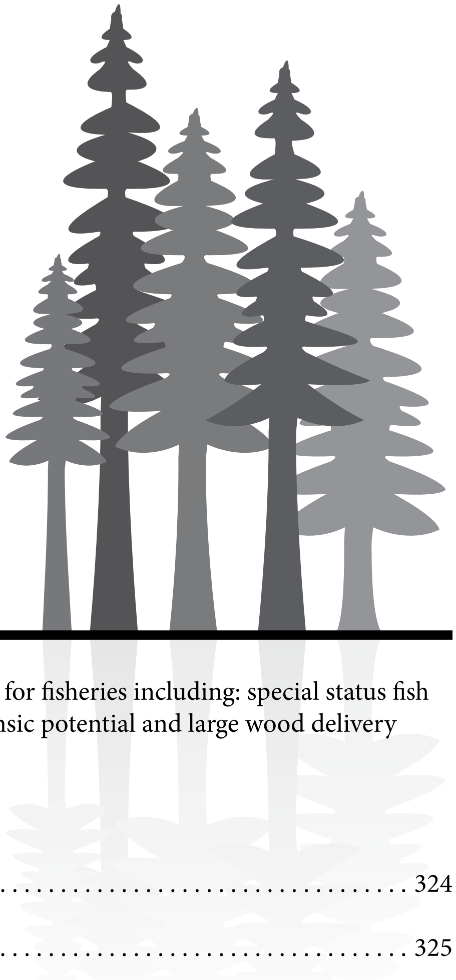
Appendix J
Fish



This appendix provides background on the analysis and modeling for fisheries including: special status fish species, status of threatened and endangered salmonids, and intrinsic potential and large wood delivery models.

In this appendix:

Special Status Fish Species in the Planning Area

Fish species designated as Federally Threatened or Endangered under the Endangered Species Act within the Planning Area, and the present status of critical habitat designations are displayed in *Table J-1*. For a complete list of non-status fish species endemic to the Planning Area, refer to the Oregon Natural Heritage Program website at (http://oregonstate.edu/ornhic/areas.html).

Table J-1. Special Status and Federally Threatened or Endangered Fish Species Within The Planning Area

Scientific Name	Common Name	ESU_DPS	Status	Critical Habitat Status
Oncorhynchus Tshawytscha	Chinook Salmon	Lower Columbia River	Threatened	Critical Habitat Designated
		Upper Willamette River	Threatened	Critical Habitat Designated
		Southern Oregon/ Northern California	Bureau Sensitive	N/A
Oncorhynchus Kisutch	Coho Salmon	Southern Oregon/ Northern California	Threatened	Critical Habitat Designated
		Lower Columbia River	Threatened	N/A
		Oregon Coast	Threatened	Critical Habitat Designated
Oncorhynchus Keta	Chum Salmon	Lower Columbia River	Threatened	Critical Habitat Designated
		Pacific Coast	Bureau Sensitive	N/A
Oncorhynchus Mykiss	Steelhead	Lower Columbia River	Threatened	Critical Habitat Designated
		Upper Willamette River	Threatened	Critical Habitat Designated
		Oregon Coast	Bureau Sensitive	N/A
Chasmistes Brevirostris	Shortnose Sucker	Klamath Basin	Endangered	Critical Habitat Proposed
Deltistes Luxatus	Lost River Sucker	Klamath Basin	Endangered	Critical Habitat Proposed
Salvelinus Confluentus	Bull Trout	Columbia River & Klamath River	Threatened	Critical Habitat Not Designated on Federal lands
Oregonichthys Crameri	Oregon Chub	Willamette River Valley[1]	Endangered	Critical Habitat not designated
Rhinichthys Cataractae	Millicoma Dace	All	Bureau Sensitive	N/A
Oncorhynchus mykiss	Inland Redband Trout (All Stocks)	All	Bureau Sensitive	N/A
Oregonichthys kalawatseti	Umpqua Chub	All	Bureau Sensitive	N/A
Lampetra Minima	Miller Lake Lamprey	All	Bureau Sensitive	N/A
Oncorhynchus Clarkii	Coastal Cutthroat Trout	Columbia River/SW Washington	Bureau Sensitive	N/A

[1] Occurs within WOPR planning area, but not on BLM-administered lands

Status Summaries for Threatened or Endangered Salmonids

The following are summaries of the status of listed fish species within the plan area. Summaries or salmon and steelhead are from the National Marine Fisheries Service (NMFS) "*Updated Status of federally Listed ESUs of West Coast Salmon and Steelhead*" (June 2005). The specific listing status of the species and the threats to the species, are given in the specific Federal Register notice for each species or group of species covered by the notice. The Federal Register notices can be found at the NMFS web site http://www.nwr.noaa.gov for anadromous fish and the U.S. Fish and Wildlife Service web site http://www.fws.gov/pacific/ for resident fish. Federal Register notices for rules regarding the designation of critical habitat can also be found at these web sites. The Federal Register notices give the basic life history requirements for the listed species, the threats that caused the listing, and for critical habitat those basic requirements necessary for the survival and recovery of the species.

