strongly recommends that other actions other than land acquisition occur to assist in the mitigation of impacts to fish and wildlife.

Ecosystem-based Management Principles Adopted in the Canadian Subwatershed

The Canadian Okanagan Basin Technical Working Group (COBTWG) has adopted an ecosystem approach to the management of fisheries to guide the implementation of fisheries actions in the Canadian reaches of the Okanagan subbasin. The COBTWG meets regularly with the US Co-managers and other interested agencies in an ad-hoc forum.

The Canadian approach is guided by agreements that include principles (paraphrased from the COBTWG Terms of Reference, January 2003) related to conservation and protection of indigenous fish stocks considered at imminent risk, and rehabilitation or restoration of highly valued indigenous fish populations and their habitats to satisfy requirements for sustainable use patterns. In addition, management efforts are directed at maintenance or restoration of normative ecosystem processes (C. Coutant 2000) considered essential to ecosystem health, and are to reflect a balance of multi-species ecosystem concerns.

Management actions are further directed by a precautionary approach, including application of an adaptive management framework for implementation of any project considered to involve moderate-to-high levels of risk or uncertainty to long-term sustainability of indigenous species within a healthy aquatic ecosystem. The adaptive management approach includes:

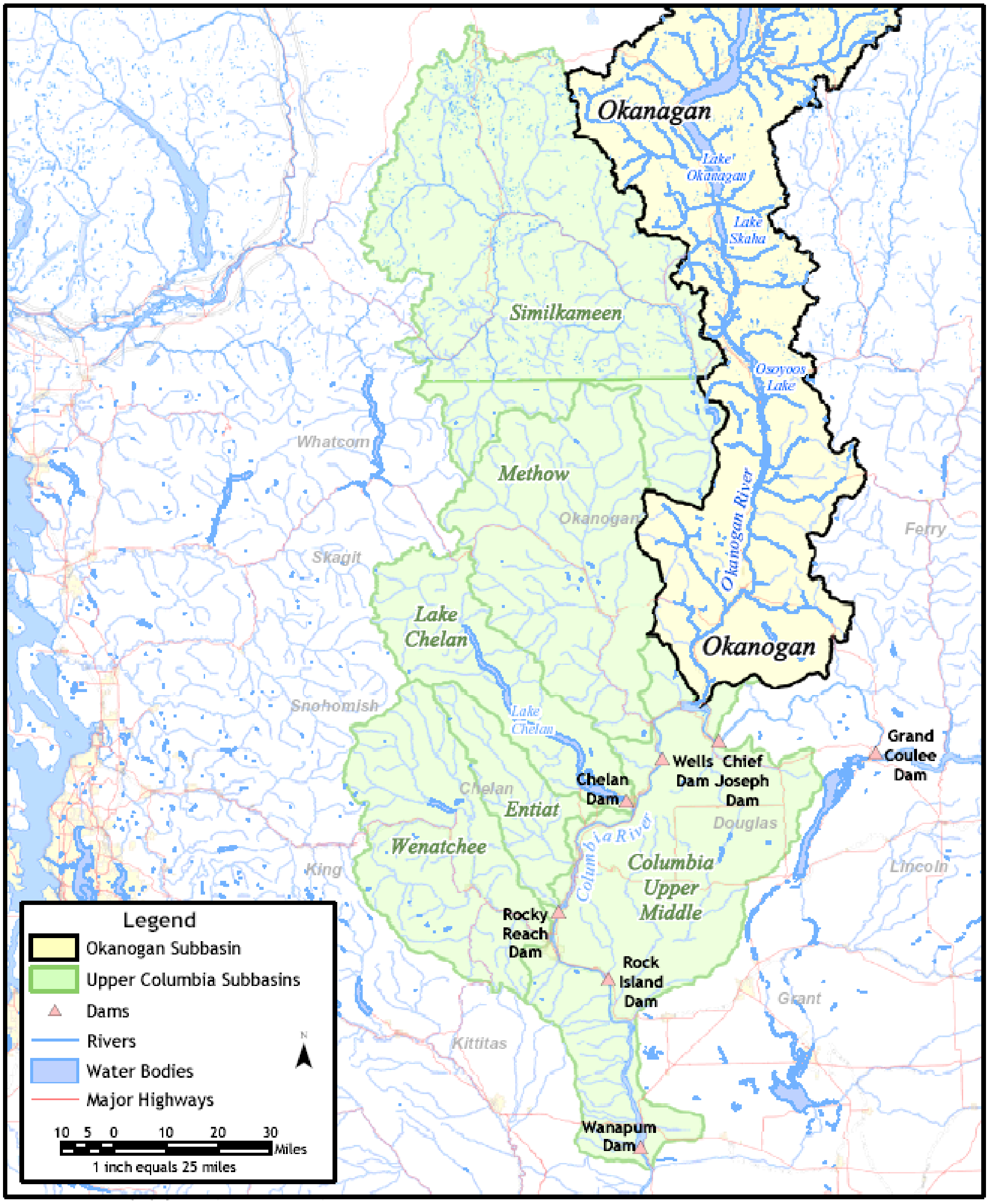
- adoption of a ‘stepwise’ approach to project implementation;
- a commitment to assessment and monitoring prior to, during, and after completion of the project; and
- a cyclical review of incoming assessment information to support a stepwise decision-making process that includes the option of project termination or reversal at any point where information clearly indicates the costs are likely to outweigh the benefits.

In addition to the elements noted under the first two bullets above, the COBTWG acknowledges support for adherence to the set of general ecosystem principles and operational guidelines adopted in May 2000 by Canada as one of the Parties to the United Nations 1992 Convention on Biodiversity.

3 Subbasin Assessment

3.1 Subbasin Overview

The Okanogan Subbasin enters the Columbia River between Wells and Chief Joseph Dams, straddling B.C. and Washington at Osoyoos Lake (Figure 3). The Subbasin is the third largest of Columbia River Basin’s 20 major subbasins, with its confluence at Columbia RM 533. The Okanogan subbasin comprises 16.2% of the Columbia Cascade Ecoprovince, and consists of 5,723,010 acres in the entire watershed.



Source: Data Layers: Watersheds & Dams (Streamnet, TRIM), Major Rivers (WA Ecology, TRIM), Major Highways (WashDOT, ESRI). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 3. Location of Okanogan subbasin in relation to the Upper Columbia River (Similkameen is part of the Okanogan watershed, but is inconspicuous in terms of the current scope of this subbasin plan. Water quality and some cultural issues are included in context.)

3.2 Subbasin Description

The Okanogan River originates in B.C. and flows south through a series of three large, and one small lake before reaching the US border. The border bisects Osoyoos Lake where the Okanagan River enters American territory in Washington State. Seventy-four percent of the subbasin is in British Columbia (B.C.), Canada, and 26% is in Washington State.

The Okanagan Watershed in Canada extends north from the Columbia Plateau in Washington State to the topographical divide separating the drainage basins of the Columbia and Fraser Rivers at Armstrong B.C. The majority of the Canadian Okanagan River mainstem lies in a valley that is a long north-south trench located in the interior plateau of B.C. The valley is 18 kilometres (11.2 miles) wide at the northern end, and only 3 – 6 miles (5 to 10 kilometres) wide at the southern end. From a few miles north of Armstrong, B.C., the entire valley drains south to the Columbia River. Many of the tributaries of the Okanogan River are small systems that arise in the hills that surround this valley. A total of 71 US subbasin tributaries were mapped for the purposes of the Okanogan Subbasin Summary 2002. In Canada, the B.C. Ministry of Water, Air and Land Protection (MWLAP) Watershed Atlas identifies an additional 94 watersheds in B.C. portions of the Okanagan watershed, including 81 greater than 50 hectares. In addition, the Similkameen River is Okanogan River's largest tributary, and includes another 110 Canadian subwatersheds (Glenfir Resources, 2002 from Watersheds, B.C. A B.C. Watershed Atlas. http:/home.gdbc.gov.bc.ca/watershedsbc) (Figure

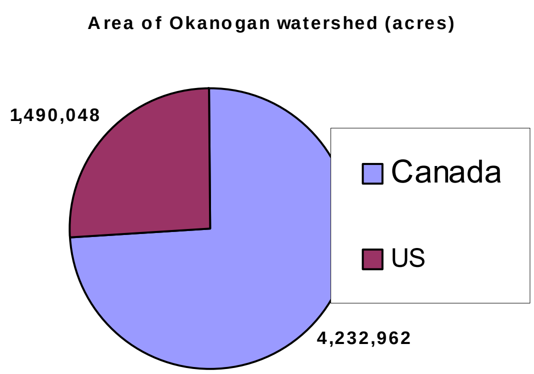


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Figure 4. Area of Okanogan watershed.

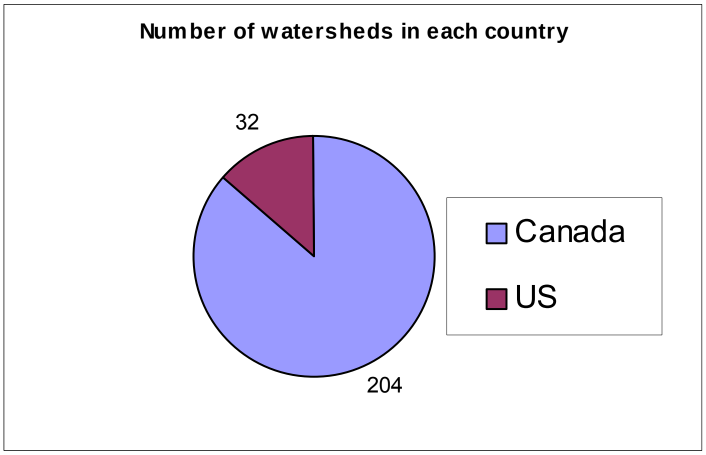


Figure 5. Number of watersheds in Canada and the U.S.

The Similkameen River enters the Okanogan River from the west approximately 20 miles south of the US-Canada border, measures approximately 317 miles in length (197 kilometres), and drains 2900 square miles (7,600 square kilometres in Canada).

The large number of Similkameen River tributaries provides lake-headed systems with more stable flow regimes. The largest subwatersheds of the Similkameen include the Tulameen River, Pasayten River and Ashnola River. Important lake-headed tributaries include Hayes Creek, Wolfe Creek, Allison Creek, and Summers Creek (tributary to Allison Creek). While most of the Similkameen River watershed lies in Canada, the confluence of the Similkameen and Okanogan rivers lies in Washington State, just south of Oroville.

The Okanogan River joins the Columbia River at river mile (RM) 533.5, between Chief Joseph and Wells dams, near the town of Brewster, Washington.

Within the United States, the watershed is about 65 miles long, averages about 35 miles wide, and covers about 1.49 million acres. There are 32 subbasins within Washington. The Similkameen River, located primarily in Canada, contributes 75% of the flow to the Okanogan River.

3.2.1 Cultural Features of the Okanogan Subbasin

Historic occupation of the Okanogan subbasin

Humans have been living in the Okanogan Basin for at least 7,000 years (Wilson, 1990). Before European settlement, native tribes lived in small, autonomous bands or villages (Honey, 1979). Most of the Okanogan natives of the region spoke Okanagan Interior Salish or Sxwuyi’71hp (Kennedy and Bochard 1975), but there were seven languages in the Okanogan area alone (Wilson, 1990).

The word “Okanogan” is derived from a Salish word that refers to the place on the Okanogan River that marks the furthest ascent of salmon up the river. Okanogan territory stretched from where the Okanogan River flows into the Columbia in the south, to beyond Lake Okanogan in the north. The tribe’s territory stretched east from the crest of the Cascades for 100 miles. Okanogans did not recognize the United States/Canadian border as a demarcation dividing the tribe, but the boundary has created somewhat different lifestyles for those north and south of the border.

At least five bands of Okanogans lived south of the United States/Canadian border in at least twelve villages. Native peoples of the region hunted, fished, and gathered throughout that territory. There were salmon traps at locations near Oroville, Monse, Malott, and Omak. Other fish were caught in various locations inland from the Okanogan River. Bear, deer, mountain goats, rabbits, and other small game, ducks, geese, and grouse were hunted throughout Okanogan territory.

Foods gathered included service berries, thorn berries, huckleberries, blueberries, raspberries, strawberries, and Oregon grape. Bitterroot was also dug up, as was some Camas. Various native medicines were also gathered, and soapstone, dyes, and paints were collected at locations west of the Okanogan River. The stretch of Okanogan River controlled by the Okanogan Tribes also constituted a portion of an important trade route, with the mouth of the Okanogan being an especially important trading location.

In the US, currently over 8,700 descendants of 12 aboriginal tribes are presently enrolled in the Colville Tribes Reservation. In Canada, over 2,000 members of the Okanagan Nation Bands reside on seven federal Indian Reserves. They are non-treaty, and are associated with the Okanagan Nation Alliance (ONA) located in Westbank.

In 1886, the Colville Tribes reservation was opened to non- settlement, but a few Okanogans received allotments west of the Okanogan River and continued to live there. Most Okanogans moved onto the Colville Tribes Reservation. Tribal members continue to utilize their traditional food resources throughout their territory, fishing for salmon, digging camas, and gathering berries (Hart 2001).

Settling of the Okanogan subbasin

Trappers and traders began moving to the area in the early to mid-1800s.

Gold mining brought a major influx of people to the subbasin in the late 1800s. Many boom towns sprang up. The most famous town was Ruby, which became the first county seat of Okanogan County in 1888. The county seat was moved 11 months later to Salmon City (now named Conconully). Soon afterwards, the gold diminished, the miners moved away, and the boom towns declined in size and distinction. Mining in the Fraser River basin in British Columbia spurred large cattle drives up the Okanogan River Valley. The British customs station at Osoyoos collected duty on 22,256 head of beef cattle between 1859 and 1870.

The mining economy was slowly replaced by dry land farming and ranching. Agriculture, primarily orchards (vineyards in Canada), livestock feed, and wheat are predominant in the valley bottom. There are also several population centers and municipalities along the river and the lower reaches of the tributaries. During high spring flows, paddle-wheel riverboats traveled up the Okanogan River to the town of Riverside to offload goods and new settlers. Orcharding gradually became the mainstay of the local economy; growth was slow because of limited transportation and the lack of irrigation (Wilson 1990). In 1914, the Great Northern Railroad came to the basin, virtually replacing the paddle wheelers.

Following in the path of the railroad and local population centers was the extensive expansion of irrigation systems throughout the valley. With the relatively fast and reliable railroad service to the area, farmers were able to convert more and more land into agricultural production. Better transportation and a solid economic base allowed the communities to become more settled and permanent.

Throughout the 1900s orchards, cattle and timber provided the primary economic generators in the Okanogan subbasin. However, by the end of the century, all three economic mainstays had undergone substantial change, reducing their economic importance, and slowly being replaced by tourism, services and value-added manufacturing.

Tribal Interests

The Okanagan Nation Alliance and the Colville Tribes

The Okanogan Bands were not parties to any treaty with the United States or Canada, and remained relatively isolated from settlers until the Colville Tribes Reservation was created by Executive Order of July 2, 1872. This was followed by ceding the northern half of the reservation in 1891, reducing the overall reservation size to 1.5 million acres. However, the "right to hunt and fish in common with all other persons on lands not allotted to said Indians shall not be taken away or otherwise abridged." (Article 6, Colville Tribes Reservation Agreement 1891).

The Okanagan Nation Alliance is an assemblage of seven Okanagan Bands located in the traditional territories in Canada. There have been no treaties signed by Canadian Okanagan Bands. The Canadian Constitution Act (1982) recognizes and affirmed the continued existence of aboriginal rights, and in 1990, the Supreme Court of Canada in its"Sparrow Decision" confirmed that fishing rights are a priority, second only to conservation.

The entire Okanogan subbasin, south of the US-Canada border, lies within the Colville Tribes' Reservation or the usual and accustomed lands and waters utilized by the Okanogan Tribe. The Okanogan Tribe is now one of 12 tribes affiliated with the Colville Tribes Reservation. Many tribal allotments still exist along the Okanogan and Similkameen Rivers and smaller creeks.

East of the Okanogan River lies the present Colville Tribes Reservation and the ceded North Half Reservation. On the Colville Tribes Reservation, the Colville Tribes have jurisdiction and management plans for natural resources within the exterior boundaries of the Reservation. On the North Half Reservation, the Colville Tribes retain hunting, fishing and gathering rights reaffirmed by the Antoine v. Washington Decision of 1975. To this day, under the management of the Colville Tribes, members continue to harvest game and fish and gather wild plant materials on or in traditional lands and waters.

The Colville Tribes hold federally reserved fishing rights through the establishment of the Colville Tribes Reservation by Executive Order in 1872. The US Court of Appeals for the 9th Circuit ruled that a primary purpose of the 1872 Executive Order was to preserve tribal fisheries and access to traditional tribal fishing areas. The Court also ruled that the Colville Tribes possess federally reserved water rights to stream flows sufficient to preserve or restore tribal fisheries. The Colville Tribes also reserved their rights to fish and fishing in the waters of ceded lands, including the Okanogan River up to the Canadian border.

In 2000, the Bureau of Reclamation agreed with the Colville Tribes that the federal government had not completed its authorized anadromous fish mitigation for construction of Grand Coulee Dam over 60 years ago. Planned artificial production programs were not implemented for the Okanogan River Basin when the outbreak of World War II halted non-war related construction projects.

Tribes of the Colville Reservation have been seriously harmed by the lack of Grand Coulee mitigation, with ceremonial and subsistence fisheries declining to minimal levels, even in years of substantial runs entering the Columbia River. Fishing opportunity is now severely limited to summer/fall Chinook immediately below Chief Joseph Dam and an occasional sockeye fishery in the Okanogan River.

This situation has been adversely compounded by later formulas for mitigation of mid-Columbia Public Utility District dams where the Federal Energy Regulatory Commission does not require mitigation for now, non-existing.

Additional hatchery production under the proposed mitigation agreement with the Public Utility Districts (PUDs) is based on the run sizes of salmon and steelhead in a 10-year period during the 1970s and 1980s (Bugert 1998). Most of these post-dam runs were supported in large part by the initial hatchery mitigation programs funded by the PUDs and the federal government. Since the Colville Tribes did not receive the initial mitigation from the construction of federal and PUD dams, the basis for the new agreements discounts obligations to the Colville Tribes.

Without the initial federal salmon mitigation that other watersheds in the province obtained, the Okanogan Basin and Colville Tribes again were provided without mitigation.

Additionally, the federal government has never provided Okanogan anadromous fish mitigation for the Colville Tribes' loss of adult and juvenile fish passing through the four Corps of Engineers' (Corps) hydroelectric projects on the Lower Columbia River. Fish mortality at these projects has been generally estimated at about 10% per project, but was historically higher. Finally, Chinook mitigation by Douglas PUD for losses, because of inundation and passage, has been sited downriver at Wells Hatchery and in the Methow River, away from the Colville Tribes' reservation fisheries.

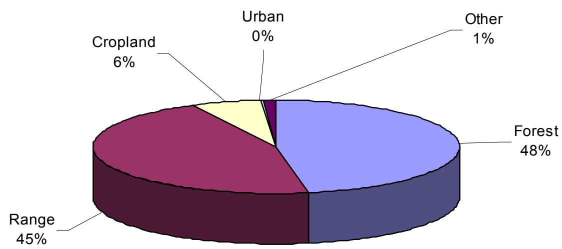
The Colville Tribes' total anadromous salmonid harvest is normally below 1,000 salmon and steelhead combined, and similar estimates are reflected in the Okanagan Nation fisheries upstream in Canada. Yet, in the 1800s, prior to over-harvest in lower river commercial fisheries and subsequent habitat destruction, the Colville Tribes were estimated to have harvested in excess of 2 million pounds of salmon and steelhead annually (Koch 1976).

3.2.2 Land Use and Water Developments

Land Use

United States

Forestry and range are by the far the major uses of land in the Okanogan subbasin in the US, followed by croplands (Figure 6). Most of the landscapes, from the riparian areas to the upper elevation forests, have been used for residential homes. The valley bottom is dominated by agriculture, primarily fruit crops, with some grain and hay production. The bench lands are dominated by livestock grazing and hay production, and most of the lower to mid-upper elevation forests have been harvested for timber and used for livestock grazing.



Source: NRCS, 2000

Figure 6. Land Use in the Okanagan subbasin

Table 1. US Okanogan subbasin land use overview

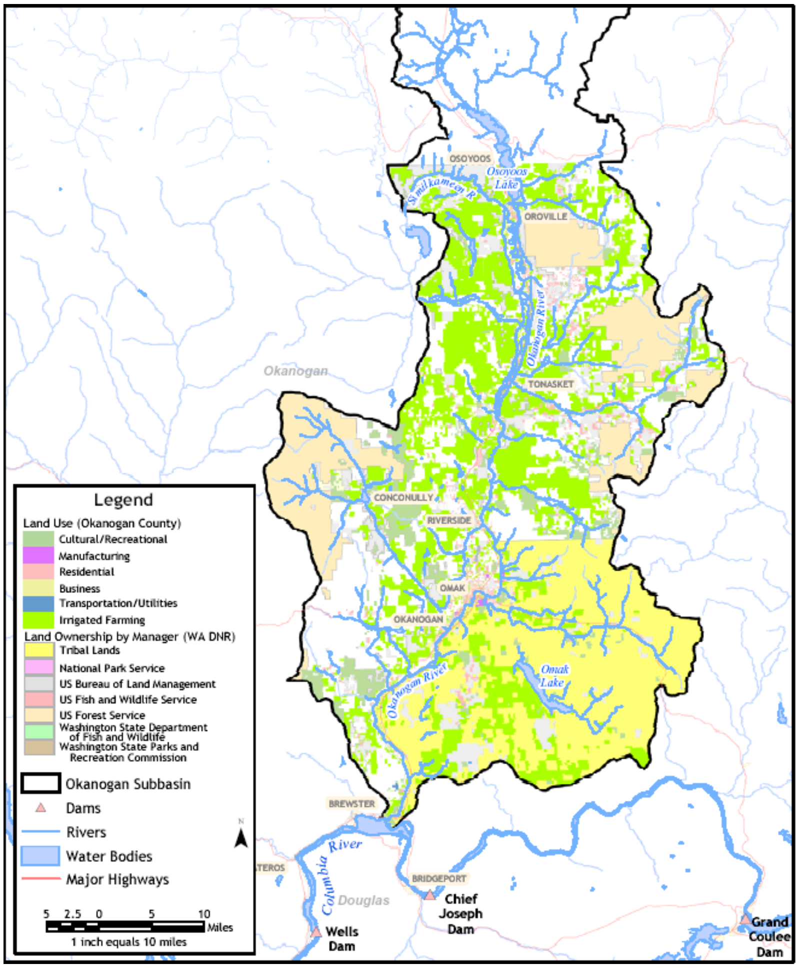
			Private Ownership			**Public Ownership**[1]		
Land Use	Number of Parcels	Acres	Number of Parcels	Acres	% of Total	Number of Parcels	Acres	% of Total
Single Family Residential	4,046	17,678	3,976	17,534	99.19%	70	144	0.81%
Other Residential[2]	357	728	344	650	89.29%	13	78	10.71%
Vacation/Cabins	439	6,314	438	6,313	99.98%	1	1	0.02%
Manufacturing	70	784	45	760	96.98%	25	24	3.02%
Transportation, Communication, Utilities	236	1,225	152	339	27.67%	84	886	72.33%
Trade	472	493	468	491	99.66%	4	2	0.34%
Services	448	952	279	314	32.98%	169	638	67.02%
Cultural, Entertainment, Recreational	600	30,856	194	607	1.97%	406	30,249	98.03%
Agriculture, Resource, Open Space	11,473	483,738	10,944	465,313	96.19%	529	18,425	3.81%

[1] includes Federal (USFS, BoR, BLM, BPA etc…), State (WDFW, DNR, Parks, DOT, etc…), Tribal (Trust, allotments, etc…), Local (County, Cities, Schools, Hosptials, Fire Districts, Housing Authorities, PUD's)

[2] - includes duplexes, apartments, manufactured home parks , condominiums and motels

			Private Ownership			Public Ownership[1]		
Undeveloped Land	5,293	109,120	4,675	63,903	58.56%	618	45,217	41.44%
Unclassified[3]	2,982	579,795	0	0	0.00%	2,982	579,795	100.00%
Totals	**26,416**	**1,231,683**	**21,515**	**556,225**	**45.16%**	**4,901**	**675,458**	54.84%

Source: OFM, 19



Source: Data Layers: Watersheds & Dams (Streamnet, TRIM), Major Rivers (WA Ecology, TRIM), Major Highways (WashDOT, ESRI). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 7. Land use types in the US Okanogan Subbasin (NRCS 2000)

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[3] - unclassified lands included State, Federal, Tribal, City, Schools and other public lands including rights-of-way, river corridors, etc…..

Canada

In British Columbia, the surrounding forested areas are public lands (Provincial Crown), and the valley bottom is predominantly privately owned or Reserve. The surrounding grass and scrub bench-lands are dedicated to cattle grazing tenures from Provincial agencies. Much of the land ownership along the Okanagan Valley bottom from Oliver north to Kelowna is dedicated to intensive orchard and vineyard agriculture, and urban development. Many transportation corridors and most settlement have occurred along the river corridor.

Water development

Stream flow in the mainstem Okanogan River is affected by a series of dams and channelization projects dating back to 1920. Water releases in mainstem lakes to meet fishery needs are negotiated yearly by a consortium of fisheries and irrigation managers from both Canada and the US Zosel dam flows are operated under the auspices of Orders set out by the International Joint Commission.

Irrigation Districts

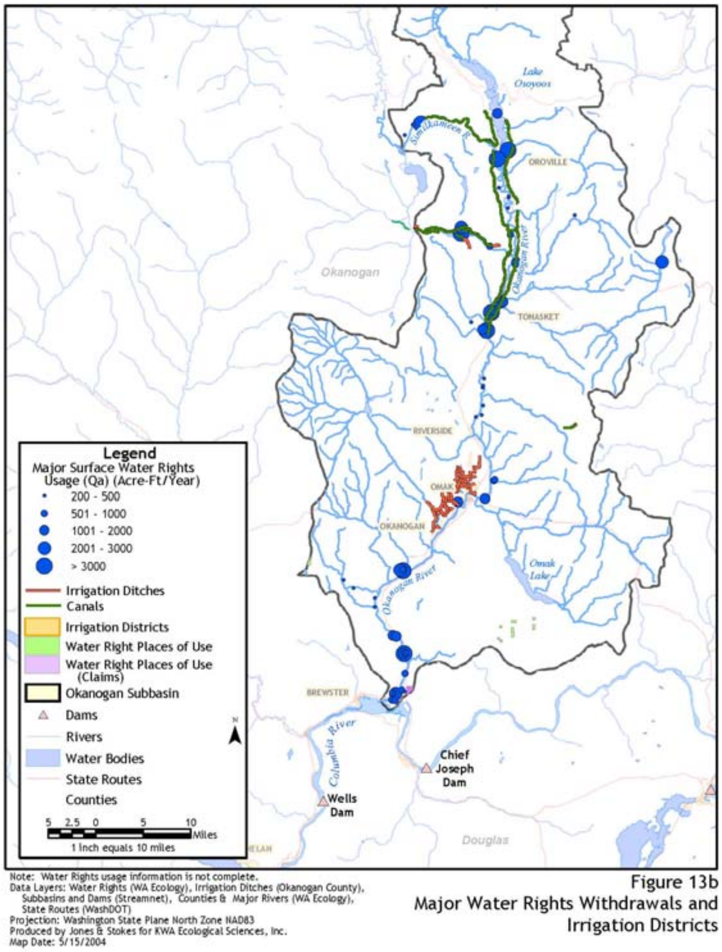
The watershed contains approximately 36,000 to 40,000 acres of irrigated area in the US portion of the subbasin. About 60 % of that acreage (24,421 acres) is contained within irrigation districts or ditch companies (Ecology 1995).

There are nine irrigation districts, reclamation districts, and canal companies operating in the Okanogan Watershed (Table 2). Major irrigation withdrawals and major water rights are illustrated in Source: Note: Water Rights usage information is not complete. Data Layers: Water Rights (WA Ecology), Irrigation Ditches (Okanogan County), Subbasins and Dams (Streamnet), Counties & Major Rivers (WA Ecology), State Routes (WashDOT). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004.

Figure 8. These water providers comprise the bulk of irrigation water delivery from surface water sources to approximately 24,710 acres (OCD 1989).

Table 2. Irrigation Districts of the Okanogan Subbasin

Irrigation District	Source	Irrigated Acres	Length	Flow
Okanogan Irrigation District	Salmon Ck, Okanogan R.	5,032	50 mi. piped. 7.6 mi. lined canal	15,000 acre ft/yr.
Oroville Tonasket Irrigation Project	Similkameen R., Lk Osoyoos, Okanogan R.	10,300	110 mi. pipe 10 mi. canal	41,200 ac ft/yr.
Whitestone Irrigation and Power Company	Toats Coulee	3,000	16 mi. pipe 14 mi. lined canal	45 cfs max
Pleasant Valley Irrigation Project	Loup Loup Creek, Okanogan River	2,000	3 mi. pipe 3 mi. canal	17 cfs max
Helensdale Irrigation District	Loup Loup Ck., Okanogan River	225	2 mi. pipe	
Brewster Flat Irrigation Project	Columbia River @ Chief Joseph Dam	2,832	28 mi. pipe	60 cfs max
Aeneas Lk. Irrigation District	Aeneas Lake	1400	4 mi. pipe	12 cfs
Alta Vista		40	1 mi. pipe	1 cfs
Black Bear	Sinlahekin Ck	105	2.5 mi. pipe	2 cfs



Source: Note: Water Rights usage information is not complete. Data Layers: Water Rights (WA Ecology), Irrigation Ditches (Okanogan County), Subbasins and Dams (Streamnet), Counties & Major Rivers (WA Ecology), State Routes (WashDOT). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004.

Figure 8. Major irrigation withdrawals and major water rights.

The most common irrigation system is a permanent solid-set sprinkler using micro sprinklers or conventional impact sprinklers. Overhead permanent sprinkler systems are selectively used. Some irrigation systems may be used for spring frost control efforts and for summer temperature modification.

Dams

There are 20 dams in the US portion of the Okanogan subbasin including 9 states, 7 private, 3 federal, and 1 PUD (Table 3). Another 15 are located on the subwatersheds, including Chiliwist, Summit, Trail, Bonaparte, and Tallant.

Table 3. Dams in the US Okanogan Subbasin (StreamNet, 2000)

Dam Name	Stream Name	Ownership	Year completed	Dam Length (ft)	Height (ft)t	Normal Storage (acft)	Max Storage (acft)
Fanchers Dam	Antoine Creek	Private	1926	450	68	500	600
Bonaparte Lake Dam	Bonaparte Creek	Private	1957	180	9	535	995
Stout Reservoir Dam	Chiliwist Creek	Private	1958	250	25	18	24
Horse Spring Coulee Dam	Columbia River	Private	1924	650	67		7,000
Fish Lake Dam	Johnson Creek	State	1920	50	7	2815	2,815
Schallow Lake Dam	Johnson Creek	State	1954	330	13	46	76
Osoyoos Lk. Control Dam (Zosel)	Okanogan River	State	1986	321	40	1,700	55,000
Leader Lake Dam	Okanogan River & tributaries	Private	1910	300	53	5,900	6,750
Leader Lake Saddle Dam	Okanogan River & tributaries	Private	1910	650	11	1,000	1,850
Little Green Lake Dam	Okanogan River & tributaries	State	1959	88	11	400	730
Salmon Lake Dam	Okanogan River & tributaries	Federal	1921	1,250	54	15,700	17,280
Sasse Reservoir Dam	Okanogan River & tributaries	State	1910	140	10	60	60
Spectacle Lake Dike	Okanogan River & tributaries	Federal	1969	1,110	25	13,450	14,080
Whitestone Lake Dam	Okanogan River & tributaries	Private	1930	375	9	2,144	2,720
Conconully	Salmon Creek	Federal	1910	1,075	72	13,000	16,570
Enloe	Similkameen River	PUD	1923	316	54	400	400
Blue Lake Dam	Similkameen River & tributaries	State	1923	1,500	32	4,416	4,416
Sinlahekin Dam No. 1	Sinlahekin Creek	State	1949	180	14	175	333
Sinlahekin Dam No. 2	Sinlahekin Creek	State	1949	248	18	52	82
Sinlahekin Dam No. 3	Sinlahekin Creek	State	1950	285	9	304	593

In 1913, a reported 11 dams had been constructed on the Canadian Okanagan watershed, and by 1998 there were 150. Currently, three Provincial dams are located on the mainstem Okanagan River, including McIntyre Dam located just north of Oliver at Vaseux Lake, Skaha Lake Dam at

Okanagan Falls, and Okanagan Lake Dam located in Penticton. Another 147 private dams are located on tributaries upstream of Okanagan Lake (Ken Hall et al. 2001).

There are also 13 vertical drop structures in the Canadian Okanogan mainstem between Osoyoos Lake and McIntyre Dam, designed to alleviate hydraulic energy that would have been dissipated in natural river meanders before channelization.

Enloe Dam is located on the Similkameen River at an abandoned power generation facility 8.8 miles above its confluence with the Okanogan River, just north of Oroville. Recently there has been interest in re-licensing the Enloe Dam, eliciting a renewed focus on upstream habitat suitability for salmon and conditions relating to cooling water flows to meet salmon needs downstream.

Fish Passage

United States

In the late 1800s, over-fishing in the lower Columbia River severely depleted salmon runs to upper Columbia River tributaries including the Okanogan River (Chapman et al. 1994a). In 1939, an extensive hatchery program was launched to offset the loss of access and mitigate for impacts created by the soon to be completed Grand Coulee Dam. Grand Coulee Dam blocked all fish passage starting in 1941 for over 1,000 miles of upstream salmon and steelhead habitats, including the Okanogan subbasin. Despite ongoing hatchery programs, resource managers have not been able to reestablish salmon and steelhead populations to self-sustaining levels.

Fish passage is not blocked in the US Okanogan mainstem, but periodically may aggravate fish passage by elevated temperatures in the Okanogan River. Dewatering in Salmon Creek occurs during low flow periods. Until 1999, fish passage was blocked on Omak Creek at two sites. All but 4 of the 15 dams on US subwatersheds are considered impassable. The 4 passable dams are on Omak and Tallant Creeks.

Enloe Dam on the Similkameen River blocks anadromous fish access to much of the Similkameen River, replacing Coyote falls, which was an historic barrier to upstream salmon migration (Chapman, 1995; Veddan, 2001). Current and historic salmon production is limited to the 8.8 miles below the dam. Recently there has been interest in re-licensing the Enloe Dam, eliciting a renewed focus on upstream habitat suitability for salmon and conditions relating to cooling water flows to meet salmon needs downstream.

Zosel Dam (RM 78) is passable by fish and controls the level of Osoyoos Lake. Reconstruction work in 1987 has improved fish passage into the lake.

Canada

The upper-most limit to migration in the Okanagan River mainstem currently remains McIntyre Dam at Vaseux Lake since 1954, although passage was partially impeded by the initial dam construction in 1919 (Butler 1974). The current structure offers some limited passage, allowing passage through Vaseux Lake up to the dam at Skaha Lake during freshet some years (pers. com. H. Wright). This allows access to limited salmon spawning habitats in the lake outlet and below Skaha Lake. Fish passage facilities are located in Skaha and Okanagan Lake, however have remained non-operational since 1954 as a function of increased vigilance over upstream flood control and a concern about invasion of exotic species. Drop structures in the engineered reaches of the Okanagan River are currently not considered an obstruction to fish passage.

Mainstem fish passage is also blocked by dams below Skaha and below Okanagan Lakes, limiting what is believed by many to be historic passage to the upper watershed. The deep cool-water refugia of Skaha and Okanogan Lake are considered important for the survival of Okanogan sockeye (H. Wright, pers. comm.). Fish-ways exist in Skaha and Okanogan Lake Dams, however have been closed since the construction of McIntyre Dam in 1920.

Impassable barriers to fish passage also exist on McIntyre (Vaseux) Creek caused by a natural obstruction in canyon approximately 1 kilometre upstream from confluence with Okanagan River. This may compound low flow and high temperature barriers in late summer and fall.

Dams on smaller tributaries upstream of Okanagan Lake are believed to be impassable to upstream fish migration and are thought to exacerbate seasonal dewatering or temperature barriers.

3.2.3 Populations and Growth Management

United States

The major US cities in the US portion of the subbasin include Oroville, Tonasket, Omak, Okanogan and Brewster. The population for the Okanogan subbasin is not readily available; however, in 1998, the population of Okanogan County (inclusively the Okanogan and Methow subbasins) (Table 4) was approximately 38,400, according to the Washington State Office of Financial Management (WOFM 1999).

Table 4. Population of major Okanogan subbasin counties, 1990-2000 (US Census Bureau, 2000)

City	1990	1998	% Increase
Brewster	1,633	2,050	25.5%
Conconully	174	205	17.8%
Okanogan	2,370	2,415	1.9%
Omak	4,117	4,435	7.7%
Oroville	1,505	1,595	5.9%
Pateros	570	595	4.3%
Riverside	223	365	63.7%
Tonasket	900	995	10.6%

Colville Reservation

On the Colville Reservation, tribal members make up approximately 61% of the population (4,760 members of 7,826 on 4/1999) within the Reservation boundaries. According to the Colville Tribes' Anadromous Fish Plan (Colville Tribes 2004 in press); the lands of the Reservation will be managed in 15 Resource Management Units (RMUs) that are further stratified into 209 Watershed Management Units (WMUs).

Canada

The population in 2001 of the plan area in Canada is estimated to be 281,140 (Statistics Canada). It is projected that the population will rise to 395,000 in the plan area by 2010. Much of this growth is occurring in and around the city of Kelowna, which has a population in excess of 100,000. Other cities in the Canadian portion of the plan area include Penticton, Vernon, Summerland, Oliver and Osoyoos. Similarly, the city of Penticton has approximately 32,000 people, and the city of Vernon has some 34,000 people. In many places this urban development is now occurring on former agricultural lands, extending well up the lower slopes because of the presence of the Agricultural Land Reserve, a provincial zoning system to maintain the production opportunity of agricultural lands.

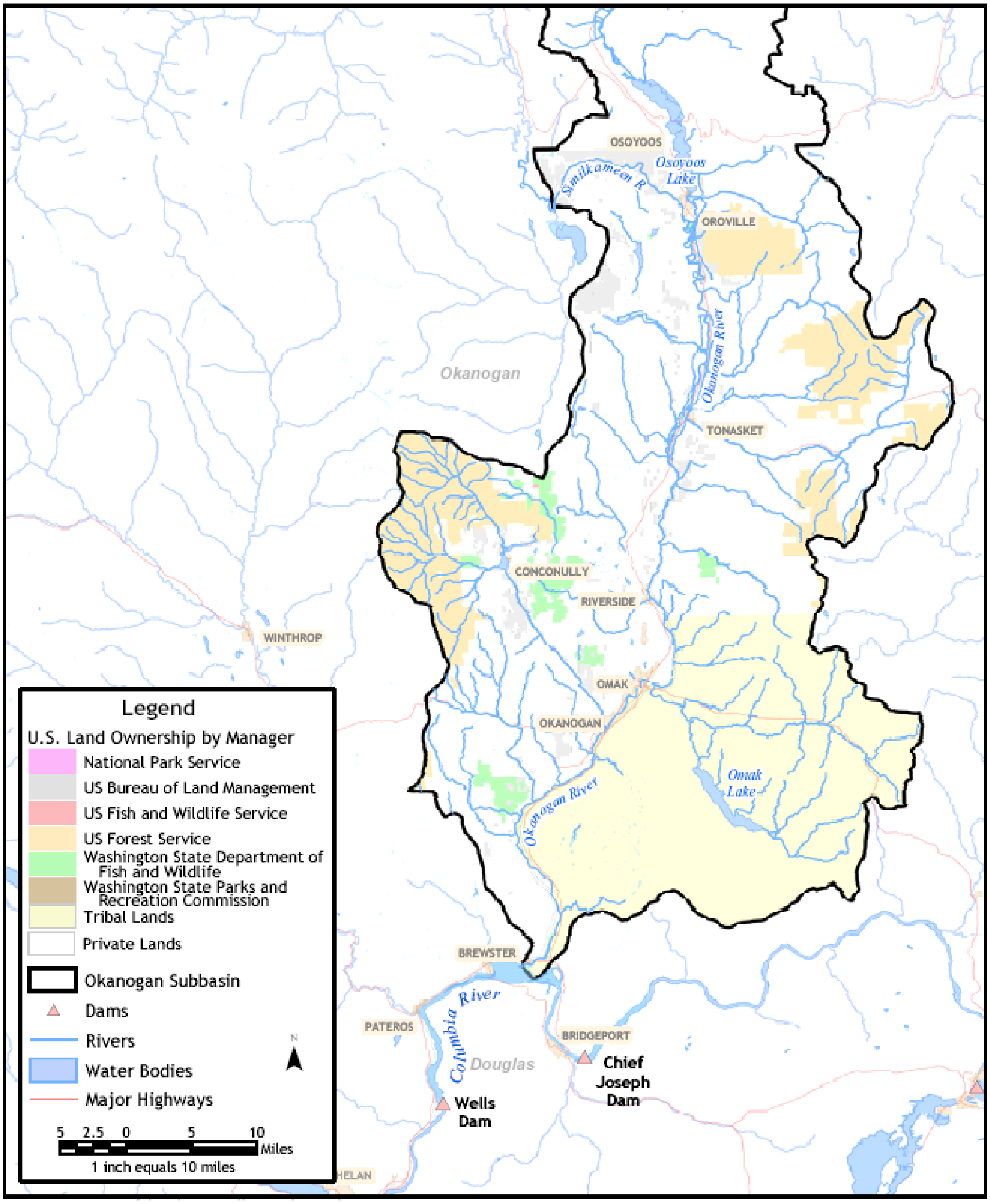
In response to the rapid growth of population in the Okanagan Valley, local government is responding to the planning challenges using various legislative tools including the Growth Management Act. The Central Okanagan Regional District, which includes the rapidly growing City of Kelowna, has Growth Management Strategies in place to provide strategic direction to land and water allocation decisions within its jurisdiction.

3.2.4 Jurisdictions and Land Ownership

Table 5. Land Jurisdictions in Okanogan Watershed

Land Jurisdictions in Okanogan Watershed				
(Percent of land area within each country)				
	US		Canada	
Public land	41		83	
	State Lands	17	Provincial Crown land	74
	Federal - USFS	21	Provincial Parks	9
	Federal - BLM	3		
Private land	34		14	
	Municipalities and Counties	34	Municipalities and Regional Districts	14
Indian (First Nation) land	21		3	

In the US, land use is managed according to Federal, State, Tribe, County and City governments (Figure 6). Land ownership within the Okanogan River subbasin is split almost evenly among public, private, and tribal ownership. The variety of land ownership and management jurisdictions across the US-Canada border complicates management of fish and wildlife corridors in the Okanogan subbasin.



Source: Note: For purposes of this plan, not all areas depicted. Data Layers: Land Ownership (WA DNR), Major Rivers and Water Bodies (WA Ecology, TRIM), Major Roads (WashDOT, TRIM). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 9. Land Ownership in the Okanogan subbasin

United States

Colville Tribes' tribal lands include both private and tribal ownership. Land ownership is primarily shared by the Colville Tribes Reservation, the USDA Forest Service, and private holdings. United States land ownership is primarily shared by the Tribes of the Colville Reservation, the USDA Forest Service, and private holdings

The north shore of the Columbia River between Chief Joseph Dam and the Okanogan River is within the Colville Tribes Reservation. The Colville Tribes reserve rights and interests for protection, enhancement, management, and harvest of anadromous fish in the upper Columbia basin. The Colville Tribes Reservation is comprised of 311,826 acres and makes up 21% of the subbasin.

Colville

The north shore of the Columbia River between Chief Joseph Dam and the Okanogan River is within the Colville Tribes Reservation. The Colville Tribes reserve rights and interests for protection, enhancement, management, and harvest of anadromous fish in the upper Columbia basin. The Colville Tribes Reservation is comprised of 311,826 acres, and makes up 21% of the Subbasin.

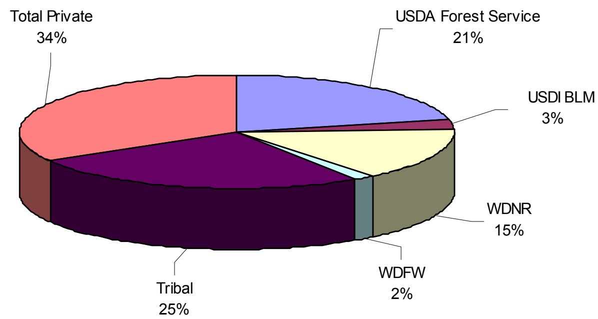
The Reservation is comprised of lands in both fee (20%) and trust (80%) status. The east half of the Reservation lies within Ferry County, the west half within Okanogan County.

Public

Public ownership comprises 41% of the subbasin, including 21% managed by the USFS, 17% managed by the State of Washington, 3% owned by the Bureau of Land Management (BLM), and the rest owned by miscellaneous agencies. The USFS manages 58% of commercial forests on public lands, the Bureau of Affairs manages 24%, and the WDNR manages 16%.

Private

The remaining 34% of the watershed is under private ownership (OWC 2000). Conversion of privately owned timber areas into other uses, such as residential subdivisions, is a trend, but not on the large scale that it is further south, in Wenatchee and Entiat (NMFS 1998). During a recent four-year period (1994 -1997), approximately 11,000 acres of forestland were subdivided (OWSAC 2000).



Source: NRCS 2000

Figure 10 Land ownership in the US Okanogan Subbasin

Canada

In Canada, land use is managed by federal, provincial, local and First Nation governments. Within the plan area in Canada, the land base is made up of varied public land (Provincial Crown land), private property, and Indian Reserves.

Public land

The provincial government, through various ministries and Crown agencies, manage most of the land and resources within the plan area, including all water allocation decisions. The major exception relating to the purpose of this plan document is the management of salmon by the Department of Fisheries and Oceans, an agency of the federal government.

Within the plan area, most Crown land is located outside the valley bottoms. These are the provincial parks (9% of the subbasin) as well as the resource lands (74% of the subbasin) that support most of the forest harvesting, range, and mining activity. Crown land also includes all aquatic land in the plan area (the beds of all lakes, rivers, and streams).

In 2001, the provincial government approved a comprehensive, strategic land and resource management plan. The Okanagan-Shuswap Land and Resource Management Plan (LRMP) provides strategic legal and/or policy direction to all provincial agencies on the use and management of Crown land and resources, and applies to most of the resource land in the subbasin. This plan was the outcome of a consensus agreement from a broad range of stakeholders and agencies. It led to the establishment of new provincial parks, as well as the establishment of resource management zones (RMZs) with associated management direction in the form of resource management objectives and strategies (Appendix E). The Okanagan-Shuswap LRMP is available online at http://srmwww.gov.bc.ca/sir/lrmp/okan/

Private land

In British Columbia, local governments regulate the use of private land. Local governments consist of municipalities and regional districts. Regional districts have many similar functions to the counties in Washington State; they regulate private property in rural areas outside urban centers. Within the plan area, the major municipalities are Vernon, Kelowna, and Penticton. The plan area comprises all of the Central Okanagan Regional District (CORD), as well as portions of the North Okanagan Regional District (NORD) and the Okanagan-Similkameen Regional District (RDOS).

Within the plan area, private lands occupy the valley bottoms and are dedicated mainly to settlement and agricultural uses.

First Nation Lands

Indian reserves are located within the plan area at Osoyoos, Penticton, Westbank and Vernon in close proximity to municipalities. The land and resources of these reserves are administered through the provisions of the Indian Act, a statute of the federal government, and through regulations of band councils. The reserve lands are used primarily for settlement, agricultural, and traditional uses.

The entire plan area lies within the traditional territory of Okanagan First Nations. Recent court decisions have affirmed that First Nations must be consulted on the potential infringement of aboriginal rights and title by proposed land and resource management decisions. First Nations are to be accommodated when infringement occurs.

3.2.5 Socio-economic Conditions

The major US cities in the subbasin include Okanogan, Oroville, Tonasket and Omak. In Canada, the major cities include Vernon, Kelowna, Penticton, Okanagan Falls, Oliver and Osoyoos. During the period 1971 to 1986, urban population increased by 63 percent, twice the rate of increase for B.C. as a whole (Okanagan Basin Study, 1974).

The population of the Canadian Okanagan Valley more than doubled from 1970 to 275,000 by 2001. At current growth rates of 2.5 percent, the Canadian subbasin population could exceed 390,000 by 2010). Rural population growth was also strong, increasing by 62 percent for the same time period (Okanagan Basin Study, 1974). Even so, the population primarily resides in urban areas with approximately 74% living in cities or smaller communities.

The Canadian portion of the plan area has become “Canada’s California.” The favorable climate, attractive scenery, excellent highway links to the Vancouver area, and local amenities have led to a highly diversified and thriving regional economy based on tourism, services, retirement, agri-business, high-tech and manufacturing.

More concise descriptions of socio-economic conditions and land use management in Canadian Reaches of the Okanagan Valley are contained within the Okanagan Shuswap Land and Resource Management Plan and the State of the Okanagan Basin report (COBTWG, 2004).

In US reaches of the subbasin, the timber, cattle and orchard industries have matured and along with a growing tourism industry impacting much of the subbasin particularly along lower elevations streams and lakes. Rural property owners and crop farmers over the last 100 years have developed much of the subbasin bottom. Table displays population figures and recent changes in population in cities in the US portions of the Okanogan subbasin.

Table 6. Population of major Okanogan subbasin cities, 1990-2000 (US Census Bureau, 2000)

City	1990	1998	% Increase
Brewster	1,633	2,050	25.5%

City	1990	1998	% Increase
Conconully	174	205	17.8%
Okanogan	2,370	2,415	1.9%
Omak	4,117	4,435	7.7%
Oroville	1,505	1,595	5.9%
Pateros	570	595	4.3%
Riverside	223	365	63.7%
Tonasket	900	995	10.6%

Agriculture- livestock and croplands

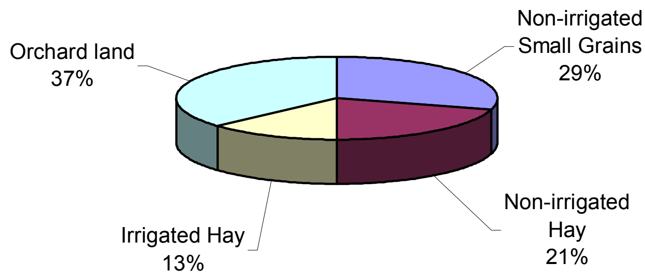
Agriculture is the dominant land use throughout the middle to lower elevation areas within both US and Canada subwatersheds. In US, livestock production is a major part of the economic base of the County. There are 754,996 acres of rangeland in the US Okanogan subbasin, owned and managed by USFS, BLM, DNR, Colville Tribes, and private owners. Cattle are grazed on forested lands and grass lands. Much of the Okanogan floodplain is used for forage crops and livestock wintering grounds (PNRBC 1977).

During the summer, cattle graze at high elevations, on state, federal, and private lands. Historically, sheep were grazed on public lands, but in 1998 the last band of sheep grazed on public lands was sold off. Currently small flocks of sheep and goats, and some horses, are grazed on private parcels in the lower basin (Keller, 2001).

The growth of the orchard industry in the semi-arid Okanogan Valley required an inexpensive supply of water available to all orchardists. Between 1860 and 1920 agriculture moved from stock raising and grain growing to intensive orcharding thus increasing demand for irrigation. This increased demand for water resulting in long, high volume, elaborate and expensive irrigation systems requiring storage, conveyance and application of water. By 1920 such a system was in place and the Okanogan fruit industry flourished.

Most of the Okanogan River valley bottom has been converted to agricultural uses, including cropland and orchards. Cropland in the Okanogan Basin is devoted to row crops, close-grown field crops, orchards, rotation hay and pasture, improved hayland, and summer fallow. Vegetables, berries, and nuts are also grown, but acreage figures were not available.

In many places in the subbasin plan, it identifies that conservation of land to agricultural use has resulted in, or contributed to, loss of habitat or negative impacts to the species that utilizes those habitats (fish and wildlife). These types of statements require that the following two discussion points be provided in the subbasin plan: 1) Not all agriculture provides negative impacts to fish and wildlife and their habitats. As such, each situation should be evaluated on an individual-by-individual basis; and 2.) In the US portion of the Okanogan subbasin, land being converted to agriculture is not occurring. In fact, agriculture as a whole is declining in the US portion of the subbasin. However in Canada, conversion of land to agriculture is occurring at quite a rate. (J. Dagnon 2004, pers. comm.).



Source: NCRS, 1998

Figure 11. Major crops of the Okanogan subbasin

Forestry

Timber production for the Okanogan National Forest increased from World War II until the mid-1960s (USFS 1998a). Timber production since the 60s has declined somewhat. Most of the forested land in the US Okanogan Subbasin is publicly owned, and it is mainly managed for timber. The major timber-producing areas in the basin are Toats Coulee, managed by the USFS, and the Loomis Forest, managed by WDNR. Forest productivity in the basin is relatively low because of the arid climate, the short growing season at high elevations, and steep, rocky terrain (NMFS, 1998).

Mining

In the US, the extraction of non-metallic minerals, including sand, gravel, gypsum, and limestone is more extensive in the basin than hard rock mining, and has played a larger role in the economy of the region. The USFS operates few gravel mine sites on the National Forest. The Okanogan County maintains numerous gravel mines, the WDNR maintains a few, and several are located on private property.

The only major placer mine in the US Okanogan Basin is located on the Similkameen River, between Oroville and Nighthawk. Within the last five years, the Kabba Texas Mine tailings area near Nighthawk was rehabilitated.

Transportation

The road and rail systems in the Okanogan subbasin were established around the turn of the century. A web of routes was developed along traditional travel corridors, typically along rivers and streams. Many of the current road locations were established at that time (Okanogan Conservation District).

During the 1920s and 1930s a number of railroad lines were built in the forested drainages of the basin. The most notable and by far the longest lasting of these was the narrow-gauge rail line into the Omak Creek watershed (Lewis, 1980). The construction of this line included a railroad grade through Omak Creek Canyon near St. Mary's Mission, and hard rock excavation was required.

There are approximately 85.5 miles of railroad in the Okanogan River Watershed (OWSAC, 2000). Almost all of the lines are located in the Okanogan River corridor. The main line is located within one half mile of the Okanogan River, from its confluence with the Columbia River to Oroville. There is no new construction of railroad lines planned in the Okanogan River Watershed.

Tourism

Tourism is a major activity within the Canadian Okanagan basin and to a lesser degree in the US portions of the subbasin because of the predominance of large Lakes. In Canada, the number of tourists in the basin noticeably increases during the summer. The US Okanogan subbasin as other historic generators decrease, tourism is starting to slightly increase. Attractive because of its considerable natural beauty and recreational opportunities, and it is emerging as the weekend getaway for those living in more populated areas.

Topographic / Physio-geographic Environment

The basin covers approximately 8,200 square miles (5.2 million acres), with 2,500 square miles or approximately 30% of the watershed in the United States. The eastern and western boundaries are steep, jagged, forested ridges at elevations ranging from 1,500 feet to over 5,000 feet above the basin floor. Tiffany Mountain is the highest peak in the drainage, at 8,242 feet above sea level.

The coastal and Cascade Mountains cast a rain shadow on the basin, creating the dry climates associated with this most northern extension of the western American deserts. The interior portion of the Okanogan is considered true desert – it receives about 3.0 to 3.3 inches of rain annually.

The open waters of the Okanogan's finger lakes moderate local temperatures, however, cooling the air in summer and warming it in winter.

The floodplain of the Okanogan River averages approximately one mile in width. The elevation of the valley floor ranges from 920 feet at the international boundary, to about 780 feet at Lake Pateros. Lake Osoyoos covers the northernmost 4 miles of the valley floor in the US, and extends several miles into Canada. Natural terraces, created mostly of glacially deposited gravel and sands, rise as much as 500 feet above the floodplain to the foot of, and between, the lateral ridges (WSDOE, 1995).

Climate and Weather

Cold, snowy winters and hot, dry summers characterize the semi-arid climate of the Okanogan River Watershed. The climate is influenced by the barrier to marine air that the Cascade Mountain Range provides, and by the mountain and valley formations of the region. Precipitation in the watershed ranges from more than 40 inches in the western mountain region to approximately 8 inches at the confluence of the Okanogan and Columbia Rivers. Precipitation in the main river valley averages approximately 12 inches annually (NOAA, 1994).

The Okanogan Highlands, in the easternmost part of the basin, receives an average of 25-35 inches per year. About 50 to 75% of annual precipitation falls as snow during the winter months. Okanogan County's forestlands receive approximately 75% of the total annual precipitation (Gullidge 1977). July, August, and September are the driest months.

Mean annual temperature for the Okanogan Watershed is 49° F. The average temperature for January is 21° F and the July average is 73° F. Temperatures and weather conditions vary widely by elevation. Wind velocities throughout the region are calm to moderate, and winds generally originate from the north or south.

Thunderstorms occur occasionally in the watershed during late spring and early summer. Summer months have approximately 5 cloudy days per month, and winter has about 20 cloudy days per month.

On average, there are 150 frost-free days each year in the main Okanogan River Valley, and about 75 frost-free days in the surrounding uplands (NOAA, 1994).

3.3 Habitat Areas and Quality by Subwatershed

3.3.1 The Canadian Subwatershed and Tributary Descriptions

The Lakes

The character of the Okanagan subbasin in Canada is, to a large extent, shaped by the lakes. The lakes moderate the climate, store the water necessary for agricultural and urban development and provide holding and rearing areas for the focal fish species.

Okanagan is by far the largest lake. It covers 35,000 hectares (88,000acres) and has a maximum depth of about 240 m (800 ft). It is cooler and more oxygen rich than the lakes downstream and may be the most suitable lake in the Basin for spawning and rearing sockeye salmon and other focal species.

McIntyre Dam has excluded anadromous fish from Okanagan Lake and Skaha Lake for about 80 years. Consideration has been given to re-introducing sockeye salmon into Okanagan Lake but fisheries authorities have expressed concerns about competition between sockeye and an already declining kokanee population. To determine the benefits and risks of reintroducing sockeye salmon into Okanagan Lake the authorities decided to use Skaha Lake for an a experimental re-introduction. Test results will eventually show whether it is wise to re-introduce sockeye to Okanagan Lake.

Skaha Lake lies south of, and downstream from Okanagan. It is smaller, more productive, and more shallow than Okanagan, and has a flushing rate of 1 year as compared with 65 years for Okanagan. Despite these characteristics Skaha may be as good or better than Osoyoos Lake for rearing sockeye and other focal species and it may be needed as climate change continually reduces the rearing capability of Osoyoos Lake.

Vaseux Lake lies south of Skaha. Most of the lake is shallow, silty and weedy and although it supports low numbers of salmonids (rainbow trout and kokanee), introduced warm-water species such as largemouth bass and smallmouth bass seem to thrive.

Osoyoos Lake spans the Canada/US Border and includes three basins. Fisheries habitat is limited in summer by a combination of low oxygen at depth and high water temperatures near the surface. The tolerable zone in between is limited in the north basin and often non-existent in the central and south basins.

Intolerable conditions in Osoyoos Lake may partially or totally responsible for the disappearance of the returning sockeye between Wells Dam and the Canadian spawning grounds.

One of the limiting factors for focal fish species within the lakes of the Okanagan is the shrimp *Mysis relicta*. Introduced into Okanagan Lake as a food source for kokanee in 1966, they have slowly emigrated downstream and they have colonized Osoyoos Lake about 5 years ago. Numbers in Osoyoos Lake are thought to be increasing and managers are concerned that competition for food and space might adversely impact sockeye salmon. Control measures involving harvesting of mysids are being tried experimentally on Okanagan Lake and the results may be useful in managing Osoyoos Lake.

The Mainstem Okanagan River – Canadian Headwaters to the US Border

Over the last one hundred years man-made changes have substantially altered Okanagan River. Major alterations have included changes in the hydrograph resulting from the impoundment of Okanagan Lake, the construction of McIntryre Dam without a fishway, and straightening, shortening and channellization of all but a few kilometres of the river.

Fortunately the river still has a short stretch of exceptionally good spawning habitat that continues to support annual runs of sockeye salmon and remnant runs of Chinook and steelhead.

The uppermost 6 km (4 mile) stretch of Okanagan River, located between Okanagan and Skaha Lakes, has been completely channelized and the grade of the lower portion is too low to be useful to the focal species except as a migration path. The middle and upper portions of this stretch of river have a suitable gradient and are presently used by spawning kokanee. This stretch of river is expected to support spawning sockeye once they are re-introduced to Skaha Lake.

The stretch of Okanagan River from the outlet of Skaha Lake downstream to McIntyre Dam Vaseux Lake is, for the most part, too low in gradient to be used by focal species. The exception is the northernmost (upstream) reach, which runs from the outlet of Skaha Lake down to the confluence with Shuttleworth Creek. This reach has not been channeled and it has a good gradient and a mixture of cobble and gravel substrate. A modest fishery for rainbow trout occurs in this reach and the area may be suitable for steelhead if they are allowed past McIntyre Dam.

McIntyre Dam is a low head dam that was constructed to divert water into a very large, and as yet unscreened, irrigation ditch. It also balances water levels for Vaseux Lake. Many years ago, when largemouth bass had just moved into the Okanagan, McIntyre Dam was rebuilt. In an attempt to restrict further upstream movement of the bass, fisheries officers decided that McIntyre Dam should not be equipped with a fishway. The dam has blocked migration for all anadromous species since then. Major efforts and discussions are underway to remove this dam or provide fish passage through improvements.

The 9 km (5 ½ mile) section of Okanagan River from McIntyre Dam downstream to the Town of Oliver is unsurpassed from a fisheries viewpoint. It is the most productive waterway in Canada for Columbia River sockeye, steelhead and Chinook. A small portion of this section (1.1 km or 3/4 mile) remains completely natural with a fully functional floodplain and ideal grade and substrate. The remainder of the section is not completely natural but much of it has setback dykes, a meandering channel and ideal characteristics needed for sockeye spawning. The setback dyke portions of the river have high potential for habitat restoration. Some riverfront properties have already been purchased in this area with the idea of restoring a fully functional river with connectivity to the existing natural section. The protection and restoration of habitat in this short section of river is without a doubt the most critical need for anadromous fish in the Canadian portion of the Okanagan Basin.

The lower 15 kilometres (9 miles) of the river, from the Town of Oliver downstream to Osoyoos Lake, have been channelized. In the main this part of the river lacks habitat diversity and features such as a floodplain, riparian vegetation, LWD, cover and pools and riffles. Furthermore much of this portion of the river is low gradient and has silty substrates. There are, however, some riffles with gravel substrate and both sockeye and Chinook spawning has been recorded.

The tributary streams

The arid conditions of the Okanagan Basin within Canada limit the number and size of the tributary streams. Many (Hester, Marron, Reed, Testalinden, and Wolfcub Creeks) are small and ephemeral, remaining dry for most of the year. Others (Ellis and Shuttleworth) have major problems with silt loading, steep gradient and confinement and the benefits to be gained by working on them outweigh the gains to fish production. Both these categories of streams are considered low priority for protection or restoration in comparison with higher-quality tributaries.

Within the present planning unit (from Trout Creek south to the Canada/US Border) the higher quality streams are (from north to south) Trout, Penticton, Shingle, Ellis, McLean, Shuttleworth, Vaseux, Park Rill and Inkaneep creeks. Each of these is discussed below.

Trout Creek

Trout Creek runs east into Okanagan Lake 7 km (4 ½ miles) north of the lake outlet in Penticton. It drains a watershed of 45,107 hectares (111,458 acres) that is 80% forested and less than 2% is agricultural in nature.

Historically, Trout Creek was a major spawning area for kokanee and both fluvial and adfluvial rainbow trout. At present both stocks are depressed. Most of the flow of Trout Creek is diverted for use by the Town of Summerland, and a massive land slippage creates heavy silt loads. In addition the lowest reach of the creek has been channeled and stripped of riparian vegetation. Fisheries and Oceans Canada and the Town of Summerland are discussing base flows and reconnaissance studies are ongoing to investigate the possibility of rehabilitation.

Despite its problems, Trout Creek is considered to be a significant producer of kokanee at least some of the time (Rae, 2004).

In order for anadromous fish to use Trout Creek they would need passage over the dams located at Okanagan Lake and Skaha Lake outlets as well as McIntyre Dam. The former two dams have fishways that just need stoplogs. McIntyre Dam could be equipped with a fishway but changes in the way the dam gates are operated could provide passage prior to the construction of a fish facility (Brian Symonds, B.C. Water Management, pers. comm.).

Penticton Creek

Penticton Creek runs into the south end of Okanagan Lake approximately 1 km east of Okanagan River. Prior to channellization in 1949 the creek was reportedly a major producer of kokanee, rainbow trout and salmon. At present most of the lower end of the stream is confined in a concreted chute. However, the Penticton Flyfishers and other stewardship groups manually transport kokanee to spawning beds upstream and over the years they have maintained a significant run.

The province of B.C. and private industrial concerns have set aside funding for rehabilitation of the lowest reach on Penticton Creek and this work is scheduled for completion in time for the fall 2004 kokanee run.

Like Trout Creek, Penticton Creek is separated from the limits of anadromy by 3 dams.

Shingle Creek

Shingle Creek and its tributary, Shatford Creek, drain a watershed of 22,040 hectares (54,460 acres). The watershed is 80% to 90% forested with 3% agricultural use.

Shingle Creek flows east into the Okanagan River in the middle of the City of Penticton. The lower part of the creek passes through the Penticton Reserve. A low 3 foot dam is located 0.6 miles upstream from the mouth to divert water, but it is equipped with a fishway.

Both Traditional and non-native historical information confirms that Shingle Creek was historically a major fishing area for First Nations. The name for this creek translates to place of the steelhead (H. Wright, ONA, pers. comm.). McIntyre Dam has cut off access for anadromous fish but the stream continues to be an important producer of fluvial and adfluvial rainbow trout and kokanee.

Ellis Creek

Ellis Creek runs west through the industrial section of Penticton and drains a watershed of 12,182 hectares (30,101 acres). It is intermittent, steep and has a substrate of large boulders and cobbles. In freshet it carries heavy loads of silt and in mid summer it dries completely. A few kokanee spawn in the lowest reach of Ellis Creek but they soon encounter an impassable concrete dam. Costs of laddering the dam would probably outweigh benefits since the upstream habitat is steep and confined.

McLean Creek

McLean Creek enters Skaha Lake from the east about 2/3 of the way down the lake. The creek is small, intermittent and channelized but it is said to support spawning kokanee in at least some years (John Gibson, resident, deceased, pers. comm.).

McLean Creek is not of importance for the focal anadromous species and like Shingle and Ellis Creeks, it is separated from the limits of anadromy by Skaha Outlet Dam and McIntyre Dam.

Shuttleworth

Shuttleworth Creek enters the Okanagan River from the east in the Town of Okanagan Falls a short distance downstream from the outlet dam of Skaha Lake. This creek has significant problems with mass wasting and unstable banks higher up in the watershed. It introduces vast quantities of silt into Okanagan River between its confluence and Vaseux Lake. A sediment catching basin has been constructed at the mouth of Shuttleworth Creek but it appears ineffective. Upstream of the sediment basin the stream is confined in a concrete chute.

Shuttleworth Creek is not considered worthy of attention at this time since costs of rehabilitation would probably outweigh the benefits.

Vaseux (alias McIntyre) Creek

Vaseux Creek enters Okanagan River from the east 1363 m downstream from McIntyre Dam. The watershed of Vaseux Creek is 80% forested and 0.7% agricultural. There is negligible urban development.

Presently this creek runs intermittently in the lower reach although there is a voluminous and continuous flow at the canyon further upstream. Local residents report that the lower section of the creek also used to run continuously and supported large numbers of sockeye and some steelhead and Chinook. Sockeye were reportedly so numerous they plugged irrigation canals. Carcasses were spread on adjacent fields as fertilizer (Blake Kennedy, resident, pers. comm.). Some say that channelization in the 1950s scoured the riverbed and opened up filtration galleries which now allow the stream to percolate underground during the summer (Barry Barrisoff, resident, pers. comm.).

Sockeye and Chinook still frequent this stream when flows are adequate (Howie Wright-ONA, pers. comm.) as do rainbow trout/steelhead. Members of Colville Tribes and Okanagan Nation Alliance visited the stream recently and were greatly impressed by its potential for the focal species. They wrote, "This stream could be key to salmon recovery effort in the Okanogan River basin…" and "… a huge potential for anadromous fish production exists."

Park Rill

Park Rill runs from the west into the Okanagan River north of the Town of Oliver. Prior to channelization in the mid 1950,s Okanagan River split into 2 channels and the western-most fork ran through the lower end of what is now Park Rill. Beds of watercress and cool summer temperatures show the presence of groundwater return at several locations along the old watercourse.

Sockeye and Chinook do not use the creek but rainbow/steelhead trout do and possibly rely on it as a critical thermal refuge since water temperatures in mid summer remain some 2 degrees C. less than those in the mainstem.

Inkaneep

Inkaneep Creek flows through the center of the Osoyoos Reserve and empties into the northern basin of Osoyoos Lake. Its watershed is 80% forested and 20% burned and agriculture uses 1.8% of the watershed. .

A natural falls about 5 kilometres (3 miles) from the mouth is a complete barrier to anadromous fish. Stream habitat below these falls is largely intact and appears to be suitable for summer steelhead and Chinook salmon (Howie Wright, ONA, pers. comm.).

Summer water temperatures are believed to be a limiting factor, which would restrict salmonid rearing to areas near ground water, but anglers reportedly catch large *O. mykiss* in the stream. These might be adfluvial rainbow trout from Osoyoos Lake or Okanogan River steelhead.

Habitat disturbances in the lower reaches include diking and riprapping as well as unscreened water diversions. In the upper stream reaches mass wasting occurs along the highway to Mount

Baldy Ski Area and this adds to the silt load experienced below. Further investigation of the factors limiting the production of focal species in this stream is warranted.

3.3.2 The US Subwatershed and tributary descriptions

The US Okanogan subbasin includes 17 tributaries. An overview of the mainstem Okanogan and its tributaties are described below, drawn from the Okanogan LFA (Entrix 2004). A useful and more detailed description of the tributaries and their limiting factors may be found in the Okanogan LFA – WRI 49 (Entrix 2004). Table 7 summarizes the subwatershed area and tributary status of Okanogan subbasin.

Table 7. Subwatershed Area and Tributary Status Of Okanogan River Subwatersheds

	Area (acres)	**Tributary to:**
Okanogan River – Interfluve	204,398	Columbia River
Nine Mile Creek	13,516	Okanogan River Interfluve
Tonasket Creek	37,874	Okanogan River Interfluve
Mosquito Creek[1]	6,093	Okanogan River Interfluve
Antoine Creek	46,690	Okanogan River Interfluve
Siwash Creek	31,032	Okanogan River Interfluve
Bonaparte Creek	97,877	Okanogan River Interfluve
Chewiliken Creek	17,125	Okanogan River Interfluve
Tunk Creek	45,586	Okanogan River Interfluve
Wanacut Creek	12,595	Okanogan River Interfluve
Omak Creek	90,691	Okanogan River Interfluve
Chiliwist Creek	27,842	Okanogan River Interfluve
Loup Loup Creek	40,868	Okanogan River Interfluve
Tallant Creek[1]	9,832	Okanogan River Interfluve
Salmon Creek	98,625	Okanogan River Interfluve
Johnson Creek	28,694	Okanogan River Interfluve
Fish Lake Basin Area[1]	23,124	Self Contained Basin
North Fork Pine Creek[1]	23,841	Self Contained Basin
Aeneas Creek	6,890	Okanogan River Interfluve
Aeneas Lake[1]	21,246	Self Contained Basin
Whitestone Creek (Spectacle Lake)	27,333	Okanogan River Interfluve
Similkameen River	228,536	Okanogan River Interfluve

	Area (acres)	Tributary to:
Sinlahekin Creek[1]	189,521	Similkameen River
Wanacut Lake[1]	13,853	Self Contained Basin
Omak Lake	68,685	Self Contained Basin
Duley Lakes/Joseph Flats Area	51,319	Self Contained Basin
Swamp Creek	64,158	Columbia River
Columbia River Interfluve - East	139,955	Columbia River
Total	1,667,798	

Reach 1

Reach 1 of the Okanogan River is shaped by the Wells Dam on the Columbia River, which creates a lentic influence to the lowermost 17 miles of the Okanogan River for approximately 17 miles. Consequently, the majority of the reach is essentially an elongated pool. Water level fluctuates frequently because of operational changes (power generation, storage) at Wells Dam. The stream banks are rarely exposed to high energy flows and remain relatively intact, because of low gradient and storage influences. Substrate consists almost entirely of mud, silt, and sand. Riparian vegetation consists of a dense layer of shrubs and saplings, which further protect the banks from scouring and erosion. There are few mature trees. In 1988, WDFW (1988) reported 70,619 summer Chinook smolts, and 22,897 summer steelhead smolts in reach 1 of the mainstem Okanogan.

Reach 2

Reach 2 is a broad, shallow, low gradient, channel with relatively homogenous habitat. There are few pools, and limited large woody debris. Sediment levels are high and substrate embeddedness is relatively widespread. There are highways on either side of the river for most of the length of Reach 2, and several communities along the river. Agricultural fields and residential areas are adjacent to the river. In 1988, WDFW (1988) reported 1,076,182 summer Chinook smolts, and 27,160 summer steelhead smolts in reach 1 of the mainstem Okanogan. The report (WDFW 1988) sites an error in the summer Chinook estimates, but does not account for the error in the reach estimates. Total summer Chinook smolts counted in the mainstem Okanogan were 1,499,712, a 352,911 difference between the individual reach information and the total mainstem information. This error may be because of the production available above Osoyoos.

Chiliwist Creek

The Chiliwist Creek subwatershed comprises approximately 27,842 acres, representing approximately 1.7% of the Okanogan watershed (OWC 2000). It is located in the southwestern corner of the Okanogan watershed, and is the lowest Okanogan subwatershed upstream of the Columbia River confluence that drains lands from the west. Chiliwist Creek enters the Okanogan River on its western side at approximately RM 15.1 (WDNR 1982).

The subwatershed includes all the habitat along the southeast border of the subwatershed (i.e., the western shore of the mainstem Okanogan) for approximately 27 kilometres (before entering the Columbia. The principal stream within this subwatershed area is Chiliwist Creek, a second order tributary, with approximately 5.9 miles of mainstem channel length. However, the subwatershed delineated for this LFA also includes the self-contained drainages of Sullivan Creek, Smith Lake, and Starzman Lake. None of these other waters within the subwatershed regularly convey surface waters to the Okanogan.

Previous problems identified for the Chiliwist Creek subwatershed by the OWC (2000) include: winter feeding areas adjacent to the stream, sediment from roads, irrigation de-watering the creek (i.e. diversions to outside of the subwatershed), and noxious weeds.

Only about the lower ½ mile of Chiliwist Creek is accessible to anadromous salmonids because a natural gradient barrier likely prevents further access upstream (Okanogan TAG). The use of this area for juvenile rearing or refuge by Chinook, steelhead and sockeye has not been formally determined. However, water quality in the lower basin would not preclude its use by any of the salmonid species in the basin for these functions. The cooler waters found within this tributary relative to the mainstem Okanogan suggest that it may be important in providing thermal staging during summer migrations of adult Chinook, steelhead and sockeye, with permissible flows. In 1988 41 summer steelhead smolts were counted in the Chiliwist subwatershed (WDFW 1988).

Dan Canyon

Dan Canyon is an intermittent, third-order tributary to the Okanogan River located entirely on the southwest plateau of the Colville Tribes Reservation. The southwest plateau also incorporates the Duley Lakes and Felix Creek subwatersheds that have been delineated for this LFA. The Dan Canyon subwatershed covers 9,081 acres and drains to the west. Dan Canyon enters the eastern side of the Okanogan River at approximately RM 5, although surface flows from Dan Canyon rarely (if ever) reach the Okanogan River. The watershed is a dense network of small, Type 4 and 5 intermittent streams, with a total stream length of 40.4 miles.

Fish presence in this area is minimal, as most streams are intermittent, and most lakes are highly alkaline or saline. Productivity in the pothole lakes is limited currently and historically by the alkaline waters condition, high water temperatures, and the fact that most of the lakes have no outlet, so no flushing can occur (Colville Tribes 2001). There are no anadromous species in the streams of the southwest plateau, including Dan Canyon. There is no historical information on fish presence, but anecdotal reports suggest that the creek may never have supported fish (Colville Tribes 2001).

The Colville Tribes Tribe used the Unified Watershed Assessment Categories (UWAC), a part of the EPA Clean Water Action Plan Criteria (EPA 1998) to characterize the condition of the watersheds on the reservation. Dan Canyon received a Category I rating, indicating that the subwatershed does not meet clean water and other natural resource goals, and needs restoration. This rating was based on general knowledge of the area, and should be field checked (Colville Tribes 2001).

Loup Loup Creek

Loup Loup Creek enters the Okanogan River at RM 16.9, in the small community of Malott, WA. Nearly the entire 40,868 acres of the watershed is categorized as forested (86.5%). Peak elevation in the subwatershed is approximately 6,100 feet (Buck Mt.), with several other peaks nearing 5,000 ft. Land ownership includes the Bureau of Land Management (BLM), Washington

Department of Natural Resources (WDNR), United States Forest Service (USFS) and private owners, with WDNR responsible for managing 31,506 acres. The Loup Loup Creek mainstem is approximately 19.8 miles long, with a total of approximately 75.9 miles of stream channel in the subwatershed.

Previous problems identified for the Loup Loup Creek subwatershed by the OWC (2000) includes: sediment from roads (i.e. SR 20 winter maintenance), irrigation de-watering the creek, 303(d) listings in the Tallant Creek area, confined pastures (also corrals) adjacent to the stream in the Tallant Creek area, heavy grazing having an adverse effect upon the plant community, herbicide and fertilizer application in an orchard near the creek and noxious weeds.

Historically, cutthroat trout likely existed in the upper reaches of Loup Loup Creek, and reliable anecdotal evidence of bull trout presence in the upper drainage reaches have also been reported (K. Williams, WDFW [retired], pers. comm. to N. Wells [Okanogan TAG]). Anadromous and resident forms of rainbow trout also existed in Loup Loup Creek. The anadromous forms of rainbow trout (i.e. steelhead) migrated as far as the falls (approximately RM 2.5). Currently fish species in Loup Loup Creek include rainbow trout and brook trout. The rainbow trout are likely remnants of a historical anadromous form. Eastern brook trout were planted by the Washington Department of Fish & Wildlife and have either hybridized or out-competed the native bull trout. Today, the range of anadromous fish in Loup Loup Creek is limited by man-made fish passage barriers and discontinuous flows. The lowermost barrier is a perched culvert at approximately RM .1. At ~ RM 2.0 water is diverted for irrigation. Typically the lower reach becomes dry during early summer (June/July), thus voiding all possible natural reproduction.

Leader Lake in the Loup Loup subwatershed is a popular recreational sport fishery. WDFW stock the Lake annually with 25,000 rainbow trout fry. During 1998 the WDFW rehabilitated Leader Lake to remove largemouth bass introduced by an unauthorized planting. Species known to exist in the upper reaches of the basin include rainbow and brook trout. There have been accounts of steelhead utilizing the lower reaches of Loup Loup Creek when adequate flows were present (Entrix 2001) and are presumed to be steelhead.

Duley Lakes/Joseph Flats

The Duley Lakes/Joseph Flats subwatershed covers 51,000 acres, and is located in the southwest plateau of the Colville Tribes Reservation, in the southeastern corner of the Okanogan River watershed. This area covers about 51,000 acres. Pothole lakes and ponds make up over 1300 acres of open water and there are no surface water connections to the Okanogan River from this subwatershed.

Previous problems identified for the Duley Lakes/Joseph Flats subwatershed by the OWC (2000) include: heavy grazing having an adverse effect upon the plant community and noxious weeds.

There are no anadromous species in the streams of the plateau. Resident fish presence in this subwatershed is minimal as most lakes are highly alkaline or saline. Carp are likely the only fish species in Duley Lake. Rainbow trout and largemouth bass have been planted in the past, but are no longer present. The lake is alkaline and does not support most species of fish. This is true of most of the lakes in the area. Little Goose Lake, north of Duley Lake, is relatively deep, and does support a population of stocked rainbow trout (J. Marco 2001, pers. comm.).

Felix Creek

The Felix Creek subwatershed comprises a variety of intermittent tributaries to the Okanogan River that drain the southwestern plateau of the Colville Tribes Reservation on the eastern side of the Okanogan River. The subwatershed is adjacent and north of the Dan Canyon subwatershed. Felix Creek, a second-order stream for which the subwatershed has been named, is the largest of the Okanogan tributaries within the subwatershed and no others have been named. Felix Creek enters the Okanogan River along the eastern side at approximately RM 24.

Surface flows from Felix Creek rarely reach the Okanogan River. The mainstem of Felix Creek is 2.6 miles long, and, based on USGS map-wheel projects, there are approximately 6.7 miles of stream channel in Felix Creek when its tributaries are included. Within the subwatershed as a whole, a total of 64.7 miles of stream channel have been identified from the USGS, although most of these channels are generally dry or ephemeral.

The Felix Creek subwatershed area is 3,405 acres, and elevation ranges from 820 feet at the mouth, to approximately 3,120 feet at the edge of the plateau from which surface waters could convey to the creek. (Colville Tribes 2001). A series of potholes dot the landscape in the Felix Creek subwatershed, the largest of which is Soap Lake. The potholes in the basin are fed by intermittent streams and groundwater, and hold water seasonally or year round. Fish presence in this area is presumed minimal to non-existent, as most streams are intermittent, and most lakes are highly alkaline or saline.

No anadromous species are known to utilize any of the streams in the Felix Creek subwatershed. However, presence/absence has not been recently confirmed in formal studies, and there is no historical information on fish presence (Colville Tribes 2001). Access would appear to be prevented by naturally inadequate flows under most conditions.

Productivity in the lakes of the Felix Creek subwatershed is limited presently and historically by the alkaline condition, high water temperatures.

Omak Creek

Omak Creek is a fourth order tributary of the Okanogan River that flows into the mainstem at RM 31. Of the 90,683 acres in this watershed, 73,029 acres are owned and managed by the Colville Tribes (Colville Tribes) (USDA 1995). The Omak Creek mainstem is approximately 22.4 miles long, with a total of approximately 272 miles of stream channel in the subwatershed. The climate of the subwatershed varies from arid to montane, with an average annual precipitation of 12 inches in the lower elevations to over 45 inches at Moses Mountain. Average daily temperatures range from 23o F in winter to 70o F in the summer. The average growing-season in the watershed lasts 120 days.

Approximately 8,112 (~9%) of the 90,683 acres within the Omak Creek watershed were burned or affected by the St. Mary's fire complex during August of 2001. The misapplication of fire-retardant chemicals inadvertently applied to Omak Creek and its riparian habitat in 2001 and 2003, resulted in a total fish kill from RM 8.4 to RM 2.9. A partial fish kill continued to nearly the confluence of the creek with the Okanogan River (RM 2.9 to RM 1.2). Over this length of creek, an estimated 10,400 fish were killed, principally resident rainbow trout, sculpin, and brook trout (Fisher and Fisher 2001, Fisher and Arterburn 2003). It is presumed that all offspring from the steelhead that successfully spawned in the creek in the spring of 2001 and 2003 were also killed from the retardant. Juvenile steelhead densities recorded upstream of the spill zone yet within the burn zone (1.12/m) were higher than the highest density of steelhead recorded in surveys of 25 arid-montane streams of Owyhee county Oregon (1.05/m) (Allen et al. 1998).

Previous problems identified for the Omak Creek subwatershed by the OWC (2000) include 303(d) listings, rural development, commercial impacts on the riparian zone adjacent to the mouth of the creek, sediment from roads, poor past forest practices such as skid trail placement, hoof shear by livestock, heavy grazing having an adverse effect upon the plant community, and noxious weeds.

The Omak Creek watershed supports a variety of fish species, including resident rainbow and brook trout, and the federally Endangered anadromous summer steelhead trout. Other species (e.g., *Cottis sp*., *Prosopium williamsoni*) also inhabit the creek, particularly in its lower reaches. In an effort to reestablish a locally adapted steelhead stock the Colville Tribes Fish and Wildlife Department, in a coordinated effort with Washington Department of Fish and Wildlife, has been stocking steelhead smolts in Omak Creek since 1980, with an increasing trend in returns.

