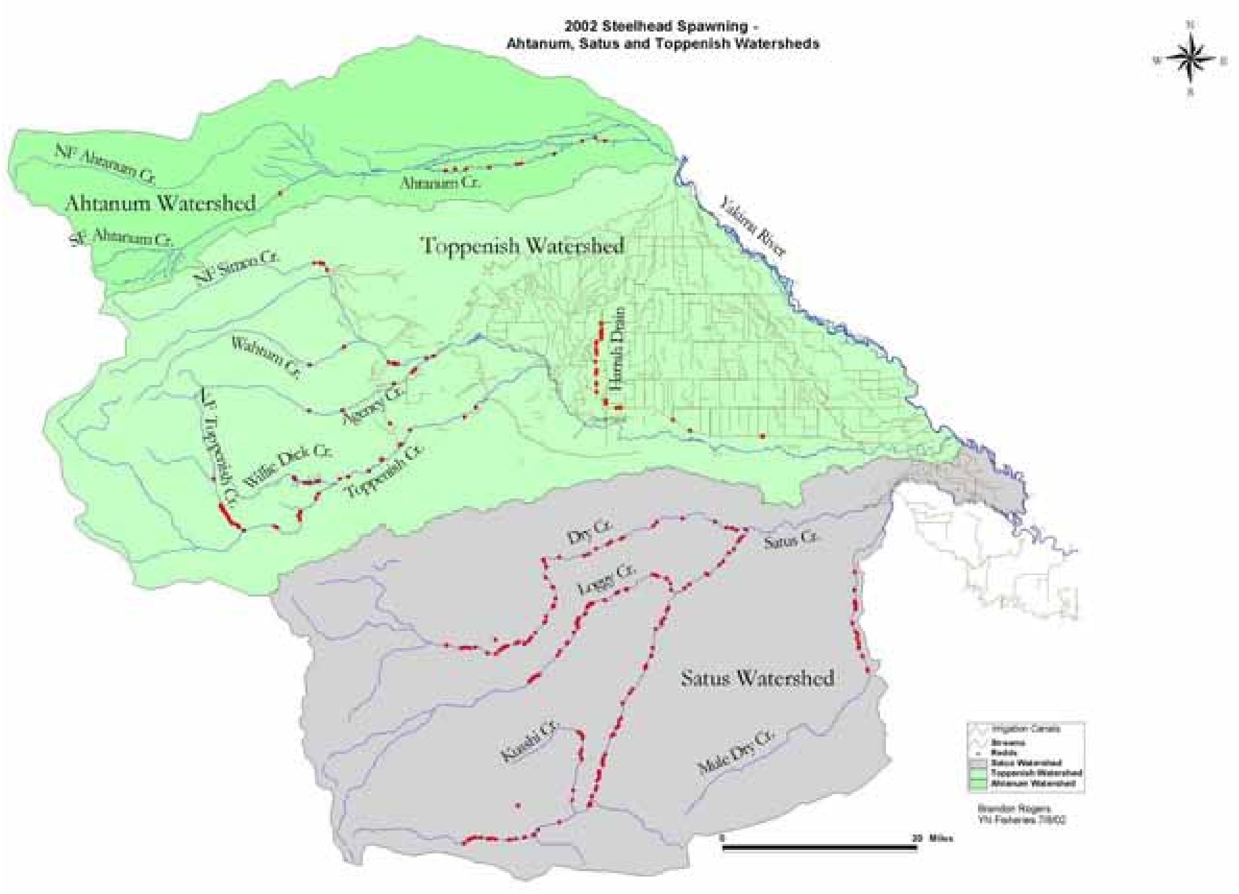


Figure 2-50. Steelhead spawning in 2002 in Ahtanum, Satus, and Toppenish watersheds

Yakima steelhead are relatively small, as might be expected for fish that are 52 percent 1-salts. The mean fork length of the fish sampled in the 1990 – 1992 broods was 66.5 cm (about 26 inches), and the mean weight was about 3.0 kg (about 6.7 lbs). In spite of their size, Yakima steelhead are quite fecund. Mean fecundity for fish collected as broodstock in brood years 1986, 1987, 1989, and 1990-1993 was 5,100 eggs (NPPC 2001).

Incubation and Emergence

Unlike other species in the *Oncorhynchus* genus, steelhead eggs incubate at the same time temperatures are increasing. Fry throughout much steelhead range emerge in July through October (Chapman et al. 1994), with time of hatching varying largely with water temperature, region, habitat and season (Bjornn and Reiser 1991). The timing of steelhead fry emergence in the Yakima Subbasin is poorly known. Field studies indicate that 50 percent of steelhead trout in a redd will have emerged when roughly 1,300 Temperature Units (TUs) have been acquired.

Based on this relationship, fry emergence probably occurs at the following times in the following places:

- Satus Creek: early May to early June
- Toppenish Creek: late May through early July
- Lower Naches and Cowiche: early June through mid July
- Upper Naches: mid June through mid July
- Upper Naches tributaries: late June through late July
- Middle Yakima and tributaries: early June through early July.
- Upper Yakima mainstem in Yakima Canyon (including Umtanum Cr and Wilson/Naneum): early June through early July
- Upper Yakima mainstem above the Yakima Canyon: mid June through late July.Upper Yakima tribs: late June through early August.

Rearing

Juvenile steelhead trout tend to rear in their natal streams for a period of several months between May and October, undertake a winter migration to positions lower in the basin sometime between October and February, overwinter in these locations, and begin outmigration in March (Figure 2-51). Pre-smolt rearing migrations are less well understood for steelhead than they are for spring chinook. The presence of steelhead juveniles in small tributaries throughout the summer, sometimes in high densities, indicates that the fish are less inclined to migrate downstream for early rearing than spring chinook. For example, smolts and pre-smolts from the upper portion Toppenish Creek have been caught in rotary screw traps in the lower section of the creek in large numbers in December and January. These migrations usually coincide with high flow events (B.Rogers, YN, pers.comm.) and the outmigrants do not appear at Prosser until late winter or early spring (D.Lind, YN, pers. comm.). A similar situation was observed at the Chandler smolt trap where virtually all winter movement occurs in February, more than a month after the typical peak of spring chinook movement. Substantial winter migrations do occur over shorter distances. In the winter of 1990-91 and the following spring, the Yakama Nation operated a smolt trap on Satus Creek just below the Logy Creek confluence. About 33 percent more steelhead juveniles moved past the Satus Creek trap that winter than the following spring. A distinct pulse of steelhead juveniles were also seen in the late fall at a smolt trap operated at Wapatox Dam from 1984 – 1990, although icing always forced closing of the trap by early December at the latest, precluding estimates of the relative magnitude of spring and winter movements.

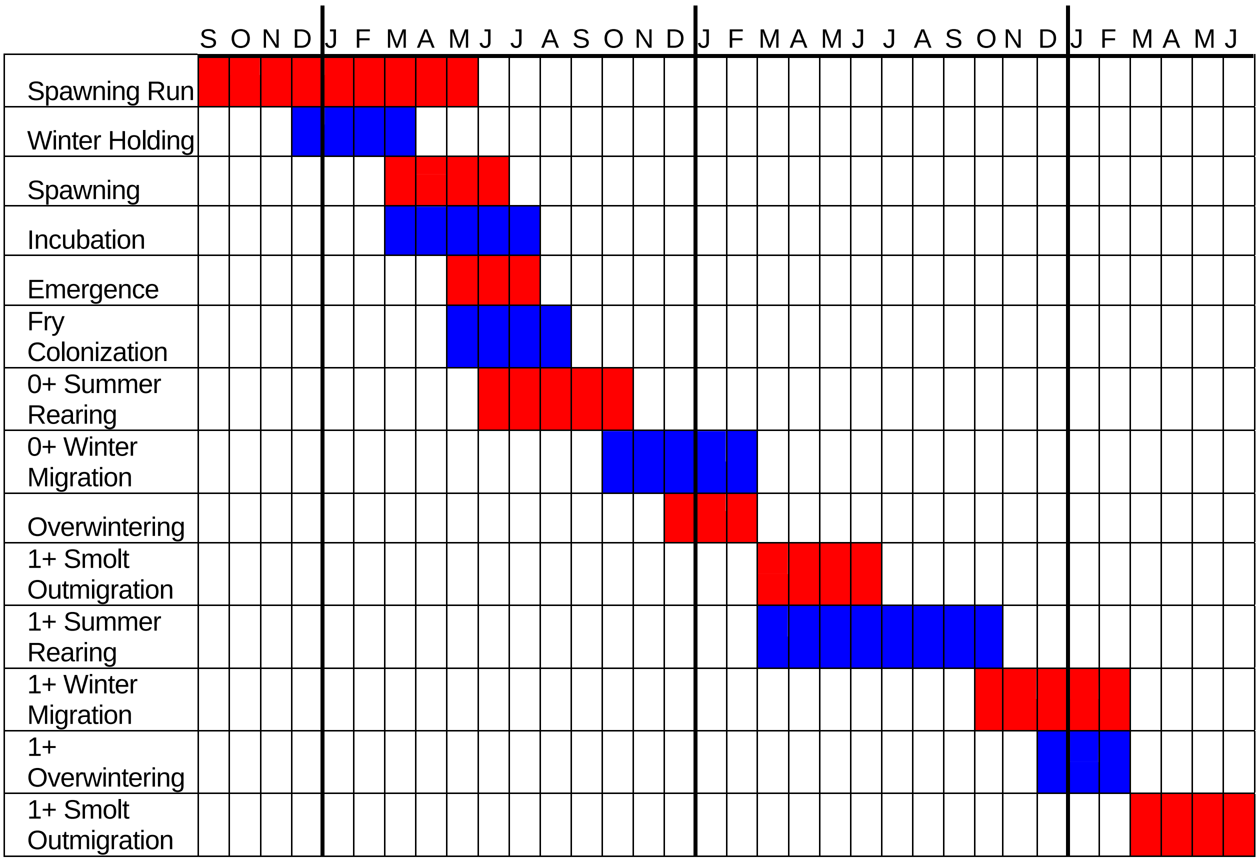


Figure 2-51. General duration of successive life stages in for Yakima Basin summer steelhead (all stocks)

Juvenile rainbow trout in the upper Yakima prefer to rear in water 10 cm deep with a current of 0.25 m/s (Wydoski and Whitney 2003). The following is taken from the WDFW 2001 Ecological Interactions Team file report: “The growth and size of fish in different geographic locales may be influenced by ecological and genetic factors. We attempted to determine some of the factors that are related to rainbow trout growth and length in 12 tributaries and seven sections of the mainstem of the upper Yakima River. Length-at-age of fish was determined from rainbow trout scales using the Dahl-Lea back calculation method.” “Preliminary results suggested that rainbow trout length-at-age is related to both ecological and genetic factors. The relative position of principal component scores of length-at-age data corresponded closely to the genetic stock structure dendogram of rainbow trout in the upper Yakima River basin. Length-at-age was negatively correlated with elevation. Furthermore, the length-at-age of trout in the tributaries was significantly less than in the mainstem of the Yakima River. Most trout spawning in tributaries were age 1+ and 2+, whereas in the mainstem river, most spawning trout were age 2+ and 3+. The minimum size of sexually mature rainbow trout was negatively correlated with elevation. We were unable to confirm repeat spawning based on scale analysis. During their first year of life, growth of rainbow trout in the mainstem of the Yakima River appeared to be low compared to the growth of rainbow trout in other large rivers of the Northwest. Slow first year growth supports the hypothesis that the young of year life stage is the one limiting rainbow trout production in the mainstem of the Yakima River.

Smolt Outmigration

As stated previously, the age at which steelhead trout outmigration occurs varies between one and three years. Analysis of scales and otoliths indicate that for three of the four Yakima Subbasin stocks the proportions of outmigrants in each age class were similar (Table 2-23). The proportion of age-1 smolts in the Satus stock was significantly greater than observed in the other stocks. One hypothesis for this result is that juveniles grow faster in Satus Creek due to warmer temperatures and consequently reach smolt status faster than other stocks.

Table 2-23. Estimates of ages of Yakima steelhead smolts by stock as determined from scales sampled from smolts and scales sampled from adults (Busack et al 1991; YN, unpublished data, 2001)

STOCK	Smolt age determined from smolt scales			Smolt age determined from adult otoliths		
	1	2	3	1	2	3
Satus	42%	57%	1%	37%	63%	0%
Naches	14%	75%	12%	10%	90%	0%
Toppenish	10%	85%	5%	0%	100%	0%
U. Yakima	11%	71%	18%	17%	83%	0%
Basin-wide	41%	56%	4%	23%	77%	0%

At Chandler, the steelhead smolt outmigration begins in late February and ends in mid June. Statistically, the mean date of passage for the 10th, 50th and 90th percentiles of the outmigration are April 6, May 1, and May 19. These are almost exactly the same dates as for spring chinook, which are, respectively, April 6, April 23 and May 20. It should be noted however, that the outmigration timing of spring chinook is more variable interannually than steelhead, even though their means are similar. In addition the timing of the steelhead outmigration is not accelerated by higher cumulative thermal units the preceding winter, as is the case with spring chinook.
The midpoint of outmigration at Wapatox is also generally around the first week in May. Given the distances involved and smolt migration rates observed, the midpoint of the outmigration of Naches steelhead would not occur at Prosser for at least another week. Thus, as many as half the smolts leaving the Naches must negotiate the perilous lower river in late May and early June (NPPC 2001).

Hatcheries

The only hatchery program in the subbasin that currently subjects steelhead to a hatchery environment is the Steelhead Kelt Reconditioning Program operated by the Yakima Klickitat Fisheries Project (YKFP) at the Chandler Juvenile Evaluation Facility. This facility has been increasingly successful at rehabilitation of kelts that would otherwise face near certain mortality in downstream migration on the Columbia. This program has restored to a significant degree an important life history to the Yakima Subbasin, and could serve as an important source of broodstock for steelhead reintroduction efforts to habitat that is suitable but currently unoccupied due to blockage to migration, such as Cowiche Creek, Manashtash Creek, Big Creek, etc. A full description of this facility is available in Chapter 3-24 and also in Appendix J. Like several other YKFP projects, this program has implications for protection and restoration of steelhead populations and the repeat spawning life history throughout the Columbia Basin and the Pacific Northwest.

Harvest

The Yakima Subbasin has been closed to all steelhead fishing since April 16, 1994 to protect wild steelhead (Table 2-24). In 1990, WDFW incorporated catch-and-release and selective gear restrictions for trout fishing in important rainbow trout/steelhead spawning and rearing habitats in the river's mainstem between Roza Dam and Easton Dam. Many of the important steelhead spawning tributaries, such as the Naches, Bumping, American, Little Naches Rivers, Rattlesnake, Taneum, Teanaway, and Naneum creeks have "selective gear rules" (no bait, lures or flies with single barbless hooks) during trout fisheries to reduce incidental impacts to listed steelhead. River and stream trout fisheries are generally open June 1 – October 31, except for the mainstem Yakima above Roza Dam which is open year-round (selective gear rules) for catch and release trout fishing. Currently there are few steelhead above Roza Dam, so this year-round fishery has little or no impact on adult steelhead.

The fall chinook and coho fisheries in the lower Yakima River occur during the early portion of the steelhead migration (salmon fishing open Sept. 16 - Oct. 31) and spatial separation is not possible. However, portions of the Yakima River providing staging areas for a large number of steelhead (around the confluences of Satus and Toppenish/Simcoe creeks) remain closed to the fall chinook and coho fisheries. WDFW monitors the fall salmon fishery to assess the steelhead encounter rate and determine the risk of incidental mortality. Based on sport sampling, we estimated steelhead were caught and released during fall salmon fisheries in the Yakima Subbasin as follows:

- 2000 – 30
- 2001 – 18
- 2002 – 13
- 2003 - 27

Overall, WDFW has implemented salmon and trout season, gear, and catch limits that are intended to give Yakima Basin steelhead an opportunity to recover and at the same time provide recreational fishing opportunity for salmon, trout and other gamefish. Additional adjustments may be made to further protect steelhead as we monitor the impacts of our fisheries. In addition, habitat protection and population enhancement are key factors that will affect steelhead.

Steelhead fisheries are not expected in the Yakima River in the next 5-10 years, because, with the exception of a kelt reconditioning program, there are no steelhead supplementation programs in the Yakima Subbasin, and the Fish and Wildlife Commission recently adopted a statewide moratorium on harvest of wild steelhead.

Table 2-24. Steelhead Harvest in the Yakima River Basin, 1982-Present.

Adult Returns					Adult Harvest		
Run Year	Prosser	Wild	Hatch.	Wild%	Tribal	Sport	**Escapement[1]**
1983-84	1,140	911	229	79.9%	28	756	356
1984-85	2,194	1,975	219	90.0%	24	1,481	689
1985-86	2,235	2,012	223	90.0%	5	702	1,408
1986-87	2,465	1,984	481	80.5%	6	514	1,822
1987-88	2,840	2,470	370	87.0%	0	395	2,365
1988-89	1,162	1,020	142	87.8%	3	142	864
1989-90	814	686	128	84.3%	45	121	539
1990-91	834	730	104	87.5%	0	28	782
1991-92	2,265	2,014	251	88.9%	2	146	2,095
1992-93	1,184	1,104	80	93.2%	0	72	1,089
1993-94	554	540	14	97.5%	0	3	551
1994-95	925	838	87	90.6%	0	0	925
1995-96	505	451	54	89.3%	15	5	485
1996-97	1,106	961	145	86.9%	0	0	1,106
1997-98	1,113	948	165	85.2%	0	50	1,063
1998-99	1,070	1,018	52	95.1%	0	12	1,058
1999-00	1,611	1,571	40	97.5%	0	0	1,611
2000-01	3,089	3,032	57	98.2%	8	0	3,081
2001-02	4,525	4,491	34	99.2%	11	0	4,514
2002-03	2,235	2,190	45	98.0%	0	0	2,235

1. Spawning Escapement is Prosser Dam count minus harvest and hatchery broodstock collections which occurred in 1985-86 through 1992-93 run years.

Protection Key Findings for Steelhead:

- Survival of steelhead kelts (mature spawned out fish with the potential to spawn again) migrating out of the Yakima Basin and through the mainstem Columbia to the ocean is at or near zero.

Restoration Key Findings for Steelhead:

- Steelhead populations have been dramatically reduced from pre-1850 abundance levels.
- Capture, rehabilitation, and release of kelts in the Yakima Basin increases survival, could act as a source of broodstock/genetic material for reintroduction efforts, and demonstrates kelt rehabilitation feasibility for application in other Columbia Basin Tribes.
- Satus and Toppenish steelhead populations are healthy, could act as a source of broodstock/genetic material for reintroduction efforts.
- Production of steelhead within the Yakima Basin is heavily weighted towards Satus and Toppenish Creeks, increasing population levels in other creeks within this AU and in other AUs will decrease risk of extinction of steelhead in the Yakima Subbasin.
- The range of anadromous steelhead is significantly reduced from 1850. Fewer tributaries are utilized for spawning and rearing than were historically.
- Ahtanum, Cowiche, Manastash, Wilson/Naneum, Taneum Creeks, and other streams that currently have areas of suitable habitat that are unoccupied or have extremely low

populations levels of anadromous fish should be the focus of a reintroduction efforts to establish steelhead populations.

Key Uncertainties for Steelhead:

- Growth of juvenile RBT is well below rates in similar Columbia Basin systems, reinforcing the hypothesis that the young of the year life stage is limiting rainbow/steelhead trout production in Upper Yakima.
- Ahtanum Creek steelhead might be a fifth population. These indications of genetic differentiation among populations should be verified using larger sample sizes.
- Anadromy in rainbow trout populations in the Upper Yakima River is presently much decreased from historic levels.

6.3.5 Bull Trout

Overview

Life History Forms

Bull trout are known for their diverse life histories. A member of the char family, they exhibit resident and migratory life histories in varying degrees across their range (Rieman and McIntyre 1993). Resident and migratory forms may be found together, and either form may give rise to offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993).

The resident life history form completes all life stages in their natal and/or nearby streams. This life form is typically found in the smaller headwater streams, including some in which lower portions of the system have been blocked by impassable barriers. Adults of this life history form are typically the smallest, usually reaching about 12 inches in length, with a range of 8-15 inches. Resident bull trout have been known to interbreed with other forms when opportunities are present.

Migratory bull trout spawn in tributary streams, where juvenile fish rear one to four years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989; Goetz 1989), or in certain coastal areas, to saltwater (anadromous) (Cavender 1978; McPhail and Baxter 1996; Washington Department of Fish and Wildlife. et al. 1997). Fluvial bull trout spawn and rear in smaller tributaries for 1-3 year then move downstream to rear in mainstem rivers, where major growth and maturation occurs. They may move randomly throughout river systems, generally congregating near spawning tributaries in summer. The adfluvial history form is characterized by a migration to lakes and reservoirs for major growth and maturation to adulthood. This form is common in the Yakima basin, with adults growing to between 20 and 32 inches. In the Yakima basin, the current status of the anadromous life history form is not known, though it has been speculated that there may have been anadromous bull trout present in the past.

In all three life histories, males typically mature at ages 4,5, and 6 and females at ages 7, 8, and 9. Reproduction occurs annually but can occur in alternate years if the food resource is limiting. Bull trout can live to 12 or more years of age and reach 20 pounds or more where forage is adequate.

Historical Distribution and Abundance

Historic abundance of bull trout is not well understood and should be regarded as a data gap. It is likely that the four known life history forms (including the anadromous form) were found in the basin historically from the delta to upper most reaches of the basin. Anadromous, fluvial and adfluvial forms could have foraged in the mainstem Yakima historically since there were thermal refugia for them to use and an abundance of food. They also would have had a connection to the cold headwater spawning tributaries that are presently cut off by dams or thermal blocks.

Current Distribution and Abundance

The USFWS Bull Trout Recovery Plan (2002) estimates that there are between 2,550 to 3,050 migratory adults in the entire Mid-Columbia Recovery Unit, which is generally considered equivalent to the Yakima Basin. The 1998 Washington State Salmonid Stock Inventory for Bull Trout and Dolly Varden (WDFW, 1998) rated eight of the nine stocks they identified as depressed, critical or unknown. Only the Rimrock Lake subpopulation was considered stable (USFWS 2002).

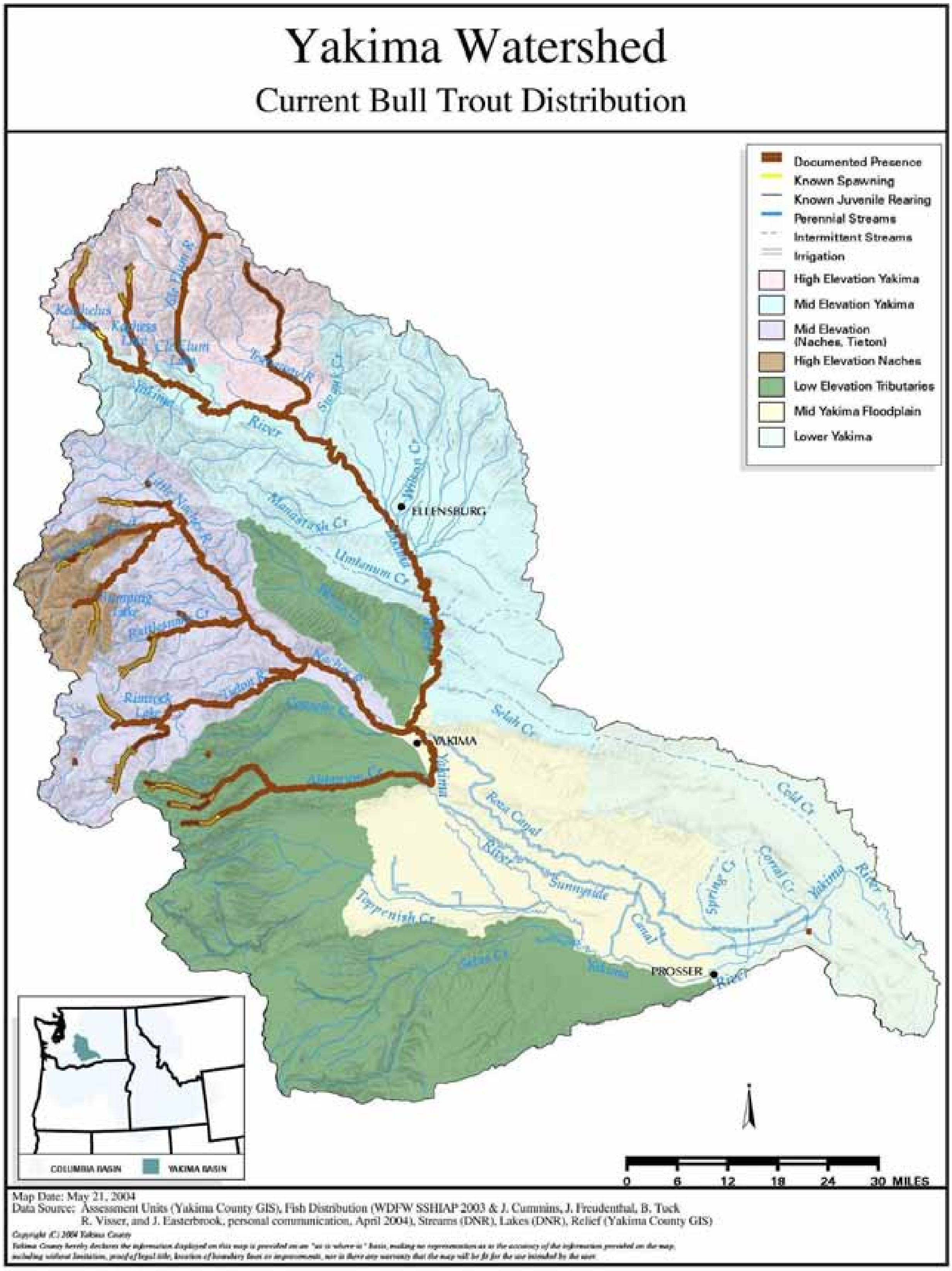


Figure 2-52. Current distribution of bull trout in the Yakima Subbasin

Important stock characteristics

According to WDFW (1998) there are nine distinct bull trout stocks present in the Yakima River Subbasin. US Fish and Wildlife Service (2003) identified 17 bull trout subpopulations in the Yakima Subbasin. There have been no previous studies to indicate that these are genetically distinct stocks; and thus the agencies have treated them separately because of the geographical, physical and thermal isolation of the spawning populations (WDFW 1998). All of these bull trout stocks in the Yakima Basin are native fish sustained by wild production. Five of the recognized bull trout stocks are adfluvial, residing in reservoirs and spawning in tributaries to these lake systems. Two river systems, the American-Naches and the Yakima River, are considered to have stocks of fluvial bull trout with various spawning tributaries. There are also two resident populations, delineated as such for their small adult size and the presence of thermal and water quality barriers. Table 2-25 illustrates this hierarchy, along with the life history form found with that population.

Table 2-25. Life history forms of bull trout in Yakima Subbasin

Stock Name/Core Area	Tributaries incl.	(Sub)Populations	Life History
AHTANUM CREEK	N, S and Mid Forks	Ahtanum Cr.	Resident
BUMPING LAKE	Deep Cr.	Bumping Lake.	Adfluvial
CLE ELUM RIVER (Upper) [1]		Cle Elum R.	Adfluvial
KACHESS LAKE [2]		(Box Canyon Cr.)	Adfluvial
		(Kachess R., upper)	
KEECHELUS LAKE	Gold Cr.	Keechelus Lake	Adfluvial
NACHES RIVER tributaries (also referred to as “American River tributaries”)		(American R.)	Fluvial/ Resident
		(Crow Cr.)	
		(Rattlesnake Cr.)	
		(Union Creek)	
RIMROCK LAKE		(Indian Cr.)	Adfluvial
		(Tieton R., S. Fork)	
TEANAWAY RIVER (N. and W. Forks)		Teanaway R. Middle Fork Teanaway (?)	Fluvial/ Resident
Taneum (?)			Resident
TIETON NF		Tieton NF	Resident
TIETON SF		Tieton SF	Adfluvial
WAPTUS LAKE	Wapatus River	Waptus River	Adfluvial
YAKIMA RIVER [3]		Yakima R.	Fluvial

[1] Also referred to as “Cle Elum [River]/Waptus)”.
[2] (Reiss 2003) refers to “Mineral Cr.”—a tributary of upper Kachess River. Mineral Creek and upper Kachess River are both used to describe this population, should clarify that this is a same population with alternate names.
[3] Also described as “mainstem” and/or “Keechelus to Easton [reach]”.

Recent genetic analysis work done by Reiss (2003) has indicated a high level of genetic differentiation among 12 bull trout spawning populations in the Yakima River basin (Figure 2-53). One contributing factor she mentions is the inclusion of three life history types mentioned above. The genetic results indicate that irrigation dams without fish passage are probably preventing gene flow between populations that historically interbred. This is the case for the Rimrock (South Fork Tieton and Indian Creek populations) sympatric populations. The South Fork Tieton adfluvial population in Rimrock Lake displays genetic similarities to the downstream fluvial populations. Indian Creek is not genetically similar to fluvial populations (Reiss 2003). There are other barriers to gene flow besides physical barriers and this is evident from the minimal gene flow among sympatric populations, which share the same lake environment, yet have distinct spawning populations.

Other Fish Species and Interactions

There are naturally reproducing populations of brook trout throughout the Mid Elevation Yakima Assessment Unit (WDFW 1998). Notable brook trout concentrations exist in the Cle Elum drainage, the upper Yakima River between Easton and Keechelus lakes, and small tributary streams of the upper Yakima River. Probable impacts to bull trout include predation on juveniles and competition for food and space. Brook trout may also pose a serious genetic threat to bull trout due to the potential for hybridization (WDW 1992; Rieman and McIntyre 1993. Although evidence is limited, it appears that the resulting offspring in some circumstances are fertile, thus providing an avenue for further introgression with bull trout populations (USFWS 2002,Wydoski and Whitney 2003).

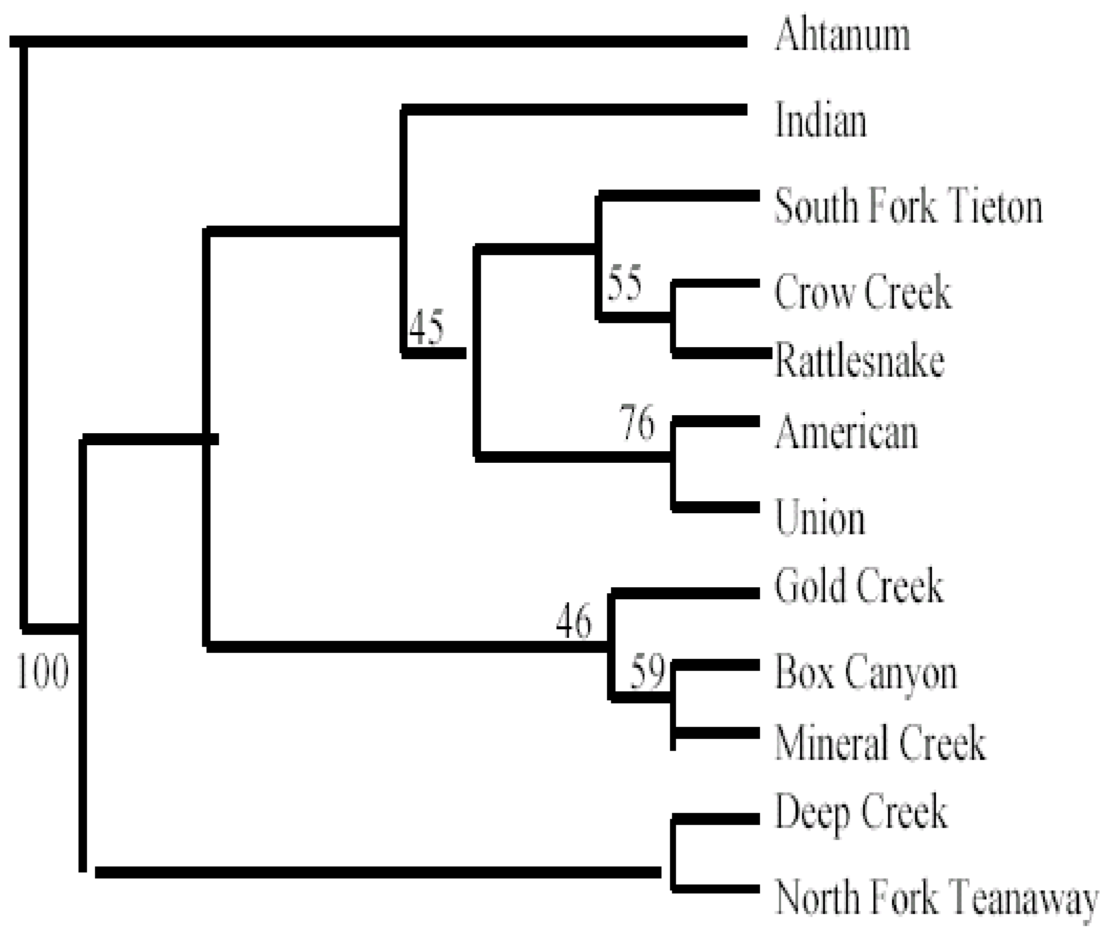


Figure 2-53. Dendrogram visualizing relationships among bull trout populations in the Yakima River Basin

In Kachess Lake, where Box Canyon Creek and Mineral Creek both have spawning bull trout populations, there are temporal differences in spawning timing Reiss (2003). Adfluvial bull trout in Box Canyon Creek move onto the spawning grounds in July, and spawn in late September and October, at the same time as most of the other Yakima River basin populations. Mineral Creek bull trout spawn in October and November, and move into the tributary just prior to spawning (Meyer 2002). Despite strong spawning site fidelity, temporal differences in spawn timing and other self-isolating behavior, evidence of gene flow among the populations with no barrier to migration implies that there is the possibility to reconnect populations if barriers are removed. Reiss (2003) suggests that though there are other barriers to gene flow in addition to dams, connectivity is and has been important to the genetic structure of bull trout populations in the Yakima Basin.

In the 2002 Recovery Plan, the USFWS also mentions three areas in which to establish populations: Taneum Creek, Teanaway River (Middle Fork), and Tieton River (North Fork). Given the unknown historic distributions, these may in fact represent reestablishment of extant bull trout populations. Existing and anticipated future levels of abundance and straying indicate that natural colonization of suitable habitats (after removal of obstructions to passage) would be very slow or non existent. Supplementation into newly re-opened habitats could accelerate/greatly improve the success rate of population reestablishment.

Spawning

Run-Timing

Run timing in bull trout is variable and appears to vary depending on life history (resident/fluvial/adfluvial), elevation, and size of adult. As explained in the USFWS Recovery Plan, "Bull trout are strongly influenced by temperature and are seldom found in streams exceeding summer temperatures of 18º C. Cool water temperatures during early life history results in higher egg survival rates, and faster growth rates in fry and possibly juveniles as well (Pratt 1992)."

Spawning

The diversity of life histories and habitat use in bull trout is also reflected in their spawning activity. Most Yakima stocks migrate to their spawning grounds between June and July (Figure 2-54) with spawning beginning as early as late August and extending to as late as mid-December (USFWS Recovery Plan 2002, Wydoski and Whitney 2003). The height of spawning occurs from early September to mid-October. Bull trout are known as repeat, annual, and alternate-year spawners, with spawning ages extending to age 12 or longer. Box Canyon Creek and Mineral Creek (also referred to as upper Kachees) have spawning populations with temporal differences in spawning timing. Box Canyon adfluvial bull trout migrate to the spawning grounds in July and spawn in September (normal pattern for most Yakima bull trout). Mineral Creek bull trout migrate to their spawning grounds just prior to the act of spawning which takes place in October and November , much later than other Yakima adfluvial stocks (Reiss 2003). Deep Creek (Bumping Reservoir) adfluvial fish move onto spawning grounds and spawn during a 2-3 week window in August. The South Fork Tieton and Indian Creek populations in Rimrock Lake have geographically separated spawning grounds and appear to be functioning as separate spawning populations.

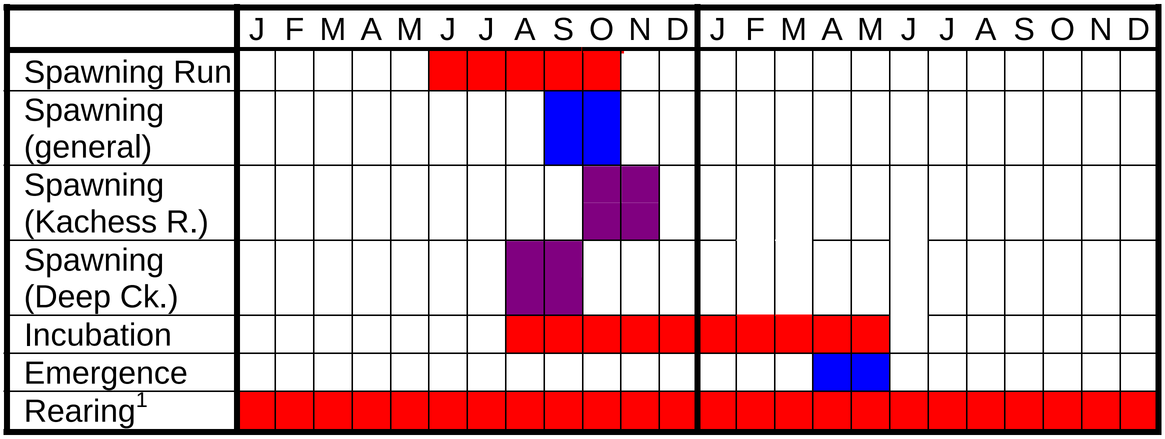


Figure 2-54. Mean timing of successive life stages of bull trout. (Sources: Wydoski and Whitney 2003, Meehan and Bjornn 1991, USFWS 2002, Reiss 2003)

[1] Rearing of resident life form occurs in natal stream throughout life cycle. Rearing of migratory life forms (fluvial and adfluvial) moves from natal stream to larger water bodies (streams and lakes, respectively) after 1 to 3 years (Goetz, F., Pers. Comm. 2004). Rearing extends for 2-4 years, with males reaching maturity at 4-6 years of age and females reaching maturity at 7-9 years.

The YSS (NPPC 2001) describes that "[p]referred spawning habitat consists of low gradient streams with loose, clean gravel in late summer and early fall (August to [December]) during periods of decreasing water temperatures. Water temperatures during spawning generally range from 4 to 10 degrees Celsius (39 to 51 degrees Fahrenheit). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996)."

Harassment of bull trout through fishing and poaching is high in Box Canyon and Gold Creek, resulting in decreased spawning success. Actions have recently been taken to reduce harassment pressure, but this problem is especially significant for the Box Canyon population, which already has a very limited amount of spawning habitat.

Incubation and Emergence

Local information about incubation and emergance times is not available, but studies in Montana showed that, depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992), and after hatching, juveniles remain in the substrate. Time from egg deposition to emergence of fry may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992).

Rearing

After emergence in spring, all three forms of freshwater bull trout begin a rearing period of 2-4 years, with full maturation of males occurring in years 5 and 6, and maturation of females occurring in years 6, 7, and 8.

Juvenile Outmigration

Juvenile outmigration occurs from the resident spawning creek to the rearing lake or river environment after 1-3 years of rearing in the headwater streams. The US Fish and Wildlife Service is funding a radio telemetry study conducted by WDFW on fluvial bull trout populations in the Yakima Subbasin that should fill in data gaps on life histories and migration patterns. (Reiss 2003)

Protection Key Findings for Bull Trout:

- Harassment such as poaching is high in Box Canyon and Gold Creek, resulting in decreased spawning success.
- Box Canyon bull trout population is naturally limited by spawning habitat that limits viability due to low population size and low spatial diversity of spawning habitat.
- Recent genetic analysis work done by Reiss (2003) has indicated a high level of genetic differentiation among 17 bull trout spawning populations in the Yakima River Basin (Figure 2-23).

Restoration Key Findings for Bull Trout:

- Bull trout population fragmented by loss of passage at Tieton, Bumping, Kachess, Kachelleus, and Cle Elum dams, making these populations more vulnerable to extinction over the long term. Despite strong spawning site fidelity, temporal differences in spawn timing and other self-isolating behavior, evidence of gene flow among the populations with no barrier to migration implies that there is the possibility to reconnect populations if barriers are removed.
- Bull trout have reduced population viability due to competition and interbreeding with brook trout.

Key Uncertainties for Bull Trout:

- In the 2002 Recovery Plan, the USFWS also mentions three areas in which to establish populations: Taneum Creek, Teanaway River (Middle Fork), and Tieton River (North Fork). Given the unknown historic distributions, these may in fact represent <u>re</u>establishment of extant bull trout populations. Existing and anticipated future levels of abundance and straying indicate that natural colonization of suitable habitats (after removal of obstructions to passage) would be very slow or non existent. Supplementation into newly re-opened habitats could accelerate/greatly improve the success rate of population reestablishment.
- Historic abundance of bull trout is not well understood and should be regarded as a data gap.
- Bull trout could migrate throughout the Yakima System, including the mid and lower Yakima Floodplains.

6.3.6 Sockeye salmon

Overview

The species *Oncorhyncus nerka* is represented by two major life history forms. The anadromous form is commonly known as the sockeye salmon and the resident form is known as kokanee salmon. *O. nerka* are unusual among Pacific salmon in that they typically require the presence of a lake during part of their life history. Sockeye salmon spend 1 to 2 years in freshwater, a significant portion of which is spent in lakes (or, occasionally, major rivers). Once beginning the journey downstream, sockeye salmon progress steadily toward the ocean. After 2 to 3 years offshore, sockeye return to spend 1-8 months in their natal waters prior to spawning. Kokanee spend the equivalent life stages in the area of their birth, sometimes migrating between their natal site and the lakes, outlet streams, and tributary streams in their larger natal area. Maturation for kokanee is typically 3-5 years to reach spawning capability.

Historical Distribution and Abundance

Gustafson et al (1977) indicated that historical populations of sockeye salmon existed in the Yakima, Wenatchee, and Okanogan Rivers. Sockeye salmon populations reportedly existed in two small lakes at the head of the Yakima River on the present site of Lake Keechelus, as well as in Cle Elum Lake, in Kachess Lake, and in Bumping Lake (Figure 2-55). The historical total run size of Yakima River sockeye salmon has been estimated at either 100,000 (Davidson 1953) or 200,000 (CBFWA 1990). Sockeye were extirpated following the completion of impassible storage dams below all natural rearing lakes in the late teens and early 1920's (NPCC 2001). Construction of crib dams without fish passage facilities at Lakes Keechelus and Kachess in 1904 and at Lake Cle Elum in 1905 eliminated sockeye salmon populations in these lakes (Bryant and Parkhurst 1950, Davidson 1953, Fulton 1970, Mullan 1986). Construction of an impassable storage dam at Bumping Lake in 1910 likewise eliminated a sockeye salmon population in that lake, with an estimated annual run of 1,000 fish (Davidson 1953, Fulton 1970).

Current Distribution and Abundance

With the introduction of dams and other migratory obstacles, sockeye have long been considered extirpated from the Yakima Basin. There are self-sustaining populations of kokanee in Rimrock, Kachess, Cle Elum, Bumping, and Keechelus Lakes. It is clear that the Rimrock population has a hatchery origin. The origin of other populations can be traced to historical populations that were present in the high elevation lakes before they were converted into reservoirs, and periodic introduction of Lake Whatcom kokanee. There have been widespread introductions of hatchery kokanee over the past 20 or more years, so it cannot be positively affirmed to what extent the natural origin stocks have been diluted in these reservoirs (Jeff Fryer, pers. comm. 2003).

In the late 1980's and early 1990's the Cle Elum Lake Anadromous Salmon Restoration Feasibility Study was implemented in order to determine if sockeye could be restored to the basin (Flagg et al. 1991, at http://www.efw.bpa.gov/Environment/EW/EWP/DOCS/REPORTS/YAKIMA/P64840-3.pdf).

Over the course of the study more than 35 adult sockeye salmon were observed returning upstream through the Yakima River system. Four returning adult sockeye salmon were observed at Roza Dam; two males were recovered on 31 July and 12 October 1991, and two females on 9

September and 8 October 1991. Adult sockeye salmon continued to return to the Yakima River Basin even after stocking from the program halted. Information from Yakama Nation fish ladder counts indicates 11 returning adults were recorded at Roza Dam in 1992. In 1993, 20 adults were documented passing Prosser Dam between July 10 and July 25 (peak on July 18) and 16 of these fish were later observed passing Roza Dam beginning July 14 and extending to August 4 (peak passage on July 27). In 1994, no fish were observed at either dam. However, again in 1995 an adult was observed passing both facilities. These were the first documented returns of sockeye salmon to the Yakima River Basin in over 60 years (Flagg and Dey 1991).

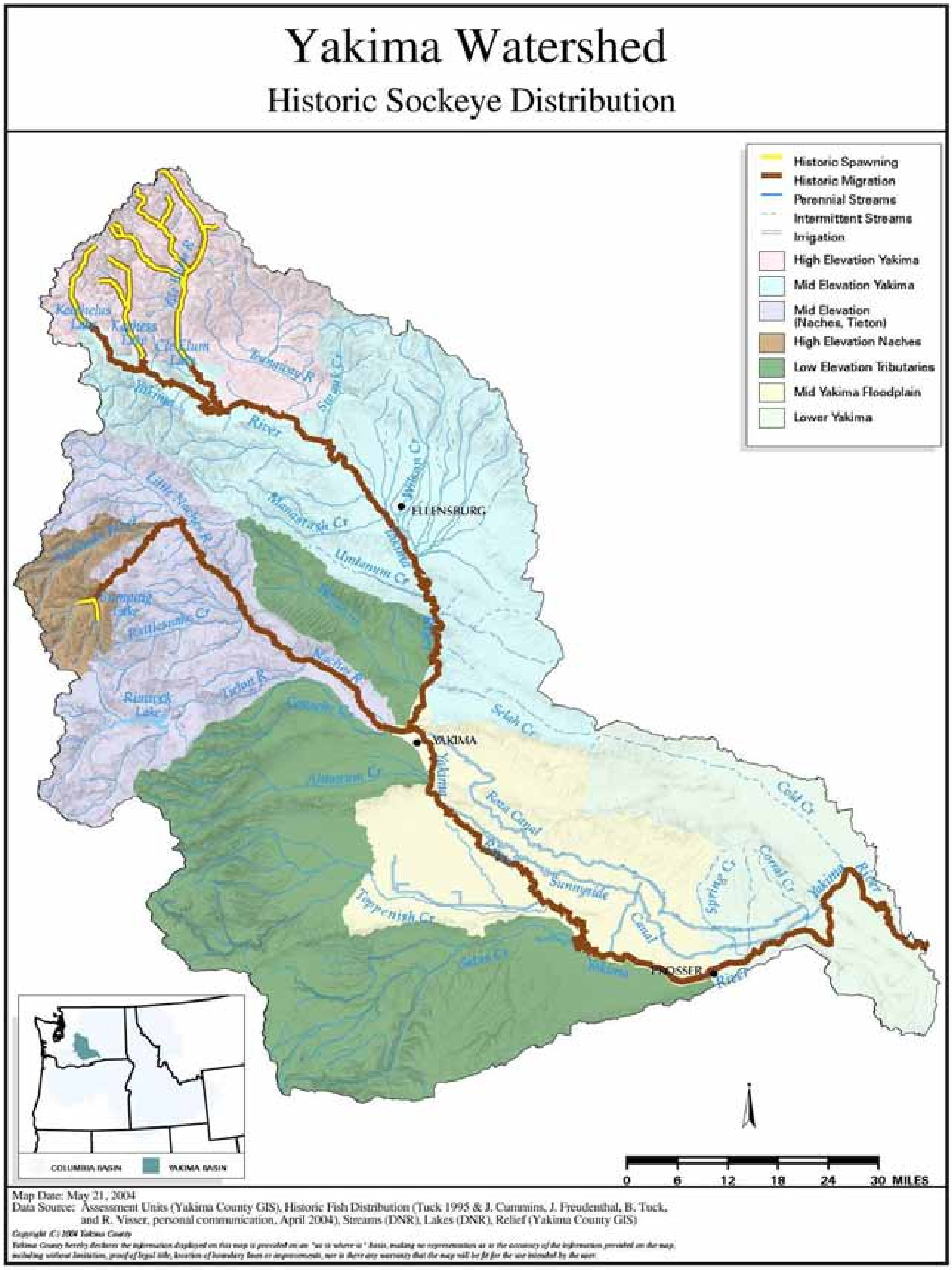


Figure 2-55. Historical spawning distribution of sockeye in the Yakima Subbasin

Important stock characteristics

Because sockeye salmon were extirpated from the Yakima Subbasin so long ago little is known about genetic or life history variation that may have occurred in individual stocks or populations. The Wenatchee River sockeye and the Okanogan River sockeye stocks are the last two remaining viable stocks in the Columbia River. Gustafson et al. (1997) highlighted several important population life history and environmental factors that differentiate these two remaining sockeye populations: juvenile outmigration timing, environmental differences in lake-rearing habitat, and age composition (Table 2-26).

Table 2-26. Life History Differences between Lake Wenatchee and Lake Osoyoos Sockeye Stocks (Gustafson et al. 1997)

Life History Stage	Lake Wenatchee Sockeye	Lake Osoyoos Sockeye
Fry Emergence and Juvenile Outmigration	Mid-March -May	March- May
Smolt outmigration	April	May
Spawning Run	May- August	June- August
Spawning	mid- September- early October	Late September- October
Lake rearing	2 years	1 year
Lake environment	Oligotrophic	Eutrophic
Temperature tolerance during adult migration	Colder than 21º C	21º C

Spawning

Run-Timing

Wherever they occur, sockeye express the “greatest diversity in adaptation to a wide variety of spawning habitats” of any of the Pacific salmon (Groot and Margolis 1991). This diversity is reflected in their run timing within the overall spawning run period. That period begins in June and extends into late September (Figure 2-57). Experience in current sockeye streams indicates that differentiation in timing within that overall period is based on several factors relating to “survival conditions for spawning, egg and alevin incubation, emergence, and subsequent juvenile feeding” (Groot and Margolis 1991). The timing is also influenced by the spawning location, with tributary spawners spawning earlier than those spawning along lakeshores. In contrast to the diverse timing of any given run, it is interesting to note that specific races tend to have very short, intensive periods for their respective migration and spawning period.

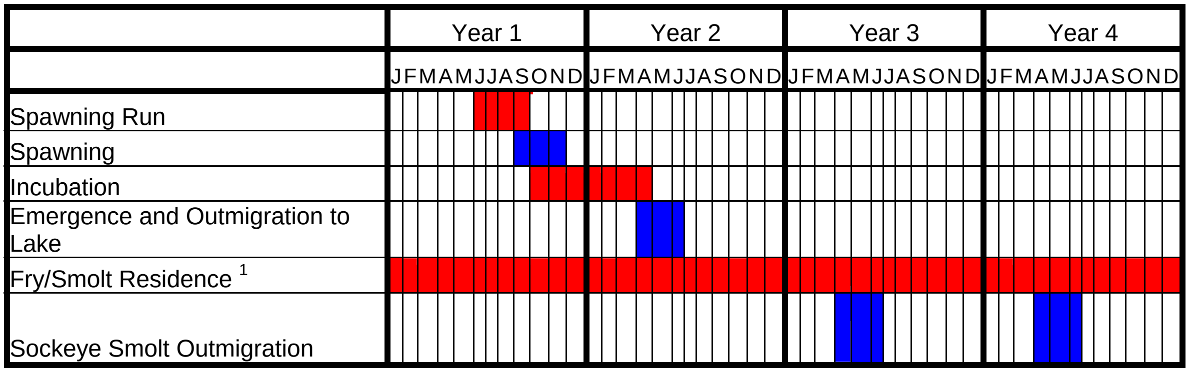


Figure 2-56. Mean timing of successive life stages of sockeye. (Sources: Gustafson et al. 1997, Meehan and Bjornn 1991, Wydoski and Whitney 2003)

[1] Whether remaining in freshwater for their entire life (kokanee) or migrating to sea (sockeye), juveniles progress from fry to outmigrating capability over a period of years. Kokanee reach mature spawning capability between 3 and 5 years, post emergence. Sockeye remain in fresh water for 1-2 years and then outmigrate to saltwater for an additional 2 to 4 years, before returning to spawn.

Kokanee demonstrate similar diversity in spawning timing, though this has not been extensively investigated in the Yakima Basin.

Spawning

Groot and Margolis (1991) state that spawning timing can vary greatly from population to population within a year, as well as among populations within a lake system. Spawning sites can also vary, but specific populations show a high level of site fidelity. Both sockeye and kokanee utilize lakeshores, headwater streams, outlet streams (including nearby tributaries), and inter-lake streams. In all cases they are seeking gravel of the desired size and the proper water flow to maintain redds. Eggs are laid in fine gravel and need cool water and good water flow (to supply oxygen) to survive. Meehan and Bjornn (1991) (citing French et al. 1976) noted that spawning typically occurs in water between 3^{o} and 7^{o} C. Wydoski and Whitney (2003) point out that, in at least one lake, sockeye looked for deeper areas where temperature is about 9^{o} C.

Kokanee prefer temperatures around 10^{o} C. When lakes are thermally stratified, kokanee will select the desired depth in the water column, even though it may be little more than 3 meters in depth (Wysocki and Whitney 2003). There appears to be little information about the specific populations of kokanee in the Yakima Basin. This should be considered a data gap.

Incubation and Emergence

Egg incubation is dependant on temperature and intra-gravel flow. The eggs and embryos incubate throughout the winter in the spawning gravel or in the cracks and crevices of larger substrates. Incubation periods vary from 42 to 150 days (Meehan and Bjornn 1991, Wydoski and Whitney 2003). After emerging from the redd, they move upstream or downstream into a nursery lake or estuary.

Fry Outmigration

Fry outmigration to the freshwater rearing areas occurs for both sockeye and kokanee from mid-April to late June.

Rearing

As noted elsewhere, sockeye rearing includes both a freshwater and a saltwater component. The typical pattern is to spend one or two years in freshwater (usually a lake, but for some stocks it may be in major rivers), followed by one to four (typically two or three) years in the ocean. Juveniles feed on small planktonic (drifting) organisms and a variety of terrestrial and aquatic insects.

Kokanee rearing takes place over three to five years, in the freshwater system in which they are spawned. Within this general pattern variation occurs in terms of residence. Most will spend the full rearing period in the lakes that are associated with their freshwater system. Some, however, may rear in major rivers, emulating the pattern found in some sockeye stocks.

Smolt Outmigration

Sockeye smolt outmigration occurs from April to June after a residency. Wenatchee sockeye typically smolt after their second year and Osoyoos sockeye smolt after their first year. There is no documentation of historical Yakima sockeye smolting timing but it can be assumed that it was more typical of the Wenatchee stock since the rearing environments are would have been similar.

Reintroduction potential

The feasibility of sockeye reintroduction should receive study, and sockeye should be reintroduced wherever it is determined that passage, habitat, and potential productivity of the environment are sufficient to support viable populations over the long term.

There are currently two stocks that contribute the majority of the sockeye runs in the Columbia Basin: the Wenatchee River stock and the Osoyoos River stock. Though there are not currently any viable sockeye populations in the Yakima Basin, it can be expected that successful reintroduction would use one or both of these remaining populations as donor stock. The Wenatchee stock has actually been planted to check the feasibility of reintroduction as described in the Cle Elum Lake Anadromous Salmon Restoration Feasibility Study (Flagg et al. 1991). Both stocks spawn at different times and that is potentially a key factor in trying to re-establish a viable run in the Yakima Subbasin. The Osoyoos stock may be better suited for the Yakima SubbasinYakima Subbasin because it has the ability to tolerate higher temperatures during adult migration. However, spawning, incubation temperatures and duration, and rearing conditions and overall productivity in the upper elevation reserviors are similar to those encountered in the Wenatchee basin and may be more favorable for the Wenatchee stock. Regardless of the chosen stock, passage over the storage impoundments is a prerequisite for successfully re-establishing viable populations. Since management of the reserviors would preclude beach spawning, natural populations of sockeye would be dependent upon available spawning habitat in the tributaries. Available habitat and productivity in these environments should be studied prior to commitment to sockeye reintroduction.

Restoration Key Finding for Sockeye:

- Sockeye were extirpated following the completion of impassible storage dams below all natural rearing lakes in the late teens and early 1920's (NPCC 2001). Construction of crib dams without fish passage facilities at Lakes Keechelus and Kachess in 1904 and at Lake Cle Elum in 1905 eliminated sockeye salmon populations in these lakes (Bryant and Parkhurst 1950, Davidson 1953, Fulton 1970, Mullan 1986). Construction of an impassable storage dam at Bumping Lake in 1910 likewise eliminated a sockeye salmon population in that lake, with an estimated annual run of 1,000 fish (Davidson 1953, Fulton 1970).
- The feasibility of sockeye reintroduction should receive study, sockeye should be reintroduced wherever it is determined that passage, habitat, and potential productivity of the environment are sufficient to support viable populations over the long term.

Key Uncertainties for Sockeye:

- Though there are not currently any viable sockeye populations in the Yakima Basin, it can be expected that successful reintroduction would use one or both of these remaining populations as donor stock.
- Introduced Kokanee in Rimrock Lake and other populations derived from Whatcom Lake stocks may present genetic risk to sockeye if they are reintroduced.
- Since management of the reserviors would preclude beach spawning, natural populations of sockeye would be dependent upon available spawning habitat in the tributaries. Available habitat and productivity in these environments should be studied prior to commitment to sockeye reintroduction.

6.3.7 Pacific Lamprey

Overview

Life History

As summarized and described in the Priest Rapids Hydroelectric Project Draft license Application (2003) and Wydoski and Whitney (2003), the Pacific lamprey is a prehistoric jawless fish with a cartilaginous skeleton that is parasitic as an adult. In salt water, Pacific lamprey feed on the blood and body fluids of fishes. They may spend two to four years in the ocean before returning to freshwater to spawn (Figure 2-57). Adults may reach 30 inches in length and weigh about 1 pound. Pacific lamprey are anadromous, and their historical distribution encompassed the entire Columbia River Basin. These fish were especially important to Native Americans for medicinal and ceremonial purposes and were considered a delicacy by many Columbia basin tribes.

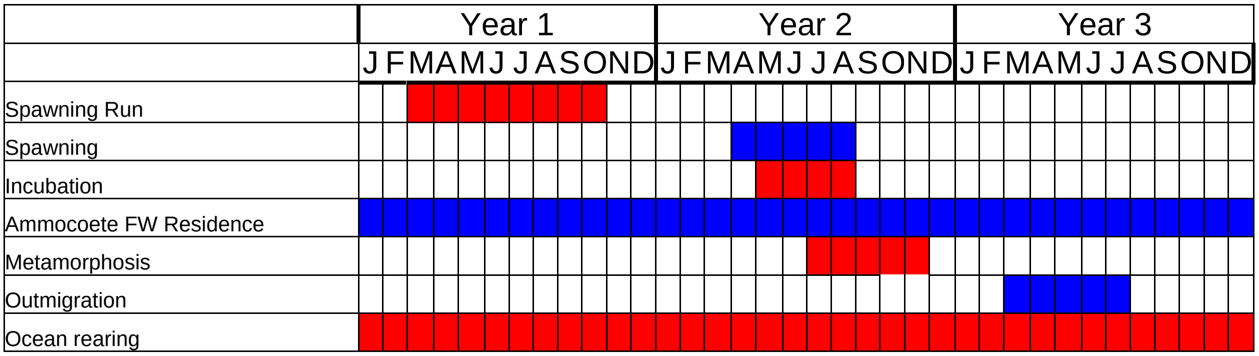


Figure 2-57. Pacific lamprey life history in the Yakima Basin (Wydoski and Whitney 2003)

6.3.7.1.1.1

Historic Distribution and Abundance

Little is known about the historic distribution and abundance of Pacific lamprey in the Yakima Subbbasin.

Current Distribution and Abundance

Pacific lamprey are currently found in the mainstem Yakima and Naches Rivers (Figure 2-58). Fewer than 15 have been observed in the Yakima system since 1992 (Wydoski and Whitney 2003). Pacific lamprey is a Washington State species of concern and is under consideration for ESA listing by USFWS. Population levels of Pacific lamprey have been dramatically reduced from pre-1850 levels, more study of the presence and life history of lamprey in the Yakima Subbasin is warranted.

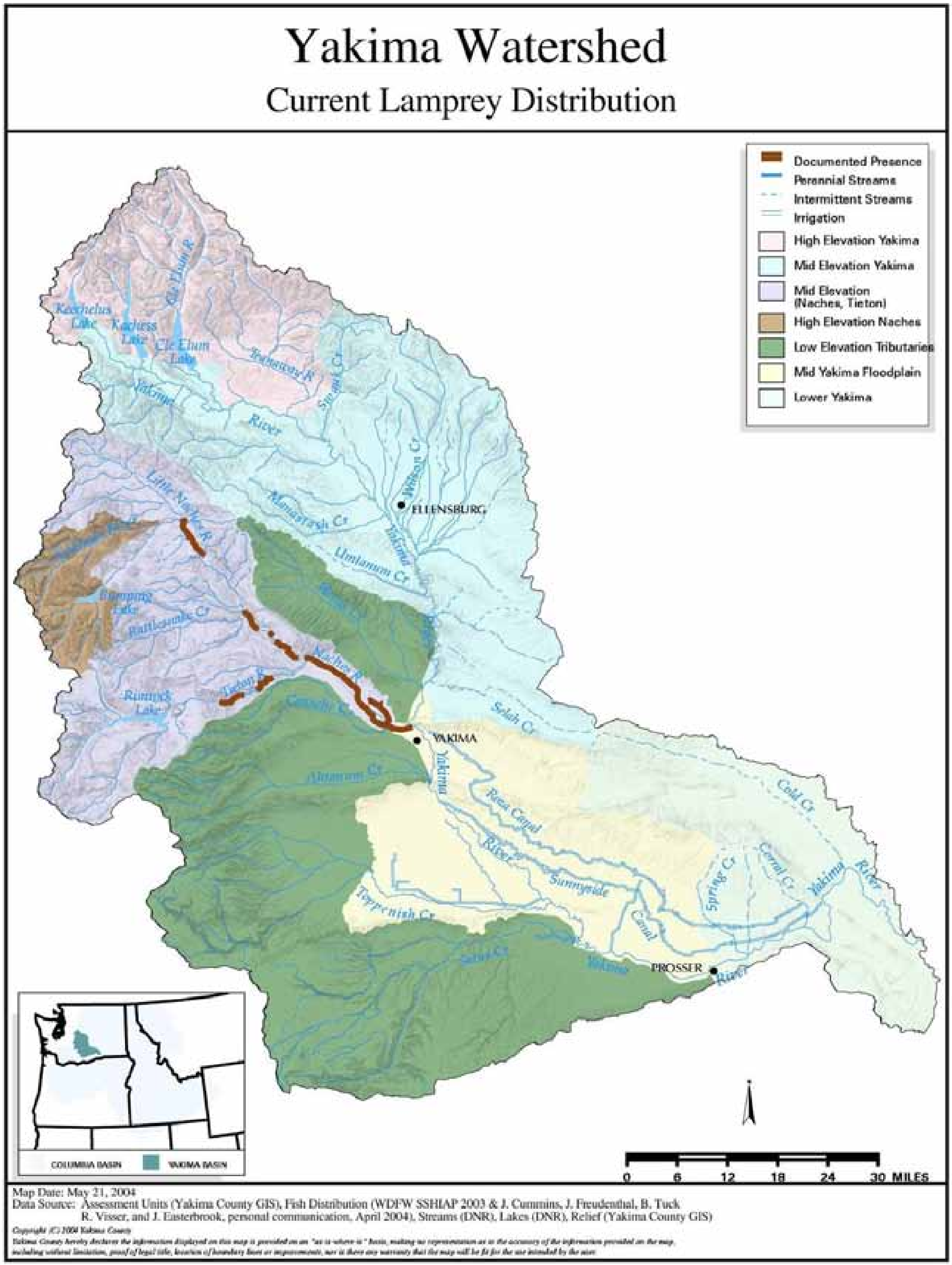


Figure 2-58. Current Pacific lamprey distribution in the Yakima Subbasin

Spawning

Run-Timing

Adult lamprey begin an upstream migration into freshwater from May to October and then overwinter in deep pools of their natal river. During April to August the adult lamprey spawn in sandy gravel on the upstream side of riffles (Wydoski and Whitney 2003). Adult lamprey usually die within a month after spawning (Figure 2-57). Spawning occurs from April through July. Nests are excavated in gravel substrates containing some fine gravel and sand (Wydoski and Whitney 2003). Males arrive on spawning grounds first. Both sexes participate in digging the nest, which may be up to 2 feet in diameter (Wydoski and Whitney 2003). Spawning sites are in riffles and tails of pools where water velocities are generally between 1.6 and 3.3 feet per second at depths usually between 1.3 and 3.3 feet (Wydoski and Whitney 2003).
Pacific lamprey can pass barriers by clinging to and slowly ascending them using their sucker like mouths. This adaptation has probably been beneficial for ascending small barriers but the construction of the mainstem Columbia dams has severely impacted both the upstream passage of adult lamprey and the downstream passage of ammocoetes.

Incubation and Emergence

The eggs incubate for two to three weeks, and the larval lamprey then emerge from the gravel and settle into backwater areas.

Rearing

Ammocoetes inhabit fine silt and mud substrates in backwaters and quiet eddies of coldwater streams with currents less than 1 foot per second (Wydoski and Whitney 2003). The young larvae spend the next four to six years feeding on detritus, diatoms, and algae that are suspended above and within the substrate

Smolt Outmigration

The ammocoetes live in freshwater for 4 to 7 years, outmigrating to the ocean during March to July of the year following their metamorphosis, with peak outmigration between April and June (Wydoski and Whitney 2003). At this time lamprey begin the transformation to a parasitic feeding pattern.

Key Findings for Pacific Lamprey

- These fish were especially important to Native Americans for medicinal and ceremonial purposes and were considered a delicacy by many Columbia basin tribes.

Key Uncertainties for Pacific Lamprey

- Little is known about the historic distribution and abundance of Pacific lamprey in the Yakima Subbbasin.
- Fewer than 15 have been observed in the Yakima system since 1992 (Wydoski and Whitney 2003). Pacific lamprey is a Washington State species of concern and is under consideration for ESA listing by USFWS. Population levels of Pacific lamprey have been dramatically reduced from pre-1850 levels, and more study of the presence and life history of lamprey in the Yakima Subbasin is warranted.

6.4 Fish Habitat and Environmental/Ecosystem Attributes

6.4.1 Assessment Units and Rationale for Selection

A broad body of information exists that describes chemical, physical, and biological interactions within the basin as they relate to the focal species. This information may take the form of peer reviewed scientific literature, applied research and technical reports, ongoing monitoring programs, and the knowledge and expertise of individuals who live and work in the basin. A comprehensive review of this information was conducted with the objective of characterizing the current state of environmental conditions in the Yakima Subbasin and describing how those environmental conditions might limit the distribution and abundance of the focal species.

The following section is organized into a discussion at the subbasin scale, and finer-level discussions centered on discrete areas in the basin identified as Assessment Units. Assessment Units are a convenient way of classifying and grouping portions of the basin with shared geographic, physiographic, hydrologic, and ecological traits. A total of seven Assessment Units were delineated for this review. The names and Key Findings codes of the Assessment Units are presented below and their location is illustrated in Figure 2-58 (Subbasin Overview Map):

- Lower Yakima
- Mid Yakima Floodplain
- Low Elevation Tributaries
- Mid Elevation Yakima
- High Elevation Yakima
- Mid Elevation Naches
- High Elevation Naches

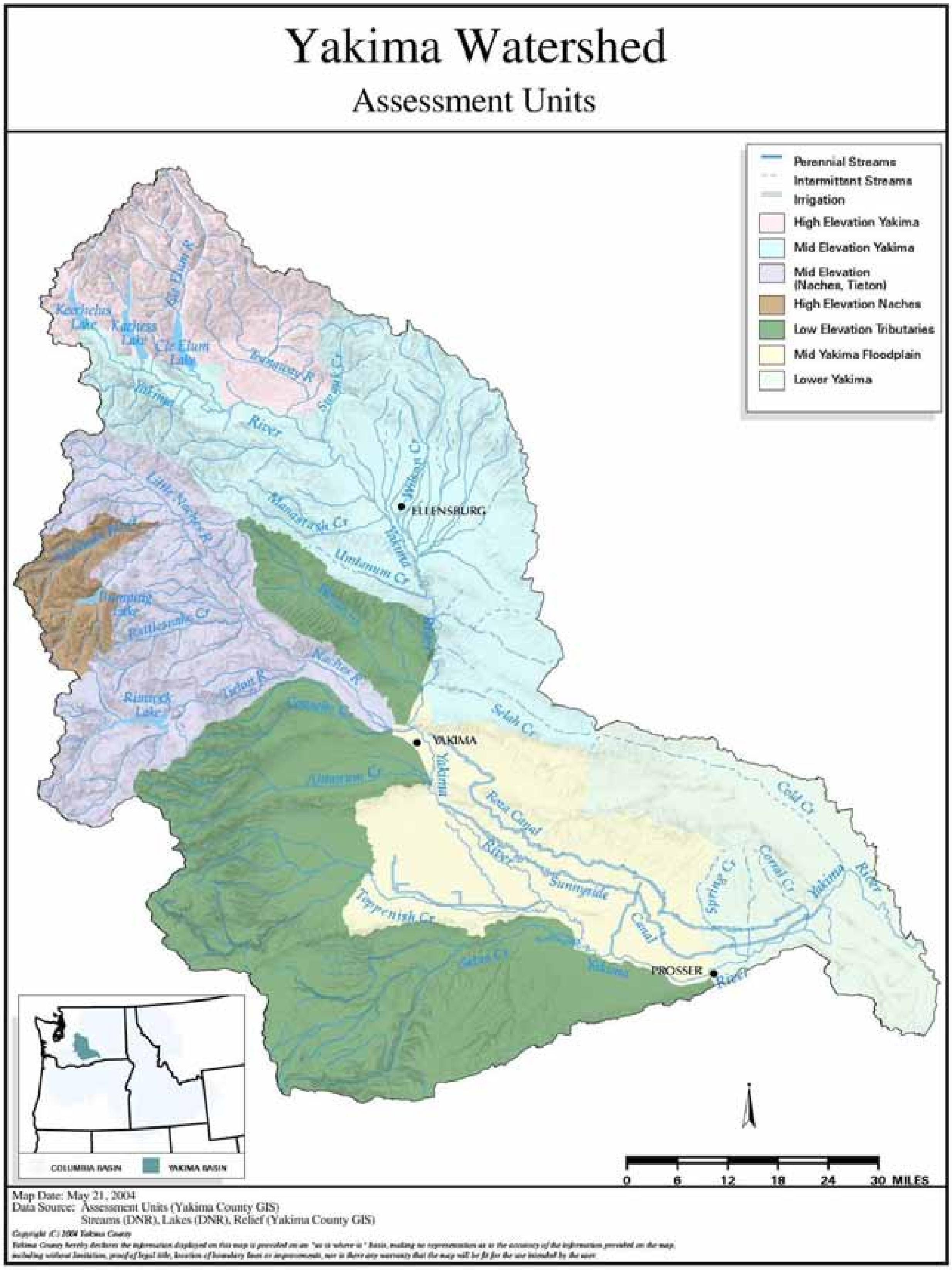


Figure 2-58. Overview of theYakima Subbasin showing the Assessment Units.