Lower Columbia River Chinook Salmon Evolutionary Significant Unit (ESU)

Status of the Species (Myers et al. 2006)

Life History

The following ESU description is extracted from Myers, et al, 2006. The Lower Columbia River Chinook Salmon ESU exhibits extensive diversity in life history traits, particularly run timing, spawn timing, and juvenile life histories. Run timing is a primary factor in the identification of distinct populations, with spring, fall and late falls present. In the coast strata (Youngs Bay, Big Creek, Clatskanie, and Scappoose) fall Chinook are present, spring, fall and late fall are present in the Western cascades strata (Clackamas and Sandy), and spring and fall Chinook are present in the Columbia Gorge strata (Lower Gorge and Hood drainages).

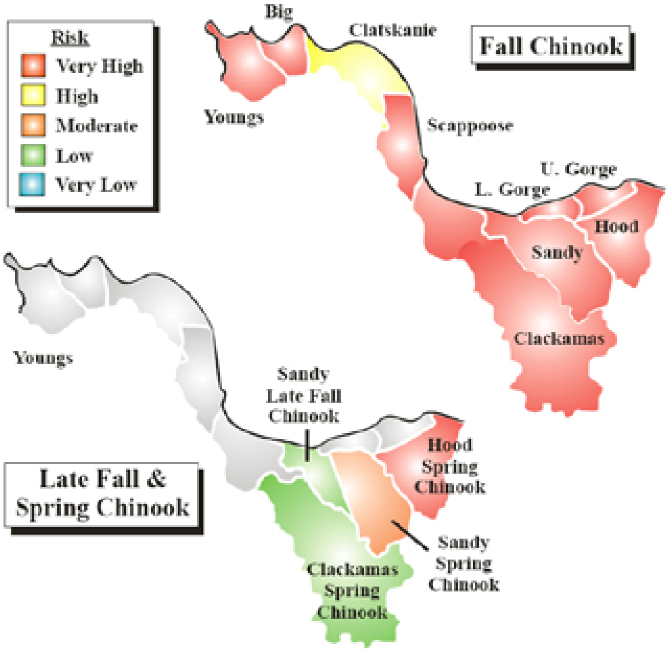
Chinook salmon generally spawn in various-sized rivers, from small streams to large systems such as the Columbia River. Chinook salmon display two dominant life history types: ocean- and stream-types (Myers et al. 1998). Individuals exhibiting an ocean-type life history usually spend only a few months in freshwater before migrating to the ocean, whereas stream-type chinook may spend 1 to 2 years in freshwater before their migration to the sea (Healey 1991, Myers et al. 1998). Both ocean- and stream-type fish can reside in the ocean between 2 and 5 years before returning to spawn (Healey 1991).

Populations

The Willamette and Lower Columbia Technical Recovery Team estimated that between eight and ten historical populations in this Evolutionarily Significant Unit have been extirpated; mostly spring-run populations. Ten of the twelve Oregon populations of listed lower Columbia River Chinook are estimated to be at high or very high risk of extinction *(see Figure J-1. Extinction risk determinations for the Lower Columbia River Chinook ESU).*

Figure J-1. Extinction Risk Determinations For The Lower Columbia River Chinook ESU

Population	**Overall Extinction Risk**
Fall Chinook	
Clatskanie	**High**
Youngs	**Very High**
Big	**Very High**
Scapoose	**Very High**
L. Gorge	**Very High**
U. Gorge	**Very High**
Sandy	**Very High**
Hood	**Very High**
Clackamas	**Very High**
Late Fall and Spring Chinook	
Sandy – Late Fall	**Low**
Clackamas	**Low**
Hood	**Very High**
Sandy-Spring	**Moderate**



Status and Distribution

The Lower Columbia River Chinook Salmon Evolutionarily Significant Unit was federally listed as threatened in March of 1999 by the National Marine Fisheries Service. Critical habitat was designated in July of 2005. Recovery planning for this ESU is in progress.