The Colville Tribes has also recently embarked upon the re-introduction of Carson Stock spring Chinook salmon into the creek, and some 100,000 fry and 40,000 smolts were released into the upper watershed in the spring of 2001. (The National Marine Fisheries Service has considered spring Chinook to be extinct in the upper Columbia for many years). These fish were obtained from the Leavenworth National Fish Hatchery Complex as part of the US v. Oregon Agreement. Historically, Omak Creek supported steelhead and Chinook salmon, which were culturally important to the members of the Colville Tribes. It is presumed that steelhead utilized most of the perennial stream channels within the watershed, although Mission Falls (RM 8) was likely an effective barrier to Chinook salmon. Counts for summer steelhead included 901 smolts for 1988 (WDFW 1988). Sampling conducted by the Colville Tribes have identified 39 steelhead redds in 2002, 22 in 2003, and 104 adult steelhead at a weir located near the confluence with the Okanogan River in 2004. Fisher and Arterburn 2003, Colville Tribes unpublished data).

Salmon Creek

Salmon Creek is a perennial tributary of the Okanogan River with a total watershed area of about 167 square miles. The Salmon Creek mainstem is approximately 42.4 miles long, with a total of approximately 167.5 miles of stream channel in the subwatershed. Salmon Creek enters the Okanogan River at the town of Okanogan. Mountains surround Salmon Creek forming its hydrologic divides. The basin is generally oriented on a northwest-southeast axis, with a broad upper watershed about 8 to 10 miles wide and 12 to 15 miles long. The North Fork, West Fork, and South Fork of Salmon Creek converge at Conconully draining the 119 square-mile upper Salmon watershed. This portion of watershed is inaccessible to anadromous fish because of Conconully Dam and Reservoir. Conconully Dam is approximately 15 miles upstream from the mouth of Salmon Creek.

The Okanogan Irrigation District (OID) manages Conconully Reservoir to serve District lands east of the watershed. Controlled releases for irrigation deliveries are made from Conconully Reservoir between April and October. These releases are conveyed through 11 miles of natural and modified stream channel (referred to as the middle reach of Salmon Creek) to the OID diversion dam, located 4.3 stream miles above the mouth of Salmon Creek. For more than eighty years, the 4.3 miles of Salmon Creek downstream of the OID diversion dam (referred to as lower

Salmon Creek) have been dewatered, except during snowmelt events that result in uncontrolled spill at the OID diversion dam.

Previous problems identified for the Salmon Creek subwatershed by the OWC (2000) include: 303(d) listing, irrigation de-watering the creek, hoof shear by livestock, heavy grazing having an adverse effect upon the plant community, sediment from roads, fish passage blockages, poor past forest practices such as skid trail placement, rural development, winter feeding areas adjacent to the stream, and noxious weeds. Colville Tribes and the Okanogan Irrigation District formed a partnership in 1997 to evaluate the feasibility of restoring year-round instream flows. Currently, an EIS is being prepared to evaluation options and select a preferred alternative to address flow and habiat issues

Anadromous salmonids known to have historically occurred in Salmon Creek include spring Chinook (*Oncorhynchus tshawytscha*) and summer steelhead (*O. mykiss*). Before the construction of Conconully Dam in 1910, these anadromous fish may have utilized the north, west and south forks of Salmon Creek for 2 to 3 miles above the dam site. Both spring Chinook and summer steelhead are listed as "Endangered" under the Endangered Species Act. Spring Chinook are thought to be extirpated from Salmon Creek. Summer steelhead are occasionally observed in the creek during high water years.

NMFS considers all Columbia River steelhead returning to spawning areas upstream of the Yakima River confluence as belonging to the same ESU (NMFS 1997). This ESU is currently listed as "Endangered," and includes the Wenatchee, Entiat, Methow, and Okanogan watersheds. The Wells Hatchery steelhead stock is also included in this ESU because it is considered essential for the recovery of the natural population.

Historically, bull trout were thought to use the North Folk of Salmon Creek. Currently, FWS has documented bull trout in this area as "unknown occupancy". The Columbia DPS for bull trout was listed under ESA as Threatened June 1998.

Wanacut Creek

Wanacut Creek is a third order intermittent tributary to the Okanogan River located on the Colville Tribes Reservation immediately north of the Omak Creek subwatershed. Wanacut Creek flows westward, entering the eastern side of the Okanogan River at approximately RM 30, (Colville Tribes 2001). The total area of the Wanacut Creek subwatershed is 12,595 acres, representing 0.76% of the total Okanogan watershed (OWC 2000). The Wanacut Creek mainstem is approximately 7.6 miles long, with a total of approximately 38.7 miles of stream channel in the subwatershed.

Previous problems identified for the Wanacut Creek subwatershed by the OWC (2000) include: heavy grazing having an adverse effect upon the plant community, sediment from roads, rural development and noxious weeds.

Brook trout, an introduced species, is the only fish species recorded in Wanacut Creek, both currently and historically (Colville Tribes 1997). There may be rainbow trout in the upper reaches (Marco 2001, pers. comm.). The stream is not currently stocked, but the presence of brook trout suggests that it was stocked in the past. There are several culverts in the lower reaches, some of which may be passage barriers to fish (Marco 2001, pers. comm.).

Johnson Creek

The Johnson Creek subwatershed area delineated for this LFA includes the self-contained basins of Fish Lake and Pine Creek that do not flow into the Okanogan River. The Johnson Creek subwatershed, independent of Fish Lake and Pine Creek, comprises approximately 28,694 acres. When these basins are included, the subwatershed area comprises 75,659 acres. The Johnson Creek mainstem is approximately 7.9 miles long, with a total of approximately 28.6 miles of stream channel in the subwatershed—excluding the Pine Creek and Fish lake drainages. It is located on the western portion of the Okanogan Watershed with the Okanogan River as its eastern boundary, the Sinlahekin State Wildlife Recreation Area as its northwest boundary, and the Salmon Creek subwatershed to southwest. Johnson Creek joins the Okanogan River along its western shore at approximately RM 35, just south of town of Riverside. The Johnson Creek subwatershed runs parallel to the Okanogan River for about 11 miles. There is a series of 21 lakes found in the south-central terraced region of this subwatershed (USGS 1984a).

The climate within the Johnson Creek valley is semiarid. The highest mountain reaches change to a subhumid, but most of the subwatershed topography is below 2500 ft. There are large seasonal temperature extremes and daily temperature and precipitation variations. For example, temperature can range annually between 112°F - -31°F in the valley. Annual precipitation is less than 12.5 inches in the main valley (MWG et al. 1995).

Previous problems identified for the Johnson Creek subwatershed by the OWC (2000) include: winter feeding areas adjacent to the stream; confined pastures (also corrals) on the stream in the North Fork Pine Creek area, lack of riparian vegetation (both rural and urban areas); heavy grazing having an adverse effect upon the plant community (specifically the NF Pine Creek area), toxicity from urban-sewage treatment, individual wells and septic systems; sediment from roads (specifically Riverside Cut-Off Road); rural development; and noxious weeds.

All runs of summer/fall Chinook, sockeye and summer steelhead occur in the mainstem Okanogan River. No spawning, rearing or migratory activities are known to occur in the Johnson Creek tributary (Okanogan TAG). According to the 1998 study on the Methow and Okanogan Basins, the section of the Okanogan River that is in the vicinity of Johnson Creek contains the third highest density (0.8) of summer Chinook redds within the Okanogan (Murdoch and Miller 1999). A total of 21 redds were documented in ground surveys, of the section between the Riverside Bridge and the Tonasket Bridge, completed during the study. There is no documentation of sockeye salmon spawning in this area.

The thermal barriers and irrigation diversions found along the length of the Okanogan adjacent to the Johnson Creek subwatershed provide migration barriers that may decrease the number of returns. Sedimentation, cover, and high temperatures provide additional constraints to overall survival and reproduction of the salmon population (MWG et al. 1995). Adult sockeye will not migrate in waters higher than 69-70°F (MWG et al. 1995).

The Johnson Creek subwatershed has two dams within its network of waterways: Fish Lake Dam and Schallow Lake Dam (NWPPC 2001). Both dams are state-owned. The three main Species of Concern do not utilize tributaries within Johnson Creek; therefore these dams are not of direct concern.

Tunk Creek

Tunk Creek is a 3rd order tributary of the Okanogan River with a total watershed area of approximately 45,585.7 acres (OWC 2000). The Tunk Creek mainstem is approximately 19 miles long, with a total of approximately 76.5 miles of stream channel in the subwatershed. The creek enters the Okanogan River approximately 5 miles north of the town of Riverside, draining lands east of the river. The basin is generally oriented on an east-west axis. The watershed consists primarily of forest (40%) and rangeland (59.1%). Resource information regarding this subwatershed is very limited. (OWC 2000).

Previous problems identified for the Tunk Creek subwatershed by the OWC (2000) include: confined pastures (also corrals) adjacent to the stream, heavy grazing having an adverse effect upon the plant community, sediment from roads, commercial impacts on the riparian zone adjacent to the mouth of the creek, rural development, and noxious weeds.

Two of the main Species of Concern (Chinook and sockeye) do not migrate or spawn in Tunk Creek. Steelhead have a current distribution to McAllister Falls, approximately ¾ to 1 mile from the Okanogan confluence. The use of lower mile Tunk Creek below the falls is predicated upon adequate flows, thus, it is generally accessible to anadromous salmonids during the winter and spring months.

Resident rainbow trout occupy habitats upstream of the anadromous zone in Tunk Creek.

Chewiliken Creek

Chewiliken Creek is a second order Okanogan tributary that drains the eastern slopes of the Okanogan watershed in between Tunk Creek to the south, and Bonaparte Creek to the north. The mainstem of the creek is approximately 11 miles long, with a total of roughly 22 miles of stream channel within the subwatershed's boundaries. Peak elevations in the subwatershed ascend to Tunk Mt. (6,054 ft), although only the northwestern flanks of this peak should drain towards Chewiliken Creek.

Of the 26.8 square miles in the subwatershed, the PSIAC estimates a total sediment recruitment into the Okanogan River mainstem of 0.33 ac-ft/sq mi, 0.99 tons/acre, and 16,954 tons/yr (as cited in OWC 2000). The sediment yield from this subwatershed represents approximately 1.1% of the 1,581,950 tons recruited into the mainstem Okanogan per year.

According to MWG et al. 1995, there are 16 groundwater claims for 144 gpm, but no groundwater permits. There are an additional 27 surface water claims for 2.3 cfs.

The TAG did not identify Chewiliken Creek as a significant tributary of the Okanogan for supporting anadromous salmonid spawning or rearing.

Aeneas Creek

Aeneas Creek enters the Okanogan River along the west side at approximately river mile 50. The Aeneas Creek mainstem is approximately 8.0 miles long, with a total of approximately 27 miles of stream channel in the subwatershed. The subwatershed comprises approximately 0.41% of the total Okanogan watershed (OWC 2000). Aeneas Creek flows in a southeasterly direction from the slopes of 3,107 ft. Aeneas Mountain to the Okanogan River (approx. 900 ft el.). The second order Okanogan tributary has a total stream length of approximately 8 miles, and flows through an area referred to as the "lime belt region." The affect of this lime belt land-type region is evident by the accumulation of calcium carbonate along the streambed channel.

Previous problems identified for the Aeneas Creek subwatershed by the OWC (2000) include: heavy grazing having an adverse effect upon the plant community, undersized culverts on private drives, and noxious weeds.

Information regarding the aquatic resources of Aeneas Creek is limited. Most information that does exist originates from reconnaissance surveys and anecdotal observations (L. Hoffman 1998, C. Fisher 1998). Two adult fish passage barriers were identified during joint surveys conducted by the Colville Tribes and Washington Department of Fish Wildlife during the summer of 1998 (Okanogan TAG). The lowermost partial barrier is a concrete box culvert located approximately ¼ mile upstream from the mouth. Potential anadromous fish use is restricted to habitat up to the lowermost falls in the system at approximately RM ¾. A private trout farm once operated in the system upstream of the falls, approximately 1 mile above the Pine Creek Rd bridge crossing (~ RM 3). It is not known whether this was simply a grow-out facility, or a complete hatchery operation.

The Whitestone Creek Watershed encompasses six main bodies of water (from north to south): Blue Lake, Wanacut Lake, Spectacle Lake, Whitestone Creek, Whitestone Lake, and Stevens Lake (DOI and BOR 1976). The Okanogan River flows along its eastern border, running 33.1 kilometre along the subwatershed from Oroville to Tonasket (Murdoch and Miller 1999). The Whitestone Creek subwatershed is an island surrounded by larger subwatersheds of the Okanogan watershed. To the west is the Similkameen River subwatershed, to the southwest is Aeneas Creek, to the southeast is the Siwash Creek, to the east is the Antoine Creek and to the northeast is the Tonasket Creek. The Whitestone Creek mainstem is approximately 2.8 miles long, with a total of approximately 83.4 miles of stream channel in the subwatershed.

Summer Chinook spawn from about early October to early November in the Okanogan and related tributaries near the Whitestone Creek confluence. The 33.1 kilometres of the Okanogan River that runs along the Whitestone Creek subwatershed's eastern border supported the highest density of summer Chinook redds throughout the Okanogan River in 1998 (Murdoch and Miller 1999). The ground and aerial survey taken from September to November counted a total of 29 redds, 33% of the total found that year (Murdoch and Miller 1999). The 1998 study estimated that, based on a 3.6 fish/redd ratio, 317 Redds expanded through tributary escapements. Compared to the total of 88 Redds found in the Okanogan, the tributaries potentially play a more dominant role in summer Chinook spawning than the Okanogan itself.

The Bonaparte Creek watershed is of mixed ownership. The acres are a mixed ownership as follows: Private ownership, 59,000 acres (58%); Washington Department of Natural Resources, 9,000 acres (9%); Bureau of Land Management managed lands, 1000 acres (1%); and the remaining 33,000 acres (32%) are managed by the US Forest Service (USFS).

Bonaparte Creek

Bonaparte Creek, a significant 4th order tributary that encompasses 102,120 acres. It enters the Okanogan River in the city of Tonasket, Washington, at River Mile (RM) 56.7 of the Okanogan River. The subwatershed at its longest (straight) axis is approximately 24 miles long; its widest point is approximately 17 miles wide. There are approximately 126 miles of stream channel throughout the subwatershed. The elevation of the confluence of Bonaparte Creek with the Okanogan River is 880 feet. The highest point in the Bonaparte Creek watershed is Bonaparte Mountain at 7,240 feet. The Bonaparte Watershed is oriented on an east to west axis.

Previous problems identified for the Bonaparte Creek subwatershed by the OWC (2000) include: winter feeding areas adjacent to the stream, hoof shear by livestock, lack of riparian vegetation, rural development (i.e. sprawl east of Tonasket along Bonaparte Creek), sediment from roads (i.e. SR 20), and noxious weeds.

Anadromous fisheries resources are restricted to the lower 1.0 mile of the Bonaparte Creek subwatershed because of an impassable waterfall. Resident trout and sculpin are found above these falls. By estimate, less than 100 square meters of suitable spawning habitat occurs in Bonaparte Creek in the accessible zone. A large area, 200 square meters (.049 acre) with suitable spawning substrate is 300 meters (328 yards)downstream in the Okanogan River.

Use of Bonaparte Creek by summer steelhead is assumed up to the impassable falls at river mile 1.0. WDFW (1988) counted 65 summer steelhead smolts from the mouth to Peony Creek. In the spring of 2001, 2 steelhead redds were observed in Bonaparte Creek (C. Fisher [Okanogan TAG], confirming the use of this system by this Endangered stock. Summer/fall Chinook salmon are known to spawn in the mainstem Okanogan River just downstream of the Bonaparte Creek confluence.

The mainstem Okanogan River is used for migration northward to Canadian waters. Most of the known summer/fall Chinook spawning areas are in the Similkameen River. It is unlikely that Chinook salmon use Bonaparte Creek, as flows in the fall are less than 5 cubic feet per second (cfs), but spawning has occurred in the mainstem Okanogan River below Bonaparte Creek. Sockeye salmon are known to use the mainstem Okanogan River by the Bonaparte Creek confluence as a migration pathway to their spawning areas in Lake Osoyoos and the upstream reaches of the Canadian Okanogan River. Sockeye salmon are not known to use Bonaparte Creek, but could use its accessible habitat during migration for holding or refuge.

Siwash Creek

The Siwash Watershed is 30,946 acres. Of these acres, 10,567 (34%) acres are managed by the USFS, the remaining 20,379 (66%) acres are a combination of ownership that includes private owners (60%), Washington Department of Natural Resources (5.5%), and Bureau of Land Management managed lands (<1%). The Siwash Creek mainstem is approximately 21 miles long, with a total of approximately 42.5 miles of stream channel in the subwatershed.

Previous problems identified for the Siwash Creek subwatershed by the OWC (2000) includes: irrigation de-watering creek, sediment from roads, confined pastures (also corrals) adjacent to the stream, and noxious weeds.

Anadromous fisheries resources are restricted to the lower 1.4 miles of the Siwash Creek subwatershed because of an impassable steep gradient channel. Suitable spawning habitat occurs in Siwash Creek only when flows are sufficient to allow migration upstream.

No data are available about the use of Siwash Creek for rearing or spawning of Upper Columbia River Summer Steelhead. It is assumed that passage of adults is not restricted up to river mile

1.4, to the steep gradient channel area. Juvenile fish, either resident rainbow trout or steelhead do invade the lower reaches in the spring.

Antoine Creek

The Antoine Creek watershed encompasses 46,695 acres of mixed ownership. The acres are a mixed ownership as follows: Private ownership, 30,000 acres (72%); Washington Department of Natural Resources, 2800 acres (6%); Bureau of Land Management managed lands, 459 acres (<1%); and the remaining 9,806 acres (21%) are managed by the US Forest Service (USFS).

Antoine Creek enters the Okanogan River 4 miles north of the city of Tonasket, Washington, at River Mile (RM) 61.2 of the Okanogan River. The watershed at its longest axis is approximately 16.5 miles long and its widest point is approximately 10 miles wide. There are approximately 55 miles of stream channel within the subwatershed.

Fancher Dam impounds Antoine Creek at approximately RM 12. Approximately 40% of the watershed acres drain to Antoine Creek above Fancher Dam, with the remaining 60% of the watershed draining to Antoine Creek below Fancher Dam. The Fancher Dam reservoir covers approximately 20 acres and is approximately 55 ft deep at its deepest point. The water stored in the Fancher Dam reservoir is used for irrigation of croplands.

Previous problems identified for the Antoine Creek subwatershed by the OWC (2000) include: sediment from roads, hoof shear by livestock, heavy grazing having an adverse effect upon the plant community, and noxious weeds.

Potential anadromous salmonid use of Antoine Creek is restricted to the lower 11.5 miles of the subwatershed due waterfalls and a steep gradient channel that begins at RM 11.5. Steelhead adults are known to use the confluence area of Antoine Creek with the Okanogan River (C. Hinkley, pers. comm.). Sockeye and Chinook salmon are not known to use Antoine Creek, but their use of the accessible habitat near the confluence for holding and limited rearing cannot be precluded. There are no data or anecdotal information indicating bull trout ever used the Antoine Creek watershed, likely because of inhospitable temperatures.

Tonasket Creek

Tonasket Creek enters the Okanogan River east of the city of Oroville, Washington, at River Mile (RM) 77.8 of the Okanogan River. The watershed at its longest axis is approximately 12 miles long and its widest point is approximately 8 miles wide. The mainstem channel of the creek is 14 miles long, and there are approximately 75 miles of stream channel total in the sub-watershed.

During July of 2001 the subwatershed experienced localized flash flooding. This event resulted in the loss of human life, and significant channel realignment and provided a vivid example of one of the major forces in the Okanogan watershed in shaping aquatic habitats.

Previous problems identified for the Tonasket Creek subwatershed by the OWC (2000) include: sediment from roads (i.e. SR 20 winter maintenance), irrigation de-watering creek, herbicide and fertilizer application in orchard near creek, and noxious weeds.

Anadromous fisheries resources are restricted to the lower 1.9 miles of the Tonasket Creek subwatershed because of the steep gradient of the channel that initiates at this point and continues to approximately RM 2.3. Above RM 2.3, it is suspected that eastern brook trout are present, though some fish shocking done in preparation for the replacement of a culvert on the paralleling County Road 9480 did not reveal any fish (L. Hofmann, pers. comm.).

Steelhead fry are observed in the confluence area where Tonasket Creek joins the Okanogan River by Ken Williams, Area Fish Biologist Region 2 WDFW (retired). He surmised that the fry were using the confluence area for rearing, and to evade predators found in the mainstem Okanogan River, and perhaps to make use of relatively warmer water temperatures in Tonasket Creek compared to the Okanogan River (K. Williams, pers. comm.). Summer steelhead smolt counts totaled 148 from the mouth to the headwaters in 1988 (WDFW 1988). An adult steelhead was caught at approximately RM 1.8 in the late 1970s (D. Buckmiller, pers. comm.)

Similkameen River

The Similkameen River is the largest tributary to the Okanogan River that originates in the Canadian Cascade range and drains the northeastern Washington Cascades. The Similkameen River enters the Okanogan River from the west approximately 20 miles south of the US-Canada border, and measures approximately 317 miles in length (197 kilometres), and drains 2900 square miles (7,600 square kilometres in Canada).

The US portion of the Similkameen Basin is approximately 666.5 square miles with a perimeter of 226.9 miles. The total Similkameen drainage basin is approximately 228,536 acres, 80% of which is in the Canadian portion of the watershed (OWC 2000, USDI 1986). It is a hydrologically complicated watershed, bordered to the southwest by the Sinlahekin River watershed, which joins the mainstem Similkameen at the Palmer Lake Reservoir. In the US, the 189,521-acre Sinlahekin subwatershed comprises the vast majority of the stream channel miles of the Similkameen subwatershed.

The large number of Similkameen River tributaries provides spawning and rearing for the tributary's mainstem resident fish, particularly lake headed systems with more stable flow regimes. The largest subwatersheds to the Similkameen include the Tulameen River, Pasayten River and Ashnola River. Important lake headed tributaries include Hayes Creek, Wolfe Creek, Allison Creek, and Summers Creek (tributary to Allison Creek). While most of the Similkameen river watershed lies in Canada, the confluence of the Similkameen and Okanogan rivers lies in Washington State, just north of Oroville.

Previous problems identified for the Similkameen River subwatershed by the OWC (2000) includes: 303(d) listings, unstable streambanks from Shankers Bend to the Canadian border and Palmer Creek to Toats Coulee Creek in the Sinlahekin Creek area, sediment from roads, lack of riparian vegetation, heavy grazing having an adverse effect upon the plant community, a monitored EPA a monitored EPA Super Fund Site, and noxious weeds.

Even though there are problems with sedimentation and water temperature, Chinook salmon runs returning to the lower reaches of the Similkameen and Okanogan Rivers have increased slightly, as a primary result of returns to the Similkameen River. Escapements have declined slightly in the Okanogan (OWC 2000).

Passage for salmon in the Similkameen is restricted at Enloe Dam, approximately 8.8 miles above the confluence with the Okanogan River (WDNR 1982). This 54 ft dam built between

1916 and 1923, was originally constructed for hydropower generation, but is no longer operational in that capacity.

Enloe Falls, prior to the construction of the dam, is believed to have restricted anadromous access to the upper Similkameen watershed, although photographic interpretations of the falls has suggested possible passage under certain flows. There is no historic record of anadromy upstream of the falls (OWC 2000), and the Okanagan Nation acknowledges the legends of the Coyote that have always prohibited salmon passage to the upper watershed.

The Canadian fisheries agencies have also committed to a policy of no salmon passage to preserve the historic ecosystem. In Canada, the Umatilla dace, chizelmouth, and mottled sculpin are on Provincial conservation lists (Appendix C). Rainbow trout stocking in the upper watershed support a recreational fishery.

The Similkameen River below Enloe Dam is one of the most heavily utilized sections of the Okanogan watershed by summer/fall Chinook. Spawning is concentrated between the dam and Driscoll Island, just upstream from the confluence with the mainstem Okanogan. Between 1977 and 1985, 17 to 43% of the Chinook redds counted from all Chinook that passed Wells Dam were recorded in the Similkameen (Mullan 1987).

The escapement into the Similkameen, where natural production is occurring, ranged from 395 to 654 fish between 1977 and 1983, and jumped up to over 1200 fish in 1984 and 1985 (Mullan 1987). Detailed studies conducted in 1991show the highest density of spawning occurs in the lower 5 miles of river (Hillman and Ross 1991).

The use of the Similkameen by other anadromous salmonids is more limited. The Similkameen historically produced steelhead, and limited use by this species continues today. No escapement or spawning data were reviewed specific to this species from this system. Sockeye salmon do not use the Similkameen for spawning, although it is likely a staging area during immigration and emigration that depends upon the cool waters as refugia during warm summer migrations. There are no records of bull trout in the Similkameen River.

Ecology of the Okanogan subbasin

Geology of the Subbasin

The Okanogan River subbasin geology and geomorphology is influenced by the Cascade Range, Northern Rockies, and Columbia Plateau Systems that border it on the west and south sides, respectively. During the Quaternary Period, glaciers sculpted the landscape below 5,000 feet, covering large areas with glacial drift and fluviolacustrine sediments.

Small alpine glaciers were also active at higher elevations. Cascade volcanoes were active during the Pleistocene and into the Holocene. Deposits of volcanic ash from these eruptions occur within the area (Hansen 1998). Due to glacial activity, rock outcrops were exposed in many places and formed a complex pattern with the materials deposited by glaciation. Much of the bedrock has been weathered to shallow soils (SCS 1980).

The erosive action at the base of the glacial ice create unconsolidated and unsorted mixtures of silt, sand, gravel, and stones. Glacial fluvial meltwater streams carried large quantities of sand and gravel, creating thick deposits of sorted materials. In areas of low gradient or local impoundment, glacial meltwater created lacustrine deposits of clay soils. Some deposits of glacial drift are mantled by volcanic ash (SCS 1980).

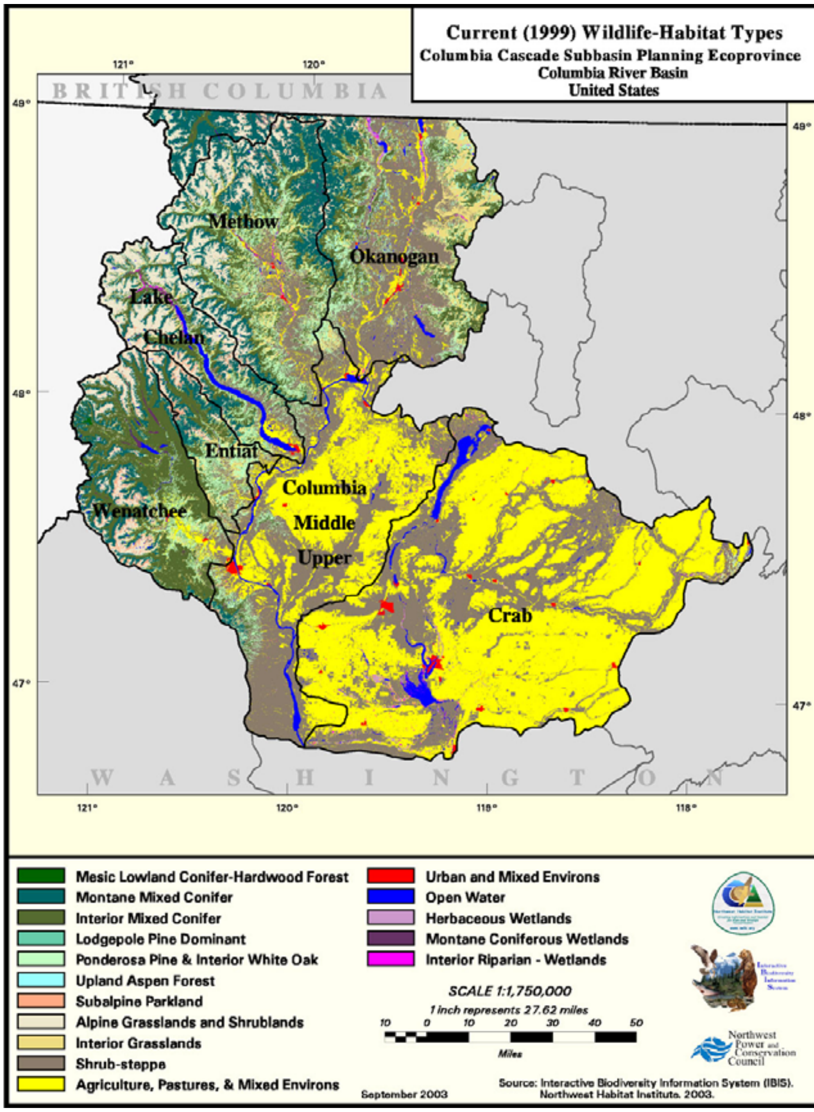
The Okanogan valley represents a northern extension of the western American deserts, and an important link between the arid regions of Washington and British Columbia. The retreat of the Wisconsinian glaciers approximately 11, 000 years ago, left behind a broad terraced valley, lined with fertile benchlands, intersected by a network of small streams draining into the chain of large Okanogan lakes.

The Okanogan River valley is broad and flat. Given the topography and geology, the river probably once meandered across the valley, and riparian habitat formed an extensive mosaic of diverse species. It was dominated by some combination of grass-forbs, shrub thickets, and mature forests with tall, deciduous trees.

The Okanogan subbasin’s riparian and wetland corridor today embodies an essential artery to the Columbia Basin, supporting Threatened populations of fish, plants and wildlife within the Columbia-Cascade eco-province (CCP). The subbasin also provides important contiguous habitats, across the Canada-US border and surrounding the riparian/wetland corridor, which connect similar vegetative zones and landscapes to the south, including the Great Basin Sonoran, Mohave and Chihuahuan deserts.

This complex of habitat corridors provides migration paths for fish and wildlife, migrating across jurisdictions that bisect the CPP. These include pine forests, shrubsteppe, riparian and herbaceous wetland plant communities, and the rugged terrains comprised of cliffs, caves and talus slopes. These habitats support a large number of fish, birds, mammals, reptiles and amphibians including several Endangered species.

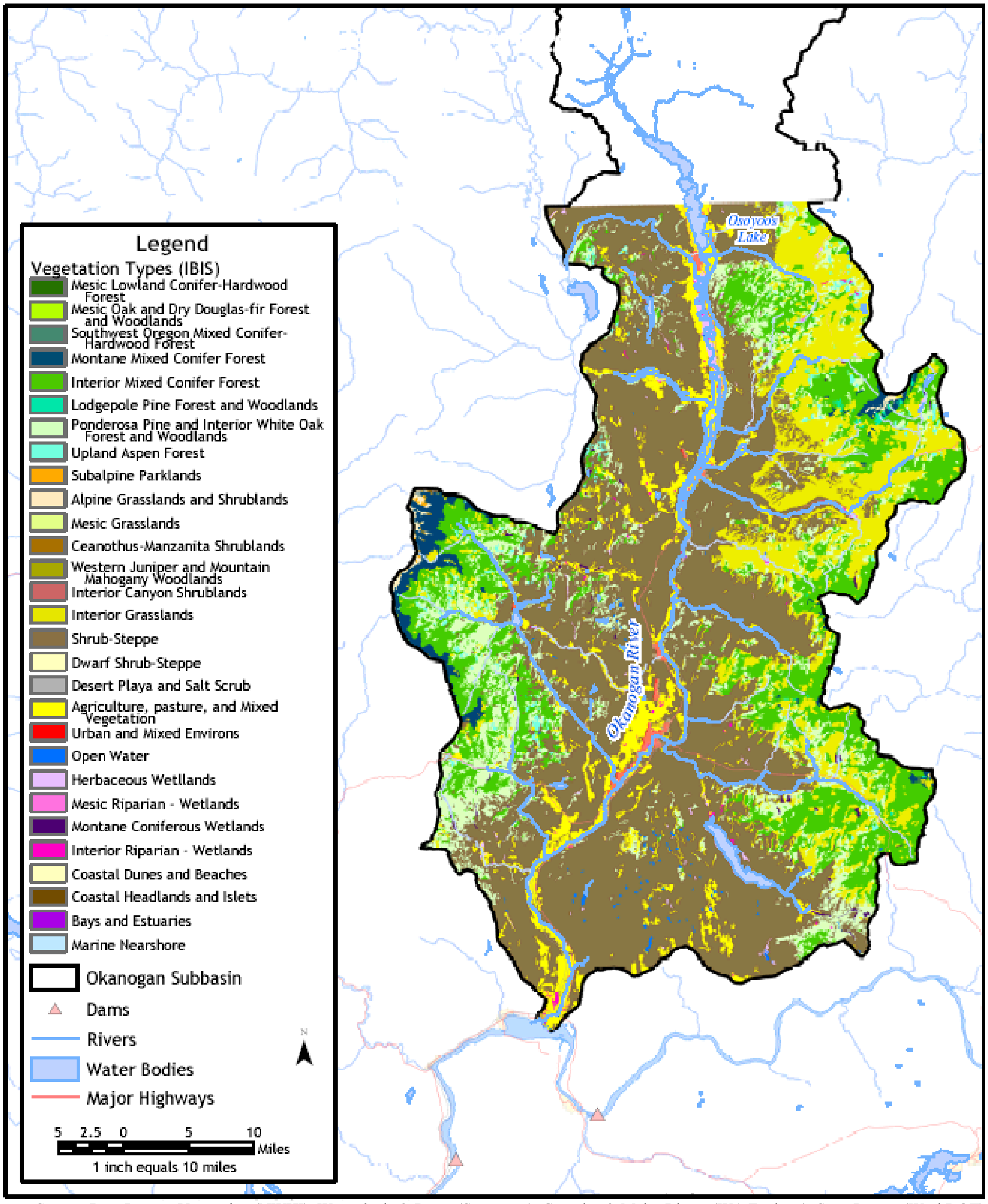
The combination of an arid/semi-arid climate with hot summers and mild winters and complex physiography provides the conditions for a wide array of ecological communities connecting the Okanogan subbasin to the CCP (**Figure 12**). A significant number of the Columbia Basin’s species and landscapes are at risk in the Okanogan, elevating the current threats to Okanogan biodiversity to an international conservation priority.



Source: IBIS 2003

Figure 12. Okanogan subbasin in relation to other Upper Columbia River subbasins and vegetative zones

The Okanogan subbasin consists of 15 wildlife habitat types, which are illustrated in Figure 12, and briefly described in Table 4. Detailed descriptions of these habitat types can be found in the Columbia Cascade Ecoprovince Wildlife Assessment and Inventory.



Source: Data Layers: Vegetation (NWHI), Watersheds & Dams (Streamnet), Counties & Major Rivers (WA Ecology), State Routes (WashDOT). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 13. Vegetation Types in the Okanogan subbasin

Table 8 Habitat types in the Okanogan subbasin

Habitat Type	Brief Description
Montane Mixed Conifer Forest	Coniferous forest of mid-to upper montane sites with persistent snowpack; several species of conifer; under-story typically shrub-dominated.
Eastside (Interior) Mixed Conifer	Coniferous forests and woodlands; Douglas-fir commonly present, up to 8 other conifer species present; under-story shrub and grass/forb layers typical; mid-

Habitat Type	Brief Description
Forest	montane.
Lodgepole Pine Forest and Woodlands	Lodgepole pine dominated woodlands and forests; under-story 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 under-story; lower elevation forest above steppe, shrubsteppe.
Upland Aspen Forest	Quaking aspen (Populus tremuloides) is the characteristic and dominant tree in this habitat. Scattered ponderosa pine (Pinus ponderosa) or Douglas-fir (Pseudotsuga menziesii) may be present.
Subalpine Parkland	Coniferous forest of subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and lodgepole pine (*Pinus contorta*).
Alpine Grasslands and Shrublands	This habitat is dominated by grassland, dwarf-shrubland (mostly evergreen microphyllous), or forbs.
Eastside (Interior) Grasslands	Dominated by short to medium height native bunchgrass with forbs, cryptogam crust.
Shrubsteppe	Sagebrush and/or bitterbrush dominated; bunchgrass under-story 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.
Open Water – Lakes, Rivers, and Streams	Lakes, are typically adjacent to Herbaceous Wetlands, while rivers and streams typically adjoin Eastside Riparian Wetlands and Herbaceous Wetlands
Herbaceous Wetlands	Generally a mix of emergent herbaceous plants with a grass-like life form (graminoids). Various grasses or grass-like plants dominate or co-dominate these habitats.
Montane Coniferous Wetlands	Forest or woodland dominated by evergreen conifers; deciduous trees may be co-dominant; under-story dominated by shrubs, forbs, or graminoids; mid- to upper montane.
Eastside (Interior) Riparian Wetlands	Shrublands, woodlands and forest, less commonly grasslands; often multi-layered canopy with shrubs, graminoids, forbs below.

Alpine-tundra

The upper Canadian subbasin includes an Alpine-tundra biogeoclimatic zone in elevations greater than 1,350 metres (4,429 feet).

Forests

US Forestland comprises approximately 47% of the American Okanogan River Basin. Dominant forest species include ponderosa pine, Douglas-fir, lodgepole pine, Englemann spruce, western larch, subalpine fir, and aspen. Whitebark pine and subalpine larch occupy alpine settings. Dominant riparian species include black cottonwood, water birch, and white and thinleaf alder (Arno1977), but riparian forests and shrub steppe have been virtually eliminated in the subbasin.

In the Canadian Okanagan, forests represent 2 biogeoclimatic zones, including Interior Douglas-fir and Englemann-spruce subalpine fir. Aspen are present in upland forests where sufficient moisture is present. Historic riparian cottonwood galleries are scarce but a few strongholds of cottonwood forest remain along the un-engineered reaches of the Canadian Okanagan subbasin and in patches along the major tributaries.

Harvest of large trees has also contributed to the current condition of dense stands dominated by small, suppressed Douglas-fir that is prone to insect infestation, disease, and catastrophic fire. An extensive road system in the forest has increased the sediment delivery to the stream channels. Sediment-laden runoff is exacerbated by the predominance of loose soil types that have high erosion potential. The road system is also a major source of weed transport, and weed infestations are present throughout the basin.

Shrubsteppes

Shrubsteppe habitat was originally a major component of the landscape in the Okanogan Basin, extending from the outer edge of the floodplain to the beginning of the lower elevation forest, at roughly 2500-foot elevation. Shrubs and perennial bunch grasses, with a microbiotic crust of lichens and mosses on the soil surface, dominate native shrubsteppe habitat. Sagebrush was the dominant shrub; bitterbrush was also an important component (Oregon-Washington Partners in Flight, 2000).

Native shrubsteppe communities have been diminished in both extent and condition as a result of overgrazing by livestock, invasion of non-native plants, agricultural conversion, and wildfire suppression. Most extant shrubsteppe may appear to be in a natural condition, but it is actually a considerably altered ecosystem, compositionally and functionally different than pre-European settlement conditions (Partners in Flight, 2000).

In Canada the Bunchgrass- Ponderosa Pine biogeoclimatic zone occupies elevations between 250 and 1000 metres (3,281 feet).

Riparian wetlands and the valley floodplain

The Okanogan River valley is broad and flat. Given the topography and geology, the river probably once meandered across the valley, and riparian habitat formed an extensive mosaic of diverse species. It was dominated by some combination of grass-forbs, shrub thickets, and mature forests with tall, deciduous trees. Common shrubs included willows, red-osier dogwood, hackberry, mountain alder, Wood’s rose, snowberry, and currant. Trees included cottonwood, aspen, and water birch (Oregon-Washington Partners in Flight, 2000). Hunner and Jones (1997) have noted that wetlands across the Colville Reservation are quite variable because of precipitation patterns, but in general their area has been shrinking over time.

There are also several population centers and municipalities along the river and the lower reaches of the tributaries. Riparian vegetation such as cottonwood, spruce, alder and a dense shrub layer have been largely lost. Agriculture, private residences, and associated roads contribute to changes in the natural watershed hydrograph, and add chemical contaminants and sediments to the streams and rivers.

Cliffs, caves and talus slopes

Although not identified as a focal species in this draft, there are significant opportunities to enhance connectivity and coordinate recovery programs for species of bat and reptile at risk in this habitat type.

Rugged terrains, predominantly cliffs, caves and rocky talus slopes are crucial habitats for many species of birds, mammals and reptiles. These habitats in the Okanogan subbasin provide important habitats for Endangered snakes, bats and raptors. Although these habitats are not as heavily impacted as other habitat types in the subbasin, they are being threatened by recreation and urbanization activities.

Fire

Prior to European settlement, frequent fires in the mid elevations, (2000 to 4500 ft) created open stands of predominantly mature, fire-resistant Ponderosa pine, with a smaller larch component above 3,000 feet. Unpublished preliminary data of forest reconstruction plots in North Central Washington indicate 12 to 20% canopy closure at these elevations. In the 1900s, fire suppression led to a dramatic increase in seedling survival, creating stands with 100% canopy closure. Shade tolerant, fire sensitive Douglas-fir is now favored over fire-tolerant, but shade-intolerant pine and larch.

Soils and Vegetation

Most Okanogan County soils are formed in materials derived mainly from volcanic ash and glaciation from the last 10,000 years. Those soils most influenced by ash are in the northern part, at elevations above 3,000 feet (SCS 1980). Because the Okanogan Valley is narrow with steep slopes, there is a high amount of runoff into the river. High rates of drainage are also attributed to streambank instability, which introduces a large amount of sedimentation.

The most erosive soils along the Okanogan River are the Colville Tribes silt loams, and the Bosel fine sandy loams. Some factors that accelerate erosion are over grazing, mining sites, logging activities, roadwork and irrigation. The lack of woody vegetation on the streambanks along the Okanogan may be increasing erosion rates. Soils are slightly acid to alkaline, and originate from sandy loam to silt loam soils formed in volcanic ash, glacial materials, and weathered granite, schist, limestone, shale and gneiss.

A semiarid climate, with dry warm summers and moderately cold winters supports such native species as big sagebrush, rabbitbrush, and bitterbrush in the valleys and on terraces (SCS 1980). The climate is influenced by the barrier to marine air that the Cascade Mountain Range provides, and by the mountain and valley formations of the region. Precipitation in the watershed ranges from more than 40 inches in the western mountain region to approximately 8 inches at the confluence of the Okanogan and Columbia Rivers.

Where annual precipitation is 8 to 11 inches, grassland is the dominant type of vegetation. In areas where the annual precipitation is 11 to 14 inches (such as in the middle and lower reaches of the Salmon watershed), the importance of Idaho fescue and bluebunch wheatgrass in the plant community increases. Perennial grasses include bluebunch wheatgrass, and giant wild rye.

Non-native plant species include wheatgrass, Russian thistle, common mullein and wooley plantain. Forested lands comprise approximately 47% of the Okanogan watershed and receive approximately 75% of the total annual precipitation (Gullidge 1977).

The density of the forest vegetation increases at elevations above 3,000 feet, where the annual precipitation is greater than 14 inches. Yellow pine (*Pinus ponderosa*) dominates in areas where the annual precipitation is 14 to 16 inches (e.g., the upper Salmon watershed). Douglas-fir (*Pseudotsuga douglasii*) is dominant in areas where the annual precipitation is 16 to 18 inches (SCS 1980).

Vegetation status

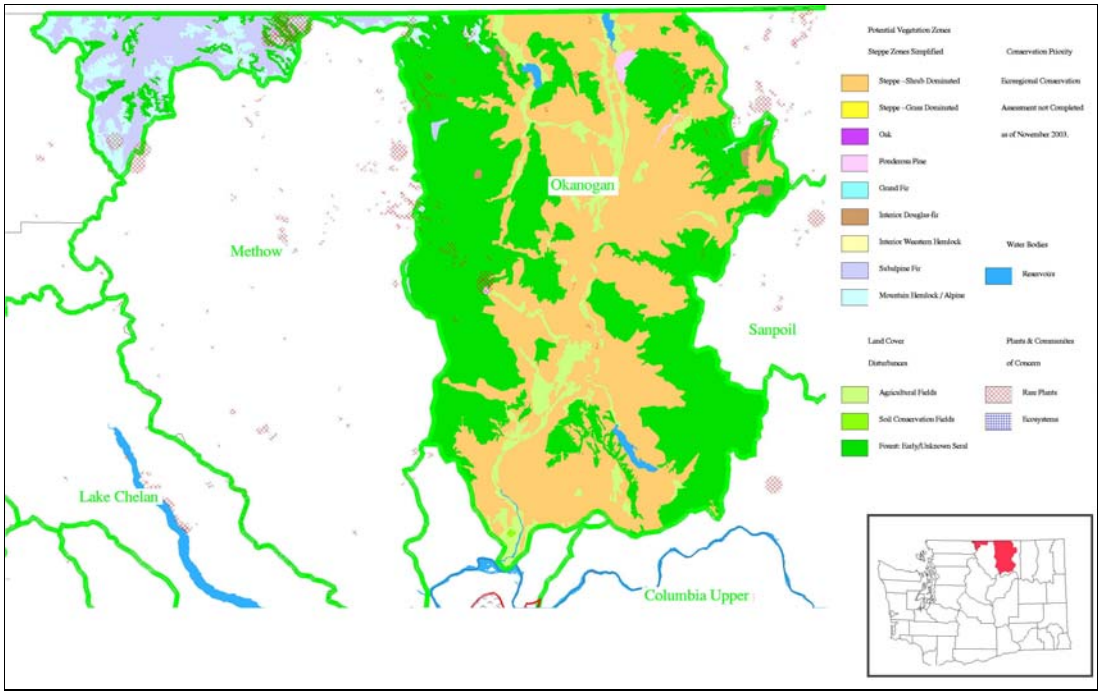
There are 71 species of state and federally listed plants in Okanogan County. (this list is available at http://www.wa.gov/dnr/htdocs/fr/nhp/refdesk/lists/plantsxco/okanogan.html).

In Canada 61plant species are listed as nationally Threatened or Endangered, along with an additional 33 considered vulnerable.

To consult current listing status in Canada, provincial listings are available at www.elp.gov.bc.ca/rib/wis/cdc/tracking.htm National listings are available at www.sis.ec.gc.ca/cgi-eas/endanew.exe - electronic summary to list these

These plants are vitally important to the quality of the fish and wildlife habitat of the region. Virtually every plant in the region is important to the Okanagan Nation and the Colville Tribes and tribal memberships for their cultural, historic, and subsistence value. The Colville Tribes and the Okanagan Nation have been involved in plant inventories in Canada and US.

The US Okanogan subbasin contains 50 rare plant communities (Appendix ?). Approximately 26% of the rare plant communities are associated with shrubsteppe habitat, 16% with riparian or wetland habitats, and 58% with upland forest habitat. Rare/high-quality plant occurrences and communities are illustrated in Figure 15.



Source: Cassidy 1997, WNHP 2003

Figure 14 Rare plant occurrence and high quality plant communities in the Okanogan subbasin, Washington

Special plant species are considered in habitat associations for wildlife, and in particular where associated with riparian areas of shared value between fish and wildlife. Approximately 26% of the rare plant communities are associated with shrub steppe habitat, 16% with riparian or wetland habitats, and 58% with upland forest habitat.

Noxious Weeds

In Okanogan County, the location and extent of noxious weed infestations are currently being mapped by the County Noxious Weed Control Office, using a Geographic Positioning System (GPS). Key weed classifications were mapped in 2000. Okanogan County has continued noxious weed mapping (Sheila Kennedy 2001, pers. comm.).

The Okanogan National Forest (ONF) has mapped noxious weed infestations on the GIS system, and continues to add more sites. They currently have 31,000 acres weed infestations across the forest, including 24,000 acres of very dense knapweed.

The ONF completed environmental assessments for their Integrated Weed Management Program in 1996, 1999, and 2001. The 1996 EA covered 34 sites, on a total of 3000 acres. The 1999 EA covered 15-18 sites, and a total of 75 acres, and the 2001 EA primarily covers the road system, a total of 1,700 miles of road.

Climate change

Study of the nutrient sources and ecological impacts on Okanagan Lake (Hall, 2001), the climate of the subbasin is getting warmer, with more precipitation during winter and spring. This is resulting in earlier snowmelt, greater run-off, lower summer flows, the peaks of run-off have increased. Increased turbidity is increasing nutrient loads and exacerbating eutrophication. There is a need for systematic review of engineering (water and flood control), operating rules, contingency plans (drought and flood) and water allocation policies.

Water Resources

The hydrology of the Okanogan River Watershed is characterized by high spring run off and low flows occurring from late summer through winter. Peak flows coincide with spring rains and melting snowpack. Low flows coincide with minimal summer precipitation, compounded by the reduction of mountain snowpack. Irrigation diversions in the lower valley also contribute to summer low flows.

Hydrography and watersheds

The average annual flow for the Okanogan River, measured at Ellisforde, is 3200 cubic feet per second (cfs). About 75% of the flow comes from the Similkameen River, located primarily in Canada. The gradient on the US portion of the mainstem Okanogan averages about 0.04%. The first 17 miles of the river are within the backwater of Wells Dam (NMFS, 2000). The gradient on the US portion of the mainstem Okanogan averages about 0.04%. The first 17 miles of the river are within the backwater of Wells Dam (NMFS, 2000).

Stream flow in the US portion of the Okanogan River is controlled by a series of 13 dams in British Columbia, and the Zosel Dam on Osoyoos Lake in Washington. Water releases to meet fishery needs are negotiated yearly by a consortium of fisheries and irrigation managers from both Canada and the US

The USGS has been recording flows in the Okanogan Basin continuously since 1911. **Table 9** summarizes USGS flow data for the basin.

Table 9. USGS Flow Records for Okanogan and Similkameen Rivers, 1911 – 1996 (USGS, 1995).

Station #	Location	Year Started	Average Flow (cfs)	High Flow (cfs)	Low Flow (cfs)
12438700	Oliver, B.C.	1944	639	3,740	55.9
12439500	Oroville, WA	1942	676	3,730	-2,270*
12445000	Tonasket, WA	1929	2,940	44,700	126
12447200	Malott, WA	1958	3,063	45,600	288 **
12442500	Nighthawk (Similk. R.), WA	1911	2,289	45,800	65

**During high flows, backflow from the Similkameen River results in negative flow values on the Okanogan at this station.*

***This record was observed.*

The WSDOE established base flows for the Okanogan and Similkameen rivers in 1976 (**Table 10**). Data are based on measurements made at the USGS Tonasket gauging station and snow survey data collected by NRCS. This table is a simplified version of the flow standards set in the Washington Administrative Code.

At the time these base flows were established, WSDOE ruled that no further appropriations of surface water shall be made from the Okanogan River and its tributaries if they would conflict with these base flows (NOAA, 2000).

Table 10. Base Flows (cfs) for the Okanogan River, as Set by WSDOE in 1976 (NMFS, 1998).

Reach	April*	May*	June*	July*	August *	September*	October*
Lower Okanogan RM 17.4 - 51	1120 1,250	1,400 4,000	4,000 4,000	2,400 1,400	1,050 800	800 800	940 1,100
Middle Okanogan RM 51 - 70	910 1,070	1,200 3,800	3,800 3,800	2,150 1,200	840 600	600 600	730 900
Upper Okanogan RM 70 - 77.6	330 340	350 500	500 500	420 350	320 300	300 300	330 370
Similkameen RM 0 - 27.3 (Canadian border)	510 640	800 3,000	3,000 3,000	1,650 900	590 400	400 400	450 500

Hydrologic regimes

Snowfall represents about 50-75% of the annual precipitation during the winter months. Rainfall and snowmelt runoff contribute approximately 3% to the average annual gauged stream flow of the Okanogan River at Mallot (USGS Gauge No. 12447200) with the remainder provided from Canadian contributions upstream.

Average annual runoff for the Okanogan River as measured at Mallot is 2,220,000 acre-foot. With about 2,150,000 acre-foot contributed annually from British Columbia and from the Similkameen tributary (OWC 2000). Annual runoff at Mallot has ranged between a minimum of 860,000 acre-foot and maximum of 4,000,000 acre-foot.

Average annual flows on the Okanogan and Similkameen Rivers have not changed significantly since gauging began in 1911 (WDOE 1995). However, seasonal low stream flows are very much affected by water usage for irrigation, water supply, and other activities.

Peak annual flows occur usually occur during a two or three week period in late May and early June, but the timing of the peak can vary substantially based on snowpack. On average, these hydrographic peaks account for approximately one-half of the annual runoff volume into the watershed.

Minimum annual flows occur in early fall to mid-winter (September through March). In arid climates such as the Okanogan valley, almost all precipitation occurring during the warm months either evaporates or is absorbed by the soil layer.

Usually only a very small amount of precipitation directly contributes to stream flow from late June through October. However, isolated summer thunderstorms in discrete sub-watersheds can yield flash flooding, resulting in devastating consequences to riparian habitats and aquatic biota. Such flooding events are non-uniform in their distribution among tributary drainages, with occurrence intervals approximately every 2 years in the Okanogan watershed overall. These events play a highly significant role in shaping aquatic habitats in the Okanogan watershed, especially within its tributaries.

The average annual flow for the Okanogan River, measured at Ellisforde, is 3200 cubic feet per second (cfs). About 75% of the flow comes from the Similkameen River, located primarily in Canada.

Groundwater

There have been several groundwater studies conducted in the US subbasin, but little is known about the deep, hard-rock aquifers. The shallow aquifers are characterized in the following quotation from a WSDOE report:

Alluvial and glacial sedimentary deposits, ranging from a few feet to several hundred feet thick, contain the main volume of groundwater in the basin, with sand and gravel layers constituting the principal water bearing zones. Most of the sedimentary deposits occur in or adjacent to major valleys and are underlain by rather impermeable bedrock which consists principally of granitic and various metamorphic rocks; limestone, dolomite, and basalt form the bedrock in small areas. Generally, the bedrock establishes the floor of the groundwater reservoir, although cracks in the bedrock below the water table become filled with water, and limestone, dolomite, and basalt formations yield small quantities of water to springs and wells.

In some places, the sedimentary deposits are thick and consist almost entirely of sand and gravel containing large quantities of groundwater. In other cases, the deposits hold little water, being thin or consisting mostly of clay or poorly permeable glacial till. (WSDOE, 1974)

Groundwater in the Okanogan tends to be more mineralized than surface water, and the chemical composition varies more. There have been occurrences of excessive iron and sulfates, but generally the water is usable for most purposes. Groundwater in the basin is typically hard to very hard. Ground water temperature ranges from 110C to 160C; the shallower zones tend to produce cooler water. Nitrate levels in tested wells ranged from 0.3 to 4.9 parts per million (Walters, 1974).

The shallow aquifers tend to be high in sediments, indicating that it is fairly susceptible to pollution during ground-disturbing activities.

The coarse soils in the basin create hydraulic continuity between the ground and surface waters. Most municipal water is supplied from wells that penetrate the groundwater aquifers.

Water quality

According to nutrient studies in Canada, 70% of nitrogen loads result from stream discharge, including forest impacts, 15% from sewage treatment, 9.6% from stormwater and 4.7% from septic tanks. There is a nitrogen deficit from agricultural activities (Hall et al. 2001). The nitrate values recorded on the Okanogan and Similkameen Rivers are well below any action level for health standards and thus acceptable for all Class A water uses.

The Okanogan and Similkameen rivers are classified by the State of Washington as Class A waters (Chapter 173 201 A 130 WAC, 1992). Classes range from A to AAA, with AAA being the highest quality. Class A waters are required to meet, or exceed, the standards established for the various uses including: water supply, recreation, fish (migration, rearing, spawning, and harvesting), wildlife, agriculture, and commercial uses.

Compliance for Class A waters includes:

- Temperature should not exceed 180°C(conversion), and pH should occur within the range of 6.5 to 8.5.
- Dissolved oxygen should not fall below 8 mg/L.
- Fecal coliform counts should be below the geometric mean of 100/100ml.
- When natural conditions result in water temperatures exceeding 180C, no discharges will be allowed which raise the receiving water temperature by greater than 0.30C. In addition, the USEPA has established the drinking water standard for nitrate at 10 parts per million.

3.3.3 Fish Populations

The Okanogan River represents the uppermost tributary of the Columbia River currently accessible to anadromous and resident fish populations. Historically, 28 indigenous species of fish populated the subbasin; 25 of these remain (**Table 11**)), and another 16 introduced species have successfully colonized the subbasin.

Table 11. **Fish species of the Okanogan/Okanagan River Subbasin**

#	Indigenous Fish Species	Characteristics	Source
1	chinook (*Oncorhynchus tshawytscha*)[2]	Spring	Ernst 2000; NMFS 1998; Miller and Hillman 1994, 1996, 1997, 1998; Utter 1993; Pinsent et al. 1974a; Butler 1974; Fulton 1968; Craig and Suomela 1941; Clemens et al. 1939; Gartrell 1936
		Summer/fall mixed	
2	sockeye (*Oncorhynchus nerka*)	Summer: lake and river rearing smolts	Hyatt and Rankin 1999; Ernst 2000; Chapman et al. 1995; McPhail and Carveth 1994; Shepherd 1990; NOAA 1977; Butler 1974; Allen and Meekin 1973
		Early summer?	H. Wright, ONA, pers. comm.
	kokanee (*Oncorhynchus nerka*)[4]	Stream and shoal spawners	MOLAP 2003
3	pink (*Oncorhynchus gorbuscha*)[1]		Butler 1974
4	chum (*Oncorhynchus keta*)[1]		Ernst 2000; Butler 1974;
		Early summer	ONA
5	steelhead (*Oncorhynchus mykiss*)[2]	Winter	Ernst, 2000; MFS 1998
		Summer	
6	Coho (*Oncorhynchus kisutch*)[1]		Ernst 2000; Butler 1974; Clemens et al. 1939

#	Indigenous Fish Species	Characteristics	Source
7	bull trout (*Salvelinus confluentus*)[2]		NMFS 1998, 2002; CTC 2001; Mullan et al. 1992 CPa
8	rainbow trout (*Salmo gairdneri*)	Fluvial and adfluvial	Bull 2003; NMFS 1998; McPhail and Carveth 1994; Pinsent et al. 1974a
9	Pacific lamprey (*Entosphenus tridentatus*)		Peven 2003; Clemens et al. 1939
10	mountain whitefish (*Prosopium williamsoni*)		Pinsent et al. 1974a; McHugh 1936
12	pygmy whitefish (*Prosopium coulted*)		McPhail and Carveth 1994; Pinsent et al. 1974a
13	bridgelip sucker (*Catostomus columbianus*)		PRC 1996; McPhail and Carveth 1994
14	largescale sucker (*Catostomus macrocheilus*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
15	mountain sucker (*Catostomus platyrhynchus*)[3]		BC Conservation Data Centre 1999
16	longnose sucker (*Catostomus catostomus*)		McPhail and Carveth 1994; Pinsent et al. 1974a
17	sculpin (*Cottus rhotheus*)		PRC 1996; McPhail and Carveth 1994
18	sculpin (*Cottus confuses*)		PRC 1996
19	mottled sculpin (*Cottus bairdi hubbsi*)[3]		McPhail and Carveth 1994
20	slimy sculpin (*Cottus cognatus*)		McPhail and Carveth 1994; Pinsent et al. 1974a
21	chiselmouth (*Acrocheilus alutaceus*)3		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
22	peamouth (*Mylocheilus caurinus*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
23	northern pikeminnow (*Ptychocheilus oregonensis*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
24	longnose dace (*Rhinichthys cataractae*)		PRC 1996
25	Umatilla dace (*Rhinichthys umatilla*)[2]	Similkameen	MOLAP 2000
26	redside shiner (*Richardsonius balteatus*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
27	burbot (*Lota lota*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
28	white sturgeon (*Ancipenser transmontanus*)	Okanagan lake	McPhail and Carveth, 1994

[1] Extirpated (National) or Red listed (Provincial)
[2] Endangered (National), Depressed (State) or Red listed (Provincial)

[3] Vulnerable or Blue listed (Provincial)
[4] Management concern

Classification fish species are identified in Table 8, including ratings from Canada, US and Global Rankings. Population characterization, an overview of species status and management regimes can be found in 2.2 “Focal Species.” Detailed classifications and status ranking may be found in Appendix C.

United States

In the US Okanogan Subbasin, part of the Upper Columbia River ESU, steelhead and spring Chinook are listed as “Endangered”, and Columbia River population segment bull trout are listed as “Threatened”. Bull trout critical habitats are proposed for critical listing here as well. Local populations of summer/fall Chinook are considered depressed. The FWS has documented bull trout within the Okanogan Watershed as “unknown occupancy” (K. Terrell personnel communication May 2004 to Keith Wolf).

Okanogan summer/fall Chinook stock is listed as Depressed based on a short-term severe decline in escapement. The Okanogan sockeye stock is currently listed in the US as Healthy (SASSI) based on escapement. However management concerns related to long-term declines exist.

Salmon Creek and Loup Loup Creek historically supported bull trout populations (*Salvelinus confluentus*). The introduction of brook trout and resulting hybridization of the two species has resulted in the decline of wild bull trout in the Okanogan River Basin (FWS 2000).

The Methow/Okanogan summer steelhead stock is listed as Depressed based on chronically low numbers (WDF and WDW, 1993).

Canada

In Canada, management agency concerns exist for Okanagan sockeye and Okanagan Lake kokanee. Bull trout, chiselmouth, and mountain Sucker are Blue Listed under Provincial designation, although the current presence of bull trout in the Canadian Okanagan subwatershed is unknown. Umatilla dace are Red Listed by the B.C. Conservation Data Center, and are candidates for federal listing under the Canadian Species at Risk Act (SARA). There are no current records of historic white sturgeon populations in the Okanagan, although the Okanagan Nation Alliance is currently verifying historic knowledge of sturgeon in Okanagan Lake.

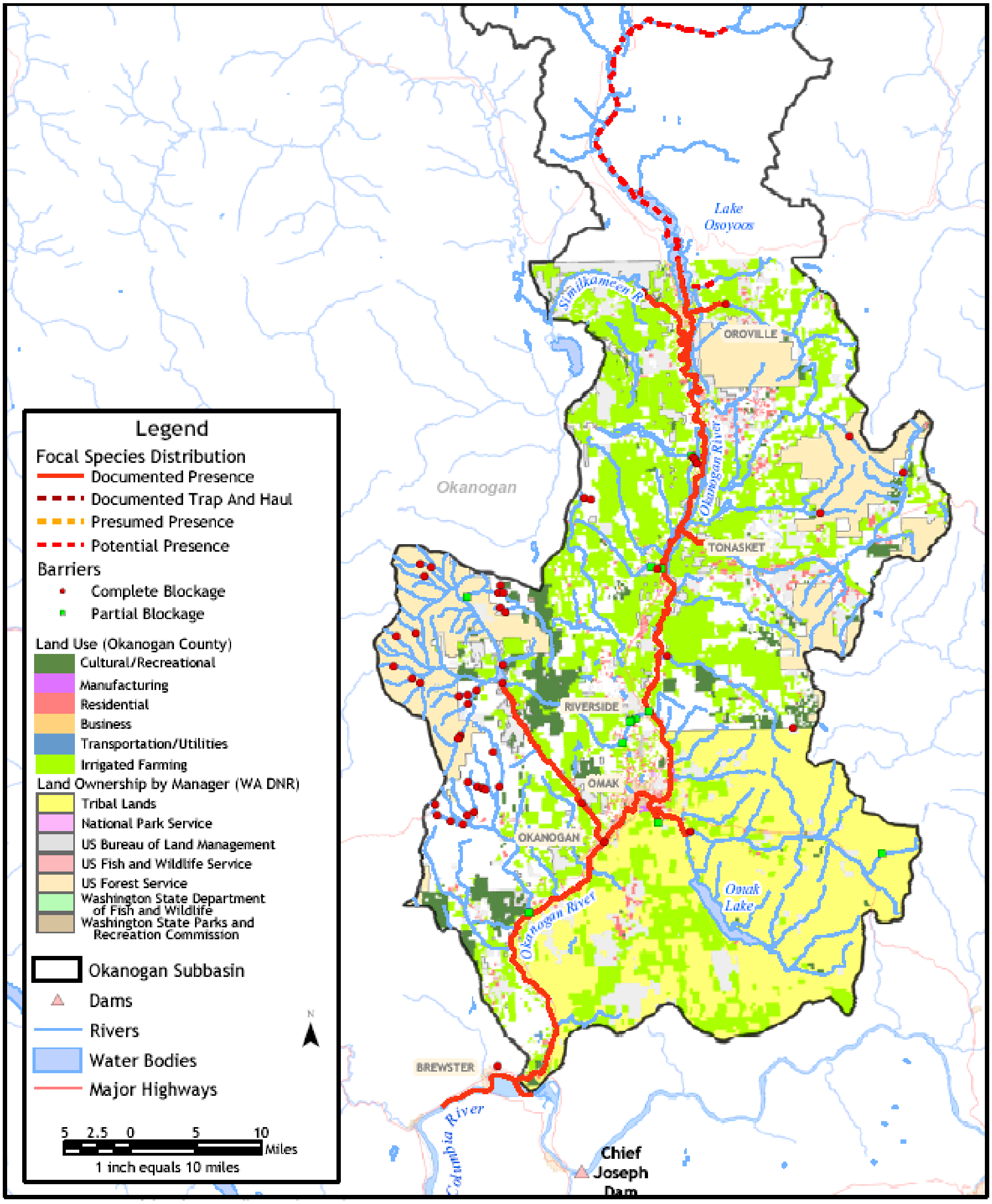
Naturally reproducing stocks of coho have been extirpated in the mid- upper Columbia for at least 70 years. Recent (after GCFMP) programs to restore coho in the mid-upper Columbia began in the 1960s with releases from WDFW hatcheries for Rocky Reach Dam mitigation. It was determined that naturally producing runs were not establishing themselves, primarily because of the stock of fish used (Lower Columbia River stock – see Mullan 1984). More recently, the Yakama Nation has been trying different rearing techniques to establish naturally reproducing runs of coho in the Wenatchee and Methow basins.

3.3.4 Aquatic/fish associations

Traditionally, as many as six runs of salmon would come up the Columbia River and its Okanagan tributary, and ascend into Skaha and Okanagan Lakes (Adrienne Vedan, 2002;

Clemens 1939). Native Okanagan Indians (Syilx) enjoyed year round fisheries on both resident and anadromous fish stocks.

Settlement of the subbasin over the last century initiated significant alterations to both natural river structure and hydrology, and was accompanied by a shift in species composition and abundance. The aquatic ecosystem changes, including the loss of some species, were coincident with exotic fish species invasions from downstream and local fish introductions (H. Wright, KD Hyatt, and C.J. Bull, 2002).



Source: Note: For purposes of this plan, not all areas depicted. Note: No information on Pacific Lamprey distribution available. Data Layers: Fish Distribution and Barriers (WDFW), Land Ownership (WA DNR), Land Use (Okanogan County), Counties & Major Rivers (WA Ecology), State Routes (WashDOT). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 15 Fish focal species distribution in relation to land use, production, irrigation, and degraded habitat features in the Okanogan subbasin.

Introduced exotic species originated from both European (carp, tench) and eastern North American sources, including a Mississippian refuge complex of fish, (smallmouth bass and yellow perch). In addition, aquatic milfoil first appeared in the lakes in the 1970s, and its growth and spread has altered littoral habitats and species utilization (H. Wright et al. 2002). Native species of macroinvertebrates (i.e. crayfish) have virtually disappeared, while mysid shrimp introduced to support recreational fish production have exhibited explosive growth.

The chain of large lakes which separate the upper and lower watershed moderates river flows, contribute nutrients and thermal units, while offering the possibility of deep water refuge for temperature sensitive salmonids during seasonal warm water events. Current barriers to upstream migration by anadromous fish have isolated the river valley bottom fish populations from the upper subbasin for at least 5 decades, and may have affected both species diversity and productivity, while some populations have become extirpated (H. Wright et al. 2002).

Recent surveys of exotic species in the large lakes suggest that exotic fish are dominant throughout the littoral zones of two out of the three large lakes (H. Wright, 2002), while significant variability in salmonid production is most visible in kokanee populations.

The loss of shoreline spawning habitats, nutrient imbalances resulting in a decline of lake productivity, and mysid competition with kokanee for macrozooplanters are all considered responsible for the decline of resident kokanee populations over the last 3 decades (Okanagan Lake Action Plan Year 6 report, 2002).

Historic accounts of a barrier to upstream fish migration in the Similkameen are contained in the traditional Okanagan story of S'enklip (A. Vedan, 2002) and refer to an impassable falls at Coyote Rock. That falls was altered during the construction of Enloe Dam in 1919 and remains the upstream barrier to fish migration.

3.3.5 Salmon and Steelhead Stocks Overview

The upper Columbia continues to support anadromous stocks of summer/fall Chinook, spring Chinook, sockeye salmon, and steelhead, while populations of coho and possibly other salmon stocks are believed to be extirpated.

In 1939, during construction of Grand Coulee Dam, the US Fish and Wildlife Service initiated a program to mitigate for the upcoming loss of over 1,100 miles of available habitat to Upper Columbia River salmonid populations (Fish and Hanavan 1948). Construction of the dam without fish passage facilities led to the program that centered on trapping at Rock Island Dam.

During the GCFMP (1939-1943), all salmon and steelhead that reached Rock Island Dam were trapped there and mixed. These fish were either transplanted to alternative spawning streams and "forced" to spawn there, or taken to newly completed hatcheries on the Wenatchee (Icicle Creek), Entiat, or Methow Rivers.

Trapped and transported spring and late-run Chinook and steelhead of mixed origins were allowed to spawn naturally in Nason Creek upstream from a rack 0.25 miles upstream from the creek mouth. Steelhead were also released in the upper Wenatchee River (upstream of Tumwater Canyon) and the Entiat River in 1939. The fish were released between two racks that forced the fish to spawn in the area selected by the biologists of the USFWS (Fish and Hanavan 1948). Sockeye and coho were raised in hatcheries and liberated in various places.

The long-term affect of the obstructions to natal spawning and rearing habitats coupled with early hatchery intervention are manifest in the presence and distribution of species and the general loss of distinct population segments. This over-all loss of diversity has altered the productivity and stability of the remaining populations, and has changed ecosystem structure and function (possibly irrevocably).

Distinct Salmon Population

Distinct salmon population segments exist within the Mid-Columbia Region for salmon and steelhead stocks, based on assessments in the SASSI (WDFW et al. 1993a, 1993b) and the WDFW Genetic Unit (GUD) classification (Busack and Shaklee 1995) which is summarized in Table 12.

Table 12 Distinct salmon population segments within the Mid-Columbia Region, including Okanogan Subbasin

#	Indigenous Fish Species	Characteristics	Source
1	Chinook (*Oncorhynchus tshawytscha*)[2]	Spring	Ernst 2000; NMFS 1998; Miller and Hillman 1994, 1996, 1997, 1998; Utter 1993; Pinsent et al. 1974a; Butler 1974; Fulton 1968; Craig and Suomela 1941; Clemens et al. 1939; Gartrell 1936
		Summer/fall mixed	
2	Sockeye (*Oncorhynchus nerka*)	Summer: lake and river rearing smolts	Hyatt and Rankin 1999; Ernst 2000; Chapman et al. 1995; McPhail and Carveth 1994; Shepherd 1990; NOAA 1977; Butler 1974; Allen and Meekin 1973
		Early summer?	H. Wright, ONA, pers. comm.
	Kokanee (*Oncorhynchus nerka*)[4]	Stream and shoal spawners	MOLAP 2003
3	Pink (*Oncorhynchus gorbuscha*)[1]		Butler 1974
4	Chum (*Oncorhynchus keta*)[1]		Ernst 2000; Butler 1974;
		Early summer	ONA
5	Steelhead (*Oncorhynchus mykiss*)[2]	Winter	Ernst, 2000; MFS 1998
		Summer	
6	Coho (*Oncorhynchus kisutch*)[1]		Ernst 2000; Butler 1974; Clemens et al. 1939
7	Bull trout (*Salvelinus confluentus*)[2]		NMFS 1998, 2002; CTC 2001; Mullan et al. 1992 CPa
8	Rainbow trout (*Salmo gairdneri*)	Fluvial and adfluvial	Bull 2003; NMFS 1998; McPhail and Carveth 1994; Pinsent et al. 1974a
9	Pacific lamprey (*Entosphenus tridentatus*)		Peven 2003; Clemens et al. 1939
10	Mountain whitefish (*Prosopium williamsoni*)		Pinsent et al. 1974a; McHugh 1936
12	Pygmy whitefish (*Prosopium coulted*)		McPhail and Carveth 1994; Pinsent et al. 1974a

#	Indigenous Fish Species	Characteristics	Source
13	Bridgelip sucker (*Catostomus columbianus*)		PRC 1996; McPhail and Carveth 1994
14	Largescale sucker (*Catostomus macrocheilus*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
15	Mountain sucker (*Catostomus platyrhynchus*)[3]		BC Conservation Data Centre 1999
16	Longnose sucker (*Catostomus catostomus*)		McPhail and Carveth 1994; Pinsent et al. 1974a
17	Sculpin (*Cottus rhotheus*)		PRC 1996; McPhail and Carveth 1994
18	Sculpin (*Cottus confuses*)		PRC 1996
19	Mottled sculpin (*Cottus bairdi hubbsi*)[3]		McPhail and Carveth 1994
20	Slimy sculpin (*Cottus cognatus*)		McPhail and Carveth 1994; Pinsent et al. 1974a
21	Chiselmouth (*Acrocheilus alutaceus*)3		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
22	Peamouth (*Mylocheilus caurinus*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
23	Northern pikeminnow (*Ptychocheilus oregonensis*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
24	Longnose dace (*Rhinichthys cataractae*)		PRC 1996
25	Umatilla dace (*Rhinichthys umatilla*)[2]	Similkameen	MOLAP 2000
26	Redside shiner (*Richardsonius balteatus*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
27	Burbot (*Lota lota*)		PRC 1996; McPhail and Carveth 1994; Pinsent et al. 1974a
28	White sturgeon (*Ancipenser transmontanus*)	Okanagan lake	McPhail and Carveth, 1994

[1] Extirpated (National) or Red listed (Provincial)
[2] Endangered (National), Depressed (State) or Red listed (Provincial)
[3] Vulnerable or Blue listed (Provincial)
[4] Management concern

Distinct population segments exist for summer Okanogan River sockeye (possibly early summer and river-rearing populations are geographically distinct - ONA pers. com.). Also, population segments exist for Methow/Okanogan River summer steelhead, and historic populations of summer/fall Chinook (SASSI, 2002).

3.3.6 Fish distribution

The Okanagan subbasin headwater areas hold a complex of small, low productivity, high gradient creeks, populated largely by a ubiquitous slow growing fluvial rainbow trout (Bull, 2003). Many of these tributaries are currently affected by forest development, are heavily subscribed for licensed water use, and a significant number contain some water control structures which are a barrier to fish migration.

The valley bottom is characterized by networks of small second- and third-order streams that are warmer, more fertile and hydraulically diverse watercourses (Bull, 2003). Here, productive fish habitats support a greater diversity of aquatic flora and fauna. It is also here that the greatest concentration of human settlement, flood control, and linear development has led to the most significant alteration of fish habitats, where fish populations have changed most significantly, and remain most vulnerable.

The current spatial distribution of fishes is affected by lake outlet dams at Vaseux (McIntyre Dam), Skaha and Okanagan Lakes on the Okanagan mainstem, and Enloe Dam on the Similkameen, and various water control structures on various tributaries. Changes to the valley bottom and riparian habitats, associated with settlement and land development, are significant to both understanding the current ecology and utilization of fish ecosystems.

Anadromous stocks have been limited to the mainstem river below McIntyre Dam since 1920 as a result of combined concerns over colonization of new exotic species upstream from the Columbia River, and flood and irrigation control. The Skaha and Okanagan Lake dams fishways were decommissioned at that time, although their structures remain functional.

The loss of access to alternative cold deep water large lakes of the Okanogan (above Osoyoos) may exacerbate temperature-induced migration mortalities in adult sockeye and possibly other anadromous salmon stocks (i.e. spring Chinook), and may also limit sockeye smolt production in the subbasin where converging deep water anoxic and warm surface waters restrict Osoyoos lake rearing habitats.

The cold water influence from the Canadian reaches of the Similkameen River may provide some limited refuge to migratory salmonids during warm water events. Many of both US and Canadian tributary habitats are restricted to the valley bottom or have limited use value because of high water temperatures, habitat alterations or impasses created by water reservoirs. Cold spring water refugia are the subject of a mapping project underway in the US subwatershed, however the results of this project are not complete. Most tributary flows are heavily subscribed by water licenses and lower than normal flows may exacerbate the affects f warm water events.

3.4 Wildlife Populations Overview

United States

There are 31 wildlife species, indigenous to the Okanogan Subbasin, that are contained in the federal ESA list as Endangered (1), Threatened (3) or are of Special Concern (26). Wildlife and plant species indigenous to the Okanogan Subbasin, with federal status classifications, global or provincial ranking, or that warrant state listing are contained in Appendix D. Plant communities in the basin range from the sub alpine in the high elevations of the Tiffany Mountain area and

Pasayten Wilderness to shrubsteppe in the lower elevations along the Similkameen and Okanogan rivers.

The Washington States List includes 2 plant and 2 wildlife species indigenous to the Okanogan Subbasin which are considered Endangered, 2 wildlife populations considered Threatened, and over 70 fish and wildlife Species of Concern. In addition, critical habitats have been identified at critical levels for several species including the spotted owl.

Canada

In Canada, the Province of B.C.'s Conservation Data center lists 67 wildlife Species at Risk including 19 that are either Extirpated, Endangered, or Threatened, and another 38 that are considered Vulnerable.

3.4.1 Terrestrial / Wildlife Associations

The subbasin supports a wide diversity of species within grassland/shrub steppes, coniferous forests and rugged terrain habitats. The Okanagan-Similkameen includes one of the greatest concentrations of Threatened species in Canada, including eight species of invertebrates found nowhere else in the world (South Okanagan-Similkameen Conservation Program, 1999). The subbasin also supports a reservoir of the remaining Canadian Columbia River stocks of salmon and the uppermost surviving tributary salmon ecosystem in the Columbia River.

Populations of Endangered yellow breasted chat, tiger salamander and peach-leaf willow share oversubscribed water resources and shrinking riparian and wetland corridor habitats with several Threatened fish populations. Grassland/shrubsteppe environments suffer from the combined affects of overuse and new exotic inhabitants and face greater threats to indigenous flora and fauna than the riparian corridor.

Historically, sage dominated steppe vegetation occurred throughout the majority of the Subbasin. Shrublands were historically co-dominated by shrubs and perennial bunchgrasses with a microbiotic crust of lichens and mosses on the surface of the soil.

Large, widely spaced, fire-resistant trees and an understory of forbs, grasses, and shrubs once characterized Okanogan subbasin forests. Periodic fires historically maintained this habitat type. With the settlement of the subbasin, most of the old pines were harvested for timber, and frequent fires have been suppressed. As a result, much of the original forest has been replaced by dense second growth of Douglas fir and ponderosa pine with little understory. Heavy grazing of Ponderosa pine stands has led to the introduction of competing exotic species.

Effects related to hydropower development and operations on wildlife and its habitats may be direct or indirect. Although there are no direct impacts of hydropower operations to wildlife in the Okanogan subbasin, indirect effects include the building of numerous roads and railways, presence of electrical transmissions and lines, the expansion of irrigation, and increased access to and harassment of wildlife.

3.5 Fish and Wildlife Species Richness and Associations

The Okanogan subbasin has the highest percentage (99) of species richness than any other subbasin in the Columbia Cascade Ecoprovince. The class and % of total richness in the CCP is provided in **Table 13**(CCP Ecoprovince Wildlife Assessment 2004).

Ninety-nine % of the wildlife species that occur in the Ecoprovince occur in the Okanogan subbasin. In addition, 100 % of the amphibian species and 100 % of the reptile species that occur in the Ecoprovince occur in this subbasin.

Table 13. Species richness and wildlife associations for CPP including the Okanogan subbasin (IBIS 2003)

Class	Subbasin														
	Entiat	%	Lake Chelan	%	Wenat chee	%	Meth ow	%	Okano gan	%	Upper Middle Mainstem	%	Cra b	%	Total (Eco prov)
Amphibians	11	65	11	65	16	94	11	65	9	53	17	100	9	53	17
Birds	218	93	221	94	215	92	221	94	222	95	234	100	214	91	234
Mammals	91	94	93	96	91	94	93	96	86	89	97	100	78	80	97
Reptiles	16	84	16	84	19	100	16	84	13	68	19	100	16	84	19
Total	336	92	341	93	341	93	341	93	328	89	367	100	317	86	367
Association															
Riparian Wetlands	72	92	73	94	70	90	73	94	73	94	77	99	73	94	78
Other Wetlands (Herbaceous and Montane Coniferous)	30	81	32	86	26	68	32	86	31	84	36	95	33	89	38
All Wetlands	102	89	105	91	96	83	105	91	104	90	113	97	106	92	116
Salmonids	77	93	75	90	76	93	75	90	71	86	81	98	72	87	82
Note: % = % of Total															

Source: Ibis 2003

3.6 Focal Species: Population and Habitat Characterization and Status

The subbasin plan used the concept of "focal species" as a way to manage both the size of the subbasin plan and the scope of the assessment, inventory and management plan. In its truest sense, this was simply a means to target management resources and cover as many species and habitats as possible.

In some limited instances this approach was also used to prioritize some actions across fish and wildlife needs or to more properly ascribe responsibilities (e.g., CWA, PCSRF, Power Act, ESA). Mitigation obligations, ESA listing status, coterminious habitat use and overlapping jurisdictions were some of the considerations used to designate focal species. However, we must clearly point out, and caution the reader, that it was not the intention of the subbasin planners to impart any value judgement, placing an emphasis or de-emphasis on the need or responsibility to protect and/or restore a particular or species or their habitats or to decouple any species from any legal, policy, or trust obligations.

A focal species has special ecological, cultural, or legal status and represent a management priority in the subbasin and by extension the ecoprovince. Focal species are used to evaluate the health of the ecosystem and the effectiveness of management actions.

Criteria used in selecting the focal species include a) designation as federal Endangered or Threatened species, or management priority as designated by a management authority b) cultural significance, c) local significance and d) ecological significance, or ability to serve as indicators of environmental health for other species.

Each of the focal species and their assemblages for the Okanogan subbasin and their associated habitats is introduced in the text below and their distribution is outlined in Table 16.

Table 14 Wildlife and fish focal species and their association with the Habitats of the Okanogan subbasin

Focal Species	Focal Habitat Represented		
	Ponderosa pine	Shrubsteppe	Riparian wetlands
Wildlife			
Brewer's sparrow		■	
Grasshopper sparrow		■	
Sharp-tailed grouse		■	
Mule deer		■	
Red-eyed vireo			■
Yellow-breasted chat			■
American beaver			■
Pygmy nuthatch	■		
Gray flycatcher	■		
White-headed woodpecker	■		

Focal Species	Focal Habitat Represented		
	Ponderosa pine	Shrubsteppe	Riparian wetlands
Flammulated owl			
Fish			
Spring Chinook			
Summer/Fall Chinook			
Coho			
Steelhead			
Bull Trout			

3.7 Focal Fish species and their Habitats

3.8 Fish Focal Species Selection

Initially, seven aquatic species were chosen as focal for Columbia Cascade Province (CCP) Subbasin Planning: steelhead and rainbow trout; spring, and summer/fall Chinook; Bull Trout; Pacific lamprey; White sturgeon; and Westslope cutthroat trout. The criteria used to select focal species was the varied aspects of the CCP ecosystems that the life histories represent; the Endangered Species Act (ESA) status; the cultural importance of the species and whether or not there was enough knowledge of the life history of the species to do an effective assessment.

These were then presented to the Regional Technical Team for the Okanogan, the citizens advisory group, and the subbasin core planning team, including by extension the relevant Canadian agencies. Consensus was achieved on their selection for the subbasin. Okanogan sockeye, summer/fall Chinook, kokanee (Canadian), rainbow trout (Canadian) and steelhead were chosen as the anadromous focal species in the subbasin.

CCP summer steelhead, spring, summer/fall Chinook, bull trout, Pacific lamprey, white sturgeon, and Westslope cutthroat trout life histories intersect a broad range of the CCP aquatic ecosystems. Given the wide range of both the spatial and temporal aspects of these life histories it can be assumed that having habitat conditions that are appropriate for these seven species will also produce conditions that allow for the ecological health of other aquatic life in the CCP.

The Okanogan subbasin represents fish and wildlife habitats, important to sustain the ecological integrity of the CCP.