In the discussion of each Assessment Unit, this document s 1) provide a general overview of each Assessment Unit, 2) describes species distributions and habitat utilization, 3) describes the condition of aquatic and riparian habitat, and 4) identifies key factors that may limit the distribution and abundance of the focal species within the unit.

The general overview section identifies important characteristics of each Assessment Unit including unit size, precipitation patterns, land use, and population. This section also identifies the presence and location of major surface water impoundments, surface water diversions, fish passage barriers, and diversion canals.

The species distribution and habitat utilization section identifies which species are known to occur within each Assessment Unit. The current and historical distribution of the focal species is discussed, as is habitat utilization during various life stages. This section also evaluates the influence that species interactions may have on the focal species.

The Aquatic and Riparian Habitat section is divided into four broad categories: 1) Stream Channel Condition and Function; 2) Riparian and Floodplain Function; 3) Water Quantity; and 4) Water Quality. The stream channel condition and function review includes topics such as channel incision, sediment load, spawning gravel abundance, substrate composition, channel modification, and channel complexity. Topics discussed in the Riparian and Floodplain Function section include the structure of riparian vegetation, woody debris recruitment, floodplain development, agricultural practices, and alteration of natural disturbance regimes. The Water Quantity section is devoted to review of the extent to which human activities have altered the streamflow patterns in the basin. Where possible, information is presented that illustrates current and historical streamflow patterns relative to the life history stages of the focal species. The Water Quality section addresses the impact of land and water resource management practices on water quality parameters including temperature, various chemical constituents, and fine sediment.

6.4.2 Assessment of the Yakima Subbasin at the Subbasin Scale

The discussions of the Aquatic Technical Committee and review of the pertinent literature revealed that the issues which deserve discussion at the subbasin scale are 1) the effects due to changes in basin level annual flow regimes, 2) changes in basin level temperature regimes, and 3) changes in sediment/energy relationships related to peak flows, confinement/constrictions, dams, etc. The majority of this section will focus on those environmental attributes, and will conclude with some additional information on basin-scale biological changes as well.

It should be noted that the assessment is conceptually based on the comparison of currently observed conditions with pre-1850 conditions in the subbasin, in an attempt to determine the effects of physical and biological changes in the watershed, and changes in land or natural resource management. In the many documents we reviewed in preparation of the assessment, there was very little information that compared the role and function of the pre-1850 lakes in creation of environmental attributes (such as flow and temperature) in river reaches directly downstream or at a subbasin scale. Most analyses of the physical characteristics of the pre-1850 subbasin treat the glacial lakes as though they did not exist prior to their conversion to reservoirs. Creating an analysis of the effect that the natural glacial lakes had on the subbasin is beyond the scope of the Subbasin Plan, but reviewers and managers should recognize that an analysis of the role of the glacial lakes in the pre-1850 environment could have a large impact on how current environmental conditions are viewed. This is especially relevant to populations such as the

Upper Yakima spring chinook whose life history is still closely linked to the temperature and flow environments of the Yakima below the former glacial lakes.

6.4.3 Flow Regimes at the Subbasin Scale

Intrannual Flow Patterns.

Pre-1850 Flow Patterns

Parker and Storey (1916) and Kinnison and Sceva (1963) are excellent reviews of the pre-1850 physical characteristics of the subbasin and their effect on the annual hydrograph of the Yakima River at various points in the subbasin. The glacially influenced topography of the upper watershed, including the 5 major natural glacial lakes – Keechelus, Big Kachess and Little Katchess, Cle Elum, and Bumping - and the broad and relatively low gradient valleys created by alpine glaciers in the upper reaches of all the major streams greatly moderated the rate of snowmelt runoff delivery to the lower elevation portions of the subbasin. The broad and ancient alluvial valleys further attenuated flood flows and spring peaks in the mainstem. These areas include McAllister Meadows (now beneath Rimrock Reservoir) on the Tieton River: the Nile and Lower Naches Valleys on the Naches River; the Cle Elum, Kittitas and Selah Valleys in the Upper Yakima; and the Union Gap, and Wapato, and Satus Valleys in the Middle Yakima; and the floodplains of lower Yakima River downstream of Benton City which include a large area of hyporheic zone and floodplain shared by the Yakima and Columbia Rivers.

Stanford and Snyder (2002) visualize these large alluvial floodplains as downwelling in the upper portions of the valley in the steeper gradient and coarser sections of the stream, and upwelling at the lower ends of the alluvial valleys as the surficial aquifer is near to the ground surface (and under positive head in many locations), feeding and driving the formation of springbrooks and side channels that occur in these locations. The energy surface of the surficial aquifer in any given valley could vary 10 to 15 feet or the course of the year, providing a natural storage reservoir and source of cool inflow as flows dropped in the later summer. So conceptually, even under natural conditions, discharge at various points in the stream channel within a given valley varied according to valley position. High discharge was present at the upper end of the valley and then decreased, until at some point near the lower 1/3 the valley, water returns to the river. From that point discharge increases until the next natural constriction is reached. Due to fluctuations in the level of the surficial aquifer, at certain times during the year during and after the recession of the spring peak flow the outflow from a given alluvial basin would have caused the net discharge from the lower end of the valley to exceed the flow at the upper end of the valley. This surface and groundwater interaction would have had a large effect on both flow and temperature during the hottest months of the summer (July and August).

These lower floodplain and upper gap areas were centers of biological diversity, but also attractive to builders of irrigation infrastructure due to the higher flows and natural anchoring points (basalt outcrops) that the “gaps” provide. The overall natural hydrology of the basin with its naturally long spring peak flows, glacial lakes that could be easily modified to act as storage reservoirs, and the floodplain gradients that allowed easy distribution of irrigation water with canals, also contributed to the attractiveness of this area for the development of large scale irrigated agriculture.

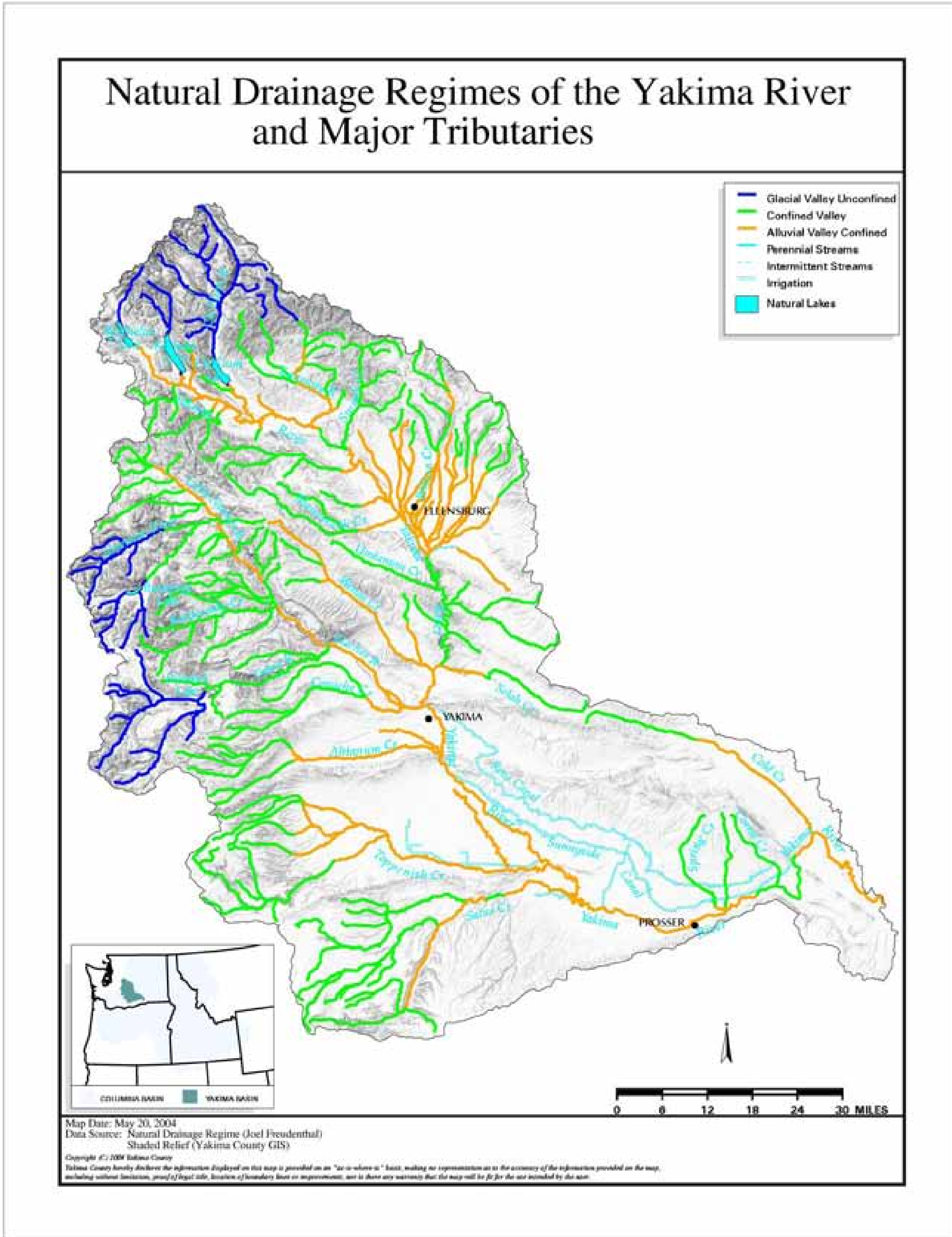


Figure 2-59. Natural drainage regimes of the Yakima Subbasin.

In the high elevation tributaries that now feed the reservoir system, spring runoff peaks were in early to mid June. The peaks were in late May in the north facing tributaries of the Naches and Upper Yakima, mid May in the south facing tributaries, and mid to early May in the low elevation tributaries such as Wenas, Cowiche, Ahtanum, Toppenish and Satus Creeks. Tributaries in the Kittitas Valley and the low elevation Tributaries flow across large alluvial fans where they discharge from the higher elevation valleys to the main valley in the Kittitas, or to each creek's own lower valley in the lower tribs. These relatively steep and porous fans have created naturally low flows and less than ideal migratory conditions on these fans in the summer and fall. At the base of these fans, water discharges form a network of cool wetlands and springs that feed more characteristically stable summer base flows (with the exception of Satus Creek, which naturally went dry for extended periods) downstream of these fans.

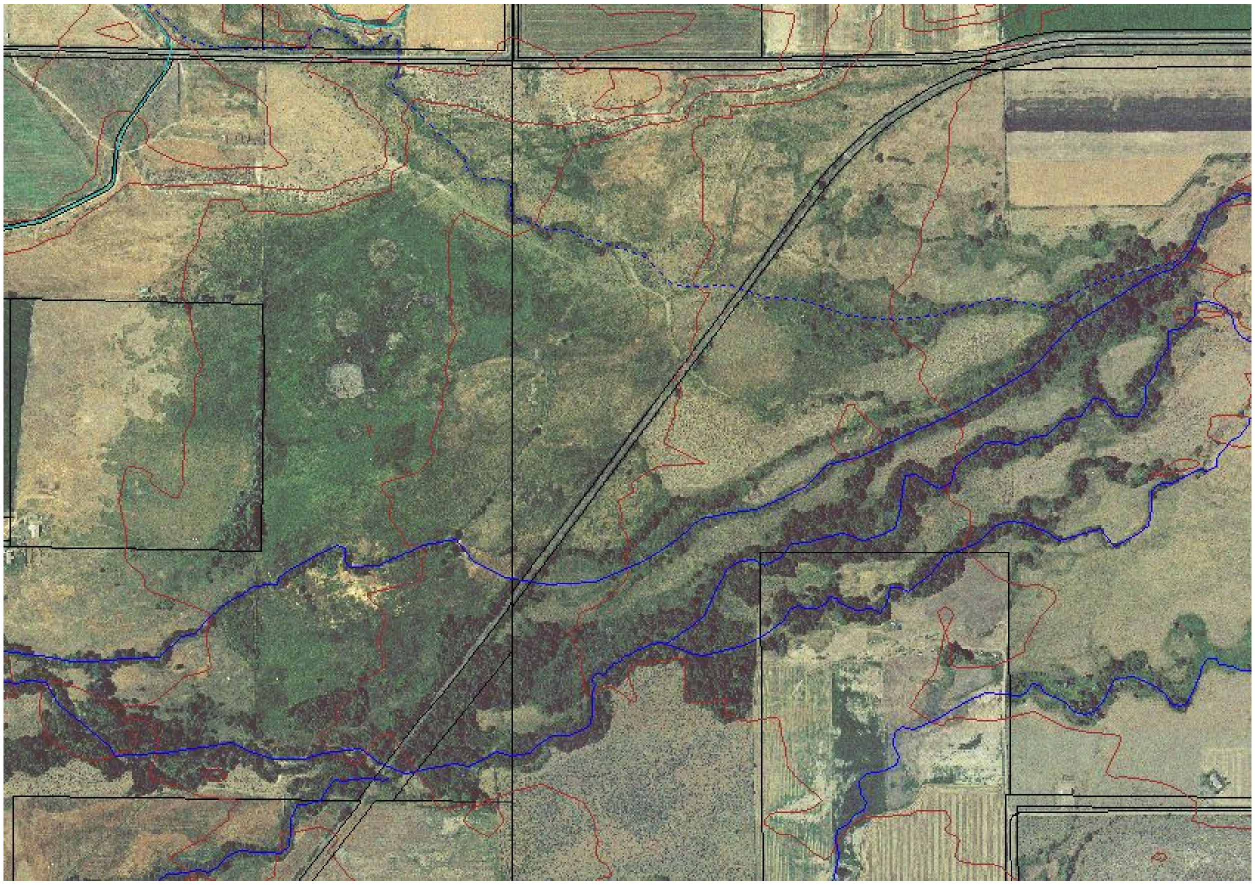


Figure 2-60. Wetland stream system at the base of the Simcoe Creek alluvial fan on the YR (Yakima County GIS, 2002)

In sum, the natural locations of relatively steep environmental gradients for flow and related environmental attributes were at the upstream and downstream portions of the glacial lakes, the downstream ends of the alluvial valleys, at the upstream and downstream portions of the alluvial fans in the tributaries, and at confluences where tributaries had earlier peak spring flows and summer low flows than the main channel. Biologically these areas of rapid change in environmental conditions should have also functioned as breakpoints between species and ecosystem communities. For the most part (the influence of temperature will be discussed below), these areas were selected as dividing points for breaking the watershed down into the 7 Assessment Units that form the basic units of analysis for this assessment.

Current Flow Patterns

In many ways, flow in the river system is managed according to two different systems – in the mainstem flows are managed by the USBR which contracts with the larger irrigation districts for delivery of water to the major agricultural areas of the basin; and in the tributaries flows are the result of natural flow regimes modified by diversion for irrigation. Currently, the models that are in use to compare pre-1850 flows in the mainstem (such as the Bureau of Reclamation's Riverware) are based on the existing physical configuration of the watershed and do not take into consideration the presence of the glacial lakes or the loss of inflow from tributaries due to withdrawal or diversion.

The purpose of this existing model is to manage the delivery of irrigation water and track the complex accounting of irrigation returns and travel times of reservoir releases in the current physical configuration of the basin, and not necessarily to model to a pre-determined standard of accuracy pre settlement flows and flow patterns. Therefore, much of the "estimated unregulated" flows are biased toward those areas of the subbasin which are components of the Yakima Project and managed by the Bureau of Reclamation, and do not include reductions in flow from the tributaries that are not managed or controlled by Reclamation. Therefore in the discussion below on the mainstem, the difference between the "estimated unregulated" flows and current flows is probably somewhat underestimated, and this underestimation likely increases as one moves downstream. In addition, Riverware does not take into account the hydraulic effects of the pre-1850 glacial lakes, and the "estimated unregulated" flows are based on a watershed that, unlike the pre-1850 Yakima Subbasin, did not contain natural lakes. This would bias model outputs for rates of rise on the rising limb of the hydrograph, and rates of fall on the declining limb.

At the largest scale, these biases can be significant, for instance see the attached flow graph from the Reaches Report that shows the difference between empirically measured flows and the "estimated unregulated" flows from Riverware. The difference in the timing and magnitude of the early May peak, and the later empirical June peak (even with the small dams on the glacial lakes that then existed) is significant. It is probably not useful to compare the later months of the graph due to the presence of significant diversions in the basin at that time, and the bias from tributaries discussed above. In sum, it is not possible at this point to determine the present day differences in flow from pre-1850 with a high degree of accuracy, though it is certain that flow rates and rates of changed are dramatically altered from the pre-1850 environment**.**

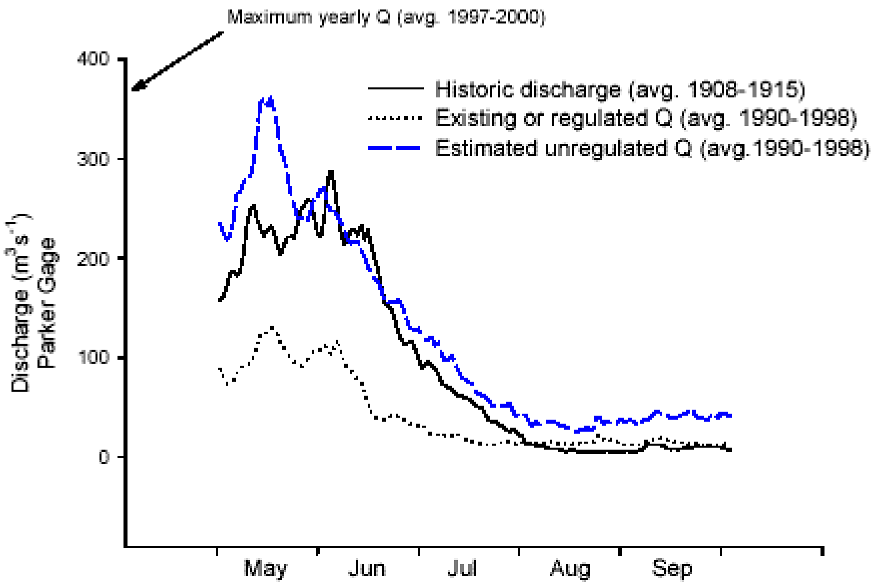


Figure 2-61. Example of "normative" flows for the Wapato reach below the Parker USBR gage. The data presented compares average discharge regimes from May to September under the following scenarios: (1) historic discharge from 1908 to 1915, (2) observed regulated discharge fro 1990 to 1998 and (3) estimated unregulated discharge from 1990 to 1998. (Graphic and text from Stanford et. al. 2002)

Mainstem (Yakima Project) Changes in Annual Flow Regime

Of the numerous physical changes to the natural conditions in the subbasin, the most important are conversion of the glacial lakes to storage reservoirs, conversion of McAllister Meadows from a glacial outwash/alluvial valley to Rimrock Reservoir, construction of the diversion dams and associated irrigation water delivery systems which are now part of the Bureau of Reclamation's Yakima Project, confinement of the river upstream and downstream of the Yakima Canyon, and the digging of drains. In many areas these drains were constructed to combat rising water tables driven by the increase in irrigation, and in other areas they were dug to lower the natural water table to increase agricultural acreage on (usually organic) soils with high productive potential.

These changes have allowed the management or regulation of flow. The total amount of available storage controlled by the reservoirs is approximately 1/3 of total annual runoff in the basin. Total irrigation use and municipal and industrial diversions on the mainstem total over 60 percent of total annual runoff. Therefore it is likely that if diversions in the tributaries are included total diversion in the subbasin exceeds total runoff, pointing out that during irrigation season water is returned to the river and diverted again many times. Regulation seeks to maintain high flow in the main stem river during irrigation season (May thru. mid-October) for delivery of water to irrigation districts that contract with USBR.

Of special concern in flow management in the subbasin is "flip-flop"**.** Due to the importance of the "flip-flop" flow management regime to both fisheries and water resource management, four different perspectives of "flip-flop" are presented below (portions of these quotations were removed where the figures referred to in the original document are not present in the Yakima

Subbasin Plan). The first view is a legal interpretation of the origin of "flip-flop" from the Bureau of Reclamation's Interim Comprehensive Basin Operating Plan (IOP) published in 2002, the second is from the Yakima Subbasin Summary (YSS), also published in 2001, which looks at "flip flop" from a fisheries management perspective, the third is also from the IOP and discusses the effect of flip flop on Yakima Project operations, and the fourth is from Snyder and Stanford's "Synthesis" report published in 2001 which examines "flip-flop" from the perspective of potential effects on the ecosystem and on river channel formation and sediment transport processes. While this is an illustration of the critical importance of flow management, it is also an illustration of the differing perspectives on flow from differing institutional, legal, management and scientific viewpoints.

1) **Legal perspective -** This pattern of water retention and release for upper Yakima and Naches storage reservoirs spares upper Yakima spring chinook redds by forcing spawners to construct redds lower in the deeper part of the channel where dewatering is much less likely when releases are cut back in the winter to fill the reservoirs.
In practice flip-flop consists of releasing virtually all of the water needed by WIP (Wapato Irrigation Project) and SVID (Sunnyside Valley Irrigation District) from the upper Yakima reservoirs until early September. During this time, releases from Rimrock (and to a much lesser degree Bumping) are reduced. Then in early September, the pattern of releases is reversed ("flip-flopped"), and releases from Rimrock and Bumping provide all the water needed for the diversions at Wapato and Sunnyside Dam, and the upper Yakima releases are curtailed. September is the beginning of the spawning period in the upper Yakima, and is late enough in the season that spring chinook which spawn in the Naches drainage above the Tieton confluence have all passed out of the lower Naches. Thus, upper Yakima spawners are forced to spawn low in the channel and Naches and American River pre-spawners are not affected by the dramatically increased flows in the lower Naches. (YSS, 2001)

2) **Fisheries management perspective -** In 1980, spring chinook spawned in the upper portions of the Yakima River between the mouth of the Cle Elum River to the mouth of the Teanaway River during the period that reservoir releases were being made to meet downstream irrigation demands. When the irrigation season drew to a close and reservoir releases were being curtailed, about 60 redds (fish nests), a portion of which were dewatered by the reduced releases, were identified in the Yakima River reach between the mouth of the Cle Elum River and the mouth of the Teanaway River. In October 1980, Judge Justin Quackenbush of the Federal District Court directed Reclamation, acting through the Yakima Field Office Manager, to release water from Yakima Project reservoirs to keep the redds covered with water. In November 1980, the Court directed the Yakima Field Office Manager to work with fishery biologists and report back prior to the 1981 irrigation season:

". . . on means by which the needs of the Yakima Project water users can be met through more efficient or less extensive use of Project waters or by modification of Project operations or facilities so as to have less impact on the fisheries resource, including the possibility of management of the various Project reservoirs and releases of water so as to provide for appropriate water flows during the spawning and hatching periods that may be practicable while at the same time providing water for irrigation purposes for users within the Project."

As a result, the "flip-flop" operation was conceived and initiated in 1981, and has since been a part of the Yakima Project operation. The flip-flop term derives from the fact that the Yakima and Naches Rivers form a "Y." In this operation, water from the three reservoirs in the upper Yakima River system (right side of the "Y") is used to meet irrigation demands downstream of the confluence of the Naches and Yakima Rivers through the first week of September, and water is retained in reservoirs of the Naches River arm (left side of the "Y") to the maximum extent possible. After the first week of September, reservoir operations are flip-flopped with demands downstream of the confluence of the Naches and Yakima Rivers being met from the Naches River system reservoirs and flows from the upper Yakima River system reservoirs are reduced.

This operation reduces flows in the upper Yakima River at the time that fish spawn, forcing the fish to build redds at a lower elevation in the stream channel. As a result, less water is needed to be released during the winter to keep the redds under water and maintain the fish eggs. (IOP, 2002)

3) **Project management perspective** - The purpose of the flip-flop operation is to encourage anadromous salmon (spring chinook) to spawn at lower river stage levels in the upper Yakima River above the mouth of the Teanaway River, so that the flows required to keep the redds watered and protected during the subsequent incubation period (November through March) are minimized from the upper Yakima reservoir storage. Historically (pre-1980), due to irrigation demands and reservoir operations, the flows in this reach would be at a higher flow level (between 300 cfs to 1,600 cfs, 38 percent of the time) during the September/October spawning period, which would in turn require larger storage releases to protect redds during the incubation period. That would likely reduce the ability to maximize storage for the next season's TWSA. Pre-storage natural flows during the spawning period for spring chinook in the Easton River reach would have been in the 100 to 250 cfs range, and approximately 300 cfs in the Cle Elum River reach. In order to support the flip-flop operation, project operations drafts heavily from Keechelus, and sometimes Kachess, and Cle Elum Lakes on the Yakima arm to meet lower basin demands during the summer (July and August) and maintains storage in Rimrock Lake on the Naches River arm to meet lower basin demands later in the year (August 25th through October 20th). The Quackenbush Decision, October 1980, directed the release of storage for protection of redds in the upper Yakima River basin. The flip-flop operation was conceived and initiated in 1981, and has been a part of the Yakima Project operations since that time.

The flow reduction process starts September 1st and is ramped down over a 10-day period. The flow in the upper Yakima River is reduced by approximately 3,000 cfs, with the majority of the cutback taking place in the Cle Elum River, which is normally reduced to 200 cfs and then reviewed by SOAC for acceptability. The Yakima River below Easton Dam, about at 400 cfs at this time, is also reduced to the 200 cfs target level starting September 1st, although this flow level may have already been obtained during the mini flip-flop operation (see below). With this reduction of flow in the upper Yakima Reach during the fall (September and October), most lower basin demands are then met with Rimrock Lake storage releases of up to 2,400 cfs to the Naches River Arm. Flip-flop operation reduces flows in the upper Yakima River during the latter portion of the irrigation season. Due to the lower water levels, a number of irrigation entities must install check dams or wing dams in the Yakima River to create enough head to divert their water supply. These structures are temporarily installed rock berms in the Yakima River in a manner consistent with issued permits, with fish passage being provided both upstream and downstream. The temporary check dams are removed following the end of irrigation season. The flip-flop operation requires that power generation water for Roza Power Plant be reduced or eliminated for brief periods of time. At times, a voluntary reduction (50 to 100 cfs) in irrigation diversions (i.e., Roza Irrigation District) is required for the flip-flop to remain functional. In normal years, expected flow in the Yakima River below the Roza Diversion Dam is in the 400 to 600 cfs range, but may drop to 300 cfs or less in below average years. The flip-flop operation does not increase flows in the Yakima River reach from the confluence of the Naches River to Union Gap. In fact, there is a reduction of flow in this reach due to reduced irrigation entitlements in September, which are more than 2,000 cfs less than August entitlements, which does not mirror the dramatic increase of flow on the Naches River. The flip-flop operation is possible because of these reduced entitlements. (IOP, 2002)

4) **Ecosystem perspective** - Under this scenario, the quantity of water from the upper Yakima supplied for irrigation is reduced beginning in mid-September, providing base flows that can be maintained throughout the incubation period required by chinook eggs. The continued demand for irrigation water is compensated for by increasing flows dramatically on the Naches River. Although not examined quantitatively, these flows appear to be sediment competent (Mark Lorang and Bruce Watson, personal observation) and are maintained for at least three weeks—much longer than a “natural” flood event.

Although some spring chinook redds are saved in the upper Yakima as a result of the flip-flop management, there has been little or no effort to understand or monitor the effects of this flow regime either on the upper Yakima or on the lower Naches River**.** In the upper Yakima, significant stranding of benthic invertebrates may occur in September. Furthermore, the elevated base flow maintained throughout the summer likely represents a significant and unnatural stress to aquatic biota, including salmonids. In the Naches River, sediment competent flows likely result in rapid rates of cut and fill avulsion, as well as generate a spectacular annual disturbance event, the magnitude and duration of which is well beyond that occurring historically. In both the upper Yakima and the lower Naches, organisms specifically adapted to the natural and predictable disturbance regime would likely be unable to adapt to the anthropogenic regime and would suffer declines in density and productivity (Resh et al. 1988). This applies both to the post-reservoir flow regime and to the alteration of that regime via flipflop. We strongly recommend that the flip-flop regime be examined carefully; a process made difficult by the lack of quantitative data. (Snyder and Stanford, 2001).

Changes to the natural flow regime have resulted in 7 different flow regimes on the mainstem Yakima and Naches Rivers:

- Natural areas - above the storage reservoirs and the American and Little Naches Rivers.
- Flip flop minor effects – from Bumping Dam downstream to confluence of Naches and Tieton. Flows in the Bumping are modified by flip-flop operations, after the confluence with the American, flows in this system are relatively natural due to the relatively small storage and release capacity of Bumping Reservoir in relation to the entire watershed area of the upper Naches.

- Flip flop major effects, Tieton and Naches – This area includes the Tieton River below Rimrock Reserviour and the Naches River below the Naches/Tieton confluence, downstream to confluence with the Yakima. These reaches show an almost inverted hydrograph with a greatly suppressed spring peak due to the high storage capacity of Rimrock, an extended summer low flow period, and annual peak flows occurring in September and October when Rimrock provides the majority of downstream flows. Winter flows are also greatly depressed in this reach, and total annual flow is approximately 72 percent of unregulated flow.
- Flip Flop Major Effects, Upper Yakima – Upper Yakima River from the base of storage dams on Kachess, Keechelus, and Cle Elum Reservoirs downstream to confluence with Naches. This flow pattern has a greatly extended spring peak due to release of stored water in the dams. This peak lasts until early September, at which point flows are decreased and a minimum flow maintained throughout the fall and winter for spring chinook spawning and incubation.
- Gap-to-Gap Reach – From confluence of Naches and Yakima to Union Gap/Wapato Dam. This reach has had its hydrograph “flattened” by regulation. High flows are maintained throughout the summer and fall to the end of irrigation season, yearly low flow has moved to October from September, and winter low flows are much lower.
- Wapato Reach –Union Gap/Wapato Dam to Prosser. The presence of two major irrigation diversion dams (Wapato Dam and Sunnyside Dam) immediately downstream from Union Gap has a tremendous influence on flow in this reach. This reach has experience the greatest net reduction in flow in the mainstem from below Sunnyside Dam to Toppenish. Spring peak flows are significantly reduced by diversion, and falls to summer low flow is steep. Summer low flow is greatly lower and of longer duration than under pre-1850 conditions, winter flows are also significantly lower.
- Lower River – Prosser Dam to mouth. Flows in this reach also show a large reduction in average annual flow due to export of irrigation water from the Yakima Subbasin to the returns in the mainstem Columbia, although the shape of the hydrograph may be the most similar to the pre-1850 hydrograph of any of the lower river reaches. Spring peaks are reduced and winter flows are much lower than pre-1850 conditions.

The effects of these flow changes are many. Generally, they can be divided into 4 geographic regions of the subbasin, the Upper Yakima, the Tieton/Naches, Union Gap Reach, and below Union Gap.

- Upper Yakima Effects – Reduction in the level of the spring runoff, with great extension of the annual peak flow well into late summer. Flow velocities are high for a much greater period of time in the summer, and the difference between summer and winter flows is much greater. These sustained flows (in combination with other physical changes such as confinement), and their quick drop off in fall have reduced or eliminated the ability of black cottonwood to regenerate (Braatne, 2002) in this reach and most other regulated reaches in the subbasin, and have reduced the natural variability of habitats and habitat types that would have occurred over the summer as flows gradually dropped. They have also dramatically altered thermal regimes throughout the year (Vaccaro, 1986), generally reducing summer temperatures, which can be expected to reduce primary productivity and affect life histories as discussed below in the temperature section. These changes are also further discussed in the Assessment Unit chapters below.

- Tieton/Naches Effects – Much longer low flow period followed by high flows with cool water. This hydrograph would directly conflict with most life histories of fish, invertebrates, and plants, especially black cottonwood, which shows a lack of regeneration in these reaches as well. Current habitat conditions in the lower Naches (large expanses of unvegetated bars, abrupt and vertical banks, increased avulsion and channel instability, reduced LWD abundance) and the low productivity of the Naches system as a whole given the relatively good condition of habitat and flow patterns in the upper watershed may reflect this severe conflict.
- Union Gap Reach – The effects here are similar to Upper Yakima, but extend to the end of the irrigation season. Flow (Q or discharge) and high temperatures are not limiting in this reach, but habitat diversity and low productivity may be limiting. Given the flow conditions in the basin, reconnection of side channels in this reach may be the best restoration action over the short term that would fit within the existing flow management regime.
- Wapato Reach and Lower Yakima – The major effects are related to simply reduced quantities of water directly resulting in decreased amount of habitat available. Flows are lower year round, and temperatures are higher for longer periods of time in summer (Vaccaro, 1986) and probably lower in the winter (sensu Ward, 1992) (Biology and Habitat, Wiley, New York). The effects of regulation and loss of flow from irrigation diversion may be further aggravated by the loss of hyporheic function due to construction of the Harrah/Mud Lake/Marion Drain systems which would have the effect of dramatically reducing the ability of the Wapato Reach to store spring and summer snowmelt in the surficial aquifer and release it in late summer and winter.

In the Naches and Tieton Rivers, black cottonwood regeneration is limited by the fall flow regime, which drowns newly established cottonwood seedlings during the fall high flows associated with flip flop. High levels of cottonwood recruitment in a natural system only occur every 15 –20 years. It seems probable that minor changes in management of the flow regime could occur on a relatively “normative” time frame. Such changes would involve management of flow in an excellent water year to allow for cottonwood establishment (i.e. spring rates of decrease in flood stage within the “Box Model” of Cottonwood Establishment (Mahoney and Rood, 1998) at an elevation above the fall high flows. Calculation of a safe TWSA (Total Water Supply Available) for implementation of such a flow management regime should be investigated.

Flip flop is incorporated into the EDT model for the Yakima Subbasin, but it should be noted that the degree of modification of the hydrograph from flip flop is outside the parameters given for ranking of the severity of change in interannual flows, or interannual change in high or low flows, and also more severe than the studies cited to develop the “curves” for those rankings as well. Therefore use of the EDT model to forecast or estimate the effect of reduction of flip flop would probably not be reflective of the true effects. This is not to point out a weakness of the EDT model, but to emphasize the uniqueness of the flip flop flow regime and that the full range of effects on the subbasin ecosystem, especially the long term effects, is not currently known.

Changes in Flow in the Tributaries

In general, major changes in intrannual flows have been the result of diversion for purposes of irrigation or stock water. The diversions themselves are usually located near the top of the alluvial fans in the stream valleys or on the valley walls of the Kittitas Valley. These locations are chosen because they represent the most downstream point at which flows are maximized throughout the year (i.e. above the high infiltration capacities of the alluvial fans) and because this landscape positions provides maximum flexibility in distribution of irrigation water across the fan itself, and/or along adjacent valley walls. In many locations irrigation diversions, in combination with the naturally high infiltration capacity of the alluvial fans, creates partial or total flow or temperature blockages to fish migration. Recently, conditions have begun to improve in many locations, most notably on Toppenish and Simcoe Creeks on the Yakima Reservation. In the Kittitas Valley, many of these streams have been directly connected to the main canals of the Kittitas Reclamation District and used as conveyances for irrigation water to lengthen the irrigation season. The disconnection of the lower ends of many of these tributaries from the irrigation system is occurring in many locations in the Kittitas Valley.

In most tributary valleys, or in portions of the basin with junior water rights from the Yakima Project, agricultural production is much more heavily weighted toward production of hay than of fruit crops. Production of hay can make use of the large spring peak runoff, and survive during years of low or no irrigation water availability later in the summer. This results in truncation in length and reduction in magnitude of spring peak flows where tributaries enter the mainstem upper or lower Yakima River. Later in the summer, use of many of these streams as conveyance will usually result in a much greater than pre-1850 flow in these same locations, providing some of the most valuable habitat (relatively slow moving and warm) water adjacent to the still fast flowing and cold upper Yakima River in the Kittitas Valley.

The effects of the changes in flow in the tributaries are similar to those in the mainstem. Riparian plant communities cannot successfully reproduce under the altered and lengthened low flow regime, or the greatly lengthened high flow regime where creeks are used as conveyance. Shifting the spring peak flow earlier in the year and reducing its magnitude may also hinder or prevent migration of some salmonid stocks such as the late portion of steelhead spawning and possibly the entire spring chinook migration timing. Spring chinook are not presently found in the tributaries, although there is strong evidence that they used to exist in Toppenish, Ahtanum, Wilson/Naneum, Swauk, and Taneum creeks, and still persist in the Teanaway River.

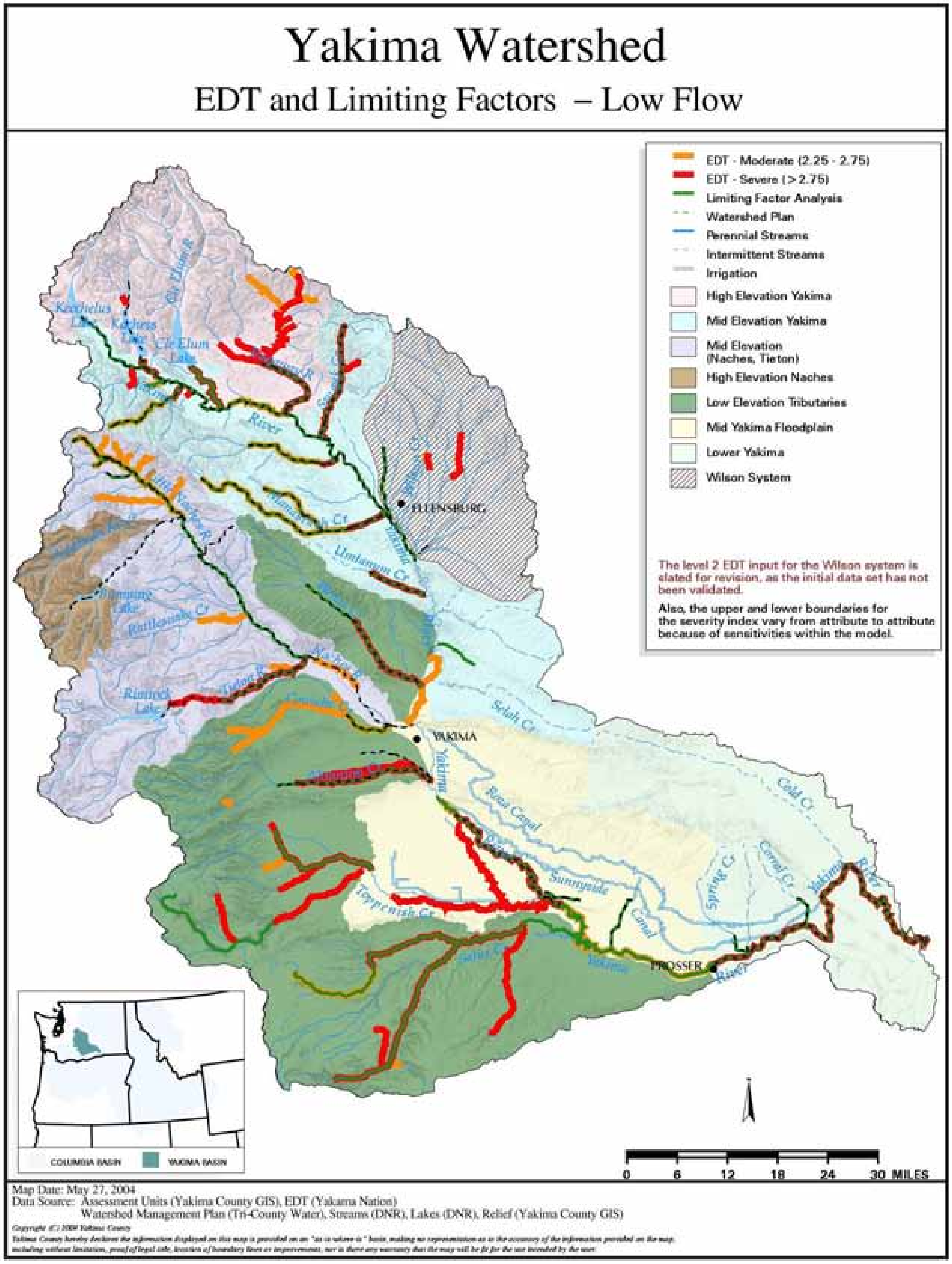


Figure 2-62. EDT and Limiting Factors for low flow

Peak Flow Patterns

Mainstem (Yakima Project) Changes in Peak Flows

While the primary purpose of the Yakima Project is to provide irrigation for agriculture, a secondary purpose is to provide flood control benefits to the basin. The reservoirs are managed according to rule curves developed to manage the trade offs between maximizing storage for irrigation and maximizing the ability to capture floodwaters to reduce flood discharge. In general, regulation of flood flows by reservoirs can be expected to significantly reduce peak flows and, depending on the rule curves for filling, reduce energy available for sediment transport and cut and fill alleviation. Several authors and studies have attributed such effects to the regulation of flood flows in the Yakima Subbasin (Stanford and Snyder, 2001 and 2002; USBR, 2003; YSS, 2001). However, it is possible that the theoretical effects of regulation (i.e. the difference between pre-1850 and current peak flow characteristics) are quite different from the actual effects due to the small storage ability of reservoirs in the basin, the rule curves used to fill the reservoirs and discharge the reservoirs to regain flood control “space” in the reservoirs, the presence of glacial lakes where the reservoirs are now located, and changes in the unregulated tributaries and their effects on flood flows.

There is little doubt that the absolute peak discharges of large flood events (i.e. above the 25 year flood) have been decreased by flood control flow regulations, but there is a large difference in degree of reduction between studies. There is also little disagreement that the effects of flood control operations are extremely variable throughout the mainstem, and that there are probably significantly reduced flood peaks and durations in the reaches immediately below the dams. See Figure 2-62.

Lorang in Stanford (2002) quantifies the relative rates of bedload movement as a function of days over a specific discharge. Based on this assumption (i.e. effective geomorphic force (Wolman, 1960), comparison with the graph above indicates that lengthening the duration of floods above a given entrainment threshold may actually increase energy available for sediment transport. If the flood flows are managed to be at or below 12,000 cfs during a flood event, and the entrainment threshold is approximately 7,000 cfs as determined by Dunne, 1976, then contrary to published reports the energy available for sediment transport and cut-and-fill alleviation may be greater now than under pre-1850 conditions.

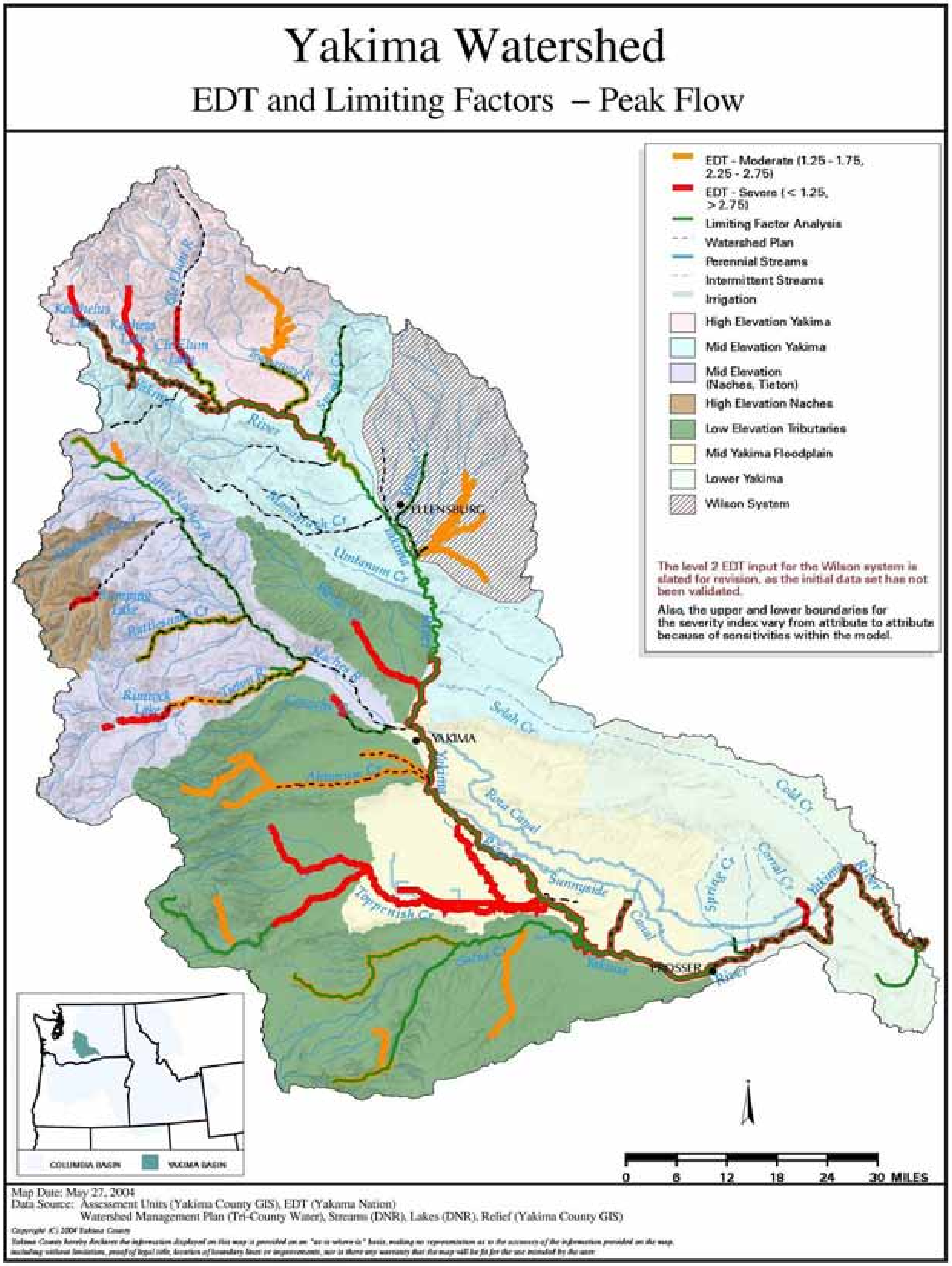


Figure 2-63. EDT and Limiting Factors for peak flow

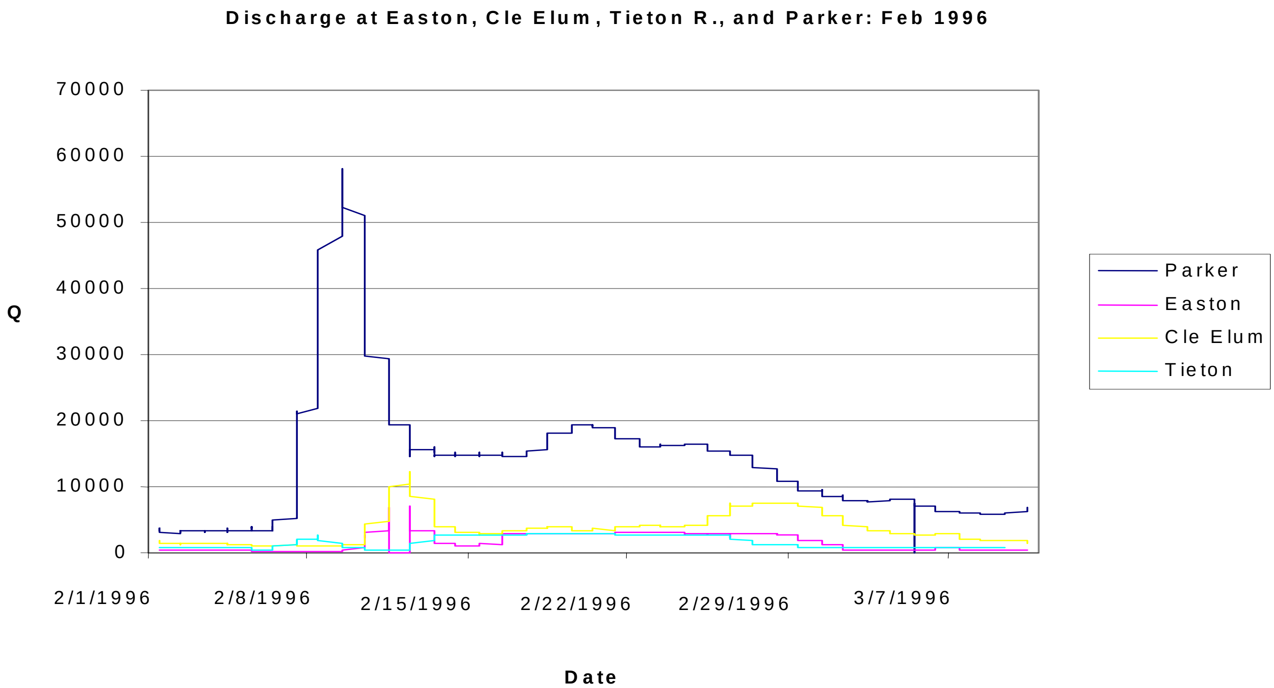


Figure 2-64. Discharge at Parker is a function of releases from the Reservoirs plus unregulated flows from the tributaries. Discharge at Easton is a function of reservoir releases from Kachess and Kechellus, Cle Elum discharge is a direct measure at Cle Elum Dam, and Tieton is a direct measure of release at Tieton Dam. Note the pattern of release at Cle Elum is inverse to the flood flow – reduced release at the peak, increased release after the peak (reservoir was full in this case) and then releases later in the month to regain flood space for flood control. Tieton and Easton also show reduced discharge during the flood event, and then spill during the remainder of February and March. (USBR hydromet)

Actual differences between current peaks and pre-1850 peaks based on the physical characteristics of the pre-1850 watershed cannot be determined with any degree of accuracy using the current peak flow models which are currently available within the Yakima Subbasin. Therefore the current or future effects of changes in peak flows due to flood control management cannot be stated in qualitative or quantitative terms. Creation of a model that incorporates the physical changes in the watershed and known watershed processes should receive emphasis in the future.

Peak Flows in the Tributaries

The examination of EDT data, recent habitat assessments, and stream gage data, show that definitive increases in peak flows in the tributaries are confined to a few watersheds. Primary among these are the Little Naches and Teanaway watersheds which share many common attributes such as a general south facing aspect, large areas of the watershed in the rain-on-snow or transient snow zone, high road densities, and current and historical large areas of clearcut timber harvest. Other areas of peak flow increases are also associated with forestry activities, generally also on south facing slopes/rain-on-snow zones such as the Wilson/Naneum system, portions of Wenas, Cowiche, Ahtanum, Toppenish and Satus Creeks.

6.4.4 Temperature at the Subbasin Scale

Mainstem Temperature Regime

The pre-1850 and recent (calendar year 1981, the year before flip flop was introduced) temperature regime has been studied by Vaccarro (1986), who discusses the effects at a macro scale of the relationships between management of the mainstem and the temperature regime. It should be noted that current models predict somewhat lower peak spring runoff and somewhat higher summer low flows than Vaccaro used in his report, but the overall relationships between the physical characteristics of water and channels remains the same. Comparison of predicted temperatures at a given date and flow from Vaccaro with empirical thermograph data from recent years (USBR hydromet) indicates that the modeled retlationships laid out by Vaccarro still hold true.

The major determinant in the rates at which rivers warm or cool and their equilibrium temperature is water depth, with air temperature and solar direct energy input distant second and third in importance in the summer months, and longwave radiation to space becoming important in the winter months. Conceptually, there is a depth threshold, or more precisely the ratio of the surface area of the stream exposed to the air and sun to the hydraulic radius or the proportion of the channel that is in contact with the channel substrate. At flows above that threshold, water temperature will tend to equilibrate to the temperature of the soil, which is roughly proportional to the average air temperature for the year. At flows below that threshold, temperatures will tend to equilibrate with air temperature and solar input. In essence, in the main channel of a river, there are two different temperature regimes, and the threshold for moving from one temperature regime to another is dependent on quantity of flow and shape of the channel at any given point in the river.

In the high flow temperature regime, water temperature tends toward equilibrium with soil temperatures, and the floodplain or bedrock materials act as an infinite heat sink in summer and an infinite heat source in winter. Therefore, major changes to the yearly temperature regimes of the mainstem are primarily related to changes in duration and timing of flows above this threshold. If flows are increased in the summer to such an extent that they are maintained above the threshold, temperatures are cooler, if they are reduced below the threshold in winter and spring, temperatures are reduced. And since the heat sinks and heat sources are essentially infinite when compared to the head budget of the river itself, inputs of cooler or warmer water can only have a localized effect, and the temperature downstream of these inputs very rapidly returns to the equilibrium temperature of the surrounding substrate. It is the above relationships that will drive the discussion below.

Flow management in the Yakima mainstem can be simplified into the 7 reaches discussed above under Intrannual Flow. In the Upper Yakima and Union Gap reaches, flows are maintained above the temperature threshold for a vast majority of the time during the summer above the confluence with the Naches River, and into fall in the Union Gap reach. This has resulted in a decrease in temperatures during the summer above Union Gap, where major irrigation diversions are located. At Parker, just below the major diversions, the river remains cool and fairly rapidly warms (Figure 2-63) throughout the summer and fall. There may be an area below Parker that has a range of temperatures that most closely approximates the pre-1850 temperature regime.

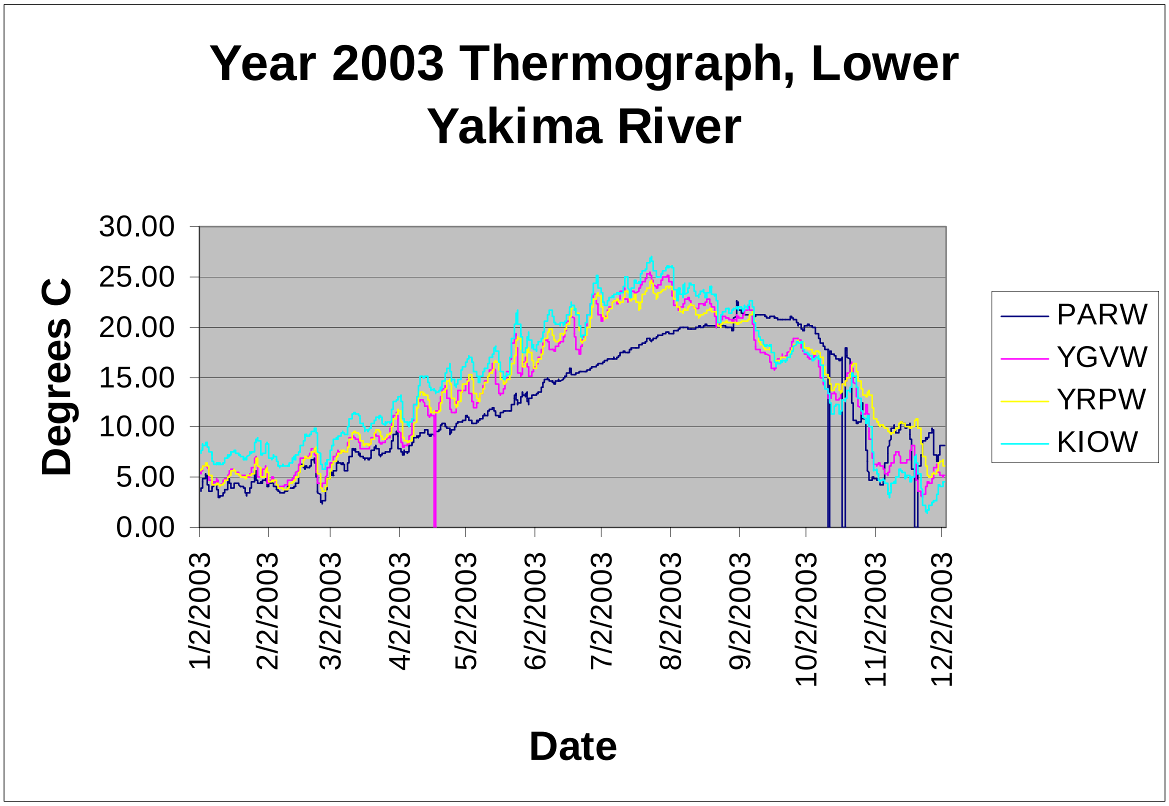


Figure 2-65. Thermographs at Parker (PARW), Grandview (YGVW), Prosser (YPRW) and Kiona (KIOW) for calendar year 2003. Parker is located immediately downstream of the major diversions at Wapato Dam and Sunnyside, and water temperature remains relatively cool at Parker throughout the Summer due to the very stable temperature regime upstream as a result of high flows throughout the summer. Downstream of Parker, temperatures increase rapidly, and are maintained through August and September. In late September, decreasing air temperatures allow the river to cool below Parker, but at Parker temperatures remain warm until the end of the irrigation season.

Downstream of Parker, truncation of the spring peak flows has reduced the duration of flows above the temperature threshold, and the duration and intensity of near lethal and lethal temperature days has increased dramatically. Approximation of the number of days (if any in certain locations) that the temperature in the lower Yakima exceeded the metabolic thresholds of the various salmonid species would require better interannual flow modeling as discussed above. These two modern temperature regimes of the upper and lower river contrast with the pre-1850 temperature regime that would have gradually changed throughout the year as temperatures changed and the normal hydrograph varied. Loss of these gradual changes has reduced the overall diversity of habitat and temperature spatial variability (the diversity of temperature regimes) at the subbasin scale.

Much less attention has been paid to the winter temperature regime, but the physical relationships would still hold, and reduction of the number of winter and spring days above these thresholds would necessarily reduce winter temperatures. Based on changes to the flow regime and the above relationships,

- Temperatures in the Upper Yakima and the Union Gap reach are colder during all times of the year than under pre-1850 conditions due to dramatically increased summer flows and decreased winter and spring flows. Because these areas have had significant changes to floodplain and channel configuration (see below), changes to channel shape (narrower and deeper) may further contribute to cooling of the river in summer.
- Temperatures in the river below the Union Gap reach are warmer for a longer duration during the summer, and colder in the winter; due to reduce flows year round.
- Temperatures in the Tieton and Naches are warmer in the summer, much colder in September and October during flip flop, and colder in the winter as well due to reduced flows.

Undoubtedly, such changes to the temperature regime would have large effects on the productivity of the system, with differential effects in different sections of the basin. Such changes can also be expected to affect the salmonids themselves. To quote Brannon (2002):

"as poikilotherms salmonids are completely dependent on temperature, which affects metabolic rate, growth, and other physiological characteristics of the species (Groot et. al. 1995). In retrospect, however, its role in life history and ultimately population structure has not been sufficiently regarded. …. when the biological entity is a poikilotherm, temperature needs to be given separate and special recognition. Water quality constituents such as sediments, nitrates, and even pesticide levels have threshold in concentration below which little or no effect can be seen on the organism. There is no comparable lack of affect on poikilotherms that accompany changes in temperature. Even minor temperature shifts have an influence on life processes among the salmonids, and can impose substantial alterations of live history patterns demonstrated at the population level (Brannon 1987, McCollough 1999)." Temperature changes in the Upper Yakima may be related to the real or pecieved changes in anadromy or residualism seen in both steelhead and spring chinook, and effect of restoration of a more normative temperature regime on those population's life histories should be investigated.

As stated above, the influences of cooler and warmer waters can have only a localized effect on the mainstem, but does not mean that their ecological importance is minor. Springbrooks and side channels that are fed by groundwater are essentially at the same (near optimal) temperature year-round (Stanford, 2002), and (under pre-1850 conditions) allowed salmonids to persist and thrive in those areas of the subbasin where temperatures in the mainstem were either suboptimal or lethal for periods of time during the year. Loss of these habitats as refugia, areas of thermal and habitat diversity, and as unique habitats themselves (for both fish and wildlife) are disproportional to their areal extent in the basin.

As is noted in the fall chinook focal species description, out migration timing has shifted likely due to lengthening of the duration of high summer temperatures in the lower river. This shift occurred in the 1930s after most of the development of the irrigation infrastructure in the subbasin had been completed, but during the time of alteration to the flow of the mainstem Columbia by construction of the FCRPS and other hydropower generation facilities. Historic General Land Office maps from the 1860's of the area of the Van Giesen Bridge in the lower river show large springs that flowed toward the lower Yakima River from the terrace to the west. Early investigations of groundwater flow for irrigation on the Hanford site indicate that large amounts of water flowed subsurface from the Columbia to the Yakima through the coarse floodplain gravels shared by the two rivers. Examination of the hydrograph of the Columbia River prior to the 1930s indicated that the spring peak in this area of the Columbia occurred at the same time as the fall chinook outmigration, in July and August, after the spring peak in the Yakima had already fallen. Loss or reduction in this inflow from the Columbia could have had a major affect on the summer low flow temperatures of the lower Yakima River. These springs still exist, but have been modified and isolated from the river, and should be considered as a focal point for restoration of the lower Yakima.

As noted in the introduction to this assessment, the role of the glacial lakes in the physical and biological processes of the basin has not received sufficient study. Undoubtedly these lakes also acted as thermal refugia and very large heat sinks and sources in the lakes themselves and for some considerable distance downstream. Similar lakes naturally supply very warm water to downstream reaches in the summer months under natural conditions, and there is no reason to believe that temperatures downstream from the lakes could have reached near lethal or lethal levels for salmonids during late summer. During the fall and winter, they would have acted to warm downstream waters from heat retained by the lakes when they “turn over”. And it appears that the Upper Yakima spring chinook migration and spawning pattern still reflects the pre-1850 temperature regime. These higher water temperatures would also have supported a more productive environment for winter and summer growth.

Tributary Temperature Regime

In general, average temperature decreases with increasing elevation and this is reflected in the distribution of species (from fall chinook at low elevation to bull trout at high elevations) and life histories, with the exception of the Upper Yakima spring chinook who spawn late at fairly high elevation due to the temperature effects of the lakes. Another influence on tributary temperature is aspect, as south facing drainages tend to show higher summer temperatures. In the mainstem, and in streams greater than 50 feet wide, the shade provided by the riparian zone is not the major determinant of summer or winter extreme temperatures. In the smaller streams of the tributaries, the influence of the riparian zone dominates the temperature regime, especially in south facing drainages. Due to their aspect and elevation in the watershed, the Teanaway and the Little Naches probably had the greatest variation in average annual water temperature. They would have been warmer than the mainstems they flowed into in the summer, and in the case of the Teanaway, much colder than the mainstem of the Upper Yakima due the influence of the glacial lakes and current reservoirs. This sharp break in temperature was the reason the Teanaway was included in the High Elevation Yakima Assessment Unit and not in the Mid elevation Yakima Assessment Unit. Both of these watersheds show elevated temperatures from pre-1850 due to loss of riparian zone from various causes, and channel widening. Even under natural conditions, both of these watersheds would have had unique temperature regimes that would have made salmonids populations somewhat unique to these drainages. The current low productivity of both drainages may reflect the loss of these adapted subpopulations and/or the inability of other local populations to rapidly invade/recolonize these areas, even under active supplementation. The uniqueness of the temperature regime in these locations should be taken into account in population management and restoration/supplementation activities.

The other general pattern that emerges in the tributaries is the strong link between development, riparian zone loss (due to conversion to other uses or from changes in flow) and increases in temperature. Nearly all tributaries have elevated summer temperatures in their lower reaches where development pressure is greatest, and several have elevated temperatures in their headwaters due to the effects of forest management or grazing, those effects are discussed Assessment Unit by Assessment Unit.

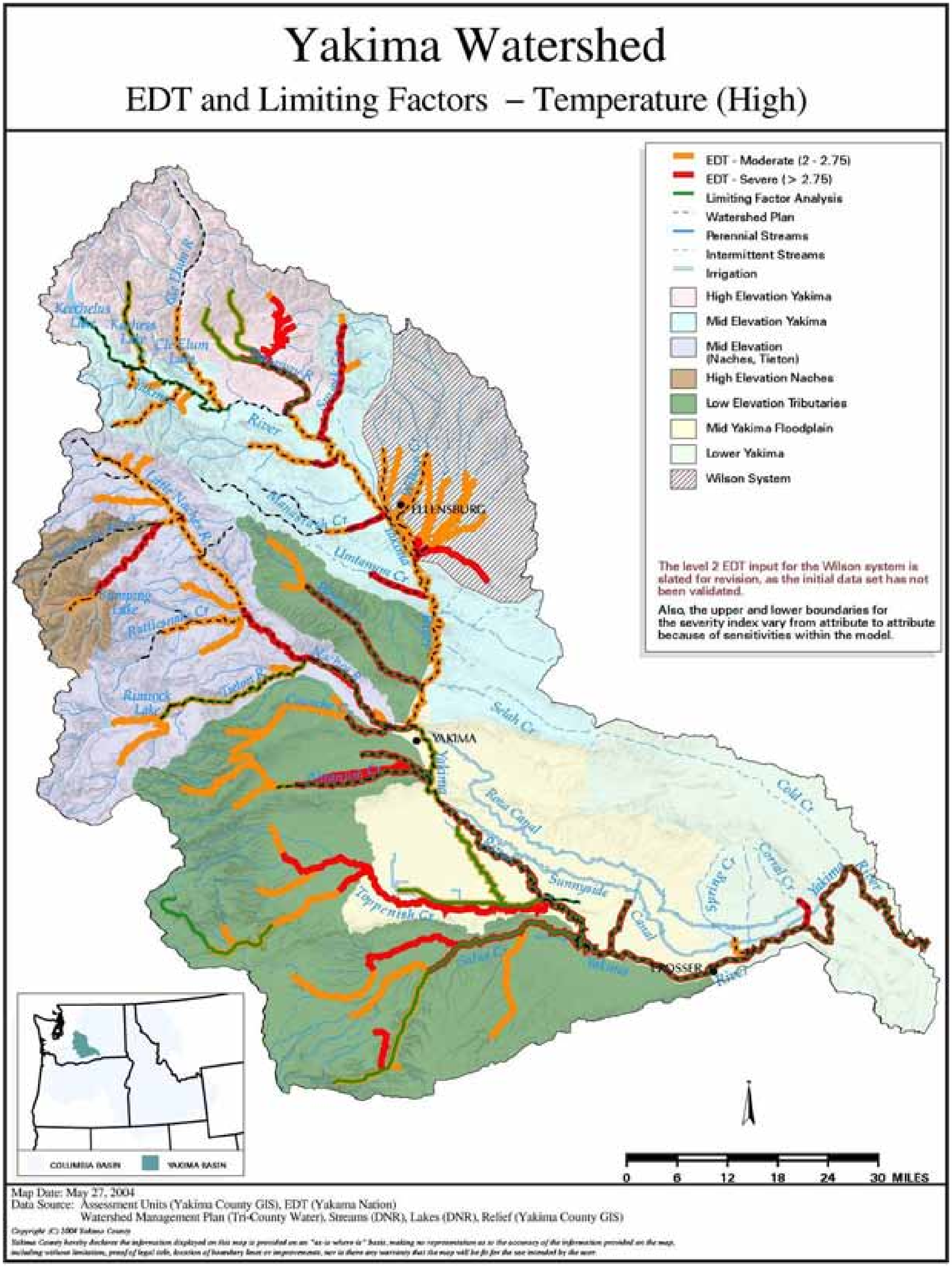


Figure 2-66. EDT and Limiting Factors for temperature (high)

6.4.5 Sediment Supply and Routing

Mainstem

Lorang, in Stanford (2002), does a thorough job of explaining the relative rates of sediment transport and the relationship between confinement by levees, changes in flow, the resultant energy available for sediment transport, and actual estimates of bedload movement. The reader is referred to that document for more information. Confinement itself has had a significant influence on habitat diversity in the basin itself, greatly lengthening the extent of “canyon habitat” in the Yakima Basin.

The Yakima River has seen more floodplain gravel mining than any other river in the State of Washington. The current impacts of gravel mines on the mainstem are primarily loss of floodplain due to the levees that protect the active and inactive pits. There have been several instances of gravel pits being captured by the Yakima River in the Kittitas, Selah and Union Gap reaches. The pits in the Kitittas and Union Gap Reaches were constructed in association with construction of Interstates 90 and 82, were relatively shallow, and capture by the river had few negative effects on channel form or process upstream and downstream (Dunne 1976) The capture of the Selah pits during the near-100 year flood in 1996 resulted in the estimated loss of 400,000 cubic yards of sediment to those pits, as well as 3 of the 4 lanes of I-82. That quantity of material was estimated by Lorang to be equal to approximately 10 years of sediment supply, and did cause significant channel incision of the mainstem Yakima downstream. These types of events can be expected to occur with more frequency in the future as the river changes location and the levees which protect these pits cease to be maintained by the mining companies. Current efforts are under way to study the tradeoffs involved in connection of gravel pits to the main river and should be completed in 2004.