The following are the summary of factors contributing to the decline of Lower Columbia Chinook Salmon (70 FR 37160) (factors in **bold** are those that BLM can influence).

- Hatchery introgression
- **Habitat blockages**
- **Logging**
- Eruption of Mt. Saint Helens
- Hydropower development
- Predation
- Harvest

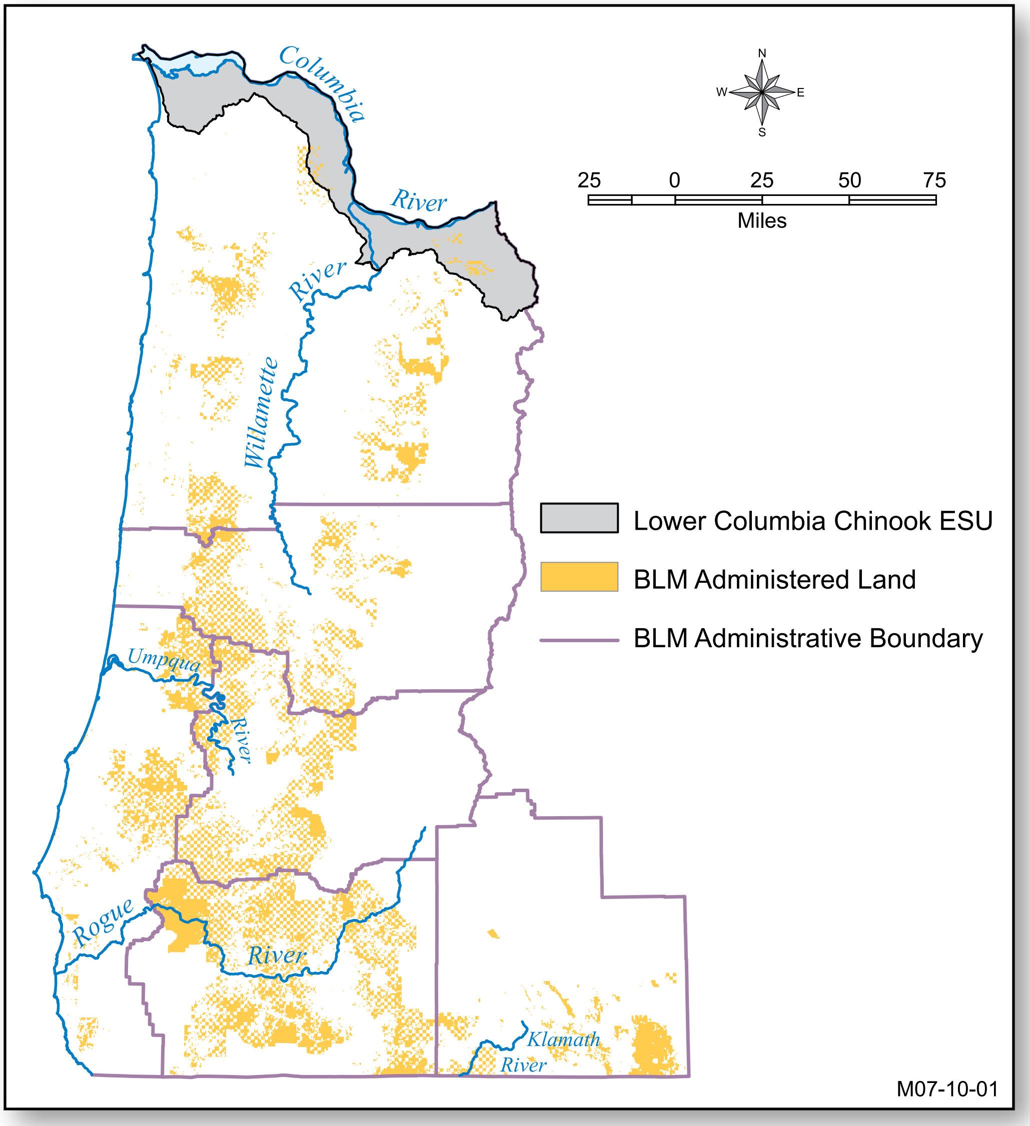
The Lower Columbia River Chinook ESU includes all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River (64 FR 14208; March 24, 1999).