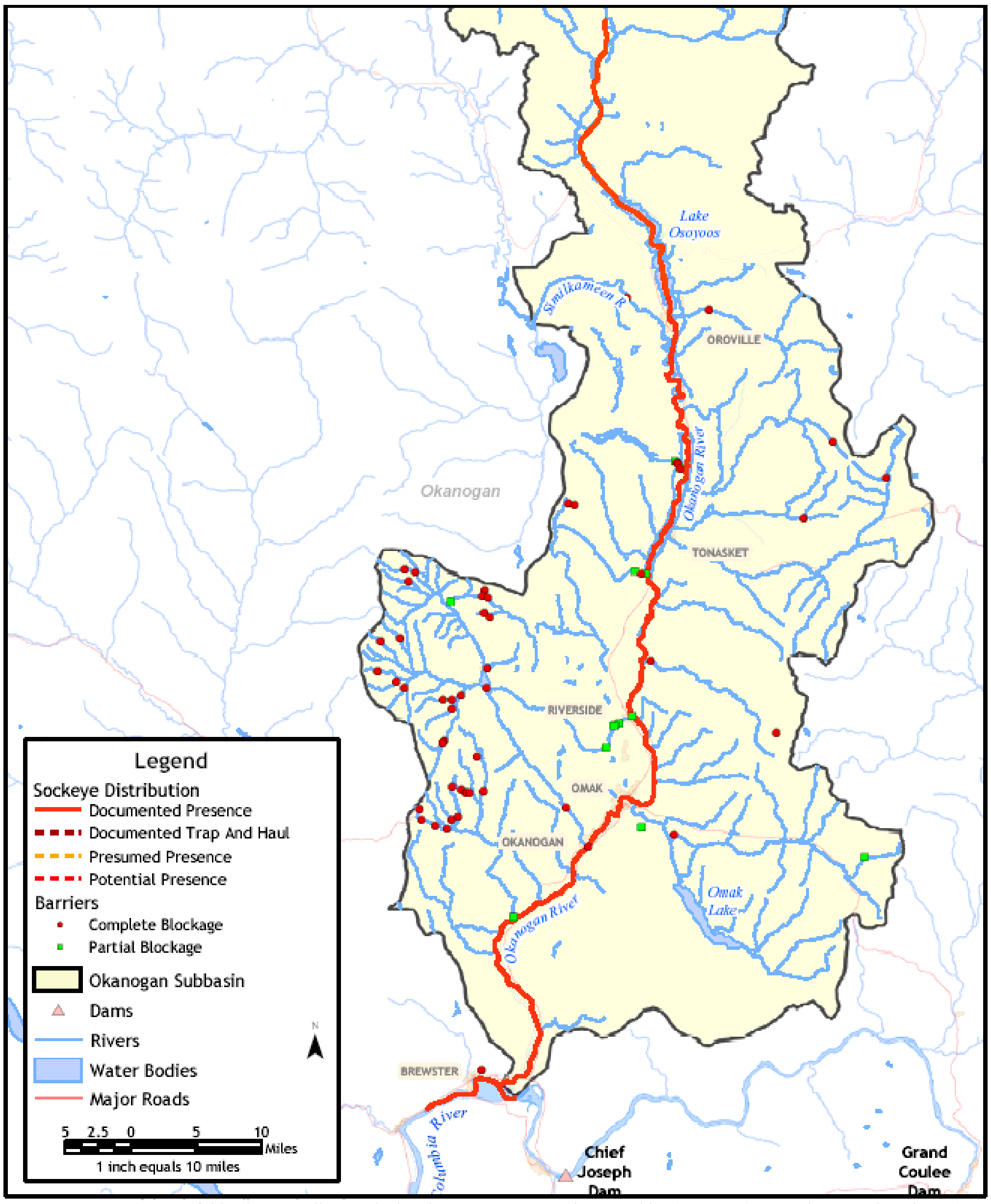
3.8.1 Sockeye

Rationale for Selection

Okanagan and Wenatchee Basin stocks are the only remaining viable populations of sockeye salmon in the Columbia drainage. They are neither considered in danger of extinction nor likely to become so according to NMFS (Gustafson et al. 1997). However, NMFS has concerns in regard to the health of both the Okanogan and Wenatchee sockeye stocks. Both these populations appear to be somewhat cyclic in nature, suggesting that out-of-basin effects such as downstream smolt survival may be dictating overall abundance.

Key Life History Strategies, Relationship to Habitat

Okanagan and Wenatchee stocks are genetically distinct (NOAA, 1997; Mullan, 1986; WDF/WDW, 1993; Chapman et al., 1995 CPb; and Shaklee et al. 1996) and are listed as separate ESUs (Gustufson et al. 1997). Okanogan adults begin migrating slightly later than Wenatchee fish, beginning to arrive at Bonneville in early to mid-June, and peaking at Bonneville in early July (WDFW, 1996). Upstream migration to Lake Osoyoos () is sometimes delayed by high water temperatures in the lower Okanogan River during July and August (Pratt 1991; Stockwell and Hyatt 2003). Peak spawning usually occurs in mid to late October, but may occur as early as September 15 depending upon water temperatures. Peak spawning takes place at approximately 11 degrees Celsius and lower according to Hatch et al., as cited in Hansen (1993).



Note: For purposes of this plan, not all areas depicted. Data Layers: Land Ownership (WA DNR), Counties & Major Rivers (WA Ecology), State Routes WashDOT). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 16 Okanogan subbasin sockeye distribution

Sockeye spawning in the Okanogan River occurs predominantly in the mainstem, upstream of Lake Osoyoos (RM 90) to McIntyre Dam (RM 106) (Peven 1992 CPb). The majority of sockeye salmon spawn in a five-mile reach of the river immediately below McIntyre Dam down to the Highway 97 bridge (Hagen and Grette, 1994).

In all but very unusual circumstances McIntyre Dam is the upstream limit of spawning and has been for over 50 years. Very infrequently, under high flow conditions and with the dam gates set to allow fish to jump through, sockeye do pass McIntyre Dam, and have been observed spawning up to the outlet of Skaha Lake (Hyatt et al. 2003).

Some spawning may occur in tributaries of Lake Osoyoos but it is unconfirmed. In addition, spawning sockeye have been observed in McIntyre Creek, a major tributary to Okanagan River immediately downstream of McIntyre Dam. They have also been recorded on occasion in the US reaches of the Okanagan and Similkameen Rivers (Chapman 1941; Bryant and Parkhurst 1950; Chapman et al. 1995 CPa). Enloe Dam blocks access to all but the lower six miles of the Similkameen River.

Lake Osoyoos is the primary rearing area for sockeye salmon in the Okanogan Basin. Eutrophic productivity and ample supplies of food produce larger smolts than Lake Wenatchee (Allen et al. 1972). In fact, Osoyoos Lake smolts are some of the largest reported anywhere. Probably as a result of their large size the smolts tend to spend less time at sea and most return at age 3 having spent two years in freshwater and one at sea (Mullan, 1986). Thus relative to sockeye from Lake Wenatchee, Lake Osoyoos fish tend to be larger upon out-migration and younger and smaller as returning adults (Mullen, 1986, Peven 1987, Peven 1991 and Carlson and Matthews 1990, 1992).

Smolt out-migration varies but generally the peak at Rocky Reach Dam occurs about mid- May (Park and Bentley, 1968; Peven 1987 CPb; Carlson and Matthews 1990, 1992; Hays et al., 1978).

Population Status

Fisheries and Oceans Canada (DFO) shares the worry with NMFS regarding downstream smolt survival and has also expressed concerns over deteriorating rearing conditions in Osoyoos Lake and climate change (Hyatt pers. com.). They consider Okanagan sockeye to be generally declining and likely to continue to do so unless a recovery plan is implemented.

DFO's conclusions stem partially from results of enumeration. A compilation of escapement data within the Canadian reaches of the Okanagan and at Wells Dam was undertaken by Stockwell and Hyatt (2003) and is known as "The Core Numbers and Traits" sockeye escapement data review. CNAT is the common reference for escapement data used as a baseline for sockeye management in the Canadian Okanagan. CNAT escapement data (shows that run strength is variable, ranging from a low of 1,662 in 1994 to a high of 127,857 in 1966, measured at Wells Dam. The 10-year average from 1986 to 95 is 28,460. Within the variability are indications of a general decline. Hyatt (pers. comm.) considers that without intervention there is a good chance of eventual extirpation.

Table 15. Sockeye escapement data at Wells Dam and on the Okanagan River spawning grounds.

Year	Wells	SEDS	PLD_{river}	PLD_{river} as % Wells	AUC_{river}	AUC_{river} as % Wells
2002	10,586		2,789	*26*	4,898	*46*
2001	74,453		24,256	*33*	33,971	*46*
2000	59,944		18,704	*31*	26,596	*44*
1999	12,228		4,376	*36*	6,907	*56*
1998	4,404	1,500	1,048	*24*	2,048	*47*
1997	24,621	12,000	11,671	*47*	16,661	*68*
1996	17,701	19,000	11,154	*63*	15,950	*90*
1995	4,892	2,669	3,900	*80*	5,972	*122*
1994	1,666	700	2,174	*130*	3,597	*216*
1993	27,894	21,505	12,163	*44*	17,338	*62*
1992	41,951	15,000	22,624	*54*	33,184	*79*
1991	27,490	10,000	10,058	*37*	14,442	*53*
1990	7,609	2,500	4,150	*55*	6,316	*83*
1989	15,976	15,000	11,763	*74*	16,787	*105*
1988	33,978	25,000	14,480	*43*	20,525	*60*
1987	40,120	15,000	22,568	*56*	31,649	*79*
1986	34,788	13,000	15,373	*44*	21,753	*63*
1985	52,989	30,000	20,742	*39*	29,137	*55*
1984	81,054	37,500	35,298	*44*	49,160	*61*
1983	27,925	3,500	6,839	*24*	10,015	*36*
1982	19,005	7,000	8,778	*46*	12,681	*67*
1981	28,234	15,000	12,293	*44*	17,516	*62*
1980	26,573	5,000	11,660	*44*	16,646	*63*
1979	26,655	2,000	11,691	*44*	16,689	*63*
1978	7,644	1,050	963	*13*	1,932	*25*
1977	21,973	8,475	8,260	*38*	11,970	*54*
1976	27,619	11,040	16,396	*59*	23,160	*84*
1975	22,286	10,000	11,711	*53*	16,716	*75*
1974	16,716	3,500	9,325	*56*	13,434	*80*
1973	37,178	8,000	8,813	*24*	12,904	*35*

Year	Wells	SEDS	PLD_{river}	PLD_{river} as % Wells	AUC_{river}	AUC_{river} as % Wells
1972	33,398	35,000	13,083	*39*	21,925	*66*
1971	48,172	35,000	30,234	*63*	53,370	*111*
1970	50,667	7,500	20,837	*41*	29,268	*58*
1969	17,352	3,500	8,148	*47*	11,815	*68*
1968	81,530	15,000	32,591	*40*	45,436	*56*
1967	107,978	35,000	17,956	*17*	25,305	*23*
1966	128,000	44,865	50,290	*39*	69,781	*55*
1965	30,655	5,408	13,214	*43*	18,784	*61*
1964	39,478	12,000	16,575	*42*	23,406	*59*
1963	45,159	35,000	18,930	*42*	26,646	*59*
1962	12,243	7,500	4,392	*36*	6,648	*54*
1961	7,554	3,500	2,075	*27*	3,462	*46*

Peven (2003) has calculated the risks of extirpation and his projections indicate the extirpation risk 100 years from now may reach 100 % depending upon the effectiveness of spawning.

Another agency expressing strong concern for the health of the stock is the Okanagan Nation Alliance. ONA points out that present day production is extremely limited by access. This is evidenced by both Traditional Okanagan and non-native knowledge that prior to blockage by dams starting about 1915, sockeye had access into both Skaha and Okanagan Lakes (Bryant and Parkhurst 1950; Fulton 1970; Mullan 1986; Vedan 2002).

Given these many concerns it is logical that sockeye should be selected as one of the focal species.

Throughout their freshwater life history stages, Okanagan sockeye are adversely affected by a number of factors including hydroelectric development, land use practice, water extraction, flood control, habitat destruction, harvest and climate change (Chapman et al. 1995, Fryer 1995). In the face of these adversities sockeye have been resilient, and have rebounded somewhat from very low counts in the 1930s. Lower harvest rates and habitat improvements in the natal systems have contributed to the recovery.

Presently, within the basin, the population is believed to be chiefly limited by reduced rearing habitat in the north basin of Osoyoos Lake because of high temperatures and low oxygen (C. Fisher, TAG), and by mortalities associated with delayed adult migration during high water temperature events (Hyatt, K D., M. M. Stockwell and D.P. Rankin. 2003). Climate change and the recent arrival of *Mysis relicta* into Osoyoos Lake are exacerbating the situation.

Recovery efforts will likely include an extension of the run into the more hospitable rearing lakes they once occupied as well as attempted improvements of current rearing conditions through the use of flushing flows and perhaps aeration. To be effective, these recovery efforts will have to be closely linked with other limiting factors such as passage at the mainstem hydroelectric project, water withdrawals and habitat loss.

Also, attention will need to be paid to losses and delays during migration. Schools of adult sockeye stage at the mouth of the river to wait for a drop in water temperatures, which is often brought on by an upstream rain event. Annual migration from Wells Dam to the spawning grounds ranges from one to three weeks, but temperature delays of several days to several weeks have been observed (Hyatt pers. com.). This may be partially or wholly responsible for annual losses averaging about 50% between Wells Dam and the spawning grounds.

Population Management Regimes and Activities

Sockeye represent one of the primary species for recovery and protection focus because they represent a life history type unique to the warm water conditions in the Okanogan. Climate extremes and global warming affects are a major concern. Escapements have continued to decline since the middle of last century (Hyatt, Stockwell and Rankin 2003) and are expected to continue to decline in the long-term (Hyatt, pers. com.). Mortalities may be direct or indirect because of loss of performance.

Based upon spawning and rearing habitat availability, Hyatt and Rankin (1999) recommend a minimum escapement objective of 58,730 adults past Wells Dam and the Canadian fisheries agencies have agreed to that objective.

Past Management Practices

Adult sockeye from several different sources were translocated to Lake Osoyoos in 1939 and 1940, as part of the GCFMP and juveniles were released there between 1941 and 1958 (Mullan 1986).

As plans were developed to channelized the Okanagan River for flood control in the 1950s, international attention was given to the fate of sockeye and that resulted in the preservation of key spawning areas, the re-design of drop structures to ensure safe passage, and pre-treatment inventories of sockeye escapements and spawning distribution.

For many years there have been annual counts of adults returning to the Okanagan. These counts are taken at both Wells Dam and the spawning grounds. Counts at the dam are usually about twice as high as those on the spawning grounds and it is not known whether this is because of differences in counting methods or mortalities en route.

In the early 1990s, Douglas PUD sponsored a sockeye hatchery program that was operated by the Colville Confederated Tribes at the Cassimer Bar Hatchery (Chapman et al. 1995 CPb). Adult brood was captured at Wells Dam and rearing took place at Cassimer Bar near the confluence of Okanagan and Columbia rivers. Resulting juveniles were released into Lake Osoyoos. Adult returns for this program were never documented and the program was abandoned in the late 1990s.

Current Management Practices

One current management program involves manipulation of flow releases to avoid egg desiccation or redd scour. An elaborate flow modeling procedure known as the Fish Water Management Tool has been designed and implemented. The work is managed by Canadian

Okanagan Basin Technical Working Group (Canadian fisheries agencies) and funded by Douglas County Public Utility District.

Another current initiative is re-introduction of sockeye into Okanagan and Skaha Lakes. The initiative, lead by Okanagan Nation Alliance and Colville Confederated Tribes and authorized by the Canadian Okanagan Basin Technical Working Group involves using Skaha Lake as an experiment. Should it prove fruitful consideration would be given to extending the run into Okanagan Lake. The program has started and will continue in 2004 if funding is available.

Facilities and Programs

When the sockeye re-introduction project was initiated in October 2003, wild Okanagan sockeye were captured as broodstock and incubated at Shuswap Falls Hatchery. Juveniles will be released into Skaha Lake in spring of 2004 if funding for the program is approved. The monitoring and evaluation program has been approved by the COBTWG and the Okanagan Nation Alliance is currently pursuing funding for the program.

One of the main concerns with the sockeye re-introduction is the possible affect on kokanee. The B.C. fisheries ministries have reported a dramatic decline of Okanagan Lake kokanee over the last three decades. Annual escapements have declined from hundreds of thousands of spawners, to fewer than 10,000 in 1999, (Andrusak et al. 1999). This has become the focus of the government-led Okanagan Lake Action Plan (OLAP) since 1996.

Declines in kokanee populations are attributed to a combination of factors, primarily including the loss of kokanee spawning habitat, nutrient imbalance (resulting in a decline of over-all lake productivity), and mysid shrimp competition. These factors enhance the concern that sockeye may add to the problem or that sockeye may experience the same problems that have caused the kokanee to decline.

Hatchery Effects on Population

Hatchery programs have been influencing the Okanagan sockeye stocks for a long period of time. Present populations are probably descendants of mixed origin fish that were captured during the GCFMP. The origin of these fish could have been from Lakes Wenatchee and Osoyoos, but most were likely from lakes upstream of Grand Coulee Dam (WDF 1938).

The extent of the contribution of these various stocks is somewhat moot, since the present two current independent populations (Wenatchee and Osoyoos) are easily separated genetically.

Hatchery fish have influenced present stocks both positively and negatively. Mullan (1986) made three conclusions in regard to the early (1940s-1960s) hatchery programs:

- contribution of hatchery sockeye to run size was substantial in some years;
- survival of hatchery juveniles to returning adults was about threefold greater in the 1940s than in the 1960s; and
- adults sacrificed for artificial propagation . . . showed no consistent increased efficiency, in point of returning adults, over natural recruitment based on spawner-recruit ratios . . ."

Chapman et al. (1995 CPb) concluded that the GCFMP was successful in reestablishing sockeye runs in the Wenatchee and Okanogan basins. They also felt that while the releases of sockeye in the 1950s and 1960s did not appear cost-effective in contributing to the commercial harvest, there was probably some benefit to the resource by adding numbers of fish to the spawning grounds.

Mullan 1986, Peven 1992 CPb, and Anas and Gauley (1956) all felt that hatchery fish influenced the run timing of juvenile sockeye. The authors found, however, that run timing is difficult to assess.

The use of artificial production strategies for recovery efforts, such as supplementation, has become a part of recovery planning in the Okanogan subbasin, as evidenced by current reintroduction experiments above Skaha Lake. While these are in the pilot phase they are currently ready for full implementation and funds for implementation are being pursued.

3.8.2 Summer/fall Chinook

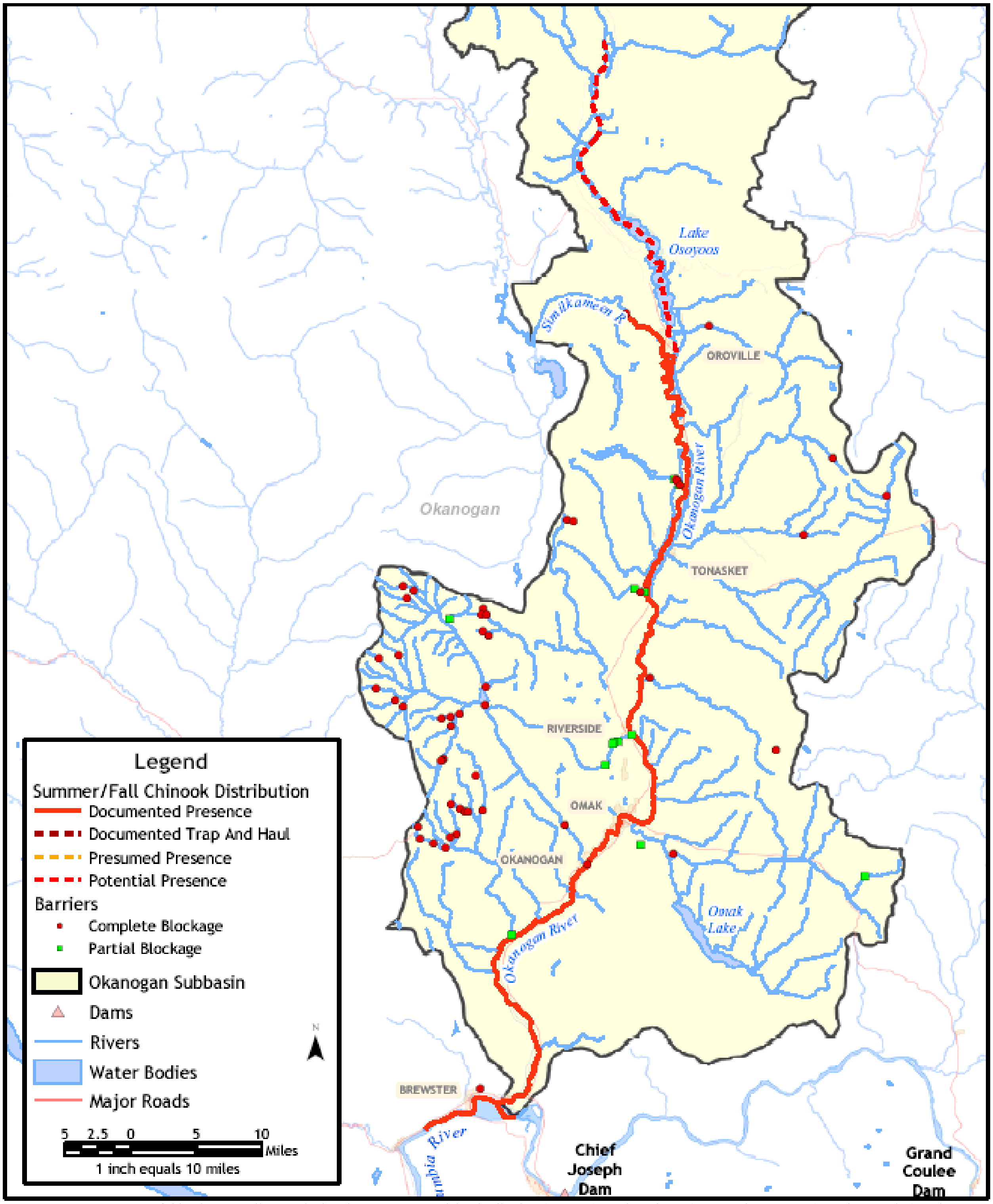
Rationale for Selection

In the 1997 "Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California", NMFS indicated that summer/fall Chinook salmon in this ESU were not in danger of extinction as a metapopulation, nor were they likely to become so in the foreseeable future (Myers et al.1998). Recent (since 2000) counts of summer/fall Chinook have surpassed historic (since the early 1930s) numbers of fish spawning in the area, which comports well with this conclusion.

However, the long-term trend for the Okanogan population is –5.2% and –8.8% in the short term (1987-96) (Brown, 1999). Highly variable escapements, the lack of productive populations utilizing Canadian Okanagan Subbasin habitats, and the desire to increase the proportion of wild origin stock in the upper Columbia River populations, makes the Okanogan River summer/fall Chinook an important stock for management attention. In addition, some tributaries that harbor historic habitat may need special management actions to increase use (and numbers).

Key Life History Strategies, Relationship to Habitat

The distribution of Chinook salmon is known upstream in the Okanogan to McIntyre Dam in Canada (Figure 1). Historically Chinook had access up into Okanagan Lake (Clemens et al. 1939, Ernst 2000, Vedan 2002). Some radio tagged fish classed as "fall Chinook" appeared in the Okanogan River when last seen in 1993 (Stuehrenberg et al. 1995). These stocks however are considered a mix between summer and fall stocks (NMFS 1998; Miller and Hillman 1994, 1996, 1997, 1998).



Note: For purposes of this plan, not all areas depicted. Data Layers: Fish Distribution (WDFW), Major Rivers (WA Ecology, TRIM), Major Roads (WashDOT, RIM). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 17 Okanogan Subbasin summer/fall Chinook distribution

Summer/fall Chinook spawning occurs primarily in the Similkameen River associated with the WDFW artificial production program. Lesser amounts of spawning have occurred in the

Okanogan River below Osoyoos Lake. Other than the Similkameen River, historic spawning habitat for summer/fall Chinook throughout the Okanogan River has been largely underutilized for decades.

Adults enter the Okanogan River from July through late September, and spawn from late September through early November, peaking in mid-October (Peven and Duree 1997, Murdoch and Miller 1999). Current Chinook spawning occurs in spatially discontinuous areas from the town of Malott upstream to Zosel Dam, approximately RM 64 of the Okanogan River (Murdoch and Miller 1999).

In the past two years, however, returns of summer/fall Chinook to the Similkameen River and upper Okanogan have increased substantially. High smolt-to-adult survival of the hatchery fish from the Similkameen Pond has produced an extremely high spawner density in the Similkameen River (>400 redds/km). Unfortunately, this has not produced the expected increase in natural-origin fish (the capacity of the Similkameen spawning habitat is being exceeded because of redd superimposition).

Of the returning adult hatchery fish between 1995-2000, 78% of the fish spawned in the Similkameen River. Of the hatchery fish that spawn in the Okanogan River, 76% spawn above Riverside (Rkm 65). Thus, a large portion of the Okanogan River is underutilized by hatchery-origin fish and the spawning habitat is under seeded. This is also seen for wild/hatchery origin Chinook observed above Osoyoos Lake in the Okanagan River. For example, in 2003 the total adult peak live plus dead Chinook enumerated was nineteen (Phillips and Wright 2004b, in press). However, the available Chinook habitat is estimated at approximately 4,300 spawning pairs based on a detailed evaluation of Okanagan River habitat between Oliver bridge and McIntyre Dam using water depth/velocity and substrate Chinook parameters (Phillips and Wright 2004a, in press).

Uneven distribution of spawners has led to a need for additional US acclimation sites to disperse the returning adults to underutilized habitat. (H. Bartlett, per. comm.). However, in Canada consideration will need to be given to the genetics of returning as preliminary genetic data suggests that adult Chinook returning to the Okanagan above Osoyoos Lake may be two additional separate populations in addition to hatchery origin fish (Phillips and Wright 2004b). Table 16 .

Year	Summer Chinook Adult	% Rocky Reach Count	Summer Chinook Jack	Total Run
2001	33,244	74	4,882	38,126
2000	6,447	44	3,709	10,156
1999	7,335	70	541	7,876
1998	3,237	48	733	3,970
1997	2,570	46	153	2,723
1996	2,225	44	165	2,390
1995	2,767	62	289	3,056

1994	4,613	80	378	4,991
1993	3,404	74	170	3,574
1992	1,343	65	631	1,974
1991	1,774	59	270	2,044
1990	3,207	78	217	3,424
1989	3,115	66	223	3,338
1988	2,411	74	360	2,771
1987	2,790	78	347	3,137
1986	3,787	78	515	4,302
1985	4,018	76	499	4,517
1984	4,768	87	1,173	5,941
1983	2,002	83	819	2,821
1982	2,223	90	1,126	3,349
1981	3,141	76	1,135	4,276
1980	3,910	79	982	4,892
22-yr average	4,742	70	878	5,620
22-yr median	3,272	74	507	3,499
22-yr range	1,343 – 33,244	44 – 90	153 – 4,882	1,974 – 38,126

Table 17

Table 16. Counts of Early-arriving Summer/fall Chinook at Wells Dam (1980 – 2001)

Year	Summer Chinook Adult	% Rocky Reach Count	Summer Chinook Jack	Total Run
2001	33,244	74	4,882	38,126
2000	6,447	44	3,709	10,156
1999	7,335	70	541	7,876
1998	3,237	48	733	3,970
1997	2,570	46	153	2,723
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22-yr median	3,272	74	507	3,499
22-yr range	1,343 – 33,244	44 – 90	153 – 4,882	1,974 – 38,126

Table 17. Counts of Late-arriving Summer/fall Chinook at Wells Dam (1980 – 2001)

Year	Chinook Adult	% Rocky Reach Count	Chinook Jack	Total Run
2001	6,928	76	2,672	9,600
2000	2,211	38	1,206	3,417
1999	1,925	35	631	2,556
1998	1,047	37	158	1,205
1997	611	25	156	767
1996	707	20	210	917
1995	1,007	27	175	1,182

1994	2,462	55	555	3,017
1993	1,061	52	160	1,221
1992	770	52	747	1,517
1991	577	43	272	849
1990	592	30	149	741
12-yr average	1,658	41	591	2,249
12-yr median	1,054	38	241	1,213
12-yr range	577 – 6,928	20 – 76	149 – 2,672	741 – 9,600

Usually 50% or more of spawning adults have a total age of 5 years, with the remainder predominantly 4-year-old fish (Murdoch and Miller 1999). In the past, sporadic reports of Chinook spawning above Lake Osoyoos have been recorded during sockeye salmon spawning ground surveys. Spawning ground data in the Similkameen River indicate that summer Chinook spawn from Enloe Dam to Driscoll Island, a total distance of 14 kilometres.

In the Okanogan River, Chinook usually spawn between RM 14.5 (just downstream of Malott) and Zosel Dam (RM 77.4). In the Similkameen River, Chinook spawn between its mouth and Enloe Dam (RM 8.9). Upstream access to spawning areas is reported to be McIntyre Dam (RM 106) in Canada, although passage beyond the structure may occur during some high flow periods (ONA, 2003).

Vaseux (McIntyre) Creek in Canada, immediately below Vaseux Lake appears to contain suitable substrates for Chinook, however it is dewatered annually from the mouth to a distance 1 kilometre upstream from its confluence with Okanagan River as a result of historic alterations to the stream bed and water withdrawal.

In both Okanogan and Similkameen Rivers, redds are highly clumped, and those distributions have not changed since 1987 when ground surveys were first conducted (Hillman and Miller 1993; Miller 2003). During that period, densities of redds in the Okanogan River were highest between Okanogan and Omak (RM 26.1-30.8), McLoughlin Falls and Tonasket (RM 48.9-56.8), and the Similkameen River confluence and Zosel Dam (RM 74.1-77.4); they were lowest between Tonasket and the Similkameen River confluence (RM 56.8-74.1) (Hillman and Miller 1993).

In the Similkameen River during the same period, densities of redds were highest between the mouth and the county road bridge (RM 0-5). Unlike in other mid-Columbia streams, Hillman and Miller (1993) found that summer/fall Chinook in the Okanogan Basin constructed most of their redds near islands, i.e., in braided segments.

Emergence timing probably occurs from January through April, although specific data on emergence studies was not identified in reviews for this LFA. Juveniles generally emigrate to the ocean as subyearling fry, leaving the Okanogan River from one to four months after emergence.

However, there is evidence that some fish undergo an extended residence period, with a protracted downstream migration. Many subyearlings rear in the mid-Columbia impoundments for various periods of time during their outmigration (Peven and Duree 1997).

Population Delineation and Characterization

In 1995, NMFS concluded that summer Chinook salmon in the mid-Columbia River are not a "distinct population segment" of a species (as defined by Waples 1991) or ESU as defined by the NMFS Policy on the Definition of Species under the U. S. Endangered Species Act (56 FR 58612 58618). Rather, they are part of a larger ESU that includes all late run (summer and fall) ocean type Chinook salmon from the mainstem Columbia River and its tributaries (excluding the Snake River) between Chief Joseph and McNary Dams (Waknitz et al. 1995).

For the purposes of sub-basin planning, it is assumed that there is one large metapopulation of summer/fall Chinook between the confluence of the Snake River and Chief Joseph Dam, but specific tributaries, in addition to limited areas of mainstem Columbia spawning, contain independent populations that need to be considered in management actions.

Population Status

In the 1997 "Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California", NMFS indicated that summer/fall Chinook salmon in this ESU were not in danger of extinction, nor were they likely to become so in the foreseeable future (Myers et al.1998). However, the long-term trend for the Okanogan population is –5.2% and –8.8% in the short term (1987-96) (Brown, 1999).

Highly variable escapements, the lack of productive populations utilizing Canadian Okanagan Subbasin habitats, and the desire to increase the proportion of wild origin stock in the upper Columbia River populations, makes the Okanogan River summer/fall Chinook an important stock for management attention.

As mentioned earlier, recent preliminary genetic evidence suggests a potential two additional populations that will most likely fall into the summer/fall ESU (Phillips and Wright 2004b, in press). However, conclusive determinations are difficult at this stage as small sample sizes and life history observations such as high rates of spawning residualized Chinook and sporadic yearling Chinook observations are more indicative of stream type populations (Phillips and Wright 2004b, in press). An additional implication from the presence of mature spawning residualized (no ocean phase) Chinook above Osoyoos Lake is some of the genetic diversity of the population may have been maintained during the GCFMP (Phillips and Wright 2004b, in press). Numerous mature male residual Chinook and one mature female were documented in 2003. However, additional genetic analysis of this stock will determine whether this is the case.

Population Management Regimes and Activities

Hatchery Effects

In 1939, during construction of Grand Coulee Dam, the US Fish and Wildlife Service initiated a program to address the upcoming loss of over 1,100 miles of available habitat to Upper Columbia River salmonid populations (Fish and Hanavan 1948). Construction of the dam without fish passage facilities led to the program that centered on trapping at Rock Island Dam.

Past Management Practices

During the GCFMP (1939-1943), all salmon and steelhead that reached Rock Island Dam were trapped there and mixed. These fish were either transplanted to spawning streams and "forced" to spawn there, or taken to newly completed hatcheries on the Wenatchee (Icicle Creek), Entiat, or Methow rivers.

Trapped and transported spring and late-run Chinook and steelhead of mixed origins were allowed to spawn naturally in Nason Creek upstream from a rack 0.25 miles upstream from the creek mouth. Steelhead were also released in the upper Wenatchee River (upstream of Tumwater Canyon) and the Entiat River in 1939. The fish were released between two racks that forced the fish to spawn in the area selected by the biologists of the USFWS (Fish and Hanavan 1948). Sockeye and coho were raised in hatcheries and liberated in various places.

Upper Columbia River Summer/Fall Chinook migrate past Wells Dam from mid-July through November. Historically, propagation of this ESU used fish passing Wells Dam from July 10th through November 15th. However since 1987, the early portion of the run, those fish passing Wells Dam from July 10th through August 28th have been collected for broodstock.

Current Management Practices

Since the mid-1940s, over 50 years have elapsed, the equivalent of about 12 generations of summer/fall Chinook. This may be sufficient time for spawning populations to develop adaptive traits appropriate for each tributary upstream from Rock Island Dam (Quinn et al. 2000; Unwin et al. 2000).

With implementation of the Upper Columbia summer/fall Chinook HGMP, the full Chinook run will again be propagated. In this plan, those Chinook passing Wells Dam from mid-July to August 28th are referred to as early-arriving summer/fall Chinook, while the Chinook passing the Dam from August 29th through November are referred to as later-arriving summer/fall Chinook. The summer/fall Chinook in the Okanogan River will be managed as a single population with a common broodstock, but recognizing the continuum in run timing and spawn timing from the upper Okanogan subbasin to the lower river reaches.

Management also includes the summer/fall Chinook destined for the Methow River in this population. This management strategy will continue until separate broodstock collection capabilities are developed in the Okanogan subbasin and at the proposed Chief Joseph Dam Hatchery. At that time, fishery co-managers will need to consider the benefits and risks of managing the Methow and Okanogan Chinook as separate populations. In addition, consideration will also be given to the preliminary genetic evidence of potentially two additional populations in the Okanagan if additional genetic analysis confirms whether this is the case.

Facilities and Programs

The summer/fall Chinook propagation program described in the Upper Columbia summer/fall HGMP is designed, first and foremost, to restore the abundance, diversity, and distribution of historical populations. Additionally, these programs are designed to restore a base level of ceremonial and subsistence fisheries for the Tribes and recreational fisheries. These primary program objectives are designed to be consistent through the marking of hatchery-origin fish and the development of live-capture, selective fishing gear.

There is currently no management of Chinook in the Canadian portion of the Okanagan River. However, efforts are underway to begin understanding the life history patterns of Chinook returning to Canada and to set the stage for recovery planning of Canadian Okanagan Chinook. A status report and habitat evaluations of Chinook habitat potential are being prepared (Phillips and Wright 2004a, Phillips and Wright 2004b). Additional monitoring may include: adult migration, spawning escapement, biological sampling, habitat mapping, genetic analysis, fry emergence, and freshwater rearing (stream and lake).

Current propagation of the Okanogan summer/fall Chinook has focused solely on (and selected for) the earlier portion of the run. The proposed artificial propagation program for summer/fall Chinook is designed to disperse production throughout the Okanogan River to rebuild viable natural spawning populations throughout their historical habitats, rather than just in the uppermost reaches of the US portion of the river.

The program is also designed to propagate Chinook from the full run, July – November, rather than July – August. Finally the program will include the release of sub-yearling fish to emulate the natural life history of the population. The current hatchery program for summer/fall Chinook is outlined below:

1. Eastbank Hatchery, Similkameen Pond, Bonaparte Pond – release of 576,000 yearling summer Chinook – Integrated Recovery Program
2. Summer/fall Chinook Integrated Recovery Program – 1,876,000 yearlings and fingerlings (576,000 is existing)
3. Summer/fall Chinook Integrated Harvest Program – 700,000 yearlings and fingerlings (new)
4. 476,000 yearling release of early-arriving summer/fall Chinook from Similkameen Pond.
5. 100,000 yearling release of early-arriving summer/fall Chinook from Bonaparte Pond.

Effects on Population

The present Wenatchee, Entiat, Methow, Similkameen, Okanogan, and Columbia River spawning summer/fall Chinook all originated from a mix of summer/fall Chinook collected at Rock Island Dam 1939-1943. The only possibility that adults of unmixed stock might have escaped the GCFMP would have returned in 1944 of progeny of the 1938 brood that went to sea in 1939 and remained there for five years. This possibility seems remote. Not only is the fraction of age 0.5 fish (six years from parent brood return to progeny adult return; see below) very small in summer/fall Chinook of the Columbia River (see below), but the likelihood that a 0.5 female would find a 0.5 male of the same natal origin rather than spawning with a colonizing mixed-origin adult is small also. Lake resident Chinook have also been recently identified in Osoyoos Lake in addition to numerous males and one spawned out female documented. This may also have the possibility of a unique upper Columbia Okanagan population that may have escaped the GCFMP. Preliminary genetic analysis suggests a separate population to that of Similkameen and Okanagan Chinook. However, more research is required.

The GCFMP extensively homogenized spring and summer/fall Chinook, steelhead, and sockeye that were of mid- and upper-Columbia river origin. Homogenization was both temporal and geographic. The manipulations of the GCFMP may have reduced the genetic uniqueness of any distinct populations, or subpopulations in the mid-Columbia.

While Fish and Hanavan (1948) concluded that the relocation of fish to the natural spawning areas "was successful to a degree exceeding expectations," Ricker (1972) felt the program "was a salvage operation which in the long run seems to have salvaged nothing." Mullan (1987) believed the program was successful in maintaining genetic diversity of the stocks to some unknown degree. Fish and Hanavan (1948) believed that the overall success of the artificial propagation part of the program was "only fair at best" which Mullan (1987) agreed with, pointing out that survival to adult for fish released was generally 1% or less.

Regardless of the degree of success of the GCFMP, the current stocks of fish that spawn in the Upper-Columbia River basin are at least partially descended from the progeny of the program.

The release of hatchery summer/fall Chinook has a substantial effect on the abundance and distribution of spawning fish as evidenced from Table 3. Dams in the US Okanogan Subbasin (StreamNet, 2000).

Table 18. Proportion of hatchery summer/fall Chinook recovered on the spawning grounds

Can't get (Colville salmon-steelhead status cd)

Harvest Effects

Harvest of summer/fall Chinook is premised on an escapement objective of 3,500 fish. Based on Chinook passing Wells Dam from 1990 – 2001, the later-arriving component of this run has averaged 24.5% of the total summer/fall Chinook run (median of 24%).

Tribal fishery

The Confederated Colville Tribes manage a C&S fishery in the tailrace immediately below Chief Joseph Dam. The fishery uses hook-and-line gear to snag UCR Summer/Fall Chinook. UCR steelhead are caught incidentally. Historically the fishery commenced on July 1 and ended no later than September 30. The fishery is designed to harvest summer/fall Chinook in excess of the current escapement objective, 3,500 fish.

Because the tailrace fishery is located in a terminal site and uses hook-and-line gear, it has very limited capacity to harvest large numbers of Chinook surplus to escapement needs. From 1980 – 2000, the fishery harvested 200 – 1,100 summer/fall Chinook and 12 – 819 steelhead. Even with the extraordinary, record run of summer/fall Chinook past Wells Dam of 47, 700 in 2001, the Tribes' harvest was estimated at only 3,400 Chinook.

There has been no recent documented Okanagan Nation Chinook harvest in the waters above Osoyoos Lake (Wright, pers. comm.).

Recreational fishery

Recreational fisheries for summer/fall Chinook in the Okanogan and upper Columbia rivers are opened when forecasted runs of summer Chinook indicate a significant surplus to broodstock and escapement needs.

A surplus is calculated as the anticipated run at Priest Rapids Dam less 5,750 fish required for broodstock at hatchery programs upstream of the Dam, less 2.5% of the Priest Rapids count for lower-river recreational fisheries, less 5% harvest by the Wanapum Tribe, less an allocation for natural escapement in the Wenatchee, Methow, Similkameen, Okanogan, Entiat, and Chelan rivers.

As escapement goals for each of these rivers has not yet been established, WDFW has conservatively used the sum of the maximum annual escapements to each river for 1996-2000, (about 11,000 fish at Priest Rapids Dam) as the limitation on recreational fisheries.

The recreational fishery in and about the Okanogan River has been very infrequent because of the consistently poor runs of summer Chinook until recent years. Anglers are allowed to harvest hatchery-origin and natural-origin Chinook.

3.8.3 Spring Chinook

Rationale for Selection

The Upper Columbia River Spring Chinook were listed as an Endangered species on March 24, 1999. The listed ESU includes all naturally spawned populations of spring Chinook in accessible reaches of Columbia River tributaries between Rock Island and Chief Joseph dams, excluding the Okanogan River, which supported large spring Chinook populations historically, but are not deemed extirpated. Several hatchery populations from the Methow and Wenatchee subbasins where included in the listed ESU.

Key Life History Strategies, Relationship to Habitat

WDW et al. (1989) states: Natural spring Chinook production in the Okanogan and Similkameen subbasins is currently not feasible because of extensive habitat alterations in the accessible reaches. Failure of inclined-plane traps to capture spring Chinook smolts during trapping of sockeye smolts in the lower Okanogan River (McGee and Truscott 1982; McGee et al. 1983) empirically supports that judgment.

Bryant and Parkhurst (1950) and Fulton (1970) claim spring Chinook used Omak Creek, although the affidavits in Craig and Suomela (1941) do not mention such use. Weitkamp and Neuner (1981) captured a handful of Chinook juveniles in a floating trap in the Okanogan River in 1981 that were large enough to be spring Chinook. The trap was downstream from the confluence of Salmon Creek, and could have resulted from spring Chinook that spawned in Salmon Creek. None were captured in 1982 or 1983 (McGee and Truscott 1982; McGee et al. 1983).

In the Mid Columbia Region, juvenile spring Chinook salmon generally spend one year in freshwater before they migrate downstream (Mullan 1987; Healey 1991); most spend two years in the ocean before migrating back to their natal streams (Mullan 1987; Fryer et al. 1992). The adults enter the tributaries to the mid Columbia River from late April through July, and hold in the deeper pools and under cover until onset of spawning. They may spawn near their holding areas or move upstream into smaller tributaries.

Spawning occurs from late July through September, usually peaking in late August (Chapman, et al. 1995a). This extended period, both as adults and juveniles, makes spring Chinook salmon typically more susceptible than ocean type Chinook salmon to impacts from habitat alterations.

Water withdrawal in some areas has a deleterious effect upon stream type salmonid spawning distribution, incubation survival, and late summer rearing habitat quality (Chapman et al. 1995a).

In the Mid Columbia Region, stream type Chinook salmon exhibit a much more diverse manifestation of life history strategies than ocean type salmonids, which is probably related to their extended freshwater residence. While the percentage of fish employing any particular strategy now or historically has not been determined, it is highly likely that the percentage shifted in response to varying environmental conditions (Stearns 1989). For example, juvenile fish that may have been inclined to overwinter in an upper tributary might instead migrate to the lower mainstem or nearby side channels and tributaries during a particularly cold winter (Bustard and Narver 1975; Beschta et al. 1987).

All stream type Chinook salmon discussed in this document are within the Upper Columbia River Spring Chinook Salmon GDU (Marshall et al. 1995). The White River population (a tributary to the Wenatchee River) has relatively distinctive allele frequencies among the stocks within this GDU. Also included in this GDU are the fish propagated at Leavenworth, Entiat, and Winthrop NFH, which was partially derived from Carson NFH, a nonlocal stock (Bugert 1996).

Critical habitat for the spring Chinook ESU was designated on February 16, 2000, and included all river reaches accessible to listed spring Chinook in Columbia River tributaries between Rock Island and Chief Joseph dams, excluding the Okanogan River (Talayco, 2001).

The Upper Columbia River Spring Chinook ESU includes stream-type Chinook salmon spawning above Rock Island Dam in the Wenatchee, Entiat, and Methow rivers. All Chinook salmon in the Okanogan River are now believed to be ocean-type and are considered part of the Upper Columbia River Summer/Fall Chinook ESU (Meyers 1998). However, historically, spring Chinook salmon were numerous in the Okanogan sub-basin as they were harvested by the Colville Tribes Confederated Tribes in the Okanogan River during their May thru October salmon fisheries (Post 1938 as quoted in NWPPC 1986).

Fulton reported that while spring and summer Chinook were limited to the Okanogan and lower 2 kilometres of the Similkameen by the late 1960s, they formerly spawned in Salmon and Omak creeks and most of the Similkameen River. These former runs were lost to irrigation development. Parkhurst reported that the large, early-day runs of Chinook were depleted because of a combination of over-exploitation by the commercial fisheries in the lower Columbia River and the destructive Indian fishery.

By 1874 over one-half of the normal salmon run reaching the Colville Tribes Confederated Tribes was destroyed by lower river commercial fisheries. In 1884, the tribes had lost about three-fourths of their fishery and by 1890, salmon runs to the Colville Tribes Confederated Tribes was almost completely destroyed (Ray 1972). The large Chinook run into Salmon Creek was lost when the Bureau of Reclamation built Conconully Dam in 1916. When surveyed in 1936, no Chinook were present in Salmon Creek (Parkhurst 1950 as cited in NWPPC 1986)

Historical Indian fisheries for Okanogan salmon in May, June, and early July were likely spring Chinook. Alexander Ross in 1811 wrote that the Southern Okanogans assembled in large bands in June for the purpose of fishing during the summer season (Ray 1972). French and Wahle (1965) designated all Chinook arriving at Rock Island Dam by June 18 to July 9 as spring Chinook. Chapman reported that fifty % of the spring Chinook run passes Rock Island Dam in mid-May with passage at Wells Dam occurring slightly later. These fish inhabited at least Salmon Creek and Omak Creek.

Production in the Similkameen River is uncertain, as a 15-foot falls was believed to be a passage barrier at lower flows. Fulton, however, reported the falls as passable. Chapman (Chapman 1995) stated that, "No reliable information indicates that spring Chinook ever used the Similkameen River."

As with sockeye, spring Chinook did migrate above Lake Osoyoos into Canada and spawned in the upper Okanogan River and other tributaries. Chapman reports that, "In 1936, spring Chinook were observed in the Okanogan River upstream from Lake Osoyoos by Canadian biologists (Gartrell 1936). That observation for May estimated 100-300 adults present on the spawning grounds." In the late 1950s and early 1960s, spring Chinook were observed in the Okanogan River as far as Okanogan Falls. Chinook were observed spawning from the falls downstream to Oliver, with concentrated spawning occurring mainly about 1½ miles above Oliver near Vaseux Creek (Roy Wahle, pers. comm.).

In recent years, Chinook have been reported in small numbers spawning in the Okanogan River above Lake Osoyoos (Langness 1991, Bartlett 2001 per. com). These remnant runs could now be summer/fall Chinook.

In addition to spring Chinook spawning in Salmon and Omak creeks, they may have inhabited several other smaller, Okanogan tributaries (e.g. Bonaparte and Loup Loup creeks) prior to irrigation development in the late 19th century. As may have occurred in other Columbia sub-basins with similar characteristics as the Okanogan, many of the juvenile spring Chinook may have migrated out of the warming waters of the Okanogan subbasin as 0-age pre-smolts or smolts. It is also probable that spring Chinook spawning above Osoyoos Lake reared in the lake prior to smoltification, a life history strategy that is very successful for sockeye and coho salmon. Large, juvenile or residual Chinook have recently been captured in gill nets set in upper Osoyoos Lake (H. Wright 2003, pers. comm.).

Spring Chinook salmon historically spawned above Redfish Lake in Idaho with the juveniles rearing in the lake with the sockeye salmon prior to their ocean migration. It is also highly likely the juvenile spring Chinook from the White and Little Wenatchee rivers rear in Lake Wenatchee (Bugert, 1998).

Reservoir rearing of juvenile spring Chinook was a successful strategy in Fall Creek and Green Peter reservoirs in the Willamette sub-basin that produced large smolts and sizeable adult runs.

Historically, spring Chinook in the Okanogan may have included the following life history types:

- Spawn, rear, and overwinter in Salmon Creek.
- Spawn and rear in Salmon Creek, overwinter in mainstem Okanogan River.
- Spawn and rear in tributaries above Lake Osoyoos; overwinter in the lake.
- Spawn, rear, and overwinter in mainstem Okanogan above Lake Osoyoos.
- Spawn, rear, and overwinter in Omak Creek.

Some of the life history observations (Chinook jack and jills) and high river temperatures where they may migrate as 0+ indicate a spring type of population (H. Wright pers. com.).

In 2001, the USFWS Winthrop Hatchery released Carson stock spring Chinook smolts and fry into Omak Creek.

Population Delineation and Characterization

The Upper Columbia River Spring Chinook ESU includes stream-type Chinook salmon spawning above Rock Island Dam in the Wenatchee, Entiat, and Methow rivers. All Chinook salmon in the Okanogan River are now believed to be ocean-type and are considered part of the Upper Columbia River Summer/Fall Chinook ESU (Meyers 1998). However, historically, spring Chinook salmon were numerous in the Okanogan sub-basin as they were harvested by the Colville Tribes Confederated Tribes in the Okanogan River during their May thru October salmon fisheries (Post 1938 as quoted in NWPPC 1986).

Population Status

Spring Chinook are considered extirpated from the Okanogan River drainage, although historical records indicate that they occurred in at least three systems: (1) Salmon Creek, prior to construction of the irrigation diversion dam (Craig and Suomela 1941), (2) tributaries upstream of Lake Osoyoos (Chapman et al. 1995), and (3) possibly Omak Creek (Fulton 1968).

Population Management Regimes and Activities

In the Chelan HCP, hatchery compensation for Okanogan Basin spring Chinook will be assessed in 2007 following the development of a continuing spring Chinook hatchery program and/or the establishment of a Threshold Population of naturally reproducing spring Chinook in the Okanogan watershed (by an entity other than the District and occurring outside this Agreement).

The Hatchery Committee shall determine whether a hatchery program and/or naturally reproducing population of spring Chinook is present in the Okanogan Basin. Should the Hatchery Committee determine that such a program or population exists, then the Hatchery Committee shall determine the most appropriate means to satisfy the 7% hatchery compensation requirement for Okanogan Basin spring Chinook.

Programs to meet the 7% hatchery requirement for Okanogan Basin spring Chinook may include but not be limited to: (1) operation and maintenance funding in the amount equivalent to 7% project passage loss or (2) replace project passage losses of hatchery spring Chinook with annual releases of equivalent numbers of yearling summer Chinook into the Okanogan River Basin or (3) provide funding for acclimation or provide funding for adult collection facilities in the amount equivalent to 7% juvenile passage loss at the Rocky Reach Project.

The programs selected to achieve NNI for Okanogan Basin spring Chinook will utilize an interim value of project survival, based upon a Juvenile Project Survival estimate of 93%, until project survival studies can be conducted on Okanogan Basin yearling Chinook.

Current Management Practices

Recent spring Chinook mitigation programs of the federal government and public utility districts have excluded the Okanogan subbasin. Only since 2002, has a small, pilot program been initiated with releases of Carson stock spring Chinook in the Okanogan River and Omak Creek.

Facilities and Programs

Artificial propagation:

Spring Chinook Isolated Harvest Program – 800,000 yearlings (new)

Spring Chinook Integrated Recovery Program – 100,000 yearlings (new

1. 50,000 yearling release in Omak Creek
2. In 2002, a pilot release of 300,000 spring Chinook from Ellisforde Pond.
3. In 2003, a pilot release of 100,000 spring Chinook from Bonaparte Pond.

2004 will be the first year for adult returns from the releases of spring Chinook in the Okanogan River and Omak Creek.

Hydroelectric Effects

WDF (1938) describes existence of potential spawning habitat in the area upstream from Enloe Dam, but provides no documentation of historical use of the area by salmon or steelhead (NMFS, 1998). Chapman et al. (1995 CPa) found no evidence that such use occurred. The underlying source for Fulton's (1968) inclusion of the Similkameen River upstream from the site of Enloe Dam as anadromous salmon habitat was WDF (1938). Review of that source does not support the Fulton observation. Cox and Russell (1942) state:

> From testimony of a Mr. McGrath at Nighthawk, who had been in that country over 40 years, we learned that before any power dam was built (Enloe Dam), the 15' to 20' natural falls already mentioned prevented salmon ascending any farther. He had often fished the river at Nighthawk but had never heard of a salmon being seen or caught above the natural falls. He stated that the Indians came in to fish at these falls each summer.....Therefore, we conclude that this power dam did not interfere with any salmon runs....

Accounts of the traditional story of coyote suggest that salmon never passed upstream of the falls, and the Native people of the Similkameen valley never sought to have fish passage there, further confirming that anadromous fish never passed the falls (Vedan 2002).

Harvest Effects

Spring Chinook are extirpated in the Okanogan River. Consequently the Colville Tribes Confederated Tribes have been denied their spring Chinook trust fisheries. It should also be noted that the Canadian Species-At-Risk act requires extirpated species to be part of the recovery plan. Currently, there is a listing petition for spring Chinook in Canada and actions in the US portion of the Okanogan watershed will have to be part of the recovery equation.

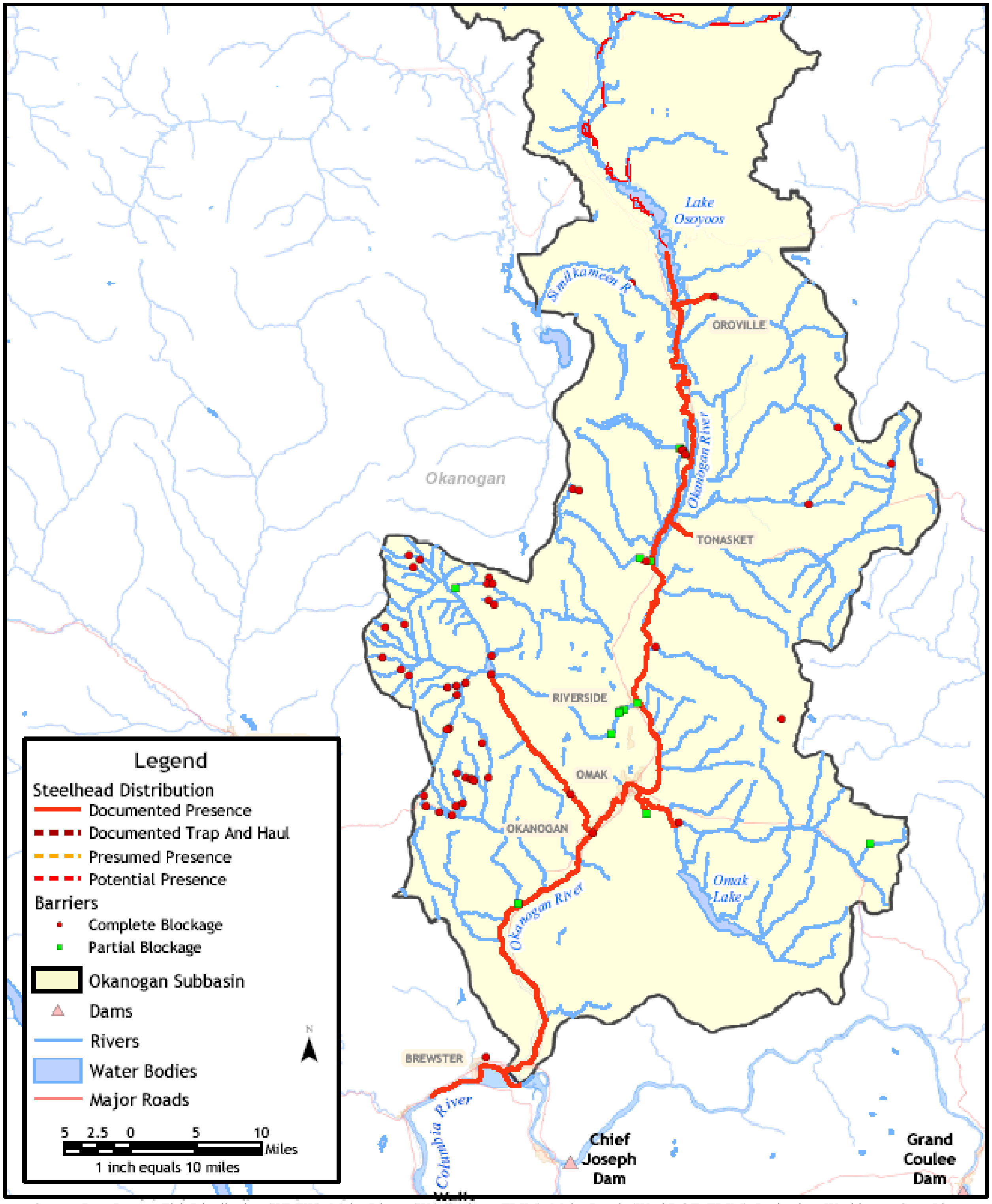
3.8.4 Steelhead

Rationale for Selection

Upper Columbia steelhead in the Okanogan are considered depressed according to SASSI (WDFW & WWTIT 1994). In addition, Upper Columbia ESU Steelhead, of which the Okanagan is a population (Busby et al. 1996), are classified as Endangered by NMFS Although the historical record for steelhead in the Okanogan Watershed is not complete, Mullan et al. (1992) asserts that few steelhead historically used the Okanogan River. . It should be noted that the NMFS review did not include the Canadian Portion of the Okanagan Basin. However, it is unknown if other historical assessments such as Mullan et al. (1992) included the Canadian portion of the Okanagan River.

Key Life History Strategies, Relationship to Habitat

Steelhead are widely distributed and have been recorded upstream in the Okanogan to the mid-reaches of the Okanagan River above Osoyoos Lake (Figure 1). Peven (2003) concluded that, for the purposes of sub-basin planning, there are four independent populations of steelhead within the larger metapopulation that spawns naturally upstream from Rock Island Dam (Wenatchee, Entiat, Methow, and Okanogan).



Source: Data Layers: Fish Distribution (WDFW), Major Rivers (WA Ecology, TRIM), Major Roads (WashDOT, TRIM). Projection: Washington State Plane North Zone NAD83. Produced by Jones & Stokes for KWA Ecological Sciences, Inc. Map Date: 5/15/2004

Figure 18. Okanogan Subbasin Steelhead distribution

The Okanogan River mainstem is primarily used as a migration corridor to clearer, colder tributaries. Current habitat conditions in the migration corridor are poor for most if not all history types. However above Osoyoos Lake, a more natural section of the mainstem river does have suitable habitat but little effort to document spawning has occurred.

Historically, steelhead had access to Okanagan Lake (Ernst 2000, Rebellato and Wright 2004, in press, Vedan 2002). However, their present day access is limited to below McIntyre Dam. The historical record for steelhead trout in the Okanogan Basin is incomplete (Mullan, et al., 1992), but it is unlikely that Okanogan River produced large numbers of steelhead. Salmon Creek, Omak Creek, and the Similkameen River supported small runs, but these were eliminated or reduced by passage barriers (NMFS, 1998). Few wild steelhead currently spawn successfully in the Okanogan Basin because many of the tributaries with spawning habitat are dewatered during the summer months. Elevated temperatures and sedimentation in the Okanogan River limit quality and quantity of cold water refugia.

Only summer-run steelhead are known to utilize the Okanogan watershed. Winter-run steelhead were not known to ever use this system, likely owing to the long migration involved. The summer run steelhead of the Okanogan are considered part of the upper Columbia summer steelhead ESU, and were listed as Endangered on August 18, 1997.

In the Okanogan Basin, Fulton (1970) named Omak and Salmon creeks as producing steelhead, and the upper Similkameen, but that seems unlikely based on evidence that fish were unable to ascend Enloe Falls prior to the dam (Chapman et al. 1994 CPa).

Mullan et al. (1992CPa) stated that steelhead never used the Okanogan in great numbers, and that Salmon Creek (blocked by a dam in 1916) and Similkameen (see discussion above concerning fish upstream of the falls) were the most probable steelhead producing streams in the basin. It is unlikely that this assessment included the Okanagan River above Osoyoos Lake.

Salmon Creek historically supported self-sustaining steelhead runs, but lack of flow currently restricts access in most years. Some evidence suggests that steelhead may also have historically used other tributaries in the Okanogan Basin (Chapman et al. 1994b). The current suitability of habitat throughout much of the Okanogan basin is generally considered poor in regard to supporting most life history requirements of steelhead.

Although steelhead were probably never abundant in the Okanogan River because of natural habitat limitations, an estimated half of the steelhead production may have been lost as a result of fish access restrictions to Salmon Creek by irrigation water withdrawals (WDF and WDFW 1993).

In 1955-56, the escapement estimate to the Okanogan was about 50 fish, from a total run size of about 97 fish (WDFW 1990). Assuming a 50 % loss in production from Salmon Creek since 1916, the average run-size prior to the extensive hydroelectric development in the mid-Columbia River reach is believed to have been about 200 fish. The estimated total run-size of naturally produced summer steelhead to the Okanogan Subbasin declined to between 4 and 34 fish, from 1977 to 1988 (WDFW 1990).

Nevertheless, 19 adult summer steelhead were trapped in Omak Creek in 2001 (C. Fisher, TAG). When considered against a total escapement to the entire system of between 4 to 34 fish from 1977 to 1988 (WDFW 1990), such populations, although small, become disproportionately important. Regardless of whether the 2001 Omak Creek steelhead returns originated from earlier smolt transplants from the Wells Hatchery into the system, the creek may be especially important for the reestablishment/recovery of the summer-run steelhead ESU within the Okanogan watershed.

Steelhead production from Salmon Creek was estimated to represent roughly 50% of the native production throughout the US portion of the watershed prior to the erection of Conconully Dam.

Documentation of steelhead utilization above Osoyoos Lake is extremely limited. No records have been kept since 1972 (Rebellato and Wright 2004). However, confirming the anadromous forms of *O. mykiss* above Osoyoos Lake is confounded by the presence of adfluvial rainbow trout which are similar in appearance, distribution and behavior to steelhead (for further details see the section on rainbow trout).

Despite the lack of information on the Canadian side, two major tributaries below McIntyre Dam (Vaseux Creek and Inkaneep Creek) plus the natural section of the mainstem river are thought to support steelhead.

Steelhead counts began at Rock Island Dam in 1933, and annual counts averaged 2,800 between 1933 and 1939 (these numbers do not reflect large fisheries in the lower river that took place at that time, estimated by Mullan et al. (1992CPa) as greater than 60%). Average decadal numbers changed little in the 1940s and 1950s (2,600 and 3,700, respectively). Large hatchery releases began in the 1960s, and the average counts increased to 6,700. In the 1970s, counts averaged 5,700 and 16,500 in 1980s (record count of about 32,000 in 1985). In the 1990s, counts decreased to 7,100, following a similar trend to Chinook. Also following a trend similar to Chinook steelhead increased substantially in the 2000s, averaging over 18,000. A high of 28,600 was experienced in 2001 (Figure 3, Table 1).

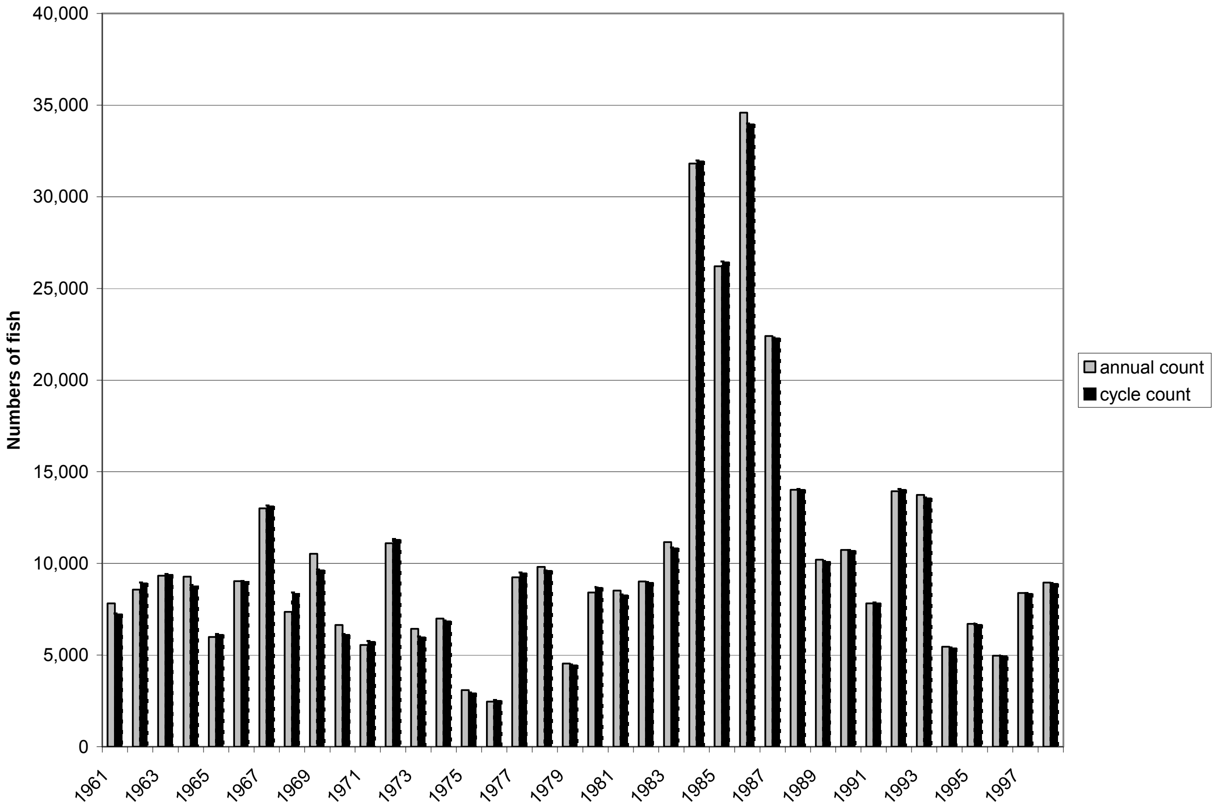


Figure 19. Comparison of cycle and annual counts of steelhead ascending Priest Rapids Dam, 1961-1999 (Grant PUD, unpublished data)

Table 19. Annual (calendar) counts of steelhead ascending Upper Columbia River Dams (1933-2002)

			Dam counts						Decadal averages		
				Wells					Wells		
	Rock	Rocky	Stlhd.	Stlhd.	Total		Rock	Rocky	Steelhead	Steelhead	Total
	Island	Reach	passed	trapped	steelhead		Island	Reach	passed	trapped	steelhead
1974	1,885	1,063	580	260	840						
1975	2,725	1,134	517	227	744						
1976	7,820	5,893	4,664	337	5,001						
1977	9,926	7,416	5,282	355	5,637						
1978	3,348	2,453	1,621	356	1,977						
1979	7,424	4,896	3,695	367	4,062		5,455	3,661	2,545	364	2,909
1980	7,017	4,345	3,443	372	3,815						
1981	7,559	5,524	4,096	650	4,746						

			Dam counts						Decadal averages		
				Wells					Wells		
	Rock	Rocky	Stlhd.	Stlhd.	Total		Rock	Rocky	Steelhead	Steelhead	Total
	Island	Reach	passed	trapped	steelhead		Island	Reach	passed	trapped	steelhead
1982	9,879	6,297	7,984	590	8,574						
1983	29,666	19,698	19,525	670	20,195						
1984	25,096	17,228	16,632	690	17,322						
1985	31,999	22,718	19,867	750	20,617						
1986	22,885	15,157	13,303	650	13,953						
1987	12,732	7,178	5,493	603	6,096						
1988	9,241	5,677	4,401	651	5,052						
1989	9,351	6,039	4,600	716	5,316		16,543	10,986	9,934	634	10,569
1990	6,946	5,033	3,815	735	4,550						
1991	10,927	7,645	7,751	726	8,477						
1992	12,478	7,516	7,027	658	7,685						
1993	4,829	2,816	2,494	633	3,127						
1994	5,620	2,818	2,163	620	2,783						
1995	4,175	1,758	942	619	1,561						
1996	7,305	5,774	4,128	509	4,637						
1997	7,726	6,722	4,107	630	4,737						
1998	4,963	4,442	2,984	460	3,444						
1999	6,269	4,814	3,504	416	3,920		7,124	4,934	3,892	601	4,492
2000	10,516	8,278	6,280	369	6,649						
2001	28,612	22,050	18,528	392	18,920						
2002	15,295	11,870	9,478	373	9,851		18,141	14,066	11,429	378	11,807
Source: Chelan and Douglas PUDs, unpublished data.											

Fish habitat in the upper Similkameen drainage, the largest tributary of the Okanogan basin, is cut off by Enloe Dam, approximately 8.5 mi from the confluence of the Similkameen River with the mainstem Okanogan. Although upstream habitats appear suitable for Chinook and steelhead, cultural stories of the Similkameen Indian Bands describe a history without anadromous fish migrations above the historic Coyote Falls, where Enloe Dam now sits, suggesting an ecology without anadromous fish populations in the upper watershed. This legend is supported by a large body of evidence that says the falls were impassable.

In the spring of 2001, Heather Barlett, WDFW fisheries biologist, and Chris Fisher, CTCR fisheries biologist, observed two steelhead redds in Bonaparte Creek and witnessed a steelhead spawning in Tonasket Creek. Whether or not the environmental conditions of Bonaparte Creek remained conducive for steelhead this year is unknown, however, Tonasket Creek is dry (Fisher, 2001).

Six life history types are identified for Okanogan steelhead:

4. Spawn, rear and overwinter in Salmon Creek, outmigrate in spring.
5. Spawn and rear in Salmon Creek, overwinter in Okanogan River; outmigrate in spring.
6. Spawn and rear in Okanogan River and tributaries upstream of Lake Osoyoos, overwinter in the lake or stream, and outmigrate in spring.
7. Spawn and rear in Okanogan River and tributaries upstream of Lake Osoyoos, overwinter in the lake or stream, and outmigrate one or more years later.
8. Spawn, rear, and overwinter in Omak Creek, outmigrate in spring.
9. Spawn and rear in Omak Creek, overwinter in Okanogan River, outmigrate in spring.

Population Delineation and Characterization

Steelhead in the Columbia River are usually designated as either "summer-or winter" types (Busby et al. 1987), which is based, again, on their entry into freshwater to spawn.

Brannon et al. (2002) combined all of the first-order metapopulations of summer steelhead upstream of the Yakima River into one metapopulation.

The ICBTRT recently listed the Okanogan Basin steelhead as an independent population: "The current status of steelhead endemic to the Okanogan is unknown. Currently, low numbers of natural steelhead return to this system, but may be offspring from hatchery returns.

The Okanogan appears to have supported an independent population of steelhead historically. Although habitat conditions for rearing are highly degraded in the system, the Okanogan and its tributaries in the US and Canada appear to have contained sufficient habitat to have supported an independent population of steelhead. In addition, the Okanogan is found in a substantially different habitat than other populations in this ESU, further supporting delineation of this population" (ICBTRT 2003). The relationship between Steelhead and adfluvial RBT is unknown.

For the purposes of sub-basin planning, it is assumed that there are four independent populations (Wenatchee, Entiat, Methow, and Okanogan) of steelhead within the larger metapopulation that spawns naturally upstream from Rock Island Dam (Peven, 2003).

Population Status

As mentioned earlier, the works of Fulton (1970), Chapman et al. (1994 CPa) and Mullan et al. (1992 CPa) indicate that steelhead never used the Okanogan in great numbers but that Omak Creek, Salmon Creek, the Similkameen River below Enloe Dam and perhaps the Canadian mainstem and tributaries were the most probable steelhead producing streams in the basin.

Busby et al. (1996) determined that the ESU for Upper Columbia summer steelhead comprised the populations that currently spawn in the Wenatchee, Entiat, Methow, and possibly Okanogan rivers.

The BRT felt that because of past hatchery practices (see below) there has been substantial homogenization of the gene pool. However, there is probably remnant genetic material from ancestral populations that could have been "stored" in resident populations (Mullan et al. 1992 CPa). Ford et al. (2001) agreed with the delineation described by Busby et al. (1996), but described each subbasin, with the possible exception of the Okanogan, as an independent population.

Spawning population escapement estimates are not available for below McIntyre Dam and above Osoyoos Lake largely because spawning occurs in May and June when tributary streams are in freshet and too colored to allow visual fish counting.

Population Management Regimes and Activities

Past Management Practices

In 1939, during construction of Grand Coulee Dam, the US Fish and Wildlife Service initiated a program to address the upcoming loss of over 1,100 miles of available habitat to Upper Columbia River salmonid populations (Fish and Hanavan 1948). Construction of the dam without fish passage facilities led to the program that centered on trapping at Rock Island Dam. During the GCFMP (1939-1943), all salmon and steelhead that reached Rock Island Dam were trapped there and mixed. These fish were either transplanted to spawning streams and "forced" to spawn there, or taken to newly completed hatcheries on the Wenatchee (Icicle Creek), Entiat, or Methow rivers.

Steelhead were also released in the upper Wenatchee River (upstream of Tumwater Canyon) and the Entiat River in 1939. The fish were released between two racks that forced the fish to spawn in the area selected by the biologists of the USFWS (Fish and Hanavan 1948).

Trapping at Rock Island Dam extended over five brood years, 1939 through 1943. The last brood to spawn naturally in natal streams was that of 1938. The GCFMP extensively homogenized steelhead that were of mid- and upper-Columbia river origin. Homogenization was both temporal and geographic. The manipulations of the GCFMP may have reduced the genetic uniqueness of any distinct populations, or subpopulations in the mid-Columbia. There may be the potential to make use of the remaining wild genetic *O. mykiss* stock contained within the adfluvial Osoyoos Lake population. However, more research of their interrelationship is required.

Peven (1992 CPb) and Chapman et al. (1994 CPa) list the extensive hatchery releases of steelhead and resident *O. mykiss* in the Upper Columbia Basin. Introduction of exogenous steelhead were from donor stocks from other parts of Washington State, primarily (e.g., Skykomish, Snoqualmie, Samish, Chambers Creek, Carson, Naches, Skamania, and Ringold), and made up winter- and summer-run populations.

Records of stocking rainbow trout into Okanagan mainstem lakes are available through (http://srmapps.gov.bc.ca/apps/fidq/stockingQuery.do). Within the current range of steelhead the stocking of Osoyoos Lake applies. A total of 900,000 rainbow trout fry were stocked sporadically between 1930 and 1964. Donor stocks came primarily from upriver areas with the Okanagan. In addition, approximately 620,000 eyed eggs were placed between 1956 and 1960 in the Okanagan River above Osoyoos Lake with approximately half from Washington State. Whether these stocking projects impacted steelhead is unknown. Rainbow Trout stocking hasn't occurred in the Osoyoos Lake since 1964 and Skaha Lake since 1979.

Current Management Practices

A steelhead program began in the early 1960s, with broodstock collected at Priest Rapids Dam. This effectively mixed adults destined for all upstream tributaries and hatcheries. That practice continued until the early 1980s, although some of the broodstock was taken at Wells Dam periodically in the 1970s (Chapman et al. 1994 CPa). Beginning in 1982, all broodstock was captured at Wells Dam and fish from this program were released into all of the main tributaries upstream of Rock Island Dam, further homogenizing the populations.

Since the late 1990s, a change in the broodstock program has emphasized more tributary-specific hatchery programs. In the Integrated Recovery Program the goal is to restore the abundance, distribution, and diversity of steelhead in the Okanogan subbasin.

Facilities and Programs

The Steelhead Integrated Recovery Program calls for reintroductions, kelt reconditioning, and broodstock improvement. To achieve target productions levels the construction of a Chief Joseph Dam Hatchery has been proposed along with the expansion of Cassimer Bar Hatchery or Colville Trout Hatchery for steelhead programs.

Hatchery Effects on Population

Chapman et al. (1994 CPa) found no information that suggested that any of the exogenous broodstock releases in the Upper Columbia have had much of an effect on the population structure. The current naturally spawning populations appear to be mostly indistinguishable from the Wells Hatchery broodstock.

Harvest Effects

Incidental harvest of steelhead is restricted under regulation of the Endangered Species Act. In 2001, steelhead mortality was limited to 200 fish.

Starting in 2002, the fishery can be extended in time, to October 31, and in location, downriver 12 miles to the confluence of the Okanogan River. Mortality of hatchery-origin and natural-origin steelhead is each specified as a percentage of the run over Wells Dam (COLVILLE TRIBES 2002).

There is a small Okanagan Nation spring harvest and a recreational fishery in tributaries, lake and the river for adfluvial rainbows and this raises the question of whether the fish captured may in fact be steelhead.

3.8.5 Rainbow Trout

Rationale for Selection

Rainbow trout are being considered a focal species by the Canadian fisheries agencies because of their significance to the subbasin's ecosystem. However, rainbow trout have not been addressed through the subject of any additional assessment as a function of this subbasin plan. Rainbow trout have been selected as a focal species because they are:

- poorly understood, but almost assuredly heavily affected by the changes that have taken place in recent times (kokanee collapses, habitat degradation, climate change etc.);
- made up of a variety of stocks, some of which are limited in number, very vulnerable to overharvest, and poorly inventoried (e.g. large lake adfluvial rainbow);
- a species of choice for harvest, consumption and non-consumptive use;
- sensitive to environmental change and thus excellent environmental indicators; and
- routinely considered a focal species and a species of management concern in other projects.

Key Life History Strategies

There are three distinct types of wild rainbow trout stocks in the Okanagan Basin. Fluvial rainbow trout spend their lives in streams and are abundant, ubiquitous and usually limited in size because streams in the Okanagan tend to be unfertile and cold.

Adfluvial rainbow trout spend most of their life in lakes but enter streams to spawn and often rear in lake tributaries for a year or more. Lake dwelling rainbows are found in two forms. The first are those that live in the small headwater lakes of the Okanagan and are insectivorous. The second form is found in the pelagic zone of large lakes of the Okanagan where they become piscivorous and grow to extremely large sizes. These fish are very limited in number and are very aggressive feeders and thus extremely vulnerable to overharvest. These rainbows require special management attention.

Spawning population escapement estimates are seldom available for pelagic adfluvial rainbows. Spawning occurs in May and June when tributary streams are in freshet and too colored to allow fish counting. In an attempt to estimate numbers of rainbow spawners in Mission Creek (the major tributary of Okanagan Lake), Pinsent et al. (1974) divided the area of spawning gravel by the estimated redd size of rainbows. They calculated a spawning population of 33,000 rainbows. A decade later a trap was placed in Mission Creek and the annual spawning count was found to vary between 200 and 500 fish. This emphasizes the vulnerability of the population and the importance of adequate inventory.

Relationship to Habitat

Small fluvial rainbow trout occupy many of the Okanagan headwater streams where temperature and flow characteristics are favorable. Often the suitability of these habitats is intermittent, particularly in third order tributaries with annually variable flows. The presence and relative abundance of these small fluvial rainbow trout provides an indicator over time of the stream and associated ecosystem health and may be valuable for managers and local residents to recognize ecosystem-level changes not otherwise apparent. However, the diversity and their broad occupation of these stream habitats provides population resilience to change.

Lake rainbow trout populations are often closed to genetic mixing with other populations except where streams connect them to other lake populations. The natural mixing is believed to broaden genetic variability providing for long-term genetic fitness. Many “closed” system lakes have been stocked over time and the genetic fitness of populations is unknown or of little management concern. Some of these lakes may winter or summer kill and may be restocked by managers.

Piscivorous adfluvial rainbow trout are of particular management interest as their pelagic and stream spawning habitats are limited and populations are less diverse. Representing both a strong indicator of lake/stream ecosystem health and a concern by managers about limited and possibly diminishing populations.

Large piscivorous lake rainbows spawn in tributary streams where their young rear for a year or more before entering the lake. The extent and quality of stream habitats is one of the limiting factors for the population. Of particular concern in the tributaries is low flow, high temperatures, and the destruction of habitat. Taylor and Galbraith (1974) showed that 90% of the stream habitats adjacent to Okanagan Lake had been lost by 1974.

In the mainstem Okanagan River high summer temperatures are a concern (Pinsent et al., 1974) and loss of habitat because of channelization has taken a major toll.

In Osoyoos, Vaseux and Skaha Lakes the combination of hypolimnetic oxygen depletion and excessive epilimnetic heating limits the rearing potential.

In all the large lakes declines in sockeye and kokanee populations must also have had a major effect, since pelagic rainbow have been shown to feed almost exclusively on these fish.

Population Status

Little information exists about population status of fluvial rainbows, but they are believed to be generally, healthy with some notable local exceptions where local tributary quality is limiting. Lake insectivorous rainbows are managed on a lake-by-lake basis.

Little is known of the populations in other tributaries but since Mission Creek is by far the largest tributary stream in the Canadian Okanagan it is assumed to support the dominant run. Nothing is known of the harvest numbers in Okanagan or any of the other lakes and this represents a large and important data gap.

In addition there is little known of the life history characteristics of rainbow in the Okanagan River mainstem. Attempts are just now being made to determine whether the large *Oncorhynchus mykiss* that spawn in the river are in fact rainbow trout from Osoyoos Lake or steelhead.

Population Management Regimes and Activities

In the 1970s and 1980s a 2-day winter fishing derby was held annually for trophy sized rainbow trout in Okanagan Lake. This event provided researchers with an efficient way to measure, age and examine the catch and also provided an inter-annual comparison of catch per unit effort. At about the same time a trap was run at a fishway in Mission Creek. This allowed an annual count of escapement. Creel surveys augmented the information.

Eventually the obstruction in Mission Creek was in-filled and no escapement counts were possible. Similarly the Fish Derbies were stopped because of conservation concerns and that source of information was no longer available. Even the creel surveys were curtailed because of government cutbacks.

No information on large lake rainbow has been gathered in recent years and no management schemes have been undertaken. These information gaps are a major management concern particularly in view of the massive declines in kokanee populations; the major food source for large pelagic rainbow.

3.8.6 Okanagan Lake Kokanee

Rationale for Selection

Kokanee are the non-anadromous form of sockeye (*O. nerka*) are, along with sockeye, sometimes referred to as 'nerkids.' Resident kokanee populations are found in all mainstem Okanagan basin lakes. The health of the resident nerkid populations is considered an important indicator of the water quality and hydrology of Okanagan lakes ecosystem. Kokanee also represent a potential source of genetic diversity. They also often support a recreational fishery. For example, Okanagan Lake supported a fishery valued at nearly Can $ 9 million annually prior to being closed in 1995 (S. Matthews Pers. com.).