The other major influence on sediment supply, which is not discussed in Lorang, is the influence of the Yakima Project infrastructure on sediment supply and transport. These effects are due to construction of dams, most notably Rimrock Dam on the Tieton River and diversion dams or structures on the mainstem Yakima and Naches Rivers. The Tieton River below Rimrock has been starved of gravel recruitment resulting in complete loss of spawning gravels or normal pool/riffle development. Plans to provide passage at Rimrock should recognize that the river below the dam to the confluence with the Naches presents passage problems and uniquely degraded habitat that may prevent migration to the dam regardless if it is made passable.

Diversion dams located at or near naturally confined areas (such as the natural “gaps” on the mainstem) tend to reduce stream gradient, and therefore the river’s ability to transport sediment. At these natural areas of confinement, gradients are already low, and relatively minor changes in bed elevation have relatively large effects in terms of area and distance upstream. Upstream of these dams the river is constantly aggrading, with gravel bars moving upstream. These areas are also the areas where the highly valuable habitats in spring brooks and side channels are located. Aggradation directly affects these side channels by filling them in and by severing their connection to the mainstem (i.e. they flow into perched gravel bars at their lower ends). In addition, the river becomes perched in these locations, disrupting the normal hyporheic functions, preventing flows from the floodplain from flowing back into a live channel.

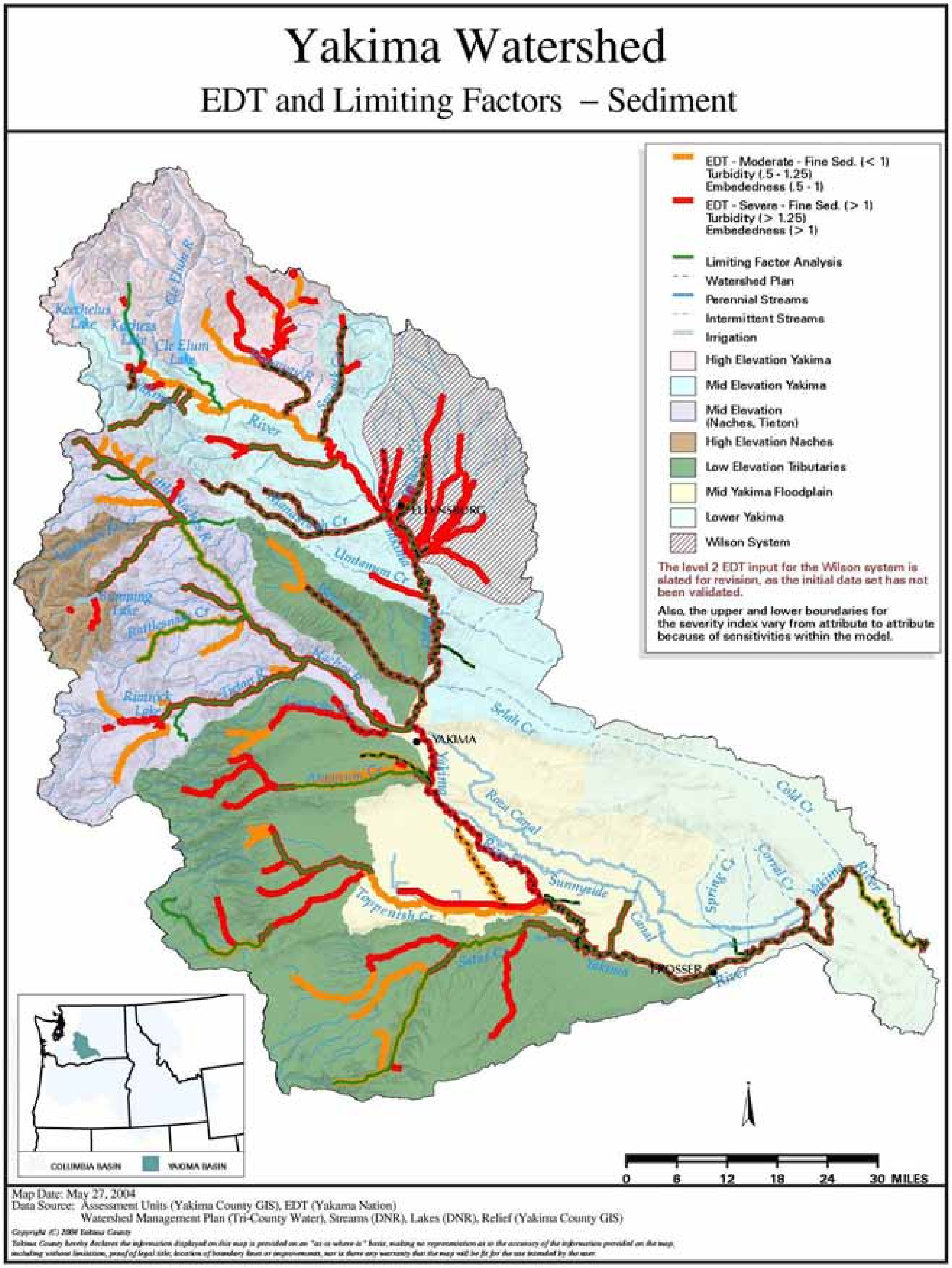


Figure 2-67. EDT and Limiting Factor for sediment

Tributaries

Very little work has been done to study sediment in the tributaries. The Teanaway and Little Naches have elevated levels of both fine and coarse sediment load due to high road densities, increases in peak flows and bank erosion, floodplain loss etc. Other increases in sediment are discussed in each Assessment Unit. A common problem across all Assessment Units is the ability of diversion dams or structures to pass sediment or maintain sediment transport through the reaches where they are located. This problem is especially significant at or near the top of alluvial fans. In these unstable environments, diversion dams change local stream gradient, causing aggradation upstream and degradation downstream, usually resulting in armoring the banks upstream to maintain the location of the channel through the dam opening. This in turn leads to more energy downstream, causing channel incision, creating a migration barrier to fish and threatening the foundations of the dam itself. Typically, repair and maintenance costs for these structures is high, as is the likelihood of failure. Replacement of these structures typically results in restarting of the cycle of destabilization, downcutting and failure. A concerted effort to design appropriate structures for these environments should be undertaken to solve the subbasin, and Columbia Basin-wide problem

6.4.6 Ecosystem Processes

Bull trout are apex predators in the aquatic ecosystem, and there is a strong relationship between the availability of prey resources and net population fecundity and population growth rate (Rieman and McIntyre 1993). Areas such as the Skagit system and Lake Wentachee support healthy bull trout populations due to good habitat conditions as well as abundant prey base. Loss of prey species and reduction in ocean-derived nutrients, proteins, and fats due to extirpation of anadromous fish species would have negative effects on bull trout population productivity, and restoration of these ocean-derived inputs would have beneficial effects**)**.

Sockye and coho were the most numerous anadromous salmonids that returned to the subbasin in the pre-1850 environment. The location of their spawning in the higher elevation tributaries and glacial lakes throughout the watershed contributed ocean-derived nutrients, proteins and fats to those most nutrient poor portions of the aquatic and upland ecosystems within the subbasin. There were at least 4 natural populations of sockeye, and there could have been as many as 17 different populations of coho based on the historic distribution map published in the Limiting Factors Analysis for the Yakima Watershed (2001).

Coho were extirpated from the Yakima Basin by the 1970s due to a combination of overharvest in the mainstem Columbia (allowed by hatchery production in those areas), the effects of the hydro system, and habitat loss and degradation within the Yakima Subbasin. This not only resulted in reduced harvest opportunities but also lessened productivity of the basin and ecosystem as a whole. Changes that have been made in the hydrosystem, harvest management and habitat restoration activities (e.g. structural, flow, barriers) in the subbasin have reversed the factors for decline of coho, and could increase the productivity and abundance of reintroduced coho populations.

It may now be possible to re establish sustainable populations of coho in the Yakima Subbasin through the use of out-of-subbasin hatchery broodstock combined with selective development of local broodstock within subbasin fish culture facilities. The Yakima Klickitat Fisheries Project is currently examining these questions. The objectives of this reintroduction of coho are to reestablish sustainable populations, improve ecosystem function and productivity, and provide meaningful harvest opportunities while keeping ecological impacts within specified biological limits. Central supplementation facilities and their associated acclimation sites can provide for quality and number of smolt, parr, fingerling or adult hatchery releases to be made to achieve the goal of sustainable populations with meaningful harvest and minimal ecological risk. These facilities have already been established in the Yakima Subbasin to futher this effort. The extirpation of coho stocks is common to many watersheds in the Upper, Middle, and Lower Columbia. The coho reintroduction project should continue, and coho should be reintroduced wherever it is determined that passage, habitat, and potential productivity of the environment are sufficient to support viable populations over the long term. Monitoring of the success or failure of coho reintroduction in the Yakima Subbasin will provide information that can be used for similar projects in other subbasins.

Intraspecies and Interspecies Relationships

Interactions between salmonids and other fish species are very complex, with the dynamics of biological communities being shaped by many direct and indirect interactions among species (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids et al. 1996). Species interactions are affected by life stage of interacting species, habitat quality and quantity, the species biological requirements, season of the year, diurnal period, the presence of non-native species, and other factors.

Perhaps the most intensively studied ecological interaction between salmon and nonsalmonid fishes in a large river has been the predation on salmon smolts in the Columbia River. Nonnative species in the Columbia River, such as walleye and smallmouth bass, eat smolts, but the most important predator is the native northern pikeminnow (Rieman et al. 1991). Pikeminnow removals have been initiated as a management measure, but experience with other aquatic ecosystems suggests that any benefits to salmon could be confounded by other species interactions (i.e., pikeminnow might control other salmon predators) or interactions between life-history stages (i.e., reduction in predation by large pikeminnows on smaller pikeminnows might result in rapid population rebound and more intense predation on salmon) (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids et al. 1996).

Interactions between hatchery salmonids and naturally spawning salmonids may affect naturally spawning populations, especially where habitat is limiting, food resources are limiting, and/or habitat quality is poor. In releasing hatchery fish from hatcheries it is important to take into consideration means for reducing the ecologic affects of supplementation programs on natural fish. Specific ecological effects, both individually and collectively, include: density dependent effects; operation of hatchery facilities; disease transmission; competition, predation, cannibalism, and residualism; passage impediments; and migration corridor/estuary effects (NMFS et al. 1998).

Ongoing research to investigate ecological interactions among fish species in response to salmon and steelhead supplementation in the Yakima Basin is conducted by the Washington Department of Fish and Wildlife on an annual basis. Recent studies focus on the impacts of a hatchery origin salmon on non-target taxa (NNT) status. Comparisons of abundance, size structure and distribution of 16 non-target taxa were assessed before and three years following annual spring releases of approximately one million yearling salmon smolts (coho and chinook).

The 2002 annual report compares data from previous years in an effort to identify preliminary trends throughout the post-supplementation period; steelhead size has significantly decreased (-1 percent, $P<0.049$). A decline in cutthroat size (-1 percent) was also observed, however was not significant ($P<0.37$), however it was noted that the power of the statistical tests was low. It was determined that supplementation was not the cause of size reduction in either species. Spring chinook and tributary cutthroat exhibited minimal overlap in distribution presenting little opportunity for inter-species interaction. In contrast, high overlap was observed between spring chinook and rainbow trout, however no differences in rainbow size were observed as a result of this interaction. The study concludes that any impacts to non-target taxa that may have resulted from releases of hatchery smolts were balanced or exceeded by the benefits.

During the 2001 study period, studies indicated that all observed changes in measured parameters were within the predetermined containment objectives for Yakima species, except for two. A slight change in steelhead size (-1 percent) was observed as well as and a -13 percent change in leopard dace abundance. According to the study, neither of these two status indicators is significantly different from pre-supplementation conditions.

Steelhead size in supplemented index areas was compared with size in non-supplemented index areas, and it was determined that supplementation was not the cause of the size reduction. Similarly, it was determined that the observed decline in leopard dace abundance is not attributable to supplementation due to the fact that predation mechanisms that are potentially influenced by yearling salmon releases were not observed.

The 2002 annual study reports that an estimated 175,712 smolts were consumed by smallmouth bass, and approximately 2,570 of these were estimated to be spring chinook. The remainder was mostly fall chinook. The 2001 study estimates that approximately 230,265 salmonids were consumed by smallmouth bass during the spring. Approximately 6,906 of these were estimated to be spring chinook and the remainders were likely fall chinook. The 2001 estimates are slightly higher than 2000 estimates (202,722 total salmonids and 3,083 spring chinook), despite the lower smallmouth bass abundance during 2001.

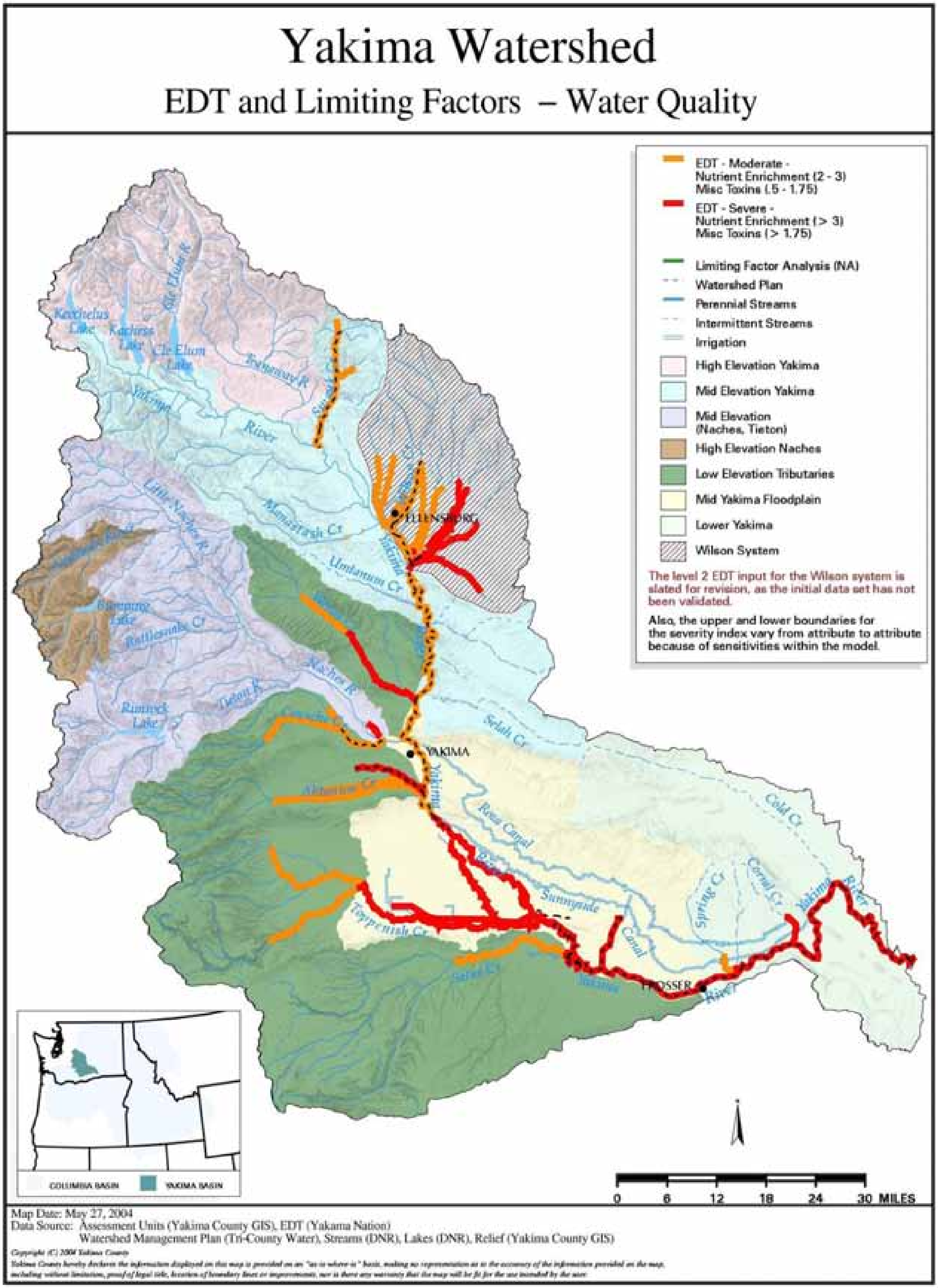


Figure 2-68. EDT and Limiting Factors for water quality

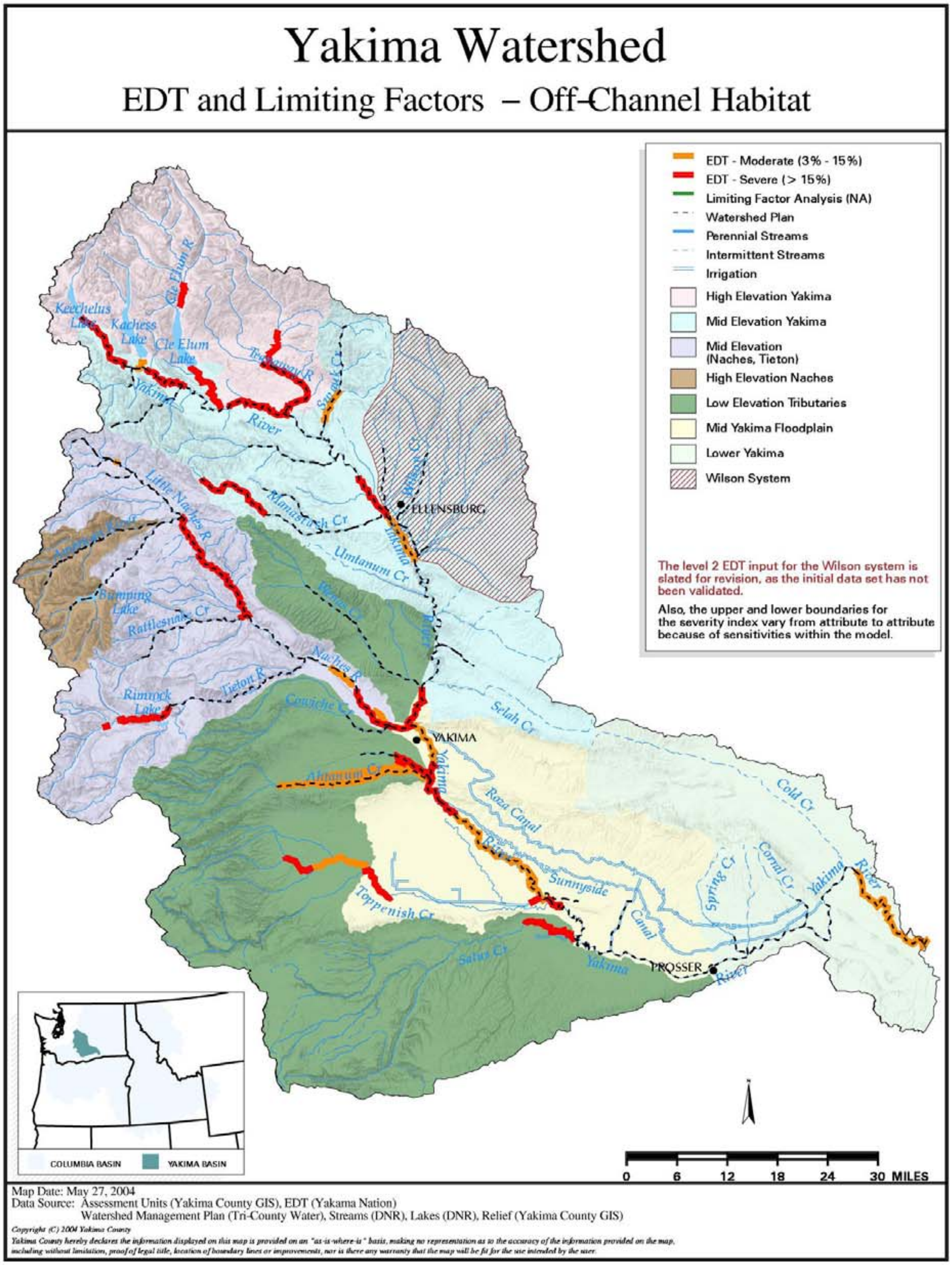


Figure 2-69. EDT and Limiting Factors for off-channel habitat

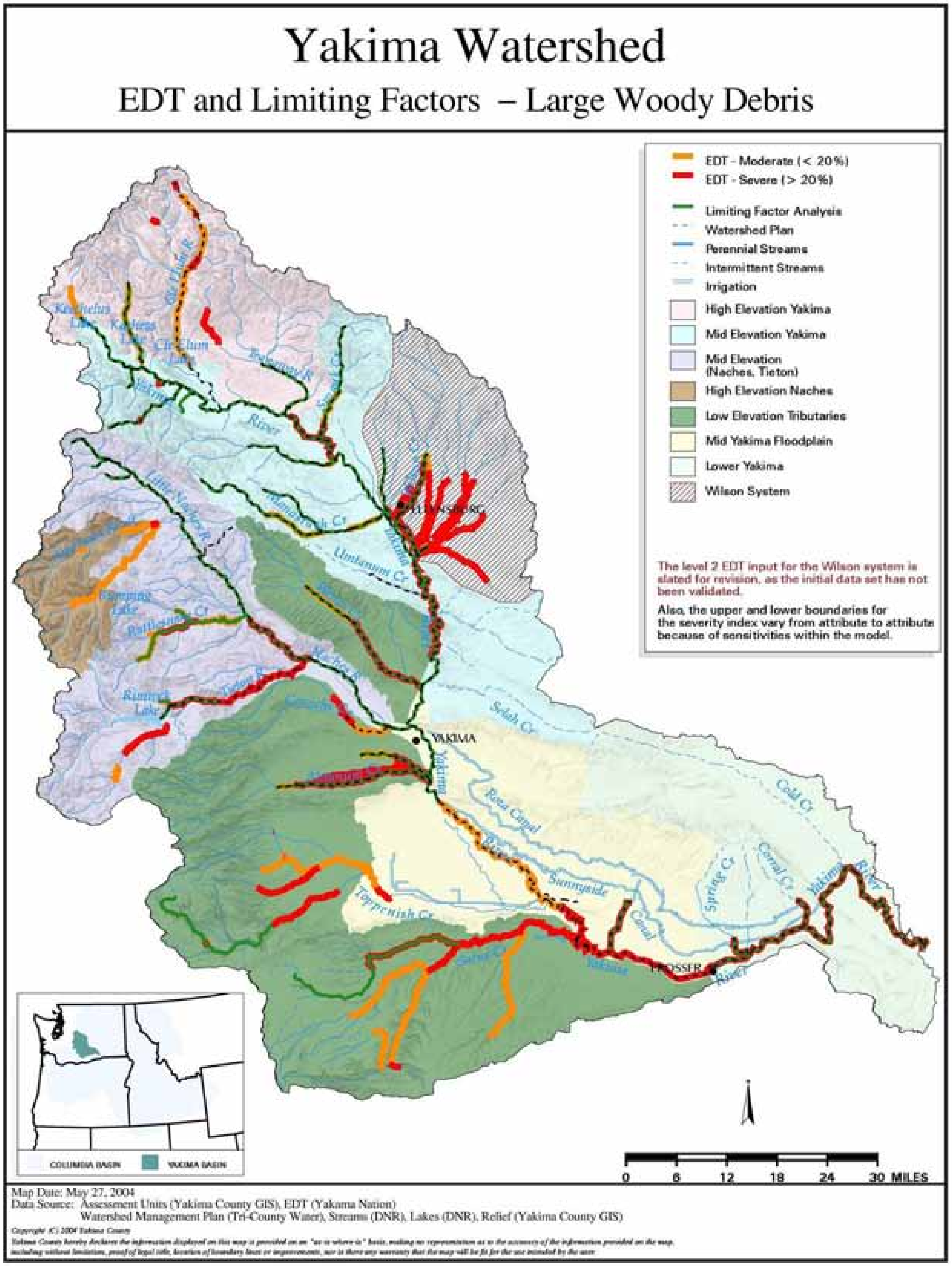


Figure 2-70. EDT and Limiting Factors for large woody debris

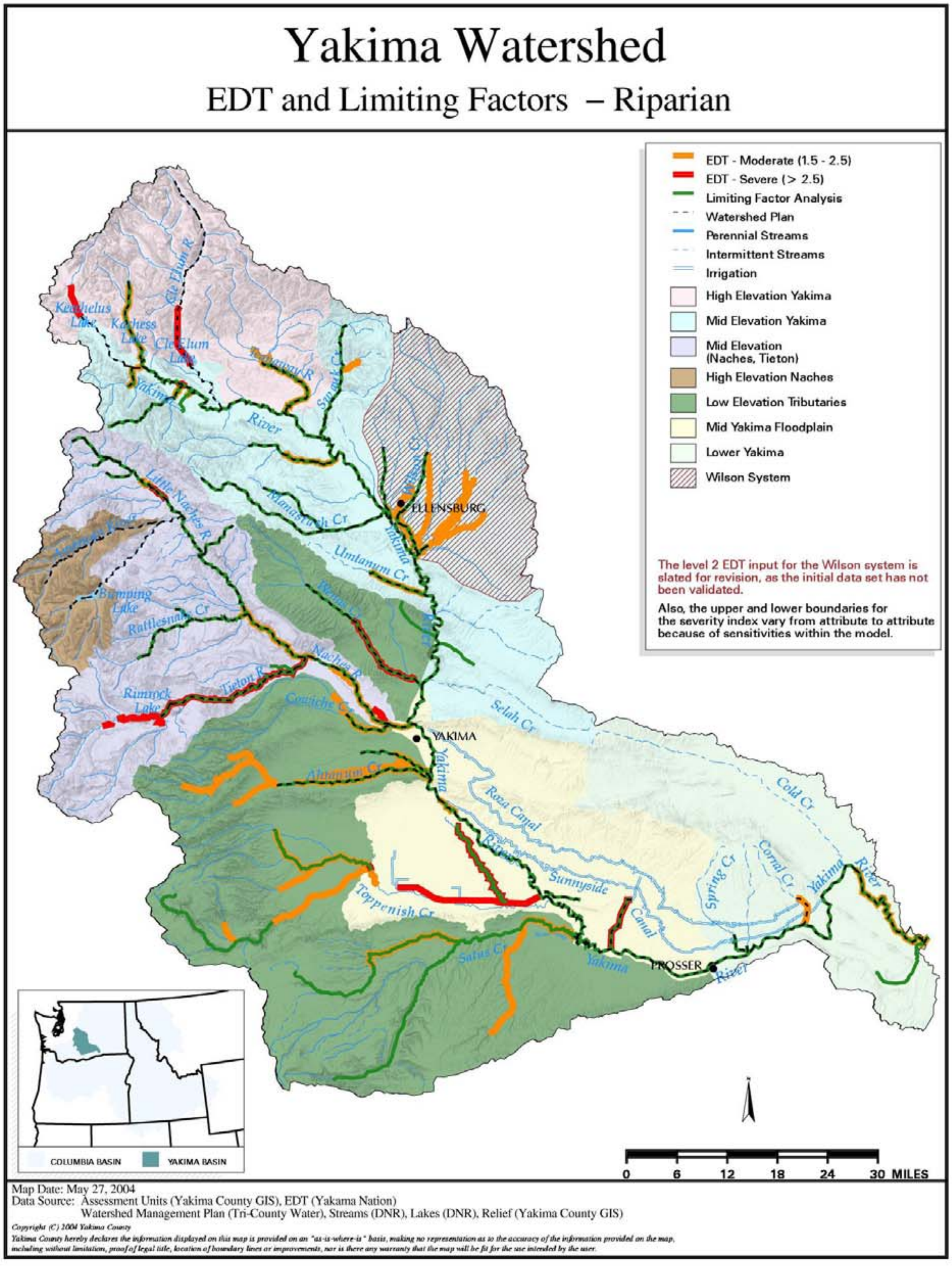


Figure 2-71. EDT and Limiting Factors for riparian

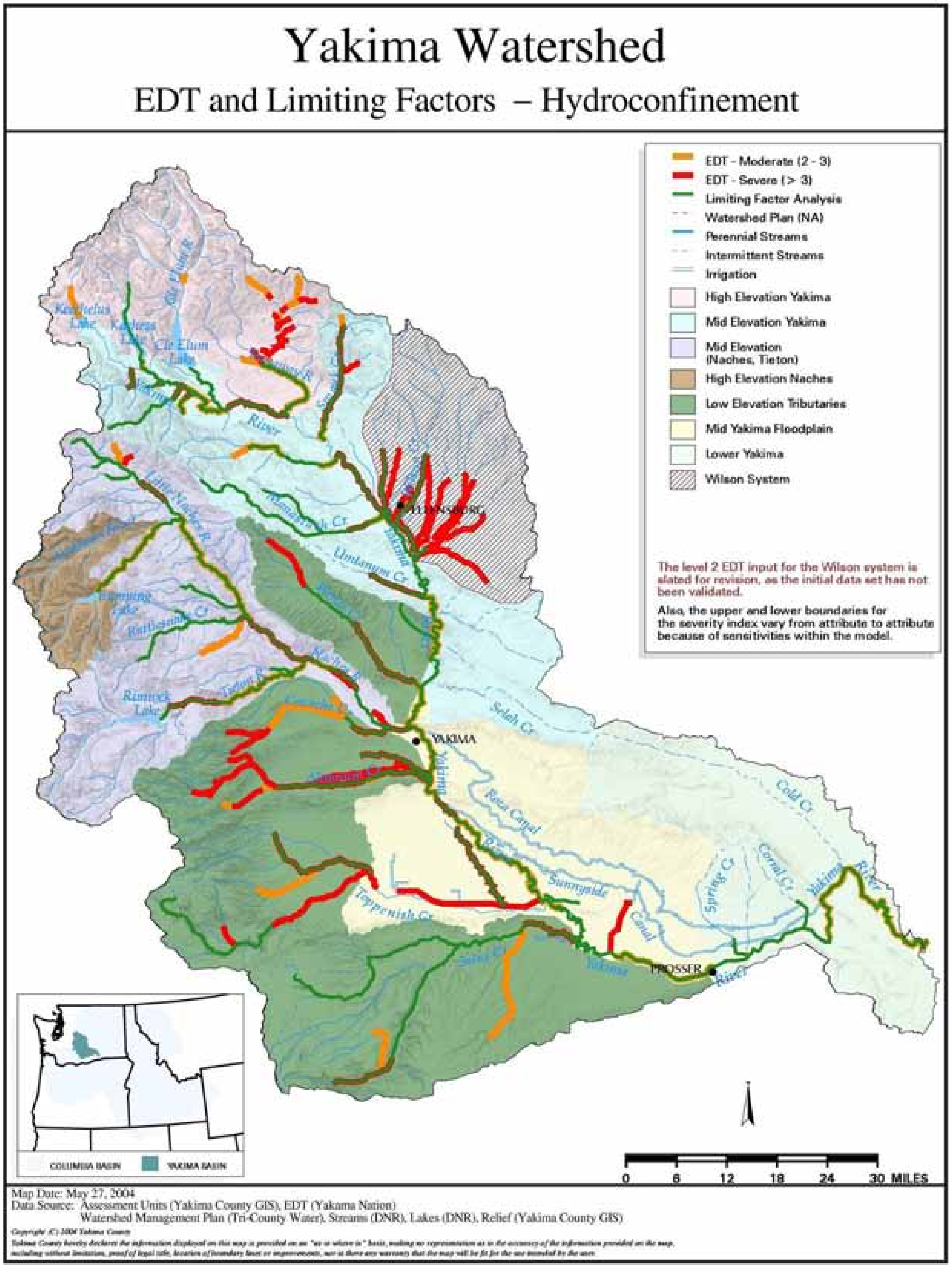


Figure 2-72. EDT and Limiting Factors for hydroconfinement

Restoration Key Findings at the Subbasin scale:

- "[A]s poikilotherms, salmonids are completely dependent on temperature which affects metabolic rate, growth and other physiological characteristics of the species (Groot et. al. 1995). In retrospect, however, its role in life history and ultimately population structure has not been sufficiently regarded." (E. Brannon, 2003)
- Changes to the natural flow regime have resulted in 7 different flow regimes on the mainstem Yakima and Naches Rivers. Loss of these gradual changes has reduced the overall diversity of habitat and temperature spatial variability (the diversity of temperature regimes) at the subbasin scale.
- Riparian communities, and black cottonwood in particular, have been negatively affected by changes in the yearly hydrograph due to the cumulative effects of management of the water resources of the basin for irrigation, domestic, and industrial uses
- Introduction of sockeye will benefit bull trout populations.
- In many locations irrigation diversions, in combination with the naturally high infiltration capacity of the alluvial fans, creates partial or total flow or temperature blockages to fish migration.
- There is little doubt that the absolute peak discharges of large flood events (i.e. above the 25 year flood) have been decreased by flood control flow regulations
- As stated above, the influences of cooler and warmer waters can have only a localized effect on the mainstem, but does not mean that their ecological importance is minor. Springbrooks and side channels that are fed by groundwater are essentially at the same (near optimal) temperature year-round (Stanford, 2002), and (under pre-1850 conditions) allowed salmonids to persist and thrive in those areas of the subbasin where temperatures in the mainstem were either suboptimal or lethal for periods of time during the year. Loss of these habitats as refugia, areas of thermal and habitat diversity, and as unique habitats themselves (for both fish and wildlife) are disproportional to their areal extent in the basin.
- Loss or reduction in this inflow from the Columbia could have had a major affect on the summer low flow temperatures of the lower Yakima River. These springs still exist, but have been modified and isolated from the river, and should be considered as a focal point for restoration of the lower Yakima
- The other general pattern that emerges in the tributaries is the strong link between development, riparian zone loss (due to conversion to other uses or from changes in flow) and increases in temperature. Nearly all tributaries have elevated summer temperatures in their lower reaches where development pressure is greatest, and several have elevated temperatures in their headwaters due to the effects of forest management or grazing, those effects are discussed Assessment Unit by Assessment Unit.
- Confinement itself has had a significant influence on habitat diversity in the basin itself, greatly lengthening the extent of “canyon habitat” in the Yakima Basin.
- Plans to provide passage at Rimrock should recognize that the river below the dam to the confluence with the Naches presents passage problems and uniquely degraded habitat that may prevent migration to the dam regardless if it is made passable.
- Aggradation directly affects channels by filling them in and by severing their connection to the mainstem (i.e. they flow into perched gravel bars at their lower ends). In addition,

the river becomes perched in these locations, disrupting the normal hyporheic functions, preventing flows from the floodplain from flowing back into a live channel.

- The Teanaway and Little Naches have elevated levels of both fine and coarse sediment load due to high road densities, increases in peak flows and bank erosion, floodplain loss etc.
- Coho were extirpated from the Yakima Basin by the 1970s due to a combination of overharvest in the mainstem Columbia (allowed by hatchery production in those areas), the effects of the hydro system, and habitat loss and degradation within the Yakima Subbasin. This not only resulted in reduced harvest opportunities but also lessened productivity of the basin and ecosystem as a whole. Changes that have been made in the hydrosystem, harvest management and habitat restoration activities (e.g. structural, flow, barriers) in the subbasin have reversed the factors for decline of coho, and could increase the productivity and abundance of reintroduced coho populations
- The coho reintroduction project should continue, and coho should be reintroduced wherever it is determined that passage, habitat, and potential productivity of the environment are sufficient to support viable populations over the long term.
- The examination of EDT data, recent habitat assessments, and stream gage data, show that definitive increases in peak flows in the tributaries are confined to a few watersheds. Primary among these are the Little Naches and Teanaway watersheds which share many common attributes such as a general south facing aspect, large areas of the watershed in the rain-on-snow or transient snow zone, high road densities, and current and historical large areas of clearcut timber harvest. Other areas of peak flow increases are also associated with forestry activities, generally also on south facing slopes/rain-on-snow zones such as the Wilson/Naneum system, portions of Wenas, Cowiche, Ahtanum, Toppenish and Satus Creeks.

Key Uncertainties at the Subbasin scale:

- Examination of the rules in EDT makes clear that the degree of hydrologic alteration in the Naches that is associated with flip flop was not included in the calibration of the general EDT model. Modeling based on EDT to determine the benefits of reduction of flip flop would probably not be reflective of the true effects.
- There has been little or no effort to understand or monitor the effects of flip flop either on the upper Yakima or on the lower Naches River.
- Very little information that compared the role and function of the pre-1850 lakes in creation of environmental attributes (such as flow and temperature) in river reaches directly downstream or at a subbasin scale.
- In water years with sufficient TWSA, flip flop should be reduced or eliminated to the extent possible to allow for periodic reestablishment of riparian communities and take advantage of short term opportunities to manage the system within a "normative" range.
- River Ware’s estimated "unregulated flows" do not take into account the necessary range of pre-1850 physical conditions in the watershed; specifically physical characteristics of the historical glacial lakes and the change in tributary flows to the mainstem due to irrigation diversions in the tributaries. Creation of a model that incorporates the physical changes in the watershed and known watershed processes should receive emphasis in the future.

- The presence of reservoirs in the system has dramatically reduced peak flows and net energy available for sediment transport. However, it is possible that the theoretical effects of regulation (i.e. the difference between pre-1850 and current peak flow characteristics) are quite different from the actual effects due to the small storage ability of reservoirs in the basin
- Much less attention has been paid to the winter temperature regime, but the physical relationships would still hold, and reduction of the number of winter and spring days above these thresholds would necessarily reduce winter temperatures. Based on changes to the flow regime and the above relationships,
- Temperatures in the Upper Yakima and the Union Gap reach are colder during all times of the year than under pre-1850 conditions due to dramatically increased summer flows and decreased winter and spring flows. Because these areas have had significant changes to floodplain and channel configuration (see below), changes to channel shape (narrower and deeper) may further contribute to cooling of the river in summer.
- Temperatures in the river below the Union Gap reach are warmer for a longer duration during the summer, and colder in the winter; due to reduce flows year round.
- Temperatures in the Tieton and Naches are warmer in the summer, much colder in September and October during flip-flop, and colder in the winter as well due to reduced flows.
- Due to their aspect and elevation in the watershed, the Teanaway and the Little Naches probably had the greatest variation in average annual water temperature. That would have made salmonids populations somewhat unique to these drainages. The uniqueness of the temperature regime in these locations should be taken into account in population management and restoration/supplementation activities.
- Current efforts are under way to study the tradeoffs involved in connection of gravel pits to the main river and should be completed in 2004.
- Very little work has been done to study sediment in the tributaries.
- A concerted effort to design appropriate irrigation diversion structures for high energy, high sediment, highly unstable environments should be undertaken to solve the subbasin, and Columbia Basin-wide problem.

6.5 Yakima Subbasin Assessment Units

6.5.1 Lower Yakima Assessment Unit

Overview

The Lower Yakima Assessment Unit (Figure 2-74) extends from Prosser Dam (Yakima RM 47.1) downstream to the confluence of the Yakima and Columbia rivers, where that confluence is inundated by the impoundment formed by the McNary Dam, 33 miles downstream on the Columbia. The unit encompasses approximately 707 square miles. Its uppermost elevations begin at its transition from the Mid-Yakima Floodplain Assessment Unit and, to a limited extent, from the upper Selah Creek portion of the Mid-Elevation Yakima Assessment Unit and from the lowermost portion of the Low Elevation Tributaries Assessment Unit, south of Prosser. Elevation within the Assessment Unit ranges from 400 ft to 4,100 ft msl. The Assessment Unit receives approximately 10-16 inches of precipitation a year. According to the 2000 United States Census, approximately 65,237 people live in the unit. Predominant land uses in the Assessment Unit include agriculture, Hanford, and rural (Figure 2-73).

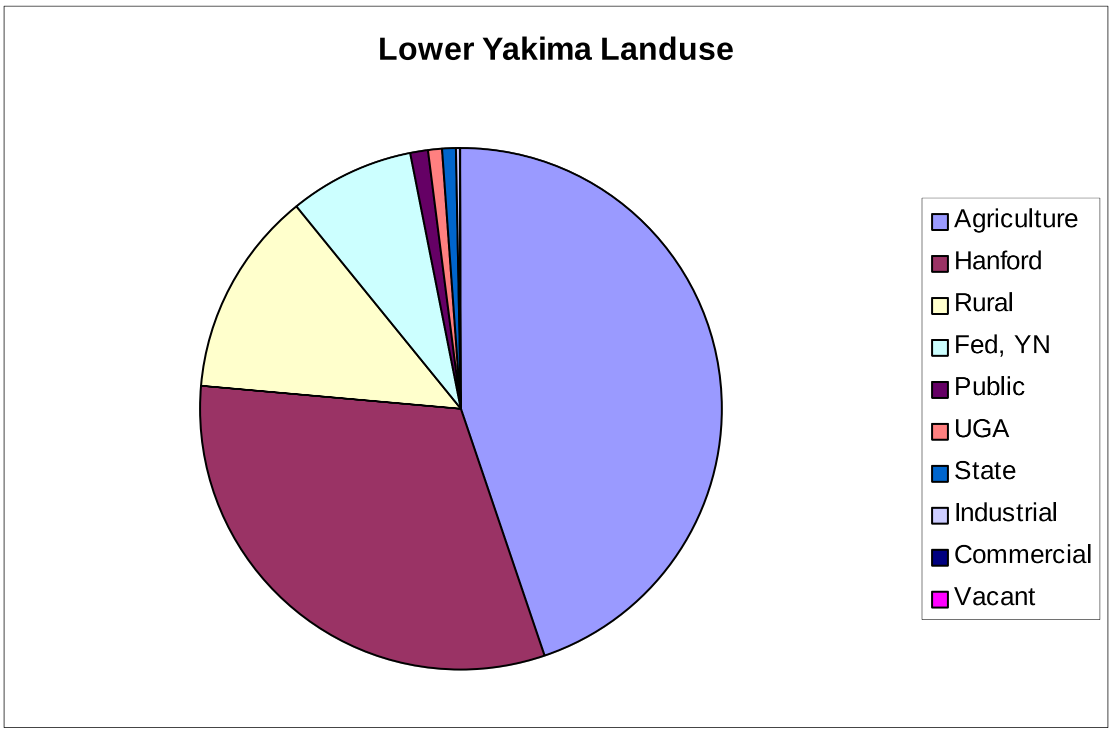


Figure 2-73. Comparison of land uses in the Lower Yakima Assessment Unit

Principal tributaries within this unit include Spring Creek, Snipes Creek, and Corral Canyon Creek (Figure 2-74). Similar to the alteration of streams in other parts of the basin, Snipes and Corral Canyon creeks have been modified to operate within the larger irrigation network found throughout. Though these two creeks retain comparatively more of their historic, natural character, they do operate as irrigation drains and/or wasteways.

The two major dams along this portion of the river are both diversion dams (Figure 2-74). The Prosser Dam diverts water to supply the Chandler Canal, which extends for 10 miles and returns to the Yakima River at RM 35.8 Some of this diverted water is not returned to the river and is routed to the Kennewick Irrigation District. The Wanawish (Horn Rapids) Dam at RM 18 supplies the Richland Canal and the Columbia Canal. Passage is provided at both of these dams, however it has been determined as inadequate in various ways.

In addition to these two dams and their associated diversion channels, the lower portions of two major canals also traverse through the Yakima in the upper portion of this unit. The Roza Canal, which originates upstream in the Mid-Elevation Yakima Assessment Unit, begins at the Roza Dam (RM 127.8) and returns to Coral Creek. The Sunnyside Canal originates in the Mid-Yakima Floodplain Assessment Unit, beginning at the Sunnyside Dam (RM 103.8), and also returns to Coral Creek. Coral Creek empties into the Yakima at RM 33.5.

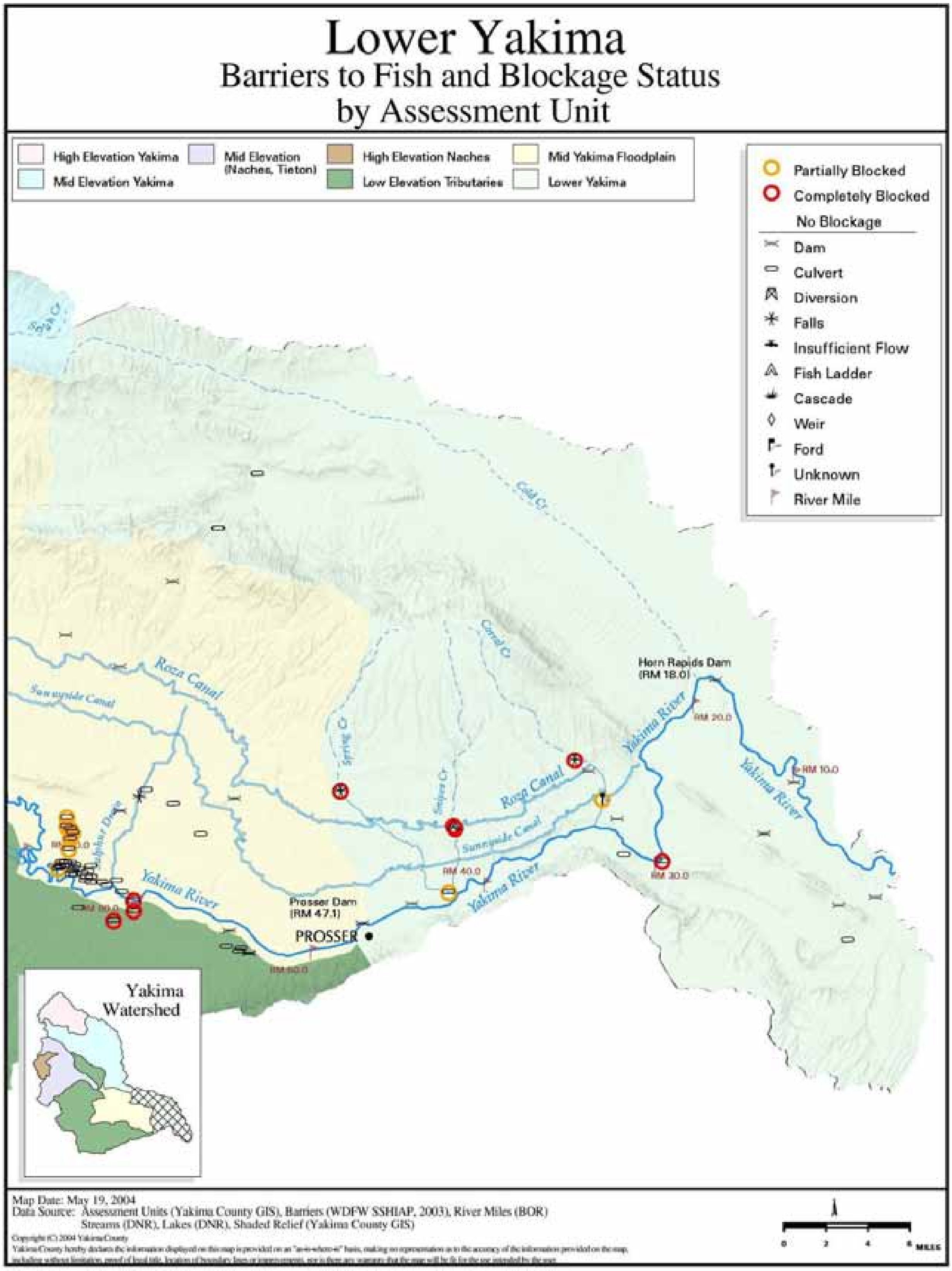


Figure 2-74. Barriers to fish passage in the Lower Yakima Assessment Unit

Aquatic Habitat

Species Distribution and Utilization

Spring and fall chinook salmon, and steelhead/rainbow trout are known to occur within the Assessment Unit. Changes in flow, decreased water quality and increased water temperatures have heavily influenced the distribution and abundance of these species. There is a steep thermal gradient that increases from Prosser dam downstream to the Yakima delta. There are a few cool water refugia in the lower river and one of these is found where Amon Creek empties into the Yakima Delta (P. LaRiviere, Golder Associates, pers. comm. 2004). The current and historical distribution of the focal species in the Yakima Subbasin is illustrated in the focal species discussion prior to the habitat conditions portion of the fish assessment.

Spring Chinook Salmon

Adult spring chinook utilize this Assessment Unit as a migration corridor. Pre-smolts of all three spring chinook stocks exhibit an extensive downstream migration in the late fall and early winter. Various observations over recent years have led to the conclusion that most spring chinook pre-smolts migrate to the lower Yakima mainstem when water temperatures fall sharply in the late fall. Most fish overwinter in the deep, slackwater portion of the mainstem Yakima above Prosser Dam, but 10-35 percent of the juveniles from a given brood year migrate below Prosser Dam during the winter (Fast et al 1991), and begin their smolt outmigration from the lower river the following spring. LaRiviere (pers. comm. 2004) mentioned that juvenile chinook (82 mm - race not known) were present in the cool waters of Amon Creek in late July.

Fall Chinook Salmon

It is generally believed that historically the primary production area in this Assessment Unit was the same as it is today - the lower Yakima mainstem, from Prosser Dam to the Columbia confluence (NPPC 2001). The expression of fall-run life-history strategies in the Yakima River are potentially biased by changes in spawning and rearing habitat and introductions of non-native populations. The development of agricultural irrigation projects on the Yakima River during the last century has resulted in lower river flows, higher water temperatures, river eutrophication, and limited or impeded migration access (Davidson 1953, BPA et al. 1996) in this Assessment Unit. 72-66 shows the relationship between fall chinook life history stages and the current and historical flows of the Yakima River at Kiona.

Several million "upriver brights" and smaller numbers of lower Columbia River fall-run hatchery chinook salmon have been released into the Yakima River (Howell et al. 1985, Hymer et al 1992b). The "upriver brights" stocks represent a composite of Columbia and Snake River populations (Howell et al. 1985). The majority of these introductions on the Yakima River have occurred below Prosser Dam (RM 125) and may be responsible for genetic and life-history differences between Marion Drain and lower Yakima River fall-run fish (Marshall et al. 1995). Water temperatures in the Yakima River have increased significantly, so that returning fall-run adults must delay river entry, and juveniles must emigrate from the river sooner than occurred historically.

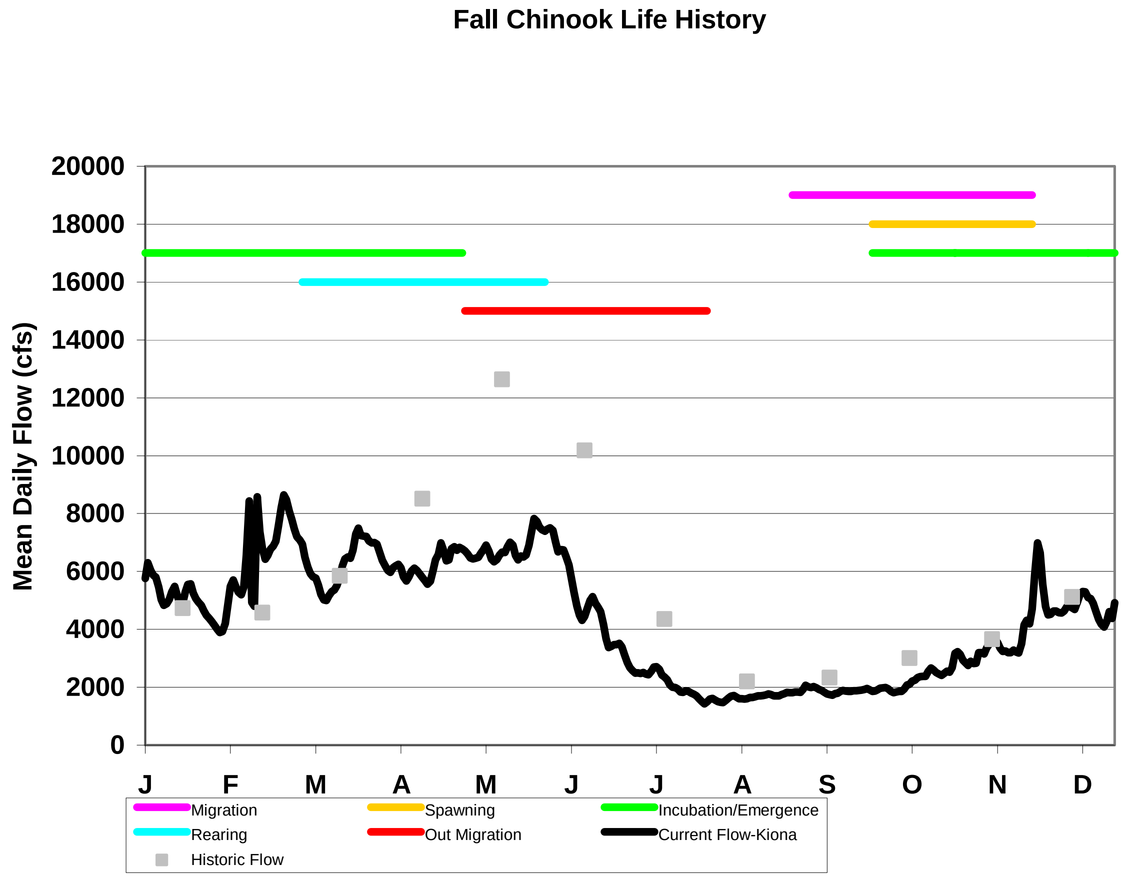


Figure 2-75. Comparison of current and historical average flows of the Yakima River at Kiona with the life history stages of fall chinook. Hydrograph data from USBR (2004)

Steelhead / Rainbow Trout

Steelhead utilize this Assessment Unit as a migration corridor. Steelhead spawn and rear in low numbers in Corral and Snipes Creeks.

Sockeye / Kokanee Salmon

Adult sockeye salmon utilized this Assessment unit as a migration corridor. This reach may be especially problematic for reintroduction of sockeye into the Yakima Subbasin. Migration through this reach during the lethal temperature periods of August may not be possible, and the late migration timing of the Lake Osoyoos stock of sockeye is the main reason it is under consideration for reintroduction, even though the holding, spawning, and rearing environments in the reserviours of the upper basin are much more similar to the Lake Wenatchee sockeye.

Bull Trout

Adult bull trout may utilize this Assessment Unit as a migration and/or foraging corridor. The extent to which bull trout utilize this Assessment Unit is unknown and will need to be studied in the future. There have been bull trout sightings near Prosser.

Pacific Lamprey

Pacific lamprey utilize this Assessment Unit as a migration corridor.

Other Fish Species and Interactions

Migrating juveniles incur losses as they pass through the bypass systems at the Prosser dam. Piscivorous animals (California gulls, great blue herons, American white pelicans, Northern pikeminnow and smallmouth bass) consume smolts and parr as they negotiate the Prosser and Horn Rapids dams. The presence and abundance of exotic species declines with distance upstream from the Yakima delta (Geoff McMichael, pers. comm.). High concentrations of predatory fish have been observed below Sunnyside and Wapato Dams during smolt outmigration (McMichael et al. 1998a, 1998b). A study was initiated in 1997 to examine the impact of piscivorous fish on the survival of outmigrating smolts in the lower Yakima River (McMichael et al. 1998a). Results indicated that predation rates were unnaturally high and were caused mainly by three predators; the indigenous northern pikeminnow, found primarily above Prosser Dam, and two exotic piscivorous species, the smallmouth bass, found primarily below Prosser Dam, and perhaps the channel catfish, found primarily in and just above the Yakima River delta.

The abundance and spatial and temporal distributions of piscivorous birds can have significant impacts to the survival of valued fish species in the Yakima River. The abundance, distribution and estimated maximum consumption (kg biomass) of fish-eating birds along the length of the Yakima River in Washington State was studied during 1999-2002 by Major, W. III. (2003). A greater diversity of avian piscivores occurred in the lower river and potential impacts to fish populations was more evenly distributed among the species. In 1999-2000, great blue herons potentially accounted for 29 and 36 percent of the fish consumed, whereas in 2001-2002 American white pelicans accounted for 53 and 55 percent. It is estimated that approximately 75,878 ±6,616 kg of fish were consumed by piscivorous birds in the lower sections of the Yakima river during the study. Bird assemblages differed spatially along the river with a greater abundance of colonial nesting species within the lower sections of the river, especially during spring and the nesting season (Major, W. III. 2003).

The EDT model hypothesizes that there are competitive interactions between hatchery fish released in this Assessment Unit (fall chinook and coho) and other portions of the basin (spring chinook and coho) that negatively impact the productivity of natural origin fish in this Assessment Unit.

Stream Channel Condition and Function

Along the river there are three distinct reaches within this unit (excluding the largely inundated delta area occupying the lowest ~2 miles of the historic river). From the delta upstream to the West Richland Bridge (RM 8.0) the river is confined as it flows through Richland. From RM 8.0 upstream to the Wanawish (Horn Rapids) Dam at RM 18, the river is naturally partially confined on the south bank and shares the geomorphic floodplain to the north with the Columbia River. From the Wanawish Dam upstream to the upper limit of this Assessment Unit at Prosser Dam (and beyond to RM 55), the river is confined in a shallow canyon, the gentle slopes of which consist of sagebrush desert or irrigated hop fields and vineyards.

The approximately 5-mile reach between Prosser Dam and the Spring Creek confluence (and possibly as far as the Corral Creek confluence, about 9 miles further downstream) has substrate that consists largely of very large boulders and sand, with bars of embedded cobble and gravel associated with islands. Downstream of Corral Creek, gravel and cobble substrates are abundant and suitable for chinook spawning all the way to the mouth (LaRiviere, pers. comm. 2004). However sediment loading throughout the lower Yakima produces a "quantity of fines in mainstem spawning areas [that] is sufficient in many areas to fully embed the substrate and is clearly sufficient to limit carrying capacity and productivity"(NPPC 2001).

During the summer months a massive growth of parrot feather and other invasive aquatic vegetationoccurs along the entire length of the mainstem in this Assessment Unit. This vegetation spans from bank to bank of the river and and has displaced fall chinook spawning and may also inhibit migration. It also dramatically alters habitat conditons such as dissolved oxygen, pH, temperature, substrate, and macroinvertebrate communities in this reach. Studies to understand the effects of this bloom and to find ways to reduce or eliminate the bloom itself are only in the beginning stages.

Riparian / Floodplain Condition and Function

The historic riparian communities along the lower Yakima are still generally recognizable. Historically, these channels would have been bordered by dense willow growth and, in the larger mature channels, cottonwoods. Large woody debris would have been extensive, and of particular importance as a mechanism of temperature moderation through pool formation. Russian olives have invaded some areas and silver maple has invaded the lower confined reach. Some cottonwoods persist in the lower 10 miles.

As noted in the subbasin summary, "Large woody debris is lacking throughout the lower Yakima…. Except for a few wide, short braids, all the lateral channels [in the alluvial reach between RM 8 and 16] have been disconnected, filled and converted to pasture or residential property. Of all the alluvial reaches in the Basin, this one has been the most thoroughly transformed by development. Because this was the last alluvial reach in the Yakima River, it was probably an important nursery area for lower river fry."(NPPC 2001)

Lack of LWD Recruitment is due to loss of large trees from riparian zone in upstream areas, and due to interception and removal of Large Woody debris at diversion dams.

Historically, the Yakima delta would also have been a critical part of the riparian/ floodplain complex. The subbasin summary explains that, "The Yakima River delta has also been radically altered. Prior to development and certainly prior to construction of McNary Dam, …the floodplain of the delta was extensive and complex. Remnant riparian forests remain on exposed portions of the extensive alluvial delta (most of the original delta is submerged). The reach is substantially modified by inundation and erosion associated with McNary Pool, but a substantial expanse of wetlands exists on the fringes. Impoundment by McNary Dam extends about 2 miles up the Yakima River channel, further modifying the floodplain system. Surface and groundwater interactions appear to be dominated by infiltration of McNary water, which probably maintains the fringing wetlands. The Yakima River confluence reach is best described now as an essentially environment. The McNary pool backwater eliminates discernable current in the channel, which is several hundred yards wide. The mouth has been channelized [particularly by railroad and highway causeways] and enters the Columbia as a single channel. Large woody debris [has been] removed [in the past] for navigation purposes and the substrate is comprised of fine sediments, which drop out in this low velocity region. There are a number of [side channels] in the area that are known to contain large numbers of smallmouth bass, and channel catfish are quite numerous in the main channel. The lack of instream cover, low water velocities, high water temperatures and dead-end “bays” all suggest this may be a region of especially high predation.”(NPPC 2001)

Examination of historical maps indicates that there were several areas of side channels in the pre-1850 environment that no longer exist. These side channels were located near Benton City (on the south bank of the river downstream), at the present location of the Van Giesen Bridge, in current West Richland, and areas downstream. The loss of these cool water rearing areas in a reach of the river that has extremely high temperatures has reduced the areal extent of habitat and the spatial and thermal habitat availability and diversity. Most of this habitat loss has occurred due to physical obstructions from road or levees, but significant areas have been converted to agricultural fields, converted to drains, or converted to irrigation ditches.

Water Quantity

Figure 2-76 presents the current (circa 1990) and historic flows at Kiona (RM 29.9)—which is a point sufficiently downstream to represent flows at the mouth (YSS, 2001). For comparison, it also illustrates the current flow at Parker (well above this Assessment Unit, at RM 103) to illustrate the broad similarity in the overall hydrographs. The summary goes on to explain that “[t] he changes made to the normative hydrograph are similar to those seen elsewhere in the basin with one major exception: current flows are always lower than historical flows. The spring freshet is more than halved, and winter flows are sub-normative, as [also] seen in the upper and middle Yakima; but late spring and summer flows are also considerably sub-normative. Lesser discharge implies lesser rearing area, especially in a relatively unconfined reach as [in the lower] alluvial reach, with its many side channels and floodways. The impact of this flow-mediated reduction in habitat area is disproportionately large, because the side channels and grassy floodways that are no longer inundated during the spring are ideal rearing areas for fall chinook fry.” Average annual flow at Kiona has been reduced by an average of a minimum 1.65 maf (out of an averge of 3.4 maf, IOP, 2002), reducing overall habitat availability/capacity year round. This reach has the second largest reduction in total annual flow of the mainstem reaches

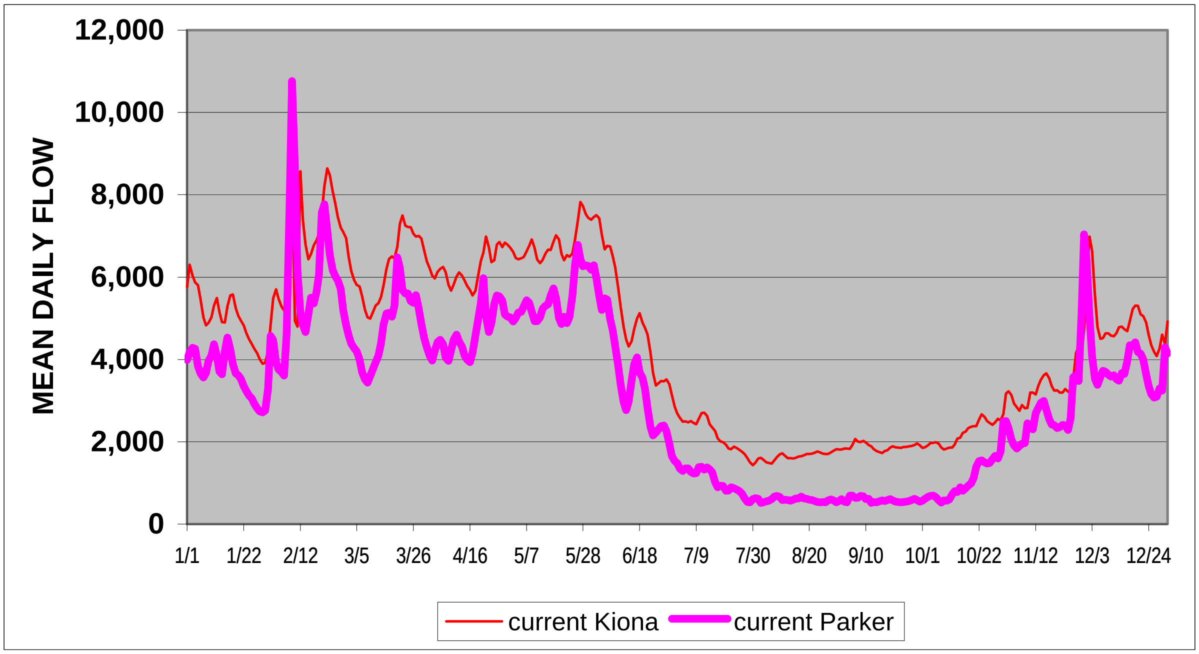


Figure 2-76. Mean daily regulated flow at Parker (RM 103) and Kiona (RM 29.9) averaged over the period 1994-2000 and estimated mean monthly historical flows at Kiona Hydrograph data from USBR (2004).

Using the Parker hydrograph as the expression of flows below Sunnyside Dam (again, well above this Assessment Unit, geographically), the correlation is presented, "The same historical/current pattern seen below Sunnyside at Parker is seen at Kiona, the only significant difference being that the addition of discharges from Marion Drain and Satus and Toppenish Creeks [all of which enter the Yakima River above this Assessment Unit] cause Kiona discharges to be from 1,000 to 2,000 cfs greater than at Sunnyside."

Prosser Dam diverts up to 1,500 cfs into Chandler Canal, over half of which is routed through a powerplant 11 miles downstream and then returned to the river. The remainder continues down the KID canal to users in the Tri-Cities. During low-flow periods, flows in this "bypass reach" can become very low, delaying smolt outmigration and increasing the effectiveness of visual predators. Lower flows also expose boulders within the channel, which [may] increase heat transfer to the surrounding water. Since 1995 and the passage of the YRBWEP legislation, flows in the bypass reach are kept between 300 and 900 cfs depending on TWSA. In addition, constraints have been put on the conditions under which flows can be diverted at Prosser for power generation. From April 1 through June 30, power production must cease (and diversions for power production halted) whenever flows in the bypass reach fall below 1,000 cfs. From July 1 through October 15, power production must be subordinated whenever 450 cfs cannot be maintained in the bypass reach or the YRBWEP-mandated flows cannot be maintained, whichever is larger. From October 15 through March 31, power subordination is triggered by bypass flows of 450 cfs or less, or as negotiated.

In this Assessment Unit, there are four irrigation return conveyances (Amon, Corral Canyon, Snipes and Spring Creeks) that share several characteristics:

- They occur in naturally formed drainage ways.
- At least a portion of their flow comes from springs, but the degree to which these springs are the result of increased water tables due to irrigation is uncertain.
- They are used by salmonids to varying degrees.

Salmonid use may be of four kinds,

1. False attraction during adult migration that either delays migration (in this temperature regime a serious effect) or results in spawning and resultant “population sink” due to poor habitat conditions for incubation and rearing.
2. Spawning and successful incubation for species that are predominantly hatchery reared such as fall chinook and coho. These habitats could be viewed as areas where independent populations, or significant contributions of natural origin fish, may establish.
3. Rearing by fish which originated in the channel
4. Rearing by fish that have not originated in the channel.

The degree and type of management of these streams is a Key Uncertainty in this plan. False attraction is obviously a negative impact on populations that normally spawn upstream, especially that portion of populations that are part of a reintroduction effort and can be expected to have high rates of straying. Successful spawning and incubation may allow for natural production and an increase in spatial and genetic diversity within the subbasin, especially in this portion of the subbasin where such habitat was naturally very limited. Rearing of either natural origin fish from within or outside of the Creek's watershed may be either positive or negative, as these creeks are irrigation return conveyances and experience dramatic increases and decreases in flow from conveyance spill, which may result in direct mortality as well as preclude the development of a stable life history associated with these environments. It appears that of the four, Amon Creek in Richland/Kennewick has the most stable flow regime and the most potential for development of stable life histories. The remainder of the streams would need significant reductions in “spill” frequency and magnitude to become stable fish habitat environments. Management options for these creeks range from water conservation/management actions within the contributing Irrigation Districts to reduce or eliminate spill, which would also have beneficial effects on water quality in the lower river, flow in the mainstem and/or water availability for irrigation, to construction of permanent or seasonal barriers to salmonid migration.

Water Quality

The Yakima Subbasin Summary (2001) points out that, “Temperature is the most serious of a number of serious water quality problems in the lower Yakima. For example, Lilga found that temperatures in the lower river from June through November (1998) were lethal (>60.8º F) for salmon egg and fry incubation between 60 percent and 85 percent of the time. Temperatures are stressful for juveniles (>64.9º F) between 25 percent and 65 percent of the time and stressful for adults (>60.8º F) between 60 percent and 85 percent of the time.

Using Hydromet data and the criteria of 70 ^{o}F and 77 ^{o}F for avoidance and upper incipient lethal temperatures, respectively, for chinook juveniles, the Yakama Nation determined the proportion of the time water temperatures equaled or exceeded avoidance and lethal levels at Prosser. Over the period 1982 – 2000, avoidance temperatures were reached in the months of May, June July, August and September an average of 0.7, 15.1, 54.4, 55.4 and 4.3 percent, respectively. For the same time period and months, lethal temperatures were reached 0, 1.7, 5.6, 3.0 and 0 percent of the time. It should be noted that these are average figures over all 19 years. Conditions are considerably worse in individual, hotter years. The hottest years in recent memory were 1992 and 1994. Over the last 10 days of June, 1992, Prosser water temperatures averaged 78.4 ^{o}F, and in July, 1992, were above 70 and 77^{o}F 100 percent and 23 percent of the time, respectively Water temperatures are generally 2 to 9^{o}F higher in the lowermost sections of the Yakima than they are at Prosser Dam (M. Johnston, YN, pers.comm., 1992). La Riviere (pers. com. 2004) noted that Amon Creek, which enters the Yakima in Richland, provides 6 cfs of cool spring fed water year round.

Other water quality problems in the reach include inadequate dissolved oxygen concentrations, excessive pH, excessive nitrite/nitrate and phosphorous concentrations, pesticide concentrations among the highest in the United States, fecal coliform concentrations, heavy metals, instream flow and turbidity. The lower Yakima River and seasonal streams in the vicinity of Prosser suffer from many of the problems associated with urban streams, such as leaking septic systems, storm sewer pollution, and agricultural runoff (WDFW 1998). Numerous excursions from state water quality standards are documented in the lower Yakima River. Various lower Yakima reaches are included on the CWA 303(d) impaired water quality list for problems including: 4,4'-DDD, 4,4'-DDE, Arsenic, DDT, Dieldrin, dissolved oxygen, Endosulfan, fecal coliform, Mercury, PCB-1254, PCB-1260, pH, Silver, instream flow, temperature, and turbidity.