The BLM-administered land within the planning area comprises less than 0.6% of the ESU. Within the planning area, there are 611 stream miles in this ESU occupied by Lower Columbia chinook; with 22 of the miles on BLM-administered land *(See Table J-2. Distribution of Lower Columbia River Chinook in the ESU and on BLM-administered Lands Within the Planning Area* and *Figure J-2. Lower Columbia River Evolutionary Chinook Significant Unit Within Planning Area).*

Table J-2. Distribution Of Lower Columbia River Chinook In ESU And On BLM-Administered Lands Within The Planning Area

		Acres in ESU	Chinook Miles in ESU (Plan Area)	Critical Habitat Miles (Entire ESU)
Salem District	**BLM**	21,470	22	10
	Other	3,448,358	589	1,268
Total	**BLM**	21,470 (.6%)	22	10
	All	3,469,828	611	1,278

Figure J-2. Lower Columbia River Chinook Evolutionary Significant Unit Within The Planning Area



Key Limiting Factors Identified For the Lower Columbia River Chinook Populations

Limiting factors outside BLM's control are not listed here. The following limiting factors, and their level of threat to the Lower Columbia River chinook ESU, were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress:

- Degraded Habitat – *Floodplain Connectivity and Function*
- Degraded Habitat – *Channel Structure and Complexity*
- Degraded Habitat – *Riparian Areas and LWD Recruitment*
- Degraded Habitat – *Stream Substrate*
- Degraded Habitat – *Stream Flow*
- Degraded Habitat – *Fish Passage*

Status of Critical Habitat

Critical habitat was designated for the Lower Columbia River Chinook ESU in July of 2005. There are 10 miles of critical habitat on BLM-administered lands in this ESU. See *Figure J-3 (Lower Columbia River Chinook Critical Habitat Within The Western Oregon Plan Revision Area)* and *Figure J-4 (Lower Columbia River Chinook CHART Streams and Watersheds).*

Figure J-3. Lower Columbia River Chinook Critical Habitat Within The Western Oregon Plan Revision Area