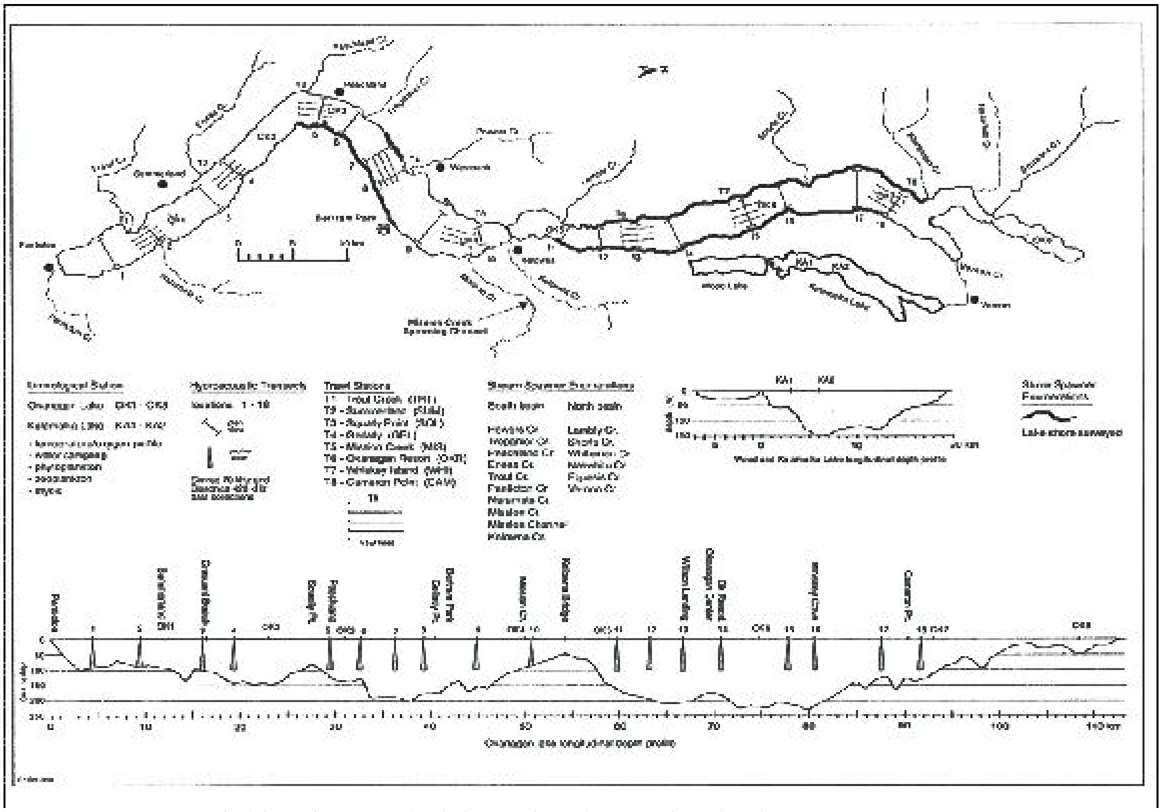
Population declines in Okanagan Lake have warranted a closure of the fishery and the development of the Okanagan Lake Action Plan to determine the causes for population declines and address the broad range of recovery issues.

Kokanee in Skaha and Osoyoos lakes are also considered depressed. Focus for sub-basin planning will be focused on Okanagan, Skaha and Osoyoos Lakes because of the importance of Okanagan Lake to the recovery effort of provincial agencies, the reintroduction of sockeye into Skaha Lake and the interactions between kokanee and anadromous fish in Osoyoos Lake.

Key Life History Strategies, Relationship to Habitat

Osoyoos, Vaseux, Skaha, Okanagan, Kalamalka, Woods, and Duck Lakes are all located within the Okanagan mainstem chain and all contain indigenous kokanee populations. Okanagan Lake is considered to have had the most historically productive kokanee populations in the Okanagan Valley. Vast shorelines complement a number of small to medium-sized tributaries to support both shoreline and tributary spawning populations.

Approximately 17 linear miles (27 kilometres) of Okanagan Lake shoreline are utilized by shore spawning kokanee (Figure 9) and are routinely monitored for spawner densities by the B.C. fisheries agencies (Northcote et al. 1972). The shoreline spawning areas are considered vulnerable to shoreline development, water quality, and water drawdown, and are the subject of conservation efforts by B.C. fisheries agencies.



Source: Map courtesy of Ministry of Water, Land and Air Protection. Okanagan Lake Action Plan 2000

Figure 20. Kokanee distribution in Okanagan Lake

Okanagan Lake has 46 named tributaries, 20 of which may support kokanee (Shepherd, 1990), and up to 16 regularly monitored (2-15 years) for kokanee spawning success. Of these, twelve support spawning populations greater than 500 fish. Stream escapements ranged from 300,000 to 850,000 in the 1970s (Andrusak et al. 1999).

Immediately downstream of Okanagan Lake is Skaha Lake. Kokanee spawn in the mainstem channel or in two tributaries (Shingle and Ellis). Shingle and Ellis Creek kokanee generally have peak spawning in the third week of September while mainstem spawners peak in mid to late October. In Osoyoos Lake kokanee are also known to spawn in Inkaneep creek and mainstem Okanagan River and peak in early to mid October.

Kokanee life history types include:

- spawn in Okanogan tributaries, rear in mainstem lake for one to four years, spawn in fall in natal tributary, and
- spawn in Okanagan lake shoreline, rear in Okanagan Lake for one to two years, spawn in late fall.

Population Delineation and Characterization

Genetic differences have been identified between shore and shoal spawning kokanee (Ashley et al. 1999). The shoal spawning population is considered 3 – 4 times larger than the stream spawning cohort (Andrusak et al. 1999) and the two populations are genetically separate (Taylor et al. 1997). However, hatchery supplementation of sockeye and kokanee that occurred during the Grand Coulee Fish Maintenance Project and other stockings may have confounded the genetic make up of stocks in Skaha and Osoyoos lakes. No genetic work has been conducted on these lakes but samples have been collected (H. Wright, pers comm.).

Population Status

The total population of all ages of kokanee in Okanagan Lake has increased since 2000 from 3.5 million to 11 million (S. Matthews, pers comm.). However, this has not correlated well with stream and shore spawning adult enumerations. Stream spawners have been consistently low. Shoal spawners may be a result of the increase in in-lake abundance but enumeration methods look at trends only.

The large increase in the total population is most likely attributed to the large 0+ population but has not resulted in a subsequent increase in age 1-3 year old kokanee in-lake abundances. This suggests that there is a low underyearling survival possibly attributable to low over-winter survival.

From the early 1990s to 2001 Skaha Lake kokanee escapements have averaged about 9,800 and this has correlated well with in-lake abundance data from 1999-2001 (P. Rankin, pers. comm.). However, in 2002 and 2003 there was an unexplained almost 10-fold increase in adult escapement. However, this has not translated in subsequent increase in in-lake population, suggesting that the quantity and/or quality of spawning habitat may be substandard.

Little work has been conducted on Osoyoos Lake kokanee but annual counts are made each year during sockeye enumerations (H. Wright, pers. comm.). The data have not been fully reported but they seem to indicate that the peak of spawning for kokanee occurs approximately one week earlier than sockeye.

Population Management Regimes and Activities

The current management emphasis for kokanee within the Okanagan basin is centered on habitat protection and water management. Additionally, MOELP and DFO have allocated resources in recent years to encourage resource stewardship with Okanagan municipalities and regional districts. MOELP has worked on optimal base flow requirements for spawning tributaries and developed tools to manage lake levels in cooperation with DFO (see below).

Emphasis on lake productivity and mitigating competition with exotic species is shaping future management plans.

Past Management Practices

Differences among resident and anadromous Okanagan valley nerkids are attributed to geographic isolation and stocking programs. For Okanagan Lake, stocking programs utilized kokanee from local populations as well as from Meadow Creek, a tributary to Kootenay Lake. A recorded 2,140,000 eyed eggs and 699,733 fry were stocked into Okanagan lake between 1928 and 1951 (B.C. Fisheries Stocking Records: http://srmapps.gov.bc.ca/apps/fidq/stockingQuery). The genetic similarities and differences between Meadow Creek kokanee and Okanagan Lake kokanee are unknown.

Skaha Lake was also stocked in the late 1930s with 240,000 eyed eggs from Meadow Creek stock. In addition, from 1981 to 1989, 2.5 million fry were stocked from Okanagan Lake and Meadow Creek kokanee.

Finally, for Osoyoos Lake, kokanee were stocked in the Okanagan River in 1971. This involved the transplantation of 33,500 fry.

Current Management Practices

Current management for Okanagan Lake is guided by the Okanagan Lake Action Plan (OLAP). The recreational fishery for kokanee has been closed since 1995 because of a kokanee collapse. Several initiatives under the OLAP are underway.

One OLAP initiative is the consideration of balancing lake nutrients. The focus is on nitrogen and phosphorous ratios and their effect on diatoms and green algae, which in turn support high food value macrozooplankton such as Daphnia.

Another OLAP initiative involves experimental selective harvest of mysid shrimp populations as a means of decreasing competition.

Water management coordination involving B.C. water managers and the Canadian Okanagan Basin Technical Working Group is another important step in managing kokanee populations. It is designed to balance salmon maintenance flows in Okanagan River with the needs of kokanee shoal spawners in Okanagan Lake (Hyatt et al. 2003).

For Skaha Lake the province conducts annual adult enumeration monitoring of the Okanagan River (1989-present). In addition, Fisheries and Oceans Canada have conducted in-lake abundance estimates in partnership with Okanagan Nation Alliance Fisheries Department. Additional effort will be given to monitoring Skaha Lake, as it is the site for the experimental reintroduction of sockeye. Considerable effort will be given to Okanagan sockeye for monitoring but data on kokanee will also be collected.

Harvest Effects

The kokanee fishery has been closed since 1995 for kokanee in Okanagan Lake. However, the rainbow fishery is still open and there is most likely a bycatch of kokanee. Under the OLAP, there will be efforts this year to examine the harvest effects on kokanee. The recreational fisheries for Skaha and Osoyoos Lakes are still open. The effects of these fisheries are unknown.

Ecologic Effects/Relationships (at subbasin scale)

As identified before, there has been numerous stocking in mainstem lakes and the resultant ecological effects/relationships are unknown.

Skaha and Okanagan lakes are of interest with the immediate experimental and long-term reintroduction of sockeye respectively. Effects will be monitored as directed by the Skaha sockeye reintroduction monitoring and evaluation plan.

The genetic and behavioral interrelationships between sockeye and kokanee in Osoyoos Lake are also unknown. With the recent identification of resident/anadromous Chinook and the presence of both adfluvial rainbow and steelhead in Osoyoos Lake, one would expect ecological interactions between sockeye and kokanee and these should be investigated further.

3.8.7 Bull trout

Rationale for Selection

In the state of Washington, population declines of bull trout have primarily occurred in the eastern part of the state. The listing of bull trout in 1998 has led to the examination of residual bull trout populations in the Okanogan subbasin as the source of future restoration efforts. Bull trout are considered to have occurred historically in the Okanagan River in British Columbia (USFWS 2002). Currently, the FWS has identified bull trout use in the Okanogan as a data gap. The Service believes that bull trout may use the Okanogan mainstem for over-wintering, foraging and possibly rearing during a portion of the year (K. Terrell personnel communication to Keith Wolf, May 2004).

Key Life History Strategies, Relationship to Habitat

Historically, there were most likely three life histories (or ecotypes) of bull trout within the CCP (adfluvial, fluvial and non-migratory), with distribution and population levels dictated by temperature and gradient (Mullan et al. 1992 CPa).

Salmon Creek and Loup Loup Creek historically supported bull trout populations (*Salvelinus confluentus*). The introduction of brook trout and resulting hybridization of the two species are considered primary factors for the decline of bull trout in the Okanogan River Basin (FWS, 1998).

Peven (2003) concluded that current distribution of bull trout within the CCP appears to be reduced from historic, especially in the lower Okanogan Basin and Lake Chelan where they are listed as occupancy unknown. The FWS concluded in their draft Bull Trout Recovery Plan that the distinct bull trout populations exist in the Wenatchee, Entiat, and Methow Rivers, which overlap with the core recovery area. The Okanogan River is not included among known distinct populations, however bull trout population, abundance and distribution in the Okanogan has been listed as a data gap (FWS 2000).

3.9 Other Important Fish Species for Management

3.9.1 Westslope Cutthroat Trout (WSCT)

The status of Westslope cutthroat (*Oncorhynchus clarki*) in the basin is unknown. They are believed to have originated from early stocking. However, the remaining stocks are believed to have become naturalized.

Key Life History Strategies, Relationship to Habitat

The only known WSCT in the Canadian portions of the Okanagan Subbasin are found in Cathedral Lakes located in the headwaters of the Similkameen River. WSCT are present in the North Fork Salmon Creek subbasin, the Sinlahekin headwaters, and in numerous US alpine lakes in the CCP. In at least some locations, these waters were known to be stocked with cutthroat in the past.

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

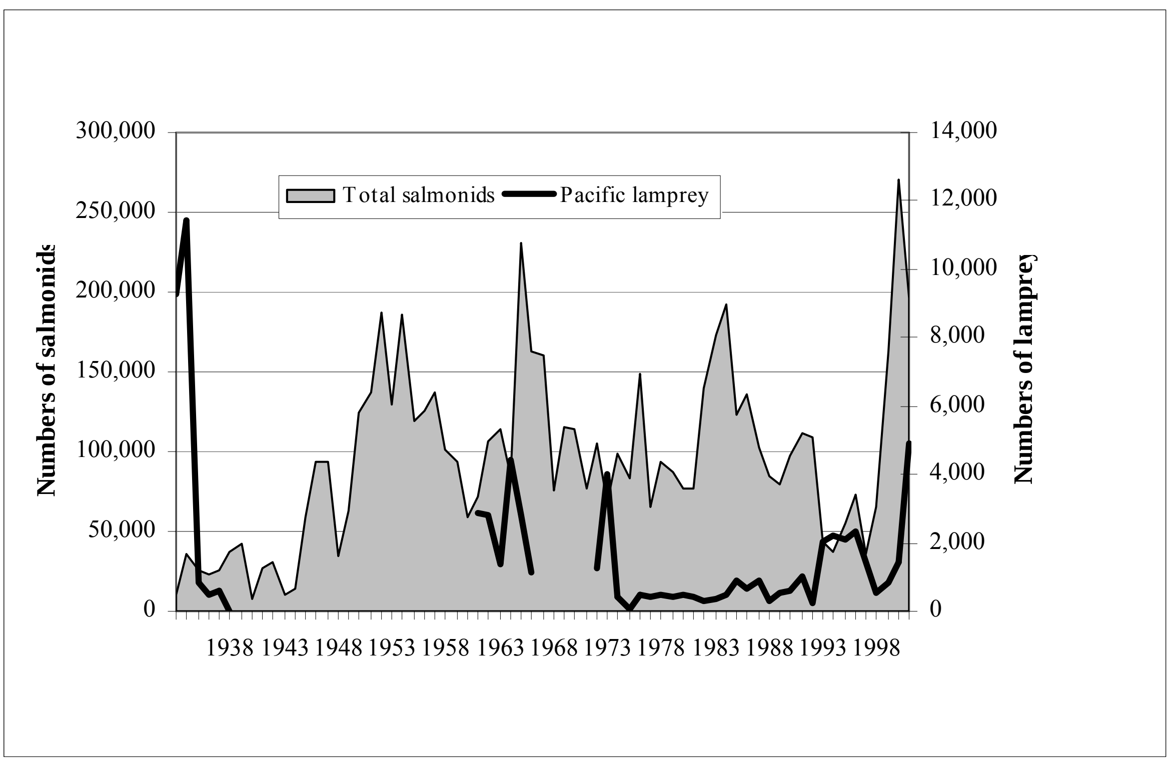
Currently, in the CCP, WSCT are found throughout the Wenatchee, Entiat, Chelan, Methow, and Okanogan River basins (Williams 1998). WSCT are found within streams and lakes throughout these basins, but spawning (for stream populations) usually occurs in the upper portions of each basin (Peven 2003). WSCT are found in the North Fork Salmon Creek, Sinlahekin headwaters, and in numerous alpine lakes (Williams 1998). They were most likely introduced into these waters (Fisher et al. 2002).). The USFS is completing a genetic analysis in 2004 for this area (Ken MacDonald personnel communication).

Limiting factors for WSCT in the Okanogan River Basin may be channel stability, habitat diversity, obstructions, temperatures and riparian. These factors need to be considered in relation to life history of WSCT (e.g., temperatures probably always limited WSCT distribution within Okanogan River streams, especially the mainstem). However, conservation of known areas of abundance would increase the likelihood that they could persist in high quality habitats. The historic temperature of the mainstem may have always limited connectivity between spawning streams in this basin, assuming that they existed at all.

Peven (2003) concluded that Westslope cutthroat appear to have expanded their range within the CCP from historic distribution, primarily from hatchery plants.

3.9.2 Pacific lamprey

Historical distribution of Pacific lamprey in the Columbia and Snake Rivers was coincident wherever salmon occurred (Simpson and Wallace 1978). A record of migration trends illustrates a significant decline in lamprey abundance over the last 50 years).



Source: Pevan 2004

Figure 21 Comparison of salmonids and Pacific lamprey ascending Rock Island Dam, 1933 – 2002

It is likely that Pacific lamprey occurred historically throughout the Okanogan basin in association with anadromous salmon (Clemens 1939). In the Okanogan Basin, Pacific lamprey were utilized by the Okanagan natives (Okanagan Historical Society, Anonymous 1954) and may have used the Okanogan River, Similkameen River, Salmon Creek, and Omak Creek.

In the upper Columbia, counts over Rock Island and Rocky Reach dams show a precipitous drop from the 1960s through the 1980s (Close et al. 1995), and appear to be rebuilding once again.

There is little information on the abundance of Pacific lamprey in the upper Columbia region. Abundance estimates are limited to counts of adults and juveniles at dams or juvenile salmonid traps. There are no estimates of redd counts or juvenile and adult counts in tributaries.

Counts of adult lamprey at dams cannot be considered total counts because there was no standardized sampling across years and counting was restricted to certain hours (BioAnalysts 2000). For example, fish counters in the past counted for a 16-hr-day shift for the main part of the salmon runs (Close et al. 1995). Because the highest movement of lamprey occurs at night (Close et al. 1995), these day counts should be considered conservative estimates.

Currently, fish counting occurs throughout the 24-hr period at most dams. At Rocky Reach and Rock Island dams, videotape or digital video record fish passage over 24 hours per day. This counting method began at Rock Island in 1992 and at Rocky Reach in 1996.

Additional problems with adult counts exist because some lamprey pass dams undetected. For example, adult lamprey can move near the bottom of the fish counting chamber making it difficult to detect them (Jackson et al. 1996). They can also bypass counting station windows by traveling behind the picketed leads at the crowder (Starke and Dalen 1995). Because of these shortcomings, adult counts at dams should only be viewed as crude indices of abundance.

Counts of juvenile lamprey at dams also suffer from sampling inconsistencies. Collection of juvenile lamprey at mainstem dams is incidental to sampling juvenile salmonids. Thus, numbers of migrants outside the juvenile salmonid migration period are unknown, since most of the literature suggests that migration occurs between fall and spring (Pletcher 1963; Beamish 1980; Richards and Beamish 1981). In addition, unknown guidance efficiencies of juvenile lamprey and unknown spill passage to turbine passage ratios reduce precise estimates of abundance (BioAnalysts 2000). Also, juveniles tend to hide in various locations in the bypass systems (Jackson et al. 1997). These problems, combined with highly variable sampling rates during periods of juvenile salmonid passage, confound estimates of juvenile lamprey abundance (BioAnalysts 2000). Juvenile counts at dams as should also be viewed as crude indices of abundance.

Large declines of adults occurred at most mainstem dams during the late 1960s and early 1970s. During the period between about 1974 and 1993, numbers of adult lamprey counted at Rock Island Dam was quite low (Figure 12). Counts of adults have increased since that time; however, this increase corresponds closely with the time that the projects began day and night counts, which may have some effect on the comparison. However, recent increases in the last few years are far greater than those in the last 10, suggesting that a true increase in abundance is occurring.

Comparing counts among different projects is problematic because of sampling inconsistencies, the behavior of lamprey in counting stations, and the ability of lamprey to bypass counting stations undetected (BioAnalysts 2000).

In summary, while it is difficult to determine the historical abundance of lamprey in the Columbia Basin, and in the CCP, circumstantial evidence suggests that they have declined. Counts of juvenile and adult lamprey fluctuate widely. It is unknown whether these fluctuations represent inconsistent counting procedures, actual population fluctuations, or both. Although these factors may make actual comparisons difficult, it appears that lamprey in the upper Columbia are increasing.

More information needs to be gathered for Pacific lamprey before any determinations of extinction risks can be made.

The American Fisheries Society's Western Division reviewed the US FWS petition to list four species of lamprey in 2001, and found strong evidence to support listing of Pacific lamprey on the Columbia, Umqua and Snake Rivers (WDAFS, 2001).

3.9.3 White sturgeon

Historically, white sturgeon moved throughout the mainstem Columbia River from the estuary to the headwaters, although passage was probably limited at times at large rapids and falls (Brannon and Setter 1992). Beginning in the 1930s, with construction of Rock Island, Grand Coulee, and Bonneville dams, migration was disrupted, because sturgeon do not pass upstream through fishways that were built for salmon, although they apparently can pass downstream (S. Hays, pers. comm.).

Current populations in the Columbia River Basin can be divided into three groups: fish below the lowest dam, with access to the ocean (the lower Columbia River); fish isolated (functionally but not genetically) between dams; and fish in several large tributaries. In the CCP, construction of Wells, Rocky Reach, Rock Island, and Wanapum Dam have disrupted upstream movement of sturgeon.

Peven (2003) concluded that white sturgeon distribution has been affected by construction of mainstem Columbia River dams. What was believed to be a relatively continuous population, traveling the length of the mainstem Columbia River below migrational barriers, is now a number of potentially disjunct populations between hydroelectric projects, although there does appear to be immigration and emigration from downstream recruitment.

3.9.4 US Rainbow Trout

In US they are present in Salmon Creek, Omak Creek, Toats Coulee, Sinlahekin Creek, Bonaparte Creek, and Tonasket Creek, and other smaller tributaries. The headwater fluvial varieties appear to have one life history pattern: to spawn and rear in upper tributaries. The population size and distribution of rainbow trout in these streams is not known (NMFS, 1998).

3.9.5 Eastern Brook Trout

Eastern Brook trout are an introduced species that is present throughout the basin. In drainages where brook trout and bull trout are both present, they hybridize. Brook trout appear to be more tolerant to disturbed habitat conditions than bull trout. Salmon Creek and Loup Loup Creek historically supported bull trout populations (*Salvelinus confluentus*). The introduction of brook trout and resulting hybridization of the two species has resulted in the decline of bull trout in the Okanogan River Basin (FWS 2000).

3.9.6 Umatilla Dace

Umatilla dace is Endangered in Canada because of an extremely small population size, restricted distribution, and limited available preferred habitat. Original habitat use by the Umatilla dace has been disrupted by the construction of dams within the watersheds. Conversely, rocks used in dike construction have increased available habitat.

Although immediate threats to populations appear to be small, one natural process that may be dangerous is eutrophication. The excessive algae that grows during the stages of eutrophication may deter Umatilla dace, as they tend to not be found around large growths of algae.

Canadian populations of Umatilla dace are found in the lower Columbia, Kettle, Kootenay, and Similkameen rivers and in parts of the Slocan River. Umatilla dace are found in the Okanagan system north of the Canadian-American border (B. Shepard, pers. Com), and it presumably could become further established if appropriate management actions are implemented. It prefers riverine habitat with cobble or stone bottom and relatively warm, productive waters.

3.10 Wildlife Focal Species and Their Habitats

3.11 Wildlife Species Richness

The Okanogan subbasin has the highest percentage (99) of species richness than any other subbasin in the Columbia Cascade Ecoprovince. The class and % of total richness in the CCP is provided in Table 20 (CCP Ecoprovince document 2003).

Ninety-nine % of the wildlife species that occur in the Ecoprovince occur in the Okanogan subbasin. In addition, 100 % of the amphibian species and 100 % of the reptile species that occur in the Ecoprovince occur in this subbasin.

Table 20. Species richness and associations for the Okanogan subbasin (IBIS 2003). – from Okanagan Subbasin Wildlife Assessment & Inventory

Class	Upper Middle Mainstem	% of Total	Total (Ecoprovince)
Amphibians	17	100	17
Birds	234	99	235
Mammals	97	98	99
Reptiles	19	100	19
Total	367	99	370
Association			
Riparian Wetlands	87		78
Other Wetlands (Herbaceous and Montane Coniferous)	56		31
All Wetlands	143		109
Salmonids	81	98	83

Representative habitat types include shrub steppe, riparian and herbaceous wetlands, and cliff, cave and talus slopes. These habitat types and their associated wildlife species are provided in Table 21

Table 21. Wildlife species occurrence by wildlife habitat type in the Okanogan subbasin (IBIS 2003).

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
American Avocet	American Badger	American Avocet
American Badger	American Beaver	American Beaver
American Crow	American Crow	American Bittern
American Goldfinch	American Dipper	American Coot
American Kestrel	American Goldfinch	American Crow
American Robin	American Kestrel	American Dipper
Bank Swallow	American Marten	American Goldfinch
Barn Owl	American Redstart	American Kestrel
Barn Swallow	American Robin	American Pipit
Barrow's Goldeneye	American Tree Sparrow	American Robin
Big Brown Bat	American Wigeon	American Wigeon
Black Bear	Bank Swallow	Baird's Sandpiper
Black-billed Magpie	Barn Owl	Bank Swallow
Black-chinned Hummingbird	Barn Swallow	Barn Owl
Black-necked Stilt	Barred Owl	Barn Swallow
Black-tailed Jackrabbit	Belted Kingfisher	Barrow's Goldeneye
Black-throated Sparrow	Big Brown Bat	Big Brown Bat
Blue Grouse	Black Bear	Black Bear
Bobcat	Black Swift	Black Swift
Brewer's Blackbird	Black-backed Woodpecker	Black Tern
Brewer's Sparrow	Black-billed Magpie	Black-billed Magpie
Brown-headed Cowbird	Black-capped Chickadee	Black-capped Chickadee
Bullfrog	Black-chinned Hummingbird	Black-chinned Hummingbird
Burrowing Owl	Black-crowned Night-heron	Black-crowned Night-heron
Bushy-tailed Woodrat	Black-headed Grosbeak	Black-necked Stilt
California Myotis	Black-tailed Deer	Black-tailed Deer
California Quail	Black-throated Gray Warbler	Blue-winged Teal
Canada Goose	Blue Grouse	Bobcat

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
Canyon Wren	Bobcat	Bobolink
Chipping Sparrow	Bobolink	Brewer's Blackbird
Chukar	Bohemian Waxwing	Brown-headed Cowbird
Cliff Swallow	Brewer's Blackbird	Bullfrog
Columbia Spotted Frog	Brown Creeper	Burrowing Owl
Columbian Ground Squirrel	Brown-headed Cowbird	California Gull
Common Garter Snake	Bullfrog	California Myotis
Common Nighthawk	Bullock's Oriole	Calliope Hummingbird
Common Poorwill	Bushy-tailed Woodrat	Canada Goose
Common Porcupine	California Myotis	Canvasback
Common Raven	California Quail	Cascade Frog
Cooper's Hawk	Calliope Hummingbird	Caspian Tern
Coyote	Canada Goose	Cedar Waxwing
Deer Mouse	Canyon Wren	Cinnamon Teal
Eastern Kingbird	Cascade Frog	Clark's Grebe
European Starling	Cassin's Finch	Cliff Swallow
Ferruginous Hawk	Cassin's Vireo	Columbia Spotted Frog
Fringed Myotis	Cedar Waxwing	Columbian White-tailed Deer
Golden Eagle	Chipping Sparrow	Common Garter Snake
Golden-mantled Ground Squirrel	Chukar	Common Loon
Gopher Snake	Cliff Swallow	Common Nighthawk
Grasshopper Sparrow	Coast Mole	Common Porcupine
Gray Flycatcher	Columbia Spotted Frog	Common Raven
Gray Partridge	Columbian Ground Squirrel	Common Yellowthroat
Great Basin Pocket Mouse	Columbian Mouse	Cooper's Hawk
Great Basin Spadefoot	Common Garter Snake	Coyote
Great Horned Owl	Common Merganser	Deer Mouse
Greater Yellowlegs	Common Nighthawk	Double-crested Cormorant
Hoary Bat	Common Porcupine	Eared Grebe
Horned Lark	Common Raven	Eastern Kingbird
Killdeer	Common Redpoll	European Starling
Lark Sparrow	Common Yellowthroat	Forster's Tern

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
Least Chipmunk	Cooper's Hawk	Fringed Myotis
Lesser Yellowlegs	Cordilleran Flycatcher	Gadwall
Little Brown Myotis	Coyote	Glaucous Gull
Loggerhead Shrike	Creeping Vole	Golden Eagle
Long-billed Curlew	Dark-eyed Junco	Great Basin Spadefoot
Long-eared Myotis	Deer Mouse	Great Blue Heron
Long-eared Owl	Double-crested Cormorant	Great Egret
Long-legged Myotis	Downy Woodpecker	Great Gray Owl
Long-tailed Vole	Dusky Flycatcher	Great Horned Owl
Long-tailed Weasel	Eastern Cottontail	Greater Yellowlegs
Long-toed Salamander	Eastern Fox Squirrel	Green-winged Teal
Mallard	Eastern Kingbird	Grizzly Bear
Merriam's Shrew	Ermine	Gyrfalcon
Mink	European Starling	Herring Gull
Montane Vole	Evening Grosbeak	Hoary Bat
Mountain Bluebird	Fisher	Hooded Merganser
Mourning Dove	Flammulated Owl	House Finch
Nashville Warbler	Fox Sparrow	Killdeer
Night Snake	Fringed Myotis	Lapland Longspur
Northern Flicker	Golden Eagle	Least Sandpiper
Northern Goshawk	Golden-crowned Kinglet	Lesser Yellowlegs
Northern Grasshopper Mouse	Golden-mantled Ground Squirrel	Lincoln's Sparrow
Northern Harrier	Gopher Snake	Little Brown Myotis
Northern Leopard Frog	Gray Catbird	Loggerhead Shrike
Northern Pocket Gopher	Gray Jay	Long-billed Curlew
Northern Rough-winged Swallow	Great Basin Spadefoot	Long-billed Dowitcher
Northern Shrike	Great Blue Heron	Long-eared Myotis
Nuttall's (Mountain) Cottontail	Great Egret	Long-eared Owl
Orange-crowned Warbler	Great Horned Owl	Long-legged Myotis
Osprey	Greater Yellowlegs	Long-tailed Vole
Pacific Chorus (Tree) Frog	Green-winged Teal	Long-tailed Weasel
Painted Turtle	Grizzly Bear	Long-toed Salamander

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
Pallid Bat	Hairy Woodpecker	Mallard
Prairie Falcon	Harlequin Duck	Marsh Wren
Pygmy Rabbit	Heather Vole	Meadow Vole
Racer	Hermit Thrush	Mink
Red-tailed Hawk	Hoary Bat	Montane Vole
Ringneck Snake	Hooded Merganser	Moose
Ring-necked Pheasant	House Finch	Mountain Lion
Rock Dove	House Wren	Muskrat
Rock Wren	Killdeer	Northern Bog Lemming
Rough-legged Hawk	Lazuli Bunting	Northern Goshawk
Rough-skinned Newt	Least Chipmunk	Northern Harrier
Rubber Boa	Lesser Yellowlegs	Northern Leopard Frog
Sage Grouse	Lewis's Woodpecker	Northern Pintail
Sage Sparrow	Lincoln's Sparrow	Northern Pygmy-owl
Sage Thrasher	Little Brown Myotis	Northern River Otter
Sagebrush Lizard	Long-eared Myotis	Northern Rough-winged Swallow
Sagebrush Vole	Long-eared Owl	Northern Shoveler
Savannah Sparrow	Long-legged Myotis	Northern Shrike
Say's Phoebe	Long-tailed Vole	Northwestern Salamander
Sharp-shinned Hawk	Long-tailed Weasel	Nutria
Sharp-tailed Grouse	Long-toed Salamander	Pacific Chorus (Tree) Frog
Short-eared Owl	Macgillivray's Warbler	Pacific Jumping Mouse
Short-horned Lizard	Mallard	Pacific Water Shrew
Side-blotched Lizard	Masked Shrew	Painted Turtle
Snow Bunting	Meadow Vole	Pallid Bat
Solitary Sandpiper	Mink	Pectoral Sandpiper
Spotted Bat	Montane Shrew	Pied-billed Grebe
Spotted Sandpiper	Montane Vole	Pine Siskin
Striped Whipsnake	Moose	Raccoon
Swainson's Hawk	Mountain Bluebird	Redhead
Tiger Salamander	Mountain Chickadee	Red-necked Grebe

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
Townsend's Big-eared Bat	Mountain Lion	Red-tailed Hawk
Townsend's Ground Squirrel	Mourning Dove	Red-winged Blackbird
Townsend's Solitaire	Muskrat	Ring-billed Gull
Turkey Vulture	Nashville Warbler	Ring-necked Duck
Vagrant Shrew	Northern Alligator Lizard	Ring-necked Pheasant
Vesper Sparrow	Northern Flicker	Roosevelt Elk
Washington Ground Squirrel	Northern Flying Squirrel	Rough-legged Hawk
Western Fence Lizard	Northern Goshawk	Rough-skinned Newt
Western Harvest Mouse	Northern Harrier	Ruby-crowned Kinglet
Western Kingbird	Northern Leopard Frog	Ruddy Duck
Western Meadowlark	Northern Pocket Gopher	Rufous Hummingbird
Western Pipistrelle	Northern Pygmy-owl	Savannah Sparrow
Western Rattlesnake	Northern River Otter	Sharp-shinned Hawk
Western Skink	Northern Rough-winged Swallow	Short-eared Owl
Western Small-footed Myotis	Northern Saw-whet Owl	Shrew-mole
Western Terrestrial Garter Snake	Northern Waterthrush	Silver-haired Bat
Western Toad	Northwestern Salamander	Snowy Owl
White-crowned Sparrow	Olive-sided Flycatcher	Solitary Sandpiper
White-tailed Jackrabbit	Orange-crowned Warbler	Song Sparrow
White-throated Swift	Osprey	Sora
Woodhouse's Toad	Pacific Chorus (Tree) Frog	Spotted Bat
Yellow-bellied Marmot	Pacific Jumping Mouse	Spotted Sandpiper
Yuma Myotis	Pacific Water Shrew	Striped Skunk
	Painted Turtle	Swainson's Hawk
	Pallid Bat	Thayer's Gull
	Pied-billed Grebe	Tiger Salamander
	Pileated Woodpecker	Townsend's Big-eared Bat
	Pine Siskin	Tree Swallow
	Prairie Falcon	Tundra Swan
	Pygmy Nuthatch	Turkey Vulture
	Raccoon	Vagrant Shrew
	Racer	Vaux's Swift

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
	Red Crossbill	Violet-green Swallow
	Red Fox	Virginia Rail
	Red-breasted Nuthatch	Western Grebe
	Red-breasted Sapsucker	Western Harvest Mouse
	Red-eyed Vireo	Western Jumping Mouse
	Red-naped Sapsucker	Western Meadowlark
	Red-tailed Hawk	Western Sandpiper
	Red-winged Blackbird	Western Screech-owl
	Ring-necked Duck	Western Small-footed Myotis
	Ring-necked Pheasant	Western Terrestrial Garter Snake
	Rough-legged Hawk	Western Toad
	Rough-skinned Newt	White-crowned Sparrow
	Rubber Boa	White-throated Swift
	Ruby-crowned Kinglet	Wilson's Phalarope
	Ruffed Grouse	Wilson's Snipe
	Rufous Hummingbird	Wood Duck
	Savannah Sparrow	Woodhouse's Toad
	Say's Phoebe	Yellow-bellied Marmot
	Sharptail Snake	Yellow-headed Blackbird
	Sharp-tailed Grouse	Yellow-rumped Warbler
	Shrew-mole	Yuma Myotis
	Silver-haired Bat	
	Snowshoe Hare	
	Solitary Sandpiper	
	Song Sparrow	
	Southern Alligator Lizard	
	Southern Red-backed Vole	
	Spotted Bat	
	Spotted Sandpiper	
	Spotted Towhee	
	Steller's Jay	

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
	Striped Skunk	
	Swainson's Hawk	
	Swainson's Thrush	
	Tailed Frog	
	Three-toed Woodpecker	
	Tiger Salamander	
	Townsend's Big-eared Bat	
	Townsend's Solitaire	
	Townsend's Warbler	
	Tree Swallow	
	Trowbridge's Shrew	
	Turkey Vulture	
	Vagrant Shrew	
	Vaux's Swift	
	Veery	
	Violet-green Swallow	
	Virginia Opossum	
	Warbling Vireo	
	Water Shrew	
	Water Vole	
	Western Bluebird	
	Western Harvest Mouse	
	Western Jumping Mouse	
	Western Pipistrelle	
	Western Rattlesnake	
	Western Screech-owl	
	Western Small-footed Myotis	
	Western Tanager	
	Western Terrestrial Garter Snake	
	Western Toad	
	Western Wood-pewee	
	White-breasted Nuthatch	

Shrub-steppe	Eastside (Interior) Riparian Wetlands	Herbaceous Wetlands
	White-crowned Sparrow	
	White-headed Woodpecker	
	White-tailed Jackrabbit	
	White-throated Swift	
	Wild Turkey	
	Williamson's Sapsucker	
	Willow Flycatcher	
	Wilson's Warbler	
	Winter Wren	
	Wood Duck	
	Woodhouse's Toad	
	Yellow Warbler	
	Yellow-bellied Marmot	
	Yellow-breasted Chat	
	Yellow-pine Chipmunk	
	Yellow-rumped Warbler	
	Yuma Myotis	

3.12 Wildlife Status

The basin is home to over two dozen species of plants and animals that are currently listed in the US and Canada as nationally Threatened, Endangered, or Vulnerable. An estimated 85% of wetland and riparian habitats in Canadian reaches are now gone (South Okanagan-Similkameen Conservation Program, 2001). A full one-third of all Red-listed species in British Columbia reside in the Okanogan. See Appendix D for classification of wildlife species within the Okanogan Subbasin.

The Okanogan Basin is an important ecological corridor for migratory megafauna. Species such as mule deer utilize the north-south corridor that connects the dry landscapes of British Columbia's interior with the grasslands to the south. In addition to important megafauna populations, this corridor is a crucial part of the flight path for many species of birds during annual migrations between summer and winter ranges.

3.13 Wildlife Focal Species Selection

Subbasin planners selected focal wildlife species based on their ability to serve as indicators of environmental health for other species, in combination with several other 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);
- special management concern or conservation status such as Threatened, Endangered, Species of Concern and management indicator species; and
- professional knowledge on species of local interest.

Wildlife species associated with focal habitats, including agriculture, are listed in Appendix B. A focal species matrix for the Okanagan Subbasin is shown in Table 22.

The pages that follow describe the wildlife focal species and focal habitat types, including limiting factors. Additional information, including information about habitat requirements, limiting factors, distribution, population trends that will be useful to recovery project planners, is included in Ashley and Stovall (unpublished report, 2004). Rugged lands (habitat of concern) are described in the Subbasin Overview. (The Subbasin Overview also includes more general descriptions of the focal habitat types and other habitat types in the Subbasin.)

3.14 Focal Wildlife Species Overview

Nine bird species and two mammalian species were selected to represent three priority habitats in the Subbasin (What about cliffs, caves and talus slopes?). Life requisite habitat attributes for each species assemblage were pooled to characterize a "range of management conditions", to guide planners in development of future habitat management strategies, goals, and objectives.

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

Establishment of conditions favorable to focal species will benefit a wider group of species with similar habitat requirements. Wildlife species associated with focal habitats including agriculture are listed in Appendix B. A focal species matrix for the Okanagan Subbasin is shown in Table 22.

Table 22 Focal species selection matrix for the Okanogan subbasin

Common Name	Focal Habitat[1]	Status[2]		Native Species	PHS	Partners in Flight	Game Species
		Federal	State				

Sage thrasher	SS	n/a	C	Yes	Yes	Yes	No
Brewer's sparrow		n/a	n/a	Yes	No	Yes	No
Grasshopper sparrow		n/a	n/a	Yes	No	Yes	No
Sharp-tailed grouse		SC	T	Yes	Yes	Yes	No
Sage grouse		C	T	Yes	Yes	No	No
Pygmy rabbit		E	E	Yes	Yes	No	No
Mule deer		n/a	n/a	Yes	Yes	No	Yes
Willow flycatcher	RW	SC	n/a	Yes	No	Yes	No
Lewis woodpecker		n/a	C	Yes	Yes	Yes	No
Red-eyed vireo		n/a	n/a	Yes	No	No	No
Yellow-breasted chat		n/a	n/a	Yes	No	No	No
American beaver		n/a	n/a	Yes	No	No	Yes
Pygmy nuthatch	PP	n/a	n/a	Yes	No	No	No
Gray flycatcher		n/a	n/a	Yes	No	No	No
White-headed woodpecker		n/a	C	Yes	Yes	Yes	No
Flammulated owl		n/a	C	Yes	Yes	Yes	No
Red-winged blackbird	HW	n/a	n/a	Yes	No	No	No

[1] SS = Shrubsteppe; RW = Riparian Wetlands; PP = Ponderosa pine; HW = Herbaceous Wetlands

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

3.15 Focal Wildlife Habitats and Representative Species

The process used to develop wildlife assessments and management plan objectives and strategies is based on the need for a landscape level holistic approach to protecting the full range of biological diversity at the Ecoprovince scale with attention to size and condition of core areas (subbasin scale), physical connections between core areas, and buffer zones surrounding core areas to ameliorate impacts from incompatible land uses. As most wildlife populations extend beyond subbasin or other political boundaries, this "conservation network" must contain habitat of sufficient extent, quality, and connectivity to ensure long-term viability of obligate/focal wildlife species. Subbasin planners recognized the need for large-scale planning that would lead to effective and efficient conservation of wildlife resources.

In response to this need, subbasin planners approached subbasin planning at two scales. The landscape scale emphasizes focal habitats and associated species assemblages that are important to Ecoprovince wildlife managers while the needs of individual species are addressed at the subbasin level.

Subbasin planners agreed with Lambeck (1997) who proposed that species requirements (umbrella species concept) could be used to guide ecosystem management. The main premise is that the requirements of a demanding species assemblage encapsulate those of many co-occurring less demanding species. By directing management efforts toward the requirements of the most exigent species, the requirements of many cohabitants that use the same habitat type are met. Therefore, managing habitat conditions for a species assemblage should provide life requisite needs for most other focal habitat obligate species.

By combining the "coarse filter" (focal habitats) with the "fine filter" (focal wildlife species assemblage) approach, Ecoprovince and 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 recovery strategies are directed towards focal species, establishment of conditions favorable to focal species will also 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 toward recovery. 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.

3.16 Selection of Focal Habitat Types and Species Assemblages

Drawing on the umbrella concept described in the technical overview above, ecoregion/subbasin planners assumed that by focusing resources primarily on selected habitat types, the needs of most listed and managed terrestrial species dependent on those habitats would be addressed during this planning period. While other listed and managed species occur within the subbasin—primarily forested habitat obligates—needs of those species are addressed primarily through the existing land management frameworks of the federal agencies within whose jurisdictions the overwhelming majority of forested habitats occur within the Okanogan subbasin (Okanogan/Wenatchee National Forest and Washington Department of Natural Resources).

Subbasin planners selected three focal habitat types: ponderosa pine, shrubsteppe, and riparian wetlands. The planners also identified rugged lands as a habitat of concern.

Ecoprovince/subbasin planners then identified an assemblage of focal species for each focal habitat type. The focal species that compose the assemblage for each focal habitat type will serve as indicators of environmental health for species that use that habitat type. The planners combined life requisite habitat attributes for each species assemblage to form a recommended range of management conditions, that, when achieved, should result in functional habitats. The rationale for using focal species assemblages is to draw immediate attention to habitat features and conditions most in need of conservation or most important in a functioning ecosystem. The corollary is that factors that affect habitat quality and integrity within the Ecoregion and subbasins also impact wildlife species. As a result, identifying and addressing limiting factors that affect focal habitats should support the needs of obligate wildlife populations as well. Planners recognize, however, that addressing factors that limit habitat does not necessarily address some anthropogenic limiting factors, including effects of human presence on wildlife species.

The focal species, focal habitat types, and habitat of concern identified in this plan will be used in other planning efforts in the Subbasin and the Ecoregion, including the South Okanagan/Similkameen Conservation Program (Canada), the Okanogan-Similkameen Conservation Corridor Program (U. S.), Ecoregional Planning (Canada and the U. S.), and Priority Habitat and Species planning (U. S.). The habitat types and their associated focal species are summarized in Ashley and Stovall, 2004.

3.16.1 Brewer's Sparrow

General Habitat Requirements

Brewer's sparrow is a sagebrush obligate species that prefers abundant sagebrush cover (Altman and Holmes 2000). 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. Knopf et al. (1990) reported that Brewer's sparrows are strongly associated throughout their range with high sagebrush vigor.

Brewer's sparrow is positively correlated with shrub cover, above-average vegetation height, bare ground, and horizontal habitat heterogeneity (patchiness). Brewer's sparrows prefer areas dominated by shrubs rather than grass. They prefer sites with high shrub cover and large patch size (Knick and Rotenberry 1995). In southwestern Idaho, the probability of habitat occupancy by Brewer's sparrows increased with increasing % shrub cover and shrub patch size; shrub cover was the most important determinant of occupancy (Knick and Rotenberry 1995).

Brewer's sparrow abundance in Washington increased significantly on sites where sagebrush cover approached the historic 10 % level (Dobler et al. 1996).

In contrast, Brewer's sparrows are negatively correlated with grass cover, spiny hopsage, and budsage (Larson and Bock 1984; Rotenberry and Wiens 1980; Wiens 1985; Wiens and Rotenberry 1981). In eastern Washington, abundance of Brewer's sparrows was negatively associated with increasing annual grass cover; higher densities occurred in areas where annual grass cover (i.e., cheatgrass) was less than 20 % (Dobler 1994). Removal of sagebrush cover to less than 10 % has a negative impact on populations (Altman and Holmes 2000).

Recommended habitat objectives include the following: patches of sagebrush cover 10-30 %, mean sagebrush height greater than 24 inches, high foliage density of sagebrush, average cover of native herbaceous plants greater than 10 %, bare ground greater than 20 % (Altman and Holmes 2000) Table 27.

Table 23 Recommended habitat objectives for plants (Altman and Holmes 2000)

Limiting Factors

Habitat loss and fragmentation, livestock grazing, introduced vegetation, fire, and predators are the primary factors affecting Brewer's sparrows. Direct habitat loss because of conversion of shrublands to agriculture coupled with sagebrush removal/reduction programs and development have significantly reduced available habitat and contributed towards habitat fragmentation of remaining shrublands. Within the entire Interior Columbia Basin, over 48% of watersheds show moderately or strongly declining trends in source habitats for this species (Wisdom et al. in press) (from Altman and Holmes 2000).

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

Introduced vegetation such as 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). 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 grasslands dominated by introduced vegetation as the fire cycle escalates, removing preferred habitat (Paige and Ritter 1998). Crested wheatgrass and other non-native annuals have also fundamentally altered the grass-forb community in many areas of sagebrush shrubsteppe, altering shrubland habitats.

Predators (of eggs and nestlings) include gopher snake (*Pituophis melanoleucus*), Townsend's ground squirrel (*Spermophilus townsendii*); other suspected predators include loggerhead shrike (*Lanius ludovicianus*), common raven (*Corvus corax*), black-billed magpie (*Pica pica*), long-tailed weasel (*Mustela frenata*), least chipmunk (*Eutamias minimus*), western rattlesnake (*Crotalus viridis*), and other snake species. Nest predation is the most significant cause of nest failure.

The American kestrel (*Falco sparverius*), prairie falcon (*Falco mexicanus*), coachwhip (*Masticophis flagellum*) have been observed preying on adult sparrows (Rotenberry et al. 1999). Wiens and Rotenberry (1981) observed significant negative correlation between loggerhead shrike and Brewer's sparrow density.

Current Distribution

Undoubtedly, the Brewer's sparrow was widely distributed throughout the lowlands of southeast Washington when it consisted of vast expanses of shrubsteppe habitat. Large-scale conversion of shrubsteppe habitat to agriculture has resulted in populations becoming localized in the last vestiges of available habitat (Smith et al. 1997). Washington is near the northwestern limit of breeding range for Brewer's sparrows (Figure 22). Birds occur primarily in Okanogan, Douglas, Grant, Lincoln, Kittitas, and Adams Counties (Smith et al. 1997).

Population Trend Status

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

Historically, the Brewer's sparrow may have been the most abundant bird in the Intermountain West (Paige and Ritter 1998) but BBS trend estimates indicate a range-wide population decline during the last twenty-five years (Peterjohn et al. 1995).

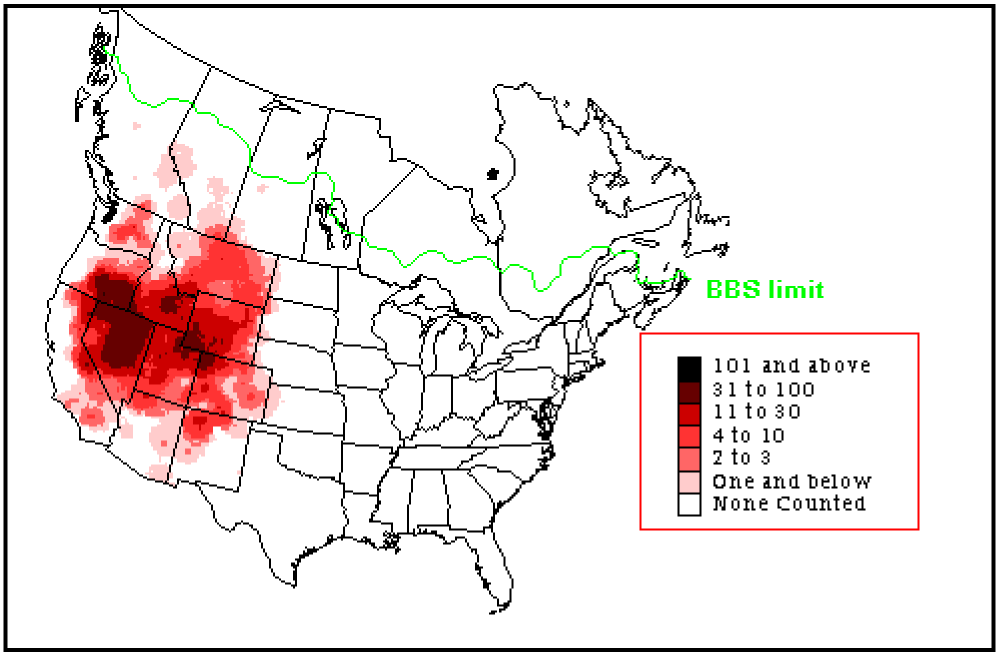
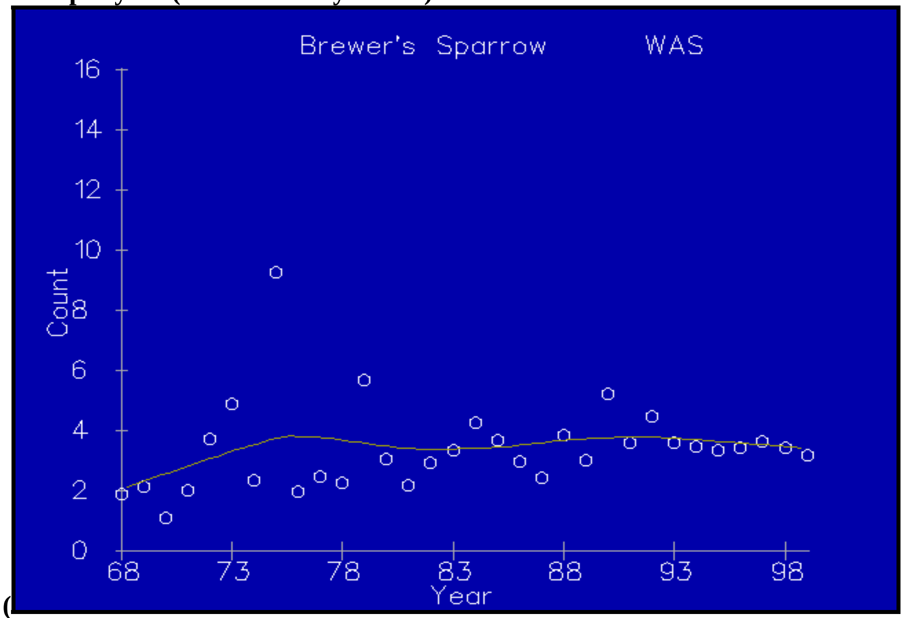


Figure 22 Brewer's sparrow breeding range and abundance (Sauer et al. 2003).

Brewer's sparrows are not currently listed as Threatened or Endangered on any state or federal list. Oregon-Washington Partners in Flight consider the Brewer's sparrow a focal species for conservation strategies for the Columbia Plateau (Altman and Holmes 2000).

Breeding Bird Survey data from 1966 to1996 show significant and strong survey-wide declines averaging -3.7% per year (n = 397 survey routes)



(Figure 23). The BBS data (1966-1996) for the Columbia Plateau are illustrated in Figure 24. Significant declines in Brewer's sparrow are evident in California, Colorado, Montana, Nevada, Oregon, and Wyoming, with the steepest significant decline evident in Idaho (-6.0 % average per year; n = 39). These negative trends appear to be consistent throughout the 30-year survey period. Only Utah shows an apparently stable population. Sample sizes for Washington are too small for an accurate estimate. Note that although positively correlated with presence of sage thrashers (Oreoscoptes montanus), probably because of similarities in habitat relations (Wiens and Rotenberry 1981), thrashers are not exhibiting the same steep and widespread declines evident in BBS data (see Sauer et al. 1997).

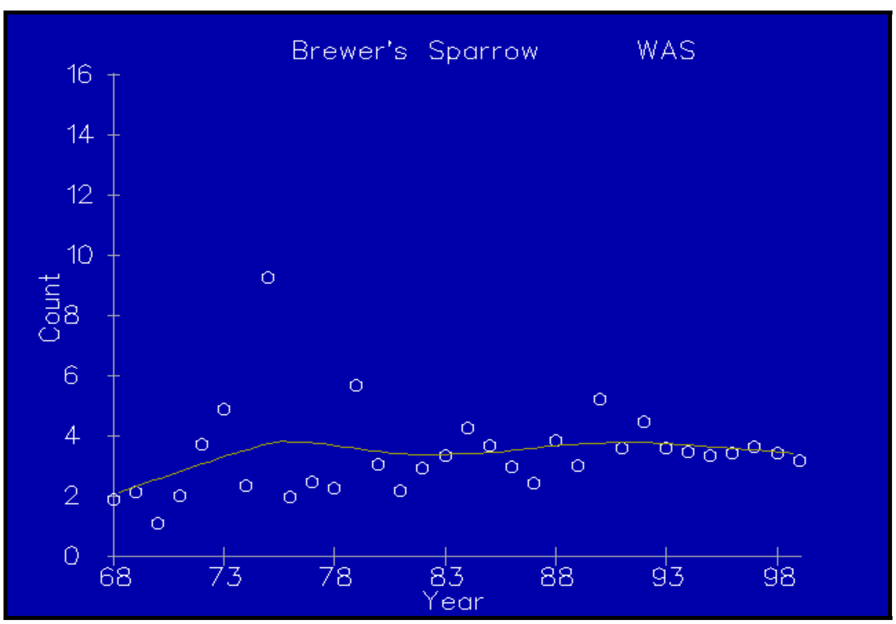


Figure 23. Breeding Bird Survey data for 1966 -1996

3.16.2 Grasshopper Sparrow

General Habitat Requirements

Grasshopper sparrows prefer grasslands of intermediate height and are often associated with clumped vegetation interspersed with patches of bare ground (Bent 1968; Blankespoor 1980; Vickery 1996). Other habitat requirements include moderately deep litter and sparse coverage of woody vegetation (Smith 1963; Bent 1968; Wiens 1969, 1970; Kahl et al. 1985; Arnold and Higgins 1986). In east central Oregon, grasshopper sparrows occupied relatively undisturbed native bunchgrass communities dominated by *Agropyron spicatum* and/or *Festuca idahoensis*, particularly north-facing slopes on the Boardman Bombing Range, Columbia Basin (Holmes and Geupel 1998). Vander Haegen et al. (2000) found no significant relationship with vegetation type (i.e., shrubs, perennial grasses, or annual grasses), but did find one with the % cover perennial grass.

In portions of Colorado, Kansas, Montana, Nebraska, Oklahoma, South Dakota, Texas, Wisconsin, and Wyoming, abundance of grasshopper sparrows was positively correlated with % grass cover, % litter cover, total number of vertical vegetation hits, effective vegetation height, and litter depth; abundance was negatively correlated with % bare ground, amount of variation in litter depth, amount of variation in forb or shrub height, and the amount of variation in forb and shrub heights (Rotenberry and Wiens 1980).

Grasshopper sparrows occasionally inhabit cropland, such as corn and oats, but at a fraction of the densities found in grassland habitats (Smith 1963; Smith 1968; Ducey and Miller 1980; Basore et al. 1986; Faanes and Lingle 1995; Best et al. 1997).

Limiting Factors

The principal post-settlement conservation issues affecting grasshopper sparrow populations include: habitat loss and fragmentation resulting from conversion to agriculture; and habitat degradation and alteration from livestock grazing, invasion of exotic vegetation, and alteration of historic fire regimes.

Fragmentation resulting from agricultural development or large fires fueled by cheatgrass can have several negative effects on land birds. These include: insufficient patch size for area-dependent species, and increases in edges and adjacent hostile landscapes, which can result in reduced productivity through increased nest predation, nest parasitism, and reduced pairing success of males. Additionally, habitat fragmentation has likely altered the dynamics of dispersal and immigration necessary for maintenance of some populations at a regional scale. In a recent analysis of neotropical migratory birds within the Interior Columbia Basin, most species identified as being of "high management concern" were shrubsteppe species (Saab and Rich 1997) that include the grasshopper sparrow.

Making this loss of habitat even more severe is that the grasshopper sparrow like other grassland species shows a sensitivity to the grassland patch size (Herkert 1994; Samson 1980; Vickery 1994; Bock et al. 1999). Herkert (1991) found that grasshopper sparrows in Illinois were not present in grassland patches smaller than 74 acres despite the fact that their published average territory size is only about 0.75 acres. Minimum requirement size in the Northwest is unknown.

Grazing can trigger a cascade of ecological changes, the most dramatic of which is the invasion of non-native grasses escalating the fire cycle and converting sagebrush shrublands to annual grasslands. Historical heavy livestock grazing altered much of the sagebrush range, changing plant composition and densities. West (1988, 1996) estimates less than 1% of sagebrush steppe habitats remain untouched by livestock; 20 % is lightly grazed, 30 % moderately grazed with native understory remaining, and 30 % heavily grazed with understory replaced by invasive annuals. The effects of grazing in sagebrush habitats are complex, depending on intensity, season, duration and extent of alteration to native vegetation. Extensive and intensive grazing in North America has had negative impacts on this species (Bock and Webb 1984).

The grasshopper sparrow has been found to respond positively to light or moderate grazing in tallgrass prairie (Risser et al. 1981). However, it responds negatively to grazing in shortgrass, semi-desert, and mixed grass areas (Bock et al. 1984).

The degree of degradation of terrestrial ecosystems is often diagnosed by the presence and extent of alien plant species (Andreas and Lichvar 1995); frequently their presence is related to soil disturbance and overgrazing. Increasingly, however, aggressive aliens are becoming established even in ostensibly undisturbed bunchgrass vegetation, wherever their seed can reach.

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).

Studies on the effects of burns on grassland birds in North American grasslands have shown similar results as grazing studies: namely, bird response is highly variable. Confounding factors include timing of burn, intensity of burn, previous land history, type of pre-burn vegetation, presence of fire-tolerant exotic vegetation (that may take advantage of the post-burn circumstances and spread even more quickly) and grassland bird species present in the area.

It should be emphasized that much of the variation in response to grassland fires lies at the level of species, but that even at this level results are often difficult to generalize. For instance, mourning doves have been found to experience positive (Bock and Bock 1992; Johnson 1997) and negative (Zimmerman 1997) effects by fire in different studies. Similarly, grasshopper sparrows have been found to experience positive (Johnson 1997), negative (Bock and Bock 1992; Zimmerman 1997; Vickery et al. 1999), and no significant (Rohrbaugh 1999) effects of fire. Species associated with short and/or open grassy areas will most likely experience short-term benefits from fires. Species that prefer taller and denser grasslands most likely will demonstrate a negative response to fire (CPIF 2000).

Mowing and haying affects grassland birds directly and indirectly. It may reduce height and cover of herbaceous vegetation, destroy active nests, kill nestlings and fledglings, cause nest abandonment, and increase nest exposure and predation levels (Bollinger et al. 1990). Studies on grasshopper sparrow have indicated higher densities and nest success in areas not mowed until after July 15 (Shugaart and James 1973; Warner 1992). Grasshopper sparrows are vulnerable to early mowing of fields, while light grazing, infrequent and post-season burning or mowing can be beneficial (Vickery 1996).

Grasshopper sparrows may be multiply parasitized (Elliott 1976, 1978; Davis and Sealy 2000). In Kansas, cowbird parasitism cost grasshopper sparrows about two young/parasitized nest, and there was a low likelihood of nest abandonment occurring because of cowbird parasitism (Elliott 1976, 1978).

Current Distribution

Grasshopper sparrows are found from North to South America, Ecuador, and in the West Indies (Vickery 1996; AOU 1957). They are common breeders throughout much of the continental United States, ranging from southern Canada south to Florida, Texas, and California. Additional populations are locally distributed from Mexico to Colombia and in the West Indies (Delany et al. 1985; Delany 1996; Vickery 1996).

The subspecies breeding in eastern Washington is *Ammodramus savannarum perpallidus* which breeds from northwest California, where it is uncommon, into eastern Washington, northeast and southwest Oregon, where it is rare and local, into southeast British Columbia, where it is considered Endangered, east into Nevada, Utah, Colorado, Oklahoma, Texas, and possibly to Illinois and a (Vickery 1996).

3.16.3 Sharp-tailed Grouse

General Habitat Requirements

The Columbian sharp-tailed grouse (CSTG) is one of six subspecies of sharp-tailed grouse and the only one found in Washington. Native habitats important for CSTG include grass-dominated nesting habitat and deciduous shrub-dominated wintering habitat, both of which are critical for sharp-tailed grouse (Giesen and Connelly 1993; Connelly et al. 1998).

Residual grasses and forbs are necessary for concealment and protection of nests and broods during spring and summer (Hart et al. 1952; Parker 1970; Oedekoven 1985; Marks and Marks 1988; Meints 1991; Giesen and Connelly 1993). Preferred nest sites are on the ground in relatively dense cover provided by clumps of shrubs, grasses, and/or forbs (Hillman and Jackson 1973). Fields enrolled in agricultural set-aside programs are often preferred. Giesen (1987) reported density of shrubs less than 3 feet tall were 5 times higher at nest sites than at random sites or sites 33 feet from the nest.

Meints (1991) found that mean grass height at successful nests averaged less than 1 foot, while 7 inches was the average at unsuccessful nests. Hoffman (2001) recommended that the minimum height for good quality nesting and brood-rearing habitat is 8 inches, with 1 foot being preferred. Bunchgrasses, especially those with a high percentage of leaves to stems like bluebunch wheatgrass, is preferred by nesting sharp-tailed grouse over sod-forming grasses such as smooth brome.

Columbian sharp-tailed grouse are able to tolerate considerable variation in the proportion of grasses and shrubs that comprise suitable nesting habitat, but the most important factor is that a certain height and density of vegetation is required. Canopy coverage and visual obstruction are greater at nest sites than at independent sites (Kobriger 1980; Marks and Marks 1987; Meints 1991).

After hatching, hens with broods move to areas where succulent vegetation and insects can be found (Sisson 1970; Gregg 1987; Marks and Marks 1987; Klott and Lindzey 1990). In late summer, riparian areas and mountain shrub communities are preferred (Giesen 1987).

Food items in the spring and summer include wild sunflower (*Helianthus* spp.), chokecherry, sagebrush, serviceberry, salsify (*Tragopogon spp*.), dandelion (*Taraxacum* spp.), bluegrass, and brome (Hart et al. 1952; Jones 1966; Parker 1970). Although juveniles and adults consume insects, chicks eat the greatest quantity during the first few weeks of life (Parker 1970; Johnsgard 1973). In winter, CSTG commonly forage on persistent fruits and buds of chokecherry, serviceberry, hawthorn, snowberry, aspen, birch, willow, and wild rose (Giesen and Connelly 1993; Schneider 1994).

Columbian sharp-tailed grouse numbers have drastically declined in Washington over the past 100 years, and they are now a federally and state listed species. The breeding population of sharp-tailed grouse in Washington is currently estimated at 380. Shrubsteppe and riparian habitat are critical habitat for sharp-tailed grouse, and both have been heavily manipulated in the basin (OWSAC, 2000). The USFWS recently issued a 90-day Finding on a petition to list sharp-tailed grouse as Threatened under the ES (USFWS, 1999).

According to early explorers sharp-tails used to be plentiful in Eastern Washington. A total of 112 sharp-tailed grouse leks (courtship areas) were documented between 1954 and 1994. Lek counts are used to estimate population size and stability. The number of males per lek and active leks also indicate stability of the population. Males per lek declined from 13 in 1954 to 5 in 1994. In Douglas County from 1954 to 1994, 46% of active leks disappeared, 65% disappeared in Okanogan County, and 61% disappeared in Lincoln County.

Limiting Factors

The primary factors affecting the continued existence of sharp-tailed grouse in Washington relate to habitat loss and alteration and the precarious nature of small, geographically isolated subpopulations. Three of the major factors that contributed to the decline of sharp-tailed grouse and their habitat in Washington are still threats today: conversion to agriculture, conversion to pastureland for livestock, and overgrazing. The removal of shrubs as part of agricultural practices reduces the quantity and quality of winter habitat, and the degradation of shrub and meadow steppe habitat as a result of livestock management reduces the quality of breeding habitat. The remaining subpopulations are small and isolated from one another, which increases the risk of extirpation.

Population isolation is potentially a major factor influencing the continued existence of sharp-tailed grouse in Washington. As grouse populations naturally fluctuate because of environmental conditions, the lower the population level, the greater the risk of extirpation. The isolation of populations may have important ramifications for their genetic quality and recruitment (Lacy 1987). It may require human transport of individuals to counteract loss of fitness because of genetic drift.

It is not clear if the Washington populations are declining because of their isolation or because of a combination of other factors. Initial evidence (M. Schroeder, pers. comm.) indicates that most movements of radio-marked birds are insufficient to allow interchange of individuals among populations in north-central Washington. Although current estimates of the total population range up to 1000 individuals, it is divided among eight small isolated subpopulations. Four of these populations are estimated to contain fewer than 25 birds. These populations are under immediate threat of extirpation (Reed et al. 1986).

Near-term extirpation risks because of population size are present for two of three other populations remaining outside the Colville Tribes Reservation (Gilpin 1987), as less than 100 individuals are estimated at each site (M. Schroeder, pers. comm.). These populations are likely much less tolerant of environmental changes, such as habitat degradation and weather extremes, than populations in Lincoln County and the Colville Tribes Reservation. Predation is more of a concern for these very small populations than it would be for larger populations in good habitat.

A wide variety of genetic problems can occur with small populations, and these genetic problems can interact with demographic and habitat problems and lead to extinction (Gilpin and Soule 1986). Overall threats to sharp-tailed grouse are greater with individuals spread through small subpopulations than one larger population.

Sharp-tails in Douglas and Okanogan counties, and to a lesser degree in Lincoln County, are now restricted to high-elevation areas, specifically those areas that have both shrubs and grasses (Schroeder 1996). High winter mortality resulting from declining quantity and quality of winter habitat is likely the most significant factor causing the decline in the sharp-tail population in Washington (Schroeder 1996). Protecting and enhancing high quality habitat where sharp-tails continue to concentrate, and restoring key low-elevation winter sites is vital to conservation of sharp-tailed grouse in Washington.

Habitat quality overall is improving for sharp-tailed grouse in Lincoln County, where WDFW and the Bureau of Land Management are actively managing habitat for sharp-tailed grouse. Continuation of lands enrolled in the Conservation Reserve Program is also important to improve habitat quality in Lincoln and Douglas counties. WDFW acquisition of lands in Okanogan County near Tunk Valley, Chesaw and Conconully should also result in improving habitats. Private and tribal lands with sharp-tailed grouse that are grazed change in habitat quality with the intensity of grazing. Trends on these grazed lands are not predictable.

Increases in grazing pressure on currently occupied sharp-tailed grouse habitat is a principal threat to the continued existence of populations. In general, when grazing by livestock reduces the grass and forb component, sharp-tailed grouse are excluded (Hart et al. 1950, Brown 1966b, Parker 1970, Zeigler 1979). Loss of deciduous cover is especially severe near riparian areas that attract livestock in summer because of water and shade; this cover provides critical foraging areas and escape cover for sharp-tails throughout the year (Zeigler 1979, Marks and Marks 1987a). Trampling, browsing, and rubbing decrease the annual grass and forbs, deciduous trees, and shrubs needed for food and shelter in winter (Parker 1970, Kessler and Bosch 1982, Marks and Marks 1987a). Mattise (1978) found overgrazing very detrimental in nesting and brood-rearing habitat.

In Montana, Brown (1968) reported that the reduction in habitat because of intensive livestock grazing resulted in the elimination of sharp-tails in particular areas. Sharp-tails were observed shifting use to ungrazed areas following livestock use of traditional sites (Brown 1968). Marks and Marks (1988) also found sharp-tails in western Idaho selecting home ranges that were least modified by livestock grazing.

The effects of grazing on sharp-tailed grouse reported vary and appear to depend primarily on intensity, duration of grazing, kind of livestock, site characteristics, precipitation levels, and past and present land-use practices. Grazing systems currently used in range management include seasonal, deferred, and rotation grazing (Stoddard, et al. 1975). Hart et al. (1950) found light to moderate grazing benefiting landowners and sharp-tails on the foothills and benchlands of Utah. Weddell (1992) concluded that rest rotation and deferred grazing were less detrimental to sharp-tailed grouse than season-long grazing, and suggested the disadvantages of increasing grazing under any of these systems outweigh the advantages for sharp-tailed grouse. Even light to moderate grazing can be detrimental in areas with a history of overgrazing, because it may prevent recovery of the native vegetation.

Kessler and Bosch (1982) surveyed sharp-tailed grouse management practices and concluded that grazing and the resulting habitat loss are the most serious threats to sharp-tailed grouse survival. Their survey of states and provinces with past or present Columbian sharp-tailed grouse populations found respondents regarded low intensity grazing as beneficial and high intensity grazing to be negative in its effects on sharp-tails (Kessler and Bosch 1982). Twenty % more respondents found moderate grazing negative in its effects and twice as many preferred deferred and rest rotation over continuous grazing. Five of the seven states or provinces with Columbian sharp-tailed grouse listed overgrazing as a major issue/problem related to maintaining this species and its habitat (Braun 1991).

Grazing is a continuing threat to sharp-tailed grouse because of unpredictable changes in land ownership, grazing economics, and the needs of private landowners. Grazing pressure is increasing in several important sharp-tail areas in Washington (M. Schroeder, pers. comm.).

The removal of CRP habitat in Lincoln, Douglas, and Okanogan counties could cause further declines in sharp-tailed grouse numbers. Contracts for approximately 318,000 ha expired in 1997. Washington farmers submitted applications for new contracts on 239,000 ha and nearly 196,000 ha were accepted. CRP lands placed back into grain production could cause further declines in the number of sharp-tailed grouse, depending upon how sharp-tailed grouse use these areas. CRP land and other habitat enhancement areas must be near existing sharp-tail populations to be beneficial (Meints et al. 1992). Although the WDFW is assisting landowners in applying for CRP funding, the long-term status of these areas is uncertain.

The loss of deciduous trees and shrubs by chemical control was associated with declining sharp-tail populations in Washington (Zeigler 1979) and Utah (Hart et al. 1950). Chemical treatment of vegetation in sharp-tailed grouse habitat is detrimental because of the direct loss of vegetation (McArdle 1977, Blaisdell et al. 1982, Oedekoven 1985, Klott 1987). Kessler and Bosch (1982) found most biologists regarded chemical brush control as a negative management practice for sharp-tails. However, in Michigan, herbicidal treatment was used to open dense areas and provide more adequate sharp-tailed grouse habitat (Van Etten 1960). In Washington, continued use of herbicides to control sagebrush and other vegetation may cause additional reductions in sharp-tailed grouse habitat.

Fire is a continual threat to sharp-tailed grouse populations. Fire has become a major tool for altering large blocks of sagebrush rangelands. In Lincoln County, three large prescribed fires and one chemical control of sagebrush in the 1980s in areas containing active leks, were believed to be directly responsible for the decline of both sharp-tailed and sage grouse populations (Merker 1988). McArdle (1977) found less use by sharp-tails in burned areas compared to other vegetation manipulations. Likewise, Hart et al. (1950) reported Columbian sharp-tails abandoning a lek site following a fire, which also caused accelerated erosion, loss of nests, and loss of winter food and cover.

Under some circumstances, burning can help improve sharp-tailed grouse habitat. Burning dense sagebrush and thickly wooded areas was found to improve sharp-tailed grouse habitat in Utah (Hart et al. 1950), North Dakota (Kirsh et al. 1973), Colorado (Rogers 1969), and Wyoming (Oedekoven 1985). In Manitoba and British Columbia, a large movement of sharp-tailed grouse occurred from a high-use lek site to a burned area following a fire that eliminated all residual grass and forbs but did not greatly affect shrub or tree cover.

Modern fire suppression policies have allowed conifers to invade bunchgrass-prairie habitats in some areas to the detriment of sharp-tailed grouse populations. In these situations, prescribed burning may be effective in maintaining suitable habitats (Giesen and Connelly 1993). In Washington, prescribed fire is not recommended in shrub/meadow steppe but may be acceptable for creating habitat where conifers have invaded traditional shrub/meadow steppe areas.

Current Distribution

Currently, Columbian sharp-tails occupy <10 % of their historic range in Idaho, Montana, Utah, Wyoming, and Washington; approximately 50 % in Colorado, and 8% in British Columbia (Oedekoven 1985; Sullivan 1988; Ritcey 1995). Columbian sharp-tailed grouse are extirpated from California and possibly Oregon and Nevada (Wick 1955; Evanich 1983; Oedekoven 1985). Possible sightings in Nevada (Goose Creek south of Twin Falls, Idaho) and Oregon (Baker County) were recently reported (Braun 1991). Columbian sharp-tails are being reintroduced in Oregon (Starkey and Schnoes 1979; Crawford 1986).

The current range of Columbian sharp-tailed grouse in Washington consists of eight small, severely fragmented populations in Douglas, Lincoln, and Okanogan Counties. Sightings of sharp-tails were reported in Asotin County in the mid-1980s; however, the Idaho Department of Fish and Game transplanted sharp-tails in Idaho at that time, and some probably dispersed to Asotin County. Sharp-tailed grouse found outside Douglas, Lincoln, and Okanogan Counties are likely transient birds that periodically occupy pockets of remaining shrub/meadow steppe. They contribute little to the statewide population in terms of reproduction or genetics.

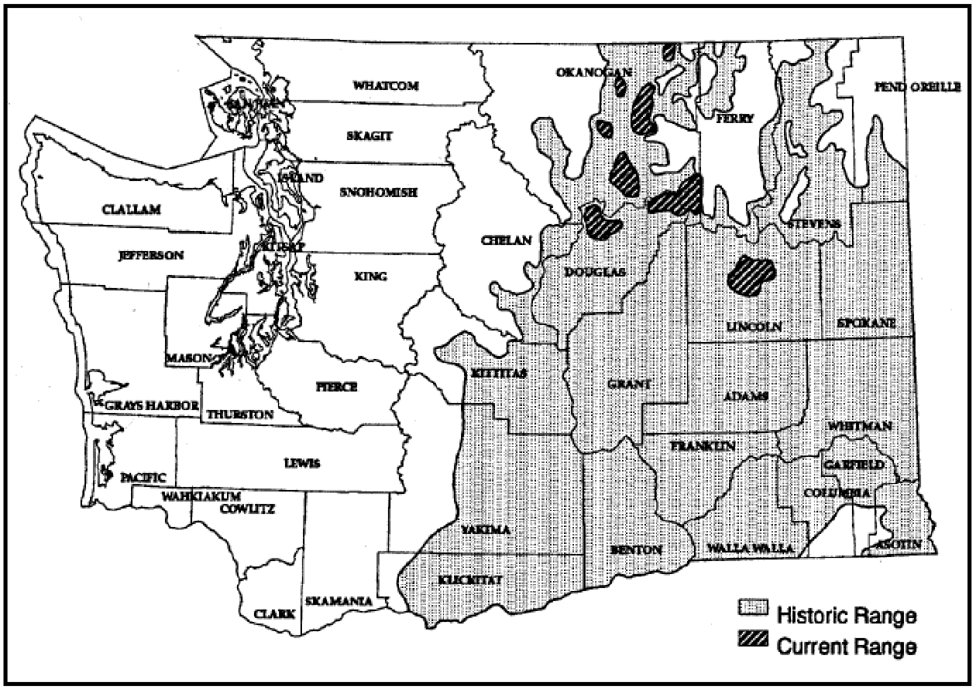


Figure 24 Historic and current range of sharp-tailed grouse in Washington (Hays et al. 1998).

Population Trend Status

The 1997 breeding population of sharp-tailed grouse in Washington has been estimated through lek counts and a population model. During spring surveys, 358 grouse were counted on 44 leks in 3 counties (Table 24). A model based on scientific literature, input and survey data from WDFW biologists, and current research in Washington was used to estimate the size of the 1997 breeding population.

Table 24 Results of 1997 sharp-tailed grouse lek counts in Washington (Hays et al. 1998).

County	Birds	Leks	Birds/lek
Okanogan	169	17	9.9
Lincoln	88	10	8.8
Okanogan (off Colville Reservation)	59	9	6.5
Douglas	42	8	5.3
TOTAL	358	44	8.1

The model assumed all leks were known and surveyed, all males were on leks during counts, and the male to female sex ratio was 1:1. This model would underestimate actual population size if some leks were not located, if all males were not on leks during counts, if the sex ratio was not 1:1, and if surveys were flawed (e.g., bad weather, incomplete counts, etc.).

The model would overestimate actual population size if lek counts included females (which are difficult to distinguish). The population estimate based on the model is 716 sharp-tailed grouse in Washington in 1997 (Table 25). Allowing for additional unsurveyed habitat, M. Schroeder (pers. comm.) suggests as many as 1000 sharp-tailed grouse may remain in Washington.

Table 25. Estimated size of the Washington sharp-tailed grouse breeding population in 1997

Sex	Population Estimate	Estimate Source
Male	358	Statewide lek counts
Female	358	1:1 sex ratio
TOTAL	716	Males + Females

The remaining sharp-tailed grouse in Washington are distributed in eight fragmented subpopulations. Of these, the subpopulation on the Colville Tribes Reservation is the largest remaining in the state (Table 26). It is estimated to include about 352 grouse and is considered self-sustaining. Of the subpopulations outside of the Reservation, the largest population is in western Lincoln County (177 birds).

The subpopulation south of Bridgeport in Douglas County contains about 31 birds. Outside the reservation, Okanogan County supports a total of only 138 birds. This includes four subpopulations that each support fewer than 25 grouse and they are likely unstable and near extirpation. Sharp-tailed grouse in each of the eight geographic areas (Figure_45) appear to be isolated (Schroeder 1996).

Table 26 Sharp-tailed Grouse populations in the State of Washington

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Structural Condition Associations

Several environmental and habitat changes appear to have led to improved sage grouse and sharp-tailed grouse populations. Sharp-tails are present in Douglas, Lincoln, and Okanogan counties. Areas supporting the most sharp-tails include West Foster Creek, East Foster Creek, Cold Springs Basin, and Dyer Hill in Douglas County; Swanson Lakes Wildlife Area in Lincoln County; and the Tunk Valley and Chesaw Units of the Scotch Creek Wildlife Area in the Okanogan Basin. Ziegler (1979) documented a 51% decline in waterbirch and aspen from 1945 to 1977 in Johnson Creek.

Waterbirch buds are the primary food of sharp-tailed grouse during the winter (Hays et al., 1988). In addition, 13% of landowners contacted in Okanogan County were planning to remove waterbirch or aspen (OWSAC, 2000). Much winter habitat in Okanogan County has been lost to residential development. One lek was destroyed by a recreational subdivision (OWSAC, 2000). Hofmann and Dobler (1988a) also reported the loss of waterbirch in two locations in Okanogan County in less than three months of observation. Sharp-tails no longer used these areas after waterbirch was removed (Hofmann and Dobler, 1988a).

WDFW has an active survey and management program for sharp-tailed grouse because of their state-listed status, and the Okanogan population is considered to be one of the last strongholds for the species. There is an augmentation program underway. Populations and habitat are surveyed annually. Birds are transplanted from elsewhere, research is underway, and WDFW is pursuing land acquisition for habitat.

The Colville Tribes is currently managing sharp-tailed grouse within the Reservation boundaries to eliminate habitat alteration, fragmentation, and human-caused events that put these populations at risk. The Colville Tribes has recently begun a study of this species in coordination with Washington State University to address limiting factors and habitat restoration within the region.

Sharp-tailed grouse structural conditions and association relationships are shown in Table 27.

Table 27 Sharp-tailed grouse structural conditions and association relationships (IBIS 2003).

Common Name	Focal Habitat	Structural Condition (SC)	SC Activity	SC Assoc.
Sharp-tailed Grouse	Shrubsteppe	Grass/Forb-Closed	B	C
		Grass/Forb-Open	B	C
		Low Shrub-Open Shrub Overstory-Mature	B	C
		Low Shrub-Open Shrub Overstory-Old	B	A
		Low Shrub-Open Shrub Overstory-Seedling/Young	B	C
		Medium Shrub-Open Shrub Overstory-Mature	B	A
		Medium Shrub-Open Shrub Overstory-Old	B	P
		Medium Shrub-Open Shrub Overstory-Seedling/Young	B	C

3.16.4 Mule Deer

General Habitat Requirements

Mule deer occupy a variety of habitat 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 and snow intercept, thermal, and escape cover.

Mule deer occupying mountain-foothill habitats live within a broad range of elevations, climates, and topography that 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 channeled scablands of eastern Washington; these areas are dominated by native bunch grasses or shrubsteppe vegetation. Mule deer also occupy agricultural areas which once where shrubsteppe.

Limiting Factors

Mule deer and their habitats are being impacted in a negative way by dam construction, 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 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 cause 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 conditions in the Ecoprovince have deteriorated in some areas and improved dramatically in others. The conversion of shrubsteppe and grassland habitat to agricultural croplands has resulted in the loss of thousands of acres of mule deer habitat. However, this has been mitigated to some degree by the implementation of the CRP. Noxious weeds have invaded many areas resulting in a tremendous loss of good habitat for mule deer.

Fire suppression has resulted in a decline of habitat conditions in the mountains and foothills of the Cascade Mountains. 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).

The reservoirs created by dams on the Columbia River inundated prime riparian habitat that supported many species of wildlife, including mule deer. This riparian zone provided high quality habitat (forage/cover), especially during the winter months. The loss of this important habitat and the impact it has had on the mule deer population along the breaks of the Columbia River may never be fully understood.

Current Distribution

Deer damage is a chronic problem in the Omak district. During severe winters, deer are often forced onto low elevation private property in close proximity to human development. At such times, damage to orchards, haystacks, and landscaping can be significant" (OWSAC, 2000).

The WDFW conducts annual mule deer and white-tail deer population surveys, and manages its wildlife areas for winter mule deer range. The USFS and WDNR also manage portions of their lands for winter deer range.

The Colville Tribes is a major financial contributor to, and is involved in, an ongoing long-term mule deer study with WFWD, Chelan Co. PUD, Forest Service, Inland NW Wildlife Council, WSU, UW, and UI. Colville Tribes is actively monitoring habitat, limiting factors and population trends. Colville Tribes performs annual aerial surveys, regulates tribal hunting seasons and manages hunter check stations.

Population Trend Status

Mule deer populations have varied dramatically throughout recorded history of the region. In the 1800s mule deer populations were reported to be extremely low (OWSAC, 2000). In the 1900s, deer populations fluctuated widely, with historic highs in the 1950s and 1960s.

Population lows are because of a number of factors, including severe weather conditions, overused winter range, and hunting pressure. Severe winter weather conditions have significantly reduced mule deer populations since 1992. The winter of 1996/97 was especially hard on the local herds.

Qualitative observations from land managers, biologists, and long time residents, and harvest figures, suggest the populations may be half of what it was in the mid 1980s and early 1990s (OWSAC, 2000).

A shorter season and reduced number of hunters in 1997 along with easier overwintering conditions during the 1997/98 winter has been beneficial to the herds (OWSAC, 2000).

Mule deer on the reservation are suffering long –term declines attributed to habitat changes, habitat fragmentation, severe weather conditions and overgrazing. Data from Colville Tribes aerial trend counts indicate severe declines in both mule deer and white-tail populations. (Sanpoil Subbasin Summary). Mule deer are important for cultural and subsistence reasons.

Mule deer structural conditions and association relationships are shown inTable 28.

Table 28 Mule deer structural conditions and association relationships (IBIS 2003).