The EDT model hypothesizes that due to the high temperatures and large variation in water quality parameters in this reach, there would be an increased potential for disease transmission to affect productivity for adult and juvenile spring and fall chinook and coho which migrate through this reach, and that the food net and food productive capacity of this reach would be severely reduced, further reducing capacity and productivity of salmonid fry of all species that rear or reside in this reach.

- There is no single cause or strongly dominant factor contributing to the thermal pollution in the lower Yakima, though it is important to note that, as a lower elevation area, somewhat higher temperatures (due to higher average and summer ambient air temperatures) would be expected as part of the normative condition. Rather, riparian degradation, channel simplification, elimination of wetlands, floodplain disconnection, water withdrawals and the elimination of annual spring flooding all play a role. Each either increases the caloric loading of the lower river or reduces the quantity of cool groundwater that can be discharged back to the river as base flow.

Protection Key Findings for the Lower Yakima Assessment Unit:

- La Riviere (pers. com. 2004) noted that Amon Creek, which enters the Yakima in Richland, provides 6 cfs of cool spring fed water year round.

Restoration Key Findings for the Lower Yakima Assessment Unit:

- 10-35 percent of the juveniles from a given brood year migrate below Prosser Dam during the winter (Fast et al 1991), and begin their smolt outmigration from the lower river the following spring.
- Water temperatures in the Yakima River have increased significantly, so that returning fall-run adults must delay river entry, and juveniles must emigrate from the river sooner than occurred historically.
- Summer/early fall habitat availability is low or eliminated by low flow and high temperature. This reach may be especially problematic for reintroduction of sockeye into the Yakima Subbasin. Migration through this reach during the lethal temperature periods of August may not be possible, Water temperatures in the Yakima River have increased significantly, such that returning fall-run adults must delay river entry, and juveniles must emigrate from the river sooner than occurred historically.
- Loss of habitat diversity/temperature diversity in off channel habitats due to filling, disconnection and low flow.
- Lack of habitat diversity (pools with cover)/Lack of large woody debris due to removal and loss of recruitment.
- Massive in-channel aquatic vegetation growth alters habitat, water quality, and ecosystem characteristics.
- High toxic pollutant levels in sediments.
- Low flow reduces/eliminates habitat availability/quality/diversity.
- Food web in lower river has been altered/reduced.
- “The Yakima River delta has also been radically altered; the delta was extensive and complex.
- Average annual flow at Kiona (has been reduced by an average of (a minimum) 1.65 maf (of an ave of 3.4 maf) (IOP, 2002), reducing overall habitat availability/capacity year round. This reach has the second largest reduction in total annual flow of the mainstem reaches.
- Predation risk to salmonids from native fish (northern pike minnow) is high. Predation risk to salmonids is high at Prosser Diversion Dam. Predation risk to salmonids from non- native fish (smallmouth bass) is high
- Predation risk to salmonids from bird populations is high.
- However sediment loading throughout the lower Yakima produces a “quantity of fines in mainstem spawning areas [that] is sufficient in many areas to fully embed the substrate and is clearly sufficient to limit carrying capacity and productivity”(NPPC 2001).

Key Uncertainties for the Lower Yakima Assessment Unit

- Massive in-channel aquatic vegetation growth alters habitat, water quality, and ecosystem characteristics.

- Operational spill and field runoff routed to several natural drainages (Amon, Corral Canyon, Snipes, Spring Creeks) attract salmonids to low quality or lethal habitat conditions (non-viable populations, population sinks), impede migration, expose migrants or rearing fish to lethal or near-lethal conditions, or could provide some beneficial functions.
- Adult bull trout may utilize this Assessment Unit as a migration and/or foraging corridor. The extent to which bull trout utilize this Assessment Unit is unknown and will need to be studied in the future. The EDT model hypothesizes that there are competitive interactions between hatchery fish released in this Assessment Unit (fall chinook and coho) and other portions of the basin (spring chinook and coho) that negatively impact the productivity of natural origin fish in this Assessment Unit.
- High temperatures have resulted in increased susceptibility of native salmonids to pathogens.

6.5.2 Mid Yakima Floodplain Assessment Unit

Overview

The Mid Yakima Floodplain Assessment Unit (Figure 2-78) encompasses approximately 838 square miles in the south-central portion of the Yakima Subbasin. Elevation within the Assessment Unit ranges between 700 ft to 4,100 ft msl. The Assessment Unit receives approximately 10-16 inches of precipitation a year. According to the 2000 United States Census, approximately 144,560 people live in the unit. Predominant land uses in the Assessment Unit include agriculture, federal and Yakama Nation land, and residential (Figures 1-3 and 2-77).

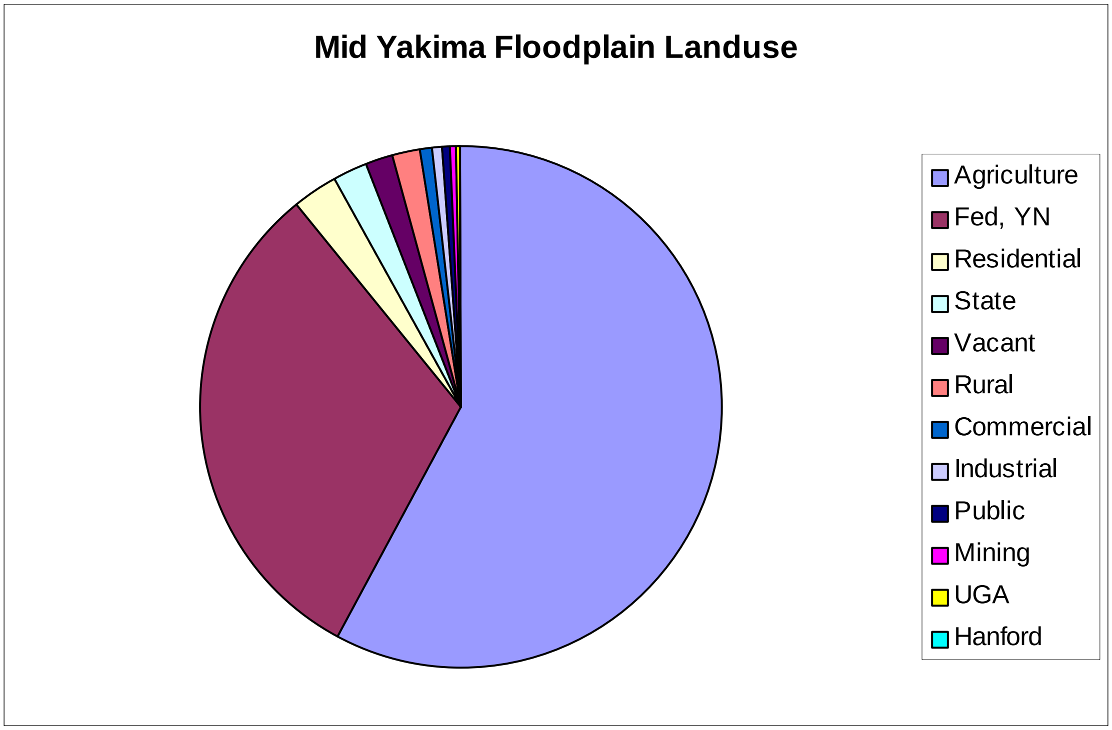


Figure 2-77. Comparison of land uses in the mid Yakima floodplain

The mainstem Yakima River is the largest of the streams in the Assessment Unit. The Yakima River, in the Mid Yakima Floodplain Assessment Unit, extends from the downstream end of Roza Dam to the city of Prosser (Figure 2-78). This reach of the river is relatively low gradient and was formerly a broad network of interconnected stream channels. Toppenish Creek is the largest of the small number of tributaries located in the Assessment Unit, and the lower 20 miles of Toppenish Creek are included in this Assessment Unit as Toppenish Creek meaders across the Holocene floodplain of the Yakima River. Because of arid conditions and generally low elevations, few tributaries originate on the eastern side of the Assessment Unit. A number of other large tributaries including the Naches River, Satus Creek, and Wenas Creek contribute flow to the mainstem Yakima River but are not included in the Assessment Unit.

Roza Dam, Wapato Dam, and Sunnyside Dam are the major impoundments located within the Assessment Unit. These irrigation diversion structures are operated by the Bureau of Reclamation and are designed to divert stream flow from the Yakima River into irrigation canals for agriculture. All of these facilities are low head dams with little storage capacity. The total diversion capacity, however, is quite large and a significant proportion of the total flow is diverted into the network of irrigation canals. Diversion capacity at Roza Dam is 2,200 cfs, Wapato is 1500, and Sunnyside is 1,320 cfs (USBR 2003). These diversions have drastically altered the flow regime in the Yakima River by reducing peak flows in the spring months and elevating base flows in the late summer and early fall (NPPC 2001). There are numerous small diversion dams in the Assessment Unit, a number of which present full or partial passage barriers to anadromous fish (Figure 2-78).

Another prominent feature of the Mid Yakima Floodplain Assessment Unit is Marion Drain, a 19-mile-long drainage canal operated by the Wapato Irrigation Project (WIP). Marion Drain was constructed in the early in the 20^{th} century to drain wetlands, lower the water table in areas where irrigation had artificially raised the water table, and convey irrigation return flows. It was subsequently enlarged over the years to serve as a major delivery canal for WIP. It discharges into the Yakima River at RM 82.6, 2.2 miles upstream of the mouth of Toppenish Creek.

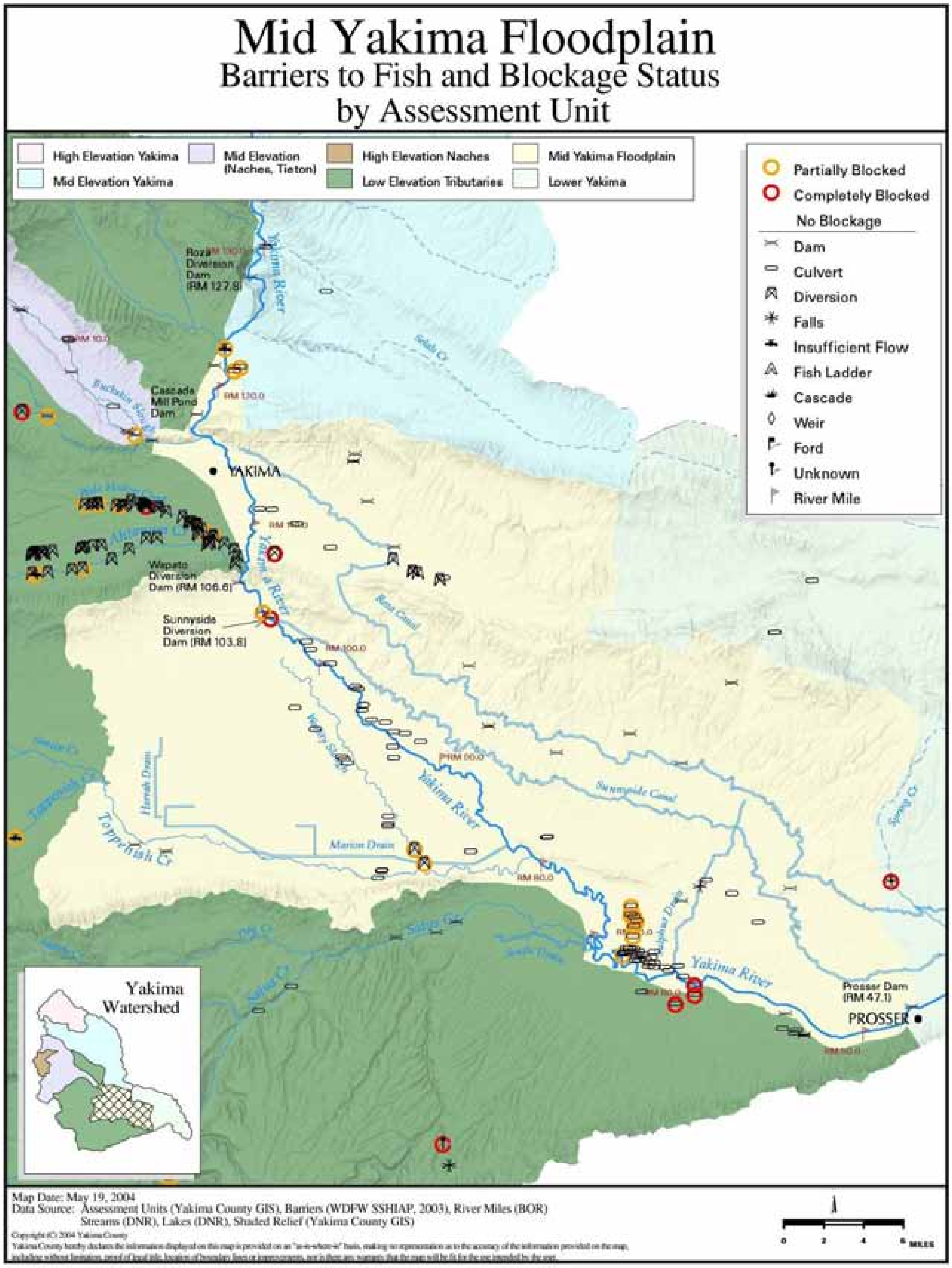


Figure 2-78. Barriers to fish passage in the Mid Yakima Floodplain Assessment Unit

Aquatic Habitat

Species Distribution and Utilization

Spring chinook salmon, fall chinook salmon steelhead/rainbow trout, pacific lamprey and bull trout are known to occur within the Assessment Unit. The distribution and abundance of these species has been heavily influenced by the placement and operation of numerous irrigation diversion dams and habitat degradation. The current and historical distribution of the focal species in the Yakima Subbasin is illustrated in the focal species discussion prior to the fish habitat conditions portion.

Spring Chinook Salmon

The reach of the Yakima River from Roza Dam to Sunnyside dam is an important rearing area for spring chinook juveniles. Juveniles from all three stocks are typically distributed throughout this reach in the late fall following emergence. Densities are highest well below the major spawning areas but above Sunnyside Dam.

Another characteristic common to all stocks of spring chinook is an extensive downstream migration of pre-smolts in the late fall and early winter. Observations in recent years indicate that most spring chinook pre-smolts migrate to the lower Yakima mainstem when water temperatures fall sharply in the late fall. This thermal trigger occurs earlier in the upper reaches of the basin. Subyearling migrants begin appearing at the Wapatox Dam smolt trap on the lower Naches (RM 17.1) and at Roza Dam trap on the mid Yakima (RM 127.9) in October and November, and usually during December at the Chandler smolt trap at Prosser Dam on the lower Yakima (Fast et al 1991). Although 10-35 percent of the juveniles from a given brood year migrate below Prosser Dam during the winter, most fish overwinter in the deep, slackwater portion of the mainstem Yakima between Marion Drain (RM 82.6) and Prosser Dam (Fast et al 1991), and begin their smolt outmigration from the lower river the following spring.

Fall Chinook Salmon

It is generally believed that the primary production area in this Assessment Unit was the same as it is today: the Yakima mainstem, from the current site of Sunnyside Dam to Prosser Dam (Subbasin Plan 2001). Approximately 30 percent of the run spawns in this Assessment Unit and appears to be synchronous in Marion Drain and the mainstem Yakima.

The expression of fall-run life-history strategies in the lower Yakima River are potentially biased by changes in spawning and rearing habitat and introductions of non-native populations. The development of agricultural irrigation projects on the Yakima River during the last century has resulted in lower river flows, higher summer water temperatures, river eutrophication, and limited or impeded migration access in the mainstem below Parker (Davidson 1953, BPA et al. 1996). Several million "upriver brights" and smaller numbers of lower Columbia River fall-run hatchery chinook salmon have been released into the Yakima River (Howell et al. 1985, Hymer et al 1992b). The "upriver brights" stocks represent a composite of Columbia and Snake River populations (Howell et al. 1985). Water temperatures in the Yakima River within this Assessment Unit have increased significantly, such that returning fall-run adults must delay river entry, and juveniles must emigrate from the river sooner than occurred historically. Marion Drain is the only location upstream of Prosser Dam where fall-run chinook salmon naturally produce smolts in any number (BPA et al. 1996). One possible explanation for this fact is that temperatures in Marion Drain are more stable than those in the mainstem Yakima.

It has been speculated that the Marion Drain fish are representative of "native" Yakima River fish (Marshall et al. 1995). If this is the case, then the phenotypic expression of their life-history traits (spawn timing, age at smoltification, age at maturation, size at maturation) may have been altered by the artificial environment in which they currently exist. For example, warmer winter temperatures and high stream productivity contribute to the production of large, 95 mm, outmigrating subyearling smolts in late April which, in turn, result in the high incidence of 2-year-old mature males observed. The persistence of life-history differences among some populations of ocean-type chinook salmon in the Columbia River Basin, despite extensive stock transfers and geographic constriction of available habitat, is indicative of the significance of these traits.

Steelhead / Rainbow Trout

It is probable that the historical spawning distribution of summer steelhead included virtually all accessible portions of Yakima Basin, with highest spawning densities occurring in complex, multi-channel reaches of the mainstem Yakima, and in third and fourth order tributaries with moderate (1-4 percent) gradients (Subbasin Summary 2001). Hockersmith et al. (1995) indicated that about 66 percent of Yakima steelhead overwinter in the mainstem Yakima in this Assessment Unit with the majority in the vicinity of the Satus creek confluence. This is the same area of the river which supports overwintering juvenile spring chinook, and this reach is the most important.

Sockeye / Kokanee Salmon

Adult sockeye salmon utilized this Assessment Unit as a migration corridor. This reach may be especially problematic for reintroduction of sockeye into the Yakima Subbasin. Migration through this reach during the lethal temperature periods of August may not be possible, and the late migration timing of the Lake Osoyoos stock of sockeye is the main reason it is under consideration for reintroduction, even though the holding, spawning, and rearing environments in the reserviours of the upper basin are much more similar to the Lake Wenatchee sockeye..

Bull Trout

Adult bull trout may utilize this Assessment Unit as a migration and/or foraging corridor. The extent to which bull trout utilize this Assessment Unit is unknown and will need to be studied in the future, but bull trout are likely limited by habitat conditions in this Assessment Unit. There have been recent sightings of bull trout near Prosser and Zillah.

Pacific Lamprey

Pacific lamprey utilization of the Mid Yakima Floodplain Assessment Unit has been documented by Wydoski and Whitney (2003).

Other Fish Species and Interactions

Migrating juveniles incur losses as they pass through the bypass systems at the lower Yakima, Wapato and Sunnyside dams. Piscivorous animals (California gulls, great blue herons, American white pelicans, Northern pikeminnow and smallmouth bass) consume smolts and parr as they negotiate the pre-bypass canal and as they are discharged back into the river. The presence and abundance of exotic species declines upstream from the Yakima delta (Geoff McMichael, pers. comm.). High concentrations of predatory fish have been observed below Sunnyside and Wapato Dams during smolt outmigration (McMichael et al. 1998a, 1998b). A study was initiated in 1997 to examine the impact of piscivorous fish on the survival of outmigrating smolts in the lower

Yakima River (McMichael et al. 1998a). Results indicated that predation rates were unnaturally high above Prosser Dam and were caused mainly by the indigenous northern pikeminnow *(Ptychocheilus oregonensi*s). The abundance and spatial and temporal distributions of piscivorous birds can have significant impacts to the survival of valued fish species in the Yakima River. The abundance, distribution and estimated the maximum consumption (kg biomass) of fish-eating birds along the length of the Yakima River in Washington State was studied during 1999-2002 by Major, W. III. (2003). A greater diversity of avian piscivores occurred in the lower river and potential impacts to fish populations was more evenly distributed among the species. In 1999-2000, great blue herons potentially accounted for 29 and 36 percent of the fish consumed, whereas in 2001-2002 American white pelicans accounted for 53 and 55 percent. It is estimated that approximately 75,878 ±6,616 kg of fish were consumed by piscivorous birds in the lower sections of the Yakima River during the study. Bird assemblages differed spatially along the river with a greater abundance of colonial nesting species within the lower sections of the river, especially during spring and the nesting season (Major, W. III. 2003).

The EDT model hypothesizes that there are competitive interactions between hatchery fish released in this Assessment Unit (fall chinook and coho) other portions of the basin (spring chinook and coho) that negatively impact the productivity of natural origin fish in this Assessment Unit.

Stream Channel Condition and Function

Lower Toppenish Creek

Downstream of the Toppenish Creek / Mill Creek confluence, the channel historically assumed an anabranched appearance and flowed through an extensive network of wetlands and contributed to the formation of Mud Lake (Toppenish Creek Corridor Plan, Yakama Nation, in prep). This area of Toppenish Creek is still used for waterfowl pond diversions and over 30 small impoundments have been constructed. These impoundments are present from October through the end of the hunting season in January (possibly as late as June under some circumstances) and contribute to the accumulation and retention of fine sediment in the bed. Although the effect of these structures is pronounced, fine sediment retention is probably of a lesser magnitude than that resulting from beaver activity prior to development on the valley floor. These diversions are not screened although efforts are underway to remedy this situation. Salmonids may still be diverted into the ponds. Although most of the diverted water is ultimately returned to the creek, the return path may be ambiguous and smolt stranding is a distinct possibility.

As the river flows eastward adjacent to Toppenish Ridge to the confluence with the Yakima River it crosses the Holocene floodplain of the Yakima River. At this point Toppenish Creek historically intermingled with a vast network of interconnected Yakima River channels. This confluence was an extensive maze of channels and wetlands (Toppenish Creek Corridor Plan, YN in prep.). Channel complexity is greatly reduced in modern times but some of the wetlands in this area still exist.

Marion Drain

Conditions in the Yakima River are generally good enough to enable fall chinook adults to access the lower 1.5 miles of Marion Drain. The drain below the tainer gates at the Highway 22 crossing is broad and shallow and the fringe of Russian olives and brush along the banks provide little cover for migrating adult salmon. It appears that adult fall chinook are reluctant to enter the lower drain until the tainer gates are abruptly opened in mid-October at the end of irrigation season. The water impounded above the tainer gate is suddenly discharged, increasing depth and dramatically increasing the turbidity of the water entering the Yakima. Seiler (1992) found that fall chinook movement commenced immediately after the gates were opened, and was minimal both before the opening and after the impounded water had drained away. The predominant substrate in Marion Drain is small gravel, with a high proportion of silt and other fine material. The impact of this sediment on incubating fall chinook eggs in the drain is much less than it would be in the mainstem, because redds are cleaned during spawning and are not "re-silted" by winter floods (the drain receives only ground water after irrigation season).

Yakima River Mainstem

The 6-mile reach of the Yakima River between the confluence with the Naches River (RM 118) and the confluence with Wenas Creek Dam (RM 124) (i.e. the Selah Reach) has been severely degraded. Much of the reach is now confined between poorly constructed levees protecting the gravel mining operation and various developed properties. Streambanks have collapsed, the width to depth ratio is large, and large woody debris is extremely scarce.

The Yakima River from RM 119.6 to 106.9 (i.e. the Gap-to-Gap reach) is very confined and is bordered by the city of Yakima on its right bank and the community of Terrace Heights and pasture land on its left bank. Riprapped dikes parallel the river along most of the reach on both banks, and all of the side channels that historically flowed through the city of Yakima on the right-bank have been filled. Large woody debris is scarce in this reach. Wood recruitment has been reduced by alteration of the upstream and adjacent riparian zones. Wood retention is inhibited by the modified channel geometry that concentrates flow into a narrow cross section. Stream velocities in this reach during the spring and summer are much higher than desired for steelhead rearing (YSP 1990, WDFW 1998), especially during the emergence period of June and July. Cobble and large gravel substrates are abundant (WDFW 1998). A small section of this reach near RM 113 contains many side-channels, islands and back water areas. A number of large and potentially productive springbrooks in the lower end of the reach have been isolated from the main channel by Interstate 82. Hatchery-reared coho salmon spawn here and in Wide Hollow Creek (Dunnigan 2001), as do steelhead (Hockersmith et al. 1995). Sporadic observations indicate that juvenile spring chinook and rainbow/steelhead rear in the slower areas. Unfortunately, these areas also support two significant predators, Northern pikeminnow and smallmouth bass (YN, unpublished data; E Anderson, WDFW, pers.comm., 1999), as well as redside shiners, a known competitor for space and food (Patten and Thompson 1970).

The section of the Yakima River from RM 106.9 –47.1 (i.e the Wapato Reach) has the broadest floodplain within Mid Yakima Floodplain Assessment Unit and the Yakima Subbasin as a whole. The current extent of the floodplain is just a fraction of historic area (Snyder and Stanford 2001). However, much of this reach is still characterized by intact floodplains, cottonwood gallery forests, and extensive riparian wetlands. To a large degree, it is still a very complex and productive portion of the basin, but its productivity and overall available habitat area are limited by low flows. Occasionally, high September temperatures in the lowermost reaches delay the entry of steelhead spawners, and low flows below Sunnyside Dam in drought years might delay migrating spring chinook.

Riparian / Floodplain Condition and Function

Lower Toppenish Creek

Channel incision has disconnected the stream from the floodplain in the reach below Simcoe Creek (Tom McCoy 2004, pers.comm., comment to 1st draft). The lower portion of Toppenish creek has many small, fenced, private pastures, and overgrazing has caused extensive bank failures. Riparian vegetation on Toppenish Creek has been heavily modified between SR 22 (RM 3.3) and the Simcoe confluence (RM 32.7). Most of the once abundant wetlands in the lower reach were lost to agriculture.

Cree Island Road and the Unit II Pump Canal is largely devoid of riparian vegetation but improves with distance downstream (Toppenish Creek Corridor Plan, YN in prep). The absence of riparian vegetation is related to channel incision and land use practices.

Riparian vegetation in the reach of Toppenish Creek between the Unit II Pump Canal and State Route 22 has been heavily modified by grazing and irrigated agriculture (Toppenish Creek Corridor Plan, YN in prep). The meandering channels, wetlands, beaver complexes, low floodplains, and upland terraces in the floodplain corridor formerly supported a shifting mosaic of habitat types. Cottonwood gallery forests and wetlands once covered thousands of acres in the floodplain corridor though extensive areas in the floodplain corridor have been altered and much of the high quality habitat has been lost, large scale efforts are occurring to reduce these trends.

Yakima Mainstem

Riparian vegetation is sparse in the Selah Gap-to-Union Gap reach of the Yakima River (WDFW 1998), as most of the right bank bordering the City of Yakima consists of a massive, riprap dike. Agricultural areas along the left bank have been cleared or overgrazed and trees in the riparian zone are largely absent (YSP 1990).

Riparian vegetation along the Wapato reach is extensive. Mature cottonwoods and an understory of willows and other brushy plants form an almost unbroken corridor from Prosser Dam to Sunnyside Dam. This corridor is interrupted infrequently by a small number of highway revetments or levees.

The structure and function of riparian forests have likely been affected by alteration of the timing, magnitude, duration, and frequency of the annual and less frequent flow events. In other systems similar flow alterations have changed the age composition forest stands by reducing the recruitment of young trees. Braatne et al (1996 or 2001) explains that the lack of cottonwood regeneration in this reach is severe, and has also effected sex ratio and reproductive capacity. Early historical accounts (LFA, Winthrop), more recent accounts (Ubelacker) and evidence of stumps in many locations along the river indicate that Ponderosa Pine formerly occupied the riparian zone of the mainstem Yakima to Prosser, and was removed for building material and firewood up until the 1930s. The current distribution ends more than 50 miles upstream on the Naches River. Loss of Ponderosa Pine has likely had effects on both terrestrial and aquatic ecosystem function.

Water Quantity

Lower Toppenish Creek

Historically, the Toppenish Lateral Canal dewatered 6.8 miles of Toppenish Creek from mid-June through mid-December. Guidelines were recently developed by Yakama Nation to assist

Wapato Irrigation Project in managing the lateral canal. A minimum instream flow of 10 cfs is also required in the stream below the lateral canal from Mid- June to October. After October demand for water decreases and only stock water is requested. At this time the Lateral will only receive 7-10 cfs depending on the availability of water. Approximately 3 miles of stream below the Lateral Canal continues to be dewatered and the Yakama Nation Fisheries Department has identified this area as a priority for future improvement efforts.

Other flow related fish passage problems include unscreened diversions on the Toppenish/Marion drain flood control ditch (RM 19), and low flows in the middle portion of Toppenish Creek. Flows in this reach go subsurface due to the combined influence of WIP withdrawals (Toppenish Lateral Canal), the presence of alluvial fans, and groundwater wells throughout Medicine Valley. It is likely that the reach is dewatered earlier than would otherwise occur, and juvenile stranding may occur (WDFW 1998).

Marion Drain has severed the hydrologic connection between the Yakima River and Toppenish Creek, which is much deeper than the creek channel for much of its length (Yakama Nation in prep). Marion Drain intercepts surface flows that historically entered the creek from various distributary channels of the Yakima River. Historically, the combined surface- and groundwater delivered year-round from the Yakima River sustained high quality base flows that supported the diverse, productive ecosystem of the Toppenish Creek corridor. Now, the quantity and quality of habitat in the stream corridor is flow-limited while Marion Drain carries high flows throughout the irrigation season. The Durham diversion dam further reduces streamflow near the lower end of the reach (YN in prep).

Yakima Mainstem

Flows in the Yakima River between Roza Dam (RM 127.8) and the confluence with the Naches River (RM 118) are heavily influenced by diversions to Roza Canal (Figure 2-79. Roza Hydrograph). Peak flows are several thousand cfs smaller than might be expected under unregulated conditions. Base flows are artificially elevated between mid July and early September and then remain low for the remainder of the year. During the spring runoff, mean daily flows may be as much as 4,000 cfs lower than under unregulated conditions (Figure 2-79, Roza Hydrograph). From July to October flows can be several hundred cfs higher than occurred under unregulated conditions. Upon conclusion of the irrigation season, flows may be 1,000-2,000 cfs lower than unregulated flows, and many of the side channels that would otherwise be used for rearing dry up (D. Eitemiller, CWU, pers.comm., 2000).

Flows in the Gap-to-Gap reach follow a similar pattern to the Selah reach flows until September, when flip flop occurs and the Naches supplies water to this reach and the major irrigation diversions downstream. Flows after September are somewhat reduced (2000 cfs) but are still well above pre-1850 flows. The low flow period is shifted from September to late October, and winter flows remain well below pre-1850 flows with the exception of flood events.

- Flows in the Wapato reach are influenced by dams and diversions in the upper basin as well as Sunnyside Dam (RM 107) and Wapato Dam (RM 110). Marion Drain, Toppenish Creek, and Satus Creek contribute flow to the Yakima River. The magnitude of these contributions is considerably less than the magnitude of the diversions. Below Sunnyside Dam, the springtime flows are less than half of what they might be in under unregulated conditions (a difference of as much as 5,000 cfs) (Figure 2-80) Low flows during the spring adversely impact spring chinook outmigration which is strongly and positively correlated with positive flow acceleration (Mundy and Watson unpublished data 1996) as is survival through the lower river (TCWRA 2003). Side channels and grassy floodways, ideal rearing areas for spring and fall chinook fry, are no longer inundated during the spring. Winter flows are also considerably reduced. Average annual flow has been reduced by 1.2 maf (out of an average of 3.1 maf) from Parker to approximately Toppenish Creek/Marion Drain. This is the greatest reduction of overall quantity of flow in any of the mainstem reaches, and occurs in the reach with the most physically intact floodplain/riparian zone.

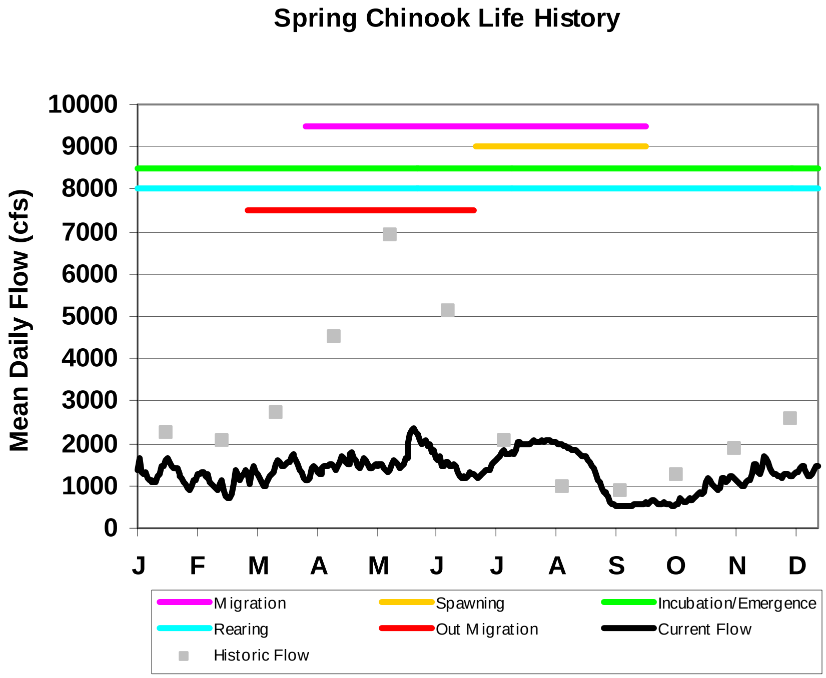
Nearly one half of the total amount of water diverted from the Yakima River during the irrigation season (May to October) is diverted at Sunnyside and Wapato Dams (Snyder and Stanford 2001), leaving substantially lower flows at and below the river gage at Parker. Since 1995, flows below the dam have been managed to achieve target flows between 300 and 600 cfs for the period between April 1 to October 31. These flows are based on TWSA (Total Water Supply Available) and have dropped below 300 cfs on only three occasions since adoption of this policy. Compliance with the target flows is dependant on the water supply for that year. Both the unnaturally high flows above Union Gap and the unnaturally low flows below Parker for significant portions of the year limit the natural progression of habitats that would have occurred in pre-1850 times. This natural progression of habitat would have been linked to the life histories of salmon and other components of the ecosystem, such as black cottonwood, which does not have the ability to reproduce sexually under either a sustained high or low flow environment. Such changes in flow patterns and associated variables such as temperature may cause disruption in the primary and secondary productivity of the food wed of the aquatic ecosystem.

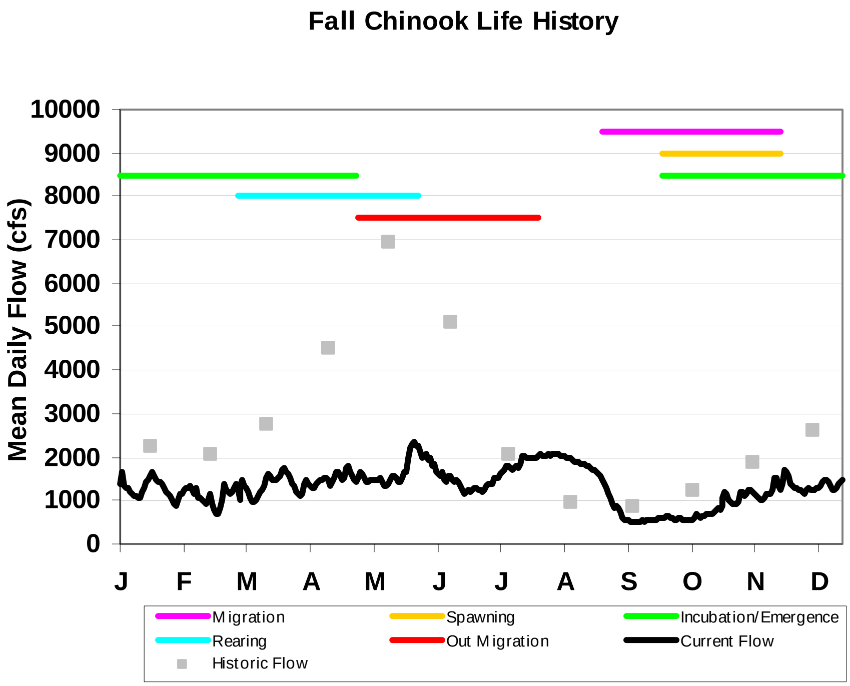
Evaluating the rate at which flows change is a useful indicator of hydrologic alteration (Ricther et al. 1996). The Bureau of Reclamation has estimated that bi-hourly fluctuations in the Yakima River can exceed 20 percent of the base flow (USBR 2000). Flow fluctuations of this rate and magnitude are large enough to strand juvenile salmonids and their invertebrate prey in various shallow side channels and sloughs. Stranding is undesirable because side channels and sloughs isolated by flow fluctuations are subject to increased temperature and reduced dissolved oxygen. Even if these conditions are not lethal, the fish may be subject to unnecessary physiological stress. Stranded fish are also more susceptible to predation. Stanford (USBR workshop, May 2000) reported that flows below about 300 cfs exposed boulders in this reach, which when fully heated by direct sunlight had the ability to increase water temperature by several degrees centigrade in a matter of a few miles.

Another issue in the section of the mainstem is false attraction. In constrast with the streams in the Lower Yakima Assessment Unit, irrigation returns in this reach (such as Granger Drain, Sulphur Creek/wasteway and Marion Drain) were constructed in areas that were not natural drainage ways. Irrigation operational spills and field runoff to these drains attract salmonids to low quality or lethal habitat conditions in this Assessment Unit. Management options for these streams range from water conservation/management actions within the contributing Irrigation Districts to reduce or eliminate spill, which would also have beneficial effects on water quality in the lower river, flow in the mainstem and/or water availability for irrigation, to construction of permanent or seasonal barriers to salmonid migration.

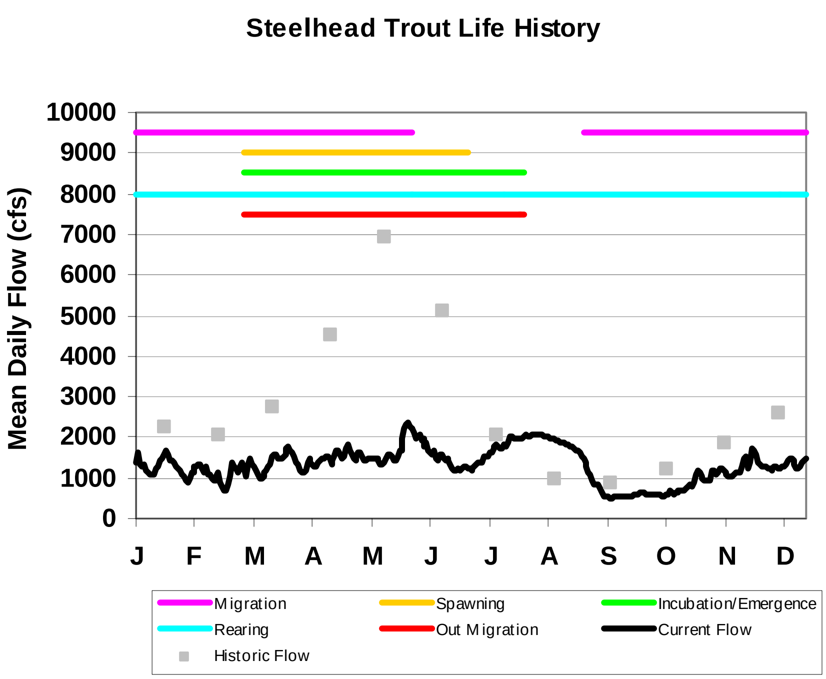
The Marion Drain fall chinook is a limited exception to this rule, as Marion drain also attracts other salmonids, including adults and juveniles, to this highly altered and artificial habitat. In addition, return flows from the Roza Power Plant at the Terrace Heights Bridge attract adult salmon homing to the upper Yakima, and can delay their spawning migration significantly. The canal is screened at its mouth (RM 113.3) but still discharges upper Yakima water and therefore induces salmon homing on the odor of upper Yakima water to remain in the vicinity.

During the summer months, a massive growth of parrot feather, an invasive non-native aquatic vegetation, occurs along the Yakima River from Toppenish to Prosser in this Assessment Unit. This vegetation spans from bank to bank of the river and and has displaced fall chinook spawning and may also inhibit migration. It also dramatically alters habitat conditons such as dissolved oxygen, pH, temperature, substrate, macroinvertebrate communities in this reach. Studies to understand the effects of this bloom and to find ways to reduce or eliminate the bloom itself are only in the beginning stages.



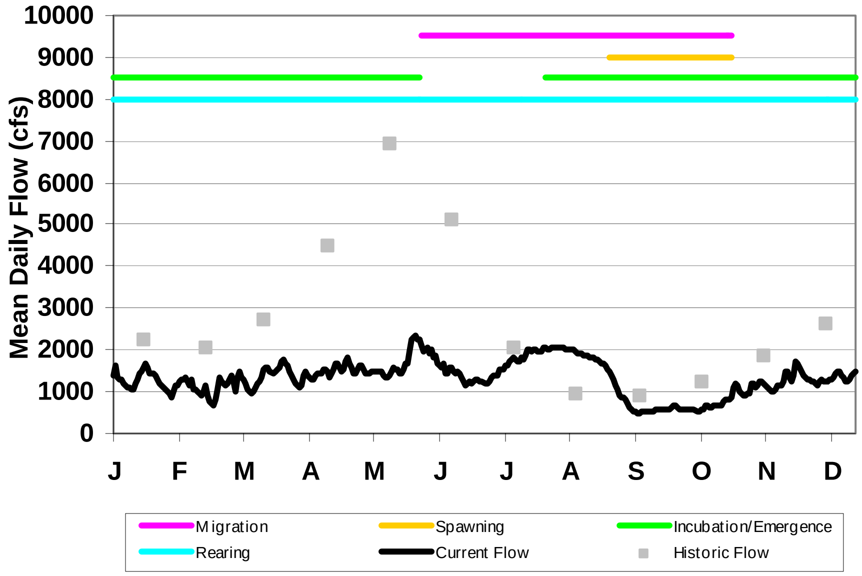


Fall Chinook Life History
Mean Daily Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
J F M A M J J A S O N D
Migration
Spawning
Incubation/Emergence
Rearing
Out Migration
Current Flow
Historic Flow



Steelhead Trout Life History
Mean Daily Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
J F M A M J J A S O N D
Migration
Spawning
Incubation/Emergence
Rearing
Out Migration
Current Flow
Historic Flow

Bull Trout Life History



Pacific Lamprey Life History

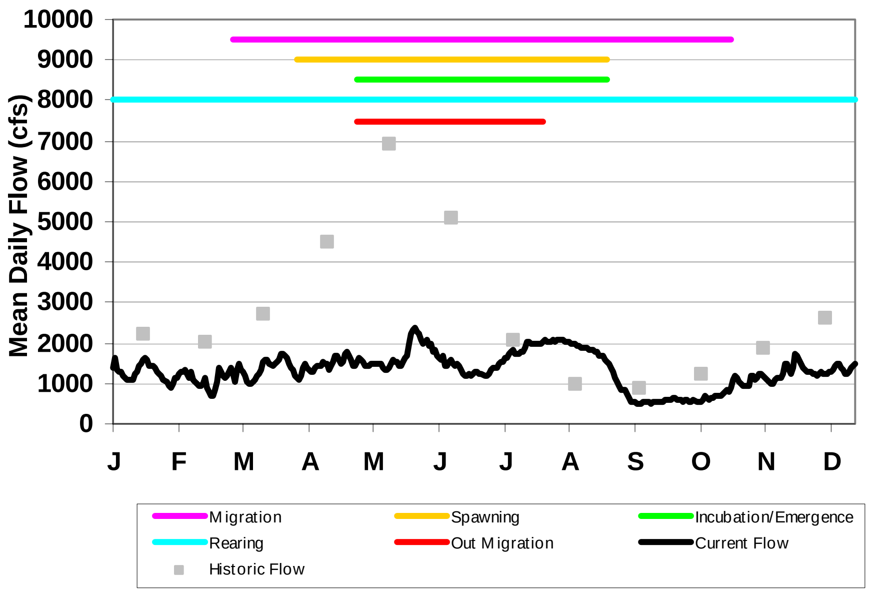
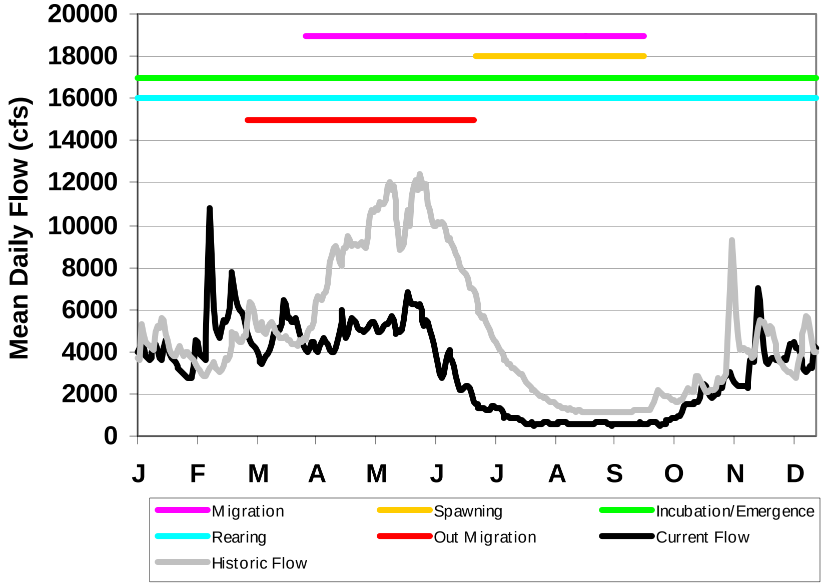
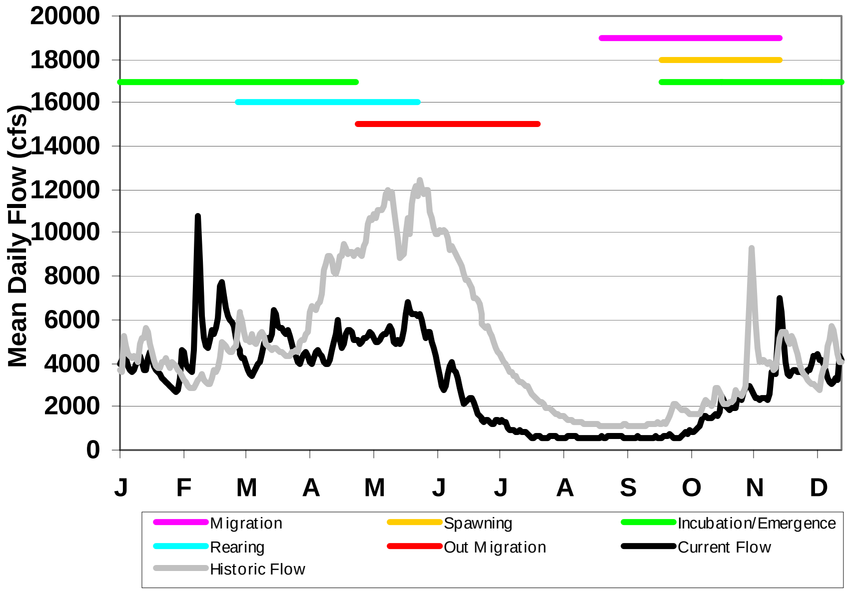


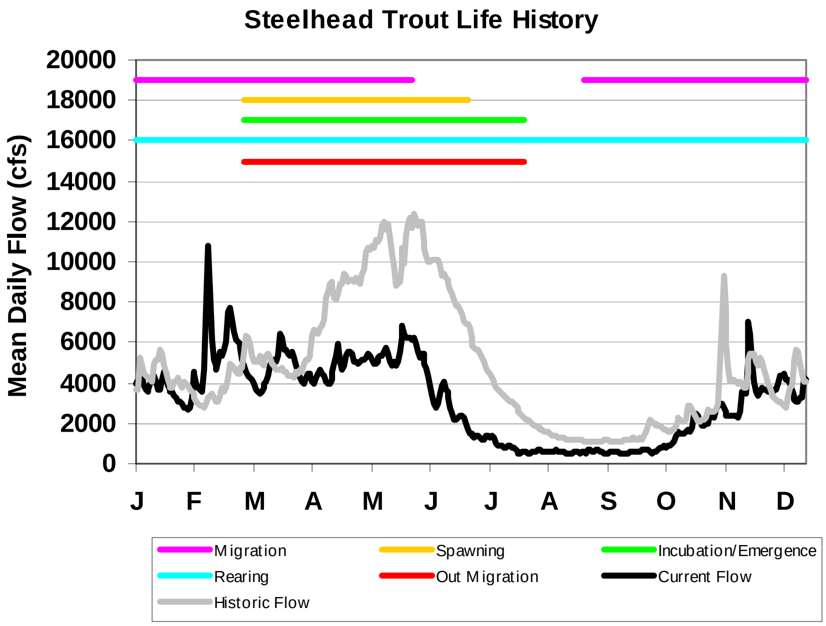
Figure 2-79. Comparison of current and historical flow of the Yakima River at Roza Dam with the life history of spring chinook, fall chinook, steelhead, bull trout, and Pacific lamprey. Hydrograph data from USBR 2004.

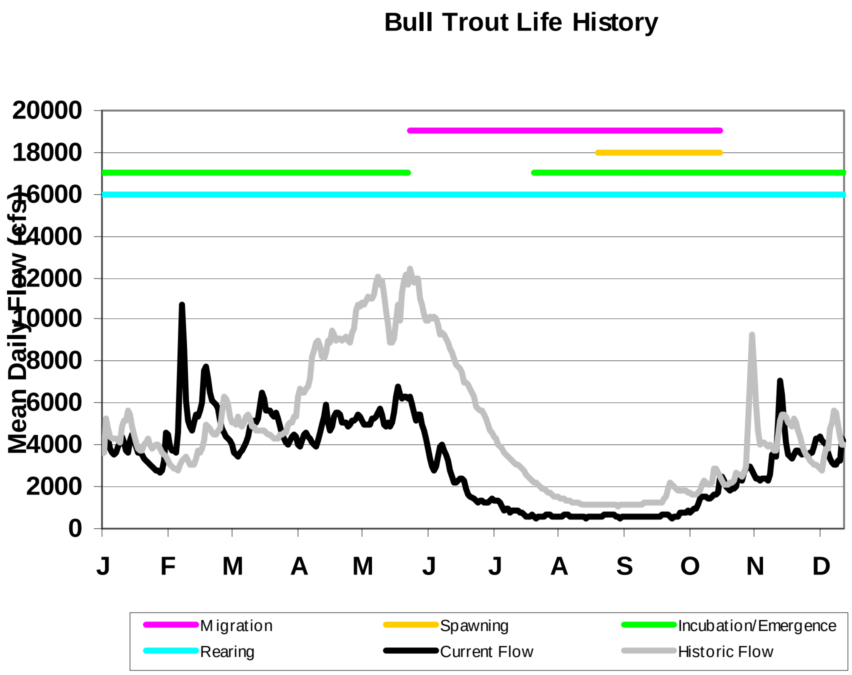
Spring Chinook Life History



Fall Chinook Life History




Steelhead Trout Life History
Mean Daily Flow (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J
F
M
A
M
J
J
A
S
O
N
D
Migration
Spawning
Incubation/Emergence
Rearing
Out Migration
Current Flow
Historic Flow


Bull Trout Life History
Mean Daily Flow (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J
F
M
A
M
J
J
A
S
O
N
D
Migration
Spawning
Incubation/Emergence
Rearing
Current Flow
Historic Flow

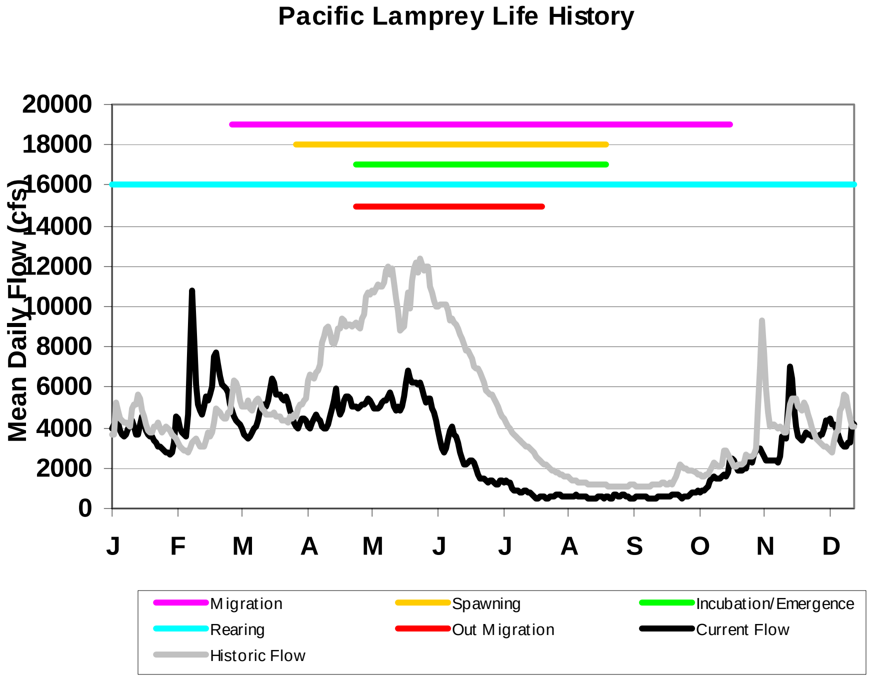


Figure 2-80. Comparison of current and historical flow of the Yakima River at Sunnyside Dam with the life history of spring chinook, fall chinook, steelhead, bull trout, and Pacific lamprey. Hydrograph data from USBR 2004.

Water Quality

Lower Toppenish Creek

Water temperatures in lower Toppenish Creek, from the confluence of Simcoe Creek (RM 32.7) to the mouth, are excessive for salmonid rearing, and may occasionally be lethal (YSP 1990, WDFW 1998). Instantaneous observations (most within a couple hours of noon) indicate that the mean temperature in July and August in this reach is 66-68°F (19-20°C); maximum temperatures observed have been as high as 85°F (31°C) just below the Satus II diversion (RM 26.5). Diel fluctuations are quite large -- 27°F (15°C) near the Simcoe confluence (YSP 1990). The median diel temperature (79°F, 26°C) in this portion of Toppenish Creek exceeds the temperature believed to cause physiological stress and loss of biomass in steelhead trout (23°C) (YSP 1990). High temperatures are due to the elimination of annual spring flooding, the draining of wetlands, riparian degradation, and the large volume of warm irrigation water (summer, 68-73°F) routed down Simcoe and Toppenish creek to the Toppenish Creek Pump and Satus II diversions (YSP 1990). Intensive timber harvest in the upper watershed have also affected the snow pack and the timing of run-off.

Since Toppenish Creek is entirely within the boundaries of the Yakama Nation Reservation, it does not fall under the jurisdiction of the state for water quality. Numerous parameters have been observed to exceed state criteria. Documented water quality excursions include fecal coliform, 4,4'-DDE, Dieldrin, DDT, 4,4'-DDD, and Parathion (DOE 1998).

Temperatures in Marion Drain are about 6°C cooler in the summer and 5°C warmer in the winter than temperatures in the mainstem. This thermal moderation is attributable to the large proportion of groundwater in the drain. If the lower end of Marion drain could be made more accessable and have higher habitat quality, or these cool waters routed to Toppenish Creek, summer, fall and winter rearing habitat could be dramatically increased in this already valuable reach.

Yakima Mainstem

Temperatures in the Yakima River in the Selah reach and the Selah Gap to Union Gap reach are moderate year-round. This is likely due to the presence of a relatively intact hyporheic system and the extensive zone of upwelling in the lower portion of the reach (Hauer et al 2002). Vaccarro attributes these cool temperatures to the changes in the annual hydrograph that have resulted in flows that are above a threshold that maintains water temperature near the temperature of the surrounding earth (i.e. the earth acts as a heat sink at high flows). The Gap-to-Gap reach is the lowermost portion of the mainstem Yakima thermally suitable for year-round rearing of salmonids.

In the Wapato reach, temperatures increase with distance downstream. Just below Sunnyside Dam there is a zone of “thermal habitability” that probably varies in size from year to year (see basinwide discussion). This area should be a focus of habitat restoration under the existing flow conditions in the basin. Vaccaro’s temperature model and recent thermographs indicate that temperatures below Parker are suitable for rearing fish, a currently limited habitat in this AU and in the Basin overall.

Temperatures below Parker warm rapidly, and temperature profiles, increases in the duration and severity of lethal or near lethal temperatures, and changes to winter temperature regimes are similar to conditions discussed above in the subbasin wide assessment, and in the Lower Yakima Assessment Unit. The loss of side channel habitats (due to low flows in this reach) in the mainstem and Toppenish Creeks also has led to a reduction in the overall temperature spatial variablility and habitat area available, especially in the Wapato reach. Also as discussed above, these areas are disproportionally valuable as rearing and migration habitats, and their loss or degradation has a correspondingly large reduction in the overall productive capacity of the subbasin as a whole.

The EDT model hypothesizes that due to the high temperatures and large variation in water quality parameters in this reach, there would be an increased potential for disease transmission to affect productivity for adult and juvenile spring and fall chinook and coho which migrate through this reach, and that the food net and food productive capacity of this reach would be severely reduced, further reducing capacity and productivity of salmonid fry of all species that rear or reside in this reach**.**

There are high concentrations of DDT and its breakdown products in the sediments of the Lower Yakima River in this Assessment Unit that have resulted in listing of several lower river waterbodies as water quality limited on the Washington State 303(d) list. Loading of DDT to the river is strongly associated with sediment loading from agricultural drains and fields. In 1995, inputs from tributary and irrigation returns contributed a significant quantity of the sediment load for the river. For example, Moxee Drain contributed 35 tons/day in the latter part of the irrigation season, while the Naches River contributed only 27 tons/day, even though discharge in the Naches was 14 times greater than Moxee Drain. TSS concentration in Granger Drain, Sulphur Creek, Spring and Snipes creeks, and combined load from the Yakama Reservation was 60, 110, 46 and 75 tons/day, respectively. Because of the 303(d) listings, DOE conducted a study to determine total maximum daily load (TMDL) criteria in the lower Yakima Basin (Joy and Patterson 1997). Because the link between total suspended sediment (TSS), turbidity and concentration of DDT had previously been established (Rinella et al. 1992, 1993), turbidity standards were limited to an increase of only 5 NTU's (nepthelometric turbidity units) between the confluence of the Naches and Yakima Rivers and Benton City (224 km). Furthermore, recommendations were made to limit tributary and drainage return concentrations to 25 NTU's (56 mg/L TSS). Of particular concern are the high concentrations of DDT (and its breakdown products DDE and DDD) in fish tissue, which are among the highest concentrations recorded in the United States (Rinella et al. 1993). Subsequently, in 1993, the Department of Health recommended that people eat fewer bottom feeding fish (Joy and Patterson 1997; Washington State Department of Health 1993). This advisory is still in effect.

The effect of DDT, dieldrin and other pesticide contamination on river ecology is not certain. Whole fish sampled by DOE in 1990, 1992 and 1995, found that nearly all concentrations exceeded 200 to 270 ug/kg, levels that exceed guidelines to protect wildlife populations from chronic carcinogenic risk (Joy and Patterson 1997), similar to results from earlier studies (Johnson et al. 1986). Furthermore, several studies have documented the presence of physical abnormalities on fish collected from agricultural drains and the lower Yakima River (e.g., Cuffney et al. 1997, USBR Denver Office monitoring project).

A sediment budget also was constructed for the lower Yakima, because of the link between TSS and DDT (Joy and Patterson 1997). The lower reach generated 67 and 92 percent of the total TSS load carried from March to October and from July to October, respectively (Table 2). This indicates that the lower Yakima reach is obtaining > 90 percent of the TSS load during July to October from sources within this reach. Of these sources, gauged drains in project areas contributed 213 tons/day, while Yakama reservation returns cumulatively accounted for 75 tons/day, ungauged drains in project areas for 43 tons/day, and unknown sources for 55 tons/day (Table 2). Finally, as flows decreased from July through October, sedimentation became prevalent. Sedimentation in the upper reach accounted for 23 percent of the total TSS load (32 tons/day), while the lower basin was characterized by a 43 percent sedimentation rate (153 tons/day).

Reduction of sediment loading from from agricultural returns has been a major success story of water quality improvement in the State of Washington as a result of implementation of the TMDL and cooperation between DOE, local agricultural organizations, the irrigation districts, NRCS, and the conservation districts. Recent monitoring indicates that:

- Moxee Drain in 1995 averaged 37 tons of sediment per day; in 2003, averaged 11 tons per day.
- Sulphur Creek drain in 1995 averaged 110 tons of sediment per day; in 2003, averaged 17 tons per day
- Granger Drain in 1995 averaged 60 tons of sediment per day; in 2003, averaged 13 tons per day
- Spring Creek/Snipes Creek in 1995 averaged 46 tons per day; in 2003, averaged 6 tons per day

The effect of these massive reductions of sediment on the total DDT and DDT byproducts concentrations in the sediments of the Yakima River is not yet known. It is believed that these reductions in sediment loading have resulted in an increase in water clarity, which in turn has allowed the formation of the large algal mats that have been observed in the lower river over the last several years. Efforts to reduce sediment loading, especially during the early part of the irrigation season when operational spills are highest, and erosion of the beds and banks of the irrigation return channels is greastest, should continue into the future.

Sediment transport processes (available energy and supply), riparian zone function, and floodplain extent in the upper portion of this Assessment Unit reach has been severely altered.

In the Selah Reach, mining of gravel in the floodplain and associated levees have resulted in floodplain loss and increased available energy for sediment transport. In the 1996 flood an estimated 400,000 Cubic Yards (approx. 10 years of sediment transport) were deposited in these pits when the levee protecting them failed.

In the Union Gap Reach and Lower Naches levees, roads and railroads which act as levees, bridges, irrigation intakes, and the Yakima Wastewater Treatment Plan and associated bank armoring have constricted the floodplain and increased sediment transport in some locations, variation in width of the levees has resulted in constrictions that effectively reduce gradient, creating depositional zones in other locations. Channel characteristics are therefore an alternating series of unstable erosion and deposition zones.

Cumulatively, constriction of the channel in Ellensburg, through the natural constriction of Yakima Canyon, and the leveed reaches of the Selah and Union Gap has reduced/eliminated floodplain where fine sediments would normally settle out, increasing fine sediment supply at the first possible location, Lower Union Gap reach.

Protection Key Findings for the Mid Yakima Floodplain:

- The reach of the Yakima River from Roza Dam to Sunnyside dam is an important rearing area for spring chinook juveniles. Juveniles from all three stocks are typically distributed throughout this reach in the late fall following emergence. Densities are highest well below the major spawning areas but above Sunnyside Dam.
- Hockersmith et al. (1995) indicated that about 66 percent of Yakima steelhead overwinter in the mainstem Yakima in this Assessment Unit with the majority in the vicinity of the Satus creek confluence. This is the same area of the river which supports overwintering juvenile spring chinook, and this reach is the most important reach for preservation or protection for all of the species in the subbasin according to the EDT model.
- Much of this reach is still characterized by intact floodplains, cottonwood gallery forests, and extensive riparian wetlands.

Restoration Key Findings for the Mid Yakima Floodplain:

- Summer/Early Fall Habitat availability is low or has been eliminated due to low flows and high temperatures (Wapato Reach).
- Loss of Habitat Diversity/Temperature Diversity in off channel habitats and in mainstem.
- Lack of Habitat diversity (pools with cover)/Lack of Large Woody Debris.
- Massive In-channel Aquatic vegetation growth alters habitat, water quality, and ecosystem characteristics.
- High Toxic Pollutant levels in sediments.

- Fine Sediment load is increased (Moxee Creek, Toppenish Drains, Marion Drain/ Mud Lake/Harrah drain), there have been recent large reductions in sediment load.
- Low Flow reduces/eliminates habitat availability/quality/diversity, including impacts to riparian plant community maintenance and establishment.
- Channel incision has disconnected Toppenish Creek from the floodplain in the reach below Simcoe Creek.
- Riparian vegetation in the reach of Toppenish Creek between the Unit II Pump Canal and State Route 22 has been heavily modified by grazing and irrigated agriculture (Toppenish Plan, YN in prep.).
- Irrigation season daily or weekly flow fluctuations greater and more frequent than under pre-1850 conditions.
- Food web in has been altered/reduced.
- Operational spill (to "creeks) and field runoff (to drains) attract salmonids to low quality or lethal habitat conditions (non viable populations, population sinks) or impede migration, or expose migrants to lethal or near-lethal conditions.
- The shape of the annual hydrograph has been severely modified. Upstream of Union Gap, the hydrograph has been "flattened" and the low flow period moved toward later in the year (Oct.), downstream the spring peak has been eliminated (on average) and the low flow period greatly lengthened. These changes greatly affect riparian and aquatic ecosystem function, productivity and stability.
- Average annual flow has been reduced by 1.2 maf (of an ave of 3.1 maf) from Parker to approximately Toppenish Creek/Marion Drain. This is the greatest reduction of overall quantity of flow in any of the mainstem reaches, and occurs in the reach with the most physically intact floodplain/riparian zone.
- Historic accounts and stumps in the floodplain indicate that riparian zone Ponderosa Pine were found as low in the basin as Prosser. Current distribution of natural origin pine ends near the confluence of the Naches and Yakima Rivers (a reduction in range of over distance of over 50 miles).
- Approximately 3 miles of stream below the Toppenish Lateral Canal continues to be dewatered and the Yakama Nation Fisheries Department has identified this area as a priority for future improvement efforts.
- Marion Drain has severed the hydrologic connection between the Yakima River and Toppenish Creek. Marion Drain is much deeper than the creek channel for much of its length (Yakima Nation in prep).
- Sediment transport processes (available energy and supply), riparian zone function, and floodplain extent in the upper portion of this Assessment Unit reach has been severely altered
- Temperatures in Marion Drain are about 6^{o}C cooler in the summer and 5^{o}C warmer in the winter than temperatures in the mainstem. This thermal moderation is attributable to the large proportion of groundwater in the drain. If the lower end of Marion drain could be made more accessable and have higher habitat quality, or these cool waters routed to Toppenish Creek, summer, fall and winter rearing habitat could be dramatically increased in this already valuable reach.
- Sustained high flows in the Upper Yakima downstream to Union Gap, and Sustained low flows in lower Naches and from Union Gap downstream, limit spatial and temporal habitat diversity.

- There is a previously unrecognized area of near normative temperatures downstream of Parker/Sunnyside Dam. This area should be a focus of habitat restoration under the existing flow conditions in the basin. Vaccaro temperature model and recent thermographs indicate that temperatures below Parker are suitable for rearing fish, a currently limited habitat in this AU and in the Basin overall.
- There are numerous small diversion dams in the Assessment Unit, a number of which present full or partial passage barriers to anadromous fish (Figure 2-71).
- Water temperatures in the (Wapato reach of the) Yakima River within this Assessment Unit have increased significantly, such that returning fall-run adults must delay river entry, and juveniles must emigrate from the river sooner than occurred historically.
- Temperatures in the Yakima River in the Selah reach and the Selah Gap to Union Gap reach are moderate year-round. ….Gap-to-Gap reach is the lowermost portion of the mainstem Yakima thermally suitable for year-round rearing of salmonids.
- Reduction of sediment loading from from agricultural returns has been a major success story of water quality improvement in the State of Washington as a result of implementation of the TMDL and cooperation between DOE, local agricultural organizations, the irrigation districts, NRCS, and the conservation districts.
- Predation risk to salmonids from native fish (northern pike minnow) is high. Predation risk to salmonids from non- native fish (Smallmouth bass) is high. Predation risk to salmonids from bird populations is high.

Key Uncertainties for the Mid Yakima Floodplain:

- Hatchery fish compete with natural origin fish for space and food resources
- High temperatures have resulted in increased susceptibility of native salmonids to pathogens.
- Massive In-channel Aquatic vegetation growth alters habitat, water quality, and ecosystem characteristics
- Bull trout use/migrate thoroughout the Yakima system, including the mid and lower Yakima floodplains

6.5.3 Low Elevation Tributaries Assessment Unit

Overview

The Low Elevation Tributaries Assessment Unit encompasses approximately 1,706 square miles in the south-central portion of the Yakima Subbasin. Elevation within the Assessment Unit ranges between 700 ft to 6,900 ft msl. The Assessment Unit receives approximately 27-33 inches of precipitation per year. According to the 2000 United States Census, approximately 121,258 people live in the unit. Most of the land in this Assessment Unit is managed by the Yakama Nation. Another predominant land use includes agriculture (Figure 2-81).

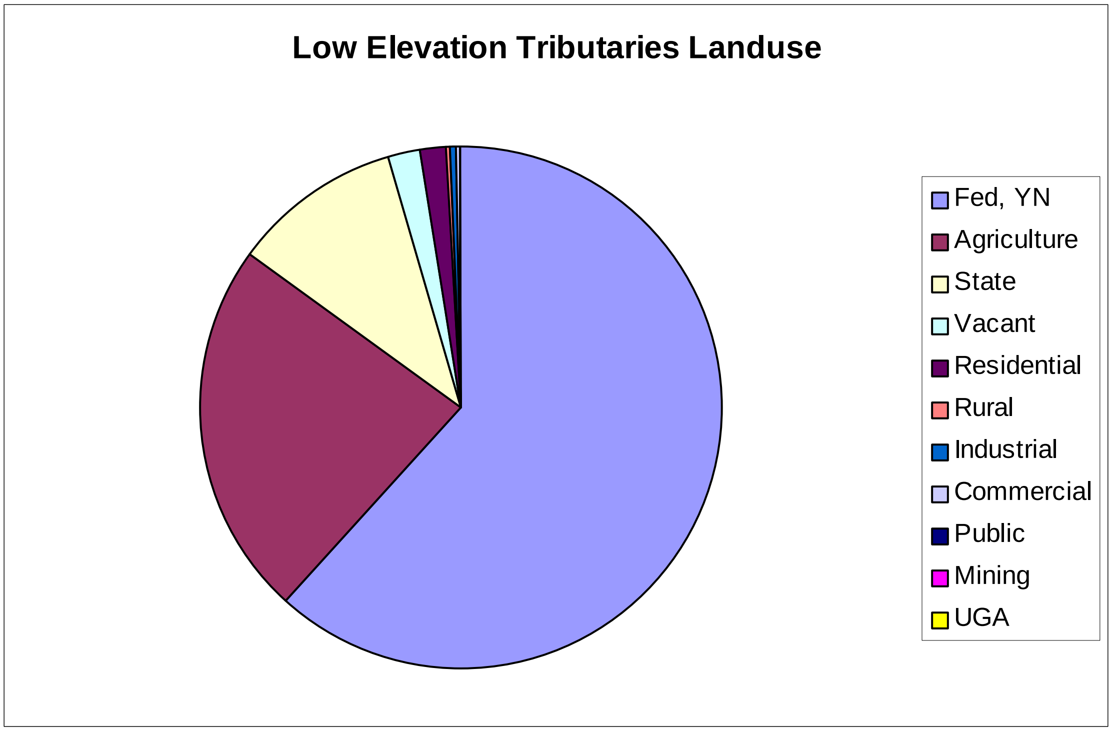


Figure 2-81. Comparison of land uses in the Low Elevation Tributaries Assessment Unit

The headwaters for streams in this Assessment Unit occur at relatively low elevations and consequently streamflow patterns differ slightly from those observed in higher elevation systems. The principal difference is an earlier spring runoff and earlier natural low flow period, as well as more susceptibility to flooding from rain-on-snow or low elevation flood events. These watersheds are extremely diverse for their size; and have vegetative types that include alkali flats, strub steppe, grassland, dry forest, mixed forest, high elevation forest. Steelhead populations in this AU would likely have high levels of genetic, life history and spatial diversity as well.