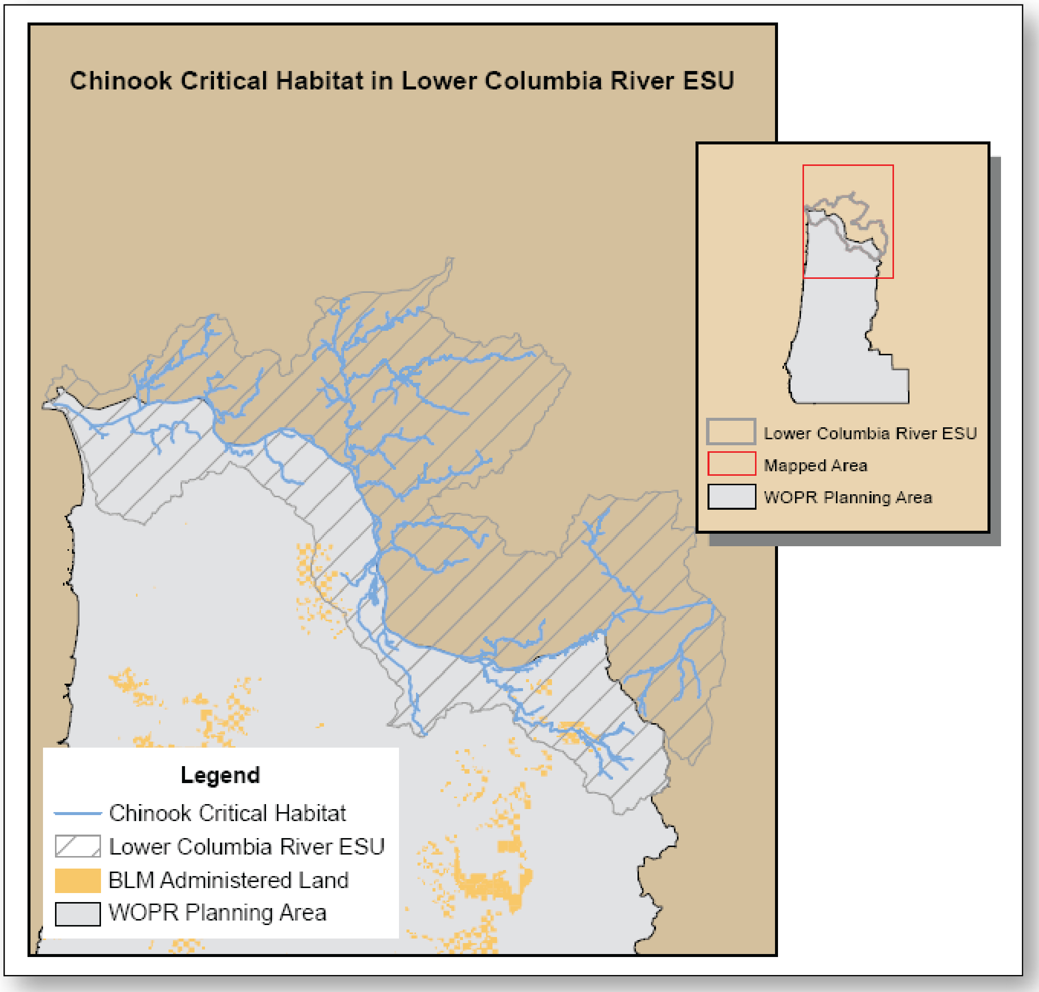
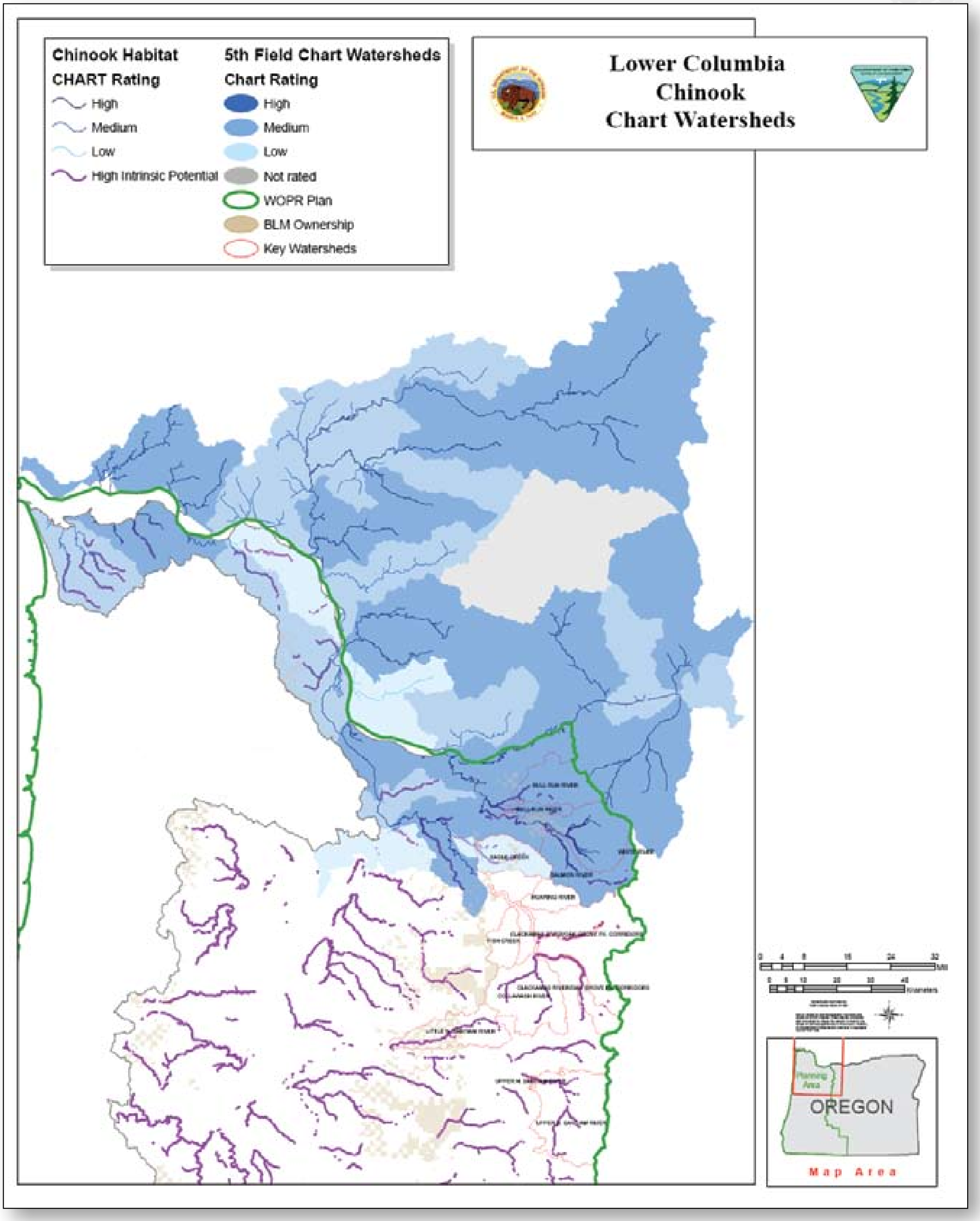