Common Name	Focal Habitat	Structural Condition (SC)	SC Activity	SC Assoc.
Mule Deer	Shrubsteppe	Grass/Forb-Closed	B	A
		Grass/Forb-Open	B	A
		Low Shrub-Closed Shrub Overstory-Mature	B	A
		Low Shrub-Closed Shrub Overstory-Old	B	A
		Low Shrub-Closed Shrub Overstory-Seedling/Young	B	A
		Low Shrub-Open Shrub Overstory-Mature	B	A
		Low Shrub-Open Shrub Overstory-Old	B	A
		Low Shrub-Open Shrub Overstory-Seedling/Young	B	A
		Medium Shrub-Closed Shrub Overstory-Mature	B	A
		Medium Shrub-Closed Shrub Overstory-Old	B	A
		Medium Shrub-Closed Shrub Overstory-Seedling/Young	B	A
		Medium Shrub-Open Shrub Overstory-Mature	B	A
		Medium Shrub-Open Shrub Overstory-Old	B	A
		Medium Shrub-Open Shrub Overstory-Seedling/Young	B	A
		Tall Shrub-Closed Shrub Overstory-Mature	B	A
		Tall Shrub-Closed Shrub Overstory-Old	B	A
		Tall Shrub-Closed Shrub Overstory-Seedling/Young	B	A

Common Name	Focal Habitat	Structural Condition (SC)	SC Activity	SC Assoc.
		Tall Shrub-Open Shrub Overstory-Mature	B	A
		Tall Shrub-Open Shrub Overstory-Old	B	A
		Tall Shrub-Open Shrub Overstory-Seedling/Young	B	A

3.16.5 Red-eyed Vireo

General Habitat Requirements

Partners in Flight established biological objectives for this species in the lowlands of western Oregon and western Washington. These include providing habitats that meet the following definition: mean canopy tree height greater than 50 feet, mean canopy closure greater than 60 %, young (recruitment) sapling trees greater than 10 % cover in the understory, riparian woodland greater than 64 feet wide (Altman 2001). Red-eyed vireos are closely associated with riparian woodlands and black cottonwood stands and may use mixed deciduous stands.

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

Limiting Factors

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

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

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

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

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

Current Distribution

The North American breeding range of the red-eyed vireo extends from British Columbia to Nova Scotia, north through parts of the Northwest Territories, and throughout most of the lower United States (Figure 25). They migrate to the tropics for the winter.

The patchy distribution in Washington for this species correlates with the distribution of large black cottonwood (*Populus trichocarpa*) groves, which are usually limited to riparian areas. The red-eyed vireo is one of the most abundant species in the northeastern United States, but is much less common in Washington because of limited habitat. Red-eyed vireo breeding and summer distribution is illustrated in Figure 26 and Figure 27.

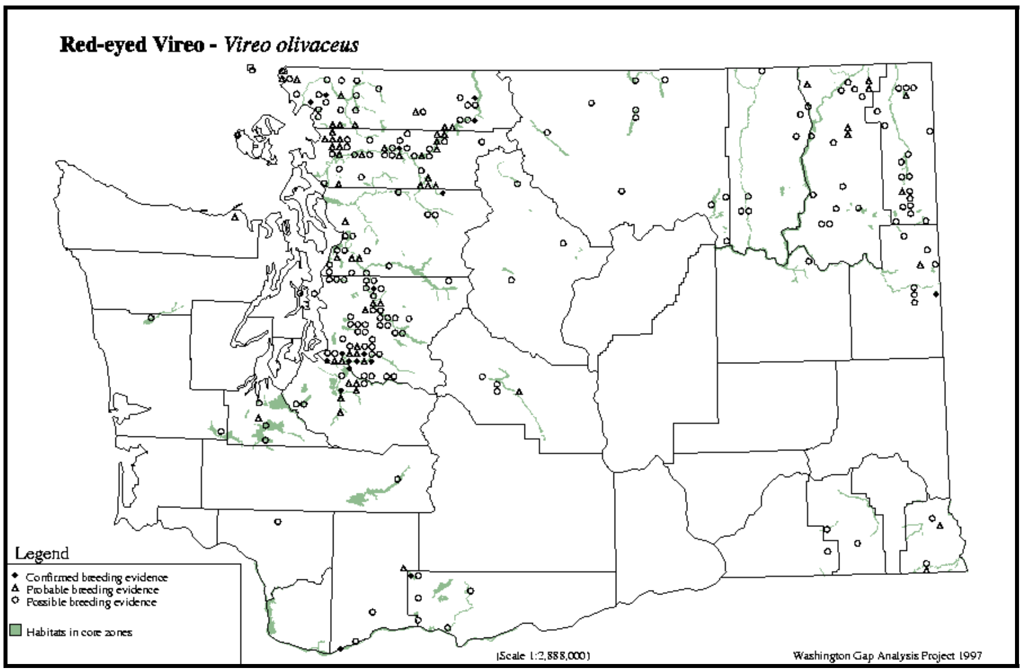

Figure 25. Breeding bird atlas data (1987-1995) and species distribution for red-eyed vireo (Washington GAP Analysis Project 1997).

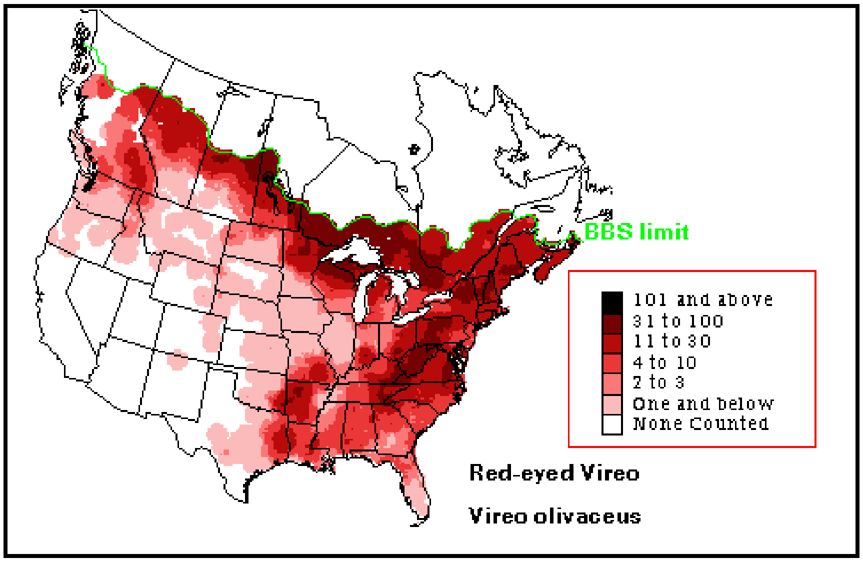

Figure 26. Red-eyed vireo breeding distribution (Sauer et al. 2003).

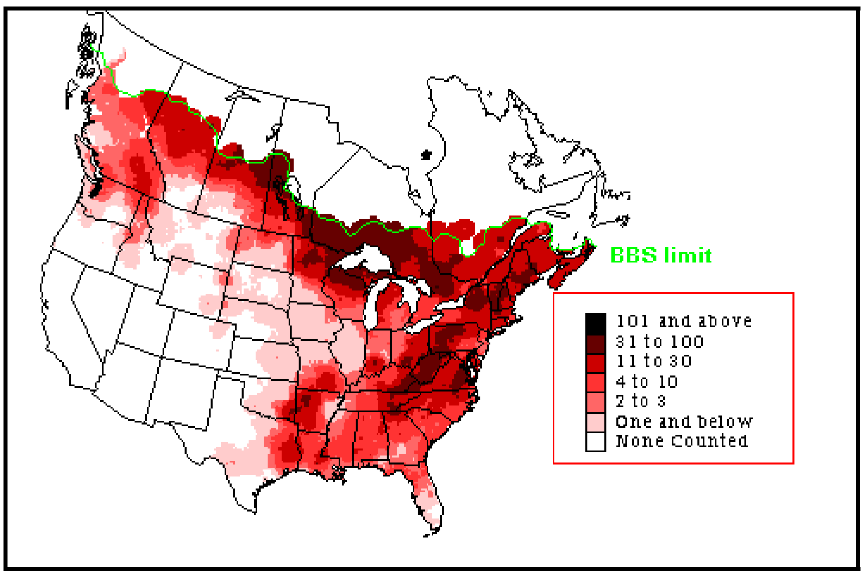

Figure 27. Red-eyed vireo summer distribution (Sauer et al. 2003).

Population Trend Status

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

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

In Washington, BBS data show a significant population increase of 4.9% per year from 1982 to 1991 (Peterjohn 1991) (Figure 55). However, long-term, this has been a population decline in Washington of 2.6% per year, although the change is not statistically significant largely because of scanty data (Sauer et al. 2003). Because the BBS dates back only about 30 years, population declines in Washington resulting from habitat loss dating prior to the survey would not be accounted for by that effort.

3.16.6 Yellow-breasted Chat

General Habitat Requirements

Yellow-breasted chats are found in second growth, shrubby old pastures, thickets, bushy areas, scrub, woodland undergrowth, and fence rows, including low wet places near streams, pond edges, or swamps; thickets with few tall trees; early successional stages of forest regeneration; commonly in sites close to human habitation. In winter, establishes territories in young second-growth forest and scrub (Dennis 1958, Thompson and Nolan 1973, Morse 1989).

Limiting Factors

Threats include habitat loss because of successional changes and clearing of land for agricultural or residential development. Frequently parasitized by the brown-headed cowbird (*Molothrus ater*), but whether this has a significant impact on reproductive success is not well known.

Current Distribution

Yellow-breasted chat breeding range includes southern British Columbia across southern Canada and the northern US to southern Ontario and central New York, south to southern Baja California, to Sinaloa on Pacific slope, to Zacatecas in interior over plateau, to southern Tamaulipas on Atlantic slope, and to Gulf Coast and northern Florida (AOU 1998).

Yellow-breasted chat non-breeding range includes southern Baja California, southern Sinaloa, southern Texas, southern Louisiana, and southern Florida south (rarely north to Oregon, Great Lakes, New York, and New England) to western Panama (AOU 1998).

Population Trend Status

North American Breeding Bird Survey (BBS) data indicate a significant population decline in eastern North America, 1966-1988; a significant increase in western North America, 1978-1988 (Sauer and Droege 1992); in North America overall from 1966-1989; there was a nonsignificant decline averaging 0.8% per year from 1966-1989 (Droege and Sauer 1990); a nonsignificant 9% decline from 1966 to 1993, and a barely significant increase of 8% from 1984 to 1993 (Price et al. 1995).

Yellow-breasted chats may have declined in south central and southeastern New York between the early 1900s and mid-1980s (Eaton, in Andrle and Carroll 1988). Numbers have steadily declined in some areas of Ohio, though the range has not changed much since the 1930s (Peterjohn and Rice 1991).

Yellow-breasted chat has declined in Indiana and Illinois since the mid-1960s. Yellow-breasted chat has declined along the lower Colorado River with loss of native habitat (Hunter et al. 1988).

In Canada, they are thought to be slowly declining because of habitat destruction in B.C. Populations in Alberta and Saskatchewan appear to be stable; population has declined at Point Pelee National Park in Ontario, which contains a considerable proportion of the province's small population; the species no longer breeds at Rondeau Provincial Park (Ontario), although the population on Pelee Island (Ontario) appears to be stable (Cadman and Page 1994).

Washington trends are illustrated in. Yellow-breasted chat breeding season abundance (from BBS data) is illustrated in .

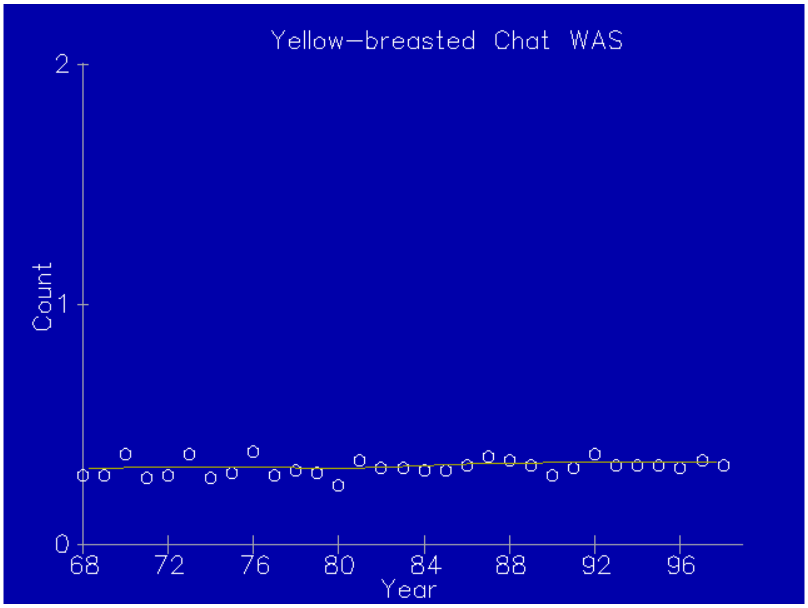

Figure 28. Population trends for Yellow-breasted chat in Washington

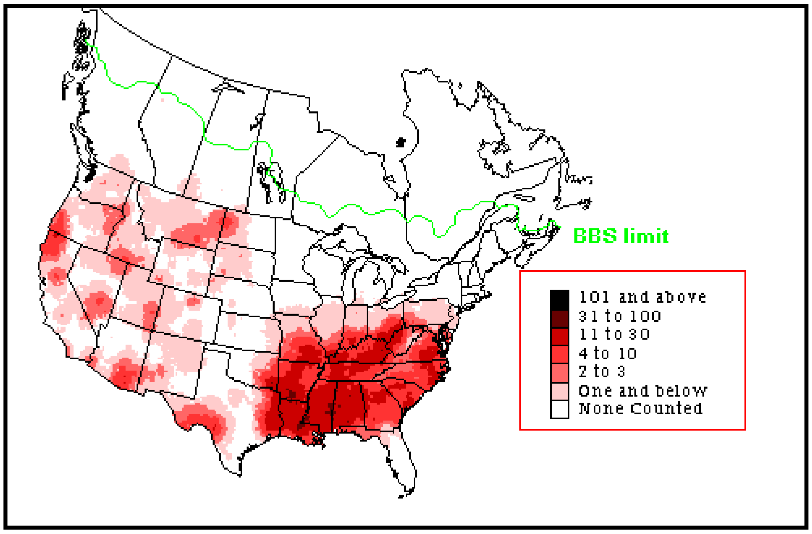

Figure 29. Yellow-breasted chat breeding abundance

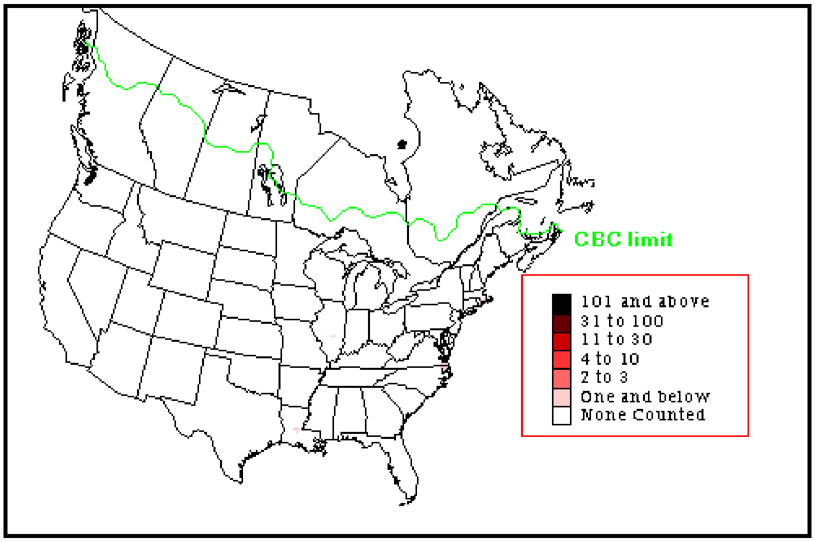

Figure 30. CBC data on winter season abundance of Yellow-breasted chat.

3.16.7 American Beaver

General Habitat Requirements

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

Beavers are generalized herbivores and appear to prefer herbaceous vegetation such as duck potato (*Sagittaria* spp.), duckweed (*Lemna spp*.), pondweed (*Potamogeton* spp.), and water weed (*Elodea* spp.) to woody vegetation during all seasons of the year, if it is available (Jenkins 1981). The leaves, twigs, and bark of woody plants are eaten, and many species of aquatic and terrestrial herbaceous vegetation.

Beaver show strong preferences for particular woody plant species and size classes (Jenkins 1975; Collins 1976a; Jenkins 1979). Denney (1952) reported that beavers preferred, in order of preference, aspen, willow, cottonwood, and alder. Woody stems cut by beavers are usually less than 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. Food preferences may vary seasonally, or from year to year, as a result of variation in the nutritional value of food sources (Jenkins 1979). Specific habitat attributes are shown in Table 29.

Table 29. Habitat attributes of beaver.

Focal Species	Focal Habitat Type	Key Habitat Relationships		Comments	Life Requisite	Selection Rationale
		Conservation Focus	Habitat Attribute (Vegetative Structure)			
Sage thrasher	Shrub-steppe	sagebrush height	sagebrush cover 5-20%	not area-sensitive (needs > 40 ac); not impacted by cowbirds; high moisture sites w/ tall shrubs	Food, Reproduction	The sage thrasher is a shrubsteppe obligate species and an indicator of healthy, tall sagebrush dominated shrubsteppe habitat.
			sagebrush height > 80 cm		Food, Reproduction	
			herbaceous cover 5-20%		Food, Reproduction	
			other shrub cover > 10%		Food, Reproduction	
			non-native herbaceous cover < 10%		Food, Reproduction	
Brewer's sparrow	Shrubsteppe	sagebrush cover	sagebrush cover 10-30%		Food, Reproduction	The Brewer's sparrow is a shrubsteppe obligate species and is an indicator of healthy sagebrush dominated shrubsteppe habitat.
			sagebrush height > 60 cm		Food, Reproduction	
			herbaceous cover > 10%		Food, Reproduction	

Focal Species	Focal Habitat Type	Key Habitat Relationships		Comments	Life Requisite	Selection Rationale
		Conservation Focus	Habitat Attribute (Vegetative Structure)			
			open ground > 20%		Food, Reproduction	
			non-native herbaceous cover < 10%		Food, Reproduction	
Grasshopper sparrow	Shrubsteppe	Native steppe/ grasslands	native bunchgrass cover > 15% and comprising > 60% of the total grass cover		Food, Reproduction	The grasshopper sparrow is an indicator of healthy steppe habitat dominated by native bunch grasses.
Sharp-tailed grouse	Shrubsteppe	Deciduous trees and shrubs	mean VOR > 6"		Reproduction	Sharp-tailed grouse is a management priority species and an indicator of healthy steppe/shrubsteppe habitat w/ healthy imbedded mesic draws.
			> 40% grass cover		Reproduction	
			> 30% forb cover		Reproduction	
			< 5% cover introduced herbaceous cover		Reproduction	
			> 50% optimum area providing nest/brood cover		Reproduction	
			> 0.25 km between nest/brood rearing habitat and winter habitat		Reproduction	
			> 75% cover deciduous shrubs and trees		Winter	

Focal Species	Focal Habitat Type	Key Habitat Relationships		Comments	Life Requisite	Selection Rationale
		Conservation Focus	Habitat Attribute (Vegetative Structure)			
			> 10% optimum area providing winter habitat		Winter	
Sage grouse	Shrubsteppe	diverse herbaceous understory, sagebrush cover	sagebrush cover 10-30%	area sensitive; needs large blocks	Reproduction	shrubsteppe obligate; State threatened, Federal Candidate species
			forb cover > 10%		Food	
			open ground cover > 10%			
			non-native herbaceous cover < 10%			
Pygmy rabbit	Shrubsteppe	deep, rock-free soil	sagebrush cover 21-36%	area sensitive, needs large blocks	Reproduction	Shrubsteppe obligate; Federal, State endangered species
			shrub height 32”			
Mule deer	Shrubsteppe	antelope bitterbrush	30-60% canopy cover of preferred shrubs < 5 ft.		Food	The mule deer is a management priority species and an indicator of healthy diverse shrub layer in east-slope shrubsteppe habitat.
			number of preferred shrub species > 3			
			mean height of shrubs > 3 ft.			
			30-70% canopy cover of all shrubs < 5 ft.			
Willow	Eastside (Interior)	shrub density	dense patches of native vegetation in the	> 20 ac; frequent cowbird host; sites	Reproduction	Indicator of healthy, diverse

Focal Species	Focal Habitat Type	Key Habitat Relationships		Comments	Life Requisite	Selection Rationale
		Conservation Focus	Habitat Attribute (Vegetative Structure)			
flycatcher	Riparian Wetlands		shrub layer > 35 $ft.^2$ in size and interspersed with openings of herbaceous vegetation	> 0.6 mi from urban/residential areas and > 3 mi from high-use cowbird areas		riparian wetland habitat
			shrub layer cover 40-80%		Reproduction	
			shrub layer height > 3 ft. high		Reproduction	
			tree cover < 30%		Reproduction	
Lewis' woodpeck er	Eastside (Interior) Riparian Wetlands	large cottonwood trees/snags	> 0.8 trees/ac > 21" dbh	Dependent on insect food supply; competition from starlings detrimental	Food	Indicator of healthy cottonwood stands with snags
			canopy cover 10-40%			
			shrub cover 30-80-%			
Red-eyed vireo	Eastside (Interior) Riparian Wetlands	canopy foliage and structure	canopy closure > 60%		Food, Reproduction	The red-eyed vireo is an obligate species in riverine cottonwood gallery forests and an indicator of healthy canopy cover.
			riparian zone of mature deciduous trees > 160 ft.		Food, Reproduction	
			> 10% of the shrub layer should be young cottonwoods		Food, Reproduction	

Focal Species	Focal Habitat Type	Key Habitat Relationships		Comments	Life Requisite	Selection Rationale
		Conservation Focus	Habitat Attribute (Vegetative Structure)			
Yellow-breasted chat	Eastside (Interior) Riparian Wetlands	dense shrub layer	shrub layer 1-4 m tall	vulnerable to cowbird parasitism; grazing reduces understory structure	Food, Reproduction	The yellow-breasted chat is an indicator of healthy shrub dominated riparian habitat and is a management priority species in the Canadian Okanogan.
			30-80% shrub cover		Food, Reproduction	
			scattered herbaceous openings		Food, Reproduction	
			tree cover < 20%		Food, Reproduction	
Beaver	Eastside (Interior) Riparian Wetlands	canopy closure	40-60% tree/shrub canopy closure		Food	The beaver is an indicator of healthy regenerating aspen stands and an important habitat manipulator.
			trees < 6" dbh; shrub height ≥ 6.6 ft.			
		permanent water	stream channel gradient ≤ 6% with little to no fluctuation		Water (cover for food and reproductive requirements)	
		shoreline development	woody vegetation ≤ 328 ft. from water		Food	
Red-winged blackbird	Herbaceous Wetlands	Open water with emergent wetlands				Wetland obligate species
Pygmy	Ponderosa Pine	large trees	> 10/ac > 21" dbh with	large snags for	Food,	The pygmy nuthatch is a

Focal Species	Focal Habitat Type	Key Habitat Relationships		Comments	Life Requisite	Selection Rationale
		Conservation Focus	Habitat Attribute (Vegetative Structure)			
nuthatch			> 2 trees > 31" dbh	nesting; large trees for foraging	Reproduction	species of management concern and is an obligate for healthy old-growth Ponderosa pine forest with an abundant snag component.
			> 1.4 snags/ac > 8" dbh with > 50% > 25"			
Gray flycatcher	Ponderosa Pine	shrubsteppe/ pine interface; pine savannah w/ shrub-bunchgrass understory	Nest tree diameter 18" dbh		Reproduction	The gray flycatcher is an indicator of healthy fire-maintained regenerating ponderosa pine forest.
			Tree height 52'		Food	
White-headed woodpecker	Ponderosa Pine	large patches of old growth forest with large trees and snags	> 10 trees/ac > 21" dbh w/ > 2 trees > 31" dbh	large high-cut stumps; patch size smaller for old-growth forest; need > 350 ac or > 700 ac	Reproduction	The white-headed woodpecker is a species of management concern and it is an obligate species for large patches of healthy old-growth Ponderosa pine forest.
Flammulated owl	Ponderosa Pine	interspersion; grassy openings and dense thickets	> 10 snags / 40 ha > 30 cm dbh and 1.8m tall	thicket patches for roosting; grassy openings for foraging	Food	The flammulated is an indicator of a healthy landscape mosaic in Ponderosa pine and Ponderosa pine/Douglas-fir forest and it is a Washington State priority species.

Limiting Factors

Beavers readily adapt to living in urban areas near humans and are limited primarily by the availability of permanent water with limited fluctuations and accessibility of food.

Riparian habitat along many waterways has been removed in order to plant agricultural crops, thus removing important habitat and food sources for beaver.

Beavers create dams that restrict fish passage, and are removed in order to restore fish passage.

Current Distribution

The beaver is found throughout most of North America except in the Arctic tundra, peninsular Florida, and the Southwestern deserts (**Figure 31**) (Allen 1983; VanGelden 1982; Zeveloff 1988).

Figure 31. Distribution of beaver.

3.16.8 Pygmy Nuthatch

General Habitat Requirements

Among all breeding birds within ponderosa pine forests, the density of pygmy nuthatches is most strongly correlated with the abundance of ponderosa pine trees (Balda 1969). In Colorado 93% of breeding bird atlas observations occurred in coniferous forests, 70 % of those in ponderosa pines. Indeed the distribution of pygmy nuthatches in Colorado coincides with that of ponderosa pine woodlands in the state (Jones 1998).

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

In California's mountains, it favors open park-like forests of ponderosa and Jeffrey pines in the Sierra Nevada Mountains (Gaines 1988) but also ranges to 3,050 m in open stands of large lodgepole pine in the White Mountains of California (Shuford and Metropulos 1996). In the Mogollon Rim region of central Arizona, it breeds and feeds in vast expanses of ponderosa pine that extend throughout the Colorado plateau, and, is also common in shallow snow-melt ravines that course through the pine forests. These snowmelt drainages contain white fir (*Abies concolor*), Douglas-fir, Arizona white pine (*Pinus strobiformis*), quaking aspen (*Populus tremuloides*), and an understory of maples (*Acer* sp.) (Kingery and Ghalambor 2001).

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

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

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

Limiting Factors

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

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

Pygmy nuthatches choosing roost sites during the non-breeding season use a different set of characteristics compared to nest sites. A considerable reduction in snag densities may affect overwinter survivorship and possibly reproduction by forcing pygmy nuthatches to use cavities in snags they would normally avoid (Hay and Güntert 1983; Matthysen 1998). More research on the differences among snags is clearly needed in order to distinguish those factors that make some snags more desirable than others.

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

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

In a recent review of the effects of recreation on songbirds within ponderosa pine forests, Marzluff (1997) hypothesized that "nuthatches" would experience moderate decreases in population abundance and productivity in response to impacts associated with established campsites (although pygmy nuthatch was not specifically identified).

Impacts associated with camping that might negatively influence nuthatches include changes in vegetation, disturbance of breeding birds, and increases in the number of potential nest predators (Marzluff 1997). However, other recreational activities associated with resorts and recreational residences might moderately increase nuthatch population abundance and productivity (Marzluff 1997). This positive effect on nuthatch populations is likely to occur through food supplementation, such as bird feeders, that are frequently visited by pygmy nuthatches.

Current Distribution

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

The pygmy nuthatch occurs in southern interior British Columbia, particularly in Okanagan and Similkameen valleys and adjacent plateaus (Campbell et al. 1997) south into the Okanagan Highlands and the northeast Cascades of Washington. It is scattered along the eastern slope of the Cascades from central Washington (Jewett et al. 1953; Smith et al. 1997) into Oregon and in the Blue Mountains in southwest Washington (Garfield County only) (Smith et al. 1997) but widespread in Oregon along the west slope of the Cascades (Gabrielson and Jewett 1940; Jewett et al. 1953; Gilligan et al. 1994). It ranges south from the Cascades in Oregon into northern California and south into the Sierra Nevadas and nearby mountains of Nevada (Brown 1978).

In the southern Sierra Nevadas it is found on the east and west side of the range in the Mono Craters and Glass Mountain region (Gaines 1988, Shuford and Metropulos 1996) and in the White Mountains of Nevada and California (Norris 1958; Brown 1978; Shuford and Metropulos 1996). It is also found throughout the mountain ranges of southern California, including the Sierra Madres in Santa Barbara County, the Mt. Pinos area (Kern and Ventura Counties), the San Gabriel and San Bernardino Mountains in Los Angeles and San Bernardino Counties (Norris 1958; B. Carlson, K. Garrett pers. comm.), the San Jacinto and Santa Rosa Mountains in Riverside County (Norris 1958; B. Carlson pers. comm.), and in the Laguna and Cuyamaca Mountains, and Mt. Palomar, Volcan and Hot Springs Mountains of San Diego County (San Diego County Breeding Bird Atlas preliminary data, B. Carlson, P. Unitt, pers. comm.). The range extends south into the Sierra Juarez and Sierra San Pedro Mártir Mountains in Baja California Norte, Mexico (Grinnell 1928; Norris 1958;).

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

Population Trend Status

Survey-wide estimates of all BBS routes suggest pygmy nuthatch populations are stable (Sauer et al. 2000). However, these estimates are based on small samples that do not provide a reliable population trend nor reliable trends for any states or physiographic regions, because of too few routes, too few birds, or high variability (Sauer et al. 2000). The lack of reliable data is particularly the case in the Black Hills, where there are too few data to perform even the most basic trend analysis (Sauer et al. 2000).

Where long-term data are available for particular populations, natural fluctuations in population numbers have been documented. For example, a constant-effort nest-finding study in Arizona recorded a major population crash. On this site between 1991 and 1996 the number of nests found each year varied from 23-65 (mean = 50.2), whereas in the same site from 1997 to 1999, only 2-5 nests were found each year (Kingery and Ghalambor 2001). Likewise, Scott’s (1979) study also portrays a pygmy nuthatch population swing, but no clear factor has been identified as being responsible for rapid changes in population numbers. No definitive explanation currently exists for why some pygmy nuthatch populations may be prone to large fluctuations, but it is suspected that an intolerance to cold winter temperatures and/or a poor cone crop may play a role.

3.16.9 Gray Flycatcher

General Habitat Requirements

[Need information]

Limiting Factors

Gray flycatchers would be vulnerable to land clearing, but generally found in very arid environments that are not usually converted to agriculture (USDA Forest Service 1994). Clearing of pinyon-juniper for mining of coal and oil shale deposits or in favor of grassland for livestock grazing, or widespread harvesting of pinyon-juniper could be detrimental (O'Meara et al. 1981, cited in Sterling 1999).

Current Distribution

Gray flycatchers are found in extreme southern British Columbia (Cannings 1992) and south-central Idaho south to southern California, southern Nevada, central Arizona, south-central New Mexico, and locally western Texas (Terres 1980, AOU 1983).

Gray flycatchers during the non-breeding season occur in southern California, central Arizona, south to Baja California and south-central mainland of Mexico (Terres 1980).

Population Trend Status

North American Breeding Bird Survey (BBS) shows a survey-wide significantly increasing trend of 10.2% average per year (n = 89), 1966-1996; a nonsignificant decline of -1.0 % average per year (n = 22), 1966-1979; and a significant increase from 1980 to 1996 of 10.0 % average per year (n = 84) (**Figure 32**). Data for Oregon reflect strong long-term increase of 7.9% average per year (n = 29), 1966-1996. Sample sizes too low for accurate trend estimates in other states (Sauer et al. 1997). Gray flycatcher breeding season abundance is illustrated in

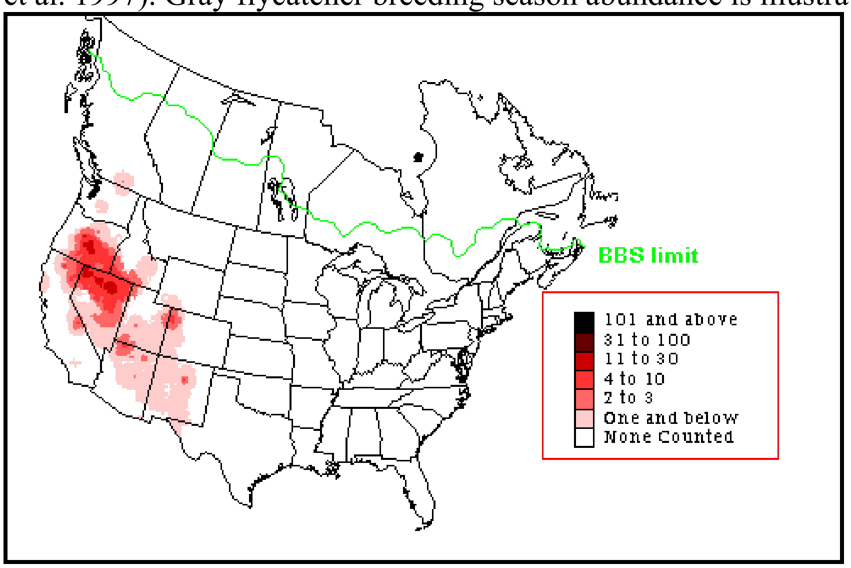

Figure 33.

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Figure 32. Gray flycatcher population trend data (from BBS data) (Sauer et al. 1997).

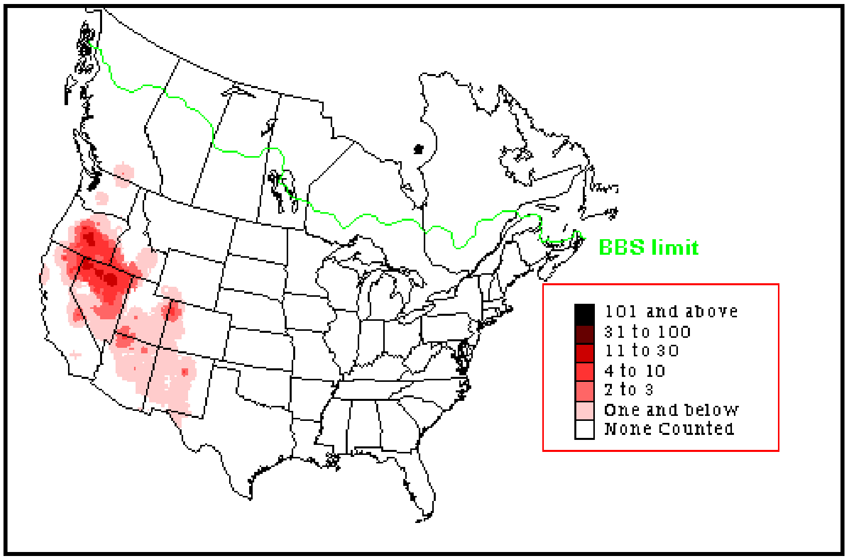

Figure 33. Gray flycatcher breeding season abundance (from BBS) (Sauer et al. 1997).

Christmas Bird Count (CB.C.) data for 1959 to 1988 show a significant survey wide increase of 4.3% average per year, and a significant increase in Arizona (4.6% average per year, n = 28). Trend for California apparently stable over the period (nonsignificant increase of 0.2% average per year, n = 21; Sauer et al. 1996).

Reportedly declining as a wintering bird in southern California; extensions in Washington and California at western edges of breeding range noted in the 1970s (USDA Forest Service 1994).

3.16.10 White-headed woodpecker

General Habitat Requirements

White-headed woodpeckers prefer a conifer forest with a relatively open canopy (50–70 % cover) and an availability of snags (a partially collapsed, dead tree) and stumps for nesting. The birds prefer to build nests in trees with large diameters with preference increasing with diameter. The understory vegetation is usually very sparse within the preferred habitat and local populations are abundant in burned or cut forest where residual large diameter live and dead trees are present. In general, open ponderosa pine stands with canopy closures between 30-50 % are preferred. The openness, however, is not as important as the presence of mature or veteran cone producing pines within a stand (Milne and Hejl 1989).

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

Limiting Factors

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.

Fire suppression has altered the stand structure in many of the forests. Lack of fire has allowed dense stands of immature ponderosa pine and 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 and a slow change from a ponderosa pine climax forest to a Douglas-fir dominated climax forest.

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

Current Distribution

White-headed woodpeckers live in montane, coniferous forests from southern British Columbia in Canada, to eastern Washington, southern California and Nevada and northern Idaho in the United States (**Figure 34**).

Population Trend Status

White-headed woodpecker abundance appears to decrease north of California. They are uncommon in Washington and Idaho and rare in British Columbia. However, they are still common in most of their original range in the Sierra Nevada and mountains of southern California.

This species is of moderate conservation importance because of its relatively small and patchy year-round range and its dependence on mature, montane coniferous forests in the West. Knowledge of this woodpecker's tolerance of forest fragmentation and silvicultural practices will be important in conserving future populations. Breeding Bird Survey population trend data are illustrated in **Figure 35**.

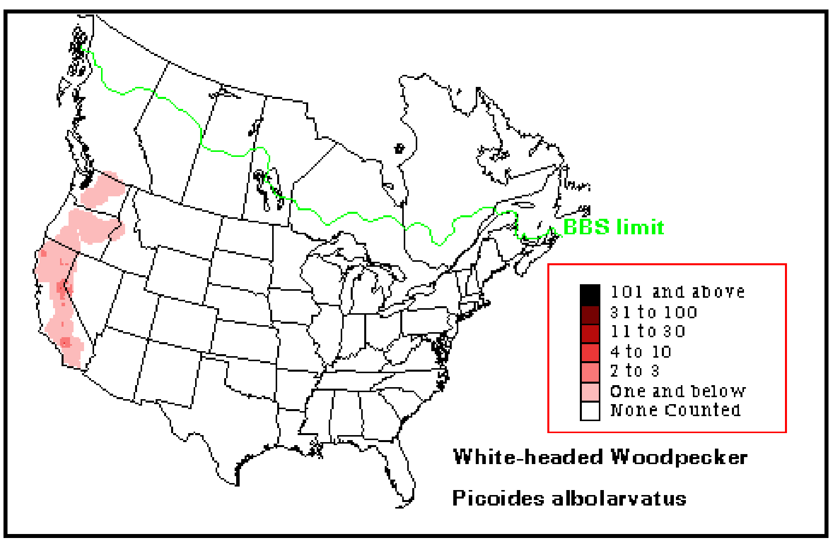

Figure 34. Current distribution/year-round range of white-headed woodpeckers (Sauer et al. 2003).

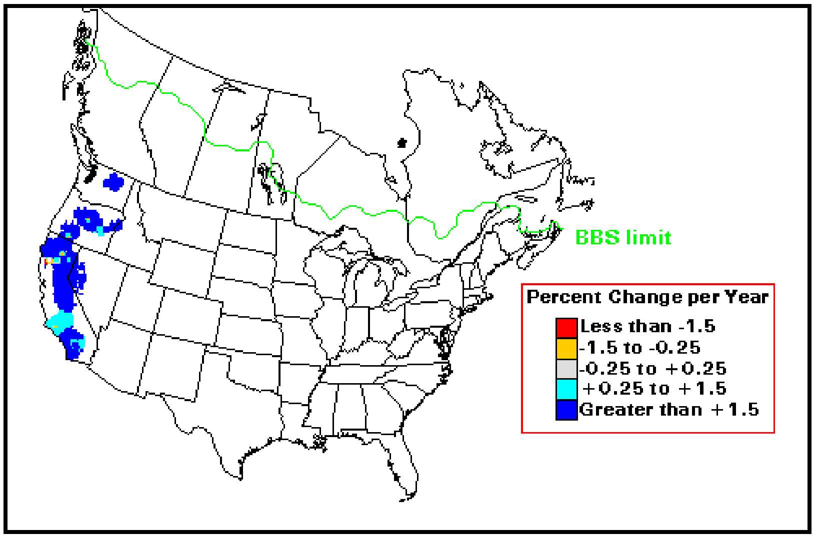

Figure 35. White-headed woodpecker BBS population trend: 1966-1996 (Sauer et al. 2003).

Structural Condition Associations

Structural conditions (IBIS 2003) associated with white-headed woodpeckers are summarized in (Table 30). White-headed woodpeckers feed and reproduce (F/R) in and are generally associated (A) with a multitude of structural conditions within the ponderosa pine habitat type. Similarly, white-headed woodpeckers are present (P), but not dependent upon sapling/pole successional forest. According to IBIS (2003) data, white-headed woodpeckers are not closely associated (C) with any specific ponderosa pine structural conditions.

Table 30. White-headed woodpecker structural conditions and association relationships (IBIS 2003)

Common Name	Focal Habitat	Structural Condition (SC)	SC Activity	SC Assoc.
White-headed Woodpecker	Ponderosa Pine	Giant Tree-Multi-Story	F/R-HE	A
		Grass/Forb-Closed	F/R-HE	A
		Grass/Forb-Open	F/R-HE	A
		Large Tree-Multi-Story-Closed	F/R-HE	A
		Large Tree-Multi-Story-Moderate	F/R-HE	A
		Large Tree-Multi-Story-Open	F/R-HE	A
		Large Tree-Single Story-Closed	F/R-HE	A
		Large Tree-Single Story-Moderate	F/R-HE	A
		Large Tree-Single Story-Open	F/R-HE	A
		Medium Tree-Multi-Story-Closed	F/R-HE	A
		Medium Tree-Multi-Story-Moderate	F/R-HE	A
		Medium Tree-Multi-Story-Open	F/R-HE	A
		Medium Tree-Single Story-Closed	F/R-HE	A

Common Name	Focal Habitat	Structural Condition (SC)	SC Activity	SC Assoc.
		Medium Tree-Single Story-Moderate	F/R-HE	A
		Medium Tree-Single Story-Open	F/R-HE	A
		Sapling/Pole-Closed	F/R-HE	P
		Sapling/Pole-Moderate	F/R-HE	P
		Sapling/Pole-Open	F/R-HE	P
		Shrub/Seedling-Closed	F/R-HE	A
		Shrub/Seedling-Open	F/R-HE	A
		Small Tree-Multi-Story-Closed	F/R-HE	A
		Small Tree-Multi-Story-Moderate	F/R-HE	A
		Small Tree-Multi-Story-Open	F/R-HE	A
		Small Tree-Single Story-Closed	F/R-HE	A
		Small Tree-Single Story-Moderate	F/R-HE	A
		Small Tree-Single Story-Open	F/R-HE	A

3.16.11 Flammulated Owl

General Habitat Requirements

The flammulated owl is a Washington State candidate species. Limited research on the flammulated owl indicates that its demography and life history, coupled with narrow habitat requirements, make it vulnerable to habitat changes. The flammulated owl occurs mostly in mid-level conifer forests that have a significant ponderosa pine component (McCallum 1994b) between elevations of 1,200 to 5,500 feet in the north, and up to 9,000 feet in the southern part of its range in California (Winter 1974).

Flammulated owls are typically found in mature to old, open canopy yellow pine (ponderosa pine and Jeffrey pine [*Pinus jeffreyi*]), Douglas-fir, and grand fir (Bull and Anderson 1978; Goggans 1986; Howie and Ritchie 1987; Reynolds and Linkhart 1992; Powers et al. 1996). It is a species dependent on large diameter ponderosa pine forests (Hillis et al. 2001) and is obligate secondary cavity nesters (McCallum 1994b), requiring large snags in which to roost and nest.

Flammulated owls nest in habitat types with low to intermediate canopy closure (Zeiner et al. 1990). The owls selectively nest in dead ponderosa pine snags, and prefer nest sites with fewer shrubs in front than behind the cavity entrance, possibly to avoid predation and obstacles to flight.

Limiting Factors

Logging disturbance and the loss of breeding habitat associated with it has a detrimental effect on the birds (USDA 1994a). The owls prefer late-seral forests. The main threat to the species is the loss of nesting cavities, as this species cannot create its own nest and relies on existing cavities. Management practices such as intensive forest management, forest stand improvement, and the felling of snags and injured or diseased trees (potential nest sites) for firewood effectively remove most of the cavities suitable for nesting (Reynolds et al. 1989). However, the owls will nest in selectively logged stands, as long as they contain residual trees (Reynolds et al. 1989).

Wildfire suppression has allowed many ponderosa pine stands to proceed to the more shade resistant fir forest types, which is less suitable habitat for these species (Marshall 1957; Reynolds et al. 1989).

Roads and fuelbreaks, often placed on ridgetops, result in removal of snags for safety considerations (hazard tree removal) and firewood can result in the loss of existing and recruitment nest trees.

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

Predators/competitors include spotted owl and other larger owls, accipiters, long-tailed weasels (Zeiner et al. 1990), felids and bears (McCallum 1994b). Nest predation has also been documented by northern flying squirrel in the Pacific Northwest (McCallum 1994a). Saw-whet owls, screech owls, and American kestrels compete for nesting sites, but flammulated owls probably have more severe competition with non-raptors, such as woodpeckers, other passerines, and squirrels for nest cavities (Zeiner et al. 1990, McCallum 1994b).

Birds from the size of bluebirds upward are potential competitors. Owl nests containing bluebird eggs and flicker eggs suggest that flammulated owls evict some potential nest competitors (McCallum 1994b). Any management plan that supports pileated woodpecker and northern flicker populations will help maintain high numbers of cavities, thereby minimizing this competition (Zeiner et al. 1990). Flammulated owls may compete with western screech-owls and American kestrels for prey (Zeiner et al. 1990) as both species have a high insect component in their diets. Common poorwills, nighthawks, and bats may also compete for nocturnal insect prey especially in the early breeding season (April and May) when the diet of the owls is dominated by moths. (McCallum 1994b).

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

Current Distribution

Flammulated owl distribution is illustrated in **Figure 36**. Flammulated owls are uncommon breeders east of the Cascades in the ponderosa pine belt from late May to August. There have been occasional records from western Washington, but they are essentially an east side species. Locations where they may sometimes be found include Blewett Pass (straddling Chelan and Kittitas Counties), Colockum Pass area (Kittitas County), and Satus Pass (Klickitat County) (**Figure 37**).

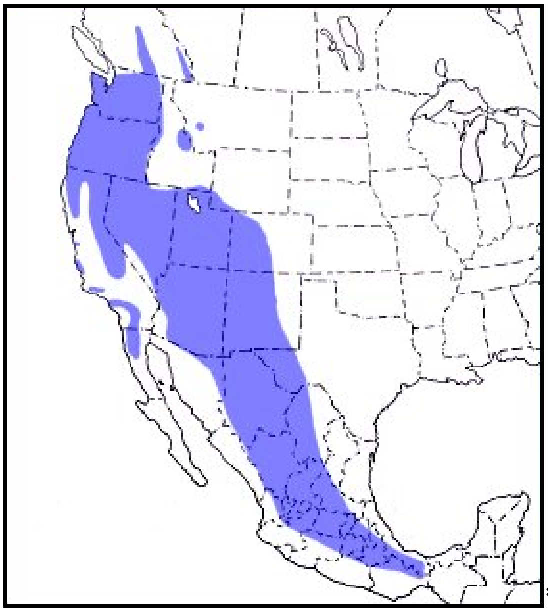
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Figure 36. Flammulated owl distribution, North America (Kaufman 1996).

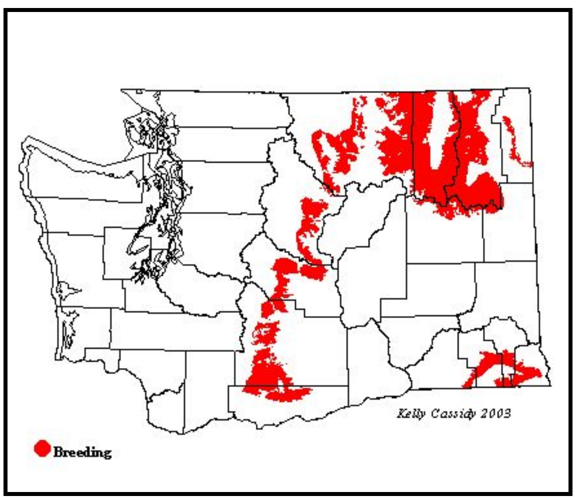

Figure 37. Flammulated owl distribution, Washington (Kaufman 1996).

Population Trend Status

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

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

Structural Condition Associations

Structural conditions (IBIS 2003) associated with flammulated owl are summarized in Table 31.

Table 31. Structural conditions associated with flammulated owls.

Common Name	Focal Habitat	Structural Condition (SC)	SC Activity	SC Assoc.
Flammulated Owl	Ponderosa Pine	Giant Tree-Multi-Story	F/R-HE	C
		Large Tree-Multi-Story-Closed	F/R-HE	C
		Large Tree-Multi-Story-Moderate	F/R-HE	C
		Large Tree-Multi-Story-Open	F/R-HE	A
		Large Tree-Single Story-Closed	F/R-HE	P
		Large Tree-Single Story-Moderate	F/R-HE	P
		Medium Tree-Multi-Story-Closed	F/R-HE	C
		Medium Tree-Multi-Story-Moderate	F/R-HE	C
		Medium Tree-Multi-Story-Open	F/R-HE	A
		Medium Tree-Single Story-Closed	F/R-HE	P
		Medium Tree-Single Story-Moderate	F/R-HE	P
		Small Tree-Multi-Story-Closed	F/R-HE	A
		Small Tree-Multi-Story-Moderate	F/R-HE	A
		Small Tree-Multi-Story-Open	F/R-HE	P

Flammulated owls feed and reproduce (F/R) in and are closely associated (C) with medium to large, multi-story, moderate to closed canopy ponderosa pine forest conditions. Similarly, flammulated owls are associated (A) with medium to large multi-story/open canopy forest and will utilize dense stands of small trees. In contrast, flammulated owls are present (P), but not dependent upon open canopy forest (IBIS 2003). Of the three ponderosa pine focal species, flammulated owls are the most structural dependent species.

3.17 Other Important Wildlife Species

3.17.1 Elk

Elk populations in Eastern Washington are strong and relatively stable due primarily to the large amount of elk winter range controlled by WDFW. Data compiled by Colville Tribes indicate that elk numbers appear to be declining reservation-wide while the population is becoming more distributed.

The Omak Creek drainage provides good elk habitat and hunter report records verify that elk are being harvested in that area. Colville Tribes collect information on herd size and structure, regulate tribal member hunting seasons, and utilize check stations. Elk are extremely important to the tribes for subsistence and ceremonial purposes.

3.17.2 Bighorn sheep

Prior to 1900, bighorn sheep roamed over much of the area, but by the turn of the century had all but disappeared. The last native bighorn sheep was killed near Loomis about 1915 (Pacific Northwest River Basins Commission, 1977). They were reintroduced to the basin starting in 1957. (WDFW 1995). Currently The WDFW is transplanting bighorn sheep to the basin.

There are isolated herds of bighorn sheep on both the North Half and on the reservation portion of the Okanogan Subbasin. The Colville Tribes does manage a tribal member bighorn sheep hunt with a drawing for one tag per year. Current information regarding total numbers and structure of the Omak Reserve herd is incomplete.

3.17.3 Small Mammals

Small mammals of particular interest to the Tribes in the Okanogan drainage area are the myotis and pallid bats, the western gray squirrel, and Merriam's shrew. Tribal management efforts extend to supporting and enhancing existing and potential habitat through reduced fragmentation of wildlife habitat necessary to provide for the life requisites of viable populations of terrestrial, avian, and aquatic species (Colville Tribes 1999).

The Tribes goal of increasing numbers of rabbits and small mammals to help support recovery of the lynx may in turn provide a prey diet base for coyote and cougar. This could help to lessen pressure on deer and elk populations.

3.17.4 Raptors

There are currently 21 known active bald eagle nesting territories on the Colville Tribes Reservation (Bald Eagle Survey 2000). Nesting activity appears to be expanding because of an increase in breeding adults produced in previous years and presence of abundant potential habitat. Nests are checked twice annually: once in April for occupancy and again in July for production (Annual Report 2000.) The Colville Tribes was an active participant in a five-year peregrine falcon reintroduction project, concluded in 1997 (Colville Tribes, 1998).

The hope is that the falcons have dispersed throughout the reservation. Additionally, golden eagle, goshawk, ferruginous hawk, merlin, prairie falcon, and flammulated owl, and other birds of prey, are currently or have been known to inhabit the Okanogan Subbasin area of the reservation.

The CRCT holds as a guideline the protection of raptor nest sites that are currently being used, and important roost trees and associated habitat in the area surrounding the nest trees (Colville Tribes, 1999). Status of all raptors is, other than bald eagles, is virtually unknown. Raptors are particularly important to the Tribes culturally and spiritually.

3.17.5 Upland and Game Birds

There are numerous upland birds and small game animals in the Okanogan Basin. Most of these species are dependent upon the riparian zone along rivers and creeks.

Upland game bird populations increased in the early years of dry-land farming, which provided winter feed for the birds and fence rows for cover. More recently, bird populations have been negatively impacted by changes in crops, farming methods, grazing, and abandonment of upland dry-land farms. (Pacific Northwest River Basins Commission 1977).

The Colville Tribes reservation supports many species of upland and other game birds. The Colville Tribes wildlife staff run annual grouse and dove counts, in cooperation with the USFWS. The Tribes provide an annual non-member game bird hunt. Dove numbers on the Okanogan route are down from the early 1990s and chukar numbers are depressed as well (Colville Tribes 2001). Doves are particularly important in a cultural aspect. Tribal members engage in turkey and grouse hunting and all game birds hold economic, subsistence and cultural value for the tribal membership. Status of birds, other than doves and chukar, is unknown.

3.17.6 Waterfowl

The 1997-98 midwinter waterfowl inventory was completed by WDFW and US Fish and Wildlife Service (USFWS). During the 1980s, ducks declined in the Pacific Flyway midwinter survey, from about 7,000,000 in the 1970s. Numbers increased from 5,473,691 in 1996-97 to 6,607,263 in 1997-98.

Principal waterfowl species of the Okanogan Basin include Canada goose, mallard, wood duck, common merganser, coot, teal, green winged teal, American widgeon, common goldeneye, Barrow's goldeneye, ruddy, ring necked duck, lesser scaup, and bufflehead. Less common species included northern pintail, shoveler, harlequin duck, redhead, canvasback, blue winged teal, cinnamon teal, gadwall, and whistling swan.

The Colville Tribes performs annual waterfowl surveys that have indicated that waterfowl numbers peaked on the Colville Tribes Reservation during the mid-80s, and though numbers are still low by comparison, they seem to be slowly increasing (Colville Tribes 2001) Waterfowl are also part of the non-member hunt, and are important, not only economically, but culturally as well.

3.17.7 Neotropical birds

Surveys for neotropical birds and their habitats have been done only in recent times on forested uplands. There is little or no existing data on which to base trends that might relate to watershed condition. Wild turkeys are being transplanted to the area to augment existing populations.

The Colville Tribes is planning to conduct surveys to assess neotropical bird populations and their habitat. There is presently little data available to determine the limiting factors on neotropical birds.

3.17.8 Reptiles and Amphibians

Very little is currently known of the herptile (reptile and amphibian) in the Okanogan subbasin area. Sagebrush lizard and western toad, both federally listed, have been documented in this area.

The Colville Tribes Wildlife department acknowledges the need to survey and does plan to collect that information and develop management objectives as resources allow.

3.17.9 Exotic wildlife species

Exotic wildlife species are considered a disturbance to indigenous populations and their habitats, but are not always considered a threat. Several species of exotic wildlife have thrived in the subbasin habitats. Little is known about their status. A listing of the species introduced into the Okanogan subbasin is provided in the Assessment section of this plan.

3.18 Environmental Conditions of the Okanogan Subbasin

Historic Reference Condition

Dramatic changes in wildlife habitat have occurred throughout the Subbasin since pre-European settlement (circa 1850). IBIS data limitations for describing historic and current habitat conditions at the subbasin level are described in section 1.1 (Ashley and Stovall, unpublished report, 2004). Due to the limitations and inaccuracies associated with the IBIS mapping, the IBIS historic vs. current characterizations of habitats is not used for subbasin level analyses. A course scale representation of current habitat types is presented in **Figure 38**.

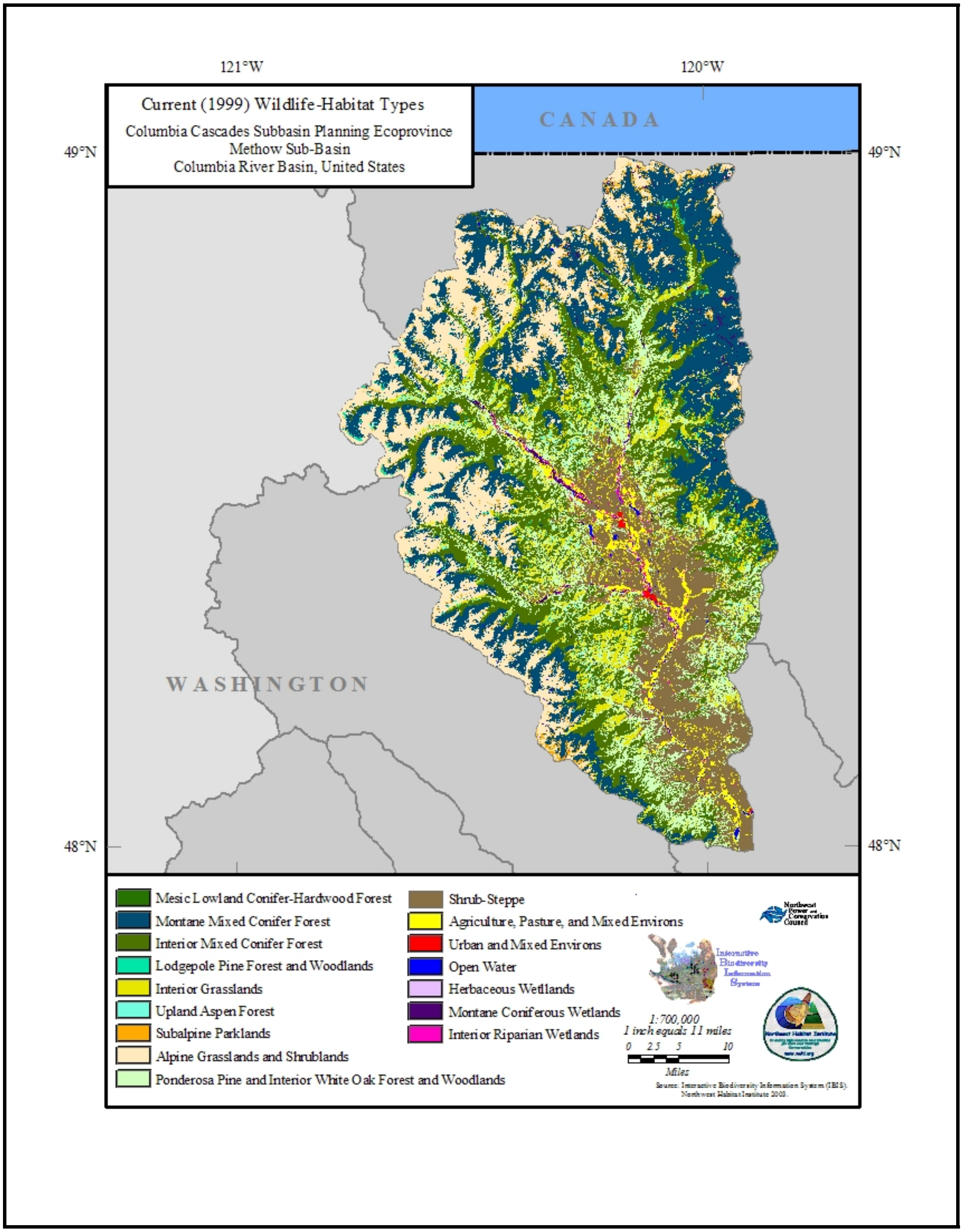

Figure 38. Current wildlife habitats in the Okanogan subbasin, Washington (IBIS 2003)

The most dramatic change in wildlife habitat type is in the loss of Ponderosa pine, riparian woodland, and steppe vegetation communities.

The most dramatic change in aquatic habitats is visible in the loss of channel sinuosity in the Okanagan mainstem in Canada, however the loss of shoreline vegetation throughout the subbasin is symptomatic of development.

Minimum flows associated with water withdrawal are considered by managers to have reduced both the magnitude and diversity of aquatic and wetland habitats in the Okanogan.

Agricultural land use has significantly changed the composition and structure of shrub and steppe vegetation communities from historic conditions. Livestock grazing tends to decrease perennial graminoids (i.e. steppe and/or grasslands and increase shrub density). In the Canadian portion of the subbasin, the Agricultural Land Reserve (ALR), a provincial zoning designation over areas of both private and public land, has slowed the conversion of agricultural lands to residential uses since its establishment in 1974. Most of the native grasses and forbs are poorly adapted to heavy grazing and trampling by livestock (Cassidy 1997).

True interior grassland habitat was not likely historically present in the subbasin and may be more appropriately described as central arid steppe.

The IBIS data also suggest that all wetland habitat types have increased over historic amounts. This in part may be because of the construction of tributary dams and the creation of reservoirs. However, accurate habitat type maps, especially those detailing the desired diversity of riparian and wetland habitats, are needed to improve assessment quality and support management strategies/actions.

Subbasin wildlife managers believe that significant physical and functional losses have occurred to these important wetland habitats from agricultural and residential development and livestock grazing.

Exotic wildlife

There are numerous introduced wildlife and plant species in the basin. Some of these were purposeful and others were incidental (migration from other areas). Many of these were introduced were introduced for recreational angling or hunting, others were associated with natural range extension from downstream or out of region introductions.

The practice of stocking exotic wildlife for hunting ended in 1983 (OWSAC, 2000). Declines in pheasant and chukar populations since may be a result of this policy change and changes in habitat and weather conditions provides a listing of wildlife species introduced into the Okanogan Subbasin (Table 32).

Table 32. Introduced wildlife species to the Okanogan subbasin

Species	When Introduced	Current Status/Remarks
California bighorn sheep	Native – reintroduced in 1957, 1970, and currently	Program to supplement native populations
Chukar	Unknown	Unknown
Hungarian partridge	Unknown	Unknown
Ring-necked pheasant	Unknown	Unknown
Turkey (Rio Grande subspecies)	1991 through 1995	Stable
California quail	Unknown	Unknown
Red fox	Unknown	Documented

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Exotic terrestrial plants/Noxious Weeds

Changes in biodiversity have been closely associated with changes in land use. Grazing, agriculture, and accidents have introduced a variety of exotic plants, many of which are vigorous enough to earn the title "noxious weed." Twenty-six species of noxious weeds occur in the Okanogan subbasin. These are listed in Table 33 along with their origin.

Table 33.Exotic terrestrial plant/noxious weed species in the Okanogan subbasin (Callihan and Miller 1994)

Common Name	Scientific Name	Origin
Babysbreath	*Gypsophila paniculata*	
Canadian thistle	*Cirsium arvense*	Eurasia
Cheat grass	*Bromus tectorum*	
Cocklebur	*Xanthium spionosum*	
Dalmatian toadflax	*Linaria dalmatica*	Mediterranean
Diffus knapweed	*Centaurea diffusa*	Eurasia
Hounds tongue	*Cunoglossum officinale*	
Japanese knotweed	*Polygonum cuspidatum*	
Kochia	*Kocha scoparia*	
Leafy spurge	*Euphorbia esula*	Eurasia
Longspine sandbur	*Cenchrus longispinus*	
Meadow hawkweed	*Hieracium caespitosum*	Europe
Mullein	*Verbascum thapsus*	
Musk thistle	*Carduus nutans*	Eurasia
Orange hawkweed	*Hieracium aurantiacum*	Europe
Oxeye daisy	*Leucanthemum vulgare*	
Perennial sowthistle	*Sonchus arvengis*	

Common Name	Scientific Name	Origin
Plumeless thistle	*Carduus acanthoides*	
Puncturevine	*Tribulus terrestris*	Europe
Purple loosestrife	*Lythrum salicaria*	Europe
Russian knapweed	*Centaurea repens*	Southern Russia and Asia
Russian thistle	*Salsola iberica sennen*	
Scotch cottonthistle	*Onopordum acanthium*	Europe
Scotchbroom	*Cytisus scoparius*	Europe
Spotted knapweed	*Centaurea Maculosa*	Europe
Spurge flax	*Thymelaea passerina*	
St. Johnswort	*Hypericum perforatum*	
Sulfur cinquefoil	*Potentilla recta*	
Tansy ragwort	*Senecio jacobaea*	Eurasia
Whitetop	*Cardaria draba*	Europe
Wild Four o'clock	*Mirabilis nyctaginea*	
Yellow star thistle	*Centaurea solstitialis*	Mediterranean and Asia
Yellow toadflax	*Linaria vulgaris*	Europe

Exotic fish and aquatic plants

Recent examination of the presence and impacts of exotic fish species introductions on indigenous aquatic environments in Okanagan mainstem lakes was undertaken in 2002 (H. Wright et al. 2002).

A detailed list of exotic fish species is found in Table 34. Some of these species are the target of sports anglers. They also provide a large biomass of fish in the basin. Inter-species competition and disease transfer are considered detrimental to indigenous fish populations, and particularly problematic to the long-term sustainability of salmonid populations.

Table 34. Exotic fish and aquatic plants first recorded in the Okanagan Subbasin, their method of entry and current distribution (adapted from H. Wright et al. 2002)

Species	Common Name	Earliest Year Stocked	Latest Year stocked	Numbers Stocked	Present limit of Range	Source
Coregonus clupeaformis	Lake Whitefish	1894	1929	Approx. 16,000,000	Throughout	www.bcfisheries.gov.bc.ca/fishinv/db and Vernon News, 1937
Oncorhynchus nerka	Kokanee	1928	1991	14,391,000	Throughout	www.bcfisheries.gov.bc.ca/fishinv/db
O. mykiss	Rainbow Trout or steelhead	1923	1979	10,185,000	Throughout	www.bcfisheries.gov.bc.ca/fishinv/db
O. nerka	Sockeye	1939	1958	4,700,000	South of McIntyre Dam	(Fryer 1995)
Salvelinus fontinalus	Brook Trout	1924	1990	617,000	Throughout	www.bcfisheries.gov.bc.ca/fishinv/db
Salvelinus	Lake Trout	1909	1978	136,000	Kalamalka Lake	www.bcfisheries.gov.b

namaycush					only	c.ca/fishinv/db
O. tshawytscha	Chinook	1928	1928	100,000	South of Vaseux Lake (occasional)	Penticton Herald, April 19, 1928
Micropteruus dolomieui	Smallmouth Bass	1985	1985	????	South of Penticton	(Shepherd 1999, per comm)
O. clarki	Cutthroat	1913	1931	33,000	Not thought to be present	www.bcfisheries.gov.bc.ca/fishinv/db

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3.19 Descriptions of Focal Wildlife Habitat Historic, Current, and Desired Future Condition

3.19.1 Ponderosa Pine

Historic

Historically in the Okanogan subbasin, old-growth ponderosa pine forests occupied large areas between the shrubsteppe zone and moister forest types at higher elevations.

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

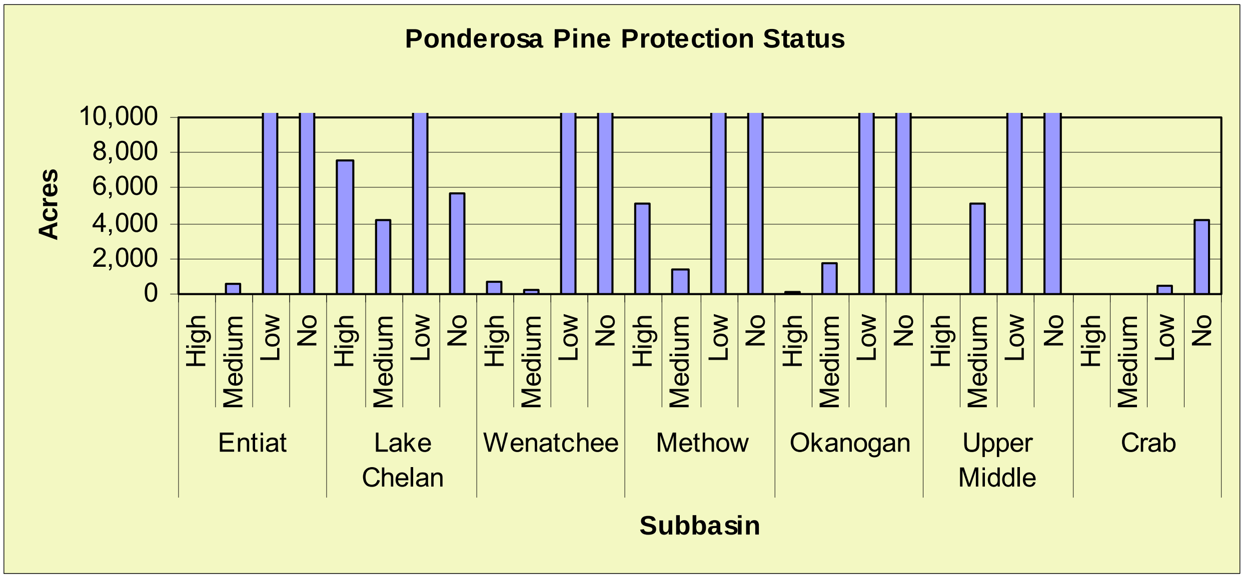
Current

The ponderosa pine zone is most narrowly defined as the zone in which ponderosa pine is virtually the only tree. Cassidy (1997) defined this zone more broadly to encompass most warm, open-canopy forests between the steppe vegetation zone and closed forest, thus it includes stands where other trees, particularly Douglas-fir, may be codominant with ponderosa pine.

Ecoprovince planners have used Cassidy's definition of the ponderosa pine vegetation zone. 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.

The major defining structural feature of this zone is open-canopy forest or a patchy mix of open forest, closed forest, and meadows. Frequent disturbance by fire is necessary for the maintenance of open woodlands and savanna (Cassidy 1997). Fire suppression favors the replacement of the fire-resistant ponderosa pine by the less tolerant Douglas-fir and grand fir.

Heavy grazing of ponderosa pine stands has lead to swards of Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*Poa compressa*) and replacement of native understory species by introduced annuals, especially cheat grass (*Bromus tectorum*). Four exotic *Centaurea* species are spreading rapidly through the ponderosa pine zone and threatening to replace cheat grass as the dominant increaser after grazing (Cassidy 1997). Open canopy conifer forest, the defining feature of this zone, covers slightly more than half the area of the zone. The status of ponderosa pine protection in the Okanogan subbasin in relation to other Upper Columbia River subbasins in illustrated.



Source: IBIS 2003

Figure 39. Protection status of ponderosa pine in the Columbia Cascade Ecoprovince, Washington (IBIS 2003).

Desired Future Condition

Recognizing that extant ponderosa pine habitat within the Ecoprovince currently covers a wide range of seral conditions. Ecoprovince planners identified three general ecological/management conditions that, if met, will provide suitable habitat for multiple wildlife species at the Ecoprovince scale within the ponderosa pine habitat type.

These ecological conditions correspond to life requisites represented by a species' assemblage that includes white-headed woodpecker (*Picoides albolarvatus*), flammulated owl (*Otus flammeolus*), pygmy nuthatch (*Sitta pygmaea*), and gray flycatcher (*Empidonax wrightii*). Species information (life requisites, distribution, status and trends) is included in Appendix F of the Columbia Cascade Ecoprovince Wildlife Assessment and Inventory. These species may also serve as a performance measure to monitor and evaluate the results of implementing future management strategies and actions.

Ecoprovince wildlife/land managers will review the conditions described below to plan and, where appropriate, guide future enhancement/protection actions on ponderosa pine habitats. Specific desired future conditions, however, are identified and developed within the context of individual management plans at the subbasin level.

Condition 1a – mature ponderosa pine forest: The white-headed woodpecker represents species that require/prefer large patches (>350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10 - 50 % and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags > 31 inches DBH). Abundant white-headed woodpecker populations can be present on burned or cut forest with residual large diameter live and dead trees and understory vegetation that is usually very sparse. Openness however, is not as important as the presence of mature or veteran cone producing pines within a stand (Milne and Hejl 1989).

Condition 1b – mature ponderosa pine forest: The pygmy nuthatch represents species that require heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age and those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 inches DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

Condition 2 – multiple-canopy ponderosa pine mosaic: Flammulated owls represent wildlife species that occupy ponderosa pine sites that are comprised of multiple-canopy, mature ponderosa pine stands or mixed ponderosa pine/Douglas-fir forest interspersed with grassy openings and dense thickets. Flammulated owls nest in habitat types with low to intermediate canopy closure (Zeiner et al. 1990), two layered canopies, tree density of 508 trees/acre (9-foot spacing), basal area of 250 ft.2/acre (McCallum 1994b), and snags >20 inches DBH 3-39 ft. tall (Zeiner et al. 1990). Food requirements are met by the presence of at least one snag >12 inches DBH/10 acres and 8 trees/acre > 21 inches DBH.

3.19.2 Shrubsteppe

Historic

Historically, sage dominated steppe vegetation occurred throughout the majority of the Subbasin. Shrublands were historically co-dominated by shrubs and perennial bunchgrasses with a microbiotic crust of lichens and mosses on the surface of the soil.

Dominant shrubs were sagebrush of several species and subspecies: basin, Wyoming, and mountain big sagebrush; low sagebrush; and early, rigid, and three-tip. Bitterbrush also was important in many shrubsteppe communities. Bunchgrasses were largely dominated by four species: bluebunch wheatgrass, Idaho fescue, needle and thread grass, and Sandberg's bluegrass. Soils, climate and topography acted to separate out distinct plant communities that paired sagebrush species with specific bunchgrasses across the landscape.

Within the shrubsteppe landscape there also were alkaline basins, many of which contained large lakes during wetter pluvial times, where extensive salt desert scrub communities occur. This characteristic Great Basin vegetation contained numerous shrubs in the shadscale group including greasewood which has wide ecological amplitude, being equally at home in seasonally flooded playas and on dunes or dry hillsides.

Current

Today, two shrubsteppe vegetation zones occur in the Okanogan subbasin. The central arid steppe vegetation zone occupies the central portion of the Subbasin (Figure 17 of the Columbia Cascade Ecoprovince Wildlife Assessment and Inventory). The average shrub cover is generally between 5% and 20 %.

In recent years, several exotic plant species have become increasingly widespread. Russian starthistle (*Centaurea repens*) is particularly widespread, especially along and near major watercourses. A 1981 assessment of range conditions rated most of the rangelands in this zone in poor to fair range condition (Cassidy 1987). Agricultural land use dominates the central arid steppe vegetation zone in the subbasin.

The three-tip sage vegetation zone also occupies the central portion of the Okanogan subbasin (Figure 17 of the Columbia Cascade Ecoprovince Wildlife Assessment and Inventory). The average shrub cover is about 12% and ranges from near 0 Percent to greater than 30 %. In recent years, tumble knapweed (*Centaurea diffusa*) has spread through this zone and threatens to replace other exotics as the chief increaser after grazing.

A 1981 assessment of rangelands rated most of this zone in fair range condition, with smaller amounts in good and poor range condition (but ecological condition is generally worse than range condition) (Cassidy 1987). Thirty-nine % of this vegetation zone is in agricultural production statewide.

Livestock grazing practices have led to trampled streambanks, increased bank erosion and sedimentation, and changes in vegetation, including loss of native grasses, impacts to woody vegetation, and establishment of noxious weeds (NPPC 2002e).

A 1970s rangeland evaluation indicated that 25% of rangeland in the Subbasin was in good condition, 34% in fair condition, and 41% was in poor condition (PNRB.C. 1977 in NPPC 2002e). According to NRCS definitions, rangelands in fair to excellent condition provide adequate ground cover to protect the soil resource. Rangeland in poor to fair condition may not protect the soil, depending on the species composition and density. Areas in poor to fair condition may be prone to accelerated erosion. Accelerated erosion will likely degrade water quality. The status of shrubsteppe protection in the Okanogan subbasin in relation to other Upper Columbia River subbasins in illustrated inFigure 40. Protection status of shrubsteppe in the Columbia Cascade Ecoprovince, Washington (IBIS 2003)..

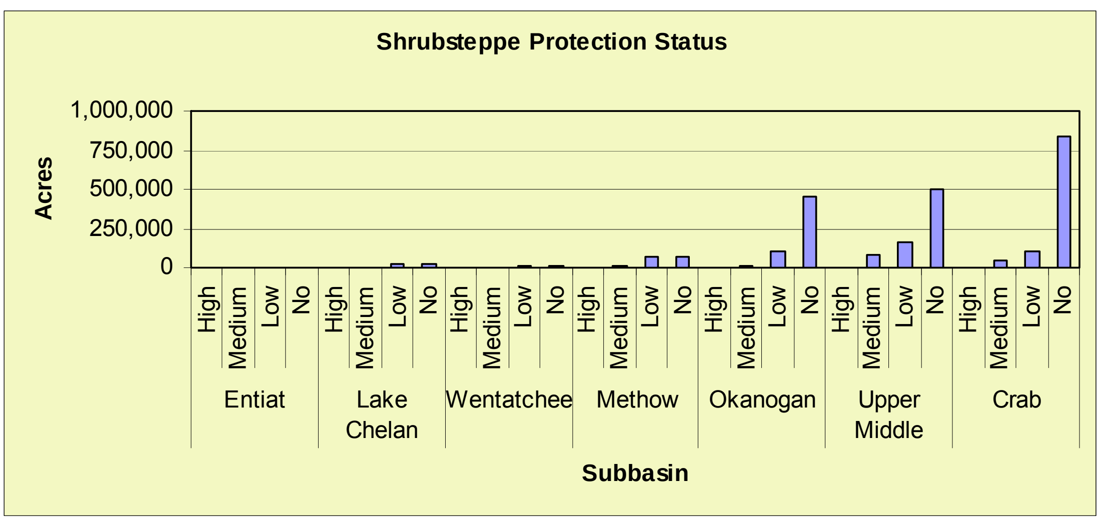


Figure 40. Protection status of shrubsteppe in the Columbia Cascade Ecoprovince, Washington (IBIS 2003).

Desired Future Condition

Shrub dominated shrubsteppe

The general recommended future condition of sagebrush-dominated shrubsteppe habitat includes expansive areas of high quality sagebrush with a diverse understory of native grasses and forbs (non-native herbaceous vegetation less than 10 %). More specific desired conditions include large unfragmented multi-structured patches of sagebrush with shrub cover varying between 10 and 30 %.

Good-condition shrubsteppe habitat has very little exposed bare ground, and supports mosses and lichens (cryptogammic crust) that carpet the area between taller plants. Similarly, subbasin land managers will manage diverse shrubsteppe habitats to protect and enhance desirable shrub species such as bitterbrush while limiting the spread of noxious weeds and increaser native shrub species such as rabbitbrush.

Ecoprovince planners have identified general ecological/management conditions that, if met, will provide suitable habitat for multiple wildlife species at the Ecoprovince scale within the shrubsteppe habitat type. Mule deer (*Odocoileus hemionus hemionus*), sage thrasher (*Oreoscoptes montanus*), sage grouse (*Centrocercus urophasianus*), and pygmy rabbit (*Brachylagus idahoensis*) were selected to represent the range of habitat conditions required by wildlife species that utilize sagebrush dominated shrubsteppe (shrubland) habitat within the Ecoprovince.

Species information (life requisites, distribution, abundance, status and trends) is included in Appendix F of the Columbia Cascade Ecoprovince Wildlife Assessment and Inventory. These wildlife species may also serve as a performance measure to monitor and evaluate the results of implementing future management strategies and actions.

Subbasin wildlife/land managers will review the conditions described below to plan and, where appropriate, guide future enhancement/protection actions on shrubsteppe habitats. Specific desired future conditions, however, are identified and developed within the context of individual management plans at the subbasin level.

Condition 1 – Sagebrush dominated shrubsteppe habitat: Sage thrasher was selected to represent shrubsteppe obligate wildlife species that require sagebrush dominated shrubsteppe habitats and that are dependent upon areas of tall sagebrush within large tracts of shrubsteppe habitat (Knick and Rotenberry 1995; Paige and Ritter 1999; Vander Haegen et al. 2001). Suitable habitat includes 5 to 20 % sagebrush cover greater than 2.5 feet in height, 5 to 20 % native herbaceous cover, and less than 10 % non-native herbaceous cover.

Condition 2 – Diverse shrubsteppe habitat: Mule deer were selected to represent species that require and prefer diverse, dense (30 to 60 % shrub cover less than 5 feet tall) shrubsteppe habitats (Ashley et al. 1999) comprised of bitterbrush, big sagebrush, rabbitbrush, and other shrub species (Leckenby 1969; Kufeld et al. 1973; Sheehy 1975; Jackson 1990) with a palatable herbaceous understory exceeding 30 % cover (Ashley et al. 1999). [Add conditions for pygmy rabbit and sage grouse]

3.19.3 Steppe/Grassland dominated shrubsteppe

The general recommended future condition of steppe/grassland dominated shrubsteppe habitat includes contiguous tracts of native bunchgrass and forb plant communities with less than 5% percent shrub cover and less than 10% exotic vegetation.

In xeric, brittle environments and sites dominated by shallow lithosol soils, areas between bunchgrass culms should support mosses and lichens (cryptogamic crust). In contrast, more mesic (greater than12 inches annual precipitation), deep soiled sites could sustain dense (greater than 75% cover) stands of native grasses and forbs (conclusions drawn from Daubenmire 1970).

Sharp-tailed grouse (*Tympanuchus phasianellus*) was chosen to represent the range of habitat conditions required by steppe/grassland obligate wildlife species. Ecoprovince wildlife/land managers recommend the following range of conditions:

- Greater than 40 % native bunchgrass cover
- Grater than 30 % native forb cover
- Less than 5% non-native herbaceous cover
- Visual obstruction readings (VOR) of at least 6 inches
- Greater than 75% deciduous shrub and tree cover

Multi-structured fruit/bud/catkin-producing deciduous trees and shrubs dispersed throughout the landscape (10 to 40 % of the total area), or within 1 mile of sharp-tailed grouse nesting/broodrearing habitats.

3.19.4 Eastside (Interior) Riparian Wetland

Historic

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

Current

Today, agricultural conversion, altered stream channel morphology, and water withdrawal have played significant roles in changing the character of streams and associated riparian areas. Woody vegetation has been extensively suppressed by grazing in some areas, many of which continue to be grazed. At lower elevations, agricultural conversions have led to altered stream channel morphology, loss of riparian vegetation and water withdrawals for irrigation.

Large areas once dominated by cottonwoods, which contribute considerable structure to riparian habitats, are being lost. The implications of riparian area degradation and alteration are wide ranging for many wildlife populations that utilize these important habitats for breeding, nesting, foraging, and resting activities.

Shallow water habitats typically connected to the mainstem of the river via culverts or small channels, provide special wildlife values. The reduced water fluctuation and protection from wave action is beneficial to wildlife, directly and indirectly, and as a result those conditions promote diverse riparian and wetland vegetative communities.

Natural flooding regimes, which promote important ecological process in riparian areas, were altered by the development of hydropower on the Columbia River. In general, there has been a decline in the diversity of riparian habitats, but an increase in the amount of habitat because of the stability the upstream storage projects provide in periods of high flows. For some species of wildlife such as migrant or wintering waterfowl, suitable habitat has increased because of increased open water associated with the reservoirs. The status of shrubsteppe protection in the Okanogan subbasin in relation to other Upper Columbia River subbasins in illustrated in Figure 41.

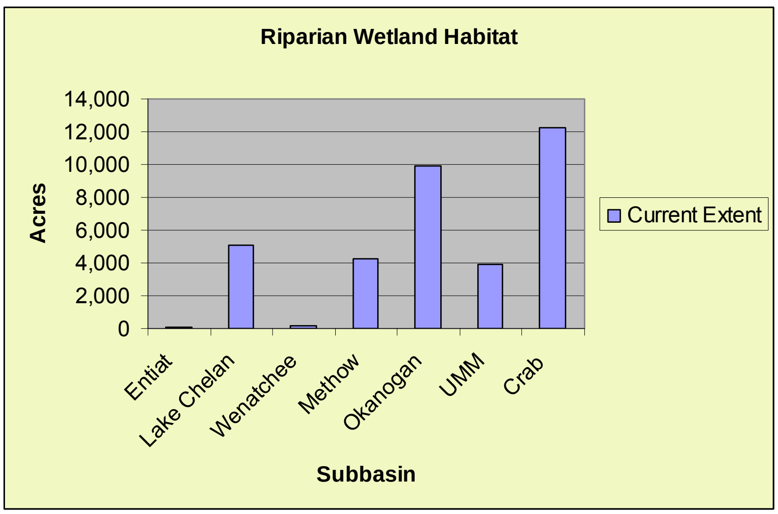


Figure 41. Protection status of riparian wetlands in the Columbia Cascade Ecoprovince, Washington (IBIS 2003).