Because of the size of the Assessment Unit and the number of streams under consideration, it is convenient to classify and group the individual streams and tributaries by shared geographic, physiographic, and hydrologic characteristics. Table 2-27 identifies the major stream groups that will be discussed in this section as well as the tributaries belonging to each stream group. The major stream groups are as follows 1) Satus Creek, 2) Toppenish Creek, 3) Ahtanum Creek, 4) Cowiche Creek, and 5) Wenas Creek.

Table 2-27. Lower Elevation Tributaries Assessment Unit stream groups

Stream Group	Major Streams or Tributaries included in Group
Satus Creek	Satus Creek Mule Dry Creek Dry Creek Logy Creek Kusshi Creek Tenie Creek North Fork Yatama Creek Knockout Creek Third Creek Seattle Creek
Toppenish Creek	Toppenish Creek Agency Creek Simcoe Creek Wahtum Creek South Medicine Creek Diamond Dick Creek Clock Creek Olney Creek Panther Creek
Cowiche Creek	Cowiche Creek Reynold's Creek
Ahtanum Creek	Ahtanum Creek Foundation Creek Wide Hollow Creek (?)
Wenas Creek	Wenas Creek Dry Creek Cottonwood Creek Roza Creek

Wenas Dam (3,200 acre feet) is the largest surface water impoundment in the Assessment Unit and blocks anadromous fish passage past this point. Numerous small surface water diversions and dams exist within these basins, mostly at fairly low elevation. (Figure 2-82).

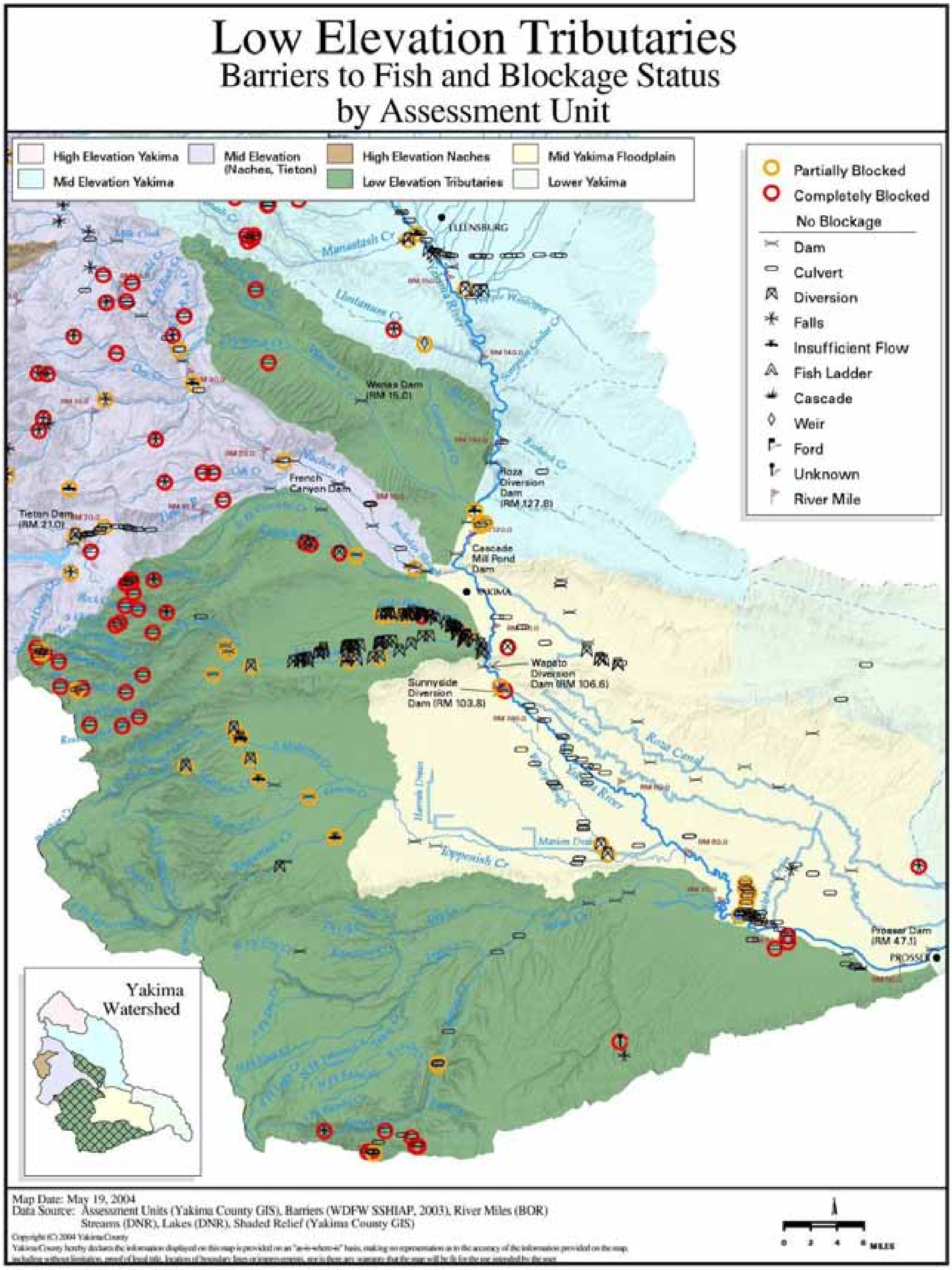


Figure 2-82. Barriers to fish passage in the Low Elevation Tributaries Assessment Unit

Aquatic Habitat

Species Distribution and Utilization

Steelhead/rainbow trout, spring chinook salmon, fall chinook salmon and bull trout are known to occur within the Assessment Unit. The distribution and abundance of these species has been heavily influenced by the placement and operation of numerous irrigation diversion dams (both large and small) and by habitat degradation in the lower reaches of these tributaries. The current and historical distribution of the focal species in the Yakima Subbasin is illustrated in the focal species discussion prior to this section.

- There are several streams in this Assessment Unit, notably Ahtanum and Cowiche Creeks, that currently have areas of suitable habitat which are unoccupied or have extremetly low populations levels of anadromous fish, including steelhead, spring chinook and coho. These areas are currently or have been in the recent past blocked to access by low flow or diversion dams, but these problems have been or soon will be rectified. Existing and anticipated future levels of abundance and straying indicate that natural colonization of suitable habitats (after removal of obstructions to passage) would be very slow or non-existent in this Assessment Unit. Supplementation into newly re-opened habitats could accelerate/greatly improve the success rate of population reestablishment.

Spring Chinook Salmon

Current distribution of spring chinook salmon is sparse compared to historic conditions. Juvenile spring chinook use the lower portion of Ahtanum Creek as rearing habitat. Spring chinook currently use only the tributary junctions (accessible portions) with the mainstem Yakima River for holding and rearing since many of the streams have been rendered inaccessible or unusable by excessive irrigation diversions or releases (Wenas, Ahtanum and Cowiche Creeks) (Tuck 1995, WDFW 2003).

Fall Chinook Salmon

Fall chinook have been documented using lower Satus Creek (WDFW 2003).

Steelhead / Rainbow Trout

It is probable that the historical spawning distribution of summer steelhead included virtually all accessible portions of Yakima Basin, with highest spawning densities occurring in complex, multi-channel reaches of the mainstem Yakima and Naches, and in third and fourth order tributaries with moderate (1-4 percent) gradients (Figure 2-49) (Subbasin Plan 2001).

Most Yakima steelhead are tributary spawners and a large percentage spawn in Satus and Toppenish Creeks. In Satus Creek, 70 percent of the spawning occurs in three areas: Satus Creek between Logy and Bull Creek (RM 23.6 – 36.0), in Dry Creek (confluence at Satus RM 18.7) and in Logy Creek (confluence at Satus RM 23.6). The remainder occurs in smaller tributaries and various Satus Creek reaches above Dry Creek (confluence at Satus RM 8.0), including 15 percent that spawn in tributaries that regularly go dry by mid to late May. Toppenish Creek drains a large watershed (~650 mi2), but only the upper half of the drainage is used for spawning. Over 57 percent of the steelhead spawning in Toppenish Creek occurs from Willy Dick Creek (RM 48.5) to Panther Creek (RM 69.2); the remainder occurs in the major tributary to Toppenish Creek, Simcoe Creek, which is also located relatively high in the drainage (confluence at Toppenish RM 32.7). In upper Toppenish Creek, about 60 percent of the spawning occurs in Toppenish Creek itself, with the remainder in two small tributaries. All but 9.7 percent of the spawning in the Simcoe drainage occurs in a number of small tributaries. Several of the upper Toppenish and Simcoe Creek tributaries are intermittent. Marion Drain is an irrigation return which parallels Toppenish Creek and into which Toppenish Creek water is diverted. It is probable that all of the steelhead that spawn in Marion Drain are or were ancestrally Toppenish Creek fish, lured into a cul de sac by Toppenish Creek water. The Toppenish Creek stock would be about 15 percent larger if the Marion Drain fish are included (NPPC 2001).

There have been recent reports of steelhead spawning in the South Fork Cowiche Creek even though a number of irrigation dams on the South Fork were thought to be impassible.

Sockeye / Kokanee Salmon

Sockeye / kokanee salmon did not historically, and do not currently, utilize stream habitat in the Low Elevation Tributaries Assessment Unit.

Bull Trout

Resident bull trout are currently found in Ahtanum Creek (North, South, and Middle forks) and are probably more abundant in the upper portions of these tributaries where habitat conditions are more favorable. Ahtanum Creek supports the furthest downstream population of bull trout known in the Yakima basin (Reiss 2003). They are seasonally isolated from fish in the Yakima River due to thermal barriers and to dewatering of lower Ahtanum creek by irrigation. USFWS (2002) indicates that the local population consists of fluvial and resident forms.

Pacific Lamprey

Pacific lamprey utilization of the Low Elevation Tributaries Assessment Unit has not been documented (Wydoski and Whitney 2003).

Other Fish Species and Interactions

Hatchery rainbow trout were stocked annually into the North and South forks of Ahtanum Creek (above RM 19.7) from the 1970’s till the early 1980’s (WDFW 2003). The rainbow trout stocking program was eliminated in the Ahtanum Creek tributaries in the early 1980’s to avoid potential impacts to native fish assemblages. In 1995, the Yakama Nation began stocking hatchery coho salmon in the Ahtanum Creek system in an effort to reestablish self sustaining coho populations (YN 2003). Coho juveniles are known to be more aggressive than other anadromous or resident species, and there is the potential of competing with or preying on bull trout fry. Generally, in basins colonized by anadromous salmon and steelhead the bull trout have successfully co-existed by occupying a different ecological niche. However, negative interactions can occur when hatchery fish (anadromous or otherwise) are stocked near bull trout spawning and rearing areas.

Stream Channel Condition and Function

Satus Creek Group

Many of the headwater streams in the Satus Creek watershed flow through low gradient valleys bordered by wet meadows. As they flow generally eastward the streams transition into high energy - high gradient systems that flow through narrow canyons. Satus Creek exits the canyon at RM 12.5 and flows eastward across the valley floor to the confluence with the Yakima River.

The lower 6 miles of Satus Creek flow through touchet deposits of silt and correspondingly sediment loads in this reach are high (T. McCoy, YN, pers.comm., comments to 1st draft).

Large sections of channel have been degraded in the Satus Creek watershed. The causes of this degradation differ from place to place but generally include grazing, road construction, timber harvest, agriculture, and possibly increased peak flows due to climate change (Satus Creek Watershed Restoration Team 2004). In the lower reach of Satus Creek heavy equipment was widely utilized to straighten stream channels, remove vegetation, and create dams for irrigation. Although these activities ceased in the late 1980's impacts to channel morphology and function remain in the form of channel instability and erosion (Satus Creek Watershed Restoration Team 2004). The channel response to these environmental conditions varies with channel type as well as the nature and magnitude of the disturbance. In the unconfined reaches of Satus Creek the total width of the stream and the area of stream bars his increased dramatically since 1949. These changes indicate a channel response to increased peak flows and/or increased sediment load from the watershed (Satus Creek Watershed Restoration Team 2004). Satus Creek does not seem to have had sufficient time to recover between major flood events that occurred in 1974, 1996, and 1997and is still unstable as a result (Tom McCoy, pers.comm., comments on 1st draft). Channel incision has occurred in many of the wet meadow systems (e.g., Starvation Flats, Seattle Springs, Indian Springs, Camas Patch, and Renschler's Meadow) as well as in salmonid bearing reaches of Satus Creek (Satus Creek Watershed Restoration Team 2004). These channel changes are thought to be associated with the loss of channel roughness elements such as beaver dams, large woody debris, and riparian vegetation which stabilizes stream banks. The Satus Creek Watershed Restoration Team (2004) noted that:

> "Highway 97 exerts a major influence on the mainstem of Satus. Construction included five crossings of Satus Creek, the shortening of a stream segment by relocating it into a straight channel blasted through bedrock, and the constriction of the stream with dikes and riprap. Two of the bridges span bedrock-constrained stream segments and have little influence on the stream. The other three, however, cross alluvial stream segments and have destabilized and degraded the channel in these vicinities. A new bridge, constructed in 1994, proved within two years to have inadequate capacity, necessitating engineering of the upstream channel to protect the bridge. Current effects of the road on Satus Creek are most noticeable between Wilson-Charley Creek and the County Line bridge, where the stream has been deprived of a substantial part of its floodplain. This stream reach has the potential to provide high quality spawning and rearing habitat, but the constricting influence of the highway maintains the creek in a degraded condition."

Much of the watershed contains substrate that is considered suitable for steelhead spawning. However, many reaches have reduced quality due to the presence of fine sediment in the interstitial spaces of the gravel. For example, Logy Creek is generally good with the exception of the lower reach in the Sheep Camp area. Dry Creek has excessive fines in the lower portion, and improves significantly in the upper reaches. The lower portion of Kusshi Creek has significant bedload movement and the channel is highly unstable. Satus Creek has excessive fines throughout its course, but improves somewhat in the upper reaches above High Bridge. The upper portions of Dry, Logy and Kusshi creeks are generally in good to excellent conditions.

Toppenish Creek Group

Much of upper Toppenish tributaries are high gradient streams that flow through narrow confined basalt canyons. These canyons were formed as the streams incised through the uplifted basalt as the Cascade Range formed (YN in prep.). Toppenish, Agency, Wahtum, Simcoe and South Medicine Creeks all eventually reach the lower elevation sections of the Assessment Unit and flow through the unconstrained valley floor.

Channel conditions upstream of the mouth of Toppenish Canyon are thought to be very good (Yakama Nation, in preparation). Most of what is known about the current state of Toppenish Creek below the canyon comes from the Toppenish Creek Corridor Enhancement Plan (Yakama Nation, in preparation). The channel conditions described in the following paragraphs are excerpts of information presented in this report.

The upper extent of the Toppenish Creek Corridor Enhancement Plan begins within Toppenish Canyon at the upstream end of the Olney dike. Here, intensive management of the stream and floodplain first occurs, and Toppenish Creek changes abruptly as the pristine canyon stream encounters the dike.

This stream reach, between the head of the Olney dike and the 3-Way diversion, is 3.4 miles long and has an average gradient of 1.1 percent. The 1/8 to ½ mile wide floodplain is vegetated with a patchwork of native and exotic species. This reach can be roughly divided into three sub-reaches: 1) a severely confined, incised, and degraded sub-reach from the head of the Olney dike, extending approximately 1.2 miles downstream, 2) a semi-confined, moderately degraded, recovering sub-reach extending approximately 0.8 miles, and 3) a severely confined and substantially degraded sub-reaching extending the remaining 1.4 miles to the 3-Way diversion.

The reach between the 3-Way diversion and Pom Pom Road occupies roughly the upper half of the Toppenish Creek alluvial fan. This reach is 3.2 miles long and has an average gradient of 1.8 percent. From the 1958 quad (before downcutting) the gradient appears to be <1.0 percent. A 20 ft downcut in 3.2 mi would add 0.12 percent. As with the reach upstream this reach can be divided into 3 sub-reaches: 1) a highly unstable, strongly depositional sub-reach extending down to the Signal Peak Highway, 2) a moderately unstable sub-reach extending from Signal Peak Highway approximately halfway to Pom Pom Road. This sub-reach is in balance with its sediment load but is incised 3-4 ft below its former floodplain; it has gained enough width between those banks to develop a meander pattern, and 3) a deeply incised, channelized sub-reach completely isolated from its floodplain and unable to capture sediment. Sub-reach 1 is wide, shallow and braided. Choked by cobbles and gravel, the low-flow channel is prone to shift during every bedload-moving event. The bank and floodplain materials are mixed alluvium ranging from silt to large cobble. The lack of sorting of these materials indicates a chaotic hydraulic environment occurs during high flows, where energy dissipation is provided by surface roughness and sediment transport."

Toppenish Creek between Pom Pom Road and the confluence of Simcoe Creek occupies the lower half of the alluvial fan. Through this reach of approximately 6 miles, the gradient drops off from about 1 percent to less than ½ percent. Bank material is generally fine-textured; bed materials are composed of a thinning layer of cobble and gravel underlain by clay hardpan. The channel throughout this reaches varies from moderately to severely incised (i.e., incised banks from 6 to 15 feet in height). This reach of Toppenish Creek can be roughly divided into 2 subreaches: 1) from Pom Pom Road to Shaker Church Road. This subreach, with a higher gradient and more energy to expend during high flows, has created enough width within the incised banks to allow some point bar development, and 2) from Shaker Church Road to the confluence of Simcoe Creek, has a lower gradient. Throughout this sub-reach, the incised banks are about the same width as the active channel. Virtually no floodplain/point bar development is occurring within this sub-reach.

Abundant high quality spawning gravel can be found throughout the uppermost portion of Toppenish Creek, as well as NF and SF Toppenish creeks (YSP 1990, WDFW 1998). Dominant particle size of the substrate in Simcoe Creek is good, but fine sediment is abundant (WDFW 1998). The quality of substrate in Simcoe Creek from the near the mouth to Olney Flat Drain (RM 1.0) ranges from poor to extremely poor (YSP 1990). Substrate size and sedimentation in NF Simcoe are good (WDFW 1998). Substrate condition is good in Agency Creek, with sedimentation of gravels rated fair (WDFW 1998).

The dam on Agency Creek (a Simcoe Creek tributary, confluence at Simcoe RM 9.5) at the Jen Weld Mill in White Swan poses a passage problem at low flows. However, much of the time adult steelhead are able to negotiate it as numerous redds and live spawners have been observed in Agency Creek in recent years.

Ahtanum Creek Group

The headwaters for Ahtanum Creek are located in both the Wenatchee National Forest and the Yakama Reservation. Channel initiation generally occurs at elevations greater than 5,000 ft. Ahtanum Creek drops roughly 3,000 feet in the course of 20 stream miles. Redd surveys conducted in 2002 indicate that steelhead trout redds were concentrated primarily below the confluence of the North and South of Fork Ahtanum Creek (Figure 2-50. 2002 Steelhead Spawning Ahtanum, Satus, and Toppenish). The gradient in the lower 8-9 miles of Ahtanum Creek is slight to moderate. Channel incision and bank erosion have increased sediment loads (YSP 1990) that affect the quality of salmonid spawning habitat. Fine sediment loads are also a problem in the upper watershed. Bambrick and Mathews (1990, unpublished report) indicated that moderate to high levels of silt (~15-25 percent particle size <.85mm) were found in some sample reaches of the upper NF and SF, with the combined average of all samples the highest in the SF Ahtanum at 25 percent silt. In 1991 Matthews (unpublished data) collected McNeil gravel samples in the MF, SF, Ahtanum Creeks and found that these tributaries ranged between 20-25 percent silt.

Cowiche Creek Group

The headwaters of Cowiche Creek and its tributaries reside within the Wenatchee National Forest. The South Fork Cowiche Creek drops from approximately 5,000 feet to just over 3,000 feet in the course of just over eight miles. The North Fork Cowiche drops through the same elevation range in just over four miles. The South Fork exits a canyon near the confluence with Reynolds Creek (RM 11.8). Although each of these streams will lose another 1,500 feet in elevation before joining the Naches River, the elevation is lost over a much greater distance. The confluence of the North and South Fork Cowiche occurs at RM 7.5.

The moderate gradient of Cowiche Creek and its forks is associated with many pools, riffles, and glides. Large woody debris and overhanging/submerged vegetation is abundant in the mainstem and South Fork. Beaver dams are common on both the mainstem Cowiche Creek and the South Fork Cowiche Creek (YSP 1990). There are enough gravel bars in Cowiche Creek and the South Fork for spawners to fully seed the available rearing habitat (YSP 1990, WDFW 1998). Siltation due to riparian overgrazing is moderate, except for the North Fork, where low flows allow fine sediment to settle (YSP 1990). Banks are stable except where grazing-induced sloughing has occurred from RM 10 to 12 on the South Fork and on the lower three miles of the North Fork (WDFW 1998).

Wenas Creek Group

The headwaters for Wenas Creek and many of its tributaries are in the Wenatchee National Forest. Upstream of the confluence with Yellowjacket Creek, Wenas Creek is a high gradient stream. Much of Wenas Creek downstream flows through a broad unconstrained valley. An impassible storage reservoir was built at RM 15 in the early 1930's, blocking migratory fish access to the upper drainage. Downstream of the dam, bank sloughing is common and the streambed often consists of mud and silt. Salmonids are not known to use Wenas Creek below RM 14. Increases in peak flows have increased bed erosion and instability

Riparian / Floodplain Condition and Function

Satus Creek Group

The Yakama Nation assessed the function and condition of riparian zones for over 25 miles of streams including portions of upper Satus Creek, South Fork Logy Creek, North Fork Dry Creek, Kusshi Creek, Tenie Creek, Lower Dry Creek, and Lower Satus Creek (Satus Creek Watershed Restoration Team 2004). Their study design included both streams in both forested areas and rangeland. The following excerpt summarizes some of their conclusions:

> "Ten miles of the surveyed reaches were assessed as seriously degraded and not functioning properly; approximately eight miles were assessed as impaired but functional; approximately seven miles were assessed as being in good condition and functioning properly. The general trend in the assessments indicates that riparian functioning condition is degraded in the lower watershed, but improves with increasing elevation. This is partly due to less disturbance and cumulative effects high in the watershed, and partly due to the increasing sensitivity of the lower gradient, alluvial stream reaches in the lower watershed. Assessments completed to date have supported the identification of restoration priorities."

Most floodplains within the Satus basin have remained intact, in that little diking has taken place. The biggest impact in terms of confining the floodway has occurred from the construction of Highway 97 and the Lakebeds Road in upper Satus Creek. Large portions of the Lakebeds Road and associated diking were removed in the late 1990's.

Although much of the reservation land along Satus Creek was once managed as open range (YSP 1990) very little streamside grazing occurs under present management. Cattle damage to riparian vegetation has been minimized but cottonwood recruitment in some areas is still poor (T McCoy, YN, pers.comm.). Aerial photography shows little black cottonwood recruitment between 1949 and 1995 (Satus Creek Watershed Restoration Team 2004). One possible explanation is that channel incision has altered floodplain disturbance regimes that contribute to germination and establishment of seedlings.

Toppenish Creek Group

Riparian condition is excellent in upper Toppenish Creek, as well as in NF and SF Toppenish Creeks, except for the stretch of several miles just upstream of the WIP diversion (YSP 1990).

Riparian conditions for the length of Toppenish Creek from Toppenish Canyon to the confluence with Simcoe Creek were evaluated as part of the Toppenish Creek Corridor Inventory (in prep). This stream segment was divided into three reaches. For the reach between Olney Dike and the 3-Way diversion:

> "Cottonwood, alder, and willow dominate near the active channel and along high flow channels; stands of sumac, woods rose, and various other shrubs are scattered across the floodplain within the canyon; noxious invasive weeds occupy large previously-disturbed areas; much of the floodplain of the middle and lower parts of this reach has been developed for pasture. There is one house on the floodplain within the canyon and two near the mouth of the canyon. Several scattered homesites and a facility for training heavy equipment operators on the north of the alluvial fan have been affected by recent floods, largely due to human-caused alterations to flood behavior. Land uses in this area are grazing and hay production."

The reach between the 3-way diversion to Pom Pom Road was further divided into three sub-reaches:

> "This sub-reach (1) is essentially devoid of riparian vegetation. The unstable cobble/gravel bars within the active channel are colonized by noxious weeds. The dominant floodplain vegetation is typical of a well-drained floodplain terrace – basin big sage, bitterbrush, Great Basin wild rye, and occasional scattered ponderosa pine and sumac. These species are indicative of the lack of shallow groundwater during the growing season." For sub-reach (2) "[v]egetative patterns are similar to those noted for sub-reach 1. Apart from an occasional willow, the active floodplain is dominated by knapweed and yellow starthistle. The terrace/former floodplain vegetation is a combination of riparian shrub (dogwood, rose, and sumac) and upland shrub-steppe communities and (comparable to those in sub-reach 1); in the downstream direction there is an increasing component of sumac and small scattered stands of stunted cottonwoods and aspen, indicative of more favorable soil moisture conditions." "At the upper extent of sub-reach 3 the channel becomes completely isolated from its former floodplain and the banks narrow to a degree that there is no room for meandering or point bar development. The high vertical banks are composed of fine sediment, indicating that historic high flow dynamics were dominated by well-vegetated floodplains. The terrace/former floodplain is increasingly dominated by sumac, rose, and dogwood, along with scattered stands of aspen and cottonwood. The presence of aspens indicates that soil moisture is maintained throughout the growing season in this area."

Riparian condition for the reach between Pom Pom Road and the confluence with Simcoe Creek are described below:

The former floodplain has mixed vegetative communities, predominantly composed of either woody riparian (i.e., cottonwood, aspen, willow, dogwood, rose, currant) or well-drained terrace (i.e., basin big sage, Great Basin wild rye, bitterbrush, rabbitbrush). Land use along this reach of the creek is limited to a few scattered homesites and grazing.

The earliest aerial photographs available (i.e., 1949) show that a number of distinct distributary channels have long flowed down the Toppenish Creek alluvial fan. These channels, separated by low-relief upland terraces, had relatively low sinuosity and narrow riparian corridors. Below the Signal Peak Highway the riparian corridors were densely vegetated with trees and shrubs. In plan view, the configuration of Toppenish Creek through this reach is not too different today. The greatest change has been the narrowing of the riparian corridor. However, the cross-section of the creek has changed substantially through incision; interactions with its former floodplain and riparian zone have been lost.

Riparian conditions in Agency Creek upstream of Ft. Simcoe are good (WDFW 1998, Tom McCoy pers.comm., 1st draft comments). The most degraded riparian area on Simcoe Creek is from the mouth to Wahtum Creek (RM 14.4)(Yakima Nation Fisheries personnel, as cited in YSP 1990). This reach rates as the second worst riparian impact to salmonids in the entirety of the Toppenish Creek watershed. Riparian conditions on the forks are good, although there are some areas impacted by grazing. Riparian condition in Agency Creek is poor in the lower part (WDFW 1998). Riparian conditions in the upper watershed are good to excellent (T McCoy YN pers.comm., 1st draft comments).

Ahtanum Creek Group

Residential development, logging, recreational vehicles, and roadways, in close proximity to the creek and riparian area have resulted in significant impacts to bank stability, riparian vegetation, and sedimentation upstream of Tampico, on both the NF and SF. (WDFW 1998). The NF, in the vicinity of Tampico Park, has been largely denuded of riparian vegetation due to extensive floodplain agricultural development. There is good riparian vegetation on the south side of the creek in the lower 8-9 miles while the distribution on the north side is patchy. Much of the riparian zone in this reach has been severely impacted by grazing (YSP 1990). Direct trampling of bull trout redds by cattle in the stream has also been a problem in upper watershed.

However, the recent construction of a 2.8-mile fence has lessened the impact on bull trout (B Rogers, YN pers.comm., 1st draft comments). Riparian condition is poor/fair downstream of Tampico, and good/excellent in the 10-20 miles of tributaries upstream of Tampico (YSP 1990, WDFW 1998). The road infrastructure, housing development, and farming have had a tremendous impact on the riparian zone in this area (Tom McCoy, pers.comm. 1st draft). Excessive off-road vehicle use both within the riparian corridor and upslope is a problem in some areas on the NF (WDFW 1998). The selective removal of large diameter trees reduces habitat complexity and quality in the Ahtanum watershed, lowering large woody debris recruitment rates, and instream cover. The Middle Fork and lower North Fork Ahtanum have a low abundance of large woody debris (Dominguez, 1997).

Cowiche Creek Group

The riparian community of the lower 3-4 miles of Cowiche Creek consists of willows, alder, and aspen, and is dense along most reaches, even in areas of residential development or cropland (YSP 1990, WDFW 1998) in the Cowiche canyon. The same is true of the middle portion of the creek and direct impacts due to agricultural development are minimal. In the upper portion of the watershed on WDFW and private timberlands the riparian condition is good to excellent in most places, with exceptions being located at road crossings or areas where the road is directly adjacent to the creek.

Wenas Creek Group

Little is known about riparian function and condition in the upper watershed. Below RM 9 the creek flows through areas heavily used for grazing, and riparian vegetation is virtually nonexistent.

Water Quantity

Satus Creek Group

Annual runoff in the Satus Creek watershed is largely dependant on winter precipitation and may vary from year to year by an order of magnitude. (Satus Creek Watershed Restoration Team 2004). Maximum and minimum flows for a given year may vary by two orders of magnitude as is typical of semi-arid watersheds. Abundant snowpack, wet meadows, and porous geology combine to store water in the headwaters of Satus Creek, North and South Fork Logy Creek, and the South Fork Dry Creek. The stored water is released gradually beginning in the spring and is responsible for much of the summer base flow in lower parts of the basin.

Mule Dry, Dry, Kusshi, and Wilson Charley creeks normally become intermittent in their lower downstream reaches beginning in late-May, while Logy Creek maintains permanent year-round stream flow (YSP 1990). The permanent annual flow in Logy Creek is explained by the large portion (63 percent) of the entire watershed that lies above the Simcoe Mountains Basalt region / layer. This layer is relatively permeable and over half (52 percent) of the Logy Creek area coincides with the western upland region, which receives the greatest annual precipitation. This allows for large quantities of water to be stored, which is gradually released into the stream as surface or sub-surface flow (Mundorff et. al., 1977). In contrast, only 25 percent of the entire Dry Creek sub-watershed, and none of the Kusshi and Mule Dry Creek areas are located inside the Simcoe Mountains Basalt region. Kusshi and Mule Dry creeks receive much less annual precipitation than either Dry or Logy Creek. In the intermittent reaches, surface flows naturally disappear as stream discharge decreases during the late summer months and become subsurface flows. Increased sediment deposition (whether natural or anthropogenic) in these alluvial, low gradient reaches may accelerate the date of transition to subsurface flow. Instream flows in Satus Creek are fair to good, except for low summer flows, particularly from RM 24-30 (YSP 1990, WDFW 1998).

Generally speaking, fish access for both adult and juvenile steelhead passage is good. Severe, natural low flows in lower Mule Dry, Dry and Kusshi creeks occur in the late spring and summer and impact upstream movement of spawners, the downstream movement of parr as well as the survivial rates for post-emergent fry.

Toppenish Creek Group

Flows in Toppenish Creek are heavily influenced by the operation of the Toppenish Lateral Canal. The following language was taken from the Toppenish Creek Stream Corridor Plan (Yakama Nation, in prep).

The Toppenish Lateral Canal (TLC), the first diversion of Toppenish Creek, is located near the mouth of the Toppenish Canyon about 1 mile below the head of the Olney dike. This 19th century canal, which can handle up to 70 cfs, historically has taken the entire creek flow from mid-June to mid-October. Water is diverted into the canal by means of a diversion dam and headworks. Since 2000, however, WIP has attempted to maintain 10 cfs in the creek below the diversion during this period.

In 1986 a juvenile fish screen bypass system was installed to prevent entrainment of downstream migrants into the canal. Due to relatively reliable flow, the canal may maintain a steelhead/rainbow trout population and can be colonized from Agency and Simcoe creeks at its downstream end.

In 1998, roughly 7 miles of Toppenish Creek below the TLC was dewatered. Changes in the operation of this diversion which were instituted in 2000 resulted in noticeable improvements. For example, during 2001, which was widely viewed as a drought year, surface flow was continuous between the TLC and the 3-way diversion (Yakama Nation, in prep).

Flow in Agency Creek is perennial in the upper reach (R. Evenson, YN, pers.comm., 2001) but goes subsurface in the downstream reach as it crosses over a large alluvial fan (Tom McCoy, pers.comm., 1st draft comments). Instream flows in Agency Creek are rated as fair (WDFW 1998). Flows in Wahtum Creek are perennial in their upper reaches (R. Evenson, YN, pers.comm., 2001).

The North Fork Simcoe Creek provides the majority of flow in the Simcoe Creek basin. Private diversions on the North Fork take a majority of the flow of the fork. Efforts are underway to control the amount of flow the irrigators are to receive. For example, a headgate was recently installed on one of the private diversions. In 2003, the Narrows in 2003 was shut down in July due to low flows, therefore leaving the majority of the flow in the stream. Despite this fact Simcoe Creek still went dry for approximately 3/4 of a mile. The Yakama Nation has implemented a 2cfs minimum instream flow for the North Fork of Simcoe Creek in attempt to provide flows in Simcoe Creek (S. Adams, YN pers.comm., 1st draft comments).

The Hoptowit diversion on the North Fork Simcoe Creek is unscreened, resulting in entrainment of virtually all outmigrating smolts (YSP 1990, WDFW 1998). The south fork ditch (Simcoe RM 0.1), the Smartlowit Ditch (Simcoe RM 16.9), and the Hubbard ditch (about 100 yards upstream of the Smartlowit diversion) all are unscreened diversions and are presumed to entrain smolts. Efforts are underway to screen these diversions. Weir traps were placed on Hoptowit and Smartlowit and efforts to rescue outmigrating smolts have been successful. Funding has been acquired that will provide for the placement of a screen at the Hoptowit diversion by February of 2004 at which time diversions at Hubbard Ditch will be discontinued. The Yakama Nation Fisheries Program continues to look for funding to screen private ditches (S.Adams, YN pers.comm., 1st draft comments).

Ahtanum Creek Group

Numerous surface water diversions are present on the lower reach of Ahtanum Creek (Figure 2-79) including one operated by the Wapato Irrigation Project at RM 19.6 and another at RM 9.8. These diversions operate during the irrigation season that generally lasts from July 10th to mid-October.

The Upper Wapato Irrigation Project formerly diverted all or most of the stream flow during the irrigation season resulting in the loss of surface flow downstream for 7-8 miles (to approximately RM 12). The lower Wapato Irrigation Project diverted the remaining flow. The operation of these diversions presented total passage barriers for adult salmonids and precluded access to high quality spawning habitat upstream (WDFW 1998, YSP 1990). 10cfs minimum instream flow has been in effect in this portion of the river since 2001and has been enforced vigilantly since 2002 (T. McCoy, YN pers.comm., 1st draft comments). At RM 12, groundwater and irrigation returns contribute to stream recharge. Instream flows upstream of Tampico and in the NF are rated as good (WDFW 1998).

Numerous unscreened diversions and pumps remain in place on Ahtanum Creek (YSP, 1990). On the NF, the John Cox diversion (~13 cfs) at RM 3 was screened in 1999, and the Shaw-Knox ditch (~2 cfs) at RM 2 is unscreened. There is at least one unscreened diversion (~2 cfs) on SF Ahtanum at RM 3 (YSP 1990). These unsreened diversions are currently in the process of being screened.

Cowiche Creek Group

Adult access and juvenile passage is the primary limiting factor in Cowiche Creek. An Alaska steep pass fishway was installed at the Yakima City Canal at the mouth of Cowiche Creek and probably provides adequate passage for adults. A wooden plank diversion dam just below the confluence of the North Fork and South Fork (RM 7.5) may be passable at high flows, but three other concrete dams on the South Fork at RM 1.3, 3.9, and 4.4 are thought to be impassible at all flows. The Yakima City Canal is screened, but the other four diversions are not (WFDW 1998). The impact of these diversions on instream flow is not well documented. All of the South Fork blockages are currently being addressed through the Yakima Tributary Access and Habitat Program.

Wenas Creek Group

A control structure at RM 12.0 diverts the stream into two channels, the “North” and “South” channels, to facilitate irrigation withdrawals. These channels reconnect six miles downstream. Summertime irrigation withdrawals from the creek and the channels remove all water between RM 9 and RM 14. Flows below RM 9 are intermittent, and only minimal where present. Recent improvements in flow in lower Wenas Creek have been the result of conclusion of the water right adjudication and enforcement actions associated with the adjudication, but instream flow is still well below pre 1850 levels in lower Wenas. Substantial irrigation with well water in the lower valley likely contributes to low flows in the creek. These low-flow conditions persist into the winter as Wenas Reservoir is refilled.

Water Quality

Satus Creek Group

Water quality throughout the Satus basin is generally considered to be good. The only exception might be lower Satus (below Plank Road) where the creek begins to flow through agricultural lands. Most of the watershed is undeveloped and is not exposed to agricultural related chemicals. For the reach of Satus Creek downstream of Wilson-Charley Canyon, water temperatures in the late spring and summer, are often sublethal (approximately 26^{o}C)(YSP 1990, Satus Creek Watershed Restoration Team 2004). What little surface flow that remains in Mule Dry is of optimal temperature (15-20^{o}C) in the shaded reaches due to the cooling effect of the subsurface flow. Similarly, Logy Creek has optimal temperatures in the summer, as well as, good surface flow. This is due to the large groundwater influence in its headwaters from water stored in the fractured basalt layer. Kusshi Creek has reasonably good water temperatures for steelhead throughout its course where surface flow persists. Satus Creek upstream to Logy Creek has reasonably good water temperatures, which may occasionally become sublethal in the middle reaches during the summer. Dissolved Oxygen tends to approach saturation levels in Satus Creek (Fretwell 1979 as reported in Satus Creek Watershed Restoration Team 200X).

It is interesting to note that the proportion of age-1 steelhead trout smolts in the Satus stock was significantly greater than observed in the other stocks (2-F9). The vast majority of steelhead trout in the Naches, Toppenish, and Upper Yakima stocks smolt at age two. One hypothesis for this result is that juveniles grow faster in Satus Creek due to warmer temperatures and consequently reach smolt status faster than other stocks.

Toppenish Creek Group

Water quality in upper Toppenish, the forks of Simcoe Creek, and Agency Creek is rated as good (WDFW 1998). Water quality in Simcoe Creek is fair, the main problem being excessive water temperature (WDFW 1998). Water quality in Agency Creek is good (WDFW 1998).

Ahtanum Creek Group

Water quality is fair downstream of Tampico, and good upstream (including the NF) (WDFW 1998). Water quality is good in the 10-20 miles of tributary stream upstream of Tampico (YSP 1990). Little is known about water quality in the lower reaches of Ahtanum Creek. Presumably water quality is degraded somewhat despite efforts to maintain minimum instream flows in the channel. Potential impacts include increased temperature, turbidity, and possibly chemical constituents related to agricultural runnoff.

Cowiche Creek Group

Cowiche Creek is on the CWA Section 303(d) impaired water quality list for fecal coliform, instream flow, and temperature. The North Fork is listed for fecal coliform and temperature; the South Fork is listed for fecal coliform and temperature; and the South Fork tributary of Reynolds Creek is also on the 303(d) list for water temperature.

Wenas Creek Group

Lack of shading and low flows combine to generate summertime water temperatures in excess of 80 ^{o}F.

Protection Key Findings for Low Elevation Tributaries Assessment Unit:

- These watersheds are extremely diverse for their size; and have vegetative types that include alkali flats, strub steppe, grassland, dry forest, mixed forest, high elevation forest. Steelhead populations in this AU would likely have high levels of genetic, life history and spatial diversity as well.
- The upper portions of Dry, Logy and Kusshi creeks are generally in good to excellent conditions.

- Channel conditions upstream of the mouth of Toppenish Canyon are thought to be very good (Yakama Nation, in preparation).
- Abundant high quality spawning gravel can be found throughout the uppermost portion of Toppenish Creek, as well as NF and SF Toppenish creeks.
- The moderate gradient of Cowiche Creek and its forks is associated with many pools, riffles, and glides. Large woody debris and overhanging/submerged vegetation is abundant in the mainstem and South Fork. Beaver dams are common on both the mainstem Cowiche Creek and the South Fork Cowiche Creek (YSP 1990). There are enough gravel bars in Cowiche Creek and the South Fork for spawners to fully seed the available rearing habitat (YSP 1990, WDFW 1998).

- Most floodplains within the Satus basin have remained intact, in that little diking has taken place.
- Riparian condition is excellent in upper Toppenish Creek, as well as in NF and SF Toppenish Creeks, except for the stretch of several miles just upstream of the WIP diversion
- In the upper portion of the watershed on WDFW and private timberlands the riparian condition is good to excellent in most places, with exceptions being located at road crossings or areas where the road is directly adjacent to the creek.

Restoration Key Findings for Low Elevation Tributaries Assessment Unit:

- Lack of habitat diversity (pools with cover)/lack of large woody debris
- Forestry activities have increased fine and coarse sediment load, and peak flows in Satus, Toppenish and Ahtanum Creeks.
- Diversion dams block access to habitat.
- Wenas Dam has eliminated habitat access to upper Wenas Creek, and dewatered lower Wenas Creek.
- Inadequate screening diverts and kills fish in many diversions.
- Low Flow reduces/eliminates habitat availability/quality/diversity
- In Satus Creek heavy equipment was widely utilized to straighten stream channels, remove vegetation, and create dams for irrigation. In the unconfined reaches of Satus Creek the total width of the stream and the area of stream bars his increased dramatically since 1949.
- Channel incision has occurred in many of the wet meadow systems (e.g., Starvation Flats, Seattle Springs, Indian Springs, Camas Patch, and Renschler’s Meadow) as well as in salmonid bearing reaches of Satus Creek (Satus Creek Watershed Restoration Team

2004). These channel changes are thought to be associated with the loss of channel roughness elements such as beaver dams, large woody debris, riparian vegetation stabilizes stream banks.

- On Ahtanum Creek, Residential development, logging, recreational vehicles, and roadways, in close proximity to the creek and riparian area have resulted in significant impacts to bank stability, riparian vegetation, and sedimentation upstream of Tampico, on both the NF and SF. (WDFW 1998). The NF, in the vicinity of Tampico Park, has been largely denuded of riparian vegetation due to extensive floodplain agricultural development. There is good riparian vegetation on the south side of the creek in the lower 8-9 miles while the distribution on the north side is patchy. Much of the riparian zone in this reach has been severely impacted by grazing (YSP 1990). Direct trampling of bull trout redds by cattle in the stream has also been a problem in upper watershed.
- Current effects of the road on Satus Creek are most noticeable between Wilson-Charley Creek and the County Line bridge, where the stream has been deprived of a substantial part of its floodplain. This stream reach has the potential to provide high quality spawning and rearing habitat, but the constricting influence of the highway maintains the creek in a degraded condition.
- On the Toppenish Creek fan, a severely confined, incised, and degraded sub-reach from the head of the Olney dike, extending approximately 1.2 miles downstream,.. Toppenish Creek between Pom Pom Road and the confluence of Simcoe Creek occupies the lower half of the alluvial fan. The channel throughout this reaches varies from moderately to severely incised (i.e., incised banks from 6 to 15 feet in height).
- The most degraded riparian area on Simcoe Creek is from the mouth to Wahtum Creek (RM 14.4)(Yakima Nation Fisheries personnel, as cited in YSP 1990). This reach rates as the second worst riparian impact to salmonids in the entirety of the Toppenish Creek watershed.
- Riparian condition is poor/fair downstream of Tampico, and good/excellent in the 10-20 miles of tributaries upstream of Tampico (YSP 1990, WDFW 1998). The road infrastructure, housing development, and farming have had a tremendous impact on the riparian zone in this area.
- On Wenas Creek, below RM 9 the creek flows through areas heavily used for grazing, and riparian vegetation is virtually nonexistent.

Key Uncertainties for Low Elevation Tributaries Assessment Unit:

- Along Satus Creek Aerial photography shows little black cottonwood recruitment between 1949 and 1995 (Satus Creek Watershed Restoration Team 2004). One possible explanation is that channel incision has altered floodplain disturbance regimes that contribute to germination and establishment of seedlings.
- Little is known about water quality in the lower reaches of Ahtanum Creek. Presumably water quality is degraded somewhat despite efforts to maintain minimum instream flows in the channel. Potential impacts include increased temperature, turbidity, and possibly chemical constituents related to agricultural runnoff.
- Existing and anticipated future levels of abundance and straying indicate that natural colonization of suitable habitats (after removal of obstructions to passage) would be very

slow or non-existent in this Assessment Unit. Supplementation into newly re-opened habitats could accelerate/greatly improve the success rate of population reestablishment.

- In 1995, the Yakama Nation began stocking hatchery coho salmon in the Ahtanum Creek system in an effort to reestablish self sustaining coho populations (YN 2003). Coho juveniles are known to be more aggressive than other anadromous or resident species, and there is the potential of competing with or preying on bull trout fry.

6.5.4 Mid Elevation Yakima Assessment Unit

Overview

The Mid Elevation Yakima Assessment Unit (Figure 2-84) encompasses approximately 1,344 square miles and includes streams in both the eastern and western portion of the Yakima Subbasin. Elevation within the Assessment Unit ranges between 1,000 ft to 6,800 ft msl. The Assessment Unit receives approximately 41-49 inches of precipitation a year. According to the 2000 United States Census, approximately 41,420 people live in the unit. Predominant land uses in the Assessment Unit include agriculture and other rural uses (Figure 2-83).

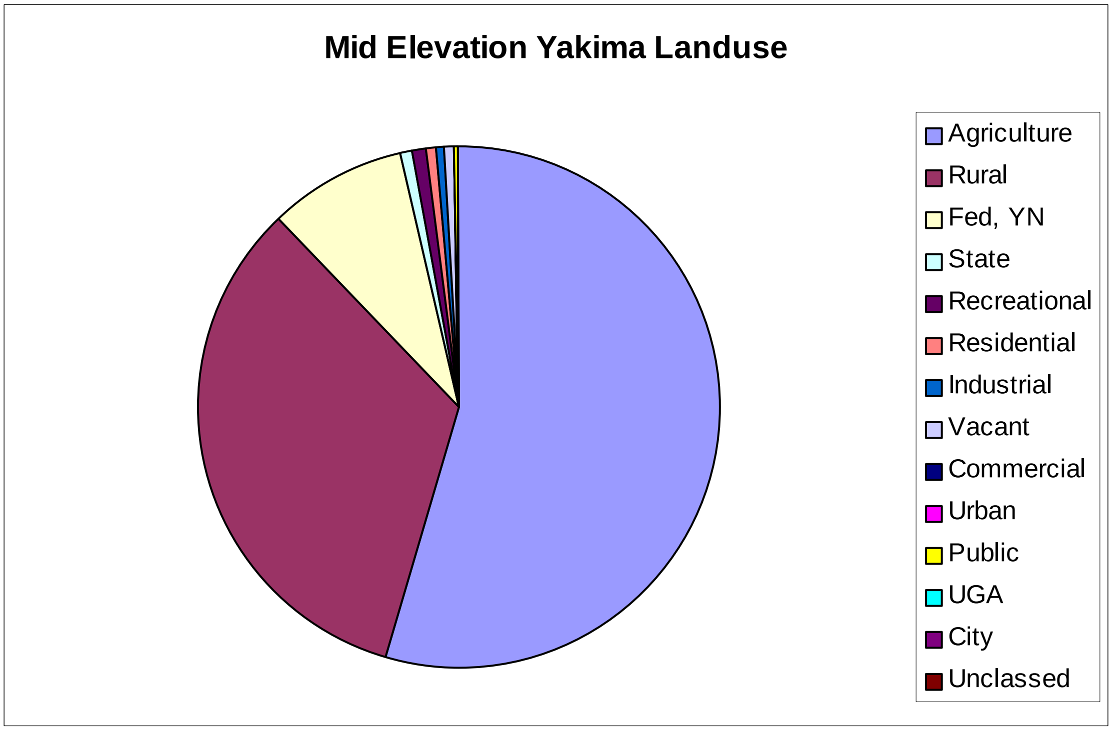


Figure 2-83. Comparison of land uses in mid elevation Yakima Assessment Unit

Because of the size of the Assessment Unit and the number of streams under consideration it is convenient to divide the streams of the Assessment Unit into the following groups that are similar in geographic location and physiographic and hydrologic characteristics 1) The Manastash group which includes Manastash Creek, Taneum Creek, Big Creek, Tucker Creek, Cabin Creek, and Little Creek; 2) the Swauk Creek group which includes Swauk, Williams, Iron and Blue Creeks; 3) the Wilson Creek Group including Wilson, Cherry, Badger, Naneum, Reecer, Currier, Dry Creeks and Coleman creeks; 4) Umtanum and Lmmuma Creeks in the Yakima Canyon; and 5) the mainstem Yakima River (Table 2-26).

Easton and Roza Damsare major irrigation diversion dams within this Assessment Unit but Keechelus (157,800 acre feet), Kachess (239,000 acre feet), and Cle Elum (436,900 acre feet) dams form the boundary between the Mid Elevation and High Elevation Yakima Assessment Units. Stream segments downstream of these dams are included within the Assessment Unit and are heavily influenced by operation of these facilities. These reservoirs are operated by the Bureau of Reclamation whose primary purpose is to provide irrigation flows for agriculture. The majority of water released from these facilities is transported to the lower basin during periods of the summer and early fall when the river would otherwise be approaching base flow (Yakima NPPC 2001). In September the summer flow regime is dramatically reduced over the span of ten days. These relatively rapid or sudden flow changes negatively affect the entire suite of ecosystem functions in the Upper Yakima Mainstem, including primary and secondary productivity of the food web. There are many smaller diversion dams in the Assessment Unit a number of which present full or partial passage barriers to anadromous fish (Figure 2-84). There are undoubtedly additional barriers that exist in this Assessment Unit which do not appear on this map. The Yakima Tributary and Habitat Program (YTAHP) is currently performing an update of habitat and passage conditions in this area. Four of six diversion dams on Manastash Creek are full or partial barriers, and impassible check dams exist on Wilson Creek and Tucker Creek.

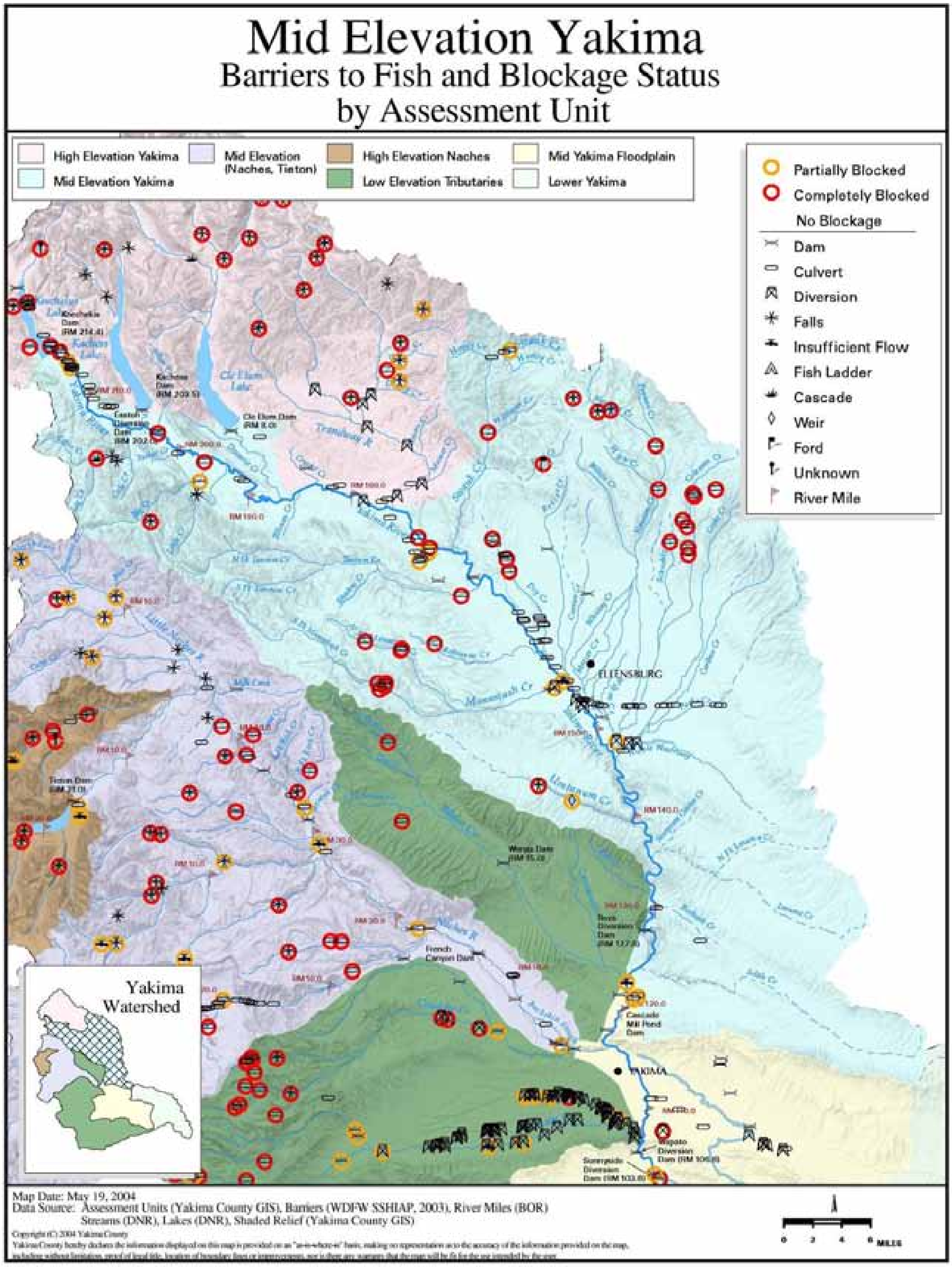


Figure 2-84. Barriers to fish passage in the Mid Elevation Yakima Assessment Unit

Aquatic Habitat

Species Distribution and Utilization

Spring chinook salmon, fall chinook salmon, steelhead/rainbow trout, pacific lamprey and bull trout are known to occur within the Assessment Unit. The distribution and abundance of these species has been heavily influenced by the placement and operation of numerous small but impassible diversion dams and habitat degradation. The range of both resident and anadromous fish has been reduced in many of the upper watersheds due to numerous blocking culverts associated with Forest roads. Roza Dam, which is the furthest downstream point within the Mid Elevation Yakima Assessment on the mainstem Yakima River, was a passage barrier for steelhead trout for roughly 18 years. The current and historical distribution of these species is illustrated in the focal species discussion prior to the fish habitat conditions portion of the fish assessment.

There are several streams in this Assessment Unit, Manastash, Wilson/Naneum, Taneum Creeks and others, that currently have areas of suitable habitat which are unoccupied or have extremetly low populations levels of anadromous fish, including spring chinook, steelhead and coho. These areas are currently or have been in the recent past blocked to access by low flow or diversion dams, but these problems have been or soon will be rectified. Existing and anticipated future levels of abundance and straying indicate that natural colonization of suitable habitats (after removal of obstructions to passage) would be very slow or non-existent in this Assessment Unit. Supplementation into newly re-opened habitats (through the use of hatchery broodstock, adult collection and involuntary spawning or other means) could accelerate/greatly improve the success rate of population reestablishment.

Spring Chinook Salmon

Spring chinook in the Mid Elevation Assessment Unit still occupy much of their historical range, although they are certainly less abundant. Notable exceptions include lengthy segments of Swauk and Manastash Creek.

The mainstem Yakima River between the Teanaway River and Keechelus Dam is the premier spring chinook spawning and rearing area in the Assessment Unit. Roughly 50 percent of all spawning spring chinook in the entire basin utilize this reach. Over 75 percent of the upper Yakima stock rely on this reach. In recent years spring chinook have occasionally been observed spawning in the lowermost section of Manastash Creek (Fast et al. 1991). Spring chinook juveniles have been observed rearing near all of the Manastash group tributaries. Rearing spring chinook juveniles have been observed in large numbers in the lower 2-4 miles of Wilson, Cherry, Badger, Naneum and Coleman Creeks (Easterbrooks, Watson 1990).

As noted in the Focal Species Assessment for spring chinook, the Cle Elum Supplementation and Research Facility is located in this reach (for more information on this project see the Inventory section), and the Clark Flats and Easton acclimation sites are located in this Assessment Unit as well. Release of hatchery origin spring chinook have increase the number of returning spawners to this Assessment Unit. The long term prospect of continued high abundance if the hatchery supplementation were to cease is unknown.

Fall Chinook Salmon

Very few fall chinook currently utilize the reach of the mainstem Yakima River from Lmmuma Creek to Roza Dam.

Steelhead / Rainbow Trout

Although the historic distribution of steelhead trout in the Mid Elevation Yakima Assessment Unit is poorly known, steelhead likely utilized many of the same tributaries utilized by spring chinook (NPPC 2001) and also used habitats at higher elevations. The EDT model hypothesizes that this Assessement Unit produced the largest number of steelhead in the subbasin. The current steelhead abundance is extremely low, and the population is dominated by resident rainbow trout. As discussed above in the Focal Species assessment for steelhead, this loss of anadromy could be due to several causes including loss of access to habitat, changes in flow, changes in temperature, stocking etc. Steelhead that return to the upper Yakima basin have very limited spawning habitat. For example, Wilson/Naneum, Taneum, Manastash, Big, Little, Swauk, Tucker, Reecer, Cook, Caribou—virtually all of the Kittitas valley tribs—have some sort of flow or structurally induced blockages that severely impair adult passage. Steelhead that don't make it into the Teanaway or Kittitas valley tribs are left with significantly simplified, physically and hydrologically imbalanced mainstem reaches of the Yakima and Cle Elum Rivers. There are only a few areas where these fish can spawn in mainstem reaches, but in these locations, as soon as fry swim up out of the redds (July and August), the USBR begins or has begun irrigation deliveries. These inordinately high flows likely sweep many small-bodied fry off the redds, simplified habitats devoid of lateral complexity and/or off-channel refugia offer little protection from high velocity main channels, and moving downstream during the summer in the Yakima Basin means certain death for most salmonids. Fish that spawn in the tribs find poor emigration conditions as smolts, are dewatered, or subjected to lethal water quality conditions, especially those tribs that are connected to the irrigation system in the Kittitas Valley

Restoration of anadromous forms of steelhead to this portion of the basin is a major objective of NOAA Fisheries restoration objectives for steelhead in the subbasin. Steelhead trout heavily utilize the mainstem Yakima River between the Teanaway River and Keechelus Dam. Steelhead spawners have occasionally been observed in various Wilson Creek tributaries (Fred Meyer FEIS, City of Ellensburg, January 1999;WDFW 1998), and wild rainbow and brook trout are found in large numbers in the forested upper reaches of Naneum, Wilson and Coleman Creeks (Geoff McMichaels, pers.comm., 1998). In recent years, steelhead have occasionally been observed spawning in Taneum and Big Creek (Fast et al. 1991). *O. mykiss* juveniles rear in some numbers near the mouths of all of the Manastash Group tributaries provided these areas have not been dewatered by irrigation diversions. Rainbow trout are also found in large numbers in both the Yakima canyon and upper flats areas, and support an economically and recreationally significant trout fishery in those areas. Steelhead and rainbow trout juveniles rear in large numbers in the lower 2-4 miles of Wilson, Cherry, Badger, Naneum and Coleman Creeks (Easterbrooks 1990).

Sockeye / Kokanee Salmon

Sockeye/kokanee are not present in this Assessment Unit. Historically this Assessment Unit was used as a migration corridor. The potential does exist that Sockeye used areas below the glacial lakes for spawning and rearing.

Bull Trout

Bull trout have been known to occur throughout the Mid Elevation Yakima Assessment Unit. A total of three fluvial bull trout redds were observed in the Keechelus to Easton reach of the Yakima mainstem in 2000 and 2001 (WDFW 2003). The staus of fluvial bull trout in this Assessment Unit is uncertain. Bull trout could be at high risk of extinction since only a few redds and individuals have been observed in the recent past. The possibility exists that the few fish that inhabit the mainstem Yakima are adfluvial fish that have passed through the high head dams from upstream populations and are currently stranded below these impassable dams (WDFW 2003).

Pacific Lamprey

Pacific lamprey utilization of the Mid Elevation Yakima Assessment Unit has been documented by Wydoski and Whitney (2003).

Other Fish Species and Interactions

There are naturally reproducing populations of brook trout throughout the Mid Elevation Yakima Assessment Unit (WDFW 1998). Notable brook trout concentrations exist in the Cle Elum drainage, the upper Yakima River between Easton and Keechelus lakes, and small tributary streams of the upper Yakima River. Probable impacts to bull trout include predation on juveniles and competition for food and space. Brook trout may also pose a serious genetic threat to bull trout due to the potential for hybridization (WDW 1992; Rieman and McIntyre 1993). Although evidence is limited, it appears that the resulting offspring in some circumstances are fertile, thus providing an avenue for further introgression with bull trout populations (USFWS 2002,Wydoski and Whitney 2003).

The EDT model hypothesizes that there are competitive interactions between hatchery fish released in this Assessment Unit (spring chinook and coho) that negatively impact the productivity of natural origin fish in this Assessment Unit. The EDT model also hypothesizes that due to flow management and loss of nutrients, the food net and food productive capacity of this reach would be severely reduced, further reducing capacity and productivity of salmonid fry of all species that rear or reside in the mainstem in this Assessment Unit.

Table 2-28. Mid Elevation Yakima Assessment Unit stream groups

Stream Group	Major Streams or Tributaries included in Group
Manashtash Creek	Manashtash Creek Taneum Creek Big Creek Cabin Creek
Swauk Creek	Swauk Creek Williams Creek Iron Creek Blue Creek
Wilson Creek	Wilson Creek Cherry Creek (including Parke, Cooke and Caribou) Badger Creek Naneum Creek Coleman Creek Reecer Creek Currier Creek Dry Creek
Umtanum Creek	Umtanum Creek Lmmuma Creek
Mainstem Yakima River	Naches River to Wenas Creek Wenas Creek to Wilson Creek Wilson Creek to Taneum Creek Taneum Creek to the Teanaway River Teanaway River to Keechelus Dam

Stream Channel Condition and Function

Manastash Creek Group.

The creeks in the Manastash Group have similar longitudinal profiles. In the headwaters they flow through a low-gradient, generally unconfined braided channels (e.g., South Fork Manastash), followed by a steeper canyon section with varying degrees of confinement and finally through 2-6 miles of low gradient valley bottom before entering the Yakima River. In the uppermost reaches clean cobble/gravel substrates are abundant and often form large gravel bars. In the steeper canyon reaches boulder/cobble matrices are common and gravel distribution is patchy. Cobble/gravel substrates are common in the valley bottom.

Habitat complexity is not ideal in the lower reaches of any of these streams, which are now almost exclusively single channels although there is limited evidence that suggests they may have once been anastomosing in the valley bottom sections of both Taneum and Manastash Creeks. Woody debris in these reaches is virtually absent. Large woody debris is abundant in the upper reaches of the South Fork of Manastash Creek (above ~RM 10 Buck Meadows), in the North Fork and South Fork of Taneum Creek (above RM 12.7), in the Fishhook Flats area of the North Fork of Taneum Creek (RM 3 NF Taneum), and above Big Creek Dam (RM 2.1) on Big Creek and contributes to habitat quality and complexity. Cabin Creek is a notable exception and its recent history of intensive timber harvest and increased peak flows precludes large woody debris.

Fishways and screens were installed on all Taneum Creek diversions by 1990 (Figure 2-84). Big Creek has two diversions, a small (2-3 cfs) berm diversion at RM 0.7, and a larger (10-15 cfs, 5-

foot head) impassable diversion dam at RM 2.1. The lower diversion dam is easily passable to adults, but the upper dam has no fishway and an unscreened ditch (YSP 1990), these passage problems are currently being corrected and should be completed in the summer of 2004. Big Creek is also heavily channelized downstream of RM 3.0, with associated channel instability and bedload deposition in the lowermost 0.25 mile (WDFW 1998). A series of cascades and waterfalls between RM 3.1 and 3.8 on Cabin Creek preclude access and therefore successful spawning by any anadromous or migratory species originating lower in the basin.

The Swauk Group

Swauk Creek and its tributaries support spring chinook (only juveniles present), steelhead (vestigial run), and bull trout (captured 200m upstream of mouth in 1993), as well as other resident salmonids and non-salmonids (WDFW 1998). Substantial recreational and commercial gold prospecting occurs on the main Swauk tributary, Williams Creek. A long history of suction dredging for gold has likely increased the presence of fines (embeddedness) in the substrate and decreased the likelihood of successful incubation and emergence of salmonid eggs (WDFW 1998). In addition, toxic chemicals such as arsenic are present from the historic gold mining and processing in the watershed, the effect of these chemicals on fish life, and mechanisms to remove them are both uncertain, but the presence of these chemicals limits restoration options due to concerns with disturbance of the bed and redistribution of these chemicals downstream. In the lower 2-3 miles of the river, a steep gradient arid canyon, the dominant substrate is comprised of mainly boulders (YSP 1990, WDFW 1998). The substrate upstream of RM 3 consists mostly of coarse rubble, with a patchy distribution of spawning gravel suitable for steelhead (YSP 1990). The streambed appears stable throughout (YSP 1990). Like other south facing tributaries, increases in peak flows have increased bed scour and channel instability in Swauk Creek.

The Wilson Creek Group

Many of the tributaries are used as irrigation delivery systems and have been re-routed, channelized and diked for that purpose. In such reaches the streams are straight, high velocity chutes with few pools, no large woody debris and minimal riparian vegetation. Most have dozens of unscreened diversions and impassible check dams, and all pass through siphons underneath three large irrigation ditches – the Kittitas Reclamation District Canal, the Cascade Irrigation District Canal, and Town Ditch Canal– which in many cases represent passage barriers. There is a large effort currently underway to rectify many of these passage problems and separate the irrigation system from the natural drainage network. Large improvements to the current conditions for passage, screening and habitat can be expected to occur in the next several years. Impassible irrigation check dams block access to all but the lower 2.4 miles of the drainage. In some cases, stream water is commingled with these large ditches, allowing fish to be entrained. Wilson Creek is heavily modified as it passes through the heart of Ellensburg, often in underground culverts, which may also represent obstacles to passage. Urban stormwater runoff is discharged directly into Wilson Creek and its tributaries. Consequently, fine sediment levels are high in the drainage below Ellensburg. Gravel quality and size distribution is good for salmonid spawning outside of the valley floor, but in the lower reaches irrigation priming and early season operations have increased fine sediment loads to the channels. Like other south facing tributaries, hydrologically immature stands of timber, especially on south facing slopes in the rain on snow zone, in combination with H road densities, lead to increases in peak resulting in increased bed scour and channel instability in the Wilson Creek Group.

Umtanum Creek

Anadromous and migratory fish species do not currently have access to Umtanum Creek upstream of RM 4.8, where a large gabion structure intended to protect a pipeline crossing is a total barrier to fish passage at all but flood flows. This obstruction is a barrier to roughly 3.2 miles of relatively good fish habitat. At RM 8.0 impassible waterfall is the effective upper limit to anadromy.

Lmmuma Creek

Lmmuma Creek has perennial surface flow and likely provides rearing habitat for spring chinook, steelhead, and possibly coho in the lower reaches, and may provide spawning habitat for steelhead during the spring snowmelt runoff. Resident salmonids are known to occur to upstream of I-82.

Mainstem Yakima

The mainstem Yakima River is roughly 100 miles in length in this Assessment Unit and, excluding the reservoirs, comprises roughly 20 percent of the wetted area of the drainage. This section of river also currently supports over 60 percent of the basin-wide spring chinook production. Natural origin coho have been extirpated from the area and steelhead are all but extirpated.

The Yakima River from Wenas Creek (RM ~15) to Wilson Creek (Yakima Canyon) is a 25-mile reach that is bordered almost continuously, on the right bank by a railroad embankment and the left by a highway. Except for a pool upstream of Roza Dam, this reach consists primarily of fast, moderately deep runs. There are a limited number of pools – usually eddies on the inside of sharp bends. This is a transport reach for large woody debris, which is almost entirely absent. Except for several stable islands some hundreds of yards long, a half-mile natural side channel and a 1,300-ft man-made “rearing alcove” built on the right bank just below the confluence of Roza Creek, there is no off-channel habitat in the canyon. The dominant substrate is primarily cobble and large gravel, is moderately embedded, and contains a considerable proportion of fines.