Figure J-4. Lower Columbia River Chinook CHART Streams and Watersheds



Lower Columbia River Coho Salmon Evolutionary Significant Unit

Status of the Species (Myers et al. 2006, ODFW 2007)

Life History

The Lower Columbia River Coho Salmon ESU historically supported large numbers (exceeding 300 thousand fish) of coho returning to river basins from the mouth of the Columbia through the Hood River. In Oregon, coho populations were designated in the Coast strata (Youngs Bay, Big Creek, Clatskanie, and Scappoose), Western Cascades strata (Clackamas and Sandy), and Columbia Gorge strata (Lower Gorge and Hood drainages). Two major life history strategies are exhibited. Early run coho tend to spawn in the upper reaches of larger systems in the lower Columbia River and in larger rivers east of the Cascades, returning from August to October and spawning from October to November. Late run coho generally spawn in small streams or the lower reaches of larger systems, returning from October to January and spawning from November to as late as March. Juvenile life histories vary little, with most fish migrating to the ocean in their second spring.

Populations

Seven of the eight Oregon populations of listed Lower Columbia River coho were estimated to be at high or very high risk of extinction. The Clackamas population is the only population rated at low risk ("viable") (See *Figure J-5. Extinction risk determinations for the Lower Columbia River Coho ESU*).

Status and Distribution

The Lower Columbia River Coho Salmon Evolutionarily Significant Unit was federally listed as threatened in July of 1995. Recovery planning for this ESU is in progress.

The following are the summary of factors contributing to the decline of Lower Columbia Coho Salmon (70 FR 37160) (factors in bold are those that BLM can influence).

- **Habitat blockages**
- Historic Flooding
- Predation
- **Water Diversion/extraction**
- Poaching
- Agriculture
- Hatchery introgression
- **Logging**
- Harvest
- **Mining**

The BLM-administered land within the planning area comprises 0.5 percent of the ESU. There are 964 stream miles in this ESU occupied by the Lower Columbia River coho; with 23 of the miles on BLM-administered land. See *Table J-3 (Distribution of Lower Columbia River coho salmon in ESU and on BLM-administered Lands within the planning area) and Figure J-6 (Lower Columbia River coho salmon evolutionary significant unit within the planning area).*

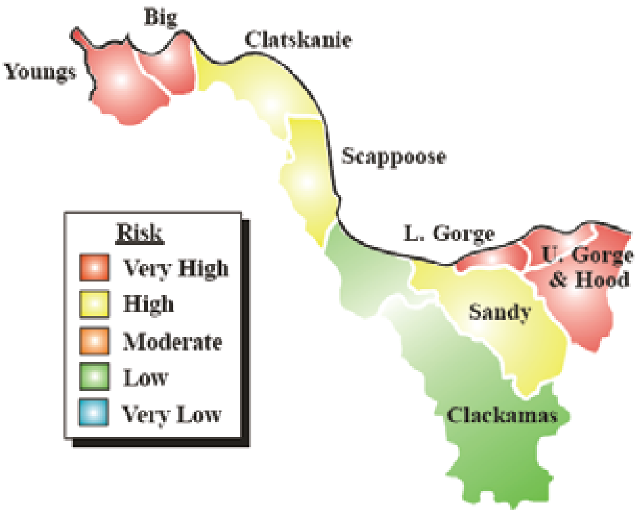
Table J-3. Distribution Of Lower Columbia River Coho Salmon In ESU And On BLM-administered Lands Within The Planning Area

		Acres in ESU	Coho Miles in ESU (Plan Area)
Salem District	**BLM**	35,668	23
	Other	1,728,798	941
Total	**BLM**	35,668 (0.5%)	23
	All*	6,716,352	964

*All includes acres in ESU outside planning area.

Figure J-5. Extinction Risk Determinations For The Lower Columbia River Coho ESU

Population	Overall Extinction Risk
Youngs	Very High
Big	Very High
Clatskanie	High
Scapoose	High
L. Gorge	Low
U. Gorge and Hood	Very High
Sandy	High
Clackamas	Low