Desired Future Condition

At the Ecoprovince level, wildlife/land managers focused on riparian (riverine) wetland habitats because of its prevalence throughout the Ecoprovince, close association with salmonid habitat requirements, and relationship to water quality issues. Subbasin level planners have the option to address lacustrine and palustrine wetland habitats at the local level.

Ecoprovince planners have identified general ecological/management conditions that, if met, will provide suitable habitat for multiple wildlife species at the Ecoprovince scale within the riparian wetland habitat type. Ecoprovince and subbasin level planners selected red-eyed vireo (*Vireo olivaceus*), yellow-breasted chat (*Icteria virens*), and beaver (*Castor canadensis*) to represent the range of habitat conditions required by wildlife species that utilize Eastside (Interior) Riparian Wetland habitat within the Ecoprovince.

Species information (life requisites, distribution, abundance, status and trends) is included in Appendix F of the Columbia Cascade Ecoprovince Wildlife Assessment and Inventory. These wildlife species may also serve as a performance measure to monitor and evaluate the results of implementing future management strategies and actions.

Ecoregion wildlife/land managers will review the conditions described below to plan and, where appropriate, guide future enhancement/protection actions on riparian wetland habitats. Specific desired future conditions, however, are identified and developed within the context of individual management plans at the subbasin level.

Wildlife/land managers have a wide array of conditions to consider. Recognizing the variation between existing riparian wetland habitat and the dynamic nature of this habitat type, recommended conditions for riparian wetland habitat focus on the following habitat/ anthropogenic attributes:

- The presence and/or height of native hydrophytic shrubs and trees
- Shrub and/or tree canopy structure, tree species and diameter (DBH)
- Distance between roosting and foraging habitats
- Human disturbance
- Ecoprovince wildlife/land managers recommend the following range of conditions for the specific riparian wetland habitat attributes:
- Greater than 60 % tree canopy closure
- Mature deciduous trees greater than 160 feet in height and 21 inches DBH
- Greater than 10 % young cottonwoods
- Tree cover less than 20 %
- 30 to 80 % native shrub cover
- Multi-structured shrub canopy greater than 3 feet in height
- Snags greater than 16 inches DBH

The status of shrubsteppe protection in the Okanogan subbasin in relation to other Upper Columbia River subbasins is illustrated.

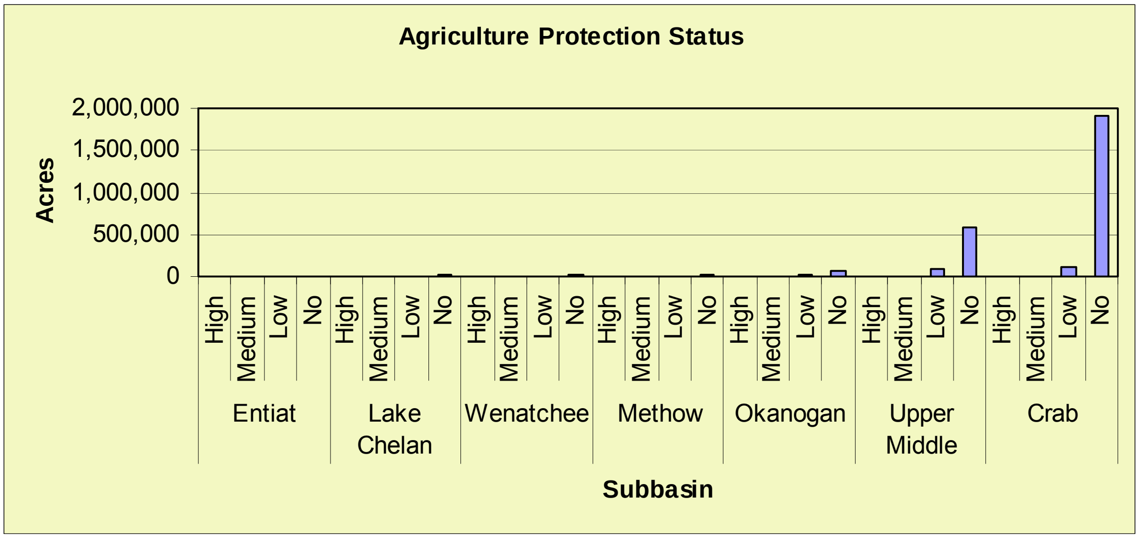


Figure 42. Protection status of agriculture in the Columbia Cascade Ecoprovince, Washington (IBIS 2003).

3.19.5 Rugged Terrains (Cliffs, Caves, and Talus Slopes) – Habitat of Concern

Although not a focal habitat type, cliffs, caves, and talus slopes within the Subbasin are very important and provide unique habitat for many birds and reptile species. Because vast areas of shrubsteppe habitat are virtually treeless, rock outcroppings provide critical nesting habitat for several raptor species.

Rock outcroppings are also used by reptiles for thermoregulation. Barren ground such as steep canyon walls and cliffs can offer protective habitat for numerous species of wildlife. This may include nesting and roosting habitat, perches for hunting, and areas for hibernating in the winter.

The Okanogan River from headwaters to the confluence of the Columbia River has sheer cliffs along much of its length that provide roosts for some bat species and nest sites for some bird species, and refugia for reptiles. Cliff-dwelling bats and birds forage in the adjacent steppe and over the river. The cliffs themselves are in little danger of development, but cliff-dwelling animals may be affected by habitat alteration of the surrounding steppe and the riparian strip (Cassidy 1997).

Species that rely on the combination of sheer cliffs and large rivers have no alternate refuge. An important management consideration is the maintenance of the continuity of riparian areas and protection of the link between cliffs, caves, and talus slopes and adjacent steppe.

3.20 Ecological Relationships in the Aquatic Ecosystem

The biotic communities of aquatic systems in the Upper Columbia Basin are highly complex. Within communities, assemblages and species have varying levels of interaction with one another. Direct interactions may occur in the form of predator-prey, competitor, and disease- or parasite-host relationships. In addition, many indirect interactions may occur between species.

These interactions continually change in response to shifting environmental and biotic conditions. Human activities that change the environment, the frequency and intensity of disturbance, or species composition can shift the competitive balance among species, alter predatory interactions, and change disease susceptibility. All of these changes may result in community reorganization.

3.21 Fish Community Structure and Interactions in the Upper Columbia Basin

Few studies have examined the fish species assemblages within the Upper Columbia Basin. Most information available is from past surveys (e.g., Dell et al. 1975; Dobler et al. 1978; McGee et al. 1983; Burley and Poe 1994; Hillman 2000; Duke Engineering 2001), dam passage studies (e.g., Mullan et al. 1986; Tonseth and Petersen 1999; Chelan PUD unpublished data), and northern pikeminnow studies (e.g., Burley and Poe 1994; West 2000).

The available information indicates that about 41 species of fish occur within the Upper Columbia Basin (from the mouth of the Yakama River upstream to Chief Joseph Dam) (Table 35). This is an underestimate because several species of cottids (sculpins) live there. Of the fishes in the basin, 15 are cold-water species, 18 are cool-water species, and 8 are warm-water species.

Table 35. Fish species of the Upper Columbia

Common name	Species	Native (N) or Exotic (E)	Feeding location in water column			Primary prey				
			Surf	Mid	Bot	Plant	Detrit	Mic	Mac	Fish
Cold-water species:										
White sturgeon	*Acipenser transmontanus*	N			x	x	x	x	X	x
Chinook salmon (juv)	*Oncorhynchus tshawytscha*	N	X	x	x				X	
Coho salmon (juv)	*Oncorhynchus kisutch*	N	X	x	x				X	
Sockeye/kokanee (juv)	*Oncorhynchus nerka*	N	x	X	x			x	X	
Steelhead/rainbow	*Oncorhynchus mykiss*	N	x	X	x				X	x
	Oncorhynchus									

Common name	Species	Native (N) or Exotic (E)	Feeding location in water column			Primary prey				
			Surf	Mid	Bot	Plant	Detrit	Mic	Mac	Fish
Cutthroat trout	*clarki*	N	X	x	x				X	x
Brown trout	*Salmo trutta*	E	x	X	x				X	x
Atlantic salmon	*Salmo salar*	E	x	X	x				X	x
Bull trout	*Salvelinus confluentus*	N	x	x	X				X	x
Brook trout	*Salvelinus fontinalis*	E	x	X	x				X	x
Mountain whitefish	*Prosopium williamsoni*	N	x	x	X				X	
Lake whitefish	*Coregonus clupeaformis*	E		x	X				X	x
Longnose sucker	*Catostomus catostomus*	N			X	x	x	x	x	
Sculpins	*Cottus spp.*	N			X				X	x
Cool-water species:										
Longnose dace	*Rhinichtys cataractae*	N			X				X	
Peamouth	*Mylocheilus caurinus*	N			X				X	x
Chiselmouth	*Acrocheilus alutaceus*	N			X	X			x	
Northern pikeminnow	*Ptychocheilus oregonensis*	N	x	x	X				X	x

Common name	Species	Native (N) or Exotic (E)	Feeding location in water column			Primary prey				
			Surf	Mid	Bot	Plant	Detrit	Mic	Mac	Fish
Redside shiner	*Richardsonius balteatus*	N	x	X	x				X	
Sand roller	*Percopsis transmontana*	N			X				X	
Bridgelip sucker	*Catostomus columbianus*	N			X	X			x	
Mountain sucker	*Catostomus platyrhynchus*	N			X	X	x	x	x	
Largescale sucker	*Catostomus macrocheilus*	N			X	X	x	x	x	
Pacific lamprey (juv)	*Lampetra tridentata*	N			X	x		X	x	
Western brook lamprey (juv)	*Lampetra richardsonii*	N			X	x	X	x		
Threespine stickleback	*Gasterosteus aculeatus*	N	x	X	x				X	
Pumpkinseed	*Lepomis gibbosus*	E		X	x				X	x
Walleye	*Stizostedion vitreum*	E		x	X				x	X
Yellow perch	*Perca flavescens*	E	x	X	x				X	x
Smallmouth bass	*Micropterus dolomieu*	E	x	x	X				X	x

Common name	Species	Native (N) or Exotic (E)	Feeding location in water column			Primary prey				
			Surf	Mid	Bot	Plant	Detrit	Mic	Mac	Fish
Sculpin	*Cottus spp.*	N			X				X	x
Warm-water species:										
Channel catfish	*Ictalurus punctatus*	E			X				X	x
Black bullhead	*Ameiurus melas*	E			X	x			X	
Brown bullhead	*Ameiurus nebulosus*	E			X	x	x	x	X	x
Tench	*Tinca tinca*	E			X	x			X	
Common carp	*Cyprinus carpio*	E			X	x	x	x	X	
Bluegill	*Lepomis macrochirus*	E	x	X	x				X	x
Black crappie	*Pomoxis nigromaculatus*	E	x	X	x				X	x
Largemouth bass	*Micropterus salmoides*	E	x	X	x				x	X

Most of the cold-water species are native to the area; only four were introduced (brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), lake whitefish (*Coregonus clupeaformis*), and Atlantic salmon (S. salar)). Four of the 18 cool-water species are exotics (pumpkinseed (*Lepomis gibbosus*), walleye (*Stizostedion vitreum*), yellow perch (*Perca flavescens*), and smallmouth bass (*Micropterus dolomieu*)), while all warm-water species are exotics.

Anadromous species within the upper basin include spring and summer/fall Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), steelhead

(*O. mykiss*), and Pacific lamprey (*Lampetra tridentata*). Atlantic salmon (*Salmo salar*) are also anadromous, but their status in the basin is largely unknown.

White sturgeon (*Acipenser transmontanus*), which may have been anadromous historically, are present as a resident population.

About half of the resident species in the upper basin are piscivorous (eat fish) (Table ?). Ten cold-water species, seven cool-water species, and five warm-water species are known to eat fish. About 59% of these piscivores are exotics (Table ?). Before the introduction of exotics, northern pikeminnow (*Ptychocheilus oregonensis*), sculpin (*Cottus spp*.), white sturgeon, bull trout (*Salvelinus confluentus*), rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), and burbot (*Lota lota*) were the primary piscivores in the region (Li et al. 1987; Poe et al. 1994).

Presently, burbot are rare in the upper basin (Dell et al. 1975; Burley and Poe 1994) and probably have little effect on the abundance of juvenile Chinook and steelhead in the region. The status of white sturgeon in the upper basin is mostly unknown, although their numbers appear to be quite low (DeVore et al. 2000).

Introduced species such as walleye, smallmouth bass, and channel catfish (*Ictalurus punctatus*) are important predators of Chinook and steelhead in the Columbia River (Poe et al. 1994). Channel catfish are rare (Dell et al. 1975; Burley and Poe 1994) and likely have little to no effect on abundance of Chinook and steelhead.

Other piscivores, such as largemouth bass (*M. salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), yellow perch, and pumpkinseed are either rare or not known to prey heavily on juvenile anadromous fish (Dell et al. 1975; Burley and Poe 1994).

What follows is a brief summary of interactions of fish, birds, and mammals with spring Chinook and summer steelhead in the Upper Columbia River Basin.

3.22 Competition

Competition among organisms occurs when two or more individuals use the same resources and when availability of those resources is limited (Pianka 2000). That is, for competition to occur, demand for food or space must be greater than supply (implies high recruitment or that the habitat is fully seeded) and environmental stresses few and predictable.

Two types of competition are generally recognized: (1) interference competition, where one organism directly prevents another from using a resource through aggressive behavior, and (2) exploitation competition, where one species affects another by using a resource more efficiently. Salmonids likely compete for food and space both within species (intra-specific) and between species (inter-specific). Inter-specific interactions are more likely to occur between native and exotic species, rather than between species that coevolved together.

Although coevolved sympatric species should segregate (i.e., partition resources in space or time or both), native species may still interaction along the margins of their spatial and temporal distributions. An example of this may occur between Chinook salmon and steelhead. This interaction was studied in the Wenatchee Basin by Hillman et al (1989a, 1989b) and found to be relatively unimportant in limiting the production of the species.

Interaction between the species was minimized because of disparate times of spawning, which tended to segregate the two species. Both Chinook and steelhead may interact competitively with other natives, such as bull trout, Westslope cutthroat trout, or redside shiners. Currently, there is no evidence that the focal species interact with bull trout or Westslope cutthroat trout. Indeed, Martin et al. (1992) indicated that juvenile bull trout and Chinook have different habitat preferences and thus do not interact competitively.

Significant interaction between redside shiners and Chinook and steelhead may occur as a result of changes or modifications in water quality (e.g., temperature). In both field and laboratory studies, Hillman (1991) found that redside shiners displaced Chinook salmon from rearing areas at temperatures greater than 18°C. In fact, at these warmer temperatures, shiners negatively affected the distribution, behavior, and production of Chinook salmon. Reeves et al. (1987) documented similar results with redside shiners and juvenile steelhead. Thus, if water temperatures increase within the basin, one can expect increased interactions between shiners and Chinook and steelhead.

Exotic species may be more likely to interact with Chinook and steelhead because exotics have not had time to segregate spatially or temporally in their resource use. For example, there is a possibility that brook trout interact with Chinook and steelhead in the upper basin. Welsh (1994), however, found no evidence that brook trout displaced Chinook salmon. On the other hand, Cunjak and Green (1986) found that brook trout were superior competitors to rainbow/steelhead at colder temperatures (9°C), while rainbow/steelhead were superior at warmer temperatures (16°C).

A potentially important source of exploitative competition occurring outside the geographic boundary of the ESUs may be between the exotic American shad (*Alosa sapidissima*) and juvenile Chinook and steelhead. Palmisano et al. (1993a, 1993b) concluded that increased numbers of shad likely compete with juvenile salmon and steelhead.

Although coho salmon were native to the upper basin, they have been absent for many decades. Recently, there have been efforts to re-establish them in the upper basin (Murdoch et al. 2002). Thus, there is the potential that reintroduced coho will interact negatively with Chinook and steelhead. However, studies conducted in the Wenatchee Basin indicate that there is little to no interaction between the species (Spaulding et al. 1989; Murdoch et al. 2002).

3.23 Predation

Fish, mammals, and birds are the primary natural predators of Chinook and steelhead in the Upper Columbia Basin. Although the behavior of Chinook and steelhead precludes any single predator from focusing exclusively on them, predation by certain species can nonetheless be seasonally and locally important.

Recent changes in predator and prey populations along with major changes in the environment, both related and unrelated to development in the Upper Columbia basin, have reshaped the role of predation (Mullan et al. 1986; Li et al. 1987).

Although several fish species can consume Chinook and steelhead in the upper basin, northern pikeminnow, walleyes, and smallmouth bass have the potential for significantly affecting the abundance of juvenile anadromous fish (Gray and Rondorf 1986; Bennett 1991; Poe et al. 1994; Burley and Poe 1994). These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey.

Channel catfish also have the potential to significantly affect the abundance of juvenile Chinook and steelhead (see e.g., Gray and Rondorf 1986; Poe et al. 1994), but because they are rare in the upper Columbia (Dell et al. 1975; Burley and Poe 1994), they likely have a small effect on survival of juvenile Chinook and steelhead there. Native species such as sculpins and white sturgeon also prey on juvenile anadromous fish (Hunter 1959; Patten 1962, 1971a, 1971b; Mullan 1980; Hillman 1989).

Most adult salmonids within the upper basin are opportunistic feeders and are therefore capable of preying on juvenile Chinook and steelhead. Those likely to have some effect on the survival of Chinook and steelhead include adult bull trout, rainbow/steelhead trout, cutthroat trout, brook trout, and brown trout. Of these, bull trout and rainbow trout are probably the most important. These species occur together with Chinook and steelhead in most tributaries, hence the probability for interaction is high. The presence of both fluvial and adfluvial stocks of bull trout in the region further increases the likelihood for interaction there.

Predation by piscivorous birds on juvenile anadromous fish may represent a large source of mortality. Fish-eating birds that occur in the upper basin include great blue herons (*Ardea herodias*), gulls (*Larus* spp.), osprey (*Pandion haliaetus*), common mergansers (*Mergus merganser*), American dippers (*Cinclus mexicanus*), cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), common loons (*Gavia immer*), western grebes (*Aechmophorus occidentalis*), black-crowned night herons (*Nycticorax nycticorax*), and bald eagles (*Haliaeetus leucocephalus*) (T. West, Chelan PUD, pers. comm.).

These birds have high metabolic rates and require large quantities of food relative to their body size. In the Columbia River estuary, avian predators consumed an estimated 16.7 million smolts (range, 10-28.3 million smolts), or 18% (range, 11-30%) of the smolts reaching the estuary in 1998 (Collis et al. 2000). Caspian terns consumed primarily salmonids (74% of diet mass), followed by double-crested cormorants (*P. auritus*) (21% of diet mass) and gulls (8% of diet mass). The NMFS (2000) identified these species as the most important avian predators in the Columbia River basin.

Mammals may be an important agent of mortality to Chinook and steelhead in the upper basin. Predators such as river otters (*Lutra Canadensis*), raccoons (*Procyon lotor*), mink (*Mustela vison*), and black bears (*Ursus americanus*) are common in the upper basin. These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993).

Black bears consume large numbers of salmon, but generally scavenge post-spawned salmon. Pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Stellar sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on Chinook and steelhead originating from the Upper Columbia basin (Spence et al. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) may also prey on adult Chinook and steelhead. Seal and sea lion predation is primarily in saltwater and estuarine environments though they are know to travel well into freshwater after migrating fish. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable.

3.24 Disease and Parasitism

Chinook and steelhead can be infected by a variety of bacterial, viral, fungal, and microparasitic pathogens. Numerous diseases may result from pathogens that occur naturally in the wild or that may be transmitted to wild fish via infected hatchery fish.

Among these are bacterial diseases, including bacterial kidney disease (BKD), columnaris, furunculosis, redmouth disease, and coldwater disease; virally induced diseases, including infectious hepatopoietic necrosis (IHN), infectious pancreatic necrosis (IPNV), and erythrocytic inclusion body syndrome (EIBS); protozoan-caused diseases, including ceratomyxosis and dermocystidium; and fungal infections, such as saprolegnia (Bevan et al. 1994).

Chinook in the Columbia River have a high incidence of BKD (Chapman et al. 1995). Incidence appears higher in spring Chinook (Fryer 1984) and can be a major problem in hatchery-reared Chinook in the upper Columbia region (Chapman et al. 1995). Viral infections such as IPNV have been detected in hatchery steelhead in the upper Columbia region (Chapman et al. 1994). Other epizootics, including *Ceratomyxa shasta* and tuberculosis, are endemic to the Columbia River basin, but it is unknown if these affect the production of Chinook and steelhead in the upper Columbia region.

Generally one thinks of epizootics killing fish outright. However, sublethal chronic infections can impair the performance of Chinook and steelhead in the wild, thereby contributing secondarily to mortality or reduced reproductive success. Fish weakened by disease are more sensitive to other environmental stresses. Additionally, they may become more vulnerable to predation (Hoffman and Bauer 1971), or less able to compete with other species. For example, both Hillman (1991) and Reeves et al. (1987) found that water temperature affected interactions between redside shiners and the focal species.

Both researchers noted that outcomes of interactions were, in part, related to infection with *F. columnaris*. In their studies, most Chinook and steelhead were infected at warmer temperatures, whereas shiners showed a higher incidence of infection at cooler temperatures.

3.25 Competition

As noted in the Ecological Interactions section, competition among organisms occurs when two or more individuals use the same resources and when availability of those resources is limited (Pianka 2000). Although competition is difficult to demonstrate, a few studies conducted within the Upper Columbia Basin indicate that competition may affect the production of Chinook salmon and steelhead in the basin.

3.25.1 Chinook/steelhead

It is possible that inter-specific competition may occur between juvenile Chinook and steelhead along the margins of their spatial and temporal distributions. Hillman et al. (1989a, 1989b) investigated the interaction between these species in the Wenatchee River between 1986 and 1989. They reported that Chinook and steelhead used dissimilar daytime and nighttime habitat throughout the year.

During the daytime in summer and autumn, juvenile Chinook selected deeper and faster water than steelhead. Chinook readily selected stations associated with brush and woody debris for cover, while steelhead primarily occupied stations near cobble and boulder cover. During winter days, Chinook and steelhead used similar habitat, but Hillman et al. (1989a) did not find them together. At night during both summer and winter, Hillman et al. (1989b) found that both species occupied similar water velocities, but subyearling Chinook selected deeper water than steelhead.

Within smaller streams, Hillman and Miller (2002) found that Chinook were more often associated with pools and woody debris during the summer, while steelhead occurred more frequently in riffle habitat. Hillman et al. (1989a, 1989b) concluded that interaction between the two species would not strongly negatively affect production of either species, because disparate times of spawning tended to segregate the two species. This conclusion is consistent with the work of Everest and Chapman (1972) in Idaho streams.

3.25.2 Redside shiners

Under appropriate conditions, inter-specific interaction may also occur between redside shiners and juvenile Chinook and steelhead. Hillman (1991) studied the influence of water temperature on the spatial interaction between juvenile Chinook and redside shiners in the field and laboratory. In the Wenatchee River during summer, Hillman (1991) noted that Chinook and shiners clustered together and that shiners were aggressive toward salmon. He reported that the shiners used the more energetically profitable positions, and that they remained closer than Chinook to instream and overhead cover.

In laboratory channels, shiners affected the distribution, activity, and production of Chinook in warm (18-21°C) water, but not in cold (12-15°C) water (Hillman 1991). In contrast, Chinook influenced the distribution, activity, and production of shiners in cold water, but not in warm water. Reeves et al. (1987) documented similar results when they studied the interactions between redside shiners and juvenile steelhead. Although Hillman (1991) conducted his fieldwork in the lower Wenatchee River, shiners are also present in the Entiat, Methow, and Okanogan rivers and are abundant in the mainstem Columbia River. At warmer temperatures, shiners likely negatively affect the production of Chinook salmon and steelhead in the upper basin.

3.25.3 Coho salmon

It is possible that the re-introduction of coho salmon into the Upper Columbia Basin may negatively affect the production of Chinook and steelhead. One of the first studies in the upper basin that addressed effects of coho on Chinook and steelhead production was conducted by Spauling et al. (1989) in the Wenatchee River.

This work demonstrated that the introduction of coho into sites with naturally produced Chinook and steelhead did not affect Chinook or steelhead abundance or growth. However, because Chinook and coho used similar habitat, the introduction of coho caused Chinook to change habitat. After removing coho from the sites, Chinook moved back into the habitat they used prior to the introduction of coho.

Steelhead, on the other hand, remained spatially segregated from Chinook and coho throughout the study. More recent studies conducted by Murdoch et al. (2002) found that juvenile coho, Chinook, and steelhead used different microhabitats in Nason Creek, and at the densities tested, coho did not appear to displace juvenile Chinook or steelhead from preferred microhabitats.

These studies indicate that the re-introduction of coho should have little to no effect on the production of Chinook and steelhead.

3.25.4 Various salmonids

It is possible that juvenile Chinook and steelhead interact with bull trout, brook trout, and cutthroat trout if they occur together. Hillman and Miller (2002) observed Chinook, bull trout, and brook trout together in several tributaries of the Chiwawa River and in the Little Wenatchee River.

In tributaries of the Chiwawa River, Hillman and Miller (2002) observed Chinook and juvenile bull trout in the same habitat. They report seeing bull trout and Chinook nipping each other in Big Meadow, Rock, and Chickamin creeks. Usually the aggressive interactions occurred in pools near undercut banks or in woody debris. In contrast, Martin et al. (1992) investigated the interaction between juvenile bull trout and spring Chinook in the Tucannon River, Washington, and found that the two species have different habitat preferences.

Juvenile spring Chinook occurred more often in open, slow-water habitat without complex hiding cover. Bull trout, on the other hand, more frequently used riffle and cascade habitat. Bull trout numbers inversely correlated with amounts of woody debris and the two species did not compete for food because food was not limiting in the Tucannon River (Martin et al. 1992).

Although Hillman and Miller (2002) observed juvenile Chinook and brook trout together in many tributaries of the Chiwawa River and in the Little Wenatchee River, they did not see aggressive interaction between the two species. Welsh (1994), on the other hand, studied the interaction between the two species in Idaho streams and found that when Chinook were introduced into a stream with brook trout, the latter was displaced into marginal habitat.

Over a six-year period, Welsh (1994) notes that brook trout vanished from his study sites. We can find no studies that address the interaction between Chinook and cutthroat trout. Although Chinook and steelhead may interact with bull trout, brook trout, and cutthroat trout, there is no evidence that they will negatively affect the production of Chinook and steelhead in the Upper Columbia basin.

3.25.5 American shad

A potentially important source of exploitative competition occurring outside the geographic boundary of the ESUs may be between the exotic American shad and juvenile Chinook and steelhead. Changes in stream flow in the Columbia River system have resulted in increased plankton production, which has apparently increased the success of introduced shad.

Shad prey on the most abundant foods (Walburg 1956; Levesque and Reed 1972). Shad in the Columbia River estuary consume amphipods, calanoid copepods (*Neomysis mercedis*), cladocerans (*Daphnia sp.*), and insects (Durkin et al. 1979). Juvenile salmonids eat the same foods (McCabe et al. 1983). Palmisano et al. (1993a, 1993b) concluded that increased numbers of shad likely compete with juvenile salmon and steelhead.

3.26 Predation

Fish, mammals, and birds are the primary natural predators of Chinook and steelhead in the Upper Columbia basin. Although the behavior of Chinook and steelhead precludes any single predator from focusing exclusively on them, predation by certain species can nonetheless be seasonally and locally important. Below is a discussion on the importance of specific predators on the production of Chinook and steelhead in the Upper Columbia basin.

3.26.1 Smallmouth bass

Smallmouth bass were introduced into the Columbia River before 1900 (Poe et al. 1994). Given their behavioral characteristics, it is assumed that they could significantly affect the abundance of juvenile Chinook and steelhead. In spring and early summer they inhabit rocky shoreline areas that are also used by juvenile salmonids (Scott and Crossman 1973; Wydoski and Whitney 1979).

Studies in Columbia basin reservoirs and Lake Sammamish, Washington, showed that smallmouth bass were highly predacious on outmigrating juvenile salmonids (Gray et al. 1984; Gray and Rondorf 1986). In contrast, studies by Bennett et al. (1983) and Zimmerman (1999) found that even though salmonids were present in Snake and Columbia River reservoirs, they were less important in the diets of smallmouth bass than other fish.

Smallmouth bass commonly consumed sculpins, minnows, suckers, and troutperches in impounded and unimpounded reaches of the lower Columbia and lower Snake Rivers during the outmigration of juvenile anadromous salmonids (Zimmerman 1999).

Sampling in the Upper Columbia Basin indicates that smallmouth bass are relatively rare (Dell et al. 1975; Burley and Poe 1994). Burley and Poe (1994) described studies that assessed the relative abundance of northern pikeminnow, walleye, and smallmouth bass in the Rocky Reach project area. Smallmouth bass constituted only 5% of the catch; northern pikeminnow and walleye made up 91% and 4% of the respective catch. Most (63%) smallmouth bass resided in the tailrace.

Very few (3%) were captured mid-reservoir. Mullan (1980), Mullan et al. (1986), and Bennett (1991) suggested that few smallmouth bass occur within the Upper Columbia because of low ambient water temperatures. Optimum growth temperatures for smallmouth bass range from 26-29°C (Armour 1993a).

Because Upper Columbia reservoirs function as a cold-tailwater to the reservoir of Grand Coulee Dam, optimal temperatures for bass occur primarily in warm backwaters (Mullan et al. 1986; Bennett 1991). The typical low water temperatures in the project area result in late spawning times, slow fry and fingerling growth, and small body size of smallmouth bass entering the first winter. This contributes to high over-winter mortality of juvenile smallmouth bass (Bennett 1991).

One could theorize that if sustained removals of northern pikeminnow significantly reduce mortality of juvenile salmonids in the project area, predation by smallmouth bass may be enhanced because of increased availability of juvenile salmonid prey. Studies in the lower Columbia and Snake rivers found that smallmouth bass did not respond to sustained removals of northern pikeminnow (Ward and Zimmerman 1999). Smallmouth bass density, year-class strength, consumption of juvenile salmonids, survival, growth, and relative weight did not increase concurrent with removals of northern pikeminnow. Likewise, it is unlikely that smallmouth bass will respond to sustained removals of northern pikeminnow in the Upper Columbia basin.

Because smallmouth bass are not abundant in the upper Columbia, they probably have a minor influence on the survival of juvenile Chinook and steelhead. Of the anadromous fish in the project area, subyearling summer/fall Chinook may be consumed more readily because their habitats overlap seasonally with smallmouth bass, and the subyearlings are ideal forage size for adult smallmouth bass (Poe et al. 1994).

3.26.2 Walleye

According to Li et al. (1987), walleye recently invaded the Columbia River from the reservoir of Grand Coulee Dam, where they are now very abundant. This fish is a large, schooling predator, unlike the native fauna, and its affect on juvenile Chinook and steelhead could be significant because of the potential for depensatory predatory-prey interactions.

Gray et al. (1984) found a high frequency of occurrence (42%) of juvenile salmonids in the stomachs of walleyes collected in the John Day tailrace during spring. In John Day Reservoir, however, Maule (1982) reported that walleyes ate few juvenile salmonids, and suggested that the probable reason was the spatial and temporal segregation of the species when walleyes were feeding most actively. Perhaps the reason that walleyes eat more juvenile salmonids in the tailrace is because the dam creates habitat that increases potential for spatial overlap, and therefore predation, between the species. This is supported by the high occurrence of juvenile salmonids in walleye stomachs collected between 1800 and 2400 hours (Gray et al. 1984), when the greatest fraction of smolts move through the powerhouse at John Day Dam (Sims et al. 1981), and when walleyes feed most heavily (Maule 1982).

Work by Zimmerman (1999) in impounded and unimpounded reaches of the lower Columbia River indicated that walleyes, like smallmouth bass, more commonly consumed sculpins, suckers, minnows, and troutperches during the outmigration of juvenile salmonids. This comports with the observations of Vigg et al. (1991), who estimated that nonsalmonid consumption rates of walleye were similar to those of smallmouth bass and exceeded those of northern pikeminnow in John Day reservoir.

Walleyes are relatively rare in the upper Columbia (Dell et al. 1975; Burley and Poe 1994). Burley and Poe (1994) reported that walleyes made up only 4% of the catch of the major predators in the Rocky Reach project area; the other two major predators, northern pikeminnow and smallmouth bass, made up 91% and 5% of the respective catch.

Most of the walleyes were captured in the tailrace. Few were captured in the forebay or mid-reservoir. The abundance of walleye appears to be limited by poor recruitment and low turbidity (Bennett 1991). Bennett (1991) reported that the most significant factor limiting abundance of walleyes is the short reservoir retention times (5.5-0.7 days), especially at the time of larvae abundance. High mortality and low food abundance for larvae probably limits recruitment of walleyes in reservoirs. In addition, low water turbidity likely affects the temporal and spatial distribution of feeding and reproduction of walleyes.

Walleyes attain maximum population sizes in shallow, large, turbid waters (Scott and Crossman 1973). They prefer turbid water because their eyes are sensitive to bright light. In clear waters, walleyes retain contact with the substrate during the day (Ryder 1977) and increase activity as light conditions decrease in the evening. Peak periods of activity in clear waters are dusk and dawn (Kelso 1976).

Mullan et al. (1992) believed that low water temperatures might limit recruitment of walleyes in the upper Columbia. Optimal water temperatures for embryo incubation range from 9-15°C (Armour 1993b). Optimal growth temperatures for juveniles and adults range from 22-28°C and 20-28°C, respectively (Armour 1993b). These thermal requirements suggest that water temperatures in the project area may not increase sufficiently fast or high enough for successful incubation, hatching, and rearing (Mullan et al. 1986; Bennett 1991). Successful incubation, hatching, and rearing may occur in backwater areas.

Because walleyes are not abundant in the upper Columbia, they probably do not significantly reduce the abundance of juvenile Chinook or steelhead in the area. Walleye predation on juvenile salmonids is probably greatest on subyearling summer/fall Chinook. Gray et al. (1984) found that about 80% of the juveniles identified in walleye stomachs were subyearlings, probably a result of their smaller size. Subyearling Chinook spend more time in shallower water than yearling spring Chinook, also increasing the likelihood of encountering walleyes.

3.26.3 Northern pikeminnow

The northern pikeminnow is a native cyprinid widely distributed throughout the Columbia River system (Mullan et al. 1986). It is the dominant predator of juvenile salmonids in the system, and predation by this species is clearly important compared to other sources of mortality (Poe et al. 1991; Rieman et al. 1991; Vigg et al. 1991; Ward and Zimmerman 1999; Zimmerman 1999).

Petersen (1994) estimated the annual loss of juvenile salmonids to predation by northern pikeminnow in John Day Reservoir to be 1.4 million, approximately 7.3% of all juvenile salmonids entering the reservoir. Predation varies throughout the system and is often highest near dams (Ward et al. 1995). Although the work by Gadomski and Hall-Griswold (1992) suggests that northern pikeminnow prefer dead juvenile Chinook to live ones, Petersen (1994) found that 78% of juvenile salmonids eaten by northern pikeminnow near a dam were consumed while alive.

Ward et al. (1995) estimated that 48% of predation occurs in mid-reservoir areas away from dams, where juvenile salmonids are presumably alive and uninjured when consumed. Of the estimated 200 million juvenile salmonids that emigrate annually through the Columbia River system, about 16.4 million (8%) are consumed by northern pikeminnow (Beamesderfer et al. 1996).

Northern pikeminnow are abundant in the Upper Columbia Basin (Dell et al. 1975; Mullan 1980; Mullan et al. 1986; Bennett 1991; Burley and Poe 1994) and large numbers pass through the fishways at dams. Of the three major predators in the Rocky Reach project area (northern pikeminnow, smallmouth bass, and walleye), northern pikeminnow made up 91% of the catch (Burley and Poe 1994). These fish were most abundant in the mid-reservoir (45% of the total catch of northern pikeminnow), with the remaining catch of northern pikeminnow split equally between the forebay and tailrace.

At other dams in the Upper Columbia basin, Burley and Poe (1994) found larger numbers of northern pikeminnow in the tailrace areas. Northern pikeminnow in the Rocky Reach project area averaged 296 mm fork length (range, 115-515 mm) (Burley and Poe 1994). Vigg et al. (1991) reported that juvenile salmonids are the major dietary component of northern pikeminnow larger than 250-mm fork length. Therefore, one would assume that northern pikeminnow could significantly affect the abundance of juvenile Chinook and steelhead in the upper basin.

Burley and Poe (1994) summarize studies that assessed the significance of northern pikeminnow predation in the Upper Columbia region. They reported that northern pikeminnow in the Rocky Reach project area consumed primarily fish during the spring and summer; crustaceans, molluscs, insects, and plants were also consumed. Typically, the highest percentage of gut contents consisting of fish occurred in pikeminnows feeding in the tailrace and forebay areas. Juvenile salmonids were a significant component of northern pikeminnow diets, especially in tailrace areas.

The concern that northern pikeminnow could significantly affect the abundance of Chinook and steelhead in the upper basin, resulted in the initiation of a pikeminnow population reduction program. Since its initiation (1994), the program has removed well over 75,000 northern pikeminnow from Rocky Reach and Rock Island project areas (West 2000). At Rocky Reach, the program removed 44,743 (average, 6,400 per year; range, 2,482-9,633) pikeminnow. The number of northern pikeminnow ascending fish ladders at both dams has declined and catch rates have decreased (West 2000).

It is reasonable to assume that the reduction in numbers of northern pikeminnow has increased survival of juvenile Chinook and steelhead in the upper basin. In the lower Columbia and Snake rivers, potential predation on juvenile salmonids by northern pikeminnow decreased 25% after a pikeminnow removal program was implemented there (Friesen and Ward 1999). Friesen and Ward (1999) estimated a reduction in potential predation of 3.8 million juvenile salmon (representing 1.9% of the total population).

Knutsen and Ward (1999) found no evidence that the surviving pikeminnow compensated for removals. That is, estimates of relative weight, growth, and fecundity of pikeminnow were similar to estimates made before pikeminnow removals. Zimmerman and Ward (1999) concluded that consumption of juvenile salmonids by surviving pikeminnow has not increased in response to pikeminnow removal. It is likely that similar results occur within the Upper Columbia basin.

Northern pikeminnow are abundant in the Upper Columbia basin and have the potential to significantly affect the abundance of juvenile Chinook and steelhead. They consume large numbers of juvenile salmonids, primarily those concentrated in the tailrace and forebay areas during the spring outmigration. They also consume large numbers of juvenile salmonids (probably summer/fall Chinook) during summer.

Currently, the factor limiting the abundance of northern pikeminnow in the upper basin is the sustained population reduction program. The program has removed large numbers of northern pikeminnow from the project area. As a result, dam passage counts of pikeminnow have decreased. This has likely resulted in increased survival of juvenile anadromous fish in the project area.

3.26.4 Sculpins

Sculpins are native and relatively common in the upper basin (Dell et al. 1975; Mullan 1980; Burley and Poe 1994). Although sculpins are not considered a major predator of outmigrating anadromous fish, they do prey on small Chinook and steelhead (Hunter 1959; Patten 1962, 1971a, 1971b; Hillman 1989).

In the Wenatchee River, Hillman (1989) noted that large concentrations (20 fish/m2) of juvenile Chinook and steelhead occupied inshore, shallow, quiet-water positions on the streambed during the night. Hillman (1989) found that many sculpins moved into these areas at night and preyed heavily on Chinook and steelhead fry. Predation on fry appeared to be limited to sculpins larger than 85 mm and ceased when prey reached a size larger than 55 mm. The number of fry eaten per night appeared to be related to sculpin size, with the largest sculpins consuming the most fry per individual.

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

3.26.5 White sturgeon

White sturgeon, a native species, are not abundant in the upper basin (Mullan 1980; Mullan et al. 1986; Gray and Rondorf 1986; DeVore et al. 2000). According to Mullan (1980), sturgeon were perhaps the most important predator on young and adult salmon, and other fishes. This is not the case now because of greatly reduced sturgeon abundance.

Using setlines and gill nets, DeVore et al. (2000) found few sturgeon in the Upper Columbia River. In Rock Island Reservoir, a total of 95 overnight setlines captured only four sturgeon. The researchers did not sample in Rocky Reach Reservoir and used only setlines in Rock Island Reservoir. Sturgeon in Rock Island Reservoir ranged in lengths from 144-192 centimetre and in weight from 31-57 kilograms. The researchers aged two fish, one at 17 years and the other at 30 years.

White sturgeon are occasionally captured during the northern pikeminnow reduction program. For example, anglers collected two sturgeon in 1998, one at Rocky Reach Dam and another at Rock Island Dam (West 1999). Angling in 1999 captured three sturgeon at Rock Island Dam (West 2000). No sturgeon were captured at Rocky Reach Dam in 1999. All sturgeon captured during the northern pikeminnow control program were 91 centimetre or larger (T. West, Chelan PUD, pers. comm.).

White sturgeon are opportunistic bottom feeders, as indicated by morphological adaptations that include ventral barbels and a ventral, protrusible, sucker-like mouth (Wydoski and Whitney 1979; Ford et al. 1995). Juveniles predominantly eat chironomids and to a lesser degree, zooplankton, molluscs, and immature mayflies, caddisflies, and stoneflies (Scott and Crossman 1973). In the lower Columbia River, juveniles primarily ate the tube-dwelling amphipod *Corophium salmonis* (McCabe et al. 1993).

Individuals larger than 48 centimetre in length eat primarily fish (Scott and Crossman 1973; Ford et al. 1995). In the Kootenai River, white sturgeon larger than 80 centimetre fed on fish (whitefish, suckers, and other unidentified fish), aquatic insects, snails, clams, leeches, and chironomids (Partridge 1983).

DeVore et al. (2000) concluded that the white sturgeon in the Upper Columbia region are recruitment-limited because spawning habitat appears to be absent and no juveniles were found. Spawning coincides with peak flows during spring and early summer. Mature adults typically spawn in swift water (mean water column velocity, 0.8-2.8 m/s) over large substrate (cobble, boulder, or bedrock) (Parsley et al. 1993; Ford et al. 1995). In the upper basin these conditions likely exist just downstream from Wells Dam and Rocky Reach Dam. It is unknown if white sturgeon spawn in these areas.

Because white sturgeon are rare in the upper basin, they probably do not significantly affect the abundance of juvenile Chinook or steelhead. Small Chinook that rear in the Columbia River may be vulnerable to predation by white sturgeon. Theoretically, this would occur primarily at night when Chinook and steelhead are stationed on the streambed.

3.27 Wildlife/Fish Interactions

3.27.1 Birds

Predation by piscivorous birds on juvenile anadromous fish may represent a large source of mortality. Birds have high metabolic rates and require large quantities of food relative to their body size.

In the Columbia River estuary, avian predators consumed an estimated 16.7 million smolts (range, 10-28.3 million smolts), or 18% (range, 11-30%) of the smolts reaching the estuary in 1998 (Collis et al. 2000). Caspian terns consumed primarily salmonids (74% of diet mass), followed by double-crested cormorants (21% of diet mass) and gulls (8% of diet mass). The NMFS (2000) identified these species as the most important avian predators in the Columbia River basin.

Currently, there is little information on the effects of bird predation on the abundance of juvenile Chinook and steelhead in the upper basin. Fish-eating birds that occur in the region include great blue herons, gulls, osprey, common mergansers, American dippers, cormorants, Caspian terns, belted kingfishers, common loons, western grebes, black-crowned night herons, and bald eagles (T. West, Chelan PUD, pers. comm.).

According to Wood (1987a, 1987b), the common merganser limited salmon production in nursery areas in British Columbia. He found during smolt migrations that mergansers foraged almost exclusively on juvenile salmonids (Wood 1987a). Maximum mortality rate declined as fish abundance increased (i.e., depensatory mortality) and did not exceed 10% for any salmonid species. Wood (1987b) also estimated that young mergansers consumed almost one-half pound of subyearling Chinook per day. Thus, a brood of ten ducklings could consume between four and five pounds of fish daily during the summer.

The loss of juvenile Chinook and steelhead to gulls is potentially significant. Ruggerone (1986) studied the consumption of migrating juvenile salmon and steelhead below Wanapum Dam and found that the foraging success of gulls averaged 65% during bright light conditions and 51% during the evening. The number of salmonids consumed ranged from 50 to 562 fish/h. Ruggerone (1986) estimated that the number of salmonids consumed by gulls foraging downstream from the turbines during 25 days of peak salmonid migration was about 111,750 to 119,250 fish, or 2% of the estimated spring migration. Ruggerone (1986) noted that gulls consumed some salmonids that had been killed when passing through the turbines.

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

Although there are no estimates of the losses associated with bird predation in the Upper Columbia basin, it appears that bird predation can significantly affect the survival of juvenile Chinook and steelhead. Accordingly, the PUDs have implemented bird harassment measures and in some cases placed piano wire across tailraces. The degree to which these measures have reduced predation on juvenile anadromous fish is unknown at this time, but they have reduced bird predation on fish in the region (T. West, Chelan PUD, pers. comm.).

3.27.2 Mammals

No one has studied the effects of mammals on numbers of Chinook and steelhead in the Upper Columbia basin. Observations by BioAnalysts (unpublished data) indicate that river otters occur throughout the region. BioAnalysts (unpublished data) found evidence of otters fishing the Wenatchee, Chiwawa, Entiat, and Methow rivers, and Icicle Creek.

Otters typically fished in pools with large woody debris. According to Hillman and Miller (2002), juvenile Chinook are most abundant in these habitat types; thus, the probability for an encounter is high. Dolloff (1993) examined over 8,000 otoliths in scats of two river otters during spring 1985 and found that they ate at least 3,300 juvenile salmonids in the Kadashan River system, Alaska. He notes that the true number of fish eaten was much higher, as it is unlikely that searchers found all the scats deposited by the otters.

Other predators, such as raccoon and mink also occur in tributaries throughout the Upper Columbia basin. Their effects on numbers of Chinook and steelhead are unknown.

Black bears are relatively common in the upper Columbia basin and frequent streams used by spawning salmon during autumn. Studies have shown that salmon are one of the most important meat sources of bears and that the availability of salmon greatly influences habitat quality for bears at both the individual level and the population level (Hilderbrand et al. 1999; Reimchen 2000).

Observations by crews conducting Chinook spawning surveys in the upper basin indicate that bears eat Chinook, but it is unknown if the bears remove pre-spawned fish or are simply scavenging post-spawned fish. Regardless, there is no information on the roll that bears play in limiting survival and production of Chinook and steelhead in the upper basin.

Pinnipeds, including harbor seals, California se lions, and Stellar sea lions are the primary marine mammals preying on Chinook and steelhead originating from the Upper Columbia basin (Spence et al. 1996). Pacific striped dolphin and killer whale may also prey on adult Chinook and steelhead. Seal and sea lion predation is primarily in saltwater and estuarine environments though they are know to travel well into freshwater after migrating fish. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable.

Although there are no estimates of the losses associated with mammal predation in the Upper Columbia basin, it appears that mammals can significantly affect the survival of Chinook and steelhead, especially in the estuary and near-shore ocean environments.

3.28 Competition with a Listed species

Bald Eagle (Haliaeetus leucocephalus)

In 1978, the bald eagle was federally listed throughout the lower 48 States as Endangered except in Michigan, Minnesota, Wisconsin, Washington, and Oregon, where it was designated as Threatened (USDI 1978). In July 1995, the USFWS reclassified the bald eagle to Threatened throughout the lower 48 states. In 1999, the bald eagle was proposed for de listing, recovered throughout the lower 48 States. This proposal is currently under review (USFWS July 1999). Eagles are further protected under the Bald and Golden Eagle Protection Act (BGEPA 1940) and the Migratory Bird Treaty Act of 1918 (MBTA 1918). Bald eagle populations have increased in number and expanded their range.

Bald eagles utilize a wide variety of prey items, although they primarily feed on fish, birds and mammals. Diet can vary seasonally, depending on prey availability. Given a choice of food, however, they typically select fish. Many species of fish are eaten, but they tend to be species that are easily captured or available as carrion. In the Pacific Northwest, salmon form an important food supply, particularly in the winter and fall. Birds taken for food are associated with aquatic habitats. Ducks, gulls and seabirds are typically of greatest importance in coastal environments. Mammals are less preferred than birds and fish, but form an important part of the diet in some areas. Deer and elk carcasses are scavenged, and in coastal areas, eagles feed on whale, seal, sea lion and porpoise carcasses (Stalmaster 1987).

3.29 Limiting Factors and Conditions

The presence, distribution, and abundance of fish and wildlife species in the Okanogan subbasin have been affected by habitat change and loss due primarily to:

- Residential development
- Agricultural development
- Livestock grazing
- Exotic species
- Hydropower development and operation
- Fire suppression

For a more in-depth discussion of limiting factors for wildlife at the Ecoprovince scale, see section 4.3 of the Columbia Cascade Ecoprovince Wildlife Assessment and Inventory and the Okanogan Limiting Factors Analysis (Ref?).

3.30 Limiting Factors Overview

Humans have impacted wildlife since before recorded history. Records begin with European exploration and settlement. Activities of the early European settlers that impacted wildlife and wildlife habitat included mining, cattle drives, fur trapping, agriculture, vineyards and orcharding, fire suppression, and forest management activities. Cities, farms and orchards fragmented wildlife habitats and hindered movement of many species.

Forest and cattle range industries have matured and a growing tourism industry leave their seasonal footprints on the upper valley and along water corridors. A growth in rural property owners and crop farmers over the last 100 years has consumed much of the valley bottom and altered riparian ecosystems.

Fur Trade

Fur bearing animals were extensively trapped in the early 1800s and by the turn of the century were practically nonexistent. Reintroduction and protective management has restored harvestable populations of some of these animals (Pacific Northwest River Basins Commission, 1977). Lynx, wolverine, and fisher are currently state and federally listed species. Several of these populations declined dramatically as a result of trapping in the early 1800s. Later, timber harvest and other resource activities further impacted remaining populations.

Mining

United States

The Jessie Moore mine, in the North Fork Salmon Creek drainage, is the only patented claim within the USFS boundary. Several claims have had plans for ground-disturbing activities in the last quarter-century, including the Silversmith Group in 1981, Quimine in 1981, and the Day Star Group in 1981. The Mar-Mac received got approval on its plans for road construction in 1983. That mine was restaked in 1993, and renamed Plata #1 (USDA, 1997).

Existing gravel mines are located well away from stream channels, and are probably not a major contributor of sediments to the streams.

In 1995, Okanogan County Health District conducted site hazard assessments on 25 mine sites in the Okanogan Basin:

6 sites were dropped because they were either active, or judged too insignificant to warrant full investigation.

3 sites were determined to be clean, and no further action was taken

16 sites were tested, and some elements were found at levels recommended for cleanup under the Model Toxics Control Act (MTCA). These elements included lead, arsenic, zinc, cadmium, copper, and antimony.

A number of sites were identified as presenting physical danger to the public because of a variety of causes including rotten or inadequate shoring, or unstable rock masses.

Lead and arsenic in both soil and water were the metals more frequently found above the MTCA’s recommended cleanup levels. Lead binds to soil particles and tends to not move significantly in the soil column. Arsenic is more prone to a slow migration through the soil column and into the groundwater.

The WSDOE will conduct site hazard assessments at each of the identified sites, as time and staffing allow, to determine the severity of the problem, rank the sites, and initiate remediation, if required (OWSAC, 2000).

The USEPA recently closed the Texas Kaaba mine, upstream of the Enloe Dam.

Canada

Mining has occurred historically in the Canadian portion of the Okanogan subbasin though specifics regarding location and numbers is not readily available for this document.

Population Growth and Residential Development

Population growth and residential development has resulted in fragmentation and replacement of large areas of habitat and increased the stress on wildlife.

Disturbance by humans in the form of highway traffic, noise and light pollution, and various recreational activities have the potential to displace wildlife or forces them to use less desirable habitat. Most land with development potential (including many areas formerly covered by wetlands) in the basin has now been developed, and urban and agricultural development are now expanding into even marginal land and rough terrain. It is anticipated that urban development will continue to expand at a great rate in the Canadian Okanagan Basin, and to a lesser degree in the US portions of the basin because of the proportionally limited lakeside recreation properties. Seasonal tourist and shoreline residential development will continue to be a major stress on aquatic, terrestrial, and wetland ecosystems of the Okanogan.

While urban areas comprise only a small percentage of the land base within the Okanogan subbasin (0.5%), their habitat impacts are significant. Cities and towns within the Subbasin are largely built along creeks and rivers.

Channelization and development along water courses has eliminated riparian and wetland habitats. Expansion of urban areas affects drainage, and homes built along streams have affected both water quality and the ability of the floodplain to function normally. Removal of woody, overhanging vegetation along stream corridors has increased stream temperatures to the point that they are unable to support coldwater biota.

Hydropower Development and Operation

The development and operation of the hydropower system has resulted in widespread changes in available riparian habitats in the Upper Columbia Biological effects related to hydropower development and operations on fish and wildlife and its habitats may be direct or indirect.

In addition to the direct loss associated with entrainment of area salmon, the cumulative affects include the building of numerous roads and railways, presence of electrical transmissions and lines, the expansion of irrigation, and increased access to and harassment of wildlife.

Water quality

There are some water quality concerns in the US Okanogan Basin. The Okanogan River and several of its tributaries are on the Washington State 303(d) 1998 list (Impaired and Threatened Waterbodies Requiring Additional Pollution Controls) for “failure to meet water quality standards including temperature, dissolved oxygen, pH, and fecal coliform" (WSDOE, 1998) Table 36

Table 36 Okanogan Basin Water bodies on the Washington State 1998 303 (d)

Water Body	Water Quality Issues
Okanogan River	temperature, DO, fecal coliform, PCB-1260, PCB-1254, 4,4'-DDE*, 4,4'-DDD*
Similkameen River	Temperature, arsenic
Salmon Creek	Instream flow
Nine-mile Creek	DDT
Tallant Creek	DDT
Lake Osoyoos	4,4'-DDE*, 4,4'-DDD*

There is a "consistent late summer water temperature criteria violation in the Okanogan (annual violations from 1983 to 1993). Fish within the watershed are subject to poor water quality and low flow conditions, and critically high water temperatures during summer months" (Ecology 1998). Temperature and flow listings pose the most significant problems to salmon recovery in the Okanogan watershed. Washington Department of Ecology (WDOE) has undertaken sampling in the Okanogan watershed to assess Total Maximum Daily Loads (TMDLs) for PCBs and DDT.

The WSDOE establishes TMDLs as the foundation of a basin-specific strategy to improve water quality. The WSDOE may establish statewide TMDLs for temperature-related parameters.

Channelization

The Okanogan and Okanogan mainstem rivers have been channelized from the Osoyoos Lake to its confluence with the Columbia River, and much of the river channel is no longer connected to its floodplain. Low head dams were placed at the outlets of Osoyoos Lake just near Oroville Washington, and in B.C. at the outlets of Vaseux, Skaha, and Okanagan Lakes which have changed migration patters of resident species and limited the upstream extend of anadromous fish migration to McIntrye Dam east of Oliver B.C. A seven-kilometre section of river remains untangled just north of Oliver.

Agricultural Development

Although agriculture is a dominant land use in the Okanogan subbasin, it is not representative of a native wildlife habitat type and is considered to replace preferred habitat types for indigenous species. Agricultural lands therefore are not treated as a focal species in this subbasin plan. However, agricultural lands converted to CRP can significantly contribute toward benefits to wildlife.

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

Riparian vegetation such as cottonwood, spruce, alder and a dense shrub layer have been largely removed. Agriculture, residences, and associated roads contribute chemical contaminants and sediments to the streams and rivers.

Conversion of shrubsteppe communities to agricultural purposes throughout the Ecoprovince, and eastern Washington in general, has resulted in a fragmented landscape with few extensive tracts of interior grassland or shrubsteppe remaining (Dobler et al. 1996).

Agricultural land uses in the Ecoprovince include dry land wheat farms, irrigated agricultural row crop production, and irrigated agriculture associated with fruit and livestock production (alfalfa and hay). Agriculture conversions concentrated in low elevation valleys have significantly affected valley bottom grasslands, shrublands, and cottonwood dominated riparian areas.

Agricultural development has altered or replaced vast amounts of native steppe/grassland and shrubsteppe habitat in the lowlands and fragmented riparian wetland habitat within the Ecoprovince. Agricultural operations have also increased sediment loads and introduced herbicides and pesticides into streams.

Livestock Grazing

A federal grazing allotment system began in the early 1900s in response to complaints about the grazing and burning of the forests. Eligible ranchers were granted permits to graze on federal lands at specific times of the year at a fee for each animal per month. In the Toats Coulee area, now DNR and USFS lands, between 1906 and 1925 1,096 cattle grazed the area from June 1 to November 15 each year.

Livestock grazing practices have led to trampled stream banks, increased bank erosion and sedimentation, and changes in vegetation, including loss of native grasses, impacts to woody vegetation, and establishment of noxious weeds.

Most of the native grasses and forbs are poorly adapted to heavy grazing and trampling by livestock (Cassidy 1997). True interior grassland habitat was not likely historically present in the Subbasin and may be more appropriately described as central arid steppe.

A 1970s rangeland evaluation indicated that 25% of rangeland in the basin was in good condition, 34% in fair condition, and 41% was in poor condition (PNRB.C., 1977).

According to NRCS definitions, rangelands in fair to excellent condition provide adequate ground cover to protect the soil resource. Rangeland in poor to fair condition may not protect the soil, depending on the species composition and density. Areas in poor to fair condition may be prone to accelerated erosion. Accelerated erosion will likely degrade water quality.

Habitat conditions in range allotments on National Forest lands are in an upward trend. Most allotments have at least one localized area of overgrazing and trampling, and the Tonasket Ranger District focuses monitoring and restoration efforts on these areas. The District monitors range allotment conditions using a 1960s inventory as a baseline. In 1999 the District began conducting environmental analyses on all allotments. The allotments are assessed in clusters based on geologic features, and are being completed at a rate of one per year (Messerlie, 2001).

The USFS standards used to assess the condition of the riparian zones are contained in the Okanogan Forest Plan (USDA, 1989). On a forest wide basis, 24% of the riparian acreage was monitored in 1997.

Livestock grazing no longer occurs in the Pasayten Wilderness. The existing conservation allotment was created in 2000. The allotment still exists, but it would require an environmental analysis to reestablish grazing, and it is considered extremely unlikely to occur (Messerlie 2001, pers. comm.).

Data gaps exist in the Okanogan National Forest include the lack of baseline monitoring data on water quality for riparian and stream systems. Much of the grazing information for the Canadian sections of the subbasin was unavailable.

Conversion of agricultural lands

Agricultural land use has significantly changed the composition and structure of shrub and steppe vegetation communities from historic conditions. Livestock grazing tends to decrease perennial foragers (i.e., steppe and/or grasslands and increase shrub density).

Conversion of agricultural lands to suburban homesites invites a second new suite of biodiversity onto the Ecoprovince. Suburbanization of agricultural lands does not necessarily favor native species. The brown-headed cowbird (*Molothrus ater*) and European starling (*Sturnus vulgaris*) have taken advantage of the new habitats and moved into the area. The black-tailed jack rabbit (*Lepus californicus*) has largely displaced the white-tailed jack rabbit (Tisdale 1961; Johnson and Cassidy 1997).

Even though the conversion of native habitats to agriculture severely impacted native wildlife species such as the sharp-tailed grouse, agriculture did provide new habitat niches that were quickly filled with introduced species such as the ring-necked pheasant (*Phasianus colchicus*) chukar (*Alectoris chukar*), and the gray partridge (*Perdix perdix*). Native ungulate populations took advantage of new food sources provided by croplands and either expanded their range or increased in number (J. Benson, WDFW, pers. comm., 1999).

Wildlife species/populations that could adapt to and/or thrived on “edge” habitats increased with the introduction of agriculture until the advent of “clean farming” practices and monoculture cropping systems.

Conversion of any wildlife habitat type to agriculture adversely affects wildlife in two ways: native habitat is replaced, and remaining habitat is isolated and embedded in a highly fragmented landscape of multiple land uses.

Species adapted to expansive landscapes of steppe and shrubsteppe communities. When landscapes are fragmented by conversion to land use types different from what occurred naturally, wildlife dependent upon the remnant native habitat may be subjected to adverse population pressures, including:

- isolation of breeding populations;

- competition from similar species associated with other, now adjacent, habitats;
- increased predation by generalist predators;
- increased nest loss through parasitism by brown-headed cowbirds;
- creation of population sinks; and
- increased conflict between wildlife species and economic agricultural crops, i.e., crop depredation.

Fragmentation of previously extensive landscapes can influence the distribution and abundance of birds through redistribution of habitat types and through the pattern of habitat fragmentation, including characteristics such as decreased patch area and increased habitat edge (Ambuel and Temple 1983; Wilcove et al. 1986; Robbins et al. 1989; Bolger et al. 1991, 1997).

Fragmentation also can reduce avian productivity through increased rates of nest predation (Gates and Gysel 1978; Wilcove 1985), increased nest parasitism (Brittingham and Temple 1983; Robinson et al. 1995), and reduced pairing success of males (Gibbs and Faaborg 1990; Villard et al. 1993; Hagan et al. 1996).

It is not known to what extent these population pressures affect birds and other wildlife species in fragmented shrubsteppe environments, although a recent study from Idaho (Knick and Rotenberry 1995) suggests that landscape characteristics influence site selection by some shrubsteppe birds.

Most research on fragmentation effects on birds has occurred in the forests and grasslands of eastern and central North America, where conversion to agriculture and suburban/urban development has created a landscape quite different from that which existed previously. The potential for fragmentation to adversely affect shrubsteppe wildlife in Washington warrants further research.

Even though the conversion of native habitats to agriculture severely impacted native wildlife species such as the sharp-tailed grouse, agriculture did provide new habitat niches that were quickly filled with introduced species such as the ring-necked pheasant (*Phasianus colchicus*) chukar (*Alectoris chukar*), and the gray partridge (*Perdix perdix*). Moreover, native ungulate populations took advantage of new food sources provided by croplands and either expanded their range or increased in number (J. Benson, [agency?], pers. comm., 1999).

Wildlife species/populations that could adapt to and/or thrived on “edge” habitats increased with the introduction of agriculture until the advent of “clean farming” practices and monoculture cropping systems.

Transportation corridors

Federal and Provincial, State, county highways parallel the river at close proximity for its entire length, in Canada from Kelowna to Osoyoos, and the US south to its confluence with the Columbia River, except for a reach from Riverside to Janis, Washington. Riverside to Janis is the only largely undeveloped reach in the US along the Okanogan River floodplain.

During construction of a railroad grade through Omak Creek Canyon near St. Mary's Mission, the crew removed 10,000 cubic yards of rock from the canyon (Lewis, 1980). Much of this was blasted or dropped into Mission Falls directly below. The extra material blocked anadromous fish passage to the waters above the falls until 1999, when the Colville Tribes and NRCS finished removing the material from the channel.

The Biles Colman narrow-gauge railroad was unusual in that it was well maintained throughout its history. The railroad ties were not treated with creosote, as is common still, because of the ready access to timber at the mill (Lewis, 1980).

Roads

There are 4,357 miles of road in the Okanogan Watershed (WDNR, 1996). The Okanogan County road system includes less than 900 miles, with about 33 miles of county road within 200 feet of a stream or river. There is no comprehensive database quantifying the unimproved roads currently within the watershed. Unimproved roads are unpaved, and may or may not be graveled.

Roads are considered to be the greatest contributing source of sediment to streams in the basin. Sedimentation is highest at road crossings over stream channels, along roads in close proximity to streams, along cut and fill slopes, and at roads and ditches that drain to stream channels. Private roads that access multiple parcels often do not have a coordinated maintenance program, leading to increased erosion and sedimentation.

Roads affect streams by accelerating erosion and sediment delivery, altering channel morphology, and changing the runoff characteristics of watersheds (Furniss et al., 1991). In addition, noxious weeds tend to spread along roads, increasing erosion potential. Herbicide treatment of noxious weeds along roadsides can lead to contamination of nearby streams through accidental spills, direct runoff, or infiltration (USDA, 2000).

Road construction is one of the largest impacts in terms of water pollution in the basin. Several thousand acres of land have been devegetated during the initial construction phases and subsequent maintenance operations, leaving the underlying soil exposed to the forces of wind and water.

Water crossing and fill failures have occurred regularly during high water periods, degrading water quality and requiring expensive repairs. In places, erosion of road fills is chronic, because of faulty road drainage or lack of fill protection such as rock armoring or vegetation.

In addition to sediments, runoff from road surfaces carry contaminants such as heavy metals, litter, rubber particles, asphalt materials, herbicides, de-icing compounds, and asphalt sealant.

The Washington State Department of Transportation (WSDOT) maintains almost 175 miles of highway in the watershed and has made significant changes to their maintenance operations in the past several years to provide better protection to the water resource.

These measures include:

Use of vacuum trucks to clean catch basins and bridge drains rather than flushing them out, with the material being recycled or properly disposed of.

Application of liquid de-ices in the fall and spring, in lieu of sanding.

Modification of sand specifications so a "cleaner" sand is being used.

The Endangered Species Act listing of the steelhead trout influenced WSDOT maintenance operations, including weed control operations, culvert cleaning, sanding and deicing practices (OWSAC, 2000). WSDOT has numerous culverts in need of cleaning. A list of all culverts identified by Washington State Department of Fish and Wildlife (WDFW) is available. Many stretches of state highway are in close proximity to streams, and it is difficult for WSDOT to keep the roads safe for travel while protecting the streams from contaminants.

Although Okanogan County Public Works does not have in place written procedures for roadway maintenance practices, the department is in the process of developing guidelines (OWSAC, 2000).

Exotic Species

The spread of non-native plant and wildlife species poses a threat to wildlife habitat quality and to wildlife species themselves. For example, noxious weeds can threaten the abundance of native plant species fed upon by wildlife, and introduced wildlife species can compete with native wildlife for resources, potentially leading to the decline of the native species. Eurasian water milfoil surveys conducted by the Chelan County Public Utility District during the mid 1980s found that milfoil is infiltrating native aquatic weed beds and displacing these native plant species (NPPC 2002e).

Noxious Weed Effects on Water Quality and Riparian and Aquatic Habitat

Noxious weeds alter riparian vegetative cover by reducing the complexity of vegetative layering and diversity, on which indigenous aquatic and semi-aquatic species rely (USDA, 2000). Infestations on stream banks may lead to increased sediment delivery when weeds replace native, fibrous-rooted plants with tap-rooted weeds, such as knapweed. The weeds use available water, but do not provide enough ground cover to prevent erosion. (USDA 2000).

Herbicide treatment of weeds also impacts streams if the herbicide reaches the channel. Herbicides may enter surface or shallow ground water when sprayed directly on running or standing water, or through drift or soil erosion, or in the case of an accidental spill.

Herbicides may indirectly affect surface waters by reducing the riparian zone vegetation, leading to increased water temperatures (USDA, 2000). Herbicides may contaminate water through accidental spills, direct application to water bodies, surface runoff or movement through the soil (USDA, 2000).

Weed treatment under the ONF preferred alternative for the Integrated Weed Management program would use a combination including herbicides and hand pulling, flower head removal, mowing and scraping. In riparian areas, glycophosphate would be sprayed during spring or fall.

Fire

Fire is a natural occurrence in most shrubsteppe ecosystems and has been one of the primary tools humans have used to manage this habitat type. Fire prevents woody vegetation from encroaching, removes dry vegetation, and recycles nutrients. Conversely, fire suppression allows shrubs and trees to encroach/increase on areas once devoid of woody vegetation and/or promotes decadence in undisturbed native steppe/grassland communities.

Although fire can benefit steppe/grassland habitat, it can be harmful too—particularly when fires become much more frequent than is natural. If too frequent, fire can remove plant cover and increase soil erosion (Ehrlich et al. 1997:201) and can promote the spread of annual grasses to the detriment of native plants (Whisenant 1990).

Fires covering large areas of shrubsteppe habitat can eliminate shrubs and their seed sources and create grassland habitat to the detriment of sage dependent wildlife species such as sage grouse. Fires that follow heavy grazing or repeated early season fires can result in annual grasslands of cheatgrass, medusahead, knapweed, and/or yellow starthistle.

In Ecoprovince forest habitats, fire suppression has resulted in the loss of climax forest communities and, in some instances, wildlife species diversity by allowing the spread of shade tolerant species such as Douglas-fir and grand fir. Prior to fire suppression, wildfires kept shade-tolerant species from encroaching on established forest communities. The lack of fire within the ecosystem has resulted in significant changes to the forest community and has negatively impacted wildlife. Changes in forest habitat components have reduced habitat availability, quality, and utilization for wildlife species dependent on timbered habitats.

Long-term fire suppression can lead to changes in forest structure and composition, and result in the accumulation of fuel levels that can lead to severe crown fires that replace entire stands of trees. The higher elevation forests have evolved with high fire severity regimes, and fire suppression effects are not detectable. Thunderstorms bring lightning ignition to forested areas susceptible to fire.

Recreational use accounts for 60 % of fire ignitions in the Chiwawa River watershed (25-year period approximately 1972 to 1997) (NPPC 2002c). As forest stands become more layered, homogenous, and loaded, the potential for catastrophic fire increases. Attempts to restore ponderosa pine forests to their pre- European structure and function (i.e. conditions prior to forest suppression) should have positive impacts on some resident bird species, such as pygmy nuthatch, but too little information is currently available (Ghalambor 2003).

Because fire is an important natural process in ponderosa pine forests and is an important factor in creating snags, the restoration of natural fire regimes has been proposed as a management tool (e.g. Covington and Moore 1994; Arno et al. 1995; Fule and Covington 1995). In particular, the use of prescribed fires to reduce fuel loads has been suggested as being necessary in order to return fire regimes to more "natural" conditions (e.g. Covington and Moore 1994; Arno et al. 1995). Because frequent, low intensity ground fires play an important role in maintaining the character of natural ponderosa woodlands (Moir et al. 1997), prescribed low intensity ground fires are presumed to have beneficial effects on the resident bird species such as pygmy nuthatch.

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

Interactions with Focal Species

The biotic communities of aquatic systems in the Upper Columbia Basin are highly complex. Within communities, assemblages and species have varying levels of interaction with one another. Direct interactions may occur in the form of predator-prey, competitor, and disease- or parasite-host relationships. In addition, many indirect interactions may occur between species. For example, predation of one species upon another may enhance the ability of a third species to persist in the community by releasing it from predatory or competitive constraints (e.g., Mittelbach 1986; Hillman et al. 1989a).

These interactions continually change in response to shifting environmental and biotic conditions. Human activities that change the environment, the frequency and intensity of disturbance, or species composition can shift the competitive balance among species, alter predatory interactions, and change disease susceptibility. All of these changes may result in community reorganization.

3.31 Historical Decline of Focal Species

Human and Natural Factors

Until 7,000 to 10,000 B.P., glacial ice blocked upper reaches of many rivers of the Pacific Northwest (Lackey 1999). Improved ecological conditions for salmon likely developed about 4,000 years ago, and aboriginal fishermen benefited. Lackey (1999) speculated that salmon populations reached their highest levels within the last few centuries.

Humans and salmon colonized and expanded their range in the Columbia River Basin after the most-recent Ice Age (10,000-15,000 years BP). American Indians developed a culture that relied extensively upon anadromous fish for sustenance in some portions of the area (Craig and Hacker 1940). Their catches must have increased as their populations rose and techniques of fishing developed. Particularly at partial obstacles for passage, Indians captured large numbers of fish for both sustenance and trade.

Native Americans had access to an abundant fish resource comprised of spring, summer, and fall runs of Chinook salmon, coho and sockeye salmon, and steelhead, and Pacific lamprey and white sturgeon. Estimates of pre-development (late 1700s) abundance of Columbia River salmon and steelhead ranged from about 8 million (Chapman 1986) to 14 million (NPPC 1986) fish. Estimates of pre-development salmon and steelhead numbers were based on maximum catches in the latter part of the 1800s and assumed catch rates by all fishing gear.

Colville Tribes Historical Use

From a historical perspective Ray (1933:28) reported that the fishing season on the Reservation began around the first of May, overlapping with root digging activities, and that sturgeon and small fish were taken first. The salmon would not start appearing until a month or so later, and the salmon fishing season would last until mid-August with some fish continuing to be taken in September and October. Many of the people chose to use fishing spots near their winter village sites while others traveled some distance to preferred locations such as the mouth of the San Poil or Spokane rivers or Kettle Falls (Ray 1933:28).

An in-depth review of historical fish population and habitat conditions on the Colville Reservation was provided by Hunner and Jones (1997) in the Phase I Hydrology report for the Integrated Resource Management Plan. This report will summarize major conclusions of that document for the purposes of evaluating alternatives presented in this programmatic EIS.

Fish species composition on the Reservation has changed from historical conditions. Formerly dominated by anadromous fish and resident species of native brook trout (bull trout), rainbow trout and cutthroat trout, fish populations are currently dominated (>70%) by eastern brook trout, with some native rainbow and cutthroat trout present. Bull trout presence on the Reservation is currently unknown. Lakes contain mostly warm water and trout species. Over 31 lakes on the Reservation are non-fish bearing because of natural water quality alkalinity levels.

Hunner and Jones (1997) attributed the decline of Reservation fisheries to three activities: over-harvest (off Reservation), water diversions, and habitat degradation. Habitat degradation has occurred from timber harvest, urbanization, conversion of land to agricultural uses, livestock grazing, fire suppression and road building activities.

Estimates of historically (pre-European influence) available anadromous salmonid spawning habitat were used by Hunner and Jones to speculate on historical population density of salmonids on the Reservation. Their calculations estimated an annual run of 20,009 spring Chinook, 13,341 summer and fall Chinook, 22,918 coho and 67,033 steelhead. Currently the Reservation does not have habitat suitable to support populations of that size.

Hunner and Jones also reported past presence of Chinook in Barnaby Creek, Bridge Creek, Gold Creek, Nineteen Mile Creek, the San Poil River, Spring Creek, Thirtymile Creek, Twenty-one Mile Creek and Round Lake. Chinook are not presently known to inhabit any of these areas.

Craig and Hacker (1940) described artisanal fishing methods and Native American utilization of catch for subsistence and trade. Methods often depended upon capturing fish at natural obstacles like waterfalls that concentrated passage points, or upon man-made weirs. As noted in the material on factors for decline, it is very unlikely that catch rates attainable by Native Americans approached those appropriate for maximum sustained yield or populations. Hence escapement rates probably exceeded optima.

Tribal populations declined sharply about 100-500 years ago, attacked by smallpox, measles, sexually-transmitted diseases, cholera, and other pathogens imported from Europe. Fishing rates likely declined in concert.

Inherent in such calculations is the assumption that fish populations in the late 1800s represented a reasonable expression of average effects of cyclic variation in freshwater and ocean habitat conditions. No one currently has determined validity of that assumption. It is, however, quite certain that salmon and steelhead have declined to a small fraction of their former abundance (Figure 3-2 in NRC 1996). Peak catches in the 1800s by all fishers may have included 3-4 million salmon and steelhead (Chapman 1986). Total run size for all salmon and steelhead recently has ranged from 1 to 2 million fish. About three-quarters of recent spring Chinook and summer steelhead runs have consisted of fish cultured to smolt size in hatcheries.

While actual numbers of adult spring Chinook salmon and steelhead produced by the upper Columbia River basin in the pre-development period are not available, one can attempt to estimate them, albeit roughly. From Fulton (1968, his Table 2), one can total formerly used spring Chinook salmon habitat throughout the Columbia River basin as 10,002 kilometres, and upper Columbia habitat (upstream from the Yakima River) as 899 kilometres, or about 9% of the total. Chapman (1986) estimated that about 500,000 spring Chinook returned to the Columbia

River in the latter portion of the 1800s. Nine % of that total would be about 45,000 spring Chinook salmon attributable to the upper Columbia River.

Anadromous fish of the upper Columbia area must have fluctuated because of variable environmental conditions. Certain combinations of freshwater and ocean habitat conditions appear to have caused very low salmon returns in some years well before non-Indians degraded habitat or began fishing intensively (Mullan et al. 1986), and probably "bonus" returns in others (as, recently, in 2002 and 2003).

Numbers of spring Chinook that escaped to the Columbia River at Priest Rapids Dam in the most-recent decade have averaged about 15,800 (adults plus jacks). This escapement would convert to approximately 21,000 fish downstream from Bonneville Dam (adjusting for 4% loss of adults for each dam between the estuary and counting station at Priest Rapids Dam, and a fishing rate of about 5%, mostly upstream from Bonneville Dam). Hatcheries had contributed about 75-80% of these fish. Thus naturally-produced spring Chinook salmon abundance in the upper Columbia area can be estimated to have declined to about 5,000 fish; a decrease of 89%. Estimation of the percentage decline in wild summer steelhead produced in the upper Columbia River would indicate a similar major decline. Salmon and steelhead genetic diversity has also declined as a result of artificial propagation and widespread stock transfers.

Both spring Chinook and summer steelhead in the upper Columbia River have been listed under provisions of the Endangered Species Act (ESA) of 1972. Factors that depressed numbers of wild spring Chinook and steelhead sufficiently to lead to ESA listing include range extirpation, fishing, artificial propagation, and habitat degradation caused by dams, irrigation, channelization, overgrazing, and public policy. Lackey (2001) wrote:

The depressed abundance of wild stocks was caused by a well known but poorly understood combination of factors, including unfavorable ocean or climatic conditions; excessive commercial, recreational, and subsistence fishing; various farming and ranching practices; dams built for electricity generation, flood control, and irrigation, and many other purposes; water diversions for agricultural, municipal, or commercial requirements; hatchery production to supplement diminished runs or produce salmon for the retail market; degraded spawning and rearing habitat; predation by marine mammals, birds, and other fish species; competition, especially with exotic fish species; diseases and parasites; and many others.

Lackey (2001) also wrote that "technocrats" who represent various organizations have developed estimates of the proportions of wild fish declines attributable to one or more of the above-mentioned factors for decline. He pointed out that models that resulted in that work usually ended up supporting the favored policy position of the supporting organization.

Fishing

It seems quite unlikely that aboriginal fishing was responsible for run declines in the Columbia River (Craig and Hacker 1940; Chapman 1986; Lackey 1999). Their artisanal fishing methods (Craig and Hacker 1940) were incapable of harvesting upper Columbia River spring Chinook and summer steelhead at rates that approached or exceeded optima for maximum sustained yield (probably 68% and 69% for spring Chinook and steelhead, respectively, as estimated in Chapman (1986)).

An intense industrial fishery in the lower Columbia River, employing traps, beach seines, gillnets, and fishwheels, developed in the latter half of the 1800s. In the early 1900s, troll fisheries developed to catch salmon even before they reached the Columbia River. The late-spring and early-summer Chinook salmon returns, which constituted the heart of the Columbia River runs, were decimated by the early 1900s (Thompson 1951).

As these run components rapidly declined, fishing shifted earlier, later, and to other species, changes that, for a time, numerically masked the precipitous decline in the sought-after late-spring and early-summer fish.

By the early 1930s, mean escapement of spring Chinook into the upper Columbia River upstream from Rock Island Dam had declined to fewer than 3,000 fish. That escapement would represent perhaps 12,000 fish arriving in the lower Columbia River, inasmuch as fishing rates exceeded 75% in that period. Only Rock Island Dam (1933) lay athwart the Columbia River. Mean returns of summer steelhead to the upper Columbia River were lower than 4,000 fish in the first part of the 1930s. Harvest rates of 70%, and probably higher, were common before the 1940s. If one assumes a 70% rate, returns of upper Columbia summer steelhead to the estuary may have amounted to about 13,000 fish.

By the 1930s and 1940s, restrictions on fishing time and gear had increased. For example, purse seines were outlawed in 1917, whip seines in 1923, fish wheels in 1927 (in Oregon), seines and traps east of Cascade Locks in Oregon in 1927, drag seines, traps, and set nets in 1935 (Washington), and seasons were gradually shortened. Catch rates almost certainly were much higher than those appropriate for maximum sustained yield or populations for several decades before then.

It is important to remember that fishing intensity, unless pursued to stock extinctions, can be relaxed by management action. If habitat remains intact, stocks can rebound. Presently, fishing rates have been reduced well below 10% for spring Chinook and 13% for summer steelhead (see section on harvest), yet wild and natural components of the respective runs in the upper Columbia River have not responded markedly. Currently, factors other than fishing depress these fish of the upper Columbia River.

Fisheries of the late 1800s

The population of humans in the Columbia River Basin developed rapidly with extensive immigration from the eastern US, beginning in the mid-1800s. Efficient fishing techniques, and preservation methods such as canning, set the stage for overexploitation of Columbia River salmon stocks. The onslaught of techniques included gillnets, traps, horse-pulled beach seines, purse seines, and fish wheels.

Intense fishing first targeted the abundant late-spring and summer components of what was a bell-shaped abundance function for Chinook salmon. Spring Chinook entered first, and in relatively small numbers (Chapman 1986). The late-spring and summer runs formed the central bulk of the abundance timing function. Finally, fall Chinook arrived in lesser numbers. Thompson (1951) showed that fishing had all but extirpated the central bulk of the return distribution by 1919. As that fishery disappeared, industry shifted to sockeye, steelhead, coho, and fall Chinook. These shifts partially masked the decline of overfished run components.

Although governmental agencies existed with nominal responsibility for fishery management (e.g., US Bureau of Fisheries, Oregon Fish Commission), demand for fish and gear competition, chiefly among commercial fishermen brooked little interference with seasons and fishing intensity. Washington passed its first gear restriction in 1866, some six years after commercial fishing became an important Columbia River industry. Oregon's first restriction came in 1878. Not until 1899 did Oregon and Washington begin to jointly manage Columbia River fisheries.

There can be little doubt that the relentless fishing intensity in most of the latter half of the 1800s and early 1900s substantially exceeded optimum rates. Chapman (1986) assumed that extant rates were 80-85% on spring and summer Chinook, 88% on fall Chinook, and 85% on steelhead.

The 1900s - decades of change

In 1909, Oregon and Washington instituted joint consistent fishing seasons. About 1910-12, as reasonably dependable internal combustion engines became available, troll fishing for salmon developed, enabling offshore fishing on Columbia River stocks mixed with fish from other rivers. Some inflation of early Columbia River landing statistics likely occurred as a result of troll-caught salmon sales inside the Columbia River mouth.

In 1917, purse seines were prohibited in the Columbia River. These regulations, as several others later, likely resulted in part from gear wars rather than conservation. Whip seines became illegal in 1923, and fish wheels in Oregon were prohibited in 1927. Fish wheels in Washington remained legal until 1935. Washington prohibited drag seines, traps, and set nets in 1935, while Oregon waited until 1949 to so act.

Washington law prohibited commercial take or sale of steelhead from the Columbia River after 1934, while Oregon continued to permit take and sale of steelhead by non-s until 1975.

Meanwhile, upriver dams began to deny salmon access to habitat. Swan Falls Dam on the Snake River was the first mainstem obstacle (1910). On the Columbia River mainstem, Rock Island Dam was completed in 1933, Bonneville Dam in 1938. These facilities provided the first consistent numerical assessments of fish passage (only harvest data were available formerly). Grand Coulee Dam denied fish access to salmon and steelhead that formerly used Canadian tributaries and the Spokane and San Poil rivers. Small irrigation dams also chipped away at fish habitat, beginning in the 1800s.

The year 1957 marked a major change in Native American fisheries. The Dalles Dam, completed in that year, flooded the most important traditional and important fishing dipnetting site in the Columbia River, at Celilo Falls. Catch rates in 1957 in Zone 6 dropped dramatically, and did not increase until the early 1960s afterIndiansshifted to set gillnets.

Commercial fishing, and most Native American subsistence fishing in the latter half of the 1900s, was confined to gillnets. Downstream from Bonneville Dam, in zones 1-5, only drift nets were employed. In Zone 6, set gillnets were used. Gillnets do not facilitate release of gilled fish alive. Hence, the principal means for protecting weak stocks of salmon and steelhead are area and time closures. Large mesh sizes in the 1990s afforded some protection for upper Columbia A-group steelhead (most upper Columbia summer steelhead are in this group of smaller steelhead), although some larger steelhead that spent two years at sea were taken during late summer during the fall Chinook season.

As upriver spring Chinook populations declined sharply in the last quarter of the 1900s, managers reduced commercial fishing seasons in zones 1-5 and tribes reduced harvest rates in Zone 6. Hatchery-produced salmon and steelhead increasingly dominated runs.