During average to water short years target flows below Roza Dam are regulated to maintain 400 cfs when the RID is receiving water, and the Roza Power Plant is generating electricity. April to May streamflow above Roza Dam is on the order of 2,000 cfs, so emigrating Upper Yakima River steelhead must transition from a flowing river through a reservoir pool, and then below the dam into the mainstem river flowing at a level well below unregulated conditions, and well below streamflows they experienced in the upper 86 miles of the River between Roza Dam and the base of Keechelus Dam. Additionally, to pass through or around Roza Dam, kelts and smolts must find the fish bypass system or sound to approximately 12 to 14 feet below the surface of the Roza pool to an opening that is 100 feet wide and less than 6 inches tall (when the subordination target below Roza Dam is 400 cfs, upstream flows are 1,800 to 2,000 cfs, and the Roza Power Plant is operating). The effects on downstream passage of this large flow differential, as well as the geometry and attraction of bypass systems and the dam opening on emigrating steelhead smolts and kelts are largely unknown. However, it is very likely that many steelhead kelts and smolts are confounded by the situation at Roza Dam, leading to smolt residualization, passage delays, and probable kelt mortality because of their weakened physical state and physiological drive to return to the ocean. Furthermore, if steelhead kelts and smolts are delayed at Roza Dam for weeks during the downstream emigration period (April to July), and this passage delay results in later arrival timing and passage through the Lower Yakima River (June to July), lethal water quality conditions and nonnative piscivorous predation likely lead to high mortality rates that remove a number of kelts and smolts from the effective population of the Yakima Basin.

Two different channel types can be observed in the Yakima River between Wilson Creek and Taneum Creek. Below the confluence with the Manastash most of the river still has multiple channels as well as a modest amount of large woody debris, some of which is provided by the remnants of the original cottonwood galleries. Above Manastash the channel is a single narrow thread, bank sloughing is common, and large woody debris is largely absent. The Upper Yakima Mainstem is severely confined, resulting in loss of habitat and altered channel form and process (incision and bed scour). The area below Manastash has relatively more riffles than the area above, which is essentially a long run with intermittent deep pools.

The Yakima River from Taneum Creek to the Teanaway River is roughly 10 miles in length. Swauk Creek flows into this reach and all but the upper three miles flow through the Ellensburg Canyon. The river in the Ellensburg Canyon closely resembles the river in Yakima Canyon with a few notable exceptions. Deep pools are more numerous, fine sediment comprises a smaller proportion of the substrate, and side channel habitat is present along roughly ten percent of the reach length. The flow regime in this reach has been substantially altered by the storage reservoirs operations located upstream.

The reach of the Yakima River from the confluence with the Teanaway River to Keechelus Dam is roughly 40 miles in length. Habitat quality is very good in this reach and is surpassed in the subbasin by perhaps only the American River. The large volumes of wood in the river, combined with a lack of natural confinement and perhaps a greater frequency of floods and disturbances, create a very complex river system. The flow regime in this reach has been substantially altered by upstream water uses. The major tributaries for this section of the mainstem Yakima River include Teanaway, Cle Elum and Kachess Rivers as well as numerous small tributaries such as Big, Little and Tucker Creeks. The complex anatomosed channel at the confluence with the Cle Elum River has been eliminated, as have a number of major side channels in the Elk Meadows area, but the majority of the various types of “off channel habitat” still exist (Johnston 1995).

Riparian / Floodplain Condition and Function

The Manastash Group

Riparian conditions are unusually good on these creeks. The vegetation communities transition from dense alder/cottonwood stands that approach complete canopy closure in the valley to equally dense growths of alder/Douglas-fir in the low-gradient upper reaches. The steep-sloped and rocky canyon sections of Manastash and Big Creek are fringed with dense growths of willow and alder. The structure and function of streamside vegetation along Cabin Creek has been substantially altered by extensive timber harvest.

The Swauk Group

The lower three miles of the watershed are located in a steep, arid canyon. Progressing upstream, willows, alder and cottonwoods gradually increase until, by RM 8, the stream flows through a conifer forest of increasing density. Riparian Condition for Swauk Creek upstream of RM 8, riparian condition is generally good, with no areas of significant overgrazing (YSP 1990, WDFW 1998). The elimination of beaver in the 1830’s, in combination with a long history of mining, eliminated a series of short, flat, unconfined areas through which Swauk Creek meandered in multiple channels. These areas were wet meadows, containing beaver dams and ponds, and functioned to conserve spring runoff and augment late summer and fall base flows. Channel incision resulting from the operation of huge stream dredges and loss of beaver dams disconnected the river from the floodplain and the adjacent wet meadows were lost.

Wilson Creek Group

The riparian zones, for the valley portions of this watershed, are extensively impacted by grazing and other agricultural practices, and by expansion of development and associated roads, and are highly variable in both quality and quantity. Some riparian communities are properly functioning, while others are completely devoid of shrubs or overstory trees.

Umtanum

Below the falls at RM 8.0, Umtanum has generally good conditions with respect to its floodplain and riparian condition. A riparian fencing project and restoration of beaver colonies above the falls might generate enough additional summer flows to increase fish production in the lower reach.

Lmmuma Creek

The riparian zone has been damaged by many years of intense grazing by livestock and by military maneuvers with both wheeled and heavy tracked vehicles. Many areas of stream are deeply incised, the water table has been reduced and woody riparian vegetation, particularly large trees, are lacking. There is little LWD or LWD-related pools.
WDFW staff indicate there were historically cottonwood stands along lower Lmmuma Creek (KCCD 1999). Riparian condition has been impaired in the watershed by grazing in the lower watershed and by roads on the Yakima Training Center. Yakama Nation staff have recommended reintroduction of beaver in lower Lmmuma Creek. The lower 7-8 miles of Lmmuma Creek are owned by a single landowner, which may provide unique opportunities to pursue restoration through conservation easement, CREP, or acquisition.

Mainstem Yakima

The annual hydrograph has been severly modified from pre-1850 conditions, resulting in the inability of black cottonwood to successfully reproduce and the loss of multi-year class stands. Riparian vegetation in the Yakima Canyon (Wenas Creek to Wilson Creek) consists of a fringe of reed canary grass and willows, and an occasional isolated Ponderosa pine.

For the reach of the Yakima River from Wilson Creek to Taneum Creek, the city of Ellensburg occupies a prominent position on the eastern bank. Gravel mining and agricultural activities in the floodplain have also severely degraded the riparian corridor. Insterstate 90 borders much of the river above Manastash Creek, where agricultural development is also more intense. Diking, riprapping and channelization has been concentrated in this area. Streamside vegetation in the riparian zone is nonexistent or severely degraded. The habitat degradation associated with rural and urban development (e.g., channel stabilization, loss of riparian vegetation, etc.) has been associated with loss of the physical and ecological processes that created the mainstem side channels. A considerable number of isolated side channels have disappeared over the years. Prior to these riparian and channel modifications, this reach probably provided exceptional spawning and rearing opportunities for salmon and steelhead

The reach of the Yakima River from Taneum Creek to the Teanaway River is approximately 10 miles in length and has not been heavily developed. The entire floodplain of the upper three miles of this reach is largely intact, but is influenced by regulated flows from Cle Elum, Kachess and Keechelus Lakes, abstraction via Easton Diversion, several diversions on the Teanaway and road and railroad revetments throughout the reach.

Riparian vegetation in the reach of the Yakima River between the Teanaway River and Keechelus Dam has been substantially altered in the urban and residential sections. Several miles of the river in the vicinity of the city of Cle Elum has been diked and riprapped on both sides. A substantial proportion of the floodplain between Cle Elum confluence and Easton Dam has been diked and riprapped to protect summer homes from floods. Summer home lots are invariably cleared to the water's edge, reducing large woody debris recruitment and cover for fry. Large Woody debris has also been reduced in this assessment unit due to removal/retention of wood by diversion dams.

Water Quantity

Manastash Creek Group.

The major creeks in this group all drain watersheds of moderate size – 50 to 95 mi^2 – and all have modest water yields, ranging from May peaks of ~175-490c fs to August/September low flows of 10-15 cfs. Annual precipitation increases with elevation in the basin and mean monthly flows generally increase from Manastash to Cabin Creek. With the exception of Cabin Creek, the quantity and quality of habitat in these streams is good. However, irrigation dams and/or withdrawals are likely significant factors limiting fish production potential. Six active diversions withdraw water from Manastash Creek between RM 1.4 and 5.7. Four of them are associated with dams that are partial or total barriers to all life stages, and none of them are screened. In the summer, Manastash Creek is dry between RM 1.4 and 3.0 and between RM 3.3 and 4.9. Virtually none of the flow in the lowermost 1.4 miles can be attributed to surface water but groundwater accretion can contribute 4-5 cfs at the mouth. The lower portion of Taneum Creek is heavily diverted, with 4 irrigation diversions in the lower 3.5 miles. Low flows in the lower 3.3 miles of Taneum Creek in the late summer and fall block spring chinook and coho from good spawning habitat upstream (YSP 1990, WDFW 1998). Big Creek has substantial perennial flows (~10 cfs in August 1988) upstream of the upper diversion, but flow downstream is ~1 cfs, most of which is leakage (YSP 1990, 303(d) Decision Matrices). Flows are recharged by groundwater over the next mile, and increase to ~3 cfs at RM 1.2 (also in August 1988). Most of this recharge is subsequently removed at the lower diversion, and the stream is totally dry or intermittent from RM 0.6 to the mouth. Precipitation in the Cabin Creek watershed is heavy (>100 inches/year), and runoff is now extremely fast because of clear-cuts that extend from the water's edge to the ridge tops. Based on observations of increased channel instability and widening in Cabin Creek, downcutting and erosion at a natural cascade that was historically utilized by steelhead may have been significant. There are no irrigation dams or diversions on Cabin Creek.

Swauk Creek Group

Although the drainage area of Swauk Creek is fairly large, precipitation is minimal and unregulated summer stream flows are now very low (YSP 1990). Flows at the mouth vary from zero during the summer and fall to about 70 cfs in May. Swauk Creek dries up or becomes intermittent somewhere between RM 3 and 5. Steelhead production in the lower 3-5 miles is severely limited by the absence of flow in the fall (YSP 1990). The streambed remains dry through early fall, precluding adult anadromous salmonid access into the upper watershed (WDFW 1998). Base flows were naturally low throughout the system and likely limited production even under pre-development conditions. Swauk Creek was proposed for inclusion on the CWA 303(d) impaired water quality list for impaired instream flow, but was not included due to any conclusive link between human actions and observed lack of instream flows. Upstream of RM 8, where the stream enters a forested zone, flows are marginally adequate through the summer (YSP 1990). The Burke diversion (RM 7) is relatively small and is the only diversion on Swauk Creek. Flows below the diversion point areso low, however, that the water withdrawn may be the difference between low flow and no flow downstream.

Wilson Creek Group

Use of the Wilson Creek Group for irrigation conveyance has resulted in changed in the hydro graph. The unregulated hydrograph has an estimated peak flow of about 440 cfs in May and a minimum of 35 cfs in September (HKM 1990).

Umtanum Creek

Low flows are a problem below the falls at RM 8.0. The maximum flow of about 15 cfs occurs in May and minimum flows of less than 1 cfs occur in September. Channel incision and overgrazing are thought to contribute to cessation of flow at RM 10.0

Lmmuma Creek

Lmmuma Creek has perennial surface flow. There is a diversion near the mouth that can dewater the stream during the summer months.

Yakima Mainstem

The hydrograph for the mainstem Yakima has been extensively altered by the large storage reservoirs in the upper basin as well as by smaller surface and groundwater diversions along the tributaries. In general, the hydrograph for the mainstem is the same throughout the Assessment Unit and shows a diminished spring peak, low flows in the winter, and a distinctly artificial period of high flow in the summer. Sustained high flow in the mainstem limits interannual or seasonal changes in habitats.

For the Yakima River reach between the Wenas Creek confluence and the Wilson Creek confluence (Yakima Canyon) the hydrograph has been significantly altered from historic conditions (Figure 2-85). Although gaging data are not available for the reach between Wilson Creek and Taneum Creek, the pattern of the hydrograph is likely similar to those observed elsewhere along the Yakima River within the Mid Elevation Assessment Unit.

Figure 2-85 is the current and historical hydrograph for the Yakima River near the mouth of Umtanum Creek (RM 139), about midway through the canyon. The general pattern seen throughout the upper Yakima is evident at this gage site: a diminished spring peak, unnaturally low flows in the winter, and a distinctly artificial period of high flow in the summer. The latter aspect of the hydrograph, in combination with the structural simplicity of the channel and the lack of large woody debris, is perhaps the most important feature of the Yakima Canyon from a fisheries perspective. Although prey organisms are plentiful and conditions are hydraulically suitable for large parr and adult trout, the velocity is simply too great for smaller life stages. The combination high summertime flows and scarce “velocity cover” has drastically limited the quantity and quality of rearing habitat for fry, especially for rainbow-steelhead fry, which emerge in late June and July. This lack of nursery habitat prompted the Yakama Nation to install 22 forty-foot boulder barbs throughout the reach in 1995, in an attempt to create additional slackwater eddies for rearing fry, as well as to provide interstitial habitat for overwintering.

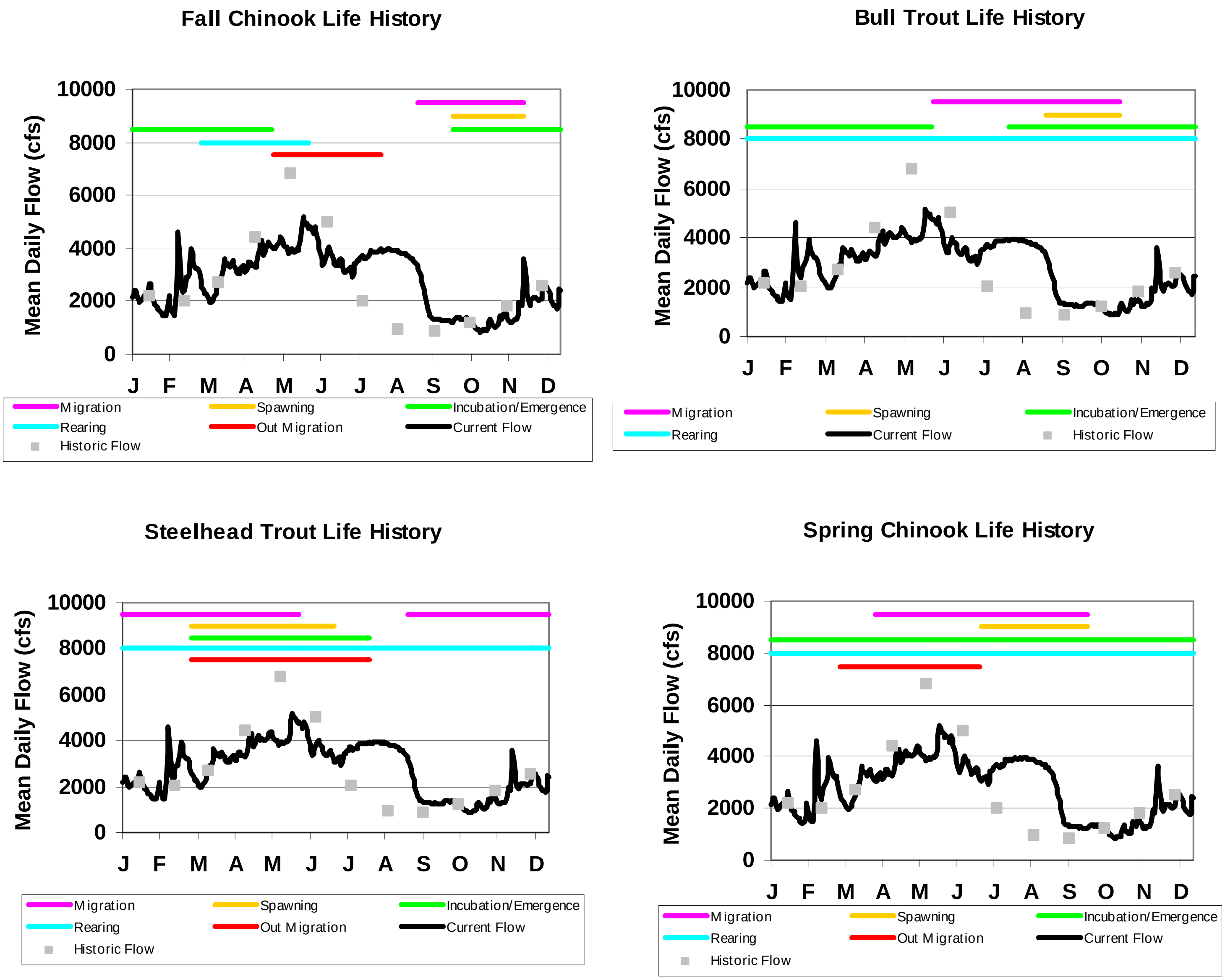


Figure 2-85. Comparison of current and historical flow of the Yakima River at Umtamun (Yakima Canyon) with the life history of spring chinook, fall chinook, steelhead, and bull trout. Hydrograph data from USBR 2004.

The Yakima River from the confluence of the Teanaway River to Keechelus Dam (40 miles) is also heavily influenced by storage reservoirs and diversions. The general pattern as repeated elsewhere in the basin is a diminished spring peak, unnaturally low flows in the winter, and a distinctly artificial period of high flow in the summer (Figure 2-85 and 2-86). The reach of river below Easton Dam suffers from occasional episodes of extreme hour-to-hour flow fluctuations. The gate at Easton Dam does not function reliably, and a number of times over the past 25 years flows have been suddenly and drastically reduced during June and July, when salmonid fry are concentrated in shallow side channel areas. The worst of these flow fluctuations can be as much as several feet in an hour. A more significant problem is the very low flows that can occur in the winter. Low flow reduces or eliminates habitat availability/quality/diversity and also encourages fish to spawn in the thalweg, increasing sensitivity to winter peak flows. The USBR has attempted to maintain flows above an absolute minimum of 30 cfs in this reach and, whenever possible, to maintain flows high enough to cover all redds deposited the preceding fall. Unfortunately, the latter goal cannot always be accomplished – the Bureau estimates water supplies will be inadequate roughly one to two years out of ten.

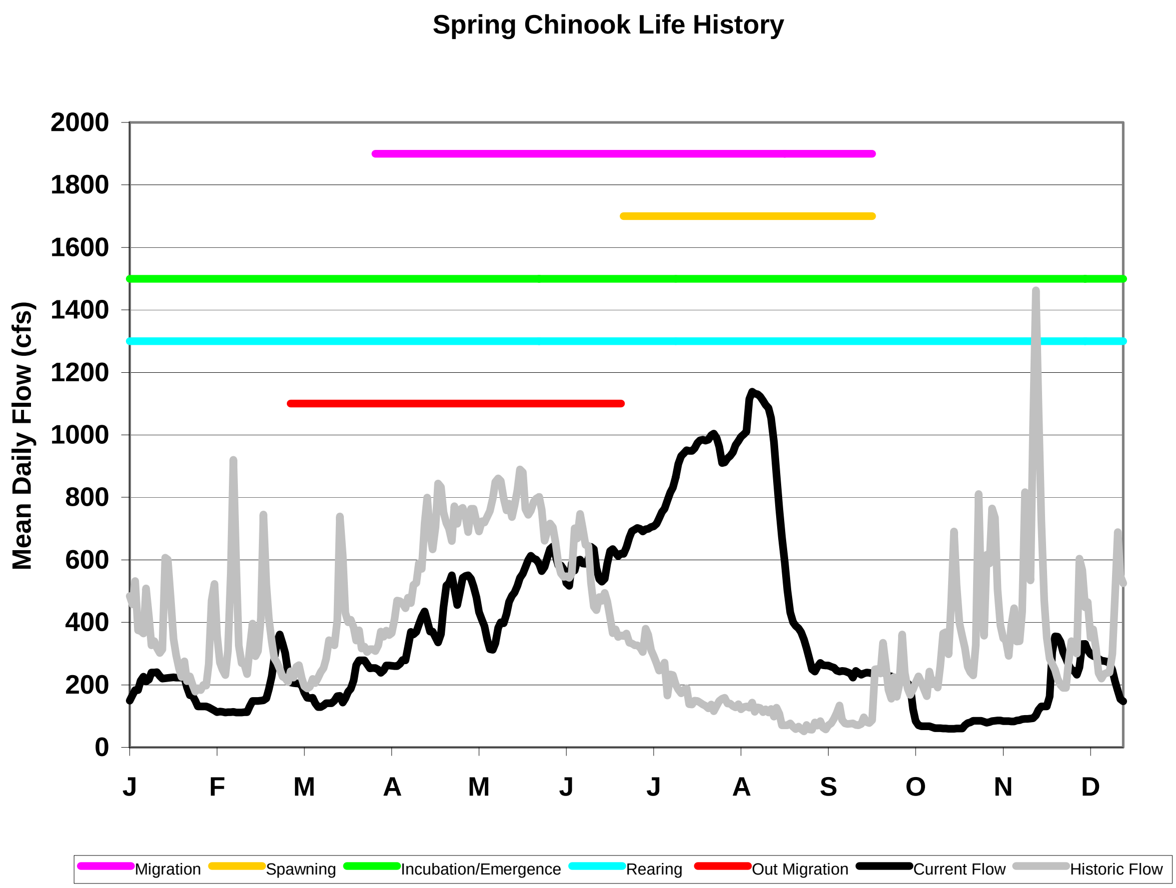


Figure 2-86. Comparison of spring chinook life history with the current and historical hydrograph at the Yakima River at the Keechelus dam. . Hydrograph data from USBR 2004.

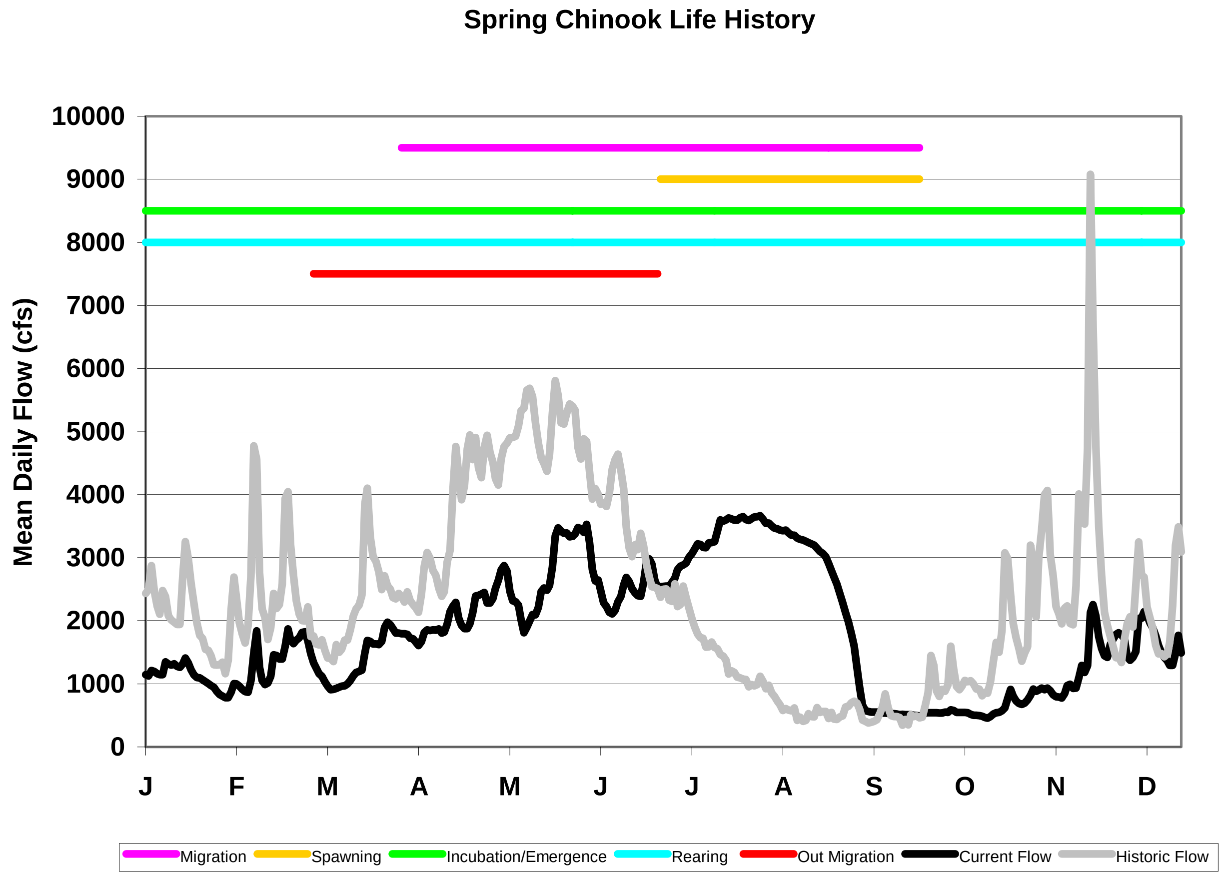


Figure 2-87. Comparison of spring chinook life history with the current and historical hydrograph at the Yakima River at the Cle Elum confluence. . Hydrograph data from USBR 2004.

6.5.4.1.1.1

Water Quality

Manastash Group

Manastash, Taneum and Big Creek are on the CWA Section 303(d) impaired water quality list for instream flow, and Cabin Creek is on the CWA 303(d) impaired water quality list for water temperature, with numerous excursions from water quality standards documented at the Forest Service boundary from 1989 to 1994.

Maximum summertime water temperatures in the lower sections of all of these creeks can occasionally approach 70^{o} F, but these episodes are brief. Diurnal fluctuations are large, and excessive temperature is not believed to be a serious problem on any of these creeks.

Swauk Creek Group

Swauk Creek water quality is fair to good, with temperatures in the perennial reaches in the 50s (F) in August 1988, but in the mid-60s (F) in the intermittent areas and pools (YSP 1990). Two reaches of mainstem Swauk are included on the CWA 303(d) impaired water quality list for water temperature. Blue, Williams, and Iron creeks (tributaries to Swauk Creek) are on the CWA

303(d) impaired water quality list for water temperature. High levels of toxics from gold minning and processing in Swauk Creek affects productivity of habitat.

Wilson Creek Group

Temperature was given a “fair” rating in the Watershed Plan (2003). A fair rating was also assigned for 303(d) pollutants. Given the extent of diversions in the basin this rating is somewhat surprising and could be related to study design or data availability. Numerous fecal coliform violations (DOE 2003, online.pdf file) have been noted throughout the Wilson Creek basin. These problems may be related to livestock, failing septic systems, urban runoff, wildlife, or irrigation practices. A TMDL for bacteria is currently under development for Wilson Creek.

Umtanum Creek

Below the falls at RM 8.0, Umtanum has generally good conditions with respect to its water quality.

Lmmuma Creek

Fine sediment load is high in Lmmuma. Roads and their location adjacent to Lmuma Creek in the Yakima training center increase sediment loading to the Creek; to some degree this drainage would have high sediment loading under natural conditions.

Yakima River

The Yakima River is currently a focus area for turbidity and pesticides (DOE March 2002, focus sheet). The Upper Yakima TMDL plan for sediment and pesticides is currently in the intitial stages of implementation. The Watershed Plan (2003) ranked temperature as “fair” throughout the entire mainstem in the Assessment Unit. For this same reach, rankings for 303(d) pollutants ranged from “good” to “fair”. As discussed above in the assessment of flow at the Subbsain Scale, flow management in the mainstem has resulted in lower summer and likely higher winter temperatures, which may limit growth rates, and productivity. Due to the close relationship between temperature and life history, the altered temperature regime also may alter traits and timing such as incubation rates and timing of emergence.

This altered thermal environment, in combination with high flows and confinement, has reduced the spatial temperature variability in the mainstem. This may explain the high densities of rearing juvenile salmonids at the mouths of tributary creeks, as these locations supply low velocity, more productive habitats that are currently limited in diversity and extent on the mainstem. Actions to remove obstructions in the lower end of these tributaries should greatly increase these types of habitats.

Protection Key Habitat Findings for Mid Elevation Yakima Assessment Unit:

- The mainstem Yakima River between the Teanaway River and Keechelus Dam is the premier spring chinook spawning and rearing area in the Assessment Unit. Roughly 50 percent of all spawning spring chinook in the entire basin utilize this reach. Over 75 percent of the upper Yakima stock rely on this reach.
- Rainbow trout are also found in large numbers in both the Yakima canyon and upper flats areas, and support an economically and recreationally significant trout fishery in those areas.
- The reach of the Yakima River from the confluence with the Teanaway River to Keechelus Dam is roughly 40 miles in length. Habitat quality is very good in this reach and is surpassed in the subbasin by perhaps only the American River. The large volumes of wood in the river, combined with a lack of natural confinement and perhaps a greater frequency of floods and disturbances, create a very complex river system.
- Large woody debris is abundant in the upper reaches of the South Fork of Manastash Creek (above ~RM 10 Buck Meadows), in the North Fork and South Fork of Taneum Creek (above RM 12.7), in the Fishhook Flats area of the North Fork of Taneum Creek (RM 3 NF Taneum), and above Big Creek Dam (RM 2.1) on Big Creek and contributes to habitat quality and complexity.
- Riparian conditions are unusually good on these creeks. Vegetation communities transition from dense alder/cottonwood stands that approach complete canopy closure in the valley to equally dense growths of alder/Douglas-fir in the low-gradient upper reaches. The steep-sloped and rocky canyon sections of Manastash and Big Creek are fringed with dense growths of willow and alder.

Restoration Key Habitat Findings for Mid Elevation Yakima Assessment Unit:

- The distribution and abundance of these species has been heavily influenced by the placement and operation of numerous small but impassible diversion dams and habitat degradation. The range of both resident and anadromous fish has been reduced in many of the upper watersheds due to numerous blocking culverts associated with Forest roads.
- Like other south facing tributaries, hydrologically immature stands of timber, especially on south facing slopes in the rain on snow zone, in combination with H road densities, lead to increases in peak resulting in increased bed scour and channel instability in the Wilson Creek Group.
- Restoration of anadromous forms of steelhead to this portion of the basin is a major objective of NOAA Fisheries restoration objectives for steelhead in the subbasin.
- Loss of side channels and springs has reduced habitat diversity and termperature spatial diversity.
- Large Woody debris has also been reduced in this assessment unit due to removal/retention of wood by diversion dams.
- Habitat complexity is not ideal in the lower reaches of any of these streams, which are now almost exclusively single channels although there is limited evidence that suggests they may have once been anastomosing in the valley bottom sections of both Taneum and Manastash Creeks. Woody debris in these reaches is virtually absent.

- Lack of habitat diversity (pools with cover) and lack of large woody debris limits productivity in this Assessment Unit.
- Sediment load is high in Swauk Wilson and Lmmuma
- Low flow in many of the tributaries results in habitat loss
- Precipitation in the Cabin Creek watershed is heavy (>100 inches/year), and runoff is now extremely fast because of clear-cuts that extend from the water's edge to the ridge tops.
- Natural glacial lakes had some effect on flow and related environmental attributes (ie temperature) in the Cle Elum and Yakima Rivers that were significantly different that those that result from current reservoir management.
- Total or partial obstructions to passage at diversion dams limits production .
- Inadequate screening diverts and kills fish.
- Riparian function has been reduced in this Assessment Unit
- Flip flop flow management negatively effects the entire suite of ecosystem functions in the Upper Yakima Mainstem.
- High levels of toxics from gold mining and processing in Swauk Creek effects productivity of habitat.
- The Upper Yakima mainstem is severely confined, resulting in loss of habitat and altered channel form and process (incision, bed scour).
- Anadromous and migratory fish species do not currently have access to Umtanum Creek upstream of RM 4.8, where a large gabion structure intended to protect a pipeline crossing is a total barrier to fish passage at all but flood flows.
- Winter Low flow reduces/eliminates habitat availability/quality/diversity, including impacts to riparian plant community maintenance and establishment. Also encourages fish to spawn in the thalweg, increasing sensitivity to winter peak flows.
- Irrigation season daily or weekly flow fluctuations greater and more frequent than under pre-1850 conditions.
- Lower summer and winter temperatures in mainstem limit growth rates, and productivity. It also alters life history traits and timing such as incubation rates and timing of emergence.
- Non-native species - eastern brook trout pose a danger to bull trout populations.

Key Uncertainties for Mid Elevation Yakima Assessment Unit:

- To pass through or around Roza Dam, kelts and smolts must find the fish bypass system or sound to approximately 12 to 14 feet below the surface of the Roza pool to an opening that is 100 feet wide and less than 6 inches tall (when the subordination target below Roza Dam is 400 cfs, upstream flows are 1,800 to 2,000 cfs, and the Roza Power Plant is operating). The effects on downstream passage of this large flow differential, as well as the geometry and attraction of bypass systems and the dam opening on emigrating steelhead smolts and kelts are largely unknown.
- Food web in has been altered/reduced in the mainstem.
- Anadromy in rainbow populations is presently much decreased from historic levels.
- Existing and anticipated future levels of abundance and straying indicate that natural colonization of suitable habitats (after removal of obstructions to passage) would be very

slow or non-exisistent in this Assessment Unit. Supplementation into newly re-opened habitats could accelerate/greatly improve the success rate of population reestablishment.

- Release of hatchery origin spring chinook have increase the number of returning spawners to this Assessment Unit. The long term prospect of continued high abundance if the hatchery supplementation were to cease is unknown.
- Bull trout could be at high risk of extinction since only a few redds and individuals have been observed in the recent past. The possibility exists that the few fish that inhabit the mainstem Yakima are adfluvial fish that have passed through the high head dams from upstream populations and are currently stranded below these impassable dams (WDFW 2003).

6.5.5 High Elevation Yakima Assessment Unit

Overview

The High Elevation Yakima Assessment Unit (Figure 2-89) encompasses approximately 562 square miles and is situated to east of the crest of the Cascade Mountains. Elevation within the Assessment Unit ranges between 1,800 ft to 7,800 ft msl. The Assessment Unit receives approximately 85-94 inches of precipitation a year. According to the 2000 United States Census, approximately 5,397 people live in the unit. Predominant land uses in the Assessment Unit include agriculture forestry, and recreation (Figure 2-88).

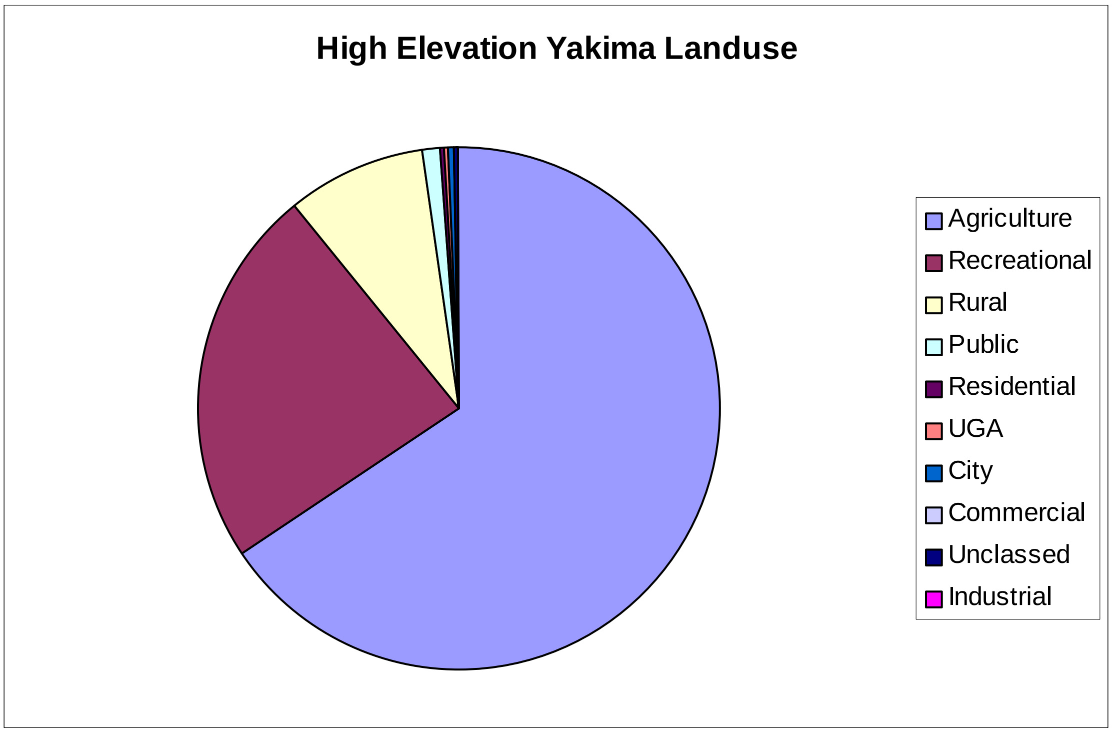


Figure 2-88. Comparison of land uses in the high elevation Yakima Assessment Unit

There are three major reservoirs in the Assessment Unit; Keechelus (157,800 acre feet), Kachess (239,000 acre feet), and Cle Elum (436,900 acre feet). Each of these reservoirs were natural glacial lakes that have been modified to increase water storage and management for downstream irrigation supply. The reservoirs and the upstream tributaries are included within the Assessment Unit. These reservoirs are operated by the Bureau of Reclamation to provide irrigation flows for agriculture. The majority of water released from these facilities is transported to the lower basin during periods of the summer and early fall when the river would otherwise be approaching base flow (NPPC 2001). Reservoirs are not managed to replicate/replace provide the habitat, flow, temperature or ecological functions and processes that the glacial lakes provided. The only basin in the Assessment Unit that does not have a major dam is the Teanaway River basin, and it is included in this Unit due to the hydrologic, climactic, geologic and vegetational similarity to the reservoir tributaries. The location of the large dams as well as a number of smaller diversions is illustrated in Figure 2-89.

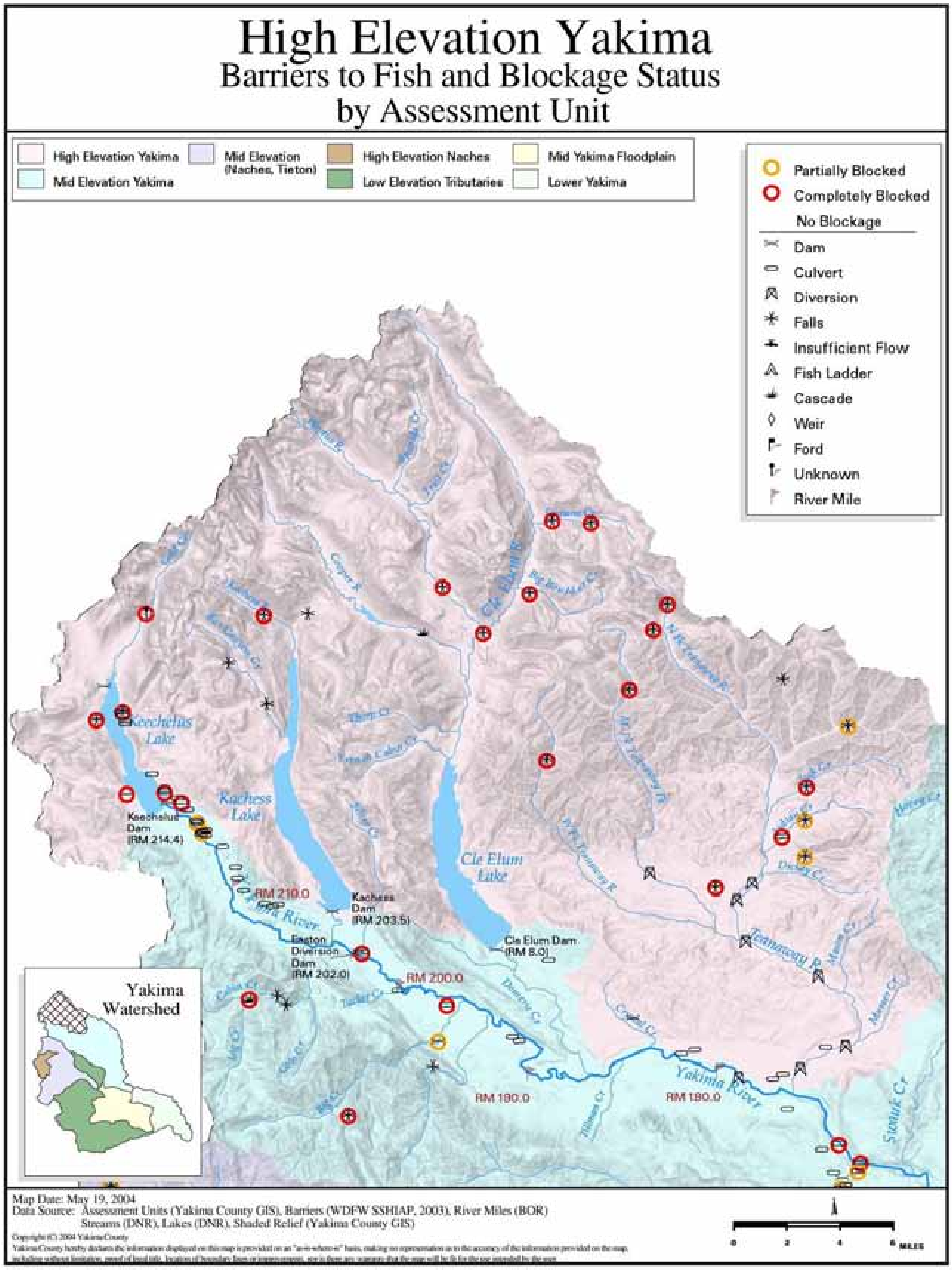


Figure 2-89. Barriers to fish passage in the High Elevation Yakima Assessment Unit

Aquatic Habitat

Species Distribution and Utilization

Steelhead/rainbow trout, bull trout, and kokanee salmon are known to occur within the Assessment Unit. Anadromous populations including spring chinook, stealhead, and sockeye have been extripated from this Unit. The distribution and abundance of these species has been heavily influenced by the placement and operation of the three major dams, all of which present impassible barriers. The extent to which anadromous fish species utilized reaches upstream of lakes is uncertain. It is clear however, that if accessible, the habitat was and is capable of supporting populations of spring chinook, steelhead/rainbow trout, bull trout, and sockeye salmon. The current and historical distribution of the focal species in the Yakima Subbasin is illustrated in the focal species discussions of the fish assessment.

Spring Chinook Salmon

In the Upper Elevation Yakima Assessment Unit, spring chinook distribution is currently limited to the Teanaway River basin, although historically they utilized the Cle Elum River upstream of Cle Elum Lake (Figure 2-38). Roughly 21 miles of the Cle Elum basin that was formerly accessible to spring chinook is now inaccessible. An additional 9 miles upstream of Keechelus Dam and Kachess Dam are currently inaccessible but could support spring chinook spawning and rearing, but whether these areas formerly supported viable populations of chinook is uncertain. Spring chinook currently spawn and rear in low numbers in the mainstem Teanaway River and in the North Fork Teanaway River as far as Stafford Creek (RM 8.3) although this area was historically one of the top producers of spring chinook (Bryant and Parkhurst 1950, as cited in YSP 1990). In 1997 the Cle Elum Supplementation and Research Facility (CESRF) began a program to determine if the abundance of spring chinook could be increased by artificial introductions (Fast and Pearson unpublished). It appears that introductions of spring chinook from the CESRF have increased the abundance of spawning fish and may lead to reestablishment of a spring chinook population or subpopulation in the Teanaway River. Roughly 810,000 smolts have been released annually as part of this program some of which were released at the Jack Creek facility on the North Fork Teanaway River. Efforts to evaluate the success of this program are currently underway. There is a potential for hatchery fish to compete with natural origin fish for space and food resources, this is the focus of ongoing study related to the CESRF.

Fall Chinook Salmon

Fall chinook did not historically, and do not currently, utilize stream habitat in the High Elevation Yakima Assessment Unit.

Steelhead / Rainbow Trout

Although the historic distribution of steelhead trout in the High Elevation Yakima Assessment Unit is poorly known, steelhead likely utilized many of the same tributaries utilized by spring chinook (NPPC 2001), and it would be typical for some use by rainbow trout to occur upstream of the upper extent of chinook use. Steelhead trout distribution in the Assessment Unit is currently restricted to the Teanaway River basin (Figure 2-45), where roughly 51 miles of the Teanaway River and its tributaries are accessible to steelhead trout (NPPC 2001). Steelhead have been observed spawning on a number of occasions in the mainstem Teanaway and in the lower West Fork (Hockersmith et al. 1995; YN, unpublished data, 2001). Recent information (WDFW 2003, the fish distribution maps) indicates that resident rainbow trout do not occur in the drainages upstream of the three reservoirs, other information suggests that rainbow trout do occur in the upper Cle Elum drainage to and above Waptus Lake (J. Cummins, pers.comm.), in fact the upper distribution of steelhead and rainbow trout in these high elevation areas remains uncertain.

Sockeye / Kokanee Salmon

Sockeye salmon were historically abundant in the High Elevation Yakima Assessment Unit but were extirpated in the 1920's following completion of impassible storage dams below Cle Elum, Kachess, and Keechelus lakes. The spawning distribution of sockeye was never extensive, even prior to 1850 (Figure 2-56). Kokanee salmon, a landlocked form of sockeye salmon, occur in all three of the reservoirs present in the Assessment Unit (WDFW 2003, source of GIS data). Both kokanee and adfluvial bull trout utilize the reservoirs for the majority of their life history, excluding brief periods where spawning, egg incubation and emergence, and outmigration occur. The current operation and management of the reservoirs is not conducive to beach spawning sockeye (Figure 2-87 and 2-88) because of flucuating and low water levels through the spawning and incubation season. If reintroduction is to be successful sufficient habitat must exist in the tributaries to support a viable population, therefore the most likely reservoir to begin reintroduction of sockeye to this Assessment Unit is Cle Elum, where a large tributary system with relatively good habitat conditions exists.

Bull Trout

Bull trout are known to occur throughout the Upper Elevation Yakima Assessment Unit. Resident and fluvial bull trout were observed upstream of Dereux Campground in the North Fork Teanaway in 1997, and juveniles have been observed in Jack Creek, Jungle Creek, and in De Roux Creek, although spawning has been observed only in De Roux Creek (WDFW 1998). The fluvial bull trout population in the North Fork Teanaway River is believed to be at high risk of extinction (USFWS 2002) due to limiting habitat area and isolation from other populations. All of the existing storage reservoirs currently support populations of adfluvial bull trout, which spawn in the larger tributaries including the upper Cle Elum River, Box Canyon Creek, the Kachess River above the reservoir, and Gold Creek. The Box Canyon Creek bull trout population is naturally limited by spawning habitat.

Pacific Lamprey

Pacific lamprey utilization of the High Elevation Yakima Assessment Unit has not been documented (WDFW 2003, source of GIS maps).

Other Fish Species and Interactions

Native fish that have naturally reproducing populations in the Assessment Unit include Cutthroat trout, mountain whitefish and pygmy whitefish. There are naturally reproducing populations of non-native brook trout throughout the High Elevation Yakima Assessment Unit (WDFW 1998). Notable brook trout concentrations exist in the Cle Elum and Waptus Lake drainages. Probable impacts to bull trout include predation on juveniles and competition for food and space. Brook trout may also pose a serious genetic threat to bull trout due to the potential for hybridization (WDW 1992; Rieman and McIntyre 1993). Although evidence is limited, it appears that the resulting offspring in some circumstances are fertile, thus providing an avenue for further introgression with bull trout populations (USFWS 2002, Wydoski and Whitney 2003).

Other nonnative species introduced into the basin include brown trout and lake trout (WDFW 1998; Snyder and Stanford 2001). Brown trout were found in Cooper Lake (upper Cle Elum River) in 1987, most likely the result of an unauthorized introduction. Surveys conducted in 1995 confirmed the presence of a wide range of sizes of brown trout, suggesting that natural reproduction is occurring. In 1996, brown trout were also discovered in the lower Waptus River.

Lake trout were probably stocked into Cle Elum, Kachess, and Keechelus lakes before 1933 (WDFW 1993). Lake trout are thought to be reproducing in Cle Elum Lake. While the abundance of lake trout in this lake is thought to be low, information regarding their current status is limited. Introductions into Kachess and Keechelus lakes are thought to have been unsuccessful; however, there are no data to confirm the present status in either lake (WDFW 1998). The potential for competition and predation on bull trout should be investigated, and if warranted, actions to reduce the impact implemented.

Stream Channel Condition and Function

Table 2-29. High Elevation Yakima Assessment Unit stream groups

Stream Group	Major Streams or Tributaries included in Group
Teanaway River	Teanaway River North Fork Teanaway River Middle Fork Teanaway River West Fork Teanaway River Jack Creek Indian Creek MasonCreek
Upper Lakes and Tributaries	Cle Elum Lake Cle Elum River Waptus Creek Cooper River Thorp Creek French Cabin Creek Kachess Reservior Kachess River Box Canyon Creek Keechelus Reservoir Gold Creek

Teanaway River

All of the mainstem Teanaway River as well as several miles of the tributary streams lie over deep alluvial deposits and prior to Euro-American settlement consisted of an unconfined network of anastomosed channels (NPPC 2001). Numerous channel alterations have occurred in the Teanaway River Basin. Large log drives out of the Teanaway basin began in the late 19th century and continued until a railroad spur was installed in 1914. Splash dams were built near the mouths of the forks and dynamited during spring runoff to move thousands of old-growth logs downriver to the Cascade mill in Yakima.

The torrent of logs swept away large woody debris, scoured the streambed, accelerated channel incision and lowered the water table. Evidence of these historic splash dams effects are still visible in the form of channel scour to bedrock and chronic bed instability in areas of sediment aggregation/diking. Stream channels were consolidated or diked to protect homes and fields. These alterations continue to reduce the frequency of out of bank flows and the degree to which shallow aquifers were recharged with cold spring run-off. Forestry activities have increased fine and coarse sediment load to the mainstem Teanaway River and its tributaries. In addition, clearcutting in the upper watershed has altered the hydrograph such that streams respond more rapidly to precipitation. Although the system was naturally somewhat flashy, changes in channel configuration (e.g., confinement and simplification) reduced the hydraulic roughness and floodplain connectivity that prolonged the duration and reduced the magnitude of peak flows. In addition, the lowering of the ground water table by confinement by roads and levees has resulting in the loss of side channels and other off channel habitat. Habitat diversity/temperature diversity has been reduced by loss of off-channel habitat (Teanaway). The extreme flashiness of the existing hydrograph causes bed scouring and reduces survival of incubating eggs and overwintering juveniles. Woody debris recruitment and retention is low in Teanaway River and has resulted in changes in channel morphology including the loss of pools and other key habitats. The current lack of large woody debris has allowed pools to be filled and gravel to be exported into the Yakima. Habitat diversity/temperature diversity has been reduced by loss of off-channel habitat (Teanaway).

Although the river has been channelized and rip rapped where it approaches Highway 97, there are extensive reaches where the river and the highway are far apart. Well over half of the mainstem is still anastomosing, even though the number of channels and interconnections is much lower than historically. Suitable spawning gravels and gradients for spring chinook, steelhead, and coho are present in most reaches of the mainstem and the lower portions of the forks, and are abundant in many areas.

Upper Lakes and Tributaries

The upper Cle Elum River is remarkably complex, containing a large, unconfined distributary fan near the lake, a confined canyon reach, a moderately steep (1.5 – 4 percent gradient) alluvial reach, and two lakes, one at the headwaters and one dividing two low gradient (0.5 – 1.0 percent gradient) lake outlet reaches with abundant, clean spawning gravel, and plentiful large woody debris.

Adult bull trout migration into and out of Box Canyon Creek, the primary spawning tributary to Kachess Lake, may be affected by the annual drawdown of the lake, especially during years where tributary inflow is low. As the lake is drawn down, the exposed stream channel on the lake bottom can become ill defined as it flows across the permeable lake sediments and may become too shallow for bull trout passage. In the fall of 1996, the Bureau of Reclamation constructed a single channel through the inundation zone. The project was successful in 1997 and 1998, but under some circumstances passage problems may still persist, particularly for adults returning to the reservoir. Similar passage problems for bull trout also occur in the Kachess River as it annually dewaters above the reservoir inundation zone. Gold Creek on the Keechelus River and Mineral Creek and the Upper Kachess are dewatered in late summer, preventing bull trout spawning and migration, and stranding of juvenile bull trout. The Box Canyon bull trout population is naturally limited by the availability of suitable spawning habitat (less than 50 redds estimated capacity) due to natural falls. Because of the small population size and lack of suitable habitat, the long-term viability of this population is low. Special care should be taken to ensure this population’s viability and that the population remains connected to the population that spawns in to Kachess River mainstem.

Riparian / Floodplain Condition and Function

Teanaway River

The structure and character of the river has been completely changed because the river has been disconnected from its floodplain and the floodplain itself has been radically altered. In order to develop valley bottomland for agriculture, wet meadows were drained and side channels were filled. Whatever beaver survived the fur trade of the early 19th century were removed because of their tendency to build dams in or near irrigation ditches. Diking and channelization have promoted the further drying out of remaining wet meadows and wetlands. Log drives lowered the riparian water table even more, retarding revegetation. In several locations in the middle and upper watershed, County and Forest roads have been located directly adject to the active channel. These roads have been protected with riprap and the riparian zone eliminated. Relocation of these road could improve riparian condition and lower sediment loading to the stream.

Despite extensive alterations, a fairly extensive wet meadow/wetland complex still exists in the lowermost several miles of the mainstem, and this area has been identified as a critical piece of habitat and a top priority for preservation. Many mature cottonwoods still line the banks of the mainstem and the lower portions of the forks, but regular spring and winter-time floods have so widened the channel that the shade from these trees in the summer does not reach the remaining flow concentrated in the center of the channel. The Washington Department of Ecology has recently applied for and been granted funds to implement a riparian restoration project to attempt to reduce summer water temperatures.

Upper Lakes and Tributaries

The riparian corridor of the Cle Elum River upstream of the reservoir is in generally good condition (YSP 1990, WDFW 1998), with the exception of impacts from roads and dispersed recreational activities that are the focus of restoration activities by the US Forest Service. Harassment of bull trout, through fishing/poaching pressure is high in Box Canyon and Gold Creek, resulting in decreased spawning success. Actions have recently been taken to reduce harassment pressure, but this problem is especially significant for the Box Canyon population that already has a very limited amount of spawning habitat.

Water Quantity

Teanaway River

The flow regime in the Teanaway River has been altered significantly from historic conditions. Peak runoff occurs about a month earlier than under historic conditions and base flows are much lower. Irrigation diversions in the lower five miles of the mainstem in dry years reduce base flows to very low levels and may preclude adult spring chinook access to the upper tributaries. The extremely low base flows that occur now (the minimum mean daily flow over years 1994 – 200 ranges from 6 to 15 cfs) not only preclude adult access, but strand or isolate juveniles in small pools where they fall victim to predators and increase temperatures dramatically. The USBR and BPA have, however, recently begun a piping and conversion of surface diversions to groundwater diversion project intended to spare this critical last increment of instream flow. The degree to which these actions will reduce stranding or isolation of juveniles and impassible low flows for returning adults will is unknown due to other attributes such as channel condition and stream temperatures during the migration period.

Upper Lakes and Tributaries

The Bureau of Reclamation resevoirs are currently operated to provide irrigation flows for downstream users during the dryer part of the year. Flows are also managed to avoid de-watering spring chinook redds in the mainstem of the Yakima River. Consequently the timing, magnitude, and duration of lake level changes are considerably different than under natural conditions. Low water levels can also cause the formation of passage barriers that prevent migrating bull trout from accessing tributaries upstream of the lakes, especially during years where there are low flows in the reservoir tributaries. Figures 2-87 and 2-88 show the relation between lake levels and life history stages of bull trout and sockeye/kokanee.

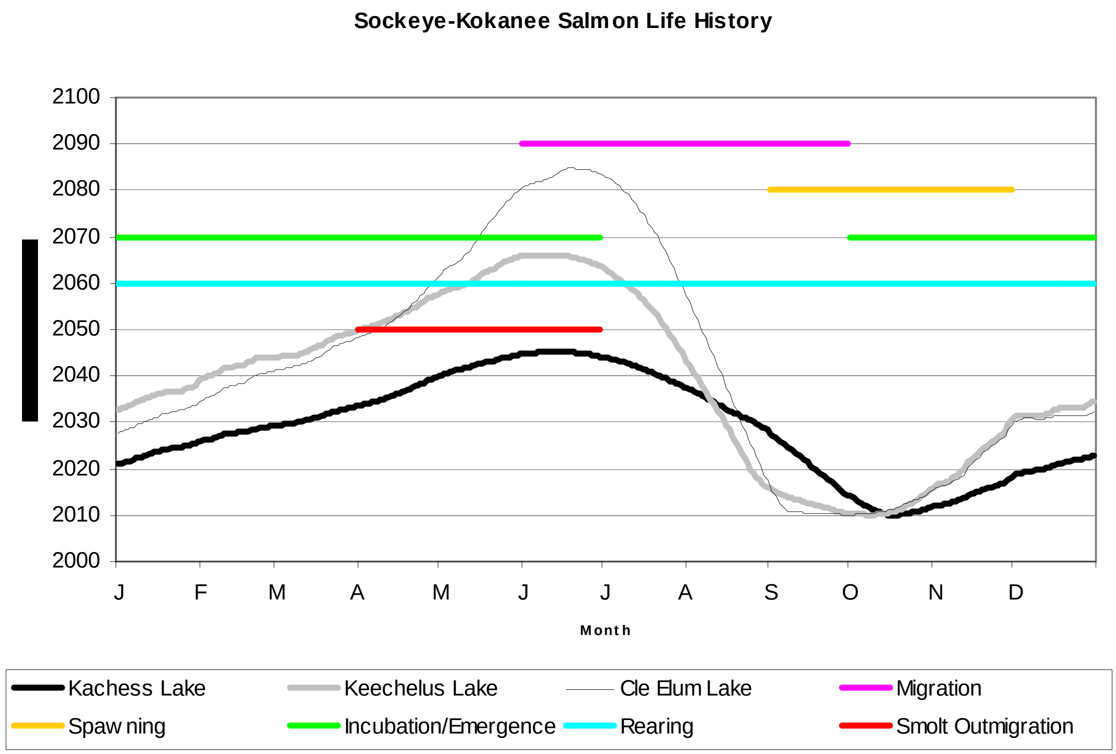


Figure 2-90. Sockeye-kokanee life history vs lake level

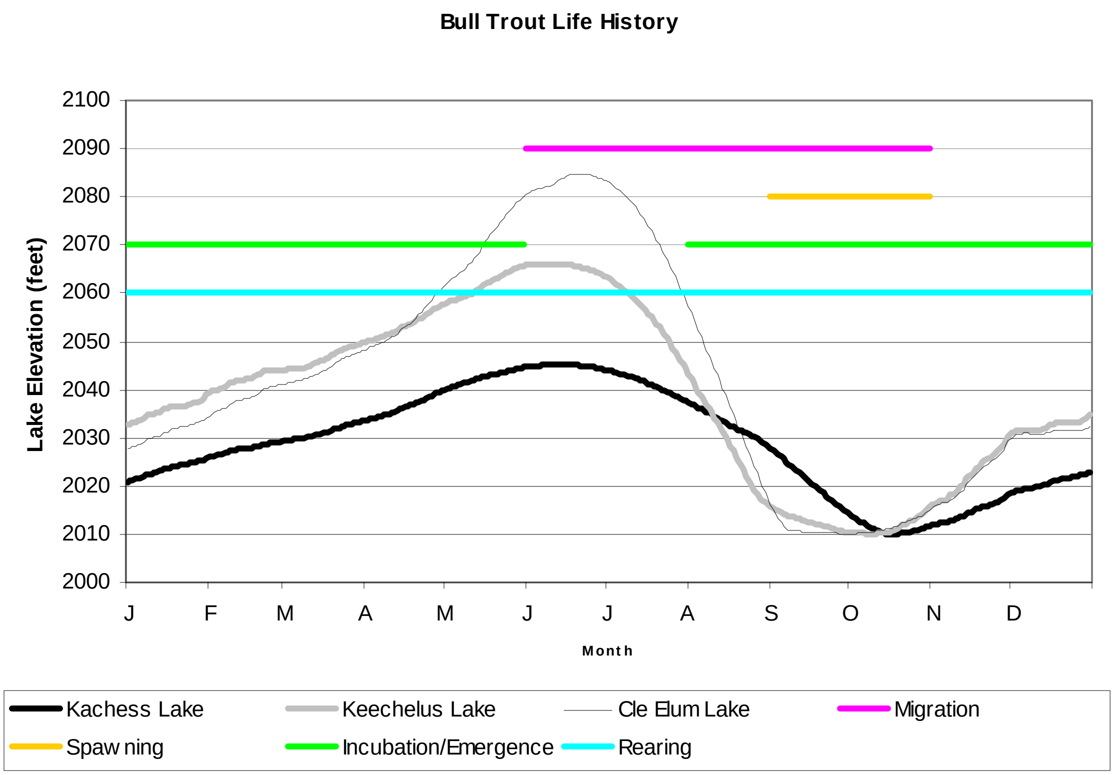


Figure 2-91. Bull trout life history vs lake level

Water Quality

Teanaway River

Water quality in the Teanaway River basin is affected by a number of factors including stream channel condition, riparian and floodplain condition, flow regime, and prevailing climatic conditions. As stated previously, the Teanaway was likely naturally disposed to high summer temperature due to the south facing aspect of the basin and natural runoff patterns, development within the basin has aggravated these conditions. The mainstem, Middle Fork, North Fork, and West Fork Teanaway River are all included on the Clean Water Act (CWA) 303(d) impaired water quality list for water temperature. Numerous excursions from state water quality standards have been noted in each area. July water temperatures over 70^{o}F have been observed in the lower North Fork (T. Pearsons, WDFW, pers.comm., 1998), and temperatures in the mid-70s have been observed in the lower mainstem in early September of 1998 (YN, unpublished data, 1998). Stafford Creek, a tributary of the North Fork Teanaway, is also on the CWA 303(d) impaired water quality list for water temperature. Low Flow/Temperature conditions in the Teanaway River alter the timing and hinder rate of migration for both anadromous and resident species.

Upper Lakes and Tributaries

Water quality in the basin upstream of Cle Elum Lake is affected by a number of factors including stream channel condition, riparian and floodplain condition, flow regime, and prevailing climatic conditions.

Thorp Creek, Cooper River, and Waptus River (all tributaries to Cle Elum River upstream of Cle Elum Lake) are on the CWA 303(d) impaired water quality list for water temperature, but these temperatures may be near natural conditions due to the presence of natural lakes which contribute naturally high temperature water from their outlets.

Protection Key Findings for High Elevation Yakima Assessment Unit:

- The fluvial bull trout population in the North Fork Teanaway River is believed to be at high risk of extinction (USFWS 2002) due to limiting habitat area and isolation from other populations.
- All of the existing storage reservoirs currently support populations of adfluvial bull trout, which spawn in the larger tributaries including the upper Cle Elum River, Box Canyon Creek, the Kachess River above the reservoir, and Gold Creek. The Box Canyon Creek bull trout population is naturally limited by spawning habitat. Well over half of the mainstem Teanaway is still anastomosing, even though the number of channels and interconnections is much lower than historically. Suitable spawning gravels and gradients for spring chinook, steelhead, and coho are present in most reaches of the mainstem and the lower portions of the forks, and are abundant in many areas. The upper Cle Elum River is remarkably complex, containing a large, unconfined distributary fan near the lake, a confined canyon reach, a moderately steep (1.5 – 4percent gradient) alluvial reach, and two lakes, one at the headwaters and one dividing two low gradient (0.5 – 1.0percent gradient) lake outlet reaches with abundant, clean spawning gravel, and plentiful large woody debris.
- The Box Canyon bull trout population is naturally limited by the availability of suitable spawning habitat (less than 50 redds estimated capacity) due to natural falls. Because of the small population size and lack of suitable habitat, the long-term viability of this population is low. Special care should be taken to ensure this population’s viability and that the population remains connected to the population that spawns in to Kachess River mainstem.
- Despite extensive alterations, a fairly extensive wet meadow/wetland complex still exists in the lowermost several miles of the mainstem, and this area has been identified as a critical piece of habitat and a top priority for preservation.
- The riparian corridor of the Cle Elum River upstream of the reservoir is in generally good condition (YSP 1990, WDFW 1998).
- Harassment of bull trout, through fishing/poaching pressure is high in Box Canyon and Gold Creek, resulting in decreased spawning success.

Restoration Key Findings for High Elevation Yakima Assessment Unit:

- Anadromous populations including spring chinook, stealhead, and sockeye have been extripated from this Unit due to unpassable dams.
- The distribution and abundance of these species has been heavily influenced by the placement and operation of the three major dams, all of which present impassible barriers. Lack of fish passage facilities at Kachess, Keechelus, and Cle Elum dams has resulted in the extirpation of sockeye and other anadromous species above the dams and disconnected resident populations, including bull trout, as well.
- The Teanaway was likely naturally disposed to high summer temperature due to the south facing aspect of the basin and natural runoff patterns, development within the basin has aggravated these conditions. The mainstem, Middle Fork, North Fork, and West Fork Teanaway River are all included on the Clean Water Act (CWA) 303(d) impaired water

quality list for water temperature. July water temperatures over 70^{o}F have been observed in the lower North Fork, and temperatures in the mid-70s have been observed in the lower mainstem in early September of 1998. Stafford Creek, a tributary of the North Fork Teanaway, is also on the CWA 303(d) impaired water quality list for water temperature.

- Low Flow/Temperature conditions in the Teanaway River alter the timing and hinder rate of migration for both anadromous and resident species.
- Reservoirs are not managed to replicate/replace provide the habitat, flow, temperature or ecological functions and processes that the glacial lakes provided. The majority of water released from these facilities is transported to the lower basin during periods of the summer and early fall when the river would otherwise be approaching base flow a
- Habitat in this AU was and is capable of supporting populations of spring chinook, steelhead/rainbow trout, bull trout, and sockeye salmon.
- Spring chinook currently spawn and rear in low numbers in the mainstem Teanaway River and in the North Fork Teanaway River as far as Stafford Creek (RM 8.3) although this area was historically one of the top producers of spring chinook (Bryant and Parkhurst 1950, as cited in YSP 1990).
- The current operation and management of the reservoirs is not conducive to beach spawning sockeye because of low water levels through the spawning and incubation season. If reintroduction is to be successful sufficient habitat must exist in the tributaries to support a viable population, therefore the most likely reservoir to begin reintroduction of sockeye to this Assessment Unit is Cle Elum, where a large tributary system with relatively good habitat conditions exists.
- There are naturally reproducing populations of non-native brook trout throughout the High Elevation Yakima Assessment Unit (WDFW 1998). Notable brook trout concentrations exist in the Cle Elum and Waptus Lake drainages. Probable impacts to bull trout include predation on juveniles and competition for food and space. Brook trout may also pose a serious genetic threat to bull trout due to the potential for hybridization (WDW 1992; Rieman and McIntyre 1993).
- Numerous channel alterations have occurred in the Teanaway River Basin. Large log drives out of the Teanaway basin began in the late 19th century and continued until a railroad spur was installed in 1914. Evidence of these historic splash dams effects are still visible in the form of channel scour to bedrock and chronic bed instability in areas of sediment aggregation/diking.
- Forestry activities have increased fine and coarse sediment load to the mainstem Teanaway River and its tributaries. In addition, clearcutting in the upper watershed has altered the hydrograph such that streams respond more rapidly to precipitation.
- Although the system was naturally somewhat flashy, changes in channel configuration (e.g., confinement and simplification) reduced the hydraulic roughness and floodplain connectivity that prolonged the duration and reduced the magnitude of peak flows.
- In addition, the lowering of the ground water table by confinement by roads and levees has resulting in the loss of side channels and other off channel habitat.
- Loss of habitat diversity/temperature diversity has been reduced by loss of off-channel habitat (Teanaway).
- The extreme flashiness of the existing hydrograph causes bed scouring and reduces survival of incubating eggs and overwintering juveniles.

- Woody debris recruitment and retention is low in Teanaway River and has resulted in changes in channel morphology including the loss of pools and other key habitats.The current lack of large woody debris has allowed pools to be filled and gravel to be exported into the Yakima.
- Management of reservoir water levels can create obstructions to access of tributaries for bull trout on spawning migrations. Adult bull trout migration into and out of Box Canyon Creek, the primary spawning tributary to Kachess Lake, may be affected by the annual drawdown of the lake, especially during years where tributary inflow is low. Gold Creek on the Keechelus River and Mineral Creek and the Upper Kachess are dewatered in late summer, preventing bull trout spawning and migration, and stranding of juvenile bull trout.
- The structure and character of the river has been completely changed because the river has been disconnected from its floodplain and the floodplain itself has been radically altered.
- In several locations in the middle and upper watershed, County and Forest roads have been located directly adject to the active channel. These roads have been protected with riprap and the riparian zone eliminated. Relocation of these roads could improve riparian condition and lower sediment loading to the stream.
- with the exception of impacts from roads and dispersed recreational activities that are the focus of restoration activities by the US Forest Service.
- Teanaway peak runoff occurs about a month earlier than under historic conditions and base flows are much lower.
- Irrigation diversions in the lower five miles of the mainstem Teanaway in dry years reduce base flows to very low levels and may preclude adult spring chinook access to the upper tributaries.
- The extremely low base flows that occur in the Teanaway (the minimum mean daily flow over years 1994 – 200 ranges from 6 to 15 cfs) strand or isolate juveniles in small pools where they fall victim to predators and increase temperatures dramatically.

Key Uncertainties for High Elevation Yakima Assessment Unit

- An additional 9 miles upstream of Keechelus Dam and Kachess Dam are currently inaccessible but could support spring chinook spawning and rearing, but whether these areas formerly supported viable populations of chinook is uncertain.
- In 1997 the Cle Elum Supplementation and Research Facility (CESRF) began a program to determine if the abundance of spring chinook could be increased by artificial introductions (Fast and Pearson unpublished). It appears that introductions of spring chinook from the CESRF have increased the abundance of spawning fish and may lead to reestablishment of a spring chinook population or subpopulation in the Teanaway River.
- There is a potential for hatchery fish to compete with natural origin fish for space and food resources, this is the focus of ongoing study related to the CESRF.
- Recent information (WDFW 2003, the fish distribution maps) indicates that resident rainbow trout do not occur in the drainages upstream of the three reservoirs, other information suggests that rainbow trout do occur in the upper Cle Elum drainage to and above Waptus Lake (J. Cummins, pers.comm.), in fact the upper distribution of steelhead and rainbow trout in these high elevation areas remains uncertain.