Effects of harvest on wild/natural spring Chinook and steelhead of the upper Columbia River are very difficult to control in mixed-stock fisheries of zones 1-5 (Columbia River mouth to Bonneville Dam) and Zone 6 (upstream from Bonneville Dam, concentrated in Bonneville, The Dalles, and John Day pools). Gillnets are the most-utilized fishing technique, indiscriminate in selecting one stock or another or hatchery fish over wild ones. Mixed-stock fisheries are particularly detrimental to naturally small populations or those depressed by human activities (Spence et al. 1996; NRC 1996).

Only through virtual elimination of fishing on weak stocks can managers achieve protection for them. Fisheries in zones 1-6 have been curtailed sharply to protect ESA-listed stocks, chiefly destined for the Snake and upper Columbia rivers. This has led to excess escapements of spring Chinook of hatchery origin, leading to public policy conflicts with respect to management use of the excess returns when they arrive at the hatchery.

Near elimination of harvest on weak stocks can be accomplished by fishery closures, restrictions on area and times of fishing, limitations on gillnet mesh sizes, sometimes combined with net modifications (e.g., trammel nets that entangle rather than gill fish).

Sport and Native American subsistence catches have been confined largely to areas short distances downstream from hatcheries where managers expect sufficient returns (e.g., on Icicle Creek downstream from Leavenworth National Fish Hatchery).

Columbia River fishery management in the last third of the 1900s was based in large measure on the concept of maximum sustained yield (MSY) (NRC 1996). At least two important issues make that concept obsolete for future management. The first is that stock-recruit models, from which MSY was determined, are based on historical adult and progeny adult information obtained under past environmental conditions. Those conditions changed, or re-set, as successive mainstem dams came on line, especially after the early 1950s. They may also change markedly over time with cyclicity of the ocean environment. Furthermore, MSY management does not acknowledge value of “excess” escapement as (1) a means of augmenting nutrient levels by bringing marine nutrients to the infertile streams of the upper Columbia River, or (2) important in fostering competition for mates and spawning sites. The MSY paradigm now does not well serve managers, especially for upriver anadromous stocks.

Current fisheries

Extremely restrictive fisheries are allowed in the lower Columbia River for spring Chinook and steelhead in order to protect listed fish (including upper Columbia River spring Chinook and steelhead). For example, a federally-established limit of 2% incidental kill of wild spring Chinook and wild steelhead was set in 2004 for non-tribal fisheries; of that allowance, a maximum kill of 1.2% was set for the recreational fishery and 0.8% for the commercial fishery in zones 1-5. These conservative impacts were emplaced in spite of an expected spring Chinook run to the Columbia River of 500,000 fish, the second largest run since 1938, when Bonneville Dam counts began. Tribal gillnet fisheries in Zone 6 are likely to harvest an additional 8 to 10%.

Current restrictions also require sport anglers between the Rocky Point/Tongue Point line in the estuary upstream to the I-5 bridge to maintain caught fish that have intact adipose fins in the water as they remove the hook. Commercial fishers must use a combination of tangle net (4.25 inch mesh) and large mesh sizes (9-9.75 inches), not longer than 150 fathoms. Recovery boxes on board must be used for any wild fish captured, and on-board observers determine the number of wild fish caught and released.

ESA-listed upriver stocks, including those in the upper Columbia, prevent directed fisheries, even though substantial numbers of hatchery-produced spring Chinook could be taken. Upriver summer steelhead may not be harvested in the commercial fishery of zones 1-5.

A set-gillnet fishery for spring Chinook and steelhead, classed as "ceremonial and subsistence" is prosecuted byIndiansin Zone 6. Steelhead captured byIndians in Zone 6 can be sold or used as "ceremonial and subsistence" harvest. Mean catch rates in the last half of the 1990s equaled about 10%.

Fishing in the future

Schaller et al. (1999) estimated spawner numbers required for full seeding of spawning areas used by wild Columbia River spring Chinook salmon as 4,808 for the Wenatchee River, 496 for the Entiat River, and 1,379 fish for the Methow River, a total of 6,683. Other estimates have placed the spawner requirement higher. Estimates for the Okanogan have been lacking. The assessment phase of subbasin planning estimates abundance potential in the *hundreds* (adults)for spring Chinook.

Mainstem multipurpose dam projects in the Columbia River kill upper Columbia River spring Chinook and steelhead smolts at cumulative rates that may approach 45-50%. Adult inter-dam loss at 4% per project accumulates to 25% (Wenatchee River fish), and more for fish destined for tributaries upstream from Rocky Reach and Wells dams. Under these pressures from dam-related mortality, wild fish cannot sustain a directed fishery prosecuted with gillnets, and their escapements, even at full seeding, are insufficient to return one progeny spawner for each parent spawner.

Four solutions are theoretically feasible. The first, the approach now employed, is to severely restrict harvest, and to supplement wild fish with hatchery programs aimed at maintaining and fostering genetic adaptiveness peculiar to each upper Columbia River spawning/rearing area. The long-term utility and appropriateness of this approach has yet to be demonstrated.

A second approach is to shift mainstem fisheries to live-catch methods that permit identification and release of wild fish unharmed (NRC 1996). Although live-catch systems would permit substantially greater harvest of hatchery fish, political resistance to this option is strong. Tribal interests regard such proposals as interference with treaty rights.

The third is to confine fisheries aimed at hatchery fish to terminal areas (e.g., Icicle Creek spring Chinook, supported by Leavenworth National Fish Hatchery and by some natural spawners not listed under the ESA, are harvestable in Icicle Creek downstream from the hatchery). Fish quality for spring Chinook destined to spawn in terminal areas of the upper Columbia River declines as fish progress upstream. Quality in the terminal areas cannot compete with quality of pen-reared, or ocean- or estuary-caught salmon. Pen-reared salmon have made up over 50% of marketed salmon in recent years.

The fourth is to stop all fishing other than terminal harvests. NRC (1996) discussed this option, but noted that it is fraught with treaty and international political and legal issues.

Effects of fishing on population characteristics

High fishing rates in the 1800s virtually extirpated some late-spring and summer stocks of Chinook salmon. Past effects of fishing on now-listed spring Chinook and steelhead of the upper Columbia River are unknown. Attempts to sustain fishing by use of hatchery fish influenced genetic composition of at least summer steelhead, as progeny of adults trapped at Priest Rapids and Wells dams were, for several generations, liberated as smolts in the major tributaries of the upper Columbia River without regard to fostering local adaptations. NRC (1996) noted: "The continual erosion of the locally adapted groups that are the basis of salmon reproduction constitutes the pivotal threat to salmon conservation today."

Nelson and Soule (1987) and Thorpe (1993) reviewed effects of fishing on genetic makeup of salmon populations. Intense fishing probably altered genetics of pink salmon in the north Pacific, for example, with the result that adult size declined. Historically, intense gillnetting in the Columbia River may have increased the proportion of smaller fish in escapements, with potential increases in jack fractions and reduced fecundity of females. Three-ocean spring Chinook adults may have been selected against at earlier high fishing rates. At current low fishing rates, genetic selection against large spring Chinook and steelhead by gillnets likely does not occur (Chapman et al. 1995).

Mainstem Columbia River dams

Spring Chinook and steelhead production areas in the pre-development period included the Wenatchee, Entiat, Methow, Okanagan, and limited portions of the Spokane, San Poil, Colville Tribes, Kettle, Pend O'Reille, and Kootenay Rivers. The Grand Coulee Dam project and Chief Joseph Dam eliminated access to the Columbia River upstream. The Grand Coulee Fish Maintenance Project (GCFMP), designed to transfer populations formerly produced upstream into remaining habitat downstream from Grand Coulee, trapped fish at Rock Island from 1939 to 1943. Managers placed some adults in tributaries (e.g., Nason Creek) to spawn naturally, and artificially propagated others. Spring Chinook from outside the upper Columbia were introduced. The extreme changes in population structures permanently transfigured populations of spring Chinook and steelhead of the upper Columbia River (Chapman et al. 1995).

The era of mainstem multi-purpose dams downstream from the Grand Coulee project began with Rock Island Dam in 1933 and culminated with completion of Wells Dam. Seven mainstem dams lie between the Wenatchee River and the sea, eight downstream from the Entiat River, and nine between the Methow/Okanagan systems and the estuary. Dam-related losses are substantial. For example, adult salmon and steelhead mortality in the reaches between projects has been estimated as 4% or more in some years (Chapman et al. 1994 and 1995), and juvenile losses at each project can amount to about 10%.

Some of the losses result from physical effects of adult and smolt passage. Others derive from altered limnological conditions that increase predation by fish and birds, or cause gas-bubble trauma. Whatever the direct causes, losses for Wenatchee adults and juveniles could accumulate to an estimated 25% and 52%, respectively. For Methow River fish, which must pass two additional dams, losses may accumulate to an estimated 31% and 61% for adults and juveniles, respectively. In a very real sense, dam-related mortality appears to have replaced mortality rates once caused by intensive mainstem fishing. The cumulative loss rates also explain why so much mitigative effort has been allocated to project-related mortality rates.

Dams for storage, like Grand Coulee, and mainstem multipurpose dams have had other effects on ecology of salmon and steelhead. Estuarine limnology has shifted from a basis of macrodetritus and benthos to a microdetrital, planktonic trophic structure that favors non-salmonids. Spring freshet flows and turbidity have declined in the river and estuary, and the Columbia River plume has been reduced seasonally (Ebbesmeyer and Tangborn 1993, Chapman et al. 1994 and 1995, NRC 1996) with potential but largely unknown effects on survival of salmon and steelhead in the estuary and nearshore ocean.

Tributary habitat degradation

Perhaps the most important habitat influence on wild spring Chinook and steelhead in the upper Columbia River involves water diversion, withdrawal, and application to crops. The Columbia Basin Project, operated by the US Bureau of Reclamation, constitutes the largest single water diversion and application system in the area. In the Wenatchee, Okanagan, and Entiat River basins, water diversion for orchards is important. In the Methow River system, crops and pasturage divert tributary and mainstem water.

For wild spring Chinook and summer steelhead, diversions on tributaries of the Wenatchee, Entiat, Okanagan, and Methow rivers must be considered a factor for decline. Instream flows have been depleted downstream from irrigation diversion dams, reducing instream habitat and improving predator access to rearing juvenile fish. Diversions were unscreened for many decades, permitting downstream migrants to pass into, and perish in, fields and orchards. Today some fish diversion screens are less than 100% effective. Diversion dams were built in some cases without adequate provision for adult passage.

Cattle pastures adjacent to tributaries can, and have, denuded riparian vegetation and permitted nutrients from fecal material, and fine sediment, to enter salmon and steelhead habitat. Overgrazing by sheep and cattle has locally increased runoff of fine sediments and increased stream flow peaks (Mullan et al. 1992).

Channelization reduces instream habitat by straightening meanders, increasing water velocity, and eliminating or reducing riparian cover and input of large woody debris. It can and has occurred associated with roads and railroad grades, residential encroachment, and protection of agricultural land. Diking and channel-bank riprap prevents stream lateral movements across alluvial floodplains, particularly in the Methow and Okanagan drainages.

Roads for logging access and log skidding can and have locally introduced fine sediments to spring Chinook and summer steelhead habitat. Riparian communities have at times been disrupted, reducing shade and availability of large woody debris. Timber removal alters hydrology of tributaries until regrowth occurs.

Of the foregoing habitat factors, diversions and associated diversion dams probably constitute the most important factors for decline. Mullan et al. (1992) concluded, after reviewing habitat conditions in the tributaries of the upper Columbia River:

Despite some abuse from the recent activities of humans, there appears to be little or no net loss of the functional features of mid-Columbia River tributaries. In large part this is a fortuitous outcome from the lack of human interplay, a result of the formidable topological and climatic barriers that restrict settlement. To be sure, there are problems in sustaining populations of salmonids, but, for the most part, these are minor, localized, and controllable compared to the mainstem Columbia River.

Hatcheries

NRC (1996) and Flagg et al. (2001) discussed at length the risks and problems associated with use of hatcheries to compensate for, or supplement, fish produced in the wild. NRC (1996) noted demographic risk, pointing out that large-scale releases of hatchery fish exacerbate mixed-stock harvest problems. Wild fish cannot sustain harvest rates that would be appropriate for hatchery fish. Demand is essentially unlimited for salmon and steelhead, and advocacy groups for various fisheries often clamor to have access to ever-more harvestable fish from hatcheries.

Solutions to the mixed-stock fishing problem are elusive. Gillnets, for example, have only limited potential for releasing wild spring Chinook and steelhead unharmed. Terminal fisheries, particularly for spring Chinook after they enter waters that contain only hatchery fish, are impractical for commercial fisheries because fish quality there has declined greatly. Steelhead are somewhat easier to manage in sport fisheries, where fish known to be of wild origin (identifiable by an intact adipose fin) can be released with minimal mortality and hatchery fish (with adipose intact) kept.

Genetic and evolutionary risks for hatchery fish and interacting populations include inbreeding depression, loss of population identity and within-population diversity, and domestication selection (NRC 1996). Recognition of these possible factors has increased in recent decades. Unfortunately, measures used in the GCFMP and steelhead management in the upper Columbia (until recently) almost certainly realized some of the listed risks and contributed to decreased genetic diversity of wild fish. Steelhead adults were collected at Priest Rapids, and later at Wells Dam, their progeny reared in hatcheries and released as smolts to the various tributaries without regard to fostering local adaptation in tributaries.

Foraging, social behavior, time of spawning, and predator avoidance can differ for fish reared in the hatchery and in the wild (Flagg et al. 2001). While resulting differences may primarily reduce survival of hatchery-produced salmon and steelhead, negative effects may carry into the wild population where adults of hatchery origin spawn with wild fish. Effects of disease on released hatchery fish and on wild fish are poorly understood, but likely to be negative (Flagg et al. 2001, tables 10-11 summarize these).

Also poorly understood are ecological effects of hatchery programs. NRC (1996) noted that 5.5 billion salmon smolts of all species are released to the wild each year around the Pacific Rim, with potential trophic effects that may lead to altered body size and survival of wild fish. Emphasis on hatchery fish denies marine nutrients to infertile rearing streams used by relatively few wild spring Chinook salmon and steelhead.

Public policy

The Marine Mammals Protection Act of 1976 afforded seals and sea lions complete protection from killing by humans. These animals increased sharply in abundance thereafter (Fresh 1996).

NRC (1996) discussed the potential for effects on salmon and steelhead. They concluded that such predation was "probably not a major factor in the current decline of salmon in general." Chapman et al. (1994 and 1995) suggested a need for adaptive management, including population control through selective harvest and/or sterilization of live-captured seals on haul-out beaches. They pointed out that although pinnipeds and salmon coexisted long before man interfered ecologically, contrary views hold that it is unrealistic for man to manage and prey upon salmon without managing one of their principal predators.

The Corps of Engineers dredges shipping channels in the lower Columbia River and has created artificial islands with the spoils. Caspian terns have exponentially increased in the Columbia River estuary after dredge spoils created near-ideal nesting sites within the boundaries of a U.S Fish and Wildlife Service refuge. Many PIT tags have been found on artificial island sites, demonstrating that terns may be very important predators on smolts that must pass through the estuary to reach the sea.

Public policy clearly has more ubiquitous influences, both direct and indirect, than the foregoing examples (NRC 1996). Mainstem dams are a direct outgrowth of public policy, constructed by the federal government (Chief Joseph, Grand Coulee, and four mainstem Columbia River dams downstream from the Snake River) or by public utilities licensed by the federal Energy Regulatory Commission (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams).

Human population growth in the Pacific Northwest, often fostered by local government boosters, places more pressure every year on salmon and steelhead. Lackey (1999, 2001) eloquently described the ramifications for salmon of human population growth and public policies and decisions. He noted that the Pacific Northwest has a population increase rate that rivals many developing third-world nations. Public policies affect water diversions, instream flows, water temperature, dam operations, manufacturing, urban development, national defense, fishing, hatchery outputs, and transportation of people and goods. All of these factors and more, some of greater influence than others, have depressed salmon and steelhead abundance and potential for restoration of depressed fish populations.

Marsh (1994) may have inadvertently captured an essence of the effects of public policy on salmon when he wrote:

…the process is seriously, significantly, flawed because it is too heavily geared towards a status quo that has allowed all forms of river activity to proceed in a deficit situation – that is, relatively small steps, minor improvements and adjustments – when the situation literally cries out for a major overhaul.

He was referring to salmon restoration and management. But the underlying question was identified by Lackey's papers: Given human population growth and perceived needs, is Pacific Northwest society prepared to make the sacrifices necessary to restore wild listed spring Chinook and steelhead in the upper Columbia River (and elsewhere in the Columbia River basin)? The answer to date appears to be "no."

3.32 Synthesis Of Previous Efforts to Determine Important Factors For Decline of Okanogan Subbasin and Upper River Columbia Fish Populations

3.32.1 Out-of-Subbasin Effects and Mortality Assumptions

Climate change affects

Decadal scale climate-driven fluctuations in marine conditions are a dominant factor influencing salmonid survival in marine waters. This factor appears to account for the greatest amount of change in survival from smolt through return as adults documented over the decades.

NOAA Fisheries (Williams et al. 2003-draft) recently characterized the importance of marine-based processes on the abundance of Columbia River salmon as follows:

Increasing evidence points to dramatic changes in the marine ecosystem of the northern Pacific Ocean resulting from shifts in climate over the past 2000 years (Finney et al. 2002, Moore et al. 2002). Throughout this region, changes in ocean-climate conditions have influenced zooplankton, benthic invertebrate, seabird, and fish populations (McGowan et al. 1998). In particular, analyses of data from the last 100 years demonstrate a strong relationship between ocean conditions and the production of Pacific salmon (*Oncorhynchus spp*.) across a range of spatial and temporal scales (Mantua et al. 1997, Beamish et al. 1999). The varied response of salmon to these past environmental changes likely reflects their complex life history and the wide diversity of freshwater and marine habitats that they occupy (Hilborn et al. 2003).

Recent evidence links Chinook salmon from the Columbia River basin to cyclic changes in ocean-climate conditions. Modeling exercises directed at explaining the negative effects of various anthropogenic activities on the productivity of Snake River spring-summer (SRSS) Chinook salmon identified the estuary and ocean environments as important sources of unexplained variation in stock performance (Kareiva et al. 2000, Wilson 2003). Using catch records from commercial fisheries, Botsford and Lawrence (2002) found reasonable correlations between the inferred survival of Columbia River Chinook salmon and physical attributes of the ocean, such as sea-surface temperature and coastal upwelling.

Building upon these previous studies, Scheuerell and Williams (in review) found that they could actually forecast changes in the smolt-to-adult survival of SRSS Chinook from changes in coastal ocean upwelling over the past 37 years, including the rapid decline in the 1960-70s and the increase in the late 1990s. All of these analyses highlight the important effects of the ocean in determining smolt-to-adult survival, and further support Pearcy's {1992 #307} assertion that the primary influence of the ocean on salmon survival occurs early within the first year that juveniles occupy coastal waters.

Smolt survival through hydro-system

Smolt and adult mortality associated with passage through the hydrosystem is still problematic, but efforts are underway to improve passages conditions and evaluate progress.

System survival studies conducted during the 1980s revealed that the survival of spring-migrating smolts was poor. Skalski and Giorgi (1999) summarized results from seven studies conducted by either the Public Utility Districts or the Fish Passage Center that decade. Four studies used yearling spring Chinook and three used steelhead. The average annual per-project survival across all studies was 86.2% (range = 83.4 to 88.7%). This equates to only 47.6% survival for smolts passing through five hydroelectric projects, from Wells Dam to Priest Rapids Dam. Today the HCP for Douglas and Chelan County PUDs specifies a smolt survival goal of 93% per project for all species of smolts. If this goal can be realized through passage improvements currently being implemented or explored at all five dams, then the smolt survival through that system would equate to 69.6%. If these passage survival goals can be achieved they would provide a substantive contribution to the recovery of ESA-listed spring Chinook and steelhead ESUs in the Upper Columbia.

The existence and magnitude of delayed effects associated with passage through the hydrosystem remains unresolved and constitutes a critical uncertainty in the context of ESU recovery.

It has been hypothesized that cumulative effects may be incurred as smolts migrate through the hydrosystem, which are not expressed until smolts enter saltwater. Such a scenario has proved difficult to test and verify. NOAA Fisheries established the Plan for Analyzing and Testing Hypotheses (PATH) in 1995. For five years this issue was one of many key ones that were investigated. Consensus was never reached. Subsequent to PATH, a number of papers were published, some supporting, and some contesting the hypothesis. The debate still continues today and is a prominent topic treated in a recent draft technical memorandum published by NOAA Fisheries (Williams et al. 2003-draft).

The condition of smolts migrating from a watershed can influence survival in subsequent life stages. Thus, improving habitat conditions may realize benefits beyond those reflected in egg to smolt survival.

Total Mortality Outside The Subbasin

The most comprehensive and instructive index of ESU survival beyond the watershed is smolt-to-adult return rate (SAR). It is a common survival index used to characterize the performance of salmonid populations throughout the Pacific Northwest. This survival index reflects all sources of mortality affecting migrating smolts through returning adults.

These include effects associated with:

- Hydrosystem operations
- Migration conditions in the mainstem, including both natural and anthropogenic causes (e.g., actions associated urbanization and industrialization)
- Fish condition that can vary annually by hatchery or rearing stream
- Marine/estuarine conditions and processes influenced by natural and anthropogenic factors
- Harvest in marine and riverine waters
- Predation

SARs can be calculated in different ways. Juvenile salmonids implanted with either PIT tags or CWT can be used to estimate SAR, if returning adults can be sampled at strategic locations. Alternatively, the survival index can be calculated by estimating smolt abundance passing some site (a dam or the mouth of a tributary), then subsequently estimating adult returns to that location for a specific brood year. Often times SARs are expressed in terms of return rates to the mouth of the Columbia River. This calculation requires additional information such as estimates of inriver harvest and adult passage mortality.

3.33 Upper Columbia Smolt-to-adult Survival

3.33.1 Spring Chinook

Historical estimates of SAR for naturally produced spring Chinook in the upper Columbia River have been reported by Mullan et al. (1992) and Raymond (1988). Mullan et al. estimated the smolt-to-adult return rate for the collective populations produced in the Wenatchee, Entiat, and Methow rivers for the years 1967 to 1987. Over that period SAR ranged from 2.0 to 10.1%. They noted that the estimates reflect corrections for adult passage mortality and marine and inriver harvest.

Raymond (1988) estimated the % returning adults to the uppermost dam on the upper Columbia River for the years 1962 through 1984. Values for wild spring Chinook ranged from 0.7 to 4.9% over those years. One reason Raymond’s values are generally lower than those reported by Mullan et al. (1992) may be that his estimates are not adjusted for adult passage mortality and marine harvest, whereas Mullan et al. (1992) were. Also, the reference locations for calculating SARs differed, with Raymond focusing on the upper dam and the other investigators referencing the spawning grounds. This raises an important point. When comparing SAR values among investigators, the locations where smolts and adults are enumerated must be known.

SAR estimates for the most recent decade have not been calculated and published by any other investigators. Thus the historical estimates provide the only guidance on this matter.

3.33.2 Steelhead

Raymond (1988) estimated smolt-to-adult return percentages for the combined wild and hatchery steelhead population (1962-1984). Adult return rates to the upper dam ranged from a low of 0.2% for the smolt migration of 1977 to a high of 6.4% for the 1982 smolt migration. Mullan et al. (1992) reported SARs for only one stock (Well Hatchery steelhead) from 1982 to 1987. The percent return to the mouth of the Columbia River averaged 6.38%, ranging from 1.32 to 14.28%. Survival back to Wells Dam averaged 3.01% and ranged from 0.72 to 7.31. These estimates aligned closely with Raymond’s estimates for the overlapping years of 1982 to 1984. Chapman et al. (1994) compiled data from three hatcheries in the upper Columbia (Chelan, Entiat, and Leavenworth) for the years 1961 to 1991. Smolt-to-adult survival averaged 1.7%, with a range from 0.16-7.54%. The foregoing information is shown.

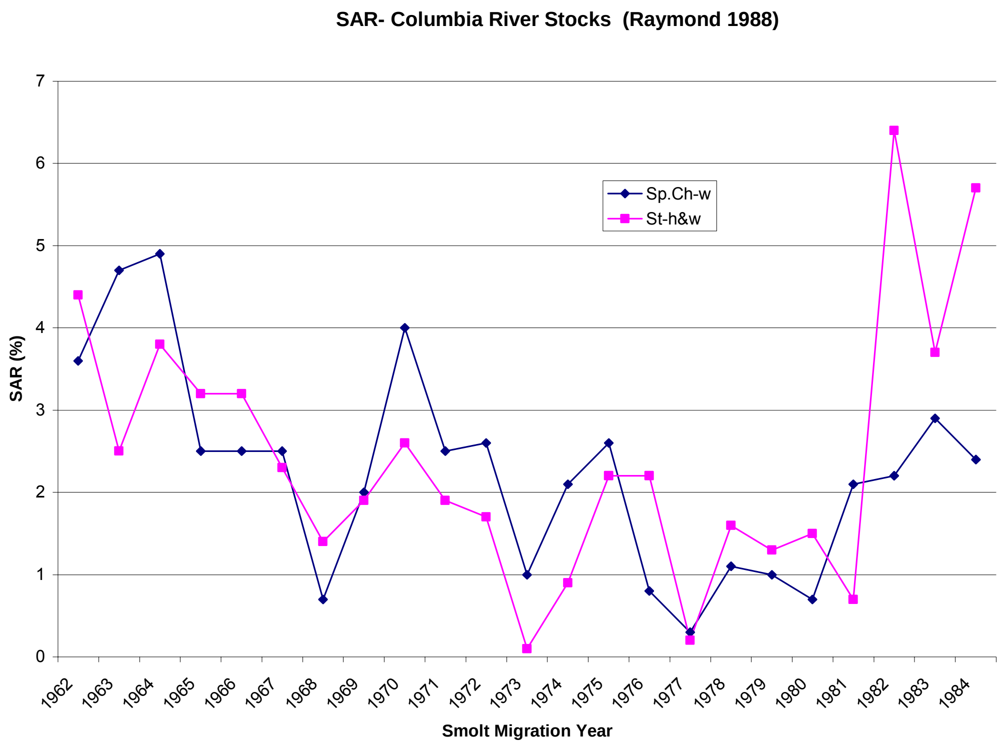


Figure 43Survival from smolt to returning adult for upper Columbia wild spring Chinook and steelhead stocks as estimated by Raymond (1988). The reference point for smolt abundance is the upper dam on the Columbia and estimated return of adults to that location. Years refer to smolt migration years.

Selecting Values for SAR to Use in ESU-Level Habitat Effectiveness Evaluations

Clearly SAR estimates for both spring Chinook and steelhead vary greatly across years. Over the decades changes spanning at least an order of magnitude were commonly observed. Thus, no single survival index value is satisfactory for accurately representing the performance of an ESU beyond the watershed. But accuracy may not be a central requirement for selecting a standard SAR that can be applied universally in habitat evaluations that use models like EDT.

In years when smolt to returning adult survival is low, survival from pre-spawner through parr in the tributaries carries more weight in terms of overall lifecycle survival. Conversely, when SARs are high the contribution of survival during the subbasin residence stages contributes less proportionately to overall gravel-to-gravel survival.

What is the importance in establishing the magnitude of survival expressed outside the boundaries of a subbasin? When resource managers wish to compare the effectiveness of tributary habitat actions among subbasins or across ESUs, then effects beyond the bounds of the subbasin or watershed become an issue. For example, if analysts in Subbasin A assume a high SAR index and they use adult abundance as a performance measure in modeling analyses, then the contribution from tributary-resident life stages is diluted. In contrast if analysts in Subbasin B assume a low SAR index, then the contribution of tributary survival is magnified in importance. One could imagine that funding agencies may prefer to invest in habitat projects where the bang for the buck might be greatest. This will be difficult to determine unless a standard out-of-subbasin survival index is adopted by all parties.

Is it practical to ignore effects outside the subbasin and not incorporate them in quantitative analyses? Not if performance measures like productivity and adult abundance are of interest; these are sensitive to hydro, marine, and harvest effects. Thus a SAR-like component should be incorporated into whatever analytical model is employed. However, it may not be practical to run a series of model analyses over a range of SARs to reflect the sensitivity of every watershed population to variable marine or hydrosystem conditions. Therefore, this is another reason why it is advantageous if a standard SAR value and approach can be selected for application when analyzing various populations emanating from different subbasins.

Out of Subbasin Survival Effects in EDT Analyses

Ecosystem Diagnosis and Treatment (EDT) evaluates habitat across the life history of a focal fish species. For anadromous species, this evaluation addresses conditions within a subbasin as well as conditions outside the subbasin in, for example, the mainstem Columbia River, estuary and ocean. Conditions outside the subbasin are often referred to as "Out-of-subbasin effects" or OOSE. While EDT includes out of subbasin effects, the focus of an EDT evaluation is on the potential of a habitat condition within a subbasin. However, it is of interest to understand how survival conditions outside the subbasin might affect protection and restoration priorities within the subbasin.

In contrast to the situation within a subbasin, in EDT, OOSE survival is not calculated from habitat information, instead a set of survival multipliers are used to achieve reported smolt-to-adult survival rates (SAR). These multipliers result in an SAR value for the focal population, which is reported in the standard EDT output summary.

The SAR, as reported in the EDT output, represents the survival from a juvenile leaving the subbasin to an adult returning. Since EDT accounts for age at emigration and at maturation, the survival value will vary depending on the age composition of a population. However, since age-composition for a given population is stable, a single SAR value can be used for each population. For some populations in some watersheds, significant numbers of juveniles that emigrate from the subbasin are not smolts. In these cases the SAR reported by EDT may be an underestimate.

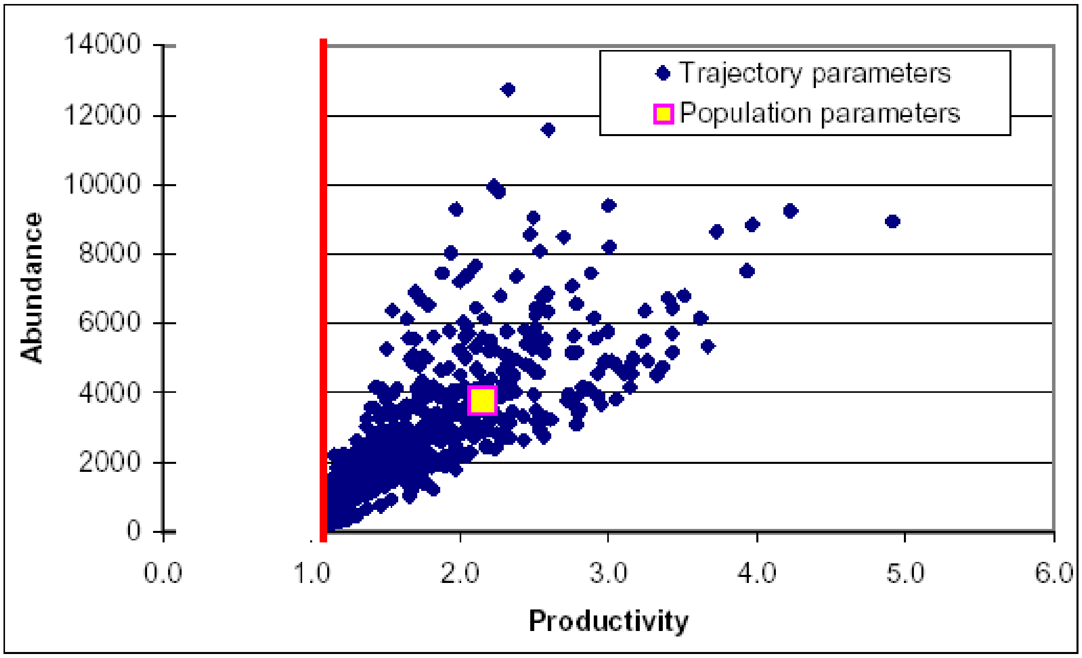
SAR has been estimated from empirical data for some species in a limited number of subbasins (NOAA 2004). Form these estimates it is clear that the SAR is highly variable from year to year and from subbasin to subbasin, and spatial or temporal trends in SAR are difficult to discern. The variability in SAR indicates that the survival rate of smolts leaving a subbasin is highly dependent on conditions both inside and outside the subbasins.

Life History Trajectories in Ecosystem Diagnosis and Treatment

To understand how the SAR affects results in EDT it is necessary to explain the concept of life history trajectories. A life history trajectory is the unbroken sequence of life stages and habitat segments that a fish moves through in completing its full life cycle. Trajectories start and end with spawning at a particular spot (i.e. a stream reach) and at a particular time within a year. At each trajectory segment (defined by a life stage, a location, and a time), the survival conditions are computed from habitat characteristics as they affect the life stage.

Trajectory segments outside the subbasin are greatly simplified by applying constant, population specific survival factors. EDT then computes the cumulative survival of all segments along each trajectory. EDT samples the environment by starting trajectories in a regular pattern along the stream course and at regular time intervals during the spawning season (Figure 44). In a typical stream, EDT generates hundreds of life history trajectories to sample and characterize the habitat conditions within a stream. EDT finally estimates survival parameters for the focal population from this collection of trajectories (Figure ?). Thus the SAR computation is embedded in the trajectory calculations.

To capture the seasonal variations of hydroelectric operations and conditions in the estuary and ocean, survival conditions outside the subbasin are shaped by month within a year.

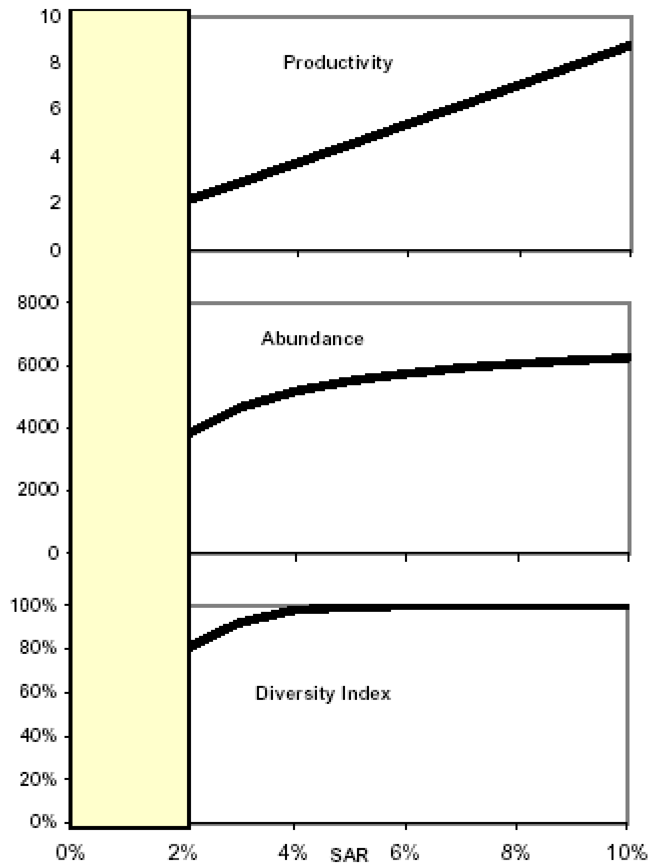


Source: Mobrand Biometrics Inc. 2004

Figure 44 Hypothetical population depicting individual trajectories, the population abundance and productivity parameters EDT derives from the trajectories

Effects of OOSE on population parameters

A hypothetical example might help illustrate how the survival outside the subbasin, the SAR, affects the EDT estimates of the population parameters of the focal population. There is a near linear relationship between productivity and the SAR as might be expected (Figure 3). The deviation from linearity is because of the fact that the SAR affects the population productivity parameter through the individual trajectories described above. For small SARs (< 2% in the example), both equilibrium abundance and the diversity index are very sensitive to changes in SAR (Figure ?). Among the consequences of this are that errors in the estimate of SAR in this range will have a significant effect on the abundance and diversity estimates. It also implies that overall improvements in productivity (e.g. through habitat restoration) will stabilize the population, making it less vulnerable to changes in SAR.



Source: Mobrand Biometrics Inc. 2004

Figure 45 Effects of SAR on EDT estimates of population productivity, abundance and diversity

3.34 Environment/Population Relationships

3.34.1 Most Important Factors For Decline

A number of key documents and reports have addressed factors affecting the decline of wild spring Chinook and steelhead in the upper Columbia. Often the assessments take the form of limiting factor analyses and are reported as such. There is not always clear agreement regarding the importance of various factors. Here we summarize and compare some of the central findings and conclusions offered in a number of key reports.

Chapman et al. (1995) reviewed the status of the spring Chinook salmon ESU of the upper Columbia Basin, including populations in the Wenatchee, Entiat, Methow, and Okanogan rivers. Their key findings and conclusions regarding factors affecting the decline of these wild populations are:

1. The extensive development of mainstem dams and upstream storage reservoirs reduced productivity by 43% from the 1950s through the 1980s.

2. Spawning and rearing habitat has not suffered functional degradation in most areas. However, water withdrawal for irrigation is a serious concern in several key tributaries, particularly in the Methow River Basin.
3. There is no evidence to indicate that inter-specific competition from exotic or native fish species reduced the productivity of this ESU.
4. Inriver harvest rates have been minimal since 1974, but in decades before that, harvest rates ranged from 40-85%. Marine harvest impacts are low, less that 1% for the years 1978 to 1993.

Their report emphasized hydro-passage effects as the primary factor limiting the productivity of this ESU. Risks associated with hatchery programs, and modest degradation in tributary habitat conditions were discussed, but they were not identified as critical factors responsible for the decline in the ESU. Inriver harvest pressures were substantial before 1974, but subsequent to that year harvest rates have been minimal or negligible with the imposition of harvest restrictions.

Chapman et al. (1994) wrote a similar status report for steelhead populations comprising the listed upper Columbia ESU. In their assessment the following factors were identified as the chief causes of the decline of wild steelhead:

- Overfishing prior to the 1950s
- Elimination of access to productive habitat above Grand Coulee Dam with dam emplacement
- Mainstem dams have been the major cause for the depressed runs in recent decades
- Additionally, they suspect two other human activities probably contributed to the decline of wild steelhead:
- Hatchery practices that mixed fish from a variety of sources to seed tributaries
- Mortality (direct and incidental) associated with sport fishing for hatchery-released and resident trout

They did not identify tributary habitat conditions as being important factors in the population decline. In fact they characterize most spawning and rearing areas as being in fair to good condition. However, they noted that irrigation withdrawals in late summer in the Methow, Wenatchee, and Okanogan rivers posed a risk.

Mullan et al. (1992) focused on conditions and processes (including both hatchery influences and habitat factors) within three major watersheds, the Wenatchee, Entiat, and Methow Rivers. In general they concluded that the carrying capacity of those rivers is similar to what it was historically. On page 28 they conclude that natural production of Chinook salmon and steelhead smolts now may be similar to historical production. However, many of Mullen's conclusions have been challenged by more recent analyses' including Shaller et al. and notably, Mullen was silent on the Okanogan as has been the case, inexpicably, with other reviews.

Overall human activities have not badly degraded the tributary habitat, although some localized problem areas were identified. Even so, they note that coho are now extinct in this area. Furthermore, they point to mainstem dams and reservoirs as critical factors impacting stocks emanating from this basin, noting that 62-71% of smolts die while passing through the hydrosystem.

More recently a series of draft subbasin summaries have been published that address limiting factors in the subbasins of the upper Columbia. Electronic copies of these are on the NPCC website. The summaries are supported by a series of limiting factor analyses that were conducted for individual subbasins. Their characterization of tributary habitat conditions as limiting factors contrast with the portrayal by Mullan et al. (1992) and Chapman et al. (1994, 1995).

In general, the limiting factors analyses describe a network of tributaries that has been degraded by assorted human activities, and ecological processes have been compromised. The implication being that some of these areas are important in limiting the productivity of anadromous fish in the basin.

The salmon and steelhead habitat limiting factors assessment for the Okanogan watershed (Entrix & Golder 2002) is the most extensive subbasin evaluation published prior to this subbasin plan. This assessment emphasizes that ongoing hatchery programs have not been able to reestablish salmon and steelhead populations to self-sustaining levels and may not be successful without concomitant improvements in habitat conditions and features across the other "H' sectors. This failure can be attributed to a number of factors including, passage problems and mortality associated with nine hydroelectric facilities on the mainstem Columbia River, unfavorable ocean conditions, harvest pressures, and degradation of ecological processes and habitat within the Okanogan watershed. Importantly, the climatic conditions of the Okanogan naturally restrict habitat use because of thermal and flow barriers that can affect the overall production in the watershed.

These natural environmental conditions limit natural production of salmonids in the Okanogan watershed. In particular, low stream flows in the summer and winter, and high ambient summer temperatures restrict or limit access to habitats. Also, extreme winter conditions can reduce fish growth and activity. In years when moisture availability is limited, dewatered reaches are not uncommon. These conditions restrict salmonid access to habitat, dewater redds, and may strand juveniles, resulting in direct mortality to salmonids.

In some portions of the Okanogan watershed, human activities have perturbed the landscape and exacerbated the degradation of the already naturally limiting habitat. These human activities have primarily occurred in the lower gradient, lower reaches of the tributaries. These impacts are mostly the result of past timber harvest operations, road building and placement, and grazing.

3.35 Synthesis

Collectively, these assessments point to two primary classes of factors associated with anthropogenic activities that have caused the decline and continue to constrain both wild spring Chinook and steelhead production in the Columbia Cascade Province. These principal factors are hydropower development on the mainstem Columbia and degradation of ecological function in important areas within these subbasins.

Although we caution that rigorous quantitative evaluations have yet to be completed. Nevertheless, in order to realize a timely recovery of these ESUs, it appears the prudent strategy is to move forward improving conditions in both sectors simultaneously. Improving access to and condition of spawning and rearing habitat, while fish passage improvements advance, will ensure that the tributaries can offer full advantage to the expected increased escapement associated with implementing the fish passage programs.

To move forward on either front alone, or delay efforts in one sector, may constrain the rate of recovery, or even prevent it. Implementing improvements in hydro and habitat in tandem should maximize productivity by compounding survival improvements across several life stages in lock-step. We think this interaction will maximize the potential for a swifter recovery of these ESUs.

Survival during estuarine and marine residence is recognized as a dominant factor influencing overall returns of adult salmonids. In recent years stocks in the Northwest have benefited from favorable ocean conditions. But climate-driven marine conditions are cyclic, and periods of poorer marine survival are inevitable in the future.

During periods of poor ocean survival, the performance of freshwater life stages takes on increased importance in sustaining robust and resilient populations. Thus, improvements in tributary habitat and hydrosystem passage can increase survival during these critical life stages, and will serve to offset looming periods of poor marine survival.

3.36 Methods and Interpretation

3.36.1 Fisheries Analysis

The Okanogan Subbasin habitat was assessed using the Ecosystem Diagnosis and Treatment (EDT) method for steelhead, spring Chinook and summer /fall Chinook, and contributed to the assessment for sockeye salmon; EDT is an analytical model relating habitat features and biological performance to support conservation and recovery planning for salmonids (Lichatowich et al. 1995; Lestelle et al. 1996; Mobrand et al. 1997; Mobrand et al. 1998). It acts as an analytical framework that brings together information from empirical observation, local experts, and other models and analyses.

Qualitative Habitat Analysis (QHA) was used in the assessment of habitats for bull trout and Westslope cutthroat trout. QHA was modified from its original intent to meet the specific needs of the Methow Subbasin planning process regarding bull trout and Westslope cutthroat trout, and has been a useful tool to organize and summarize a large amount of information into a useable format.

Developing Fisheries Hypothesis, Management Strategies and Priorities

The Information Structure and associated data categories are defined at three levels of organization. Together, these can be thought of as an information pyramid in which each level builds on information from the lower level (Figure 46. Data/information pyramid—information derived from supporting levels for use in the Ecosystem Diagnosis and Treatment model. “Tribes” refers to the Colville Tribes.e . As we move up the through the three levels, we take an increasingly organism-centered view of the ecosystem.

Levels 1 and 2 together characterize the environment, or ecosystem, as it can be described by different types of data. This provides the characterization of the environment needed to analyze biological performance for a species. The Level 3 category is a characterization of that same environment from a different perspective: “through the eyes of the focal species" (Mobrand et al.

1997). This category describes biological performance in relation to the state of the ecosystem described by the Level 2 ecological attributes.

The organization and flow of information begins with a wide range of environmental data (Level 1 data) that describe a watershed, including all of the various types of empirically based data available. These data include reports and unpublished data. Level 1 data exist in a variety of forms and pedigrees. The Level 1 information is then summarized or synthesized into a standardized set of attributes (Level 2 ecological attributes) that refine the basic description of the watershed. The Level 2 attributes are descriptors that specify physical and biological characteristics about the environment relevant to the derivation of the survival and habitat capacity factors for the specific species in Level 3. Definitions for Level 2 and Level 3 attributes can be found at www.edthome.org, together with a matrix showing associations between the two levels and various life stages.

The Level 2 attributes represent conclusions that characterize conditions in the watershed at specific locations, during a particular time of year (season or month), and for an associated management scenario. Hence an attribute value is an assumed conclusion by site, time of year, and scenario. These assumptions become operating hypotheses for these attributes under specific scenarios. Where Level 1 data are sufficient, these Level 2 conclusions can be derived through simple rules. However, in many cases, experts were needed to provide knowledge about geographic areas and attributes where Level 1 data are incomplete. Regardless of the means whereby Level 2 information is obtained, the characterization it provides can be groundtruthed and monitored over time through an adaptive process.

The EDT model measured salmon/steelhead performance using 3 indicators: abundance, productivity, and life history diversity. Abundance (adults and smolts) was based on the capacity of the watershed that was a measure of the habitat quantity. Productivity, or density-independent reproductive rate (returning adults per spawner), was a measure of the habitat quality. Life history diversity was the range of distributions and pathways that can be used successfully by a population. The life history diversity index in EDT output was reported as a % of current life history trajectories that were successful, relative to the template potential. For more detail on EDT output parameters see documentation at www.edthome.org.

Sockeye salmon could not be modeled in EDT because bio-rules do not exist for this species. Therefore, a qualitative assessment of priority areas for restoration and protection was conducted by the Canadian Habitat Workgroup.

For the species where EDT rules do exist, the following life history assumptions were used.

Table 37. Life history assumptions used to model summer steelhead in the Okanogan Subbasin.

Stock Name:	Okanogan River Summer steelhead
Geographic Area (spawning reaches):	Not known; All mapped reaches were assumed to be potential historic spawning habitat.
River Entry Timing (Columbia R):	Wells Pool: April-February

	peak September 15 90 % by November 1
River Entry Timing (Okanogan R.):	August to March; (peak October 15) 90% by November 30 (PUD radio telemetry)
Adult Holding:	Wells Pool: 50% (PUD radio telemetry) Methow R.: 50%
Spawn Timing:	Feb 15-June 15 (mean April 1)
Spawner Ages: **(from Wells Dam 1997-2002)**	1-salt = 49 % 2-salt = 51 % 3-salt = 0 %
Emergence Timing (dates):	May 15-July 15; (mean June 15)
Smolt Ages:	age-1 = 9 % age-2 = 81 % age-3+ = 10 %
Juvenile Overwintering:	Columbia River: 21%
	Okanogan Basin: 79%
Stock Genetic Fitness:	85%
Harvest:	0%
Fecundity:	5913 eggs/female

Table 38. Life history assumptions used to model spring chinook in the Okanogan Subbasin.

Stock Name:	Okanogan River Spring Chinook
Race:	Spring
Geographic Area (spawning reaches):	Omak Creek (RM 0-6.3)

	McIntyre Creek (RM 0-?)	
River Entry Timing (Columbia R):	March 1-June 1	
River Entry Timing (Okanogan R):	May 1- August 15	
Spawn Timing:	August 1- September 15, (peak August 31)	
Emergence Timing (dates):	February 15 to March 31	
Juvenile Life History: **(No data)**	Ocean type:	0%
	Reservoir type:	10 %
	Stream type:	90 %
Stock Genetic Fitness:	85%	
Harvest	0%	
Spawner ages: [From collections at Wells Dam (1996,1998); Wells Dam and WNFH, MSFH 2000; and Methow tributaries (2003)].	Age 3 (1.1) = 18% Age 4 (1.2) = 70% Age 5 (1.3) = 12%	
Fecundity:	4608 eggs/female	

Table 39. Life history assumptions used to model summer/fall chinook in the Okanogan Subbasin.

Stock Name:	Okanogan River Summer Chinook	
Race:	Summer/Fall	
Geographic Area (spawning reaches):	Malott to McIntyre River (BC); Similkameen (RM 0-4)	
River Entry Timing (Columbia R):	Mid June – early August	
River Entry Timing (Okanogan R):	August 1 –November 1	
Spawn Timing:	September 30 – November 20, (peak October 15).	
Emergence Timing (dates):	March 1 to April 15	
Juvenile Life History:	Ocean type:	70 %
	Reservoir type:	27 %
	Stream type:	3 %
Stock Genetic Fitness:	85%	
Harvest (In Basin):	0%	
Spawner ages: (Based on total age from wild fish 1993-2002; WDFW unpublished data)	Age 2 (1.0; 0.1) = 1 % Age 3 (1.1; 0.2) = 8 % Age 4 (1.2; 0.3) = 57 % Age 5 (1.3; 0.4) = 33 % Age 6+ (1.4; 0.5) = 0 %	
Fecundity:	Mean = 4958 eggs/female	

Prioritization

Reach analysis tables (EDT consumer reports tables) were used to determine primary and secondary limiting factors within each Assessment Unit. The Subbasin Core Team factored in the results of assessments on focal species and across all reaches in each assessment unit. In general, a survival factor was considered a primary limiting factor if there was high or extreme impacts to key life stages. Exceptions included some reaches where sediment load or temperature only had a high impact to spawning or egg incubation. Additionally, a survival factor was considered a primary limiting factor if there was small to moderate impacts across most (9-12) life stages, thereby producing a cumulative impact that could be just as severe as high and extreme impacts to fewer life stages. Secondary limiting factors generally had small to moderate impacts to several (5-8) life stages. An exception occurred with the survival factor "food"; when there was small to moderate impacts to two or three juvenile life stages in most of the reaches of a particular assessment unit then we considered it a secondary limiting factor. In most reaches and assessment units, the break between primary and secondary limiting factors was fairly obvious. In some cases where EDT results were not as obvious, other information, such as the Limiting Factors Reports, RTT Biological Assessment, professional opinion, and local knowledge were factored into the decision.

EDT Model Input

To perform the assessment we first structured the entirety of the relevant geographic areas, including marine waters, into distinct habitat reaches. The Okanogan drainage was subdivided into 221 stream segments (reaches) including obstructions [United States (140) and Canada (81)] within the estimated historic range of each focal species. A stream reach was a segment of river in which environmental, anthropogenic, and biological attributes affecting the focal species were relatively constant.

Some reaches were identified on the basis of similarity of habitat features, drainage connectivity, and land use patterns; some of the primary factors that influenced reach breaks included mainstem inundation, focal species bearing tributaries, obstructions to passage, changes in confinement (valley width), gradient, hydraulic roughness, dewatering reaches, thermal gradients, gross changes in riparian condition or channel form, urban-rural interface, and hatchery release points. Such a detailed reach structure, however, was counterproductive for displaying results and implementing a management plan. Therefore the reaches were grouped into 18 larger geographic areas, or assessment units. Reaches were grouped into assessment units (AU) based on common problems and common solutions such that an AU strategy and plan can be easily described and implemented. A set of standard habitat attributes and reach breaks developed by MBI were used for the mainstem Columbia River, estuarine, nearshore, and deep-water marine areas (Appendix A). We then assembled baseline information on habitat and human-use factors and fish life history patterns for the watersheds of interest. This task required that all reaches be completely characterized by rating the 46 level 2 environmental attributes.

A habitat work group (HWG) was formed for the Okanogan Basin for the purpose of rating the Level 2 habitat attributes for the freshwater stream reaches. The work group drew upon published and unpublished data and information for the basin to complete the task. Expert knowledge about habitat identification, habitat processes, hydrology, water quality, and fish biology was incorporated into the process where data was not available. Protocol for rating attributes was taken from "Attribute Ratings Guidelines (January 2003 revision) and "Attribute ratings Definitions" (January 2003); written and distributed by MBI (www.edthome.org). In addition, MBI personnel were available for consultation and assistance with rating some attributes when local resources were not sufficient.

The sources and methods used for rating the individual attributes are briefly outlined in (Appendix B). The patient current condition attribute ratings represent a variety of sources and levels of proof. Levels of proof (or confidence levels) assigned to ratings are directly from developed rating methods by MBI specifically for the EDT process. The attributes assigned to each reach are assigned a numerical value from 1 to 5 where: 1 is empirical observation; 2 is expansion of empirical observation; 3 is derived information; 4 is expert opinion; 5 is hypothetical. The distribution of the confidence levels assigned to attributes is presented in Appendix B. The template (reference) conditions were either a default, where level of proof was not applicable, or they were determined by expert opinion from the HWG or other contributors to the EDT process that were solicited for participation by the HWG.

Two scenarios were modeled that represent the current and template. Our estimates of a template condition represent an approximation of historic conditions that was intended to calibrate the model to the range of conditions that could naturally occur in the Okanogan basin given the prevailing climatic, geologic, geographic, hydrologic, and biological characteristics. The objective of the diagnosis then became identifying the relative contributions of environmental factors to the reduction of focal species performance. The comparison of these scenarios formed the basis for diagnostic conclusions about how the Okanogan watershed and associated salmonid performance have been altered by human development. To accomplish this, we performed two types of analyses, each at a different scale of overall effect.

Analysis of Model Output

The first analysis considered conditions within individual stream reaches and identified the most important factors contributing to a loss in performance at specific life stages (1-12) corresponding to each reach. This analysis, called the Stream Reach Analysis (www.mobrand.com/edt/NWPCC/index.htm), identified the survival factors (classes of Level 2 environmental attributes) that, if appropriately moderated or corrected, would produce the most significant improvements in overall fish population performance. The stream reach analysis identified the factors that should be considered in planning habitat restoration projects. Reach analysis tables (EDT consumer reports tables) were used to determine primary and secondary limiting factors within each Assessment Unit. Results were factored in from assessments on several species and across all reaches in each assessment unit and reported the results in the Assessment Unit Summary Sheets in Section 2.6 (Synthesis and Interpretation). In general, a survival factor was considered a primary limiting factor if there was high or extreme impacts to two or more life stages. Exceptions included some reaches with a high impact to a single life history stage involving a critical survival factor such as sediment load and egg incubation or temperature and spawning. Additionally, a survival factor was considered a primary limiting factor if there was small to moderate impacts across most (9-12) life stages, thereby producing a cumulative impact that could be just as severe as high and extreme impacts to fewer life stages.

Secondary limiting factors generally had small to moderate impacts to several (4-8) life stages. An exception occurred with the survival factor “food”; when there was small to moderate impacts to two or three juvenile life stages in most or all of the reaches of a particular assessment unit, and then we considered it a secondary limiting factor. In most reaches and assessment units, the break between primary and secondary limiting factors was fairly obvious. In some cases where EDT results were not as obvious, other information, such as the Limiting Factors Reports, RTT Biological Strategy, professional opinion, and local knowledge were factored into the decision.

The second analysis was conducted across geographic areas (assessment units) relevant to populations, where each geographic area typically encompassed many reaches. This analysis, called the Geographic Area Analysis, identified the relative importance of each area for either restoration or protection actions. In this case, we analyzed the effect of either restoring or further degrading of environmental conditions on population performance. The unscaled output estimated the total potential for increase or decrease (because of restoration or protection actions) within an assessment unit, regardless of its length relative to other assessment units. The EDT model normally has the capability to compare unscaled output from in-basin versus Out-of-Subbasin-Effects (OOSE) and compare the potential change in salmon and steelhead performance between these two habitats. However, the web based version available for use in this subbasin plan was set up to only use current conditions in the mainstem; therefore, we could only evaluate the potential benefit and tradeoffs between actions within the watershed. Therefore, the underlying assumption for this analysis was that the majority of impact to abundance, productivity, and life history diversity occurs outside the Okanogan basin, similar to other subbasins of similar distance to the ocean with similar numbers of hydroelectric projects to overcome.

Integrated Priority Assessment Units

The EDT model estimated the potential increase in salmon/steelhead performance because of restoration and protection actions in two ways; 1) unscaled % increase in life history diversity, productivity, and abundance 2) rank of each assessment unit based on the sum of potential increase in each of the categories. However, because of uncertainties of modeling results, we converted ranks to categories (A,B,C,D) which approximate high, moderate, and low priority assessment units for each species.

Sockeye could not be modeled with EDT so we (US and Canada) determined the qualitative importance of each assessment unit for inclusion in the integrated priorities. Results were then integrated for individual species to create a single list of priority assessment units for restoration and protection actions that incorporated results for all anadromous focal fish species. For each focal species-AU combination, categorical ranks (A,B,C) were converted to numerical values (1,2,3) and a value of 4 was assigned to the assessment unit if a particular species was absent. We then summed across all focal species and ordered the list by prioritizing Endangered fish first and non-listed focal species second.

All assessment units with a primary benefit to an Endangered species (steelhead) were in the integrated category “A”, and where then ordered within category “A” based on their score (lowest sum across all focal species). All remaining assessment units with a primary benefit to summer/fall Chinook or sockeye were in the category “B”, and were then ordered within category “B” based on their score (lowest sum across focal species with Endangered fish first, all fish second). Remaining assessment units were considered category “C” and were ordered in the same fashion as previously described. We also integrated the inter-species priority list with the assessment unit limiting habitat attribute summary analysis to provide a matrix of “where” and “what” was highest priority for restoration in the Okanogan Subbasin.

Qualitative Habitat Analysis (QHA)

The QHA relies on the expert knowledge of natural resource professionals with experience in a local area to describe bull trout and Westslope cutthroat trout use in the target stream. From this assessment, planners are able to develop hypotheses about the population and environmental relationships of the bull trout and Westslope cutthroat trout. The ultimate result is an indication of the relative importance for restoration and/or protection management strategies at the sub-watershed scale addressing specific habitat attributes.

The primary strength of the QHA is its ability to conveniently store and summarize a substantial amount of information relating focal species to their habitats. Consequently, planners chose to view the assessment in as a tool for examining three fundamental questions:

1. Where have significant bull trout and Westslope cutthroat trout use changes occurred since the historic reference condition.
2. What changes are thought to have most significantly affected the distribution and abundance of bull trout and Westslope cutthroat trout (sub-populations within the watersheds),
3. Where are the greatest opportunities to protect and/or enhance habitat attributes that will potentially provide the greatest benefits to fish populations within the subbasin?

Current and historic focal species distribution was described by ranking focal species use for each of the stream reaches. The QHA values were compared to existing literature to insure consistency and credibility as well as the EDT habitat analysis.

The technical sub-committee used the subbasin vision, goals and biological objectives as a backdrop for describing a desired future condition. The technical team evaluated where the most affective application of various actions might occur and describe the extent that specific attributes may need to change in order to achieve stated goals and objectives.

Each of these reference conditions were evaluated and compared. Findings from this evaluation are found in the Assessment / Synthesis sub-chapter within this document.

The QHA was used in the Methow subbasin planning process for two fundamental reasons; 1) the tool is a straight forward means to summarize a substantial amount of information associated with bull trout and Westslope cutthroat trout in an accessible manner, and 2) rules of bull trout and Westslope cutthroat trout have not been developed for the EDT model. The subbasin planners have developed various approaches to communicate the findings of the QHA to the general public and scientific community as a basis for the development of management strategy recommendations. Regardless of the shortcomings of the QHA, the methodology was successful in its intent in describing the fundamental changes in bull trout and Westslope cutthroat trout use that have occurred in the Methow subbasin and has served as a catalyst for describing future management direction.

The prioritizations are relative and qualitative in nature. In the Assessment Unit maps and summaries to follow, the priorities are not intended to be prescriptive; rather they focus on a logical series of actions for use and consideration in developing future programs and projects.

The priorities reflect where and when to focus efforts to support the subbasin plan goal and key objectives based on the findings in the EDT analysis. Then the priorities are presented to include the range of possible and reasonable actions.

The prioritization approach was to:

- Estimate status of habitat processes historically and currently;
- Evaluate current and historic fish population use of these habitats;
- Characterize actions and strategies through the use of working hypothesis statements; and,
- Identify a list of measurable objectives (link to M&E), and identify strategies to guide the development of projects, programs and actions for the next 15 years.

The assessment focused on identification of limiting factors, specific habitat and ecosystem attributes relative survival and/or mortality, and location and spatial extent of the habitats themselves. Our analytical method and tool (EDT) allowed us to do this "through the eyes of the fish."

The goals and species objective sections of this plan describe the future desired condition for fish populations in terms of long-term viability, sustainability and opportunities for ceremonial, subsistence and recreational harvest. These are tied directly to the assessment findings and subsequent and derived guidance provided in this section.

In summary, the ecosystem diagnosis method used (the assessment) was intended primarily to address the question: Is there potential to improve anadromous salmonid population status through improvements to habitat conditions in tributary environments.

Central fish habitat hypothesis: Improvements in habitat conditions will have a positive effect on habitat productivity and thus, improve fish population status through increased abundance, diversity, and spatial structure.

3.37 Developing Wildlife Hypothesis, Management Strategies and Priorities

While all habitats are important, focal habitats were selected in part because they are disproportionately vulnerable to anthropogenic impacts, and likely have received the greatest degree of existing impacts within the subbasin. In particular, the majority of shrubsteppe and ponderosa pine habitats fall within the low or no protection status categories defined above. Some of the identified impacts are, for all practical purposes, irreversible (conversion to urban and residential development, primary transportation systems); others are already being mitigated through ongoing management (i.e., USFS adjustments to grazing management).

Emphasis in this management plan is placed on the selected focal habitats and wildlife species described in the inventory and assessment. It is clear from the inventory and assessment that reliable quantification of most subbasin level impacts is lacking, however, many anthropogenic changes have occurred and clearly impact the focal habitats: riparian wetlands, shrubsteppe and ponderosa pine forest habitats.

It is impractical to address goals for future conditions within the subbasin without consideration of existing conditions; not all impacts are reversible. The context within which this plan was drafted recognizes that human uses do occur, and will continue into the future. Recommendations are made within this presumptive framework.

A working hypothesis is a statement that summarizes the subbasin planners' understanding of the subbasin at the time of development of this plan, based on assessment data and analysis. Working hypotheses provide the rationale for the objectives and management strategies.

Subbasin planners have developed a goal for each of the three focal habitat types. Achieving the goal for each focal habitat type should result in functional habitats for the focal species assemblage selected to represent that habitat type, and hence for other species dependent on the habitat type.

The planners have identified both habitat and biological objectives that will advance the goals for each habitat type. Objectives describe the types of changes within the subbasin needed to achieve the goals and, ultimately, the vision for the subbasin. When insufficient data are available, objectives describe the research that will need to be done to identify physical and biological changes needed to achieve goals.

Strategies are sets of actions to accomplish objectives. The strategies in the table below are intended to serve as guidance for development of projects to accomplish the objectives listed above. Each of the strategies is intended to further one of the objectives; the number in the left-hand column shows which one.

Central Wildlife Habitat Hypothesis

Natural habitats exist with sufficient quantity, quality and linkages to perpetuate existing native wildlife populations into the foreseeable future. Where sufficient habitat exists, through a combination of protection and restoration, extirpated wildlife species are restored within the subbasin.

3.38 Synthesis of Key Findings - Okanogan Subbasin Basin EDT Species Results

3.38.1 Sockeye

The highest priority assessment units (Category A) for restoration and protection of sockeye can be seen in Tables 6 and 7. A summary of limiting habitat attributes and survival factors for each assessment unit and species specific life stage generated in the reach analysis of EDT can be found on the assessment unit summary sheets in Section 2.6, Synthesis of Key Findings.

3.38.2 Summer Chinook

The EDT model predicted large increases in summer/fall Chinook performance based on restoration actions in several key assessment units. The unscaled results predicted 5-6 fold increases for productivity and abundance, with a 20 fold increase to life history diversity (Table 4). The majority (61%) of potential performance increase was attainable within the middle and lower Okanogan mainstem assessment units, with an additional 32% in the upper Okanogan and Similkameen (category A)(Table 4). All four assessment units were considered of primary importance to summer/fall Chinook so we did not break the priorities into categories.

The EDT model predicted much smaller benefits to summer/fall Chinook performance based on protection actions, compared to restoration benefits. The unscaled results predicted 1-1.8 fold decreases for life history diversity, productivity, and abundance if habitat conditions were to degrade further (Table 5). The majority of protection benefit (65%) was attainable in the middle

Okanogan assessment unit (category A), with an additional 33% of the cumulative protection benefit in the lower Okanogan, upper Okanogan, and Similkameen assessment units (Table 5). We did not anticipate that the model would predict the Similkameen as the lowest priority of the 4 main assessment units for protection of summer/fall Chinook habitat. The Similkameen River represents a small but critical spawning area and provides important pre-spawn holding habitat. However, juvenile rearing habitat is very limited. The size of the area compared to other assessment units is small so the overall protection ratings may have been lower in the model as it relates to the entire Okanogan subbasin when compared to other main-stem Okanogan assessment units. Future-modeling efforts should re-examine the environmental attribute ratings for current and template conditions in the Okanogan mainstem and Similkameen Rivers and include a scaled model run to help determine if this is a function of model parameters, data input, scale, or true environmental conditions.

A summary of limiting habitat attributes and survival factors for each assessment unit and species specific life stage generated in the reach analysis of EDT can be found on the assessment unit summary sheets in Section 2.6, Synthesis of Key Findings.

3.38.3 Spring Chinook

Quantitative estimates of spring Chinook performance changes because of restoration and protection actions could not be evaluated with the EDT model because of the extremely poor performance of spring Chinook in the Okanogan basin. The model predicted productivity was so low (0.04) that equilibrium abundance was not attainable (Neq =0) under current habitat and mainstem conditions. We were, however, able to evaluate the relative importance of each of the assessment units to spring Chinook based on restoration actions. The majority of potential benefit would come from restoration actions in the Lower Salmon (49%) assessment unit (Table 3). Other important assessment units included the Similkameen (35%) and Omak Creek (11%), for a cumulative total of 94% of the restoration potential that might improve spring Chinook performance Table 3. However, because of the experimental status and uncertainties of historic distribution and abundance of spring Chinook we applied a default benefit category of C to all assessment units. Spring Chinook priority areas overlapped with steelhead and summer/Fall Chinook priorities so this species needs are being addressed in the priority lists, they are just not being given preference over other focal species.

A summary of limiting habitat attributes and survival factors for each assessment unit and species specific life stage generated in the reach analysis of EDT can be found on the assessment unit summary sheets in Section 2.6, Synthesis of Key Findings.

3.38.4 Summer Steelhead

The EDT model predicted large increases in steelhead performance based on restoration actions in several key assessment units. The unscaled results predicted 4-7 fold increases for productivity and abundance, with over 60 fold increases to life history diversity (Table 1). The majority (67%) of potential performance increase was attainable within the Lower Salmon and Omak Creek watersheds, with additional noteworthy potential in the small tributaries (upper and middle basin) and Loup Loup assessment units (24%) (Category A) (Table 1).

The EDT model predicted much smaller benefits to steelhead performance based on protection actions, compared to restoration benefits. The unscaled results predicted 1-1.7 fold decreases for life history diversity, productivity, and abundance if habitat conditions were to degrade further (Table 2). The majority of protection benefit (75%) was attainable in the Lower Salmon assessment unit (category A), with an additional 20% of the cumulative protection benefit in Omak Creek and the small tributaries (upper and middle basins)(category B)(Table 2). The lower Salmon Creek assessment unit was modeled with spring flows that would allow steelhead passage. This assumption was not applied to assessment units with similar water diversion issues such as Loup Loup Creek. If water management scenarios do not provide access to lower Salmon Creek then it would have no preservation value for steelhead. A summary of limiting habitat attributes and survival factors for each assessment unit and species specific life stage generated in the reach analysis of EDT can be found on the assessment unit summary sheets in Section 2.6, Synthesis of Key Findings.

Data Availability and Quality

In general, the data sources available to aid the habitat work group in rating the 46 environmental attributes for EDT were only adequate for a qualitative evaluation of the Okanogan basin. However, when the model was populated with the best available information we received quantitative output, but the accuracy of the output was questionable because of the heavy reliance on qualitative model input. We evaluated 5018 data points entered into the EDT model to determine the % frequency of each level of proof (LOP) category for each environmental attribute that was rated for current conditions (Appendix B). Category one was used for attributes where data was available in a specific reach and was direct measure of the environmental attribute. Category two was used to expand empirical information to adjacent reaches, or to other reaches within the same sub-watershed, if appropriate. Category three was used when data was available to deduce the EDT score, but it was indirectly related to the EDT attribute or expanded from another sub-watershed where applicability was suspect. Category four was for expert opinion and was used for attributes where no data was available, so they had to be rated qualitatively. Category five was hypothetical, and was also based on opinion, but with less confidence and was sometimes used to highlight critical data gaps.

Overall, 43% of the data that populated the model for the Okanogan Basin was based on expert opinion or hypothetical (because of lack of confidence in the educated guess), whereas the remainder consisted of empirical (16%), expanded from empirical (11%), or derived (30%) (Figure 3). In some cases, derived information was adequate for general modeling purposes and as good as we could expect in the near future. For example, the attribute "flow flashy" is a measure of the estimated increase in flashy flows because of anthropogenic influences. Since no data existed regarding pre-development flashiness and no trends were evident in the 20-40 year data sets available from USGS gauging stations we worked with a USFS hydrologist to develop an index of relative increase based on road density. Another example is the attribute "harassment", which was a relative measure of the proximity to population centers and the potential for disturbance and poaching on a fish population. Empirical data did not exist and will never exist for this attribute as it was defined in the attribute rating guidelines. It was included in EDT for watersheds that might have issues related to major population centers such as in the Puget Sound area. These attributes probably could have been categorized as expert opinion but we had some links to data that warranted a slightly better level of proof rating. Several other attributes that were rated qualitatively using derived information included pathogens and predation.

Conversely, many of the data points in the derived category needed improvement because of their sensitivity within the model and importance to other attributes. For example, to rate the attribute "confinement-hydromodifications" we measured the linear distance of roads that encroached the floodplain (in Terrain Navigator Pro) and added in any known distances of dikes, bank hardening, or other structures that impeded sinuosity, potential channel migration, and off-channel habitat. Although this method provided a decent initial quantification of hydroconfinement, we felt that a formal survey by trained geomorphologists, mapped in GIS (for updating and repeatability) was the correct method to quantify this very important attribute. Although its only a modifying attribute to any one life stage within EDT, it has important repercussions for evaluating template or future desired conditions related to sinuosity, off-channel habitat, bed scour, riparian function, pool riffle ratios, key habitat quantity, channel width, LWD, temperature spatial variation, hyporheic function, peak flow, low flow, and possibly others.

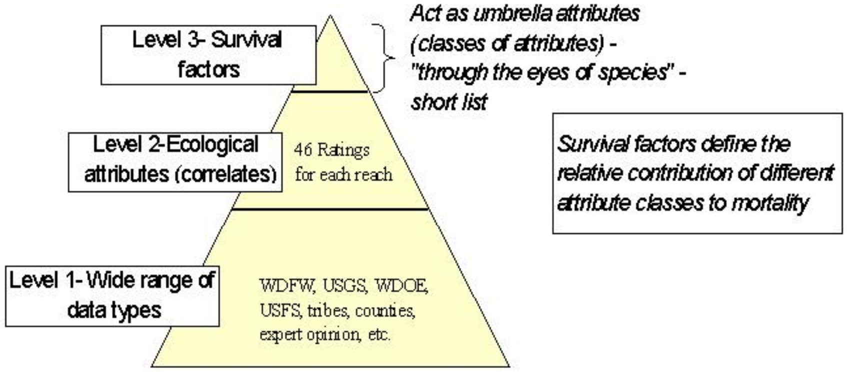
Other key attributes with the majority of their LOP in the "needs improvement" sub-category of "derived," included bed scour and low flow. Bed scour is the primary modifier for the survival factor "channel stability" that was rated as a primary or secondary limiting factor for many of the assessment units thereby increasing the models sensitivity to this environmental attribute. Given the importance of bed scour related to egg incubation and productivity, we were not satisfied with the multiple regression using other attribute ratings to come up with EDT scores for bed scour (see Appendix B). However, until bed scour is measured using empirical studies at multiple locations throughout the watershed, we will have to rely on our initial indirect estimate. For low flow, we had to use outdated relationships between surface flow, irrigation withdrawals and groundwater recharge. Our results indicated that flows were a secondary limiting factor, however, we intend to improve the model input data once the Watershed Plan information is available. Once this attribute is revisited it could increase or decrease in importance as a potential limiting factor.

Uncertainties and Limitations

This assessment used a model as a tool to predict results based on the best available information we could compile and incorporate in the limited timeframe available under the subbasin planning process. We used the EDT model to generate hypotheses about environmental conditions that had the biggest impact to our focal species. The EDT "bio-rules", defined here as "changes in productivity and life stage specific habitat requirements associated with various environmental conditions", were based on a range of information from empirical to expert opinion that we had no control over. The algorithms that define the bio-rules were hard wired into the model and it was beyond the scope of this assessment to test their validity. We were working under the assumption that the bio-rules in EDT were the "best available science"; although we recognize that the algorithms linking environmental conditions to life-stage specific survival may not have universal support of the scientific community. We would have preferred that an exhaustive review of the bio-rules and model sensitivity had been conducted so that we could fully evaluate the potential bias and error in our model estimates. Therefore, uncertainty exists in the accuracy of the results and potential changes to population performance based on restoration or protection actions in specific assessment units. However, we do have confidence in the precision of the EDT model because it systematically applied the same bio-rules throughout the basin, and related the bio-rules to the spatial and temporal dynamics of each focal species in relation to each assessment unit.

In general, we believe that the EDT model runs for steelhead and Chinook in the Okanogan basin were adequate to appropriately guide restoration and protection efforts. However, even where good empirical data existed, the model could not incorporate the measurement error or natural variation associated with the data. Additionally, if we were to model upper and lower error bounds associated with key environmental attributes the benefits would be diluted by the presence of derived and expert opinion ratings with no measurement error for other attributes. We created a table to outline the level of proof (LOP) used to rate each attribute and provide insight as to what data what used and how we expanded or derived ratings in areas with no empirical observations. We felt this was the most effective way to allow reviewers to evaluate the model inputs, without providing a very long and complex methods section (Appendix B). The EDT model uses each attribute multiple times as primary and/or secondary modifiers for various life stage survival factors (for details see www.edthome.org). Therefore, inaccuracies and bias in rating environmental data could be amplified or diminished, depending on the survival factor and life stage being evaluated. This kind of sensitivity analysis is well beyond the scope of this planning document.

High summer temperatures are known to be a natural limiting factor in the Okanogan basin. If natural high temperature conditions were on the edge of salmonid tolerance levels then only slight increases, because of anthropogenic affects, could have large ramifications for salmonid survival. Initial model runs failed to produce viable summer/fall Chinook runs because of warm summer temperatures killing all the prespawn holding adults. However, it is well documented that summer/fall Chinook are able to tolerate the thermal stress and successfully spawn in the upper Okanogan and Similkameen assessment units. Therefore, we concluded that the model was too sensitive to temperature, given all the other degraded habitat conditions, or that we had a locally adapted stock of Chinook with higher thermal tolerance, or that there was patches of thermal refuge that were not captured in the temperature data. Either way, it was beyond the scope of this planning document to change the bio-rules for temperature or collect more temperature data. Therefore, we reduced the EDT scores of current temperatures to allow for appropriate survival of summer/fall Chinook (similar to adult escapement estimates), thereby reducing the models ability to evaluate temperature as a potential limiting factor. However, when filling out limiting factors on the Assessment Unit Summary Sheets we still identified temperature as a primary limiting factor.



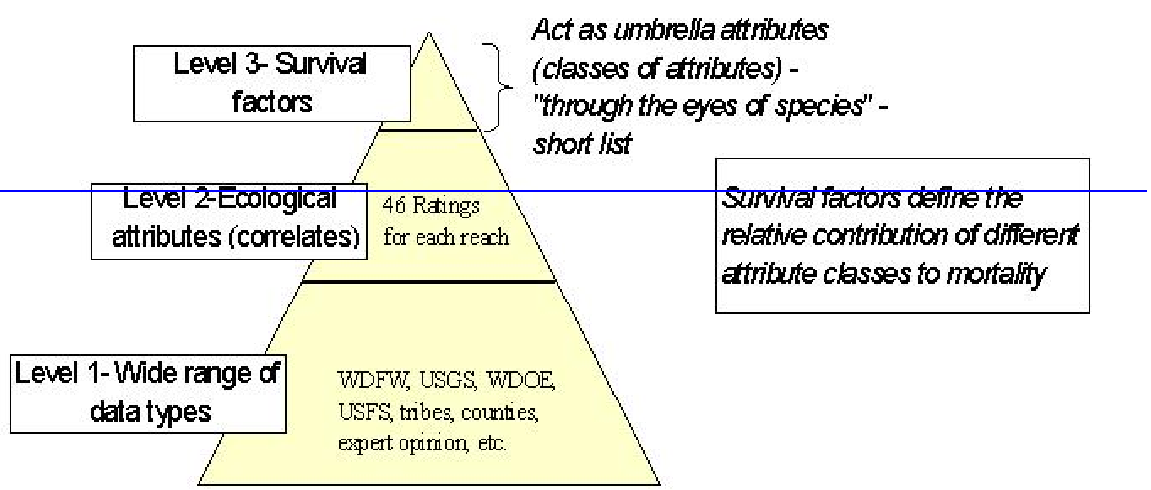


Figure 46. Data/information pyramid—information derived from supporting levels for use in the Ecosystem Diagnosis and Treatment model. "Tribes" refers to the Colville Tribes.

Table 40. Ecosystem Diagnosis and Treatment Model predictions of potential increases in three performance measures due to habitat restoration actions for summer steelhead in Geographic Areas of the Okanogan basin, Washington. N(eq) was the equilibrium abundance of returning adult spawners. The cumulative benefit does not include Out-of Subbasin-Effects on the three performance measures.

			Unscaled			
Geographic Area / Assessment Unit	**Diversity Index**	**Product-ivity**	**N(eq)**	**Sum**	**Cumu-lative**	**Cate-gory**
Omak Creek	2198%	114%	179%	2490%	34%	A
Lower Salmon	2114%	77%	237%	2428%	67%	A
Small Tribs (Middle and Upper Basin)	721%	68%	68%	857%	79%	B
Loup Loup	670%	83%	68%	821%	91%	B
Okanogan Middle	288%	5%	23%	317%	95%	B
Similkameen River	133%	40%	37%	210%	98%	B
Chilliwist/Talent	91%	25%	24%	140%	99.7%	C
Okanogan Lower	0%	4%	9%	13%	99.8%	C
Okanogan Upper	2%	0%	8%	10%	100%	C
Vaseux/McIntyre	0%	0%	0%	0%	100%	D
Canada mainstem middle	0%	0%	0%	0%	100%	D
Vaseux Lake and Mainstem Reaches	0%	0%	0%	0%	100%	D
Canada mainstem Lower	0%	0%	0%	0%	100%	D
Canada mainstem upper	0%	0%	0%	0%	100%	D
Osoyoos Lake South Central	0%	0%	0%	0%	100%	D
Canada mainstem to Okanogan Lake	0%	0%	0%	0%	100%	D
Skaha Lake	0%	0%	0%	0%	100%	D
Upper Salmon	0%	0%	0%	0%	100%	D
Total	6216%	415%	656%	7287%		

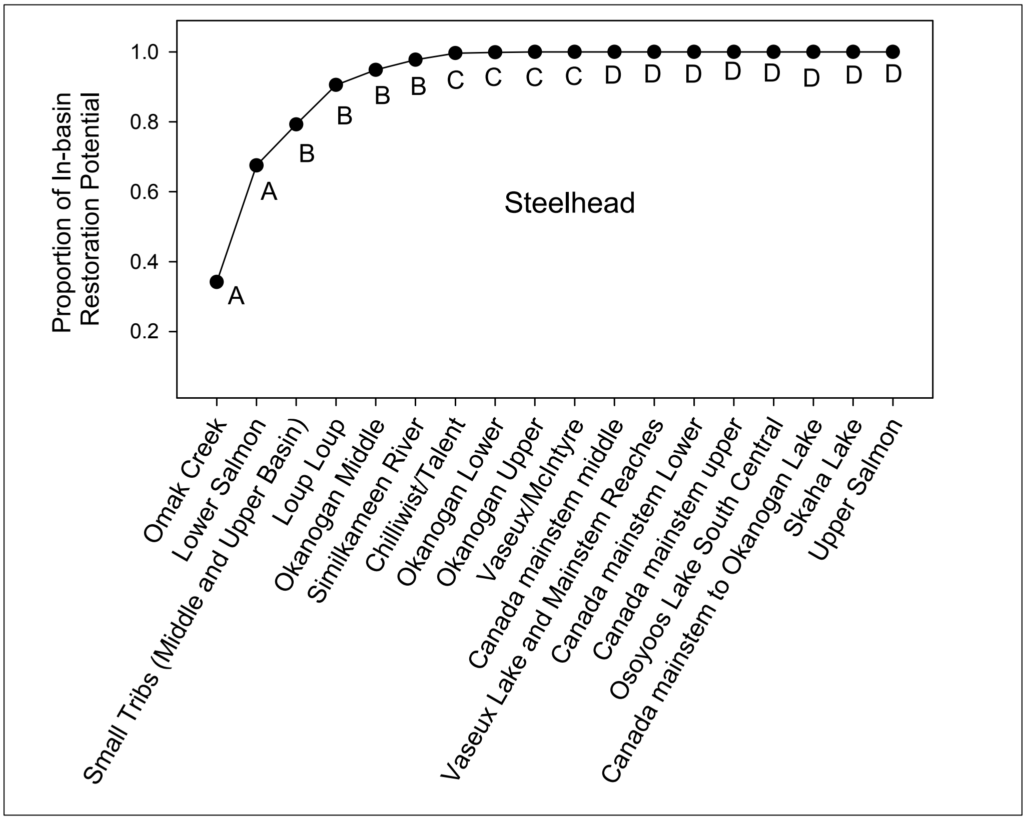


Figure 47. Ecosystem Diagnosis and Treatment Model predictions of potential increased steelhead performance in the Okanogan basin, Washington, due to restoration actions in specific assessment units. Improvements to 3 measures of performance (life history diversity, productivity, and equilibrium abundance) were summed for unscaled output and grouped into 4 categories of high (A), moderate (B), and low (C), and zero (D) potential benefit. Also shown is the cumulative effect of 100 % restoration in each assessment unit for unscaled output, if conducted in the order of highest unscaled rank. Out-of-Subbasin-Effects (OOSE) are not accounted for in the proportion of potential increase.

Table 41. Ecosystem Diagnosis and Treatment Model predictions of potential decreases in three performance measures due to habitat degradation if assessment units are not protected for summer steelhead in Geographic Areas of the Okanogan basin, Washington. N(eq) was the equilibrium abundance of returning adult spawners. The cumulative benefit does not include Out-of Subbasin-Effects on the three performance measures.

		Unscaled				
Geographic Area / Assessment Unit	**Diversity Index**	**Product-ivity**	**N(eq)**	**Sum**	**Cumu-lative**	**Cate-gory**
Lower Salmon	-84%	-94%	-100%	-278%	75%	A
Omak Creek	0%	0%	-45%	-45%	87%	B
Small Tribs (Middle and Upper Basin)	-16%	-6%	-8%	-30%	95%	B
Okanogan Middle	0%	0%	-8%	-8%	97%	C
Okanogan Lower	0%	-2%	-3%	-5%	99%	C
Similkameen River	0%	0%	-4%	-4%	100%	C
Canada mainstem middle	0%	0%	-1%	-1%	100%	C
Okanogan Upper	0%	0%	0%	0%	100%	D
Chilliwist/Talent	0%	0%	0%	0%	100%	D
Vaseux Lake and Mainstem Reaches	0%	0%	0%	0%	100%	D
Loup Loup	0%	0%	0%	0%	100%	D
Vaseux/McIntyre	0%	0%	0%	0%	100%	D
Osoyoos Lake South Central	0%	0%	0%	0%	100%	D
Canada mainstem Lower	0%	0%	0%	0%	100%	D
Canada mainstem to Okanogan Lake	0%	0%	0%	0%	100%	D
Canada mainstem upper	0%	0%	0%	0%	100%	D
Skaha Lake	0%	0%	0%	0%	100%	D
Upper Salmon	0%	0%	0%	0%	100%	D
Total	-100%	-102%	-170%	-372%		

Table 42. Ecosystem Diagnosis and Treatment Model predictions of potential increases in three performance measures due to habitat restoration actions for spring Chinook in Geographic Areas of the Okanogan basin, Washington. N(eq) was the equilibrium abundance of returning adult spawners. Spring Chinook could only be evaluated on a relative scale between assessment units because the model predicted low productivity that could not attain a viable N(eq) at the subbasin scale. The cumulative benefit does not include Out-of Subbasin-Effects on the three performance measures.

	Unscaled Relative EDT Output				
Geographic Area / Assessment Unit	**Diversity Index**	**Product-ivity**	**N(eq)**	**Cumu-lative**	**Cate-gory**
Lower Salmon	65.9%	34.5%	45.4%	49%	A
Similkameen River	14.2%	34.8%	54.6%	83%	A
Omak Creek	17.2%	16.4%	0.0%	94%	B
Small Tribs (Middle and Upper Basin)	2.4%	3.5%	0.0%	96%	C
Okanogan Upper	0.3%	1.8%	0.0%	97%	C
Okanogan Middle	0.0%	1.0%	0.0%	97%	C
Vaseux Lake and Mainstem Reaches	0.0%	0.8%	0.0%	98%	C
Canada mainstem middle	0.0%	0.8%	0.0%	98%	C
Okanogan Lower	0.0%	0.8%	0.0%	98%	C
Canada mainstem Lower	0.0%	0.8%	0.0%	98%	C
Canada mainstem upper	0.0%	0.7%	0.0%	99%	C
Osoyoos Lake South Central	0.0%	0.7%	0.0%	99%	C
Canada mainstem to Okanogan Lake	0.0%	0.7%	0.0%	99%	C
Inkaneep Creek	0.0%	0.7%	0.0%	99%	C
Upper Salmon	0.0%	0.7%	0.0%	100%	C
Skaha Lake	0.0%	0.7%	0.0%	100%	C
Vaseux/McIntyre	0.0%	0.7%	0.0%	100%	C
Total =	100.0%	100.0%	100.0%		

Table 43. Ecosystem Diagnosis and Treatment Model predictions of potential increases in three performance measures due to habitat restoration actions for summer/fall Chinook in Geographic Areas of the Okanogan basin, Washington. N(eq) was the equilibrium abundance of returning adult spawners. The cumulative benefit does not include Out-of Subbasin-Effects on the three performance measures.

				Unscaled		
Geographic Area / Assessment Unit	**Diversity Index**	**Product-ivity**	**N(eq)**	**Sum**	**Cumu-lative**	**Benefit Category**
Okanogan Middle	800%	126%	173%	1099%	36%	A
Okanogan Lower	462%	137%	172%	771%	61%	A
Okanogan Upper	382%	97%	112%	591%	80%	A
Similkameen River	195%	96%	97%	389%	93%	A
Omak Creek	85%	23%	34%	141%	97%	C
Small Tribs (Middle and Upper Basin)	31%	5%	9%	44%	99%	C
Canada mainstem middle	18%	1%	2%	22%	100%	C
Canada mainstem Lower	5%	0%	0%	5%	100%	C
Vaseux Lake and Mainstem Reaches	5%	0%	0%	5%	100%	C
Canada mainstem upper	0%	0%	0%	0%	100%	D
Vaseux/McIntyre	0%	0%	0%	0%	100%	D
Canada mainstem to Okanogan Lake	0%	0%	0%	0%	100%	D
Inkaneep Creek	0%	0%	0%	0%	100%	D
Osoyoos Lake South Central	0%	0%	0%	0%	100%	D
Skaha Lake	0%	0%	0%	0%	100%	D
Total	1982%	485%	601%	3068%		

Table 44. Ecosystem Diagnosis and Treatment Model predictions of potential decreases in three performance measures due to habitat degradation if assessment units are not protected for summer/fall Chinook in Geographic Areas of the Okanogan basin, Washington. N(eq) was the equilibrium abundance of returning adult spawners. The cumulative benefit does not include Out-of Subbasin-Effects on the three performance measures.

				Unscaled		
Geographic Area / Assessment Unit	**Diversity Index**	**Product-ivity**	**N(eq)**	**Sum**	**Cumu-lative**	**Benefit Category**
Okanogan Middle	-85%	-87%	-100%	-272%	65%	A
Okanogan Lower	-28%	-7%	-48%	-83%	84%	B
Okanogan Upper	-13%	-7%	-21%	-41%	94%	B
Similkameen River	-5%	-2%	-10%	-17%	98%	B
Canada mainstem upper	-3%	0%	0%	-3%	99%	C
Omak Creek	-3%	0%	0%	-3%	99%	C
Skaha Lake	-3%	0%	0%	-3%	100%	C
Vaseux Lake and Mainstem Reaches	0%	0%	0%	0%	100%	D
Canada mainstem to Okanogan Lake	0%	0%	0%	0%	100%	D
Vaseux/McIntyre	0%	0%	0%	0%	100%	D
Small Tribs (Middle and Upper Basin)	0%	0%	0%	0%	100%	D
Inkaneep Creek	0%	0%	0%	0%	100%	D
Canada mainstem Lower	0%	0%	0%	0%	100%	D
Canada mainstem middle	0%	0%	0%	0%	100%	D
Osoyoos Lake South Central	0%	0%	0%	0%	100%	D
Total	-138%	-103%	-180%	-421%		

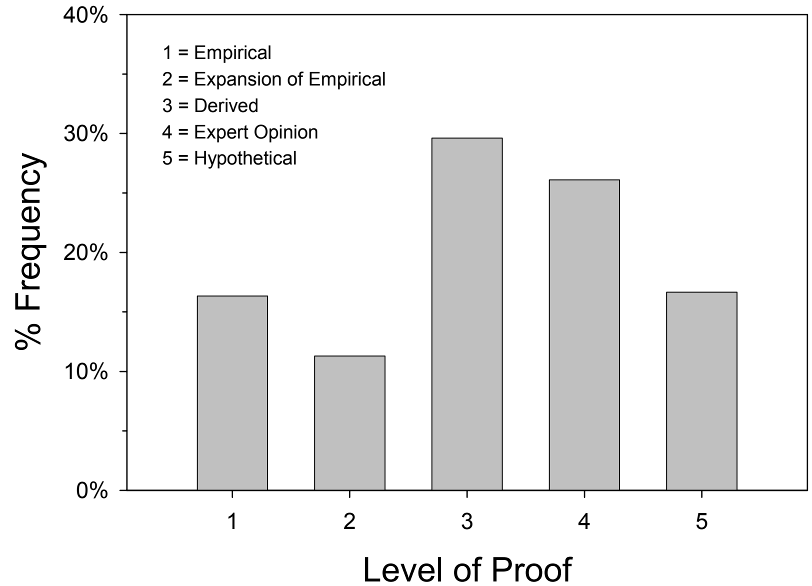


Figure 48. Summary of basin-wide level of proof used to rate EDT input data for current environmental conditions in the Okanogan sub basin, Washington.

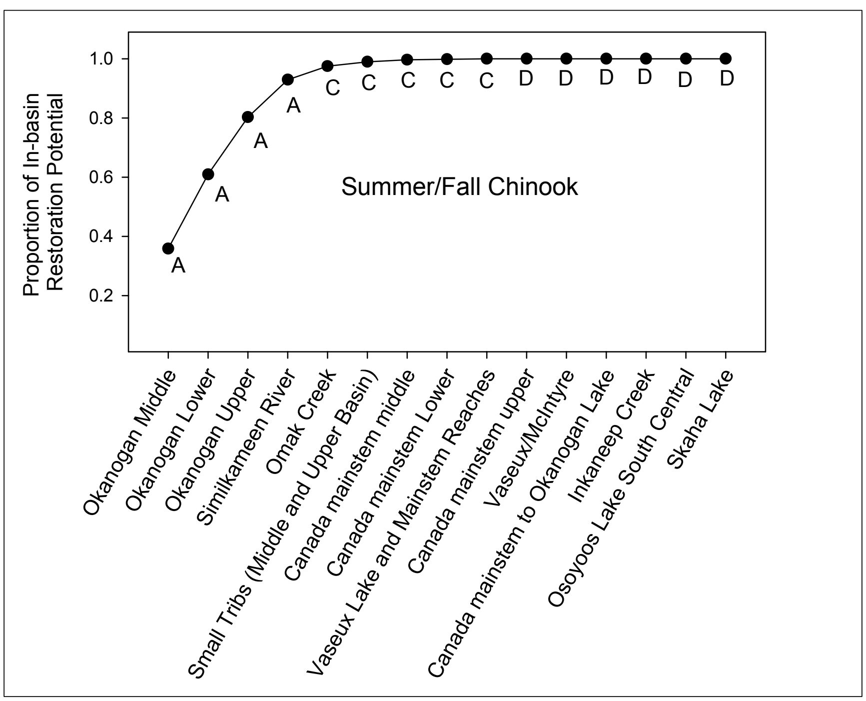


Figure 49. Ecosystem Diagnosis and Treatment Model predictions of potential increased summer/fall Chinook performance in the Okanogan basin, Washington, due to restoration actions in specific assessment units. Improvements to 3 measures of performance (life history diversity, productivity, and equilibrium abundance) were summed for unscaled output and grouped into 4 categories of high (A), moderate (B), and low (C), and zero (D) potential benefit. Also shown is the cumulative effect of 100 % restoration in each assessment unit for unscaled output, if conducted in the order of highest unscaled rank. Out-of-Subbasin-Effects (OOSE) are not accounted for in the proportion of potential increase.

Table 45. Priority assessment units and priority survival factors in the Okanogan subbasin, Washington. Priorities were determined using the EDT model for steelhead and Chinook, and the QHA method for bull trout and cutthroat trout. For survival factors, 1=primary limiting factor, 2= secondary limiting factor, blank cells were minor or not considered limiting factors.

Geographic Area / Assessment Unit	Integrated Priority Restoration Category	Habitat Diversity	Key habitat quantity	Sediment load	Obstructions	Temperature	Channel Stability	Flow	Predation	Chemicals	Pathogens	Harrassment/Poaching	Oxygen	Food	Competition (other species)	Competition (hatchery fish)	Withdrawls
Lower Salmon	A	1	1	2	1	2	1	1					2				
Similkameen River	A	1		1	2	2	2	2	2	1	1	2					
Omak Creek	A	1	2	1	1		1	2	2					2			
Okanogan Middle	B	1		1		1	2		2	2							
Okanogan Lower	B	1	1	1		1			2	2		2					
Okanogan Upper	B	1		1		1			2	2							
Vaseux/McIntyre	B	1					2	1									
Canada mainstem to Okanogan Lake	B	1	1		1		2		2			2		2			
Skaha Lake	B				1						2				2		
Inkaneep Ck	B	2	1	1	1	1	2										
Canada mainstem middle	C	1	1					2	2		2	2					
Vaseux Lake and Mainstem Reaches	C	1	1			2	2		1		2		2		2		
Canada mainstem Lower	C	1	1				1				2	2					
Osoyoos Lake South Central	C					1			2		2		1				
Small Tribs (Middle and Upper Basin)	C	1	1	1	1	2	1	1	2	2		2		2			
Loup Loup	C	1	1		1			1									

Geographic Area / Assessment Unit	Integrated Priority Restoration Category	Habitat Diversity	Key habitat quantity	Sediment load	Obstructions	Temperature	Channel Stability	Flow	Predation	Chemicals	Pathogens	Harrassment/Poaching	Oxygen	Food	Competition (other species)	Competition (hatchery fish)	Withdrawls
Upper Salmon	C	1		2		2		2		2							

Table 46. Integrated priority geographic areas for habitat restoration for summer steelhead (Stlhd), spring Chinook (SprChk), summer/fall Chinook (S/FChk), and sockeye salmon in the Okanogan River Subbasin, Washington. For each focal species-AU combination, categorical ranks (A,B,C) were converted to numerical values (1,2,3) and a value of 4 was assigned to the assessment unit if a particular species was absent. Intra-specific priorities were generated using the Ecosystem Diagnosis and Treatment model unscaled output to estimate potential benefit categories for steelhead and Chinook, whereas a qualitative assessment of potential benefit was made for sockeye. Inter-specific (integrated) priorities were generated by giving preference to assessment units with primary importance to endangered fish first, then all focal species. Categories (A,B,C) represents groups of assessment units with the highest, intermediate, and lowest priority for habitat restoration actions.

	EDT Restoration Priorities							
Geographic Area / Assessment Unit	**Steel-head**	**Spr-Chk**	**Sum-Fal-Chk**		**Sockeye**	**Endangered Fish Sum**	**All Fish Sum**	**Cate-gory**
Lower Salmon	1	1	3		4	2	9	A
Similkameen River	2	1	1		4	3	8	A
Omak Creek	1	2	3		4	3	10	A
Okanogan Middle	2	3	1		2	5	8	B
Okanogan Lower	3	3	1		2	6	9	B
Okanogan Upper	3	3	1		2	6	9	B
Canada mainstem upper	4	3	3		1	7	11	B
Vaseux/McIntyre	4	3	4		1	7	12	B
Canada mainstem to Okanogan Lake	4	3	4		1	7	12	B
Skaha Lake	4	3	4		1	7	12	B
Inkaneep Ck	4	4	4		1	8	13	B
Canada mainstem middle	4	3	3		2	7	12	C
Vaseux Lake and Mainstem Reaches	4	3	3		2	7	12	C
Canada mainstem Lower	4	3	3		2	7	12	C
Osoyoos Lake South Central	4	3	4		3	7	14	C
Small Tribs (Middle and Upper Basin)	2	3	4		4	5	13	C
Loup Loup	2	3	4		4	5	13	C
Upper Salmon	4	3	4		4	7	15	C

Table 47. Integrated priority geographic areas for habitat restoration for summer steelhead (Stlhd), spring Chinook (SprChk), summer/fall Chinook (S/FChk), and sockeye salmon in the Okanogan River Subbasin, Washington. For each focal species-AU combination, categorical ranks (A,B,C) were converted to numerical values (1,2,3) and a value of 4 was assigned to the assessment unit if a particular species was absent. Intra-specific priorities were generated using the Ecosystem Diagnosis and Treatment model unscaled output to estimate potential benefit categories for steelhead and Chinook, whereas a qualitative assessment of potential benefit was made for sockeye. Inter-specific (integrated) priorities were generated by giving preference to assessment units with primary importance to endangered fish first, then all focal species. Categories (A,B,C) represents groups of assessment units with the highest, intermediate, and lowest priority for habitat restoration actions.

	EDT Protection Priorities							
Geographic Area / Assessment Unit	Steel-head	Spr-Chk	Sum-Fal-Chk		Sockeye	Endangered Fish Sum	All Fish Sum	Cate-gory
Lower Salmon	1	1	4		4	2	10	A
Omak Creek	2	1	4		4	3	11	A
Similkameen River	3	1	1		4	4	9	A
Okanogan Middle	3	4	1		4	7	12	B
Vaseux Lake and Mainstem Reaches	4	4	4		1	8	13	B
Canada mainstem Lower	4	4	4		1	8	13	B
Canada mainstem upper	4	4	4		1	8	13	B
Inkaneep Ck.	4	4	4		1	8	13	B
Okanogan Lower	3	4	2		2	7	11	C
Okanogan Upper	4	4	2		2	8	12	C
Osoyoos Lake South Central	4	4	4		2	8	14	C
Skaha Lake	4	4	4		2	8	14	C
Small Tribs (Middle and Upper Basin)	2	4	4		4	6	14	C
Loup Loup	4	4	4		3	8	15	C
Vaseux/McIntyre	4	4	4		3	8	15	C
Canada mainstem to Okanogan Lake	4	4	4		3	8	15	C
Canada mainstem middle	3	4	4		4	7	15	C
Upper Salmon	4	4	4		4	8	16	C

Integrated Priority Assessment Units

We integrated quantitative EDT model output (steelhead & Chinook)] and qualitative (Sockeye) output across multiple focal species and determined that the highest priority assessment units for restoration and in the Okanogan basin were Omak Creek Lower Salmon Creek, small tributaries (upper and middle basin), and Loup Loup (Tables 6). These assessment units ranked the highest on our priority lists because they were in the top category (A) of our EDT model predictions for unscaled steelhead performance (life history diversity, abundance, and productivity)(Tables 1-7) and we gave preference to assessment units that were of primary importance to Endangered species. For protection, Loup Loup was not a high priority because it was modeled with no passage at the irrigation diversion. If the Lower Salmon Creek assessment does not have passage and flow because of restoration actions then it will also fall off the list of priority areas for protection. The Okanogan mainstem and Similkameen assessment units would then become the next highest priority for protection actions (Tables 6,7).

The EDT model predicted that much larger gains in salmon/steelhead performance could be made through restoration actions, rather than protection (Tables 1-7), because of the degraded nature of many critical habitat features in these sub watersheds (see Table 8 for a summary or the Assessment Unit Summary Sheets for details).

Limiting Environmental Attributes

The Okanogan Basin is a naturally harsh environment for fish with high peak flows, low base flows, warm summers, and cold winters. Our assessment was not designed or intended to evaluate the conditions that naturally limit salmonid production. We determined limiting factors from EDT output that identified the survival factors that deviated the most from template conditions. If low base flow and warm summer temperatures are the natural limitations to salmonid production in the Okanogan Basin then our assessment would not identify those factors (we assume a level of local adaptation; unless it was determined that current flow is lower and current temperatures are warmer. This is an important distinction because the goal of this assessment was to identify the greatest opportunities for improvement within the Okanogan basin, not the natural limits of the watershed or to compare and contrast cost-benefit tradeoffs of improving survival inside the Okanogan basin versus in the mainstem Columbia River or other area outside the basin.

Throughout the Okanogan Subbasin, habitat diversity was the most common limiting factor to focal fish species (Table 8). Habitat diversity was a function of gradient, natural confinement, man-made confinement, floodplain connection, off-channel habitat, LWD, and riparian vegetation. The effect of man-made confinement, riparian function, and template LWD were driving these results, but there was no way to validate our assumptions about template conditions. Losses to habitat diversity affected most life stages from moderate to high degrees depending on the assessment unit and species. See the working hypothesis in the Assessment Unit Summary Sheets for predictions of life stages most affected by losses of habitat diversity.

Other critical limiting factors included key habitat quantity (which was primarily a function of reduced quality pools for rearing and holding and reduced pool tailouts for spawning), sediment load (turbidity, embeddedness, and % fines), obstructions, channel stability (bed scour, icing, riparian function, wood, man-made confinement, flashy flow, change in annual peak flow), and temperature. We assumed that man-made confinement, recent and historic removal of LWD, increased bed scour, and degraded riparian zone vegetation had reduced the number of quality pools, pool tailouts, and LWD in most of the lower reaches of the Okanogan River and its tributaries.

The difference between current and template values for these assumptions were driving the results that these survival factors were primary limiting factors in the Okanogan Basin but there was no way to validate our assumptions about template conditions. Channel stability (bed scour) and sediment load (% fines and embeddedness) were particularly problematic for egg incubation and fry colonization life stages, whereas obstructions and key habitat quantity varied by assessment unit depending on localized conditions within the assessment unit. See the working hypothesis in the Assessment Unit Summary Sheets for predictions of life stages and assessment units most affected by these habitat attributes. High summer temperatures are a well-documented problem for salmonids in the mainstem Okanogan, but the EDT model, or the resolution of data that went into the model, were not capable of evaluating this extreme environmental condition (see "Uncertainties and Limitations" for a full explanation of how we handled temperature in the mainstem for modeling purposes.

Common secondary limiting factors included flow (reduced base flow, increased peak flow), predation, and pathogens (Table 8). Although there was a slight increase to peak flow and flashy flow because of road density, the majority of flow related problems in the Okanogan basin were related to water withdrawals affecting summer and winter low flows impacting juvenile rearing life stages for summer steelhead, and prespawn holding and migration for summer/fall Chinook and sockeye salmon. We did not attempt a scientifically defensible analysis of base flow in relation to salmonid performance, however, the EDT model is capable of evaluating the benefit of alteration to flow regimes. This tool could be used in the future to predict benefits and tradeoffs, once options are identified for improving flow conditions in the Okanogan basin.

The assessment identified flow as a secondary limiting factor to salmonid performance, except for in a few key areas such as Lower Salmon Creek and Loup Loup Creek; therefore, opportunities to fill data gaps regarding flow or increase flow during base flow conditions should be pursued, but not at the expense of other primary limiting factors. See the working hypothesis in the Assessment Unit Summary Sheets for predictions of life stages and assessment units most affected by these secondary-limiting attributes. Predation and pathogens were commonly identified as a secondary limiting factor because of increased exotic species, higher temperatures, and hatchery releases, particularly in the mainstem Okanogan in the US and Canada. In reality, the effect of these factors are data gaps in the Okanogan because no one has actually measured the predation rate on the focal species. However, in the EDT model, qualitative ratings were used to estimate an impact to give us an idea of the importance of these attributes relative to other environmental conditions.

3.39 Ecosystem Diagnosis and Treatment - Key Findings

The EDT reports (subbasin, assessment unit, and reach level) of are intended to provide an integrated and step-wise description of findings for use by subbasin planners.

Table 48Provides a subbasin summary list of the Okanogan subbasin's key factors limiting fish habitat productivity—and by extension, characterizes viability concerns associated with low abundance, limited diversity and insufficient spatial structure.

A set of EDT report maps provide an overview by Assessment Unit to aid in spatial understanding.

The Assessment Unit (AU) Summary tables (AU Summaries) provide more exhaustive and detailed information about geographic location, priority factors, working hypotheses, data gaps and objectives. Reach-level habitat attributes information and analysis can be found in Appendix B, EDT Output Tables.

Table 48 List of Key Limiting Factors for the Okanagan Subbasin condensed and derived from the Assessment Unit Summaries.

Key Limiting Factor or Problem	Management Strategies	Applicable AU's
Barriers to Chinook, steelhead and sockeye migration/spawning/rearing	Plan and implement fish passage; inventory barriers. Assess passage conditions. Address thermal blocks and low flow barriers.	2, 3, 9, 15- Mainstem Okanagan River at McIntyre Dam. Many tributaries. McIntyre/Vaseux, Omak Creek, Salmon Creek.
Fish losses in unscreened irrigation canals	Prepare and implement screening plan. Complete survey where lacking information. Assess entrainment.	16 – Mainstem Okanagan River at McIntyre Dam 13 – Inkaneep Creek
Water Temperature & Dissolved Oxygen	Investigate extent of problem. Prepare plan for remedies (e.g. flushing flows, hypolimnetic aeration, etc.)	2, 3, 9, 15, 11 & 12 North, South and Central Basins of Osoyoos Lake
Predation	Investigate extent of losses. Prepare plan for control	01 – 04 Lower reaches of Okanogan River
Predation	Limit range of walleye by constructing selective fishway	11 - Osoyoos Lake
Unknown loss of 50% returning adult sockeye between Wells Dam and spawning grounds	Use mark and recapture or radio tagging to determine where and why losses are taking place	1 – 12 Migratory route between Wells Dam and spawning grounds.
Undetermined numbers and types of Chinook and steelhead in Canadian waters	Inventory Chinook and steelhead and develop a management plan	11 - 15 Osoyoos Lake, Inkaneep Creek, Vaseux Creek and Okanagan River. Applies to Ninemile and Antoine (US) also.
Habitat Diversity	Increase LWD, Reconnect to floodplain areas. Increase side channel habitat. Install habitat boulders and artificial log-jams. Improve riparian habitats with the potential to contribute to future LWD recruitment. Create side-channel habitats, islands, spawning channels, and reconnect back channels to increase LWD deposition, channel complexity and riparian areas.	1-8, 13-17, and 19. Lower Salmon, portions of Omak Creek, Small tributary systems. Inkaneep, McIntyre, Shingle, Ellis, Trout et al.
Sediment	Establish baseline for residual pool depths. Monitor residual pool depths annually and evaluate trends. Conduct sediment reduction strategies throughout the Okanogan subbasin especially in the upper portions of the watershed.	1-9, 13-17 and 19. All Mainstem, especially prevalent in Similkameen and those units just below Similkameen/Okanogan Confluence. Also, Tonasket, Bonaparte, Shingle, Ellis, McIntyre and select other small tributary systems.

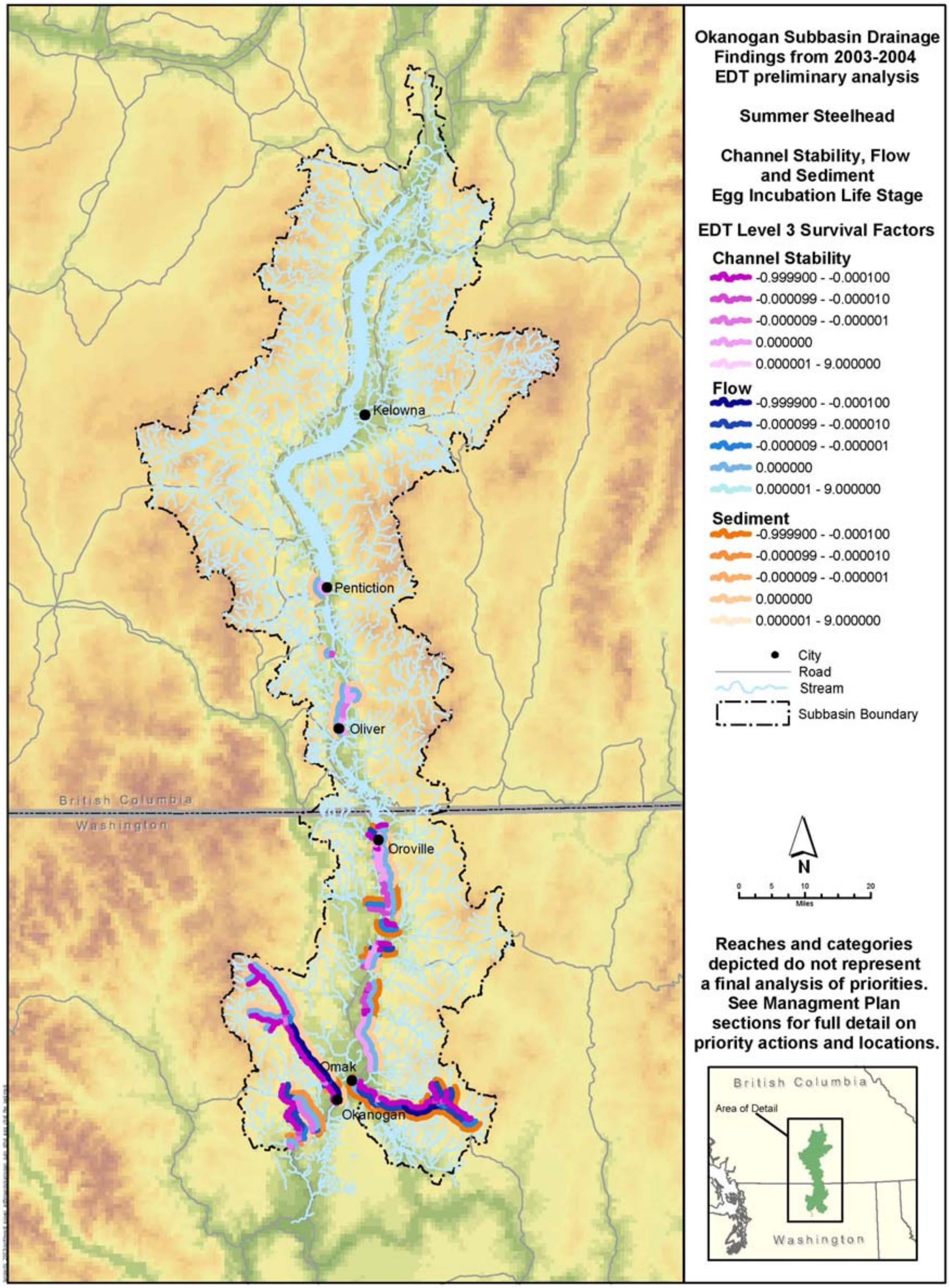
Key Limiting Factor or Problem	Management Strategies	Applicable AU's
Salmon Carcasses (low abundance of salmon/steelhead and their nutrients in general)	Increase or maintain artificial production capacity at levels necessary to meet management needs, maintain new and existing acclimation sites, and support existing and new scatter plantings. Program is intended to support conservation, reestablishment of natural broodstock and interim harvest opportunities.	All tributaries with present or historic anadromous use. Less prevalent in AUs 1-9 and somewhat in 15.
Loss of Floodplain Connectivity	Reestablish back channels, re-slope vertical banks, and establish wetland habitats that allow floodplain inundation to occur approximately every 2 years. Conduct a channel migration corridor study and monitor trends. Protect and re-establish groundwater sources. Protect and re-establish all ground-water sources. Numerous others found in AU summaries.	1-9, 13-17 and 19. All Mainstem, especially prevalent in Similkameen and those units just below Similkameen/Okanogan Confluence. Also, Tonasket, Boneparte, Shingle, Ellis, McIntyre and select other small tributary systems.
Mining and Other Water Quality Issues besides temperature	BMP, enforcement, clean-up of existing land-fill, pesticide dumps etc.	Down stream effects in Similkameen, 2 and some tributary systems.

3.40 EDT Results Illustrated

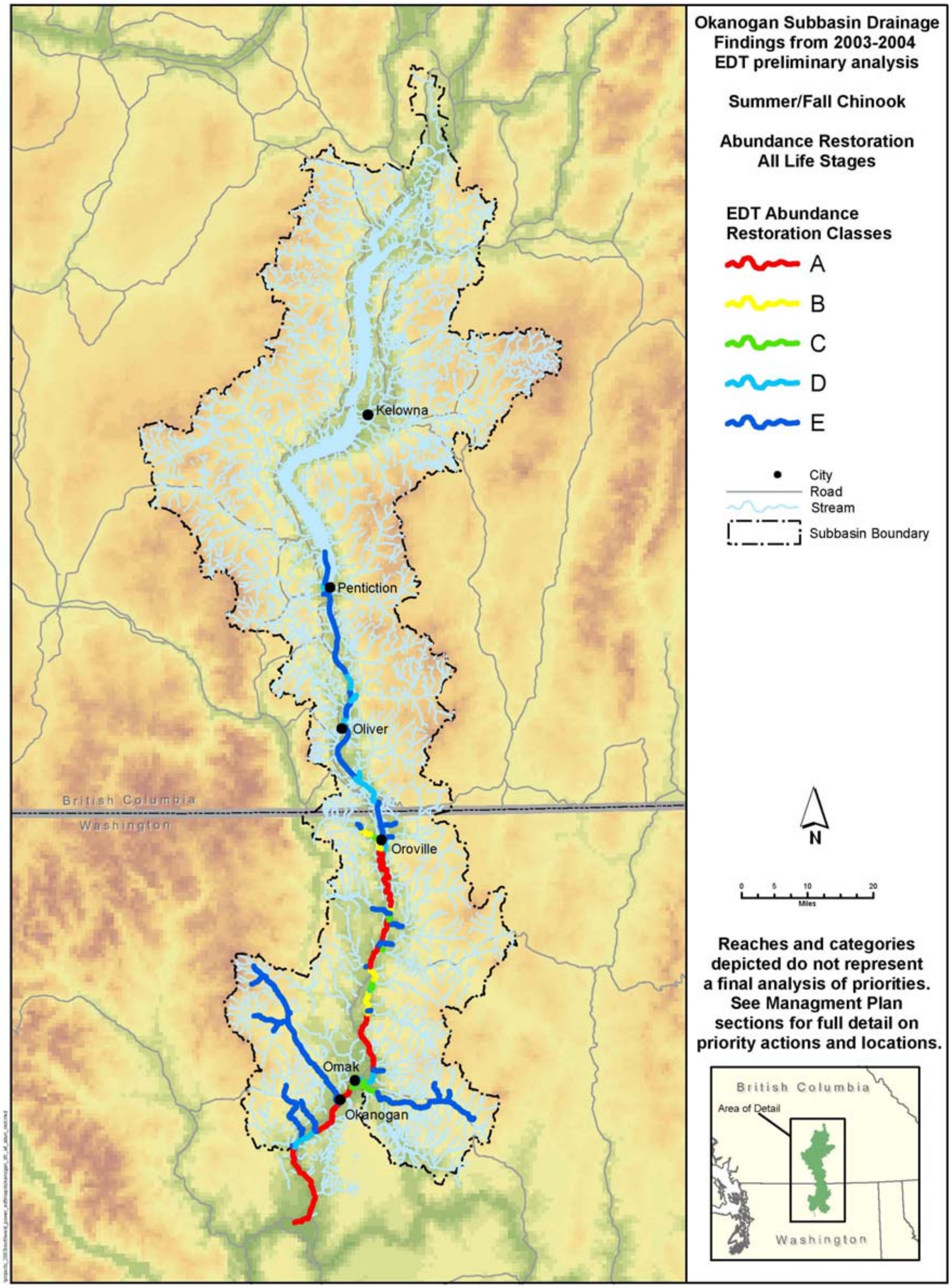
The following maps depict results from the EDT analysis for three of the focal species; summer/fall and spring Chinook and steelhead. Rule sets do not currently exist for sockeye or for other species, although some inferences about habitat conditions and general patterns of degradation can be inferred.

These maps are a subset of the available data to planners in this format. They outline geographic areas where the analysis found representative differences between the current and the historic habitat conditions and what attributes drove the finding. These results were based upon the initial habitat attribute ratings and categories, and therefore can only in limited instances be viewed as a depiction of priority areas without verification by other information in the plan. Thus, the reader is strongly cautioned against making priority determinations or inferences based on these maps, or the EDT results themselves, alone.

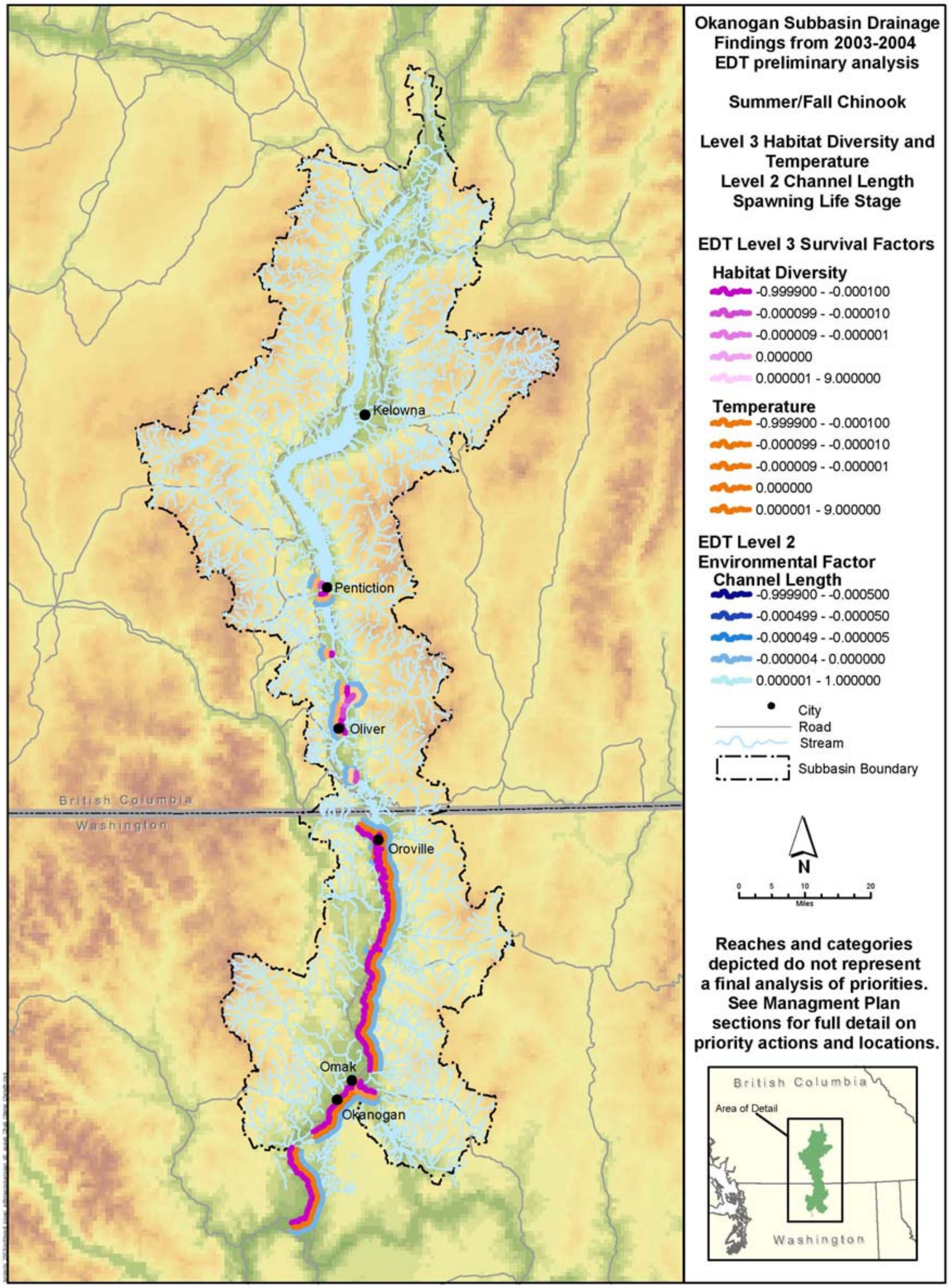
The maps are useful for identifying areas and attributes that limit salmon and steelhead productivity and for viewing attributes and species across the extent of the entire subbasin. In the very near future, a web-based application (available now in beta version) will allow subbasin planners to query any existing EDT data set to produce these maps "on-the-fly." The utility of this kind of interactive query will be an important part of the analytical decision-making and action planning (e.g., projects, programs) phases.

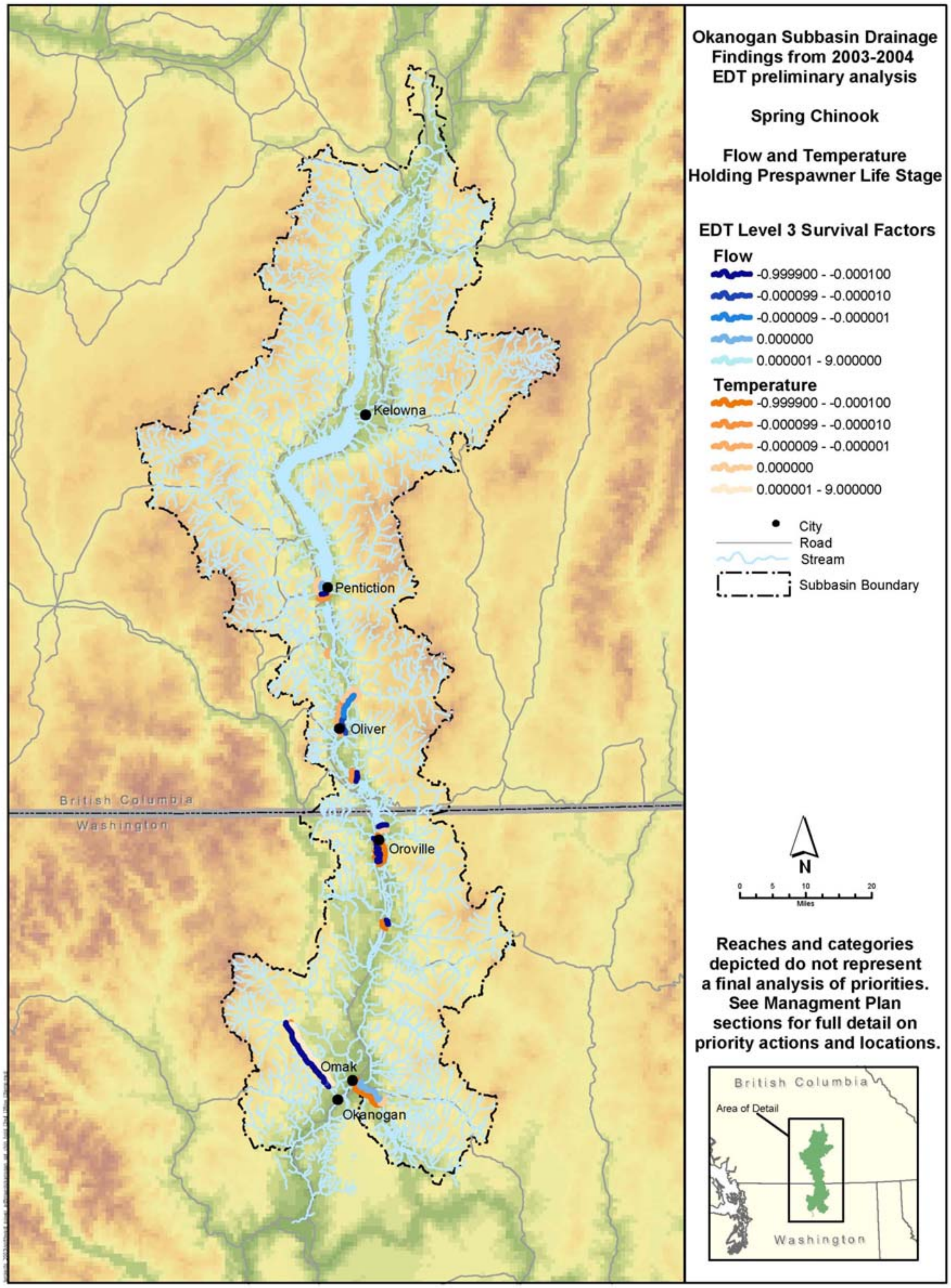


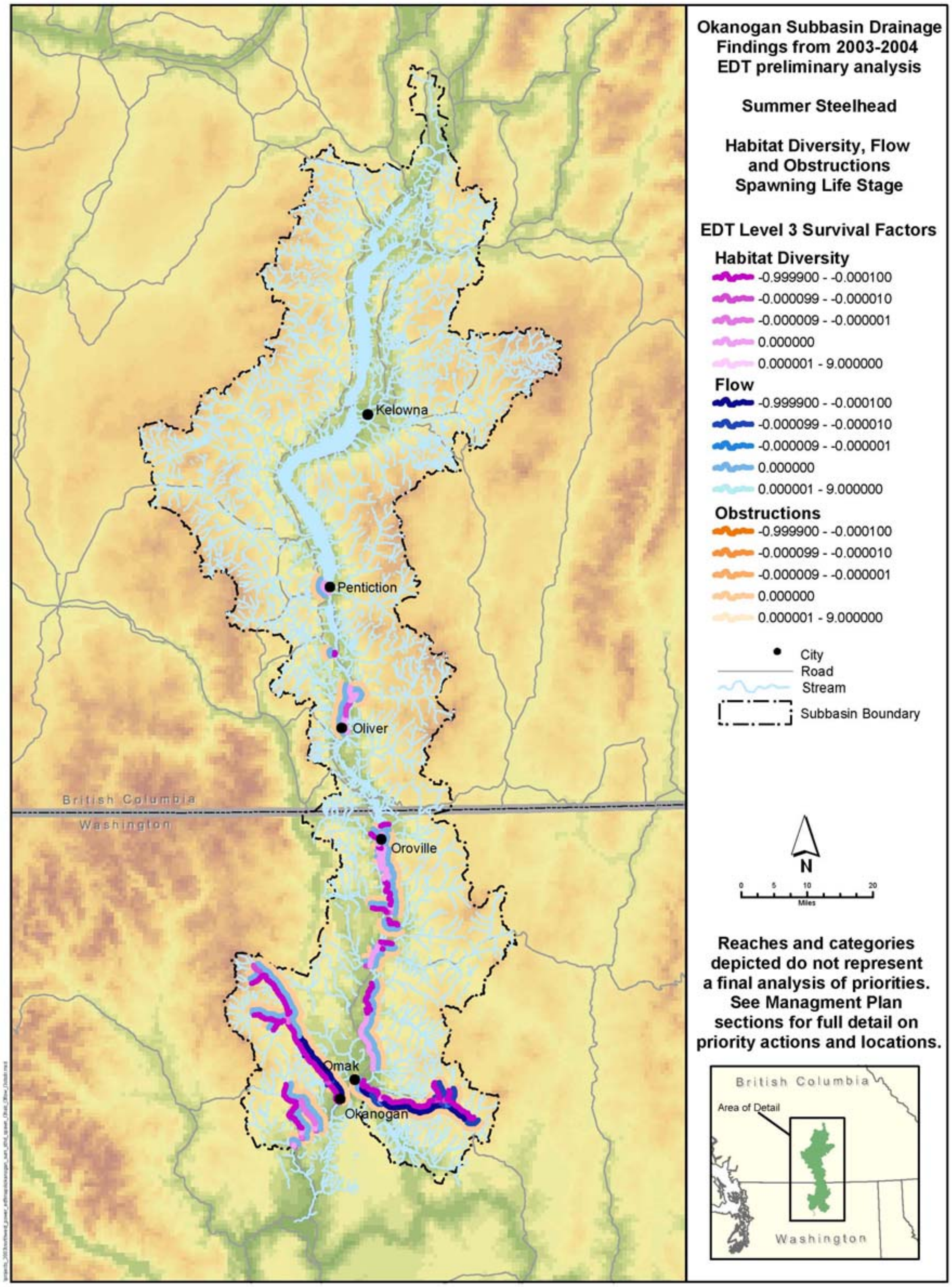
Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer Steelhead
Channel Stability, Flow
and Sediment
Egg Incubation Life Stage
EDT Level 3 Survival Factors
Channel Stability
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Sediment
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
Subbasin Boundary
N
0
5
10
20
Miles
Reaches and categories
depicted do not represent
a final analysis of priorities.
See Managment Plan
sections for full detail on
priority actions and locations.
British Columbia
Area of Detail
Washington
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
Omak
Okanogan



Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer/Fall Chinook
Abundance Restoration
All Life Stages
EDT Abundance
Restoration Classes
A
B
C
D
E
City
Road
Stream
Subbasin Boundary
N
Miles
Reaches and categories depicted do not represent a final analysis of priorities. See Managment Plan sections for full detail on priority actions and locations.
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
Omak
Okanogan
Area of Detail


Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer/Fall Chinook
Level 3 Habitat Diversity and Temperature
Level 2 Channel Length
Spawning Life Stage
EDT Level 3 Survival Factors
Habitat Diversity
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Temperature
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
EDT Level 2
Environmental Factor
Channel Length
-0.999900 - -0.000500
-0.000499 - -0.000050
-0.000049 - -0.000005
-0.000004 - 0.000000
0.000001 - 1.000000
City
Road
Stream
Subbasin Boundary
N
0 5 10 20
Miles
Reaches and categories depicted do not represent a final analysis of priorities. See Managment Plan sections for full detail on priority actions and locations.
British Columbia
Area of Detail
Washington
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
Omak
Okanogan


Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Spring Chinook
Flow and Temperature
Holding Prespawner Life Stage
EDT Level 3 Survival Factors
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Temperature
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
Subbasin Boundary
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
Omak
Okanogan
N
0 5 10 20
Miles
Reaches and categories depicted do not represent a final analysis of priorities. See Managment Plan sections for full detail on priority actions and locations.
Area of Detail


Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer Steelhead
Habitat Diversity, Flow
and Obstructions
Spawning Life Stage
EDT Level 3 Survival Factors
Habitat Diversity
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Obstructions
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
Subbasin Boundary
N
0 5 10 20
Miles
Reaches and categories
depicted do not represent
a final analysis of priorities.
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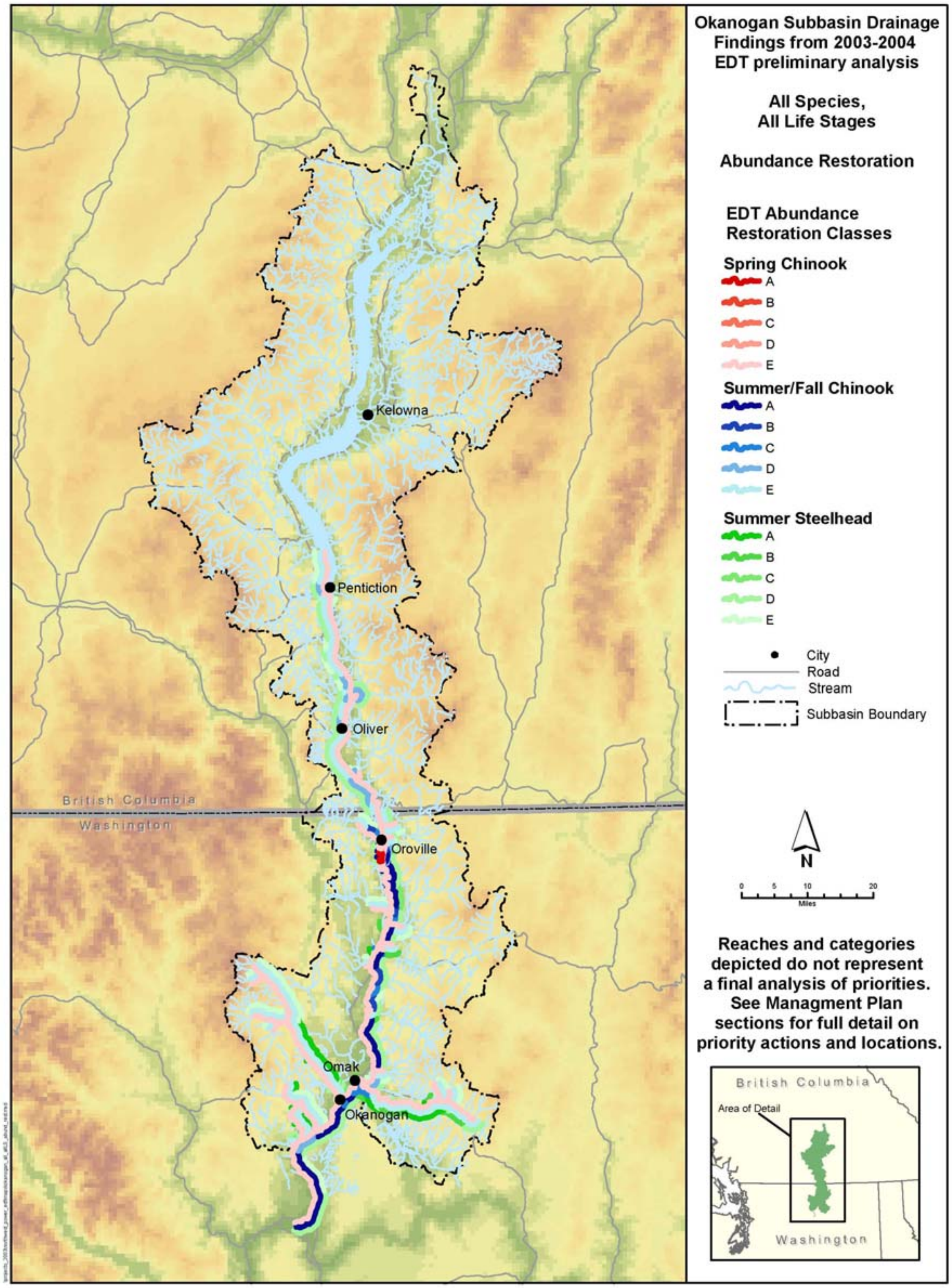
sections for full detail on
priority actions and locations.
British Columbia
Area of Detail
Washington
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
Omak
Okanogan


Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
All Species,
All Life Stages
Abundance Restoration
EDT Abundance
Restoration Classes
Spring Chinook
A
B
C
D
E
Summer/Fall Chinook
A
B
C
D
E
Summer Steelhead
A
B
C
D
E
City
Road
Stream
Subbasin Boundary
N
0 5 10 20
Miles
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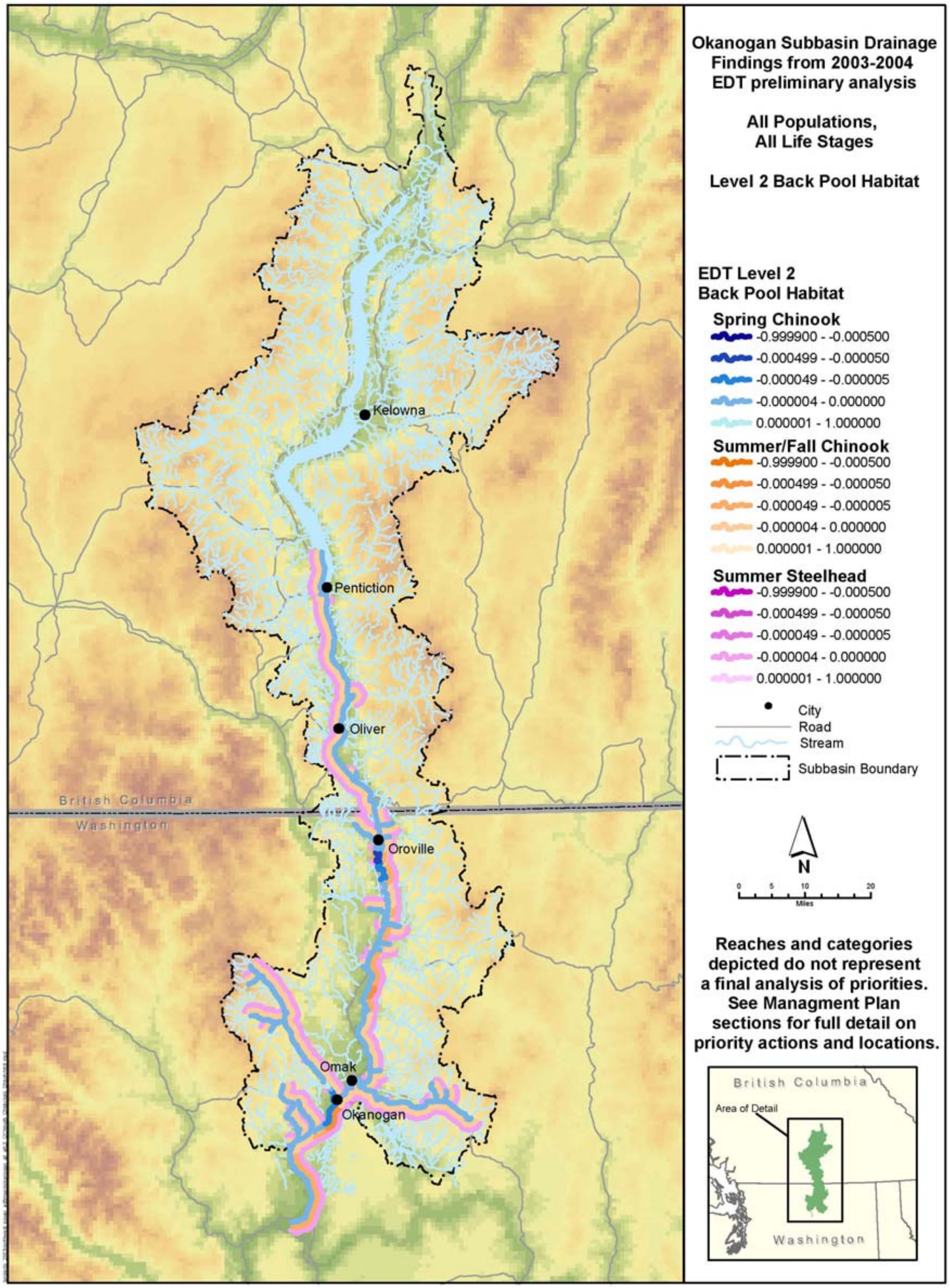
Kelowna
Penticton
Oliver
Oroville
Omak
Okanogan
British Columbia
Washington
Area of Detail



Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
All Populations,
All Life Stages
Level 2 Back Pool Habitat
EDT Level 2
Back Pool Habitat
Spring Chinook
-0.999900 - -0.000500
-0.000499 - -0.000050
-0.000049 - -0.000005
-0.000004 - 0.000000
0.000001 - 1.000000
Summer/Fall Chinook
-0.999900 - -0.000500
-0.000499 - -0.000050
-0.000049 - -0.000005
-0.000004 - 0.000000
0.000001 - 1.000000
Summer Steelhead
-0.999900 - -0.000500
-0.000499 - -0.000050
-0.000049 - -0.000005
-0.000004 - 0.000000
0.000001 - 1.000000
City
Road
Stream
Subbasin Boundary
N
0
5
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20
Miles
Reaches and categories
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British Columbia
Area of Detail
Washington
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
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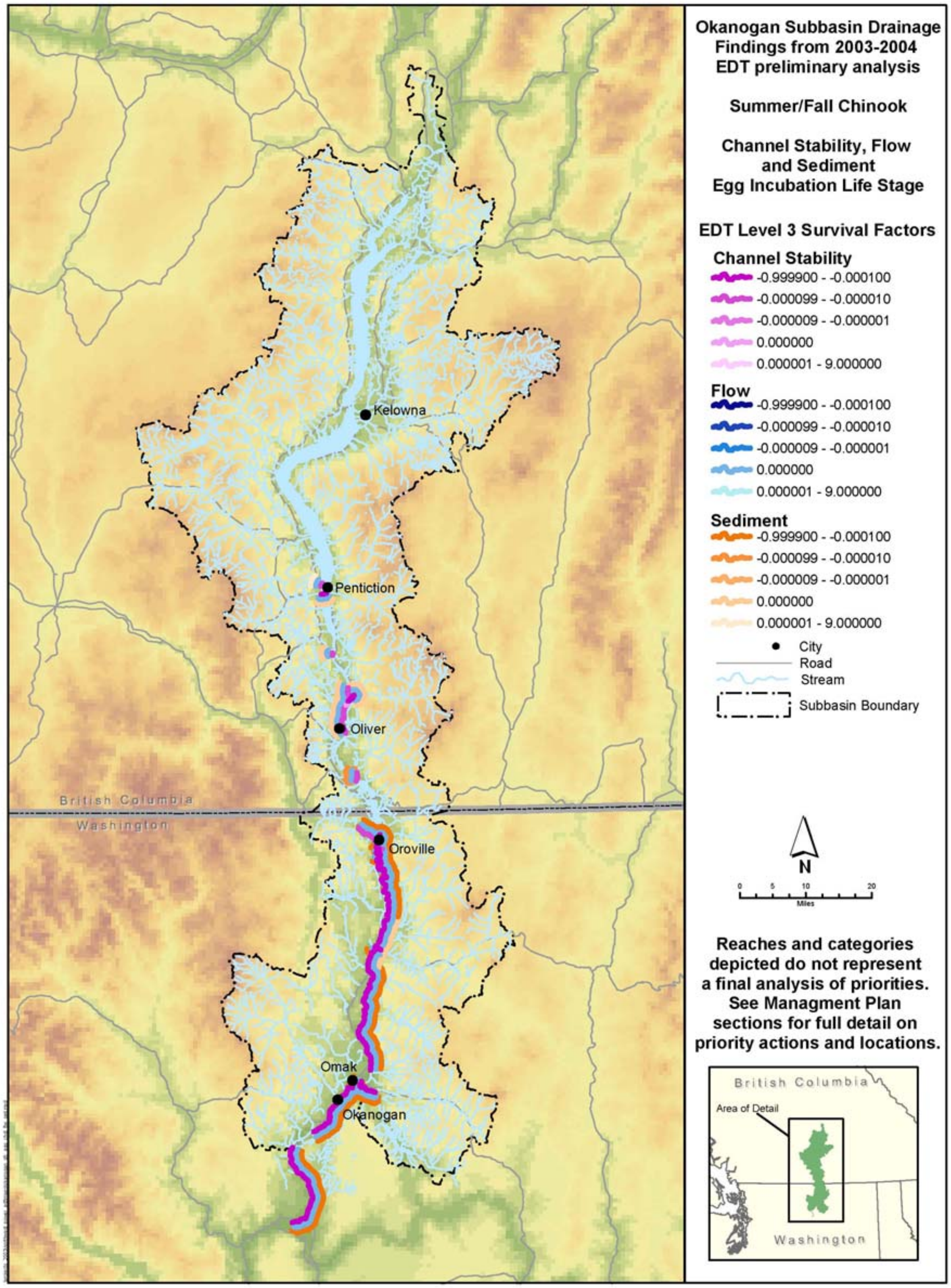
Okanogan


Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer/Fall Chinook
Channel Stability, Flow
and Sediment
Egg Incubation Life Stage
EDT Level 3 Survival Factors
Channel Stability
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Sediment
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
Subbasin Boundary
N
0 5 10 20
Miles
Reaches and categories
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a final analysis of priorities.
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British Columbia
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Washington
Kelowna
Penticton
Oliver
British Columbia
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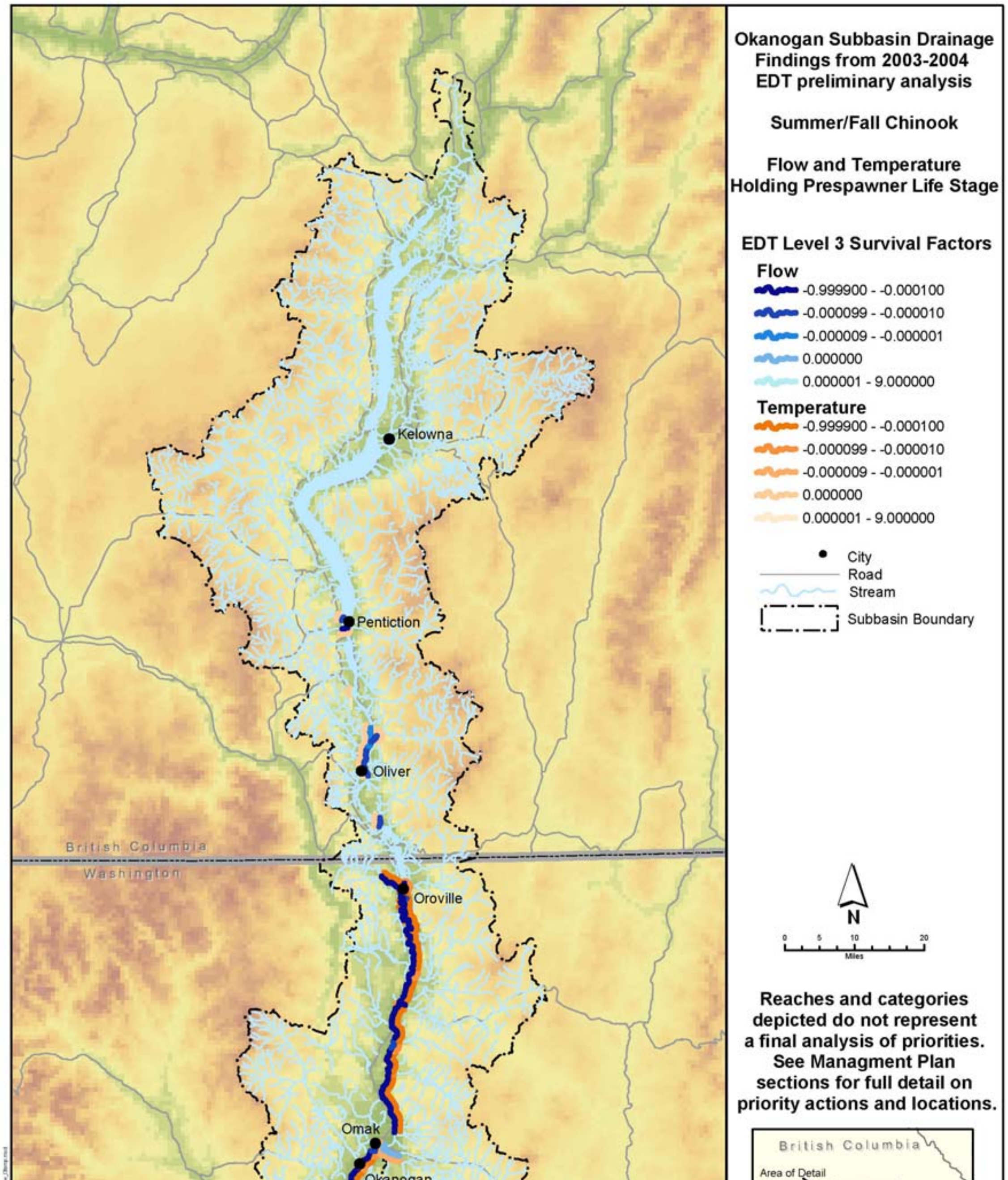
Okanogan



Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer/Fall Chinook
Flow and Temperature
Holding Prespawner Life Stage
EDT Level 3 Survival Factors
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Temperature
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
Subbasin Boundary
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
Omak
Okanogan
N
0
5
10
20
Miles
Reaches and categories
depicted do not represent
a final analysis of priorities.
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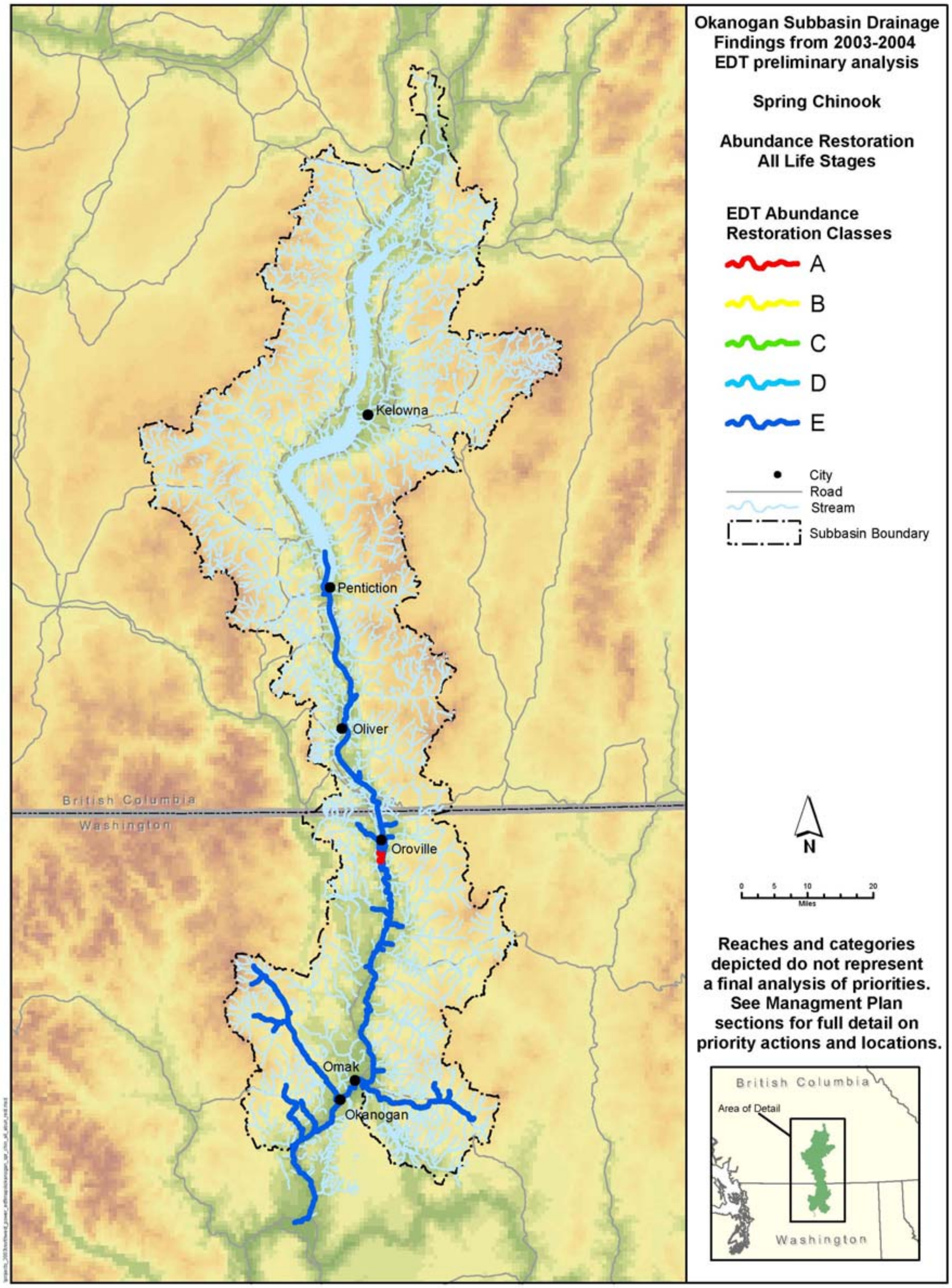
sections for full detail on
priority actions and locations.
British Columbia
Area of Detail
Washington


Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Spring Chinook
Abundance Restoration
All Life Stages
EDT Abundance
Restoration Classes
A
B
C
D
E
City
Road
Stream
Subbasin Boundary
Kelowna
Penticton
Oliver
British Columbia
Washington
Oroville
Omak
Okanogan
N
0
5
10
20
Miles
Reaches and categories
depicted do not represent
a final analysis of priorities.
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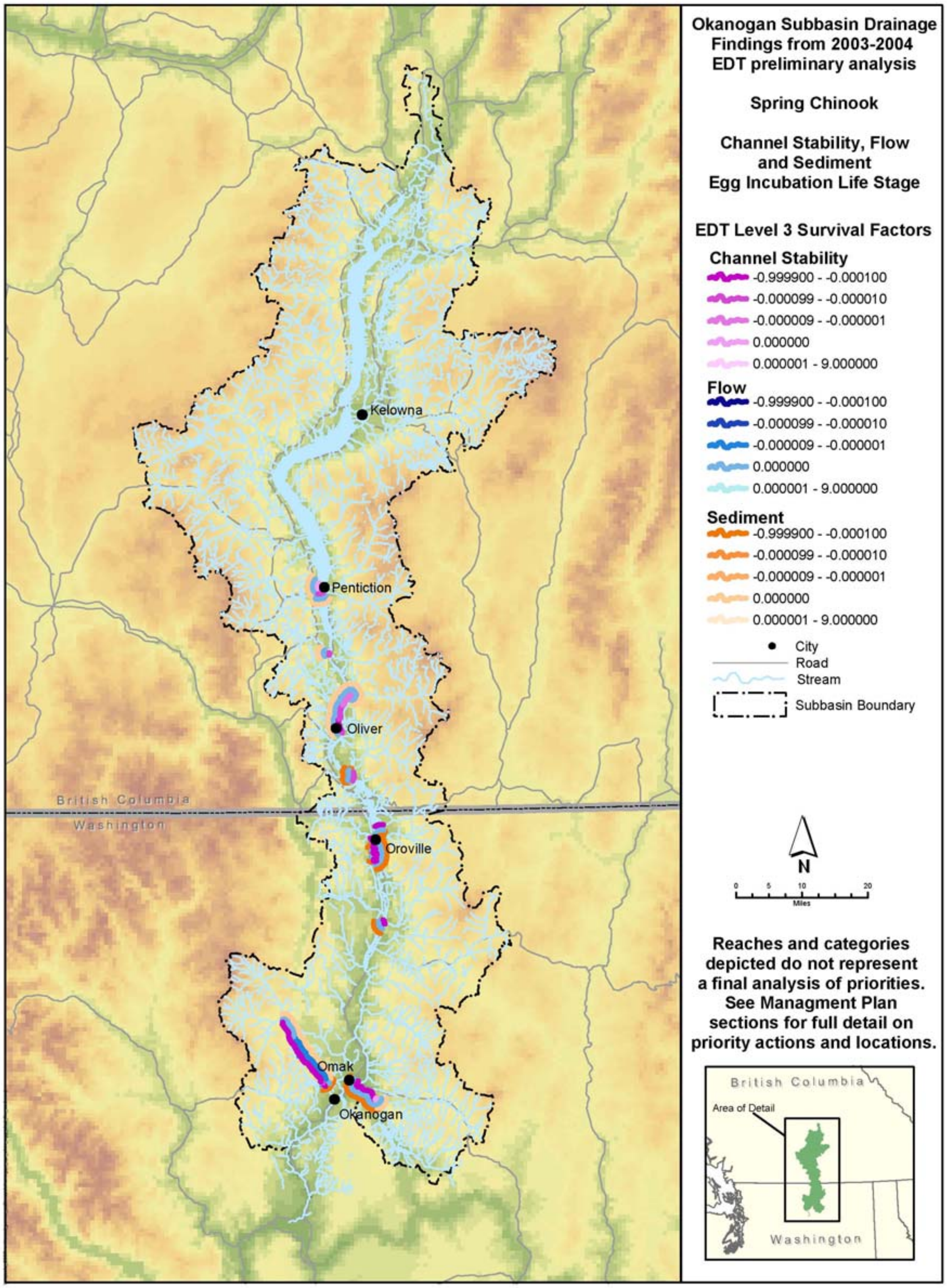
priority actions and locations.
British Columbia
Area of Detail
Washington


Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Spring Chinook
Channel Stability, Flow
and Sediment
Egg Incubation Life Stage
EDT Level 3 Survival Factors
Channel Stability
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Sediment
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
Subbasin Boundary
Kelowna
Penticton
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Reaches and categories
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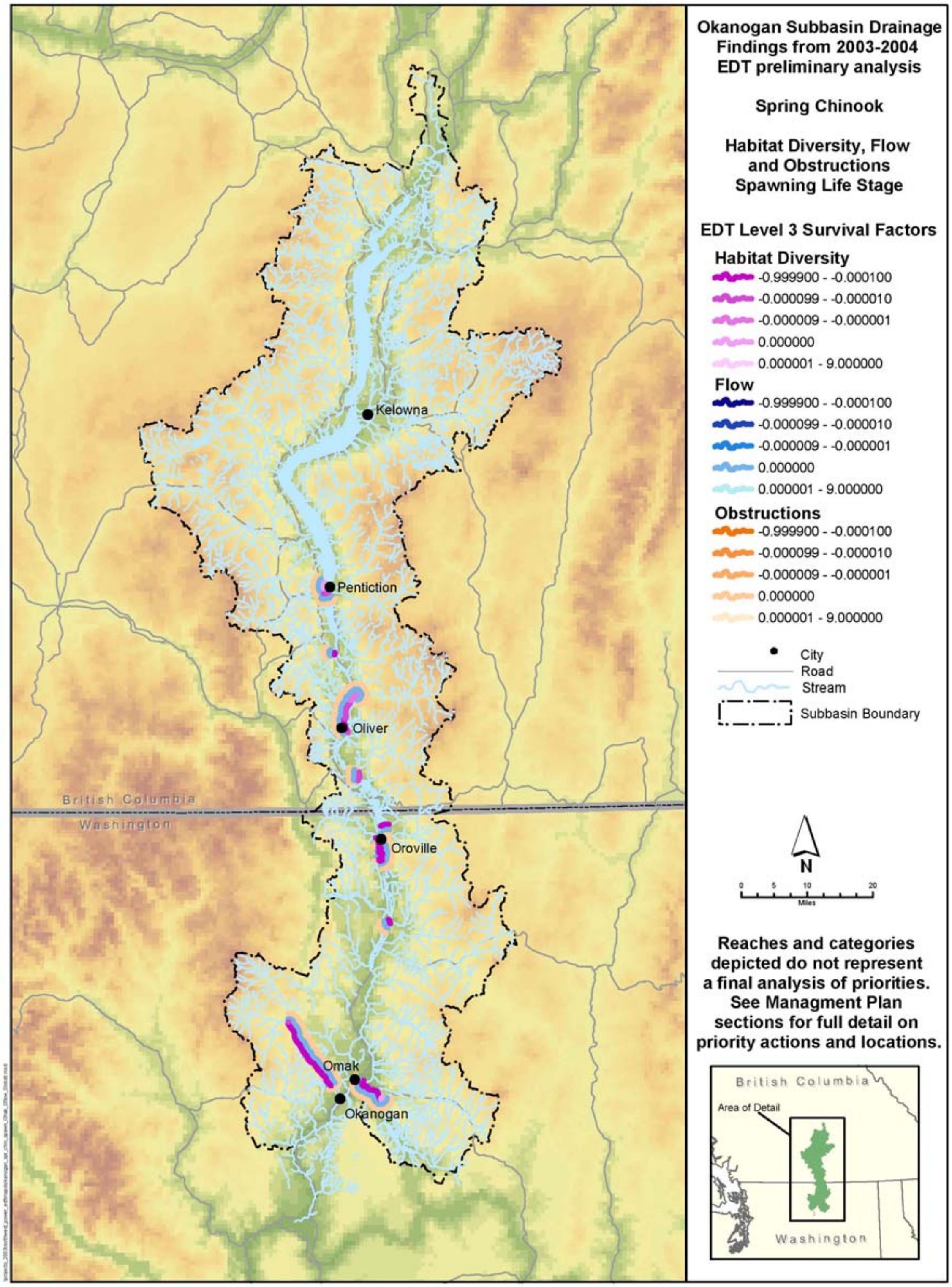
British Columbia
Area of Detail
Washington



Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Spring Chinook
Habitat Diversity, Flow
and Obstructions
Spawning Life Stage
EDT Level 3 Survival Factors
Habitat Diversity
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Obstructions
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
Subbasin Boundary
N
0 5 10 20
Miles
Reaches and categories
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priority actions and locations.
Kelowna
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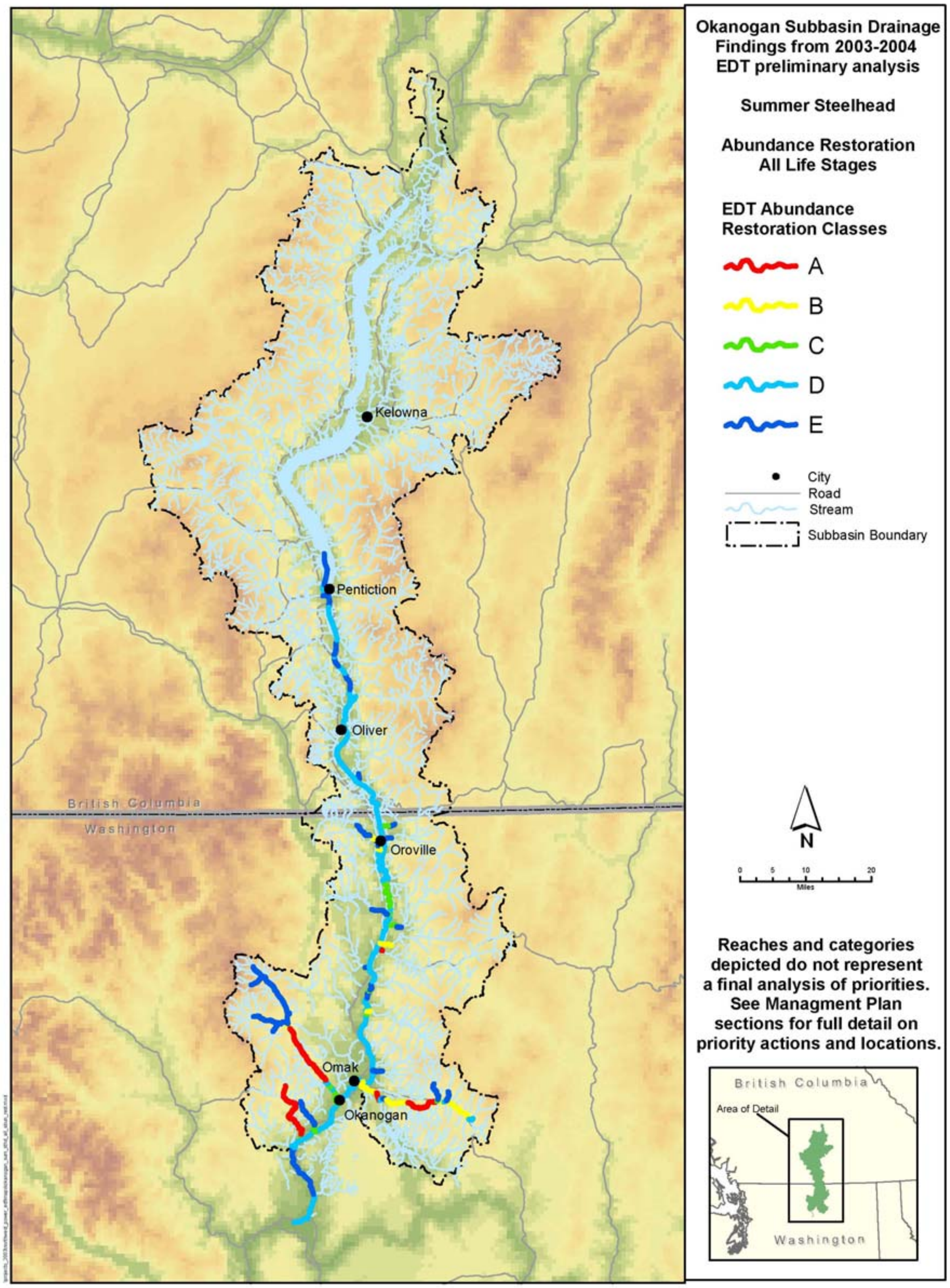
Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer Steelhead
Abundance Restoration
All Life Stages
EDT Abundance
Restoration Classes
A
B
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British Columbia
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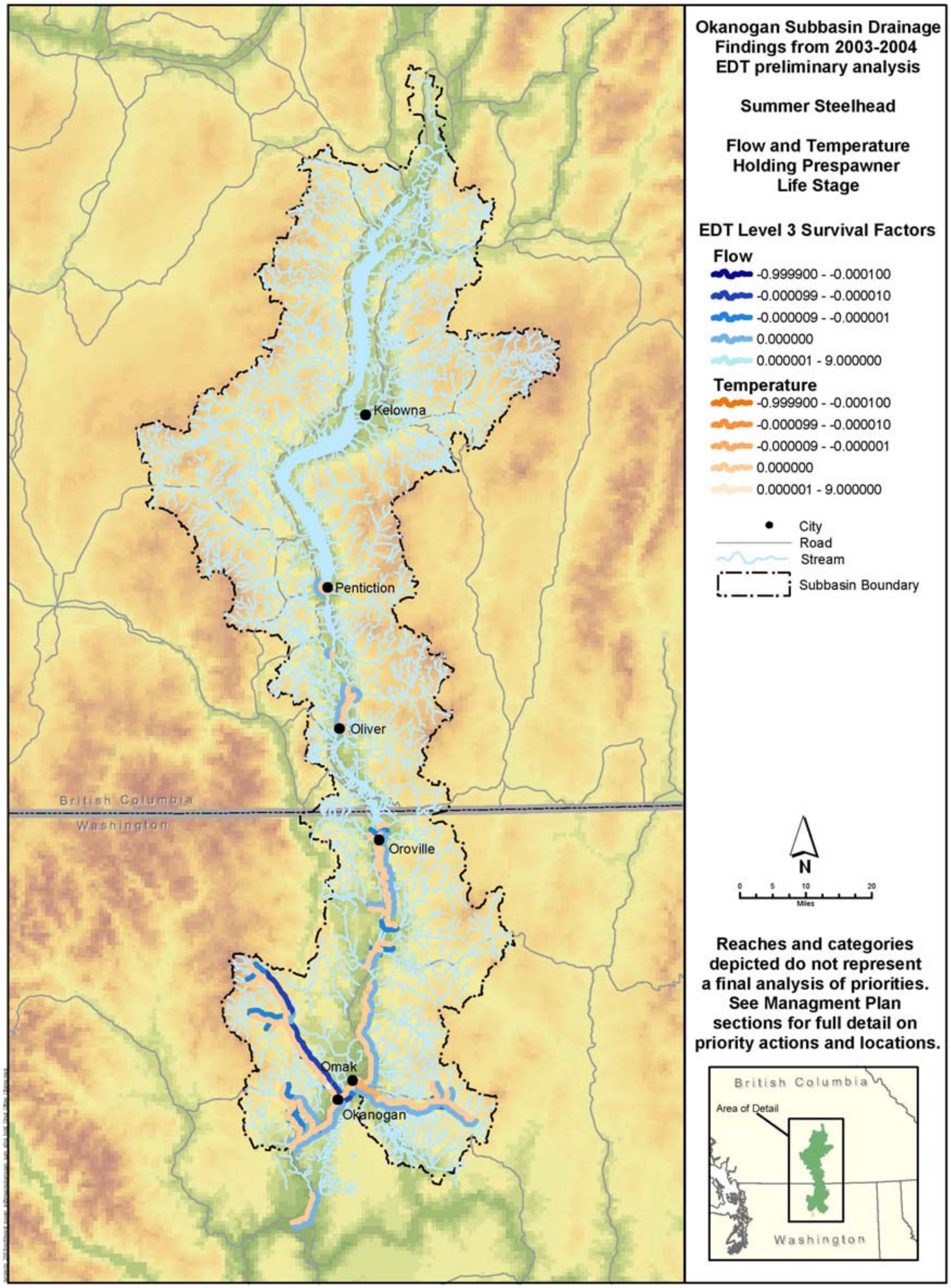
Okanogan Subbasin Drainage
Findings from 2003-2004
EDT preliminary analysis
Summer Steelhead
Flow and Temperature
Holding Prespawner
Life Stage
EDT Level 3 Survival Factors
Flow
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
Temperature
-0.999900 - -0.000100
-0.000099 - -0.000010
-0.000009 - -0.000001
0.000000
0.000001 - 9.000000
City
Road
Stream
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Kelowna
Penticton
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