- Recently piping and conversion of surface diversions to groundwater diversion intended to spare the critical last increment of instream flow have begun in the Teanaway. The degree to which these actions will reduce stranding or isolation of juveniles and impassible low flows for returning adults is unknown due to other attributes such as channel condition and stream temperatures during the migration period.
- Pacific lamprey utilization of the High Elevation Yakima Assessment Unit has not been documented (WDFW 2003, source of GIS maps).
- Lake trout are thought to be reproducing in Cle Elum Lake. While the abundance of lake trout in this lake is thought to be low, information regarding their current status is limited. Introductions into Kachess and Keechelus lakes are thought to have been unsuccessful; however, there are no data to confirm the present status in either lake (WDFW 1998). The potential for competition and predation on bull trout should be investigated, and if warranted, actions to reduce the impact implemented.

6.5.6 Mid Elevation Naches-Tieton Assessment Unit

Overview

The Mid Elevation Naches-Tieton Assessment Unit encompasses approximately 834 square miles (Figure 2-90). Its uppermost elevations begin along portions of the crest of the Cascade Mountains and its lowermost elevation is at its transition into the Mid-Yakima Floodplain Assessment Unit, just upstream of the Naches River confluence with Cowiche Creek. Elevation within the Assessment Unit ranges from 1,200 ft to 8,000 ft msl. The Assessment Unit receives approximately 54-63 inches of precipitation a year. According to the 2000 United States Census, approximately 18,653 people live in the unit. Predominant land uses in the Assessment Unit include forestry, recreation, and agriculture (Figure 2-89).

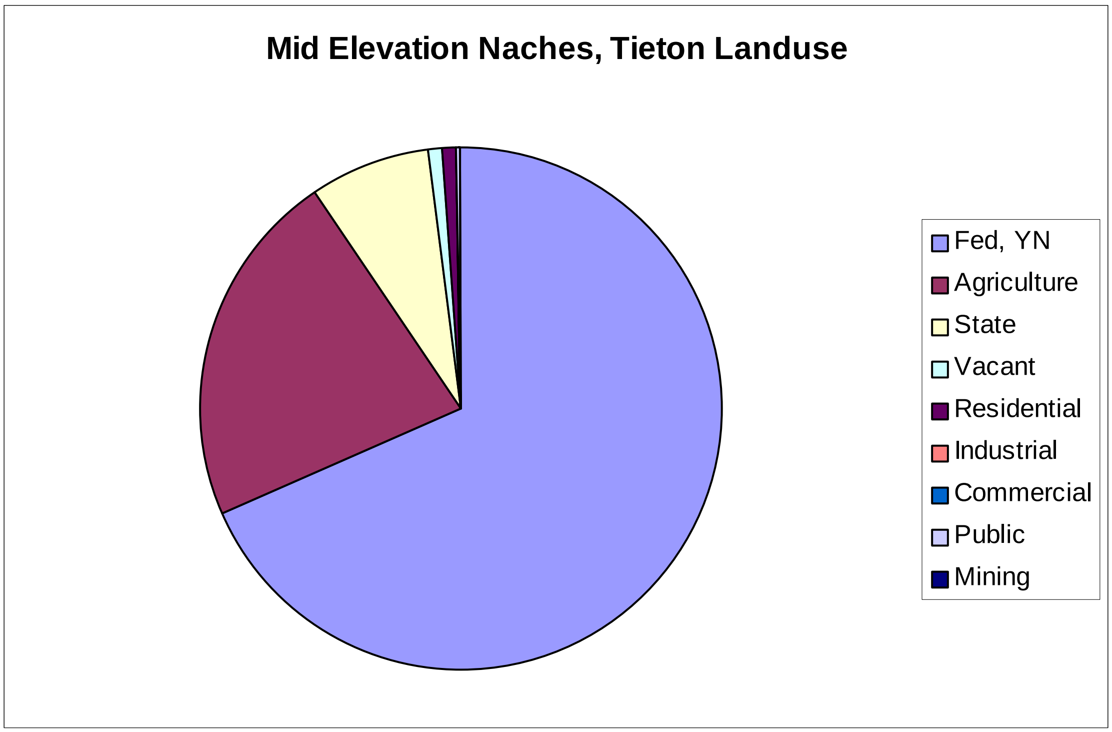


Figure 2-92. Comparison of land uses in Mid Elevation Naches-Tieton Assessment Unit

This unit consists of four subareas (Figure 2-89). The Little Naches River/Lower Bumping River subarea includes all the headwaters and tributaries of the Little Naches and the entire Bumping River watershed below the Bumping Lake Dam. The Rattlesnake Creek subarea includes the entire watersheds of Rattlesnake and Little Rattlesnake creeks down to the confluence with the Naches River at RM 27.8. The Tieton River subarea includes the entire Tieton watershed down to its confluence with the Naches at RM 17.5. The Naches River subarea includes all of the Naches, from its origin at the confluence of the Little Naches and Bumping rivers (Naches RM 44.6) down to the confluence of Cowiche Creek (Naches RM 2.7), as well as all its other tributaries not included within one of the other three subareas. Principal streams in each of these subareas are shown in the following Table 2-30

Table 2-30. Mid Elevation Naches-Tieton Assessment Unit stream groups

Sub area	Major Streams or Tributaries included in Sub area
Little Naches River/	Little Naches River North, Middle, South forks of Little Naches River Crow Creek Quartz Creek West Quartz Creek Bear Creek
Lower Bumping River	Lower Bumping River
Rattlesnake Creek	Rattlesnake Creek North Fork Rattlesnake Creek Little Rattlesnake Creek Hindoo Creek
Tieton River	Tieton River North, South forks of Tieton River Clear Creek Indian Creek Oak Creek
Naches River	Naches River Nile Creek

There is one major impoundment and several other dams in this unit (Figure 2-89). The Tieton Dam creates the Rimrock Lake impoundment. This reservoir is for storage only, with a 319-foot-high earthfill dam that was completed in 1925. It impounds a drainage area of 187 square miles. Bureau of Reclamation data indicates a peak inflow into the reservoir of 159,600 cfs and a total storage volume of 285,700 acre-feet. There is no fish passage provided at this dam. Due to the submerged and unscreened outlet of Rimrock lake, fish (principally Kokanee and Bull Trout) in the lake become entrained during the rapid drawdown of the lake in September and October.

A lesser storage-only impoundment, Clear Lake, is created by the Clear Creek Dam, which impounds the North Fork Tieton River just above the upstream end of Rimrock Lake. Here, Bureau of Reclamation data describes an 84-foot-high concrete arch dam that impounds a 60-square-mile drainage area (a subset of the Tieton Dam drainage area) with a capacity of 5300 acre-feet. Peak inflow volume is 36,450 cfs. USBR indicates that there is an 18-inch fish bypass, but the subbasin summary states that the North Fork Tieton is “rendered inaccessible or unusable by [the] unladdered dam” (p. 36). However, it subsequently states that there is a fish ladder, but “probably because of insufficient attraction flow, the ladder is not used by bull trout”.

In addition to the above dams, the Wapatox Dam, at Naches RM 17.1, is a diversion dam that historically supported a water diversion of as much as 450 cfs. There is fish passage through this diversion.

The Tieton Diversion Dam, at Tieton RM 14.2, is downstream of the Tieton Dam at Rimrock Lake. The diversion dam, built in 1908 is regarded as an upstream migration barrier during low flows.

As summarized in the Yakima Subbasin Summary (2001), “There are in addition several clusters of smaller diversions on the lower Naches below Wapatox. The South Naches Channel (RM 14.0) diverts up to 141 cfs (USBR Hydromet data) for seven small irrigation canals serving orchards on the right bank of the lower Naches, and discharges some of its diverted flow back to the river at about RM 10. Below the South Naches Channel diversion, the Kelley-Lowerey (RM 13.7) diverts up to 30 cfs, the Gleed (RM 9.4) up to 40 cfs, the Congdon (RM 8.8) up to 55 cfs, the Chapman-Nelson (RM 6.0) up to 40 cfs, the City of Yakima (RM 3.6) up to 15 cfs and the Naches-Cowiche (RM 3.6) up to 40 cfs.

While not a severe a problem as in other locations in the basin, some individual irrigation pumps and diversions remain unscreened. Replacement of these screens will result in improved productivity. At many locations in the upper reaches of the tributaries, culverts fully or partially block access, See Figure 2-90 for a depiction of current fish passage barriers.

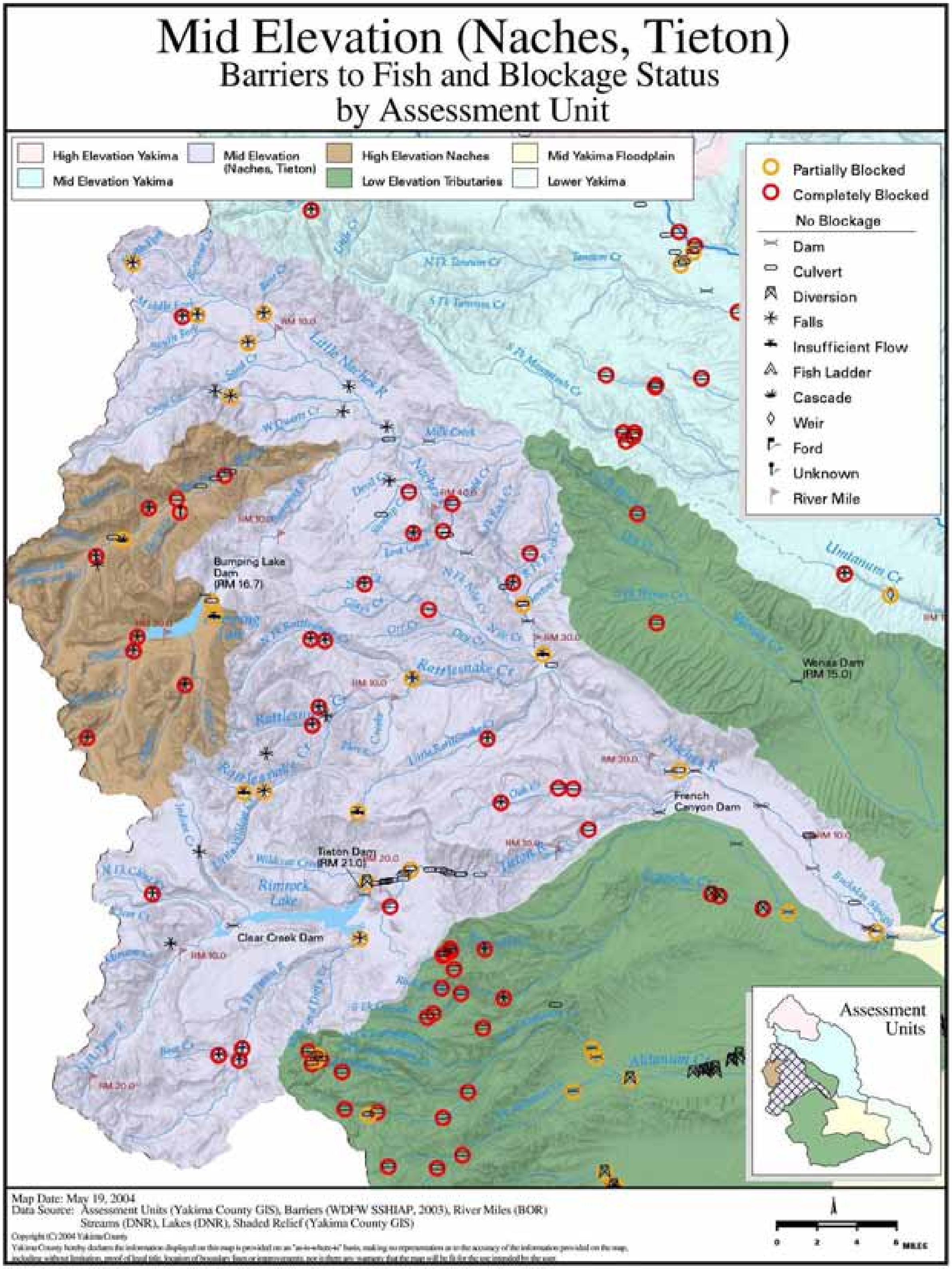


Figure 2-93. Barriers to fish passage in the Mid Elevation Naches-Tieton Assessment Unit

Aquatic Habitat

Species Distribution and Utilization

Spring chinook salmon, steelhead/rainbow trout, bull trout, Pacific lamprey and kokanee salmon are known to occur within the Assessment Unit. The distribution and abundance of these species has been heavily influenced by the placement and operation of the Rimrock Dam and the other small diversion dams that present partial barriers. A particular concern affecting juvenile salmonids is that the relatively sudden and dramatic increase in flow during flip-flop. The “flip-flop” reservoir management program of the Bumping and Rimrock reservoirs has reduced spawning and rearing habitat in the lower Naches and Tieton Rivers and caused juvenile downstream displacement from these rivers. At a minimum, the increases in flow associated with flip-flop can cause fish to vacate feeding territories and migrate to new areas, increasing competition and stress, reducing growth, and increasing the likelihood of mortality (CSRP 1990). The current and historical distribution of the focal species in the Yakima Subbasin is illustrated in the focal species section earlier in this document.

Spring Chinook Salmon

Current distribution of spring chinook salmon has likely remained relatively similar to historic except for streams rendered inaccessible or unusable by excessive irrigation diversions or releases (e.g., the lower Tieton River) (NPPC 2001). The Naches stock is one of the three genetically distinct Yakima stocks and is the second most populous stock in the basin. This stock spawns in the Bumping River, the Little Naches River, Rattlesnake Creek and in the mainstem Naches above the Tieton confluence.

Productivity of the Little Naches population is currently low possibly due to poor fitness of the population, naturally variable temperature and flow regimes (similar to Teanaway), and impacts from forestry management activities. Rattlesnake Creek supports spring chinook, as well as non-salmonids (WDFW 1998). Chinook redds are usually found from the mouth of Rattlesnake Creek to the Little Rattlesnake, although Naches Ranger District biologists discovered several spring chinook redds in Rattlesnake Creek above the North Fork in 1998 (K. Lindhorst, USFS, pers.comm., 1998).

Fall Chinook Salmon

Fall chinook did not historically utilize stream habitat in the Mid Elevation Naches Assessment Unit. Fish distribution data from WDFW (2003) indicates that fall chinook are utilizing the mainstem Naches from the mouth upstream to the confluence with the Tieton (Figure 2-45), but this area is not considered to contribute any abundance or productivity of fall chinook.

Steelhead / Rainbow Trout

It is probable that the historical spawning distribution of summer steelhead included virtually all accessible portions of Yakima Basin, with highest spawning densities occurring in complex, multi-channel reaches of the mainstem Naches, and in third and fourth order tributaries with moderate (1-4 percent) gradients (NPPC 2001).

In the Naches, 69 percent of spawning occurs in only two reaches, the Naches between Cowiche Creek. (RM 2.7) and the Tieton River (RM 17.5), and the Naches between Rattlesnake Creek (RM 27.8) and the Little Naches River (RM 44.6). The Bumping River (confluence at Naches RM 44.6) and the Naches between the Tieton River and Rattlesnake Creek each support 11.5

percent, and Rattlesnake Creek and the Naches from the mouth to Cowiche Creek each support 3.8 percent. Importantly, about 43 percent of all spawning occurs below the Tieton River confluence, and progeny are therefore subject to the most severe impacts of flip-flop (NPPC 2001). No spawning has been observed in the Tieton River. The lack of spawning in the Tieton is to be expected because it has been swept virtually clean of spawning gravel.

It is very unlikely that steelhead or even spring chinook would be able to spawn in the large rubble in the main channel now, but steelhead can and do spawn in the lower Naches. Steelhead are spawning in higher elevation side channels and floodways that are inundated during April and May. The viability of many of these redds is, however questionable, given the rapid drop of flows during the late spring. It is very likely that many are dried up before emergence is complete in June and July.

Sockeye / Kokanee Salmon

Sockeye salmon and kokanee trout were not present historically in the Mid Elevation Naches Assessment Unit but were introduced in the 1920's (Lake Whatcom stock) following completion of Rimrock Dam (WDFW 2003). These non-native stocks may present genetic risks to sockeye if they are able to exit Rimrock and interbreed with sockeye. Both kokanee and adfluvial bull trout utilize the reservoir for the majority of their life history, excluding brief periods where spawning, egg incubation and emergence, and outmigration occur. Kokanee provide the major forage base for the adfluvial bull trout present in Rimrock reservoir.

Bull Trout

Bull trout are known to occur throughout the Mid Elevation Naches Assessment Unit. Local fluvial populations have been identified in Naches River tributaries (Rattlesnake Creek, and Crow Creek) and adfluvial populations in Indian Creek and S. Fork Tieton River above Rimrock reservoir. Bull trout redds have been observed above the North Fork Rattlesnake Creek confluence (WDFW 1998), and rearing occurs in the mainstem Rattlesnake Creek as well as Hindoo Creek. Bull trout populations are fragmented by the loss of passage at Rimrock and Bumping dams, making these populations more vulnerable to extinction over the long term. Management of reservoir water levels can create obstructions to access of tributaries for Bull trout on spawning migrations (Rimrock).

Bull trout have also been observed in the Little Naches River, the Bumping River below Bumping dam, the Tieton River below Rimrock dam and other small tributaries (WDFW 1998).

Historically the South Fork Tieton population exhibited a fluvial life history and the Indian Creek population had a resident life history, but after the construction of Rimrock Dam, both of these populations evolved into distinct adfluvial populations. Based on spawning surveys, the Rimrock populations represent the strongest stocks in the Yakima Core area.

Grazing impacts bull trout in SF Tieton River. The grazing occurs during spawning and can impact spawning by repeated disturbance of spawning fish, and redds through trampling by cattle either resting, drinking from or crossing SF Tieton.

Pacific Lamprey

Pacific lamprey utilization of the Mid Elevation Naches Assessment Unit has been documented by Wydoski and Whitney (2003).

Other Fish Species and Interactions

Non-native brook trout were stocked in the Rimrock Lake drainage in the past, but stocking was eliminated due to concerns over hybridization with bull trout (WDW 1992). However, naturally reproducing brook trout populations still persist in some areas of the Naches drainage. One bull/brook hybrid was captured in October, 1994 in a trap at the mouth of Indian Creek. Hybridization was confirmed through genetic analysis (WDFW 2002). Widespread hybridization does not appear to have occurred in the drainage. Cuthrout trout and mountain whitefish are common in the Assessment Unit.

Stream Channel Condition and Function

Naches River

The Naches River has a moderate gradient averaging 0.58 percent (0.28-0.71 percent range). There is a small, ~4-mile unconfined alluvial section centered on the Rattlesnake Creek confluence (Naches RM 27.8) and a large unconfined alluvial section extending from the Wapatox Dam (RM 17.1) to the Cowiche Creek confluence (RM 2.7). Outside of these alluvial areas, the river is generally confined—although not so tightly as to preclude a number of side channels and islands. Development has radically changed the structure and hydrograph of the lower Naches. The downstream end of the valley has been converted to orchards, residences, a golf course/trailer park/RV Park and, below the Cowiche confluence, a freeway and shopping mall. Most of the springbrooks and side channels that funneled into Buckskin Slough (a natural springbrook system in the lower Naches) have been filled, but a number still emerge from the ground for short distances and the lower 2-mile portion of Buckskin Slough itself still exists and is heavily used for spawning by coho and occasionally by steelhead. Highway 12 bisects the floodplain and restricts the river floodplain to half or less of its historical width. About half of the original cottonwood stands remain, the rest having been cleared for various kinds of development. Large woody debris is scarce, probably because of accelerated stream velocities and removal by private citizens, although some was recruited from upstream during the flood of 1996.

The South Naches channel, as well as a number of smaller springbrooks and side channels on the left bank, has been channelized and converted into irrigation canals. The diversity of channel types has been greatly reduced, and what was formerly a valley-wide complex of main channels, side channels, wall-base channels, sloughs, and wetlands is now generally two or three larger channels connected by braids, with a fair number of narrow, brushy side channels between a quarter mile and four miles long. The river is usually confined on both sides either by basalt canyon walls or by riprapped dikes or road embankments. Highway 410 parallels most of the left bank of the upper Naches and virtually all of the embankment is riprapped. In many places summer homes and residences on the right bank are protected by riprapped revetments as well. Bedload movement is apparent in some of the more narrowly confined reaches, and the right bank revetments have cut off historical side channels and springbrooks.

The proportion of fine sediments in the lower Naches appears to be quite high. The dominant substrate particles are from one half to three quarters embedded. The narrower, faster flows of the Naches transport smaller particles into the middle Yakima. The substrate of the lower Naches is now an unusual mix of large (5-7 inches) cobble and sand except in some floodways and side channels where smaller gravels heavily embedded in sand are found.

There have been numerous changes to sediment transport processes in this Asseessment Unit. Most significantly, Rimrock Dam has starved the Tieton and portions of the Naches of sediment since its construction. This has resulted in severe degradation to the habitat conditions in the Tieton River.

In the Lower Naches structure such as levees; roads and railroads which act as levees, bridges, irrigation intakes, and the Yakima Waste Treatment Plant and associated bank armoring have constricted the floodplain and increased sediment transport in some locations, variation in width of the levees has resulted in constrictions that effectively reduce gradient, creating depositional zones in other locations. Channel characteristics are therefore an alternating series of unstable erosion and deposition zones separated by large areas more or less "natural" channel characteristics.

In the Little Naches, the construction of the main Forest Service road up the Little Naches has resulted in loss of floodplain and channel constriction for several miles in the lower river. This contributes to channel instability.

The irrigation diversion dam at Powerhouse Road acts to change the gradient of the Naches River, causing sediments to be deposited upstream, and starvation of downstream reaches. This seriously disrupts hyporheic function in this lower reach by elimination through filling of existing springbrooks and preventing the formation of new ones.

Little Naches /lower Bumping River

The Little Naches River is a free-flowing stream as it joins with the Bumping River to form the Naches River. The Bumping River ends at the Bumping Lake Dam, which separates that watershed into distinct upper and lower reaches. Little Naches tributaries accessible to upstream migrants include Crow Creek, Quartz Creek, and the North, Middle and South Little Naches forks. Although of different sizes in terms of mean annual flow, these and other Naches tributaries have a similar, moderate gradient of from slightly less than 1.0 percent (Bumping River below American confluence) to slightly more than 2.0 percent (Rattlesnake Creek). The Little Naches River is unregulated and is not diverted, but the Bumping River is regulated. The lower Bumping River is a stable, pocketwater type stream, with a few short side channels in lower gradient flats. Upstream of Salmon Falls, habitat in the Little Naches is nearly pristine, with abundant spawning gravel, excellent riparian condition, adequate summer flows, and plentiful large woody debris and instream cover (YSP 1990). However, the 4.4 miles of the Little Naches below Salmon Falls was severely degraded by a series of floods in the late-1970s, and by an emergency campground restoration and protection project that removed bedload material, widened and channelized the riverbed, and eliminated riparian vegetation (YSP 1990). An instream restoration project completed in 1988 included the installation of large boulders intended to scour holes for holding and rearing habitat and the planting of riparian vegetation. This project was not successful and the lower 4.4 miles of the Little Naches now affords the poorest spawning and rearing habitat in the drainage.

Although extensive gravel bars are not often found in the lower Bumping, patch gravel of high quality associated with large woody debris and large boulders is well distributed. Spawning gravel is abundant in the Little Naches River and tributaries, although fine sediment levels range from 12 percent to 24 percent (YSP 1990; J. Matthews, YN, pers.comm., 2000). Deposition of fine sediments has increased since the initiation of large-scale clearcutting in the upper watershed (YSP 1990, WDFW 1998).

Substrate condition in the lower Bumping River downstream is fair to good, with very little sedimentation of gravels (YSP 1990, WDFW 1998). The Bumping does, however, have many bouldery reaches unsuitable for spring chinook spawning, but which are probably adequate for steelhead (YSP 1990).

Tieton River

The Tieton River is significantly altered from its historic condition by the presence of a diversion dam and reservoir storage dam. These dams have altered flow patterns, sediment transport processes, thermal conditions, fish passage and other conditions.

Above the Tieton Dam, the upper watershed consists of the North and South forks of the river. Upstream of Rimrock Lake, the North Fork is, even today, somewhat steeper (gradient ~2.5 percent), with larger substrate and less complex channel structure, but an abundance of large woody debris. Clear Creek Dam, on the lower North Fork of the Tieton several miles upstream of Rimrock Lake, has a fish ladder. However, probably because of insufficient attraction flow, the ladder is not used by bull trout. Therefore, the North Fork of the Tieton has no known resident population of bull trout, although at least one single fish has been documented.

Although Tieton Dam also blocks the South Fork of the Tieton, there is a waterfall on the lower South Fork that is now inundated by Rimrock Lake. It is therefore possible that the South Fork would remain inaccessible to salmon and steelhead even if passage could be restored over Tieton Dam.

High flows associated with summertime releases of water from Rimrock Lake have swept the lower Tieton clean of gravel, in many places down to bedrock. In the lower Tieton, the quality of the small pockets of gravel that still exist is good, although heavy rains increase turbidity due to large natural slide areas (WDFW 1998). Because of the natural confinement, large woody debris probably never was abundant, and the few pools present were likely to have been associated with large boulders. The lower half of the reach has a slightly lower gradient and probably contained point bars of spawning gravel historically, but the substrate of the steeper upper section probably always consisted primarily of large rubble. Tributaries to the lower Tieton are small, flow through shrub-steppe, and sometimes go dry in the summer. The Yakima-Tieton diversion dam at RM 14.5 of the lower Tieton is a barrier to upstream migration at low flows (WDFW 1998).

Rattlesnake Creek

Rattlesnake Creek penetrates a very mountainous area, is slightly larger than other Naches tributaries (134 mi^2), is tightly confined in a very deep and steep-walled canyon above the Little Rattlesnake confluence (RM 1.1), and is very flashy. Major tributaries accessible to upstream migrants include Little Rattlesnake Creek (RM 1.1), the North Fork (RM 7.7) and Hindoo Creek (RM 13.2). An 8-ft cascade at RM 14.2 of Rattlesnake Creek may represent a passage barrier at low flows (Bryant and Parkhurst 1950). There is a substantial alluvial fan at its mouth where it enters the Naches River. This alluvial fan and the adjacent floodplain have been significantly altered by roads, irrigation diversions and housing development. During low flow or drought years the combination of low flow, diversions, and the porous nature of the alluvial fan can create passage problems for spring chinook and bull trout.

Substrate consists primarily of large cobble and gravel, and generally contains a low percentage of fines. Bedload movement is frequent and areas scoured to bedrock are common in the canyon. Pools are relatively numerous throughout, but usually lack cover, and the entire stream, except for the depositional area near the mouth, is lacking in large woody debris. Spawning habitat in Rattlesnake Creek and its tributaries is generally limited to patches—except in the lower mile.

Riparian / Floodplain Condition and Function

Naches River

Upstream of the confluence with the Tieton, riparian condition on the Naches are generally good to excellent, with some significant areas of lesser quality due to confinement by highways and roads, levee construction and homesite development. Downstream of the confluence, the riparian zone is significantly degraded in many locations. Much of the degradation on the north bank is due to the presence of Highway 12 in close proximity to the river. The flip flop management regime in this reach has had severe consequences on regeneration and even survival of cottonwood. This in turn has lead to sedimentation, channel widening and chronic instability, lack of woody debris recruitment, and other problems. Recent purchase of the Wapatox powerplant by the Bureau of Reclamation, and the significant restoration of summer flow to a large portion of this reach should improve riparian condition significantly in this reach.

Little Naches / lower Bumping River

The Little Naches River watershed is moderately large (102 mi^2) and heavily timbered, although extensive clear-cutting has occurred over the last decade. Historically the river flowed through a narrow, heavily wooded mountain valley. In many places the side walls are canyonlike, rising sheer from the river on one side or the other. The forests on the side slopes and river bottoms are composed principally of pine with fir, larch, hemlock and cedar also present. A few scattered cottonwood and alder are found along the streambanks. None of the valley is under cultivation. This is a fast moving stream with excellent riffles and fine spawning gravels. Deep holes are scattered throughout its course providing excellent cover and resting pools for migrating salmonids. Numerous windfalls and small logjams also provide cover. There is a small cascade, [Salmon Falls, with a total drop of about eight feet at RM 4.4. These falls were marginally passable, and have been improved by construction of a fishway in 1983. Its current riparian condition is regarded as excellent upstream of Salmon Falls (YSP 1990, WDFW 1998), but poor below (floods and channelization described previously).

The riparian corridor on the Bumping River is generally excellent, except in increasing numbers of areas where there are clusters of summer homes, with associated removal of riparian vegetation and riprap armoring of the streambanks (WDFW 1998). In the Little Naches, the condition of the upper watershed in some upland areas has, however, been damaged by extensive clear-cutting.

Tieton River

Riparian condition in the lower Tieton is reasonably intact except where eliminated by the embankment of Highway 12 (WDFW 1998).
The lower Tieton flows through a narrow, heavily forested canyon with steep side walls. The floodplain is minimal and the stream rarely flows through more than a single channel. The river is confined by the canyon walls on one side and the embankment of Highway 12 on the other for almost its entire length. Because of the natural confinement, large woody debris probably never was abundant, and the few pools present were likely to have been associated with large boulders. The lower half of the reach has a slightly lower gradient and probably contained point bars of

spawning gravel historically, but the substrate of the steeper upper section probably always consisted primarily of large rubble.

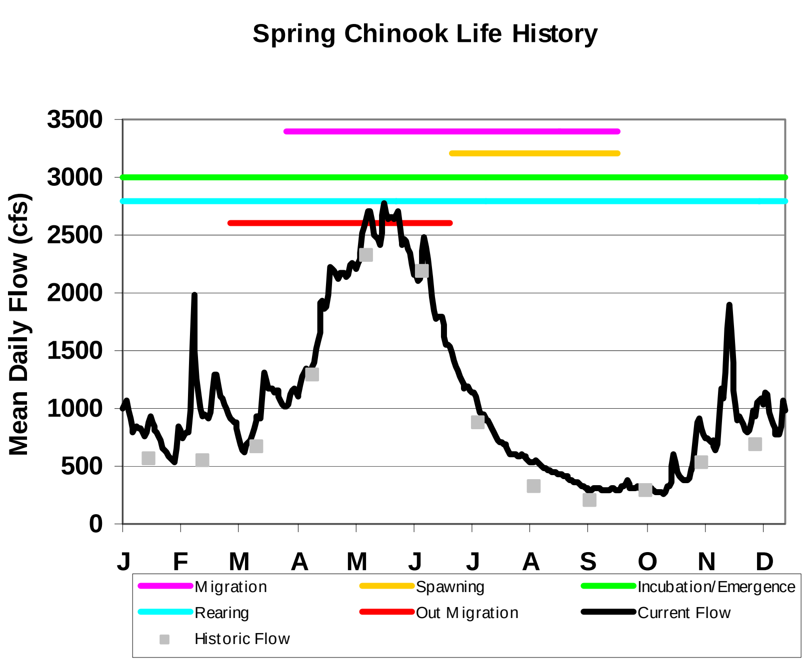
Rattlesnake Creek

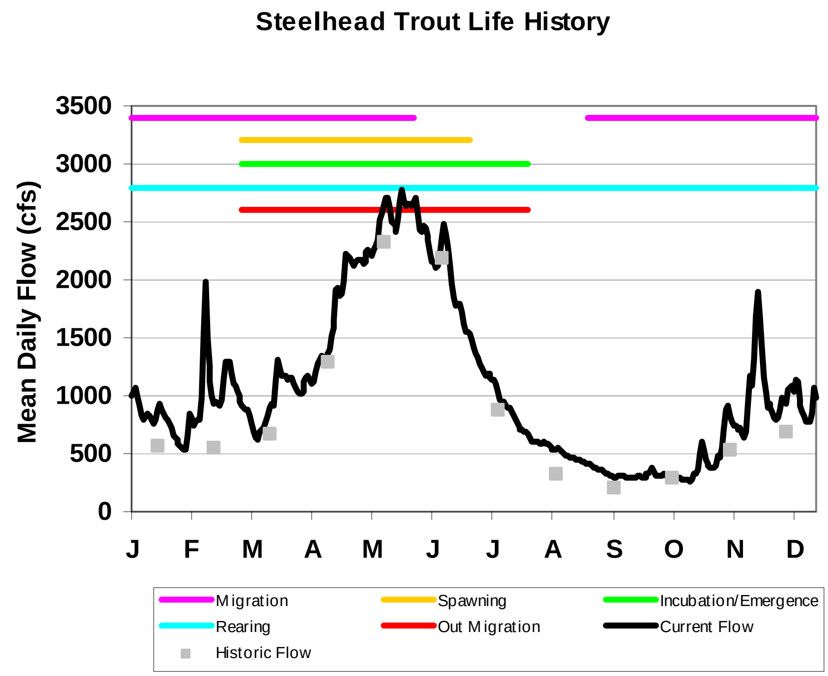
Conifers are abundant where side slopes of the canyon are not so steep as to preclude them. Before development and channelization, the lower several miles of the stream were fringed with dense growth of alders, willows, and cottonwoods. The middle canyon reaches are virtually devoid of woody vegetation because the spring freshet is large enough to strip the banks and scour the stream bottom, in some places to bedrock. Pools are relatively numerous throughout, but usually lack cover, and the entire stream except for the depositional area near the mouth is lacking in large woody debris. Upstream of the Little Rattlesnake confluence, riparian conditions along Rattlesnake Creek are good where the canyon walls are not too steep to support trees (Bryant and Parkhurst 1950).

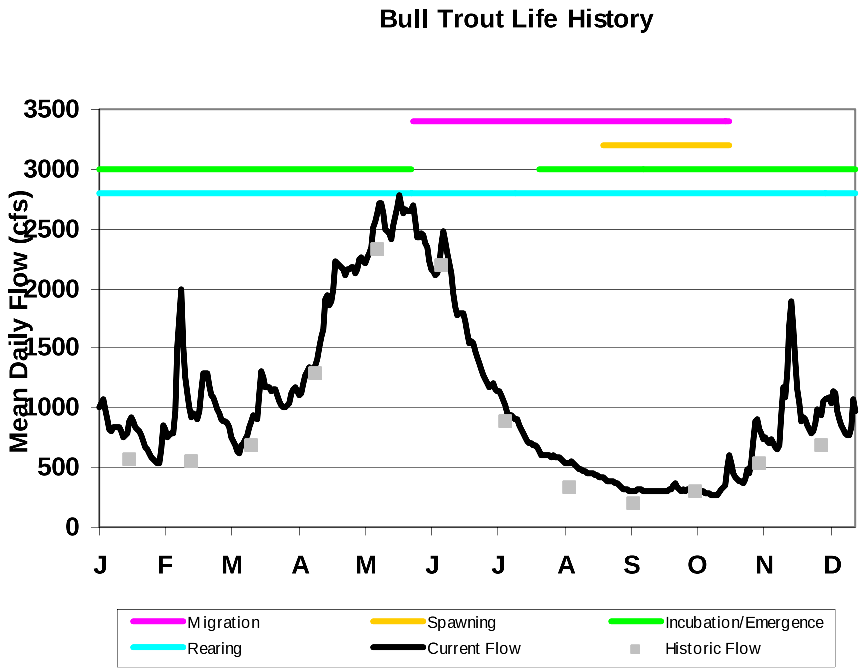
Water Quantity

Naches River

Water management in the Yakima/Naches basin incorporates a coordinated sequence of reservoir releases referred to as the “flip-flop”. This practice consists of emphasizing the release of waters from the reservoirs of the upper Yakima through the irrigation season until early September, during which time releases from Rimrock Lake and (to a much lesser degree Bumping Lake) are reduced. This pattern is then reversed (hence, “flip-flop”), with Rimrock and Bumping lakes providing all the water needed to support the Wapato and Sunnyside diversions, and a corresponding curtailment of releases from the upper Yakima reservoirs. The hydrograph in the upper Naches (Figure 2-94, based upon flows at the Cliffdell gage, RM 38.8) over the past seven years is virtually indistinguishable from the mean historical hydrograph. This is to be expected in a river reach subject only to the regulatory capacity of the 33,000 AF Bumping Reservoir.




Steelhead Trout Life History
Mean Daily Flow (cfs)
3500
3000
2500
2000
1500
1000
500
0
J
F
M
A
M
J
J
A
S
O
N
D
Migration
Spawning
Incubation/Emergence
Rearing
Out Migration
Current Flow
Historic Flow


Bull Trout Life History
Mean Daily Flow (cfs)
3500
3000
2500
2000
1500
1000
500
0
J
F
M
A
M
J
J
A
S
O
N
D
Migration
Spawning
Incubation/Emergence
Rearing
Current Flow
Historic Flow

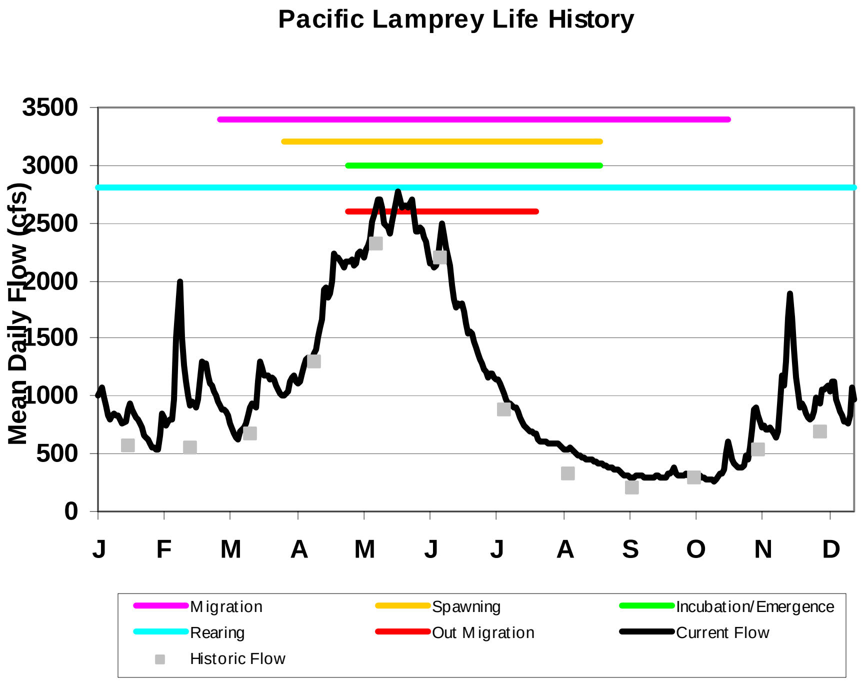


Figure 2-94. Comparison of current and historical average flow of the Naches River at Cliffdell with the life history stages of spring chinook, steelhead, bull trout, and Pacific lamprey. Hydrograph data from USBR (2004).

Within the lower Naches, up to 450 cfs was historically diverted at Wapatox Dam (RM 17.1) year round. Most of this water was used for hydroelectric generation and all but 50 cfs (which is used for irrigation April 1 – October 14) was returned to the river at a powerplant located at RM 9.7. The US Bureau of Reclamation has purchased the Wapatox Power Plant and diversion infrastructure, and is in the process of eliminating the water power diversion and setting up managment of the irrigation water right and infrastructure over the long term. There are, in addition, several clusters of smaller diversions on the lower Naches below Wapatox. The portion of the lower Naches which was most severely impacted by all of these diversions is the so-called “bypass reach”, which extends 7.4 miles from the Wapatox diversion to the powerplant outfall. Within the bypass reach, the Naches River had to supply the needs of the South Naches Channel and the Kelly-Lowerey Ditch before being recharged with ~400 cfs of Wapatox water at the powerplant. During drought years, flows had historically become exceedingly low in the bypass reach, resulting in stranding juvenile salmonids in the many side channels and braids.

Assessing the benefits of the Wapatox purchase is not possible at this time due to the ability that USBR has to manage the purchased water right through storage or transfer to benefit the fisheries resource. Final disposition of the water purchased with the Wapatox power plant has yet to be decided. It is certain that the restoration of flow to this reach will have a major beneficial effect on habitat forming processes in the Lower Naches.

Even with the restoration of flow to the bypass reach, summer low flows are still well below pre-1850 flows due to the flip flop flow regime. The length and severity of the low flow season have been increased by flow regulation resulting in an overall loss of habitat capacity due to reductions in habitat diversity, spatial temperature diversity (dewatered side channels) and habitat area.

Little Naches / lower Bumping rivers

The Little Naches River is unregulated but is not diverted, and the Bumping River is regulated. Water quantity is not a substantial issue in the lower Bumping except for rare periods of low flow associated with the malfunction or repair of the outlet structure at Bumping Dam. In the Little Naches, there has been some concern that clearcutting and fires in the upper watershed would increase peak flows, possibly to damaging levels, as well as decreasing already marginal summer low flows. There is, however, no conclusive evidence of a change in the hydrograph (YSP 1990; Figure 2-97). Low fall flows probably limit production of spring chinook in the Little Naches by reducing the quantity of suitable spawning habitat (YSP 1990, WDFW 1998).

Tieton River

The hydrograph of the lower Tieton River has been reversed as a result of impoundment above Tieton Dam and water releases for irrigation needs. The natural period of peak flows has been shifted from April-June to August through mid-October and increased in magnitude by about one third, from values on the order of 1,200 cfs to 1,800 cfs. Low flows during winter have been decreased radically, from historical values in the neighborhood of 200 cfs to values as low as 8-10 cfs in the past seven years, and to zero in the past.

Rattlesnake Creek

Rattlesnake Creek is unregulated, but diverted. The natural low flows combined with several diversions and the condition of the stream as it crosses the porous alluvial fan can create migration barriers for spring chinook, steelhead, and bull trout near the creek mouth, especially during drought years.

Water Quality

Naches River

Excursions from state water quality standards for water temperature have been documented on the Naches River, which is listed on the CWA Section 303(d) impaired water quality list for pH, silver (further sampling was recommended in 2001 as not consistent with other water quality samples), and temperature. In addition, water temperature excursions are documented for Gold Creek (tributary to upper Naches River, which is also on the 303(d) list). Of the these water quality problems, the most significant is temperature. Although the mean July and August water temperatures in the lower Naches over the years 1988-2000 are only 62.2^{o}F and 64.1^{o}F (USBR Hydromet data), maximum single day mean temperatures over this period have reached the mid 70s. Elevated temperatures can be expected to constitute a significant problem during very low flow years such as 1992 or 1994, when the entire flow of the stream is concentrated in a trickle in the center of the streambed, especially in the bypass reach. The effect of recent increases in flow on temperatures in the Bypass Reach is not currently known, but the Naches is the subject of a TMDL study for temperature in 2004-2005. Modeled temperature profiles and temperature monitoring associated with the study should provide this information.

Little Naches/lower Bumping Rivers

Currently, summertime water temperatures along the Naches can reach 72-73 ^{o}F (22.2 to 22.8^{o}C; Naches Ranger District, unpublished data). This increase is due to changes affecting the hydrology of the Bumping and Little Naches rivers. The percent fines in the Little Naches over the period 1991-1996 ranged from 11 to 24 percent (J. Matthews, YN, pers.comm., 2000).

Maximum water temperatures in the low 70s (Naches Ranger District, unpublished data) have been observed in both the Bumping and Little Naches Rivers near their mouths, where they merge to form the Naches. Despite the fact that maximum temperatures, particularly in low flow years like 1992 and 1994, can be stressfully high, mean summer temperatures are higher than optimal but not critically high. Mean July and August temperatures at Cliffdell (RM 38.8) over the years 1992 – 1999 were 60 and 63.4^{o}F (15.5 and 17.4^{o}C), respectively (USBR Hydromet data).

The Bumping River is listed on the CWA 303(d) impaired water quality list for water temperature. There were numerous excursions from the temperature standards documented on the Bumping River at the American Forks campground from 1991-1994, and the USFS has documented instances in which the maximum temperature exceeded 70^{o}F (21.1^{o}C). The differences between the current and historic temperature regime in the Bumping River is uncertain, since the natural Bumping Lake would also have contributed high temperature water to the river similar to results for the Upper Yakima lakes presented in Vaccarro (1986). Water quality in the Little Naches is quite good except occasionally for temperature (WDFW 1998). The following Little Naches tributaries have been placed on the CWA Section 303(d) impaired water quality list for temperature: Bear, Blowout, Mathew, and Crow Creeks. Water temperatures in excess of 70^{o}F (21.1^{o}C) have been observed in the lower Little Naches itself (Naches Ranger District, unpublished data).

Tieton River

Water quality is not an issue in the lower Tieton (YSP 1990, WDFW 1998). During the winter months, high turbidity can be observed in the Tieton and Naches Rivers. It appears that the source of this turbidity is wind and wave erosion of the bed of the reservior as it is being filled over the winter. The effects of this fine sediment load is unknown, but may be related to the embeddedness mentioned in the mainstem Naches earlier.

Rattlesnake Creek

Excursions from state water quality standards for water temperature have been documented on both Rattlesnake and Little Rattlesnake creeks, which are listed on the CWA Section 303(d) impaired water quality list for temperature. Other than temperature, water quality in Rattlesnake Creek is generally good.

Protection Key Habitat Findings for the Mid Elevation Naches-Tieton Assessment Unit:

- Historically the South Fork Tieton population exhibited a fluvial life history and the Indian Creek population had a resident life history, but after the construction of Rimrock Dam, both of these populations evolved into distinct adfluvial populations. Based on spawning surveys, the Rimrock populations represent the strongest stocks in the Yakima Core area.

Restoration Key Habitat Findings for the Mid Elevation Naches-Tieton Assessment Unit:

- Due to the submerged and unscreened outlet of Rimrock lake, fish (principally Kokanee and Bull Trout) in the lake become entrained during the rapid drawdown of the lake in September and October.
- Grazing impacts bull trout in SF Tieton River. The grazing occurs during spawning and can impact spawning by repeated disturbance of spawning fish, and redds through trampling by cattle either resting, drinking from or crossing SF Tieton.
- Grazing impacts bull trout in SF Tieton River. The grazing occurs during spawning and can impact spawning by repeated disturbance of spawning fish, and redds through trampling by cattle either resting, drinking from or crossing SF Tieton.
- Large woody debris is scarce, probably because of accelerated stream velocities and removal by private citizens, although some was recruited from upstream during the flood of 1996.
- Spawning gravel is abundant in the Little Naches River and tributaries, although fine sediment levels range from 12 percent to 24 percent (YSP 1990; J. Matthews, YN, pers.comm., 2000). Deposition of fine sediments has increased since the initiation of large-scale clearcutting in the upper watershed (YSP 1990, WDFW 1998).
- Low Flows reduce/eliminate habitat availability/quality/diversity.
- Lack of Habitat diversity (pools with cover)/Lack of Large Woody Debris.
- Productivity has been lost due to loss of access to habitat.
- While not a severe a problem as in other locations in the basin, some individual irrigation pumps and diversions remain unscreened.
- At many locations in the upper reaches of the tributaries, culverts fully or partially block access,
- The diversity of channel types has been greatly reduced. The river is usually confined on both sides either by basalt canyon walls or by riprapped dikes or road embankments
- Sediment transport processes have been altered in the Naches River.
- Flip-flop flow management negatively affects the entire suite of ecosystem functions in the Tieton and Naches reaches.
- Highway 410 parallels most of the left bank of the upper Naches and virtually all of the embankment is riprapped. In many places, riprapped revetments protect summer homes and residences on the right bank as well.
- Bedload movement is apparent in some of the more narrowly confined reaches, and the right bank revetments have cut off historical side channels and springbrooks.

- Management of reservoir water levels can create obstructions to access of tributaries for Bull trout on spawning migrations (Rimrock).
- Bull trout populations are fragmented by the loss of passage at Rimrock and Bumping dams, making these populations more vulnerable to extinction over the long term.
- Upstream of Salmon Falls, habitat in the Little Naches is nearly pristine, with abundant spawning gravel, excellent riparian condition, adequate summer flows, and plentiful large woody debris and instream cover (YSP 1990). However, the 4.4 miles of the Little Naches below Salmon Falls was severely degraded by a series of floods in the late-1970s, and by an emergency campground restoration and protection project that removed bedload material, widened and channelized the riverbed, and eliminated riparian vegetation (YSP 1990). This project was not successful and the lower 4.4 miles of the Little Naches now affords the poorest spawning and rearing habitat in the drainage.
- Rimrock Dam has inundated some of the most productive pre-1850 habitats in the Tieton Basin. Restoration of passage at Tieton Dam may not result in viable anadromous salmonid populations due to this habitat loss and severely altered habitats downstream.
- Pools are relatively numerous throughout, but usually lack cover, and the entire stream, except for the depositional area near the mouth, is lacking in large woody debris. Spawning habitat in Rattlesnake Creek and its tributaries is generally limited to patches—except in the lower mile.
- Within the lower Naches, up to 450 cfs was historically diverted at Wapatox Dam (RM 17.1) year round. Most of this water was used for hydroelectric generation and all but 50 cfs (which is used for irrigation April 1 – October 14) was returned to the river at a powerplant located at RM 9.7. The US Bureau of Reclamation has purchased the Wapatox Power Plant and diversion infrastructure, and is in the process of eliminating the water power diversion and setting up managment of the irrigation water right and infrastructure over the long term.
- Assessing the benefits of the Wapatox purchase is not possible at this time due to the ability that USBR has to manage the purchased water right through storage or transfer to benefit the fisheries resource. Final disposition of the water purchased with the Wapatox power plant has yet to be decided. It is certain that the restoration of flow to this reach will have a major beneficial effect on habitat forming processes in the Lower Naches.
- (Rattlesnake Creek)During low flow or drought years the combination of low flow, diversions, and the porous nature of the alluvial fan can create passage problems for spring chinook and bull trout.

Key Uncertainties for the Mid Elevation Naches-Tieton Assessment Unit:

- The effect of recent increases in flow on temperatures in the Bypass Reach is not currently known, but the Naches is the subject of a TMDL study for temperature in 2004-2005. Modeled temperature profiles and temperature monitoring associated with the study should provide this information.
- Productivity of the Little Naches population is currently low possibly due to poor fitness of the population, naturally variable temperature and flow regimes (similar to Teanaway), and impacts from forestry management activities. Planted kokanee in Rimrock Lake are successfully reproducing, and these fish from Whatcom Lake stocks may present genetic

risk to sockeye if they are reintroduced.Bull trout have reduced population viability due to competition and interbreeding with brook trout.

6.5.7 High Elevation Naches Assessment Unit

Overview

The High Elevation Naches Assessment Unit (Figure 2-94) encompasses approximately 155 square miles and is situated just east of the crest of the Cascade Mountains. Elevation within the Assessment Unit ranges from 2,800 ft to 7,700 ft msl. The Assessment Unit receives approximately 61-71 inches of precipitation a year. According to the 2000 United States Census, approximately 518 people live in the unit. The US Forest Service manages the vast majority of the land in this Assessment Unit (Figure 2-92).

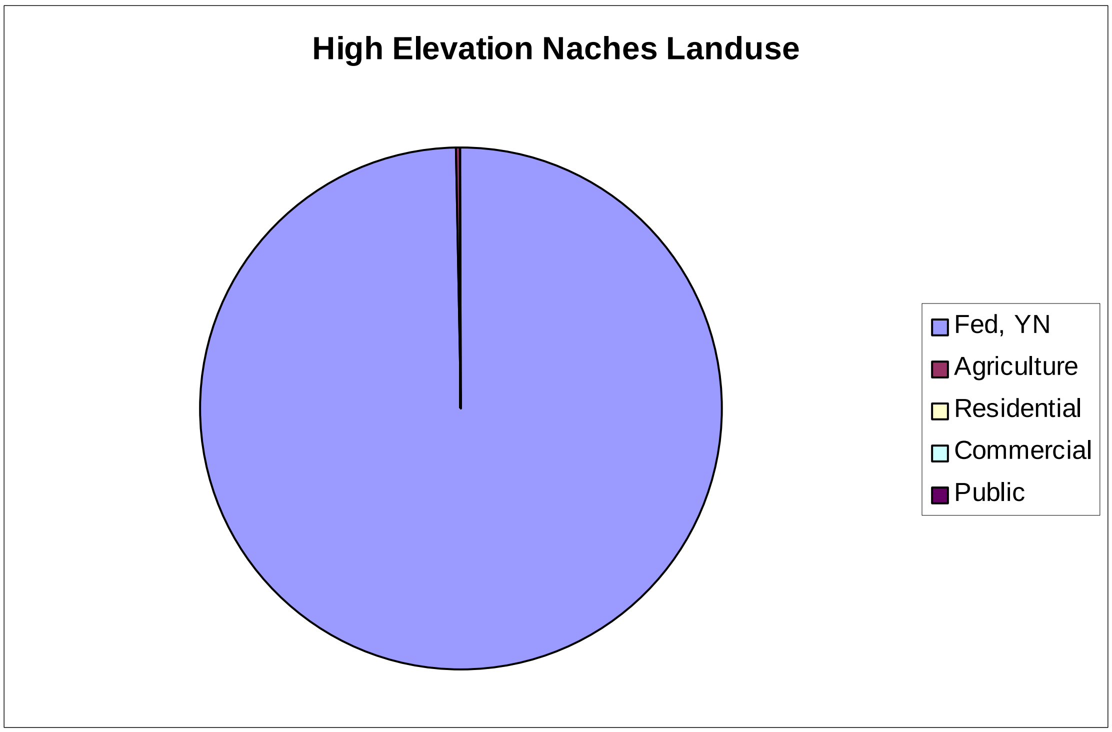


Figure 2-95. Comparison of land uses in High Elevation Natches Assessment Unit

This unit consists of two major, independent, subwatersheds (Figure 2-94). The subwatershed occupying the northern portion of the unit consists of the American River, from its headwaters to the point of its confluence with the Bumping River, and all the American River tributaries above that confluence. Principal tributaries of the American River include Mesatchee Creek, Union Creek, Kettle Creek, and Morse Creek. This subwatershed is bounded on the west by the Cascade crest, on the north and east by its transition into the Mid-Elevation Natches/Tieton Assessment Unit, and on the south by the other subwatershed of this unit, the upper Bumping River subwatershed.

The second subwatershed of this unit (roughly half of the unit) is the upper Bumping River subwatershed, from its headwaters to the Bumping Lake Dam, including all the Bumping River tributaries above the dam. Principal tributaries of the upper Bumping River include Copper Creek, Deep Creek, Cougar Creek, and Cedar Creek. This subwatershed also is bounded by the

Cascade Crest on the west, by the Mid-Elevation Natches/Tieton Assessment Unit on the east, and by the American River watershed on the north.

There is only one major impoundment in this unit, Bumping Lake, created by the Bumping Lake Dam (Figure 2-95). This is solely a storage reservoir, formed when the 61-foot-high earthfill dam was completed in 1910, impounding a drainage area of 68 square miles. USBR data indicate that the total storage volume of this facility is 33,000 acre-feet (USBR 2004). There is no fish passage provided at this dam. Lack of fish passage facilities at Bumping Lake Dam has resulted in the extirpation of sockeye and other anadromous species above the dam. In addition, culverts on forest roads have reduced habitat availability in parts of the Assessment Unit.

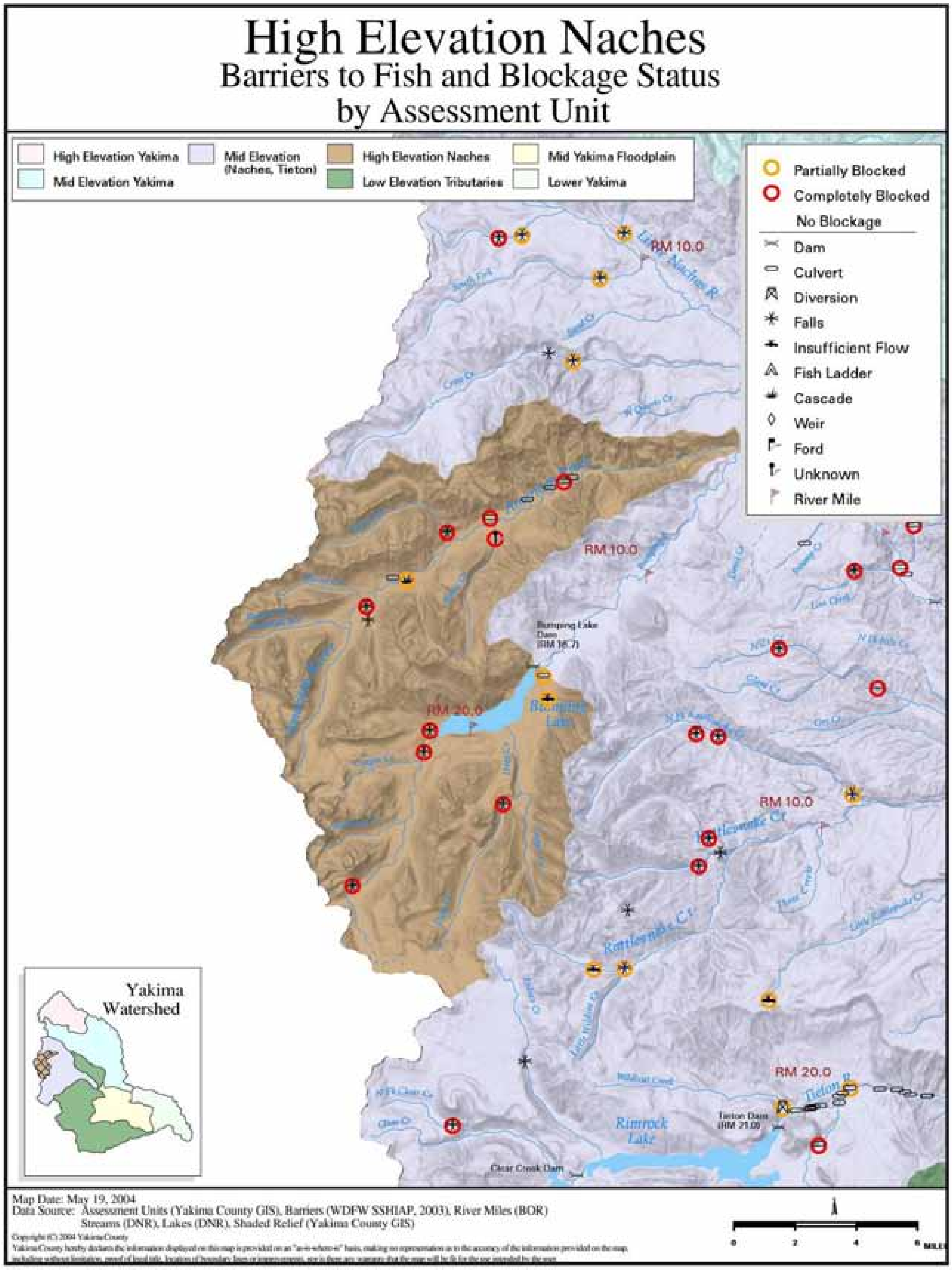


Figure 2-96. Barriers to fish passage in the High Elevation Naches Assessment Unit

Aquatic Habitat

Species Distribution and Utilization

The High Elevation Naches Assessment Unit supports spring chinook, rainbow and bull trout, as well as other salmonid and non-salmonid species (Table 1-5). In 1950 Bumping Lake was treated with rotenone to kill northern pikeminnow and suckers. This also killed a variety of other fish species, including bull trout. Bull trout and kokanee were able to re-colonize the lake in subsequent years, but it was probably a slow rebuilding process. The current and historical distribution of the focal species in the Yakima Subbasin is illustrated in the focal species discussion of this fish assessment.

Spring Chinook Salmon

Some of the best spring chinook spawning and rearing habitat in the entire Yakima Subbasin is found in the American River between RM 5 and 15.8 (WDFW 1998). American River spring chinook are one of the three genetically distinct Yakima stocks and are the least numerous stock in the basin. They spawn exclusively in the mainstem American River. The American River stock differs from the other two in that the commencement of spawning occurs earlier and consists primarily of 5-year-old fish (see focal species section for more details).

Fall Chinook Salmon

Fall chinook did not historically, and do not currently, utilize stream habitat in the High Elevation Naches Assessment Unit.

Steelhead / Rainbow Trout

Hatchery rainbow trout have been stocked in Bumping Lake for at least the past 25 years. Although catchable-size rainbows are no longer stocked in the lake, rainbow fry continue to be stocked. In their survey of the American River in 1935, Bryant and Parkhurst (1950) reported that “rainbow, cutthroat and Dolly Varden trout are plentiful in this stream in abundance in the order named”, and that “no steelheads or species of salmon other than chinooks are reported to be present in this stream although it is probable that steelhead do make a spawning migration into the area”. These reports are at variance with the observations of Yakama Nation (unpublished data 2001), who have rarely if ever observed adult or juvenile O. mykiss in the American River. Similarly, Hockersmith et al. (1995) radiotagged steelhead trout and although fish were tracked to many other parts of the basin, no tagged fish were observed entering the American River. The current scarcity of rainbow/steelhead in the American is puzzling, given the pristine nature of the American River and their presence in the neighboring Bumping River.

Sockeye / Kokanee Salmon

Sockeye salmon were historically abundant in the High Elevation Yakima Assessment Unit but were extirpated in the 1920’s following completion of impassible storage dams below Bumping Lake. The distribution of sockeye was never extensive, even prior to 1850 (Figure 2-56). Kokanee salmon, a landlocked form of sockeye salmon, occur in Bumping reservoir (WDFW 2003, source of GIS data). Both kokanee and adfluvial bull trout utilize the reservoirs for the majority of their life history, excluding brief periods where spawning, egg incubation and emergence, and outmigration occur. There are self-sustaining populations of kokanee in Bumping Lakes, but since there have been introductions it cannot be positively affirmed these populations are of natural origin (Jeff Fryer, pers. comm. 2003). Reservoir management is not conducive to beach spawning sockeye. If reintroduction is to be successful, sufficient habitat must exist in the tributaries to support a viable population.

Bull Trout

Bull trout are known to occur in the High Elevation Naches Assessment Unit. Bumping Lake currently supports a population of adfluvial bull trout, which spawn in Deep Creek (WDFW 1998). The Deep Creek population probably originated from a native adfluvial life history form, which was present before the construction of Bumping Dam (USFWS 2002). Fluvial bulltrout redds are repeatedly observed in the American River watershed in and around Union Creek (RM 11.5) and upstream of Lodgepole Campground RM 15.5)(WDFW 1998). The adfluvial bull trout population in Bumping Lake and the fluvial population in the American River are believed to be at high risk of extinction (USFWS 2002). Bull trout populations have been fragmented by loss of passage at Bumping Dam, making the Bumping Lake population more vulnerable to extinction over the long term.

Pacific Lamprey

Pacific lamprey utilization of the High Elevation Naches Assessment Unit has not been documented (WDFW 2003, source of GIS maps).

Other Fish Species and Interactions

Naturally reproducing brook trout populations occur in tributary streams in the Naches drainage that are known to have negative impacts on bull trout populations (WDFW 1998). Probable impacts to bull trout include predation on juveniles and competition for food and space. Brook trout may also pose a serious genetic threat to bull trout due to the potential for hybridization (WDW 1992; Rieman and McIntyre 1993). Although evidence is limited, it appears that the resulting offspring in some circumstances are fertile, thus providing an avenue for further introgression with bull trout populations (USFWS 2002,Wydoski and Whitney 2003). Cuthroat trout and mountain whitefish are also common.

Stream Channel Condition and Function

American River Group

The American River, along with its tributaries, is noted for its pristine status and the unique run of spring chinook it supports. Most of the river from its mouth upstream to Mesatchee Creek (RM 15.8) flows through a wide, marshy floodplain in a multitude of small channels conducting flows around a series of beaver dams. Side channels are common above RM 5, as are wet meadows. The river enters a narrow gorge above Union Creek, at RM 14, where it drops 100 feet in 400 yards in a series of cascades. These cascades may be a barrier to upstream migration at low flows (YSP 1990, WDFW 1998). The American River is considered to be routinely accessible to spring chinook as far as the Cascades and occasionally accessible up to the beaver dam marsh just below Mesatchee Creek.

The mean gradient of the American River is 1.4 percent, although in the lower five miles the gradient is considerably steeper (3-4percent) and the river is filled with large boulders and large woody debris.

From RM 5 to the confluence of Mesatchee Creek (RM 15.8), large woody debris and deep, well-protected resting pools are abundant. There are also numerous large gravel bars consisting of a high proportion of small gravels and generally less than 10 percent fines (YSP 1990, WDFW 1998; J. Matthews, YN, pers.comm., 2000). Above Mesatchee Creek, for a distance of 1.5 mi the substrate becomes primarily sand and, where beavers are active, mud. The substrate is gravel and cobble in the headwater reaches

Upper Bumping River Group

These headwater areas were made inaccessible to salmon and steelhead by impassible storage dams. Yet most of these streams are relatively pristine, occupying watersheds that are largely undeveloped. The upper Bumping River, along with these many other headwater and upper tributary reaches, is cold, small and often rather steep (gradient >4 percent). Some were probably negotiable by steelhead, although probably not spring chinook and coho. It is a relatively intact portion of the watershed.

Riparian/Floodplain Condition and Function

Upper Bumping River

There is no specific information documenting floodplain and riparian conditions. As an area that is relatively intact (with the exception of the portion of the river inundated by the reservoir), these conditions and the related functions are also presumed to be close to the historically natural state.

American River

Except for some bank damage at several campgrounds, the riparian corridor of the American River is pristine, consisting in most places of an overstory of old growth Douglas-fir and an understory of willows and alder.

Water Quantity

Upper Bumping River

There is no specific information on the hydrograph of the upper Bumping River as it enters the reservoir or of the other tributaries of this subwatershed. Given the largely unaltered landscape of these areas, the flows are presumed to be essentially natural. Unlike the other lakes in the watershed, there is no information regarding the pre-impoundment lake levels of Bumping Lake.

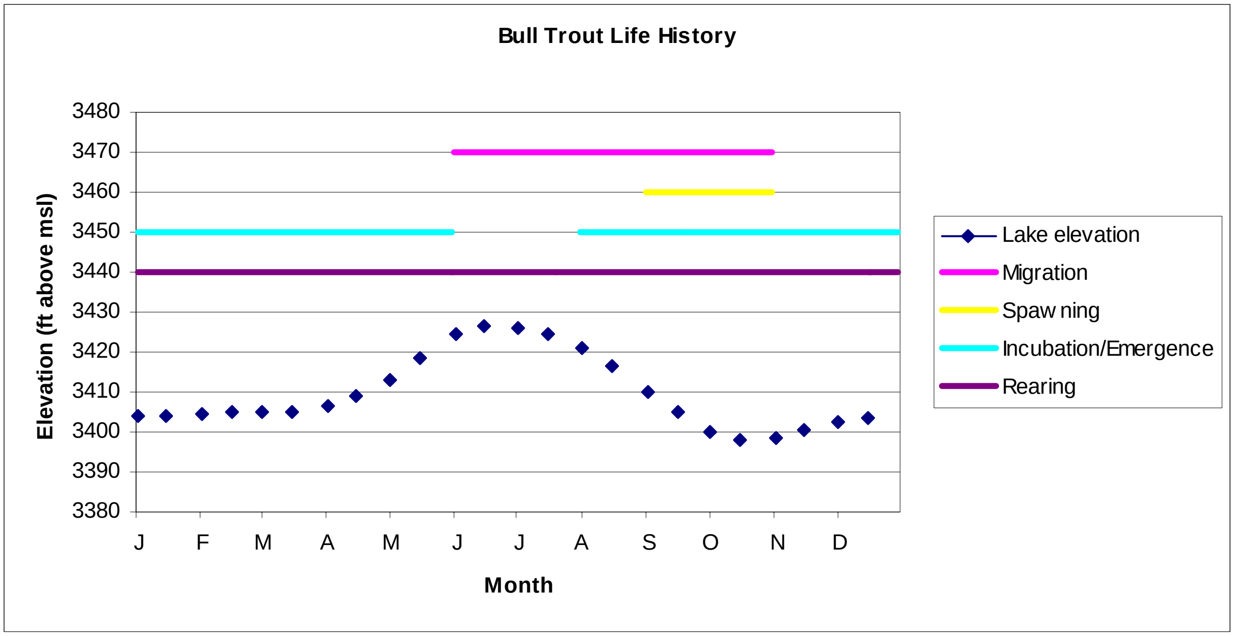


Figure 2-96. Comparison of Bumping Lake average elevations from 1912-2003 with bull trout life history stages. Lake data from USBR (2004).

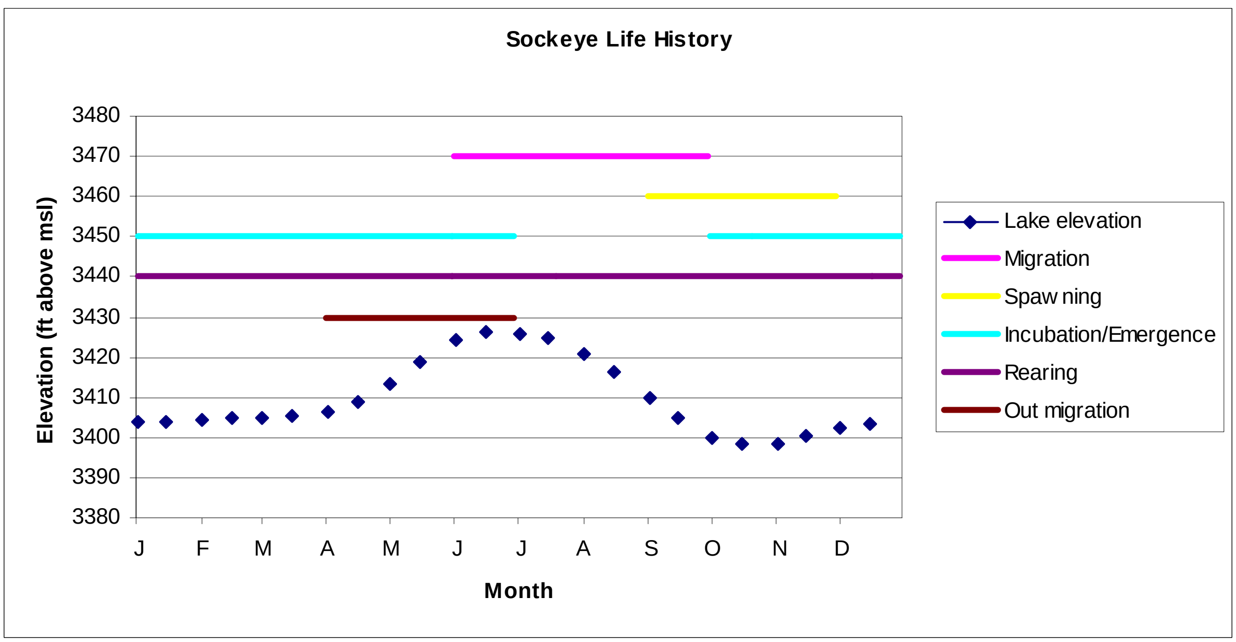


Figure 2-97. Comparison of Bumping Lake average elevations from 1912-2003 with sockeye salmon life history stages. Lake data from USBR (2004).

American River

The hydrograph of the American River is considered to be essentially natural. Mean monthly flows typically range from about 50 cfs in September to 650-700 cfs in May, although extreme low flow periods in recent years have been concentrated in the fall and winter months (October through January). In the drought years of the 1980's and the very dry years of 1992 and 1994, late fall/winter flows below 30 cfs were not uncommon. A peak flow of 2,857 cfs was observed in the American during the February flood of 1996. Production may be limited by naturally low flows in the summer fall and winter combined with extremely cold and long winters.

Water Quality

The subbasin summary reviews the water quality ratings for the streams in this Assessment Unit and notes that, with specific 303(d) list exceptions, the waters of both the American River and upper Bumping River subwatersheds is classified as AA (exceptional). It also notes that many of these listings are for temperature exceedence, including temperatures of 61^0F (16^0 C) at locations in both the American and Bumping River watersheds (NPPC 2001). Both the Bumping River and the American River are briefly mentioned in the Snyder and Stanford (2000) as having temperatures in exceedence of 61^0F (16^0 C) and as having excellent water quality.

Upper Bumping River

There is no other specific information on water quality in the upper Bumping River (as it enters the reservoir) or of the other tributaries of this subwatershed. Given the largely unaltered landscape of these areas, water quality is presumed to be essentially natural—that is, meeting the standards for class AA waters.

American River

Water quality is generally excellent in the American River (YSP 1990). Although 23 excursions for water temperature were documented at RM 0.5 in the very hot years of 1992 and 1994. Percent fines over the period 1991-1996 in the American River have consistently been about 10 percent (J. Matthews, YN, pers.comm., 2000).

Protection Key Habitat Findings for the High Elevation Naches Assessment Unit:

- Some of the best spring chinook spawning and rearing habitat in the entire Yakima Subbasin is found in the American River between RM 5 and 15.8 (WDFW 1998). American River spring chinook are one of the three genetically distinct Yakima stocks and are the least numerous stock in the basin.
- The adfluvial bull trout population in Bumping Lake and the fluvial population in the American River are believed to be at high risk of extinction (USFWS 2002).
- The American River, along with its tributaries, is noted for its pristine status.
- The Bumping Lake tributaries are relatively pristine, occupying watersheds that are largely undeveloped. The upper Bumping River, along with these many other headwater and upper tributary reaches, is cold, small and often rather steep (gradient >4 percent). Some were probably negotiable by steelhead, although probably not spring chinook and coho. It is a relatively intact portion of the watershed.
- The American River riparian corridor is pristine, consisting in most places of an overstory of old growth Douglas-fir and an understory of willows and alder.
- The hydrograph of the American River is considered to be essentially natural.
- Given the largely unaltered landscape of these areas, water quality is presumed to be essentially natural—that is, meeting the standards for class AA waters.
- Water quality is generally excellent in the American River (YSP 1990).

Restoration Key Habitat Findings for the High Elevation Naches Assessment Unit:

- There is no fish passage provided at Bumping Lake Dam.
- Lack of fish passage facilities at Bumping Lake Dam has resulted in the extirpation of sockeye and other anadromous species above the dam.
- Some culverts on forest roads have reduced habitat availability in parts of the Assessment Unit.
- Sockeye salmon were historically abundant in the High Elevation Yakima Assessment Unit but were extirpated in the 1920's following completion of impassible storage dams below Bumping Lake.
- Reservoir management is not conducive to beach spawning sockeye. If reintroduction is to be successful, sufficient habitat must exist in the tributaries to support a viable population. Bull trout population have been fragmented by loss of passage at Bumping Dam, making the Bumping Lake population more vulnerable to extinction over the long term
- Probable impacts to bull trout include predation on juveniles and competition for food and space. Brook trout may also pose a serious genetic threat to bull trout due to the potential for hybridization (WDW 1992; Rieman and McIntyre 1993).
- There is bank damage associated with several campgrounds along the American River

Key Uncertainties for the High Elevation Naches Assessment Unit:

- There are self-sustaining populations of kokanee in Bumping Lakes, but since there have been introductions it cannot be positively affirmed these populations are of natural origin (J. Fryer, pers. comm. 2003).

- Unlike the other lakes in the watershed, there is no information regarding the pre-impoundment lake levels of Bumping Lake.
- Concerning the American River Bryant and Parkhurst (1950) reported that “rainbow, cutthroat and Dolly Varden trout are plentiful in this stream in abundance in the order named”, and that “no steelheads or species of salmon other than chinooks are reported to be present in this stream although it is probable that steelhead do make a spawning migration into the area”. These reports are at variance with the observations of Yakama Nation (unpublished data 2001), who have rarely if ever observed adult or juvenile O. mykiss in the American River. Similarly, Hockersmith et al. (1995) radiotagged steelhead trout and although fish were tracked to many other parts of the basin, no tagged fish were observed entering the American River. The current scarcity of rainbow/steelhead in the American is puzzling, given the pristine nature of the American River and their presence in the neighboring Bumping River.

7 Out-Of-Subbasin Effects

The following discussion of out-of-subbasin effects is taken from a general discussion of out-of-subbasin effects titled “Understanding Out-of-Subbasin Effects for Oregon Subbasin Planning, With particular reference to Ecosystem Diagnosis and Treatment Assessments” prepared by the Oregon Technical Outreach and Assistance Team (TOAST, 2004). Originally, this information was supposed to be supplied to Subbasin Planning Groups by the Level 3 Regional Coordination Group, but that information has not been made available. Since the preparation of this information was outside of the contractual scope for the preparation of the Subbasin plan, and not included in the original workplan for the Subbasin Planning Board, this information is presented for informational purposes. This document has not been reviewed by the Aquatic Technical Committee or the Co-managers of the Fishery Resource, and inclusion of this information does not represent approval or acceptance of the any party associated with preparation or review of the Yakima Subbasin Plan. This is not in any way to find fault with TOAST in the preparation of this information, as it was outside their workplan as well, and their provision of this summary to Subbasin Planning groups throughout the Columbia basin was a great service.

It should be noted however, that while the information presented below is of some value in providing context to actions that occur within the Yakima Subbasin, it lacks the types of analysis, especially when EDT data is available, that is recommended for inclusion in Subbasin Plans.   The data presented below includes only one reference condition, the Current condition of ecosystem attributes in the Columbia and Snake mainstems. Data for the Historic or Template conditions are not given for comparision, nor is Potential reference condition (i.e. the potential effect of restoration or changes in hatchery, harvest or hydropower operation; or the desired end state for the mainstem) presented. The lack of this information limits the utility of the information in providing context to the relationship between population performance in the tributaries and historic, current, and potential future conditions in the Mainstem.

7.1 Understanding Out-Of-Subbasin Effects For Oregon Subbasin Planning

7.1.1 Introduction

Subbasin planning, by definition, is focused on the major tributaries to the mainstem Columbia and Snake Rivers. However, many focal species migrate, spending varying amounts of time and traveling sometimes extensively outside of the subbasins. Salmon populations typically spend most of their lives outside the subbasin. Unhindered, sturgeon will spend short periods in the ocean. Lamprey typically spend most of their life as juveniles in freshwater, but gain most of their growth in the ocean. Planning for such focal species requires accounting for conditions during the time these populations exist away from their natal subbasin. Out-of-subbasin effects (OOSE) encompasses all mortality factors from the time a population leaves a subbasin to the time it returns to the subbasin. These effects can vary greatly from year to year, especially for wide ranging species such as salmon. Out-of-subbasin factors can be natural in origin (e.g. ocean productivity), human-caused (e.g. fisheries) or a combination (e.g. mainstem survival is dependent on both mainstem flows and dam operations). Because of the richness and depth of information available for salmon outside their natal subbasins and because of the scarcity of information available for other anadromous focal species, the remainder of this report describes out-of-subbasin effects for salmon only.

This report is organized into four main sections. The first two describe, in qualitative terms, the OOSE structure of the EDT model and environmental cycles which cause salmon survival to vary widely. The third section describes quantitatively OOSE survival estimates under base period conditions and an expected survival range to represent environmental variation. The fourth section offers guidance for evaluating subbasin plans in light of OOSE survival and variation. The following discussion draws from existing data and previous analyses. It is a summary of existing knowledge and hypotheses. The following discussion is confined to OOSE pertaining to salmon populations, because of data limitations for other migratory species. Particular attention is given to out-of-subbasin effects as represented in the Ecosystem Diagnosis and Treatment (EDT) model because this is the most commonly used tool for developing assessments for salmon during this round of subbasin planning. Although much of the following discussion centers around the EDT model, the final recommendations can be used with any assessment tool.

7.1.2 EDT Baseline Conditions

N.B. This section is abstracted from Marcot et al. 2002. Readers are referred to that report for additional details. The use of personal pronouns in this section refers to the original authors.

It is important to note that the EDT analyses do not include any new data or information about survival outside the subbasins.

EDT is a habitat model and is structured differently from population models typically used to define and estimate survival parameters in the mainstem Columbia, therefore there is no direct correspondence between EDT parameters and those used by other models. For example, EDT incorporates growth, development, migration patterns and travel speeds for individuals (i.e. individual life history trajectories), rather than for populations or groups of fish.

In general the default values for out-of-subbasin survival are those used in the “Multi-Species Framework” analysis (Marcot et al 2002). Where more recent information is available for harvest impacts on individual populations, that information has been incorporated.

The simplest way to summarize the assumptions built into the EDT model for the out-of-subbasin portion of the salmon life history is to compute the average survival for a population from juveniles entering the mainstem Columbia (or Snake) River to adults reentering the subbasin. This Juvenile to Adult Return rate (JAR) is computed as the total number of adult returns divided by the total number of juvenile outmigrants. These outmigrants include juveniles of all ages and life stages entering the mainstem and may not be directly comparable to the smolt to adult return rates estimated from empirical data. The composition of out migrants (age, size, and life stage mix) is affected by habitat conditions in both the mainstem and the subbasin and varies between subbasins and between current and historic conditions.

The following briefly summarizes the out-of-subbasin assumptions in the EDT tool. Readers are referred to the methods section in the Multi-Species Framework Report (Marcot et al. 2002) for a fuller description of most of the assumptions.

7.1.3 Mainstem Passage Effects

This is the most complex part of the EDT tool, outside of the natal subbasins. Juvenile survival through the mainstem Columbia and Snake rivers depends upon habitat quality and quantity, river flow, juvenile travel time, juvenile migration timing, dam survival, transportation survival, survival of naturally migrating fish, and competitive interactions with hatchery fish.

Habitat Quality and Quantity

Biological rules do not exist for deriving mainstem habitat ratings; therefore, we constructed the quality ratings for mainstem habitat, for the Historic Potential and Current Potential, based on existing literature and the professional expertise of fisheries biologists familiar with both Columbia and Snake River systems. The biologists used the existing data and their knowledge to rate the following biological performance attributes for each river reach of interest:

- Habitat Quality
- Temperature
- Predation
- Competition with Hatchery Fish
- Competition with Other Species
- Habitat Diversity

The quantity of both riverine and reservoir habitat presented under both conditions were estimated from USGS Topo maps, average monthly river flow, and reservoir size and length data presented in the CRiSP 1.5 manual (Anderson et al., 1996).

River Flow

We obtained estimates of average monthly river flow for both the Columbia and Snake rivers under the Current Potential and Historic Potential from streamflow model runs developed by Council staff.

Juvenile Travel Time

We assumed that the time required for subyearling and yearling chinook to migrate through the mainstem corridor is affected by river flow (water velocity) and habitat types present (i.e., riverine or reservoir). Thus, juvenile migration speed is assumed to differ under the Current Potential (primarily reservoir) and Historic Potential (riverine).

We developed subyearling and yearling chinook travel speeds for both conditions using CRiSP Model 4. A description of the model, inherent assumptions, formulas and inputs can be found in Zabel and Anderson (1997). In addition, for the Historic Potential, we estimated water velocity by dividing average monthly river flow by the average cross section of each stream reach. We used travel speed and timing data in this analysis to determine the survival conditions encountered by each juvenile as it migrates through the mainstem Snake and Columbia Rivers.

Juvenile Migration Timing

We approximated subyearling and yearling juvenile migration timings from data developed by the Fish Passage Center (FPC 1999). Yearling chinook were assumed to migrate during the period April – June and subyearling chinook during the period June – August.

Dam Survival (Juveniles)

Dam survival rates for juvenile salmonids are discussed below for the Current Potential only; dams do not exist for the Historic Potential, thus survival estimates are not needed for that condition.

The survival rate of juvenile salmonids migrating past Columbia and Snake River hydroelectric projects is dependent on riverine conditions, juvenile behavior, and physical facilities present at each project. We calculated both yearling and subyearling survival rates through spillways, turbines, and juvenile bypass systems for each project using data presented in the NMFS white paper titled "Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams" (NMFS 2000). It should be noted that the survival values do not include the mortality component associated with juvenile passage through reservoirs (see below).

In-river Survival (Juveniles)

The survival rates used for modeling the Current Potential for subyearling and yearling juveniles migrating in-river through the hydroelectric complex were based on the range of values presented in recently published scientific literature.

Data presented by NMFS (2000) show that from 1993-1999 yearling survival from Lower Granite Reservoir to the tailrace of Bonneville Dam ranged from about 31 percent to 51 percent. This equates to a project survival rate of approximately 86-92 percent. For modeling the Current Potential, we assumed that yearling survival past eight hydroelectric projects averages 36 percent (88 percent per project).

For subyearling chinook we assumed that in-river survival from the head of Lower Granite Reservoir to the tailrace of Bonneville Dam was 29 percent. This equates to a project survival rate of ~85 percent. The survival value only applies to active migrants. For inactive migrants, or life history trajectories that spend more time in the reservoirs (rearing stage), mortality increases in proportion to the time spent in the reservoirs. Thus, overall survival varies dependent on the trajectory examined. This approach is consistent with the data presented in a recent NMFS document titled *"Passage of Juvenile and Adult Salmonids Past Columbia and Snake River*

Dams." NMFS scientists reported that subyearling survival varied dramatically (13-51 percent) in tests conducted in the Snake River from 1995-1999. However, these survival estimates included mortality from parr to the active migrant stage.

The juvenile survival rates presented above formed the basis for model calibration with regard to overall survival through the mainstem Columbia and Snake Rivers. Because the dam survival values were fixed, the overall survival targets for both life histories required that juvenile survival rates through the reservoirs be adjusted as needed, which we achieved by modifying the habitat quality attributes for each reservoir during the key juvenile migration periods (see Juvenile Migration Timing). It should be noted that juvenile survival through the reservoirs is affected by the amount of time the juvenile spends in the reservoir and the benchmark survival value for the specific life stage (subyearling, yearling, etc.).

We set the survival benchmarks for yearling and subyearling chinook at 97.5 percent and 35 percent, respectively. These benchmark survival values were based on the assumption that yearlings require 14 days, and subyearling 56 days, to migrate from natal streams to the estuary under ideal environmental conditions. This equates to a daily survival rate of 99.8 percent ($97.5^{1/14)}$ for yearlings and 98.1 percent ($0.35^{1/56}$) for subyearlings.

For each reservoir, we calculated the daily survival rate for juvenile chinook using the following formulas:

Daily Yearling Survival Rate = $(B*RSR)^{1/14}$
Daily Subyearling Survival = $(B*RSR)^{1/56}$

Where-

B= benchmark survival rate
RSR = Reservoir survival rate by month

For example, the daily survival rate for a yearling chinook migrating through Lower Granite Reservoir in May would be 99.1 percent $(0.975*0.91)^{1/14}$.

We calculated the survival values based on mainstem habitat quality, juvenile travel time through each reach, and the benchmark survival values used for each life stage.

Fish Transportation (Juveniles)

Survival associated with juvenile fish transportation is presented below for Current Potential only; juvenile transport does not occur under the Historic Potential.

We assumed 98 percent of the transported juveniles survive to the point of release (NMFS 2000 White Paper Transportation). We also assumed survival rates of transported Snake River yearling and subyearling chinook once released from the barges are 50 percent and 35 percent that of juveniles migrating in-river, respectively. We selected these values based on a review of recent literature estimating the differential post-Bonneville Dam survival for in-river and transported juvenile salmonids. The 50 percent value we used for yearling chinook was based on data presented in Bouwes et al. (1999). The subyearling value (35 percent) was based on data presented in PATH (1999). We increased the transport survival rate for subyearlings transported from McNary Dam to 60 percent to maintain a transport survival benefit for subyearling chinook migrating from the mid-Columbia River.

Competitive Interactions with Hatchery Fish

In the EDT analysis, hatchery fish can affect wild/natural populations through ecological or genetic interactions. Ecological interactions involve competition for food and space, predation (directly or indirectly by affecting behavior of predators), and ecological function. Genetic interactions result from hatchery fish interbreeding with wild fish in the natural environment.

We estimated competition effects due to hatchery fish based on estimated densities of hatchery juveniles by stream reach over time and on maximum densities drawn from the literature. We computed the density of hatchery fish from time and rate of release of hatchery fish at each facility and estimated rates of downstream movement of those fish. Using the Beverton-Holt survival function and benchmark maximum density parameters, we estimated the survival impacts on wild fish for every stream reach and time period. We did not include direct and indirect effects of predation in this analysis. We did include ecological effects due to nutrient enhancement from carcasses (positive increase in survival) and due to pathogens associated with hatchery programs as direct, site specific inputs.

Hatchery fish access natural spawning grounds inadvertently through straying or as a result of supplementation with the intent to augment natural spawning.

Adult (upstream) Dam Survival

Adult chinook survival past each mainstem dam was assumed to average 93 percent under the Current Potential (PATH 2000). Thus, total adult survival through mainstem river reaches is highly dependent on the number of dams each adult must pass. For example, adult chinook returning to the Salmon River would have to pass eight mainstem dams, and thus their overall survival rate would be 56 percent (0.93^8 = 56 percent)[6]. In contrast, the survival rate for adults returning to the John Day River would be approximately 80 percent because they must migrate past only three mainstem dams.

Under the Historic Potential, adult chinook survival through the mainstem Columbia and Snake Rivers was assumed to average 92 percent.

Genetic Effects of Hatchery Spawners

EDT assumes that, if hatchery fish are present in any specific population, they will spawn with naturally produced fish in the wild

Hatchery fish access natural spawning grounds inadvertently through straying or as a result of supplementation with the intent to augment natural spawning. We relied on RASP (1992) for estimates of the survival (fitness) effect on natural populations of hatchery introgression as a function of the hatchery-natural composition of the spawning population (Table 2-31). In order to calculate the ratio of hatchery to wild and compute the demographic contribution of hatchery spawners to the subsequent generation, we somewhat arbitrarily assumed that the total escapement (hatchery plus natural) to the spawning grounds would not exceed the natural spawner capacity.

[6] Corrected from 0.98^8=60% in Marcot et al. (2002).

Table 2-31. Relative survival parameters for hatchery produced fish and for natural populations influenced by hatchery fish (Moderate worldview).

Culture Method	Multiplier on natural production based on presence of hatchery fish			
	Percent hatchery fish spawning with naturally produced fish			
	> 50%	20-50%	10-20%	<10%
Conventional hatchery	75%	83%	93%	100%
Supplementation hatchery	82%	88%	95%	100%

7.1.4 Estuary Effects

Because biological rules were not developed for these areas, we used data from the literature and professional expertise to determine juvenile survival in each component of the marine environment. These survival rates were applied to each of the 74 salmon stocks analyzed.

For the estuary, biologists determined impacts to salmonids by developing ratings for a subset of the biological performance attributes. The ratings were based on USGS river flow data, river temperature information, the results of bird predation studies conducted near the mouth of the Columbia River (Roby et al. 1998) and marine mammal predation studies (reviewed in Park 1993).

7.1.5 Natural Ocean Survival

The nearshore area was used to describe the early ocean life of juvenile salmonids (period from ocean entry to December 31).

Chinook ocean survival rates used for modeling purposes beginning with the first full year in the ocean were the same as those used by the Pacific Salmon Commission Chinook Technical Committee (CTC 1988). The derivation of these rates is undocumented but are used the CTC for chinook cohort analysis, thus are consistent with their ocean modeling exercises. The rates are summarized by age (shown are ages for ocean type life history) in Table 2-32.

Table 2-32. Ocean survival rate by age class (chinook).

Age	Ocean Survival
2	0.6
3	0.7
4	0.8
5	0.9

7.1.6 Harvest

We obtained the data used in this analysis to determine the rate and location of adult harvest from the following sources:

- Fisheries Regulatory Assessment Model (**FRAM**)
- Chinook Technical Committee, Pacific Salmon Commission (**??**)
- Status Report, Columbia River Fish Runs and Fisheries, 1938-2000. (WDFW and ODFW 2002)
- 1996 All Species Review, Columbia River Fish Management Plan. US V. Oregon, **Technical Advisory Committee, 1997**.
- Biological Assessment, **Technical Advisory Committee. 1998**

For this analysis, we defined the harvest rate base period to be 1992-1996, and we developed harvest rates for both ocean and mainstem Columbia River fisheries (Zones 1-6). We based the harvest rates used in this analysis on published rates for ten Columbia River Harvest indicator stocks (see Marcot et al. 2004 for specific details). These indicator stocks were used in setting harvest rates for each of the 74 fish populations examined in the Multi-Species Framework analysis. The analysis does not include estimates of sport or commercial harvest in the tributaries. Thus, the adult run sizes reported for each subbasin are based on the number of fish entering each tributary.

7.1.7 Modifying Conditions

Pacific Decadal Oscillation

Ocean conditions strongly affect overall salmon survival. Salmon spend most of their life in the ocean and early ocean survival is widely considered to be a time of particularly high mortality. In recent years, a growing body of evidence from field, tagging, and correlation studies shows that Pacific salmon experience large year-to-year fluctuations in survival rates of juvenile fish making the transition from freshwater to marine environment (Hare et al. 1999). Climate-related changes have the most affect on salmon survival very early in the salmon’s marine life history (Pearcy 1992, Francis and Hare 1994).

The Pacific Decadal Oscillation is a pan-Pacific, recurring pattern of ocean-atmospheric variability that alternates between climate regimes every 20-30 years (Hare et al. 1999). The PDO affects water temperatures off the coast of Oregon and Washington and has cold (negative) and warm (positive) phases (Hare et al. 1999). A positive PDO phase brings warmer water to the eastern North Pacific, reducing upwelling of nutrient-rich cooler water off the coast of North America and decreasing juvenile salmon survival (Hare et al. 1999). The negative phase of the PDO has the opposite effect, tending to increase salmon survival.

Climatic changes are manifested in both returns and harvests. Mantua et al. (1997) found evidence of an inverse relationship between harvests in Alaska and off the coast of Oregon and Washington. The negative phase of the PDO resulted in larger harvests of Columbia River stocks and lower harvests of Alaskan stocks. In the positive phase, warmer water resulted in lower harvests (and runs) in the Columbia River, but higher harvests in Alaska. Phase reversals occurred around 1925, 1947, 1977, and possibly 1999. The periods from 1925-1947 and from

1977-1999 were periods of low returns to the Columbia River, while periods from 1947-1977 and the current period are periods of high returns.

El Nino/Southern Oscillation

The El Nino-Southern Oscillation (ENSO), commonly referred to as El Nino and La Nina), like the PDO, affects water temperatures off the coast of Oregon and Washington and has both a cold (negative) and warm (positive) phase. ENSO events are much shorter than PDO events in that events typically occur every 2-7 years and last 12-18 months. Positive ENSO events occur more frequently during positive PDO phases and less frequently during negative PDO phases (Hare et al. 1999). ENSO events intensify or moderate the effects of PDO changes on salmon survival.

A positive ENSO (El Nino) event also results in higher North Pacific Ocean temperatures, while a negative ENSO (La Nina) results in lower temperatures. Positive ENSO events occur more frequently during positive PDO phases and less frequently during negative PDO phases (Hare et al. 1999).

PDO and ENSO also affect freshwater habitat of salmon. Positive PDO and ENSO events generally result in less precipitation in the Columbia Basin. Lower stream flows result in higher water temperatures and a longer outmigration. It is likely that less water will be spilled over mainstem Columbia and Snake River dams to assist smolt outmigration (Hare et al. 1999).

Climate Change

Climate change on a longer term than the PDO could have a large impact on the survival of Columbia Basin salmon. Finney et al. (2000) used lake sediment elemental composition to find evidence of very long term cycles of abundance of sockeye salmon the Bristol Bay and Kodiak Island regions of Alaska over the past 300 years. No doubt there have been similar variations in the abundance of Columbia Basin salmon.

Computer models generally agree that the climate in the Pacific Northwest will become, over the next half century, gradually warmer and wetter, with an increase of precipitation in winter and warmer, drier summers (USDA Forest Service 2004). These trends mostly agree with observed changes over the past century. Wetter winters would likely mean more flooding of certain rivers, and landslides on steep coastal bluffs (Mote et al. 1999) with higher levels of wood and grass fuels and increased wildland fire risk compared to previous disturbance regimes (USDA Forest Service 2004). The region’s warm, dry summers may see slight increases in rainfall, according to the models, but the gains in rainfall will be more than offset by losses due to increased evaporation. Loss of moderate-elevation snowpack in response to warmer winter temperatures would have enormous and mostly negative impacts on the region’s water resources, forests, and salmon (Mote et al. 1999). Among these impacts are a diminished ability to store water in reservoirs for summer use, and spawning and rearing difficulties for salmon.

Climate models lack the spatial resolution and detailed representation of critical physical processes that would be necessary to simulate important factors like coastal upwelling and variation in currents. Different models give different answers on how climate change will affect patterns and frequencies of climate variations such as ENSO and PDO.

For the factors that climate models can simulate with some confidence, however, the prospects for many Pacific Northwest salmon stocks could worsen. The general picture of increased winter flooding and decreased summer and fall streamflows, along with elevated stream and estuary temperatures, would be especially problematic for in-stream and estuarine salmon habitat. For salmon runs that are already under stress from degraded freshwater and estuarine habitat, these changes may cause more severe problems than for more robust salmon runs that utilize healthy streams and estuaries.

While it is straightforward to describe the probable effects of these environmental patters individually, their interaction (PDO, ENSO, climate change) is more problematic. The main question appears to be the duration of the present favorable (for salmon) PDO period and the timing and intensity of the subsequent unfavorable period. Prudence suggests planning for a shorter favorable period and a subsequent longer, if not more intense, unfavorable period.

7.1.8 Synthesis

To simplify application of OOSEs to subbasin assessments, we have aggregated the major sources of impact into a single smolt-to-adult-return rate (SAR) for survival from the time a population leaves the subbasin to the time it returns. If and when planners want to address the balancing of impacts across the four Hs (hydropower, habitat, harvest, hatcheries), SAR numbers will have to be disaggregated into the various components.

Aggregate Effects

The juvenile-to-adult ratios (JARs) used in the EDT Multi-Species Framework assessments are provided by Mobrand Biometrics (Chip McConnaha, pers.comm.) in Table 2-33. These rates are the total survival rate of juvenile fish from the mouth of the subbasin to their return to the subbasin as adults. They were calculated from intermediate EDT results.

Table 2-33. Juvenile-to-Adult survival rates (percent) for chinook salmon used in EDT (Mobrand 2003)

	Yearling Outmigrants	Subyearling Outmigrants
Lower Granite Pool	0.9	0.4
Little Goose Pool	1.0	0.4
Lower Monumental Pool	1.1	0.5
Ice Harbor Pool	1.3	0.6
Lower Snake River	1.4	0.8
McNary Pool	1.4	0.7
John Day Pool	1.5	0.8
The Dalles Pool	2	0.9
Bonneville Pool	2.2	1.0
Lower Columbia River	3.1	1.4
Wells Pool	0.7	0.3
Rock Island Pool	0.9	0.4
Wanapum Pool	1.1	0.4
Priest Rapids Pool	1.2	0.6
Hanford Reach	1.4	0.8

The EDT estimates of survival were compared to smolt-to-adult survival estimates for springchinook (yearling) populations above Lower Granite Dam (C. Petrosky, Idaho Department of Fish and Game January 9, 2004 e-mail), Table 4. These data update the earlier run reconstruction data reported by Marmorek et al. (1998). Since 1992 (the period used for the Multi-Species Framework project), the SAR geometric mean has been 0.8 percent and with an SAR range of 0.19 percent to 3.0 percent. The JAR from EDT of 0.9 percent is very close to the post 1992 geometric mean. Therefore, we feel the EDT JARs can be used as a reasonable point estimate for yearling chinook SARs for those life history types entering each of the mainstem Columbia/Snake river reservoirs. To avoid excessive jargon we will use the acronym SAR to refer to survival from the time a fish leaves its natal subbasin to the time it returns as an adult, whether the number comes from EDT or empirical observations.

Table 2-34. Estimated smolt to adult survival from Lower Granite Dam to Lower Granite Dam for spring chinook and steelhead smolt outmigration years 1964-2000 based on run reconstruction.

Smolt Outmigration Year	Chinook SAR	Steelhead SAR
1964	2.35%	4.21%
1965	2.32%	3.68%
1966	2.31%	3.93%
1967	4.49%	4.01%
1968	2.58%	3.39%
1969	3.83%	3.66%
1970	1.92%	2.55%
1971	1.53%	2.27%
1972	1.02%	1.52%
1973	0.49%	0.63%
1974	1.39%	1.29%
1975	3.11%	1.84%
1976	0.92%	1.70%
1977	0.35%	0.90%
1978	0.98%	3.07%
1979	1.09%	3.18%
1980	0.55%	2.54%
1981	1.39%	1.11%
1982	1.70%	3.37%
1983	1.83%	2.63%
1984	2.56%	3.66%
1985		3.07%
1986		3.05%
1987		3.63%
1988		2.01%
1989		1.02%
1990		2.33%
1991		1.55%
1992	0.19%	1.04%
1993	0.38%	1.07%
1994	1.02%	1.18%
1995	0.31%	1.40%

1996	0.36%	1.61%
1997	1.72%	1.39%
1998	1.15%	1.89%
1999	2.91%	3.16%
2000	3.00%	4.68%

Given the exceptionally low 1992 SAR of 0.19 percent, we used the geometric mean for the four poorest post-1992 SARs (1992, 1993, 1995, and 1996) of 0.3 percent to represent for a SAR lower bound. And we used the highest SAR (3.0 percent in 2000) to represent good outmigration/ocean conditions for yearling chinook entering the Snake River above Lower Granite Dam. Choosing these estimates means that, under good conditions, SARs are 3.0/0.9=3.3 or 330 percent better than the point estimate. Under poor conditions, SARs are 0.3/0.9=0.33 or 33 percent of the point estimate. We applied this range of 33 percent to 330 percent to each point estimate from EDT to obtain the range of estimates for yearling chinook outmigrants entering each reservoir listed in Table 2-33.

Table 2-35. Smolt-to-Adult (SAR) survival estimates (percent) with ranges for chinook yearling outmigrants.

Point of Entry	EDT Point estimate	Lower range	Upper range
Lower Granite Pool	0.9	0.30	2.97
Little Goose Pool	1.0	0.33	3.30
Lower Monumental Pool	1.1	0.36	3.63
Ice Harbor Pool	1.3	0.43	4.29
Lower Snake River	1.4	0.46	4.62
McNary Pool	1.4	0.46	4.62
John Day Pool	1.5	0.50	4.95
The Dalles Pool	2	0.66	6.60
Bonneville Pool	2.2	0.73	7.26
Lower Columbia River	3.1	1.02	10.23
Wells Pool	0.7	*	*
Rock Island Pool	0.9	*	*
Wanapum Pool	1.1	*	*
Priest Rapids Pool	1.2	*	*
Hanford Reach	1.4	*	*

* Specific SAR estimates for these populations were not available

No similar run reconstruction data is available for subyearling outmigrants. However, the Pacific Salmon Commission does calculate survival indices for fall chinook originating from the Hanford Reach. There is a significant linear relationship between the fall chinook survival indices and the spring chinook SARs since 1992 ($p<0.001$, $r2=0.749$, Figure 98). Furthermore, the rate of change between the SAR and the indices is similar as the slope of the regression line is 0.96. Therefore, it seems reasonable to use the same range (33 percent to 330 percent) around the subyearling chinook SARs as the yearling chinook SARs. The results are shown in Table 6.

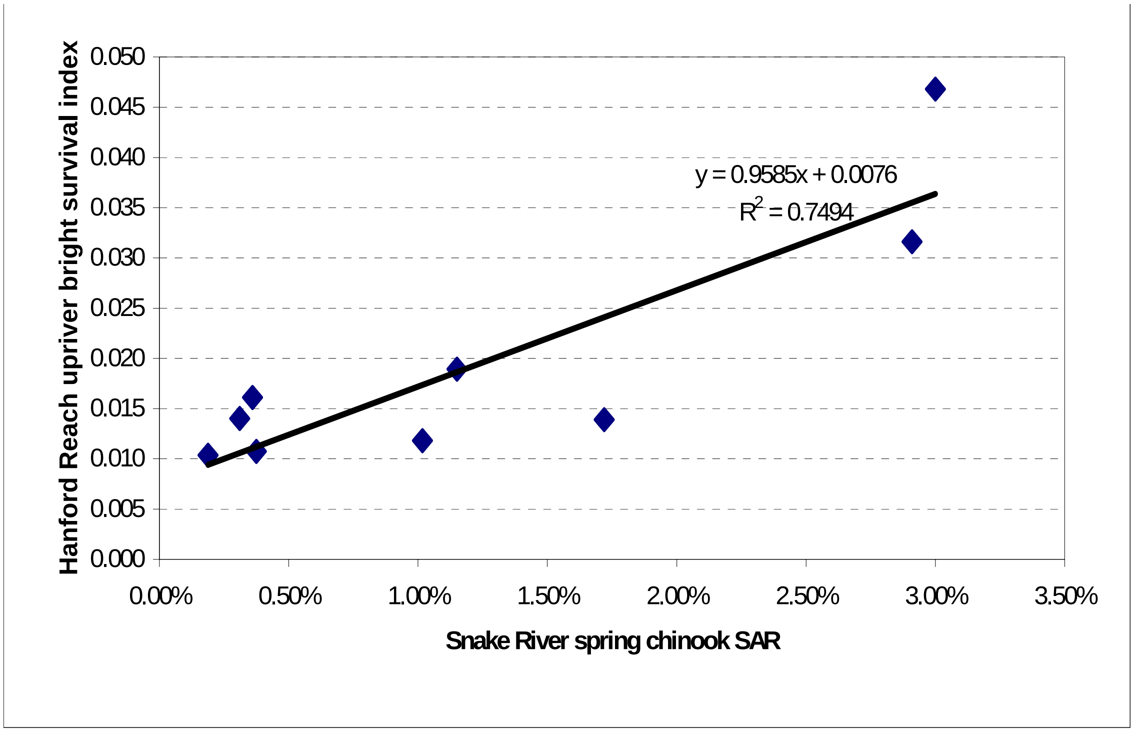


Figure 2-99. Comparison of Snake River spring chinook SARs and Hanford Reach upriver bright survival indices for smolt outmigration years 1992-2000

Table 2-36. Smolt-to-Adult (SAR) survival point estimates (percent) with ranges for chinook subyearling outmigrants.

Point of Entry	EDT Point Estimate	Lower Range	Upper Range
Lower Granite Pool	0.4	0.13	1.32
Little Goose Pool	0.4	0.13	1.32
Lower Monumental Pool	0.5	0.16	1.65
Ice Harbor Pool	0.6	0.20	1.98
Lower Snake River	0.8	0.26	2.64
McNary Pool	0.7	0.23	2.31
John Day Pool	0.8	0.26	2.64
The Dalles Pool	0.9	0.30	2.97
Bonneville Pool	1.0	0.33	3.30
Lower Columbia River	1.4	0.46	4.62
Wells Pool	0.3	*	*
Rock Island Pool	0.4	*	*
Wanapum Pool	0.4	*	*
Priest Rapids Pool	0.6	*	*
Hanford Reach	0.8	*	*

* Specific SAR estimates for these populations were not available

7.1.9 Species Other Than Chinook

Steelhead

EDT assessments for steelhead populations were not included in the Multi-Species Framework project. Therefore, we used SAR survival estimates for steelhead populations above Lower Granite Dam (C. Petrosky, Idaho Department of Fish and Game January 9, 2004 e-mail), Table 4. The geometric mean SAR since 1992 for steelhead has been 1.69 percent. The minimum SAR since 1992 was 1.04 percent in the 1992 smolt year, while the maximum SAR was 4.68 percent in the 2000 smolt year. We assumed the same per-dam mortality rate as that for spring chinook to develop the SAR estimates in Table 2-37.

Table 2-37. Smolt-to-Adult (SAR) survival point estimates (percent) with ranges for steelhead outmigrants.

Point of Entry	Point Estimate	Lower Range	Upper Range
Lower Granite Pool	1.69	1.04	4.68
Little Goose Pool	1.88	1.16	5.20
Lower Monumental Pool	2.07	1.27	5.72
Ice Harbor Pool	2.44	1.50	6.76
Lower Snake River	2.63	1.62	7.28
McNary Pool	2.63	1.62	7.28
John Day Pool	2.82	1.73	7.80
The Dalles Pool*	6.76	2.31	10.40
Bonneville Pool*	4.13	2.54	11.44
Lower Columbia River*	5.82	3.58	16.12

* Values are extrapolated from observations at Lower Granite Dam. Local data should be used instead, if available.

Sockeye

Sockeye salmon SARs were estimated for the three existing stocks (Fryer memo). Redfish Lake (Salmon River) sockeye SARs were from data supplied by Idaho Department of Fish and Game while Okanogan and Wenatchee SARs were computed using smolt estimates from smolt traps as well as the age composition of returning adults. Salmon River estimates represent the 1989-1994 brood years, Wenatchee estimates represent the 1995-1997 brood years, while the Okanogan estimates represent the 1994-1997 outmigration years. Two different techniques were used to estimate SARs for basins where sockeye reintroduction may be considered. Given the proximity of the mouths of the Grande Ronde and Salmon Rivers, the Grande Ronde SAR was assumed to be the same as the Salmon River SAR. Yakima and Deschutes SARs were estimated from Wenatchee SARs after factoring out 15 percent per project mortality.

Table 2-38. Smolt-to-Adult (SAR) survival point estimates (percent) with ranges for sockeye salmon outmigrants.

Stock	Point Estimate	Minimum	Maximum
Wenatchee	1.3%	0.39%	4.29%
Okanogan	0.9%	0.27%	2.97%
Salmon	0.18%	0.05%	0.59%
Grande Ronde*	0.18%	0.05%	0.59%
Yakima*	2.2%	0.66%	7.26%
Deschutes*	3.0%	0.90%	9.90%

* Specific SAR estimates for these populations were not available

7.1.10 Out-of –Subbasin Effects – Conclusion:

While the document above lays out the effects of the hydrosystem on survival, it does not lay out the effect of other conditions in the mainstem (hatcheries, harvest, or estuarine habitat quality and quantity) below Bonneville. This is significant from the standpoint that post Bonneville mortality due to the supposed combination hatchery and harvest effects is significant (i.e. over 20 percent for Yakima Subbasin spring Chinook). It was the desire the of Council to hold OOSE for the hydrosystem as a constant for subbasin planning, and harvest management effects in the mainstem and in individual subbasins should be included in the assessment of focal species, and within subbasin effects of hatcheries should be examined as well, the cumulative effects of out-of-subbasin hatchery releases on natural origin populations has not received attention in the Subbasin planning process devised by the Council (i.e. Artificial Production Review and Evaluation or APRE), nor in NOAA Fisheries Hatchery and Genetic Management Plans (HGMP). The APRE does recommend examination of the cumulative effect of hatchery releases on specific populations to resolve this uncertainty and provide a better information base for decisions regarding the scale of hatchery releases, especially BPA funded hatcheries, and their effect on natural origin fish in the mainstem, at a Columbia Basin Scale.

8 EDT-based Reference Conditions

As discussed above, the *Technical Guide for Subbasin Planning* recommends that EDT-based reference conditions be used to evaluate the overall effectiveness of a restoration strategy. This section of the assessment will give an overview of EDT and how it was used in the Assessment, the process that was used to generate the reference conditions, and the model results.

8.1 The EDT Method

The EDT method was designed to provide a practical, science-based approach for developing and implementing watershed plans. The method provides decision makers with the technical information needed to develop plans that will achieve their goals. EDT has been used to develop fish and wildlife plans for many watersheds throughout the Pacific Northwest.

The EDT method has six steps:

- Identify objectives
- Perform analysis and diagnosis (run the EDT model)
- Formulate treatments
- Describe benefits and risks (trade-off analysis)

- Refine project objectives
- Apply treatments, monitor, and evaluate

The conceptual framework for the EDT method was developed with an aim toward utility for salmon management but also with the important goal of maintaining consistency with an ecosystem approach. The framework accomplishes this by viewing salmon as the indicator, or diagnostic, species for the ecosystem. The salmon's perspective-its perception of the environment-becomes a filtered view of the system as a whole. Within the limitations of the salmon's perspective and our ability to interpret it, this approach provides a framework for formulating strategies for salmon in the context of watershed management.

The EDT framework was designed so that analyses made at different scales-from tributary watersheds to successively larger watersheds-might be related and linked. Ultimately, conditions within these watersheds are linked to those within the marine environment (Puget Sound and the North Pacific). Biological performance is a central feature of the framework. It is defined in terms of three elements-life history diversity, productivity, and capacity. These elements of performance are characteristics of the ecosystem that describe persistence, abundance, and distribution potential of a population.

The analytical model is the tool used to analyze environmental information and draw conclusions about the ecosystem. The model incorporates an environmental attributes database and a set of mathematical algorithms that compute productivity and capacity parameters for the diagnostic species.

The general approach for comparing existing and desired conditions is called the Patient (Current)-Template Analysis (PTA). This approach compares existing conditions of the diagnostic populations and their habitat (patient) with a hypothetical potential state (Template), where conditions are as good as they can be within the watershed. The Template is sometimes approximated with a reconstruction of historic conditions. Sufficient information normally exists to do this with the level of clarity needed for the analysis. The Template is intended to capture the unique characteristics and limitations of the watershed due to its combination of climate, geography, geomorphology, and history.

The diagnosis is performed by comparing the Patient and Template to identify the factors or functions that are preventing the realization of objectives. The diagnosis can be qualitative or quantitative, depending on the type and quality of the information used to describe the ecosystem. Regardless, the diagnosis forms a clear statement of understanding about the present conditions of the watershed as related to the diagnostic species. Following the diagnosis, potential actions to achieve goals are identified. Candidate actions are tailored to solve problems that were identified in the diagnosis. Restoration plans are comprehensive, long-term plans for the entire ecosystem. They consist of suites of actions designed to meet goals. One of the main benefits of the EDT method is that it allows us to build diverse suites of actions and analyze their cumulative effects.

Through an EDT assessment a diagnosis is made comparing current and historic habitat conditions. This diagnosis represents our best working hypothesis of how current habitat conditions affect (positive and negative) salmonid populations, and what habitat changes have occurred from historical times as best we understand them. The EDT model is designed to be periodically updated as new habitat information becomes available (both current and historically). Thus the working hypothesis of how the basin impacts salmonid populations both positively and negatively, and the reasons why will change somewhat based upon new information.

8.2 Use of EDT in the Yakima Subbasin Plan

The Yakima Klickitat Fisheries Project has been building and maintaining the data structure of a Yakima Subbasin-specific EDT model for over the last 10 years. This existing data framework was the basis for assessment of habitat within the Subbasin. Practically, in the last several years, major documents such as the Watershed Plan, Limiting Factors Analysis, the Subbasin Summary, and the Stanford and Snyder papers had been released, and since each of these documents evaluated habitat conditions at somewhat different scales and from somewhat different perspectives, the major task in preparation of the Assessment for the Subbasin plan was to compare these document's habitat assessment across the Subbasin, and the EDT model framework was the most complete data set to use as a base for this comparision.

The process of comparision consisted of:

- Summarizing and having on hand all of the relevant documents,
- Convening the Aquatic Technical Advisory Committee (for membership see Appendix) by geographic area
- Going through the habitat ratings of the EDT data, comparing those ratings with the other documents, and with new data such as recent screening, water conservation, or passage projects.
- Assigning new habitat condition ratings in the EDT model where appropriate, or noting habitat conditions for non-EDT attributes.

The parameters that the EDT model uses for input (level 2 values) have all been shown in numerous studies to have strong relationships to overall habitat productivity. There has been considerable debate regarding the utility of the EDT model due to its complexity and "overparameterization" (http://research.nwfsc.noaa.gov/trt/rsrpdoc2.pdf.). However the utility of the data structure of the model has high value in a watershed as large and diverse as the Yakima. Information such as the loss of side channels, locations of obstructions, etc. are valuable in and of themselves, especially in a referenced database, whether that data is used to run a particular model or not. In addition, while each of the EDT attributes has a strong correlation to productivity, abundance and diversity, the list of EDT level 2 attributes is not exhaustive – there are other issues that EDT does not address that effect productivity, abundance and diversity. In the Yakima Subbasin these non-EDT variables are phenomena such as flip-flop, conditions within lentic environments such as lakes and reservoirs, direct trampling of redds by cattle, lower river eutrophication, etc. In addition, EDT datasets models only exist for Coho, Steelhead, Spring and Fall Chinook in the Yakima Subbasin, and do not exist for other focal species such as Bull Trout, Lamprey and Sockeye. Therefore the EDT model's data structure was used for the comparision of habitat conditions in different documents, but the list of variables that could be assessed and captured in the comparision was much broader than the EDT dataset alone. This exercise and resultant data formed the backbone of the Aquatic Habitat Assessment, and the recommendations in the Management Plan.

While we had the Aquatic Technical Committee present, we also generated the EDT reference condition, which we will title the Restoration reference condition. For those attributes that could be characterized in the EDT model, and were considered major limiting factors (i.e. factors that are now included in the Key Findings Table in the Management Plan) to productivity, we asked the technical committee how much they thought a given attribute could be improved over the next 30 years (roughly the time for riparian vegetation to mature if planted) given the current conditions in the basin, and an unlimited budget, and using existing protection or restoration techniques such as riparian zone planting, purchase of water rights, levee relocation, etc. For example, in the Upper Yakima it was not thought likely that a massive relocation of Interstate 90 was going to occur, so confinement - hydromodification (a major limiting factor in the upper Yakima) was rated to remain nearly the same, while in the Union Gap reach, it could conceivably increase by over 40% without relocating the freeway or the Cities of Yakima or Union Gap. In a few cases, such as reaches located in Urban Growth Areas or other rapidly developing areas with still good habitat, some slight decreases in habitat quality were also entered into the model. The fundamental questions that we were trying to answer (within the limitations of the EDT model) were "Can we restore the productivity and capacity within the current and near term future development, water and land use patterns? Or would we have to change current development patterns, water and land use fairly drastically to meet the objective of healthy, harvestable populations?" In this exercise, no specific (i.e. abundance) population objectives were pre-determined, but the practical limits of habitat restoration were determined to the best of our ability.

8.2.1 EDT Reference Condition Model Results -

It should be noted that the Yakima Klickitat Fisheries Project had not used the EDT model in this way before – i.e. to model wholesale changes in habitat conditions across the entire watershed. The EDT model had been used at a reach and multiple reach scale to design habitat improvement and protection strategies, or to estimate juvenile rearing capacity for to assist in the citing of acclimation facilities or other fairly site specific uses. The structure of the model makes the description and evaluation of Subbasin-wide restoration actions a very labor, time, and computer intensive exercise. Accordingly, the model run for the Restoration reference condition was simplified procedurally through the following three actions –

1. Obstructions – existing obstructions to passage were assumed to be made totally passable (with the exception of the major storage dams). In most locations, this is a good assumption. For the storage dams, only Bumping Lake and Lake Cle Elum were assumed to be made passable, these locations are currently under study to restore passage.

2. Improvements did not Cascade – In the real world, improvements in one attribute could be expected to have secondary effects on other attributes, or "cascade" through the ecosystem. For example, improvements in flow in one reach may or may not improve flow downstream, may or may not improve riparian condition, may or may not improve the temperature regime, etc. Within the model, changes were made to the selected attributes only, and other attributes were held constant for the model run. This means that the Restoration reference condition is very conservative in regards to estimated productivity, abundance and diversity.

3. The <u>EDT model cannot be used to predict the rate and eventual success of colonization of new habitat</u>. In the real world, in order to meet the predicted abundance and productivity levels, artificial supplementation, and likely supplementation of breeding adults into appropriate (especially spawning and

incubation temperature for a given stock) habitats would be required. Therefore new spawning reaches in newly opened habitat, or entirely new populations were not defined for this model run, only existing defined populations were used.

Some estimate of the model-estimated productivity of newly established populations can be inferred from the information presented for coho, as these populations are actually the subject of a reintroduction program, as the native coho stock was extirpated in the 1970s. The lack of new populations in the model run is also conservative, since, as mentioned in the conceptual foundation, there is considerable uncertainty in the expected success of re-establishing populations, and the first priority of restoration of the subbasin should be on ensuring that further loss of existing populations is prevented.

8.2.2 Model Run Results

The tables below have 6 columns each as explained below:

Population – an independent population of salmonids that is currently defined in the Yakima Subbasin EDT model

Scenario – Reference condition used in the model run.

Current no Harvest – the current modeled value for each population attribute (the next 4 Columns) for habitat and population conditions that currently exist in the subbasin and in the Mainstem Columbia assuming no harvest.

Current with Harvest – the same as above but with the current harvest management effects (in the Subbasin and Mainstem) included in the model.

Restoration – the Restoration Reference Condition of unlimited funding constrained by existing institutional factors such as infrastructure, water rights, etc.

Historic – the estimated productivity of the historic watershed but not the historic conditions in the Mainstem Columbia. The numbers in the charts represent only the theoretical productive potential within the Subbasin and not any further improvements or restoration in the Mainstem Columbia.

Diversity Index – The EDT model calculates the number of successful life history types that existed in the Historic reference conditions, based on estimated historic attributes within the watershed and a library of standard life histories for the species under consideration. The percentage figures in this column are an index of the proportion of those life histories that can be successfully completed under the conditions within that scenario. Larger numbers represent populations which are theoretically more resilient to disturbance and productive.

Productivity – a coarse measure of the ration of adult returns to the watershed for each adult fish that successfully spawns in the watershed. A productivity of 10 means that for each mating pair (2 fish), 20 fish will return as adults to the watershed (10 per spawner) that could be allowed to spawn, harvested or suffer other mortality within the watershed.

Capacity – a measure of spawning habitat available, based on the modeled estimated quality and quantity of habitat available. (Note that because no new spawning reaches were established in the model these number do not reflect large changes in capacity due to restoration)

Abundance – estimated geometric mean number of adults that return to the Subbasin under each scenario.

Below the tables are Ladder Charts for each population. These charts depict graphically the degree to which a population would be harmed by degradation of the habitat in each geographic area, or benefited by restoration of each geographic area. Normally, these charts are used to prioritize protection or restoration strategies in different geographic areas in a watershed. Here, they only apply to the Restoration reference condition, and they reflect the degree to which conditions "have been restored" (in the degradation column) or still "could be restored to better conditions" (in the restoration column) after actions in the reference condition have been implemented. It is a way to look at how far the Aquatic Technical Committee thought we could go under the existing social and physical constraints using standard restoration techniques.

Results

Overview

In looking at the results in the table, other EDT outputs for limiting factors, and the inputs that were used to run this reference condition, the single largest variable estimated by the Aquatic Technical Committee was the degree to which low flows in the lower Naches (i.e. below the confluence with the Tieton) and lower Yakima (below Wapato Dam) could be improved. The model run reflects only a 10 to 15% improvement in flow conditions in these reaches, which would still leave them at only an estimated 20 to 30% of low flow conditions on average. Therefore the species that depend most on those reaches to complete their life histories – Spring and Fall Chinook, and Coho, show the smallest relative (though still very significant) gains in all categories, while Steelhead, which are much less dependent on those reaches during times of the year when flows are limiting, show a large relative response.

Note also that lack of passage at Tieton Dam is clearly reflected in the chart for the Naches Spring Chinook, as it is also reflected in the ladder charts for Steelhead. Since the current population definitions in the EDT model do not route Upper Yakima Spring Chinook, Steelhead or Coho into or above those blockages, the lack of passage at Kachess and Kechellus does not seem to effect Upper Yakima Spring Chinook or Steelhead.

Spring Chinook – The American River population, which has excellent spawning habitat, shows the smallest increase in population attributes, since it is currently limited by rearing habitat in the lower river, this population remains below an abundance level of 500, and that raises some concerns for its long term viability. The Naches population benefits (triples in abundance) from improved spawning habitat and riparian conditions, especially in the tributaries, but is limited by flow. The Upper Yakima population benefits from expanded range and removal of obstructions (increased rearing habitat in the upper Yakima) and modest improvements in spawning habitat capacity. Again, the common parts of their life history – rearing in the lower river – act as a common limiting factor to these populations.

Table 2-39. EDT Population Attributes for Yakima Subbasin Spring Chinook

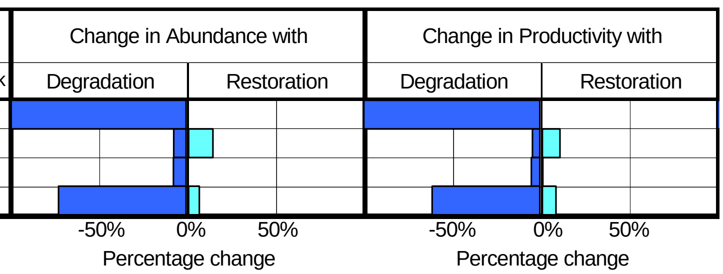
Population	Scenario	Diversity index	Productivity	Capacity	Abundance
American Spring Chinook	Current no Harv.	70%	5	358	285
	Current w Harv	69%	5	333	261
	Restoration	72%	6	407	338
	Historic	84%	13	1,811	1,666
Naches Spring Chinook	Current no Harv.	36%	3	1,737	1,114
	Current w Harv	35%	3	1,620	1,007
	Restoration	64%	3	4,123	2,918
	Historic	95%	14	21,233	19,693
Upper Yakima Spring Chinook	Current no Harv.	23%	3	4,889	3,382
	Current w Harv	22%	3	4,555	3,084
	Restoration	42%	3	6,588	4,604
	Historic	97%	11	38,283	34,757

The Ladder charts show that, with the exception of restored flow in the lower Naches and lower Yakima, the standard restoration techniques employed within the bounds of current social and economic conditions do an excellent job of restoring the productive capacity of the habitats needed for completion of Spring Chinook life histories

.

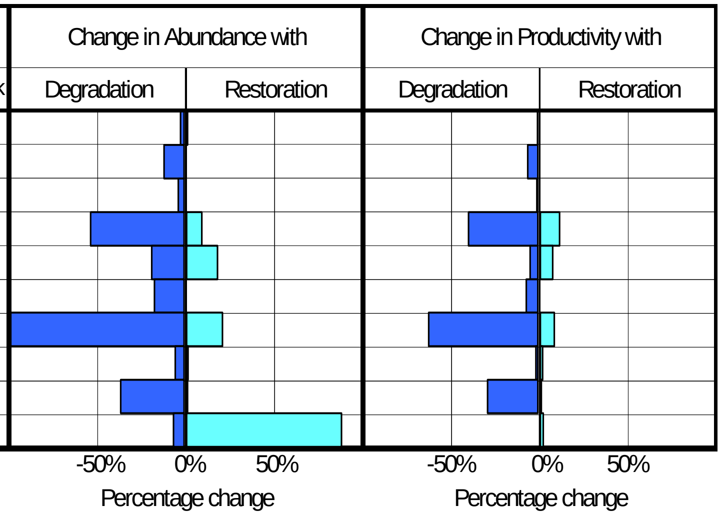
American River Spring Chinook

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
American	A	1	C	4
Lower Yakima	C	4	A	1
Middle Yakima	C	3	C	3
Naches	B	2	B	2



Naches Spring Chinook

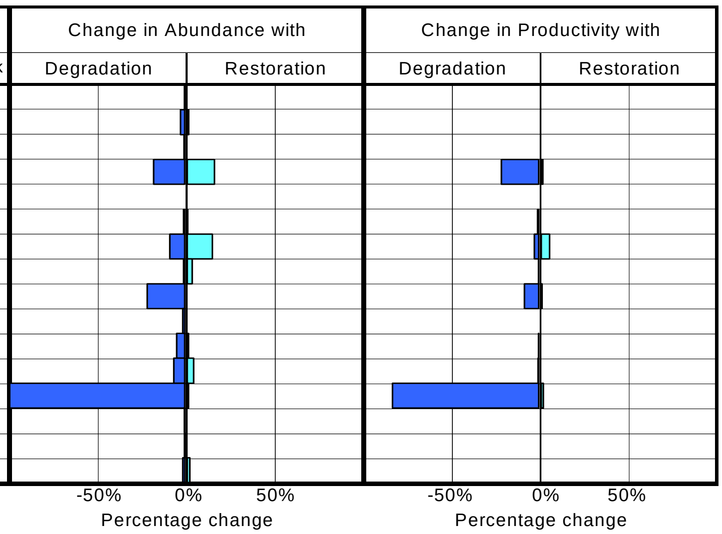
Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Ahtanum	D	8	C	4
American	C	4	D	6
Cowiche	D	6	D	5
Little Naches	B	2	B	2
Lower Yakima	C	4	B	2
Middle Yakima	C	5	D	5
Naches	A	1	A	1
Nile	D	6	C	3
Rattlesnake	B	3	C	4
Tieton	D	7	A	1



Upper Yakima Spring Chinook

Fall Chinook – The same pattern is evident here for fall Chinook, which are the most dependent on these mainstem reaches. Lack of improvement in flow/temperature conditions for rearing truncates that life history. Life histories that migrate earlier in the year are very successful with improved channel conditions and cover, and actually recover to almost half of the historical levels, and probably provide the greatest opportunity for harvest. These figures should be used with caution however, since this mainstem fall Chinook population is also the subject of a reintroduction program and lacks a defined life history which results in a large uncertainty is associated with population response to habitat enhancement/manipulation.

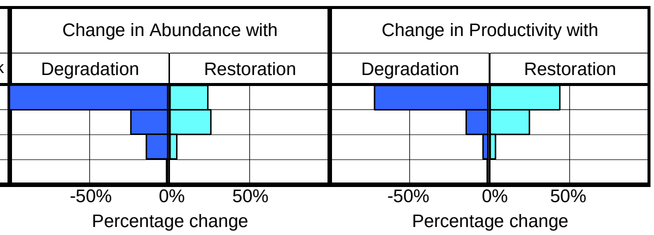
Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Ahtanum	E	15	E	9
Ahtanum	D	8	D	7
Ahtanum	E	12	E	11
Cle Elum	B	3	A	1
Currier	E	16	D	8
Kachess	D	7	D	7
Lower Yakima	C	4	B	2
Manastash	E	9	C	4
Middle Yakima	B	2	D	8
Swauk	E	10	E	10
Taneum	D	6	D	7
Teanaway	C	5	C	5
Upper Yakima	A	1	B	3
Wenas	E	13	E	10
Wide Hollow	E	14	E	12
Wilson	E	11	D	6



Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Lower Yakima Fall Chinook	Current no Harv.	30%	3	15,078	9,994
	Current w Harv	6%	2	6,842	3,086
	Restoration	61%	5	17,085	13,625
	Historic	93%	10	35,501	31,931
Marion Drain Fall Chinook	Current no Harv.	12%	2	203	120
	Current w Harv	5%	1	109	33
	Restoration	16%	2	298	158
	Historic	97%	7	2,333	1,998

Steelhead – As discussed above, Steelhead respond well to restoration, all existing populations are modeled to improve substantially, and population levels are well above minimum thresholds for viability. The ladder charts show that the lower Naches and lower Yakima reaches are of

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
Lower Yakima1	A	1	B	2
Lower Yakima2	B	2	A	1
Lower Yakima3	C	3	C	3
Marion	D	4	D	4

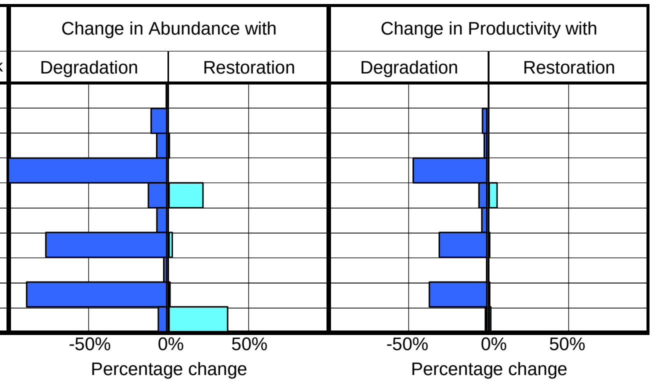


much less importance for this species. For this species, the upper Yakima steelhead/rainbow population estimates are for both forms of the species, and due to the uncertainty regarding what determines anadromy, the two forms are not broken out. Significantly, the increase in capacity in this population indicates that habitat conditions get dramatically better, which should mean an increase in both anadromous and non-anadromous forms.

Upper Yakima steelhead/rainbow
Naches Steelhead

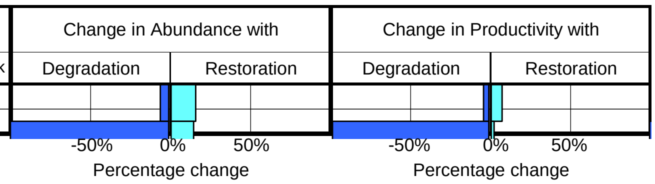
Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Naches Steelhead	Current no Harv.	11%	2	2,451	1,020
	Current w Harv	11%	2	2,451	1,020
	Restoration	60%	3	7,563	4,911
	Historic	92%	16	28,096	26,348
Satus Steelhead	Current no Harv.	38%	2	1,634	975
	Current w Harv	38%	2	1,634	975
	Restoration	49%	5	3,379	2,733
	Historic	91%	17	10,961	10,300
Toppenish Steelhead	Current no Harv.	12%	3	848	510
	Current w Harv	12%	3	848	510
	Restoration	37%	5	2,238	1,784
	Historic	94%	15	8,749	8,147
Upper Yakima Steelhead	Current no Harv.	7%	2	3,113	1,429
	Current w Harv	7%	2	3,113	1,429
	Restoration	33%	3	9,931	6,553
	Historic	92%	16	46,254	43,424

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Ahtanum	E	9	D	7
American	C	5	D	6
Cowiche	D	6	C	5
Little Naches	A	1	C	4
Lower Yakima	B	3	A	1
Middle Yakima	C	4	D	8
Naches	B	2	B	2
Nile	D	8	C	5
Rattlesnake	B	2	B	3
Tieton	D	7	B	2



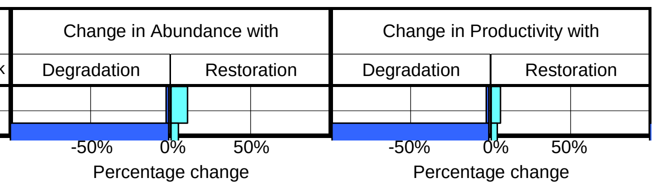
Toppenish Steelhead

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Lower Yakima	B	2	A	1
Toppenish	A	1	B	2



Satus Steelhead

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Lower Yakima	B	2	A	1
Satus	A	1	B	2



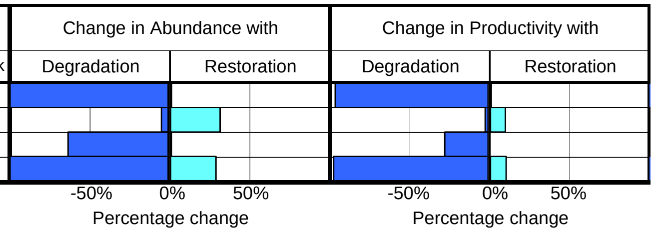
Coho - The population parameters increase in all populations, but the lack of a clearly defined life history strategy at the current time limits the utility of such population predictions, especially at this large scale. These populations have been defined within the EDT model for much smaller scale habitat improvement and reintroduction strategies and it is probably not appropriate to put a high degree of confidence in the results given here, especially over a longer time frame. Coho are especially dependent on side channels in mainstem alluvial floodplains, the continuing low abundance levels of coho reflect that under the Restoration reference condition, more emphasis should be placed on restoration flow in the lower river.

Population	Scenario	Diversity index	Productivity	Capacity	Abundance
American Coho	Current no Harv.	4%	2	81	29
	Current w Harv	4%	2	81	29
	Restoration	6%	2	111	62
	Historic	17%	5	1,110	872
Naches Coho	Current no Harv.	4%	1	722	205
	Current w Harv	4%	1	722	205
	Restoration	15%	2	1,244	527
	Historic	81%	5	14,779	11,941
Upper Yakima Coho	Current no Harv.	5%	2	2,234	999
	Current w Harv	5%	2	2,234	999
	Restoration	12%	2	3,453	1,667
	Historic	85%	6	35,230	28,993

Figure XXXX Ladder Charts for Yakima Subbasin Coho

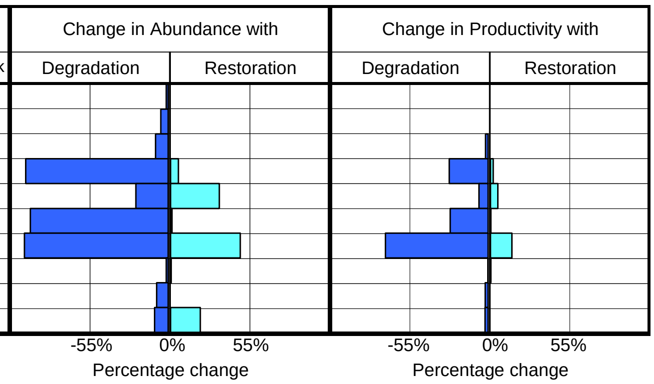
American Coho

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
American	B	2	B	2
Lower Yakima	D	4	A	1
Middle Yakima	C	3	C	3
Naches	A	1	A	1



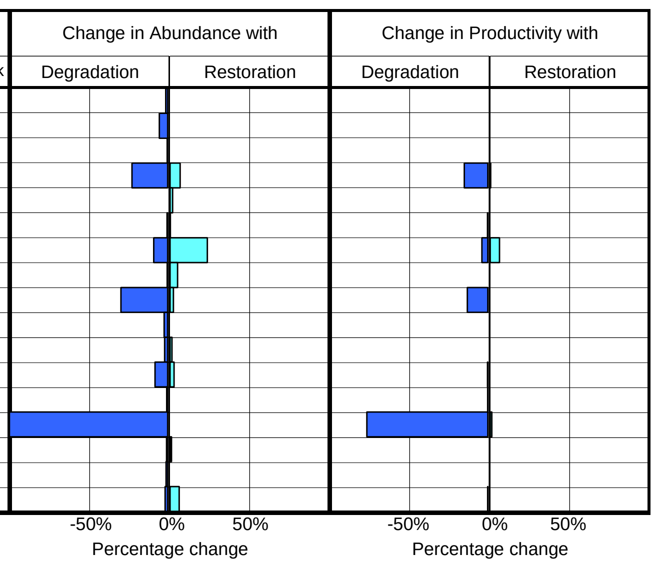
Naches Coho

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Ahtanum	E	10	E	8
American	E	9	E	9
Cowiche	D	6	E	7
Little Naches	B	2	C	3
Lower Yakima	C	4	B	2
Middle Yakima	B	3	D	6
Naches	A	1	A	1
Nile	D	8	D	5
Rattlesnake	D	7	E	9
Tieton	C	5	C	4



Upper Yakima Coho

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Ahtanum	E	11	D	11
Ahtanum	D	7	D	9
Ahtanum	E	14	D	10
Cle Elum	B	2	A	2
Currier	E	15	C	6
Kachess	D	8	D	9
Lower Yakima	C	4	A	1
Manastash	E	12	C	5
Middle Yakima	B	3	B	4
Swauk	D	9	D	10
Taneum	D	10	C	7
Teanaway	C	5	C	5
Umptanum	D	8	D	8
Upper Yakima	A	1	B	3
Wenas	E	13	D	9
Wide Hollow	E	12	D	10
Wilson	D	6	B	4



Summary

These EDT model results should be interpreted with caution, and used as only the most coarse approximation of the effectiveness of the strategies contained in the Restoration reference condition in producing sustainable and harvestable populations. This conservative approach indicates that the restoration strategy is reasonable with the exception of the need for flow improvements in the Naches and lower Yakima using strategies that are more effective at flow improvement than the standard approaches of purchase or transfer of water rights or improvements in water use or conservation. As stated numerous times in this Assessment Chapter, improvement in low flow conditions in those reaches limit the productivity of the ecosystem as a whole, the EDT model does an adequate job of reflecting the importance of these reaches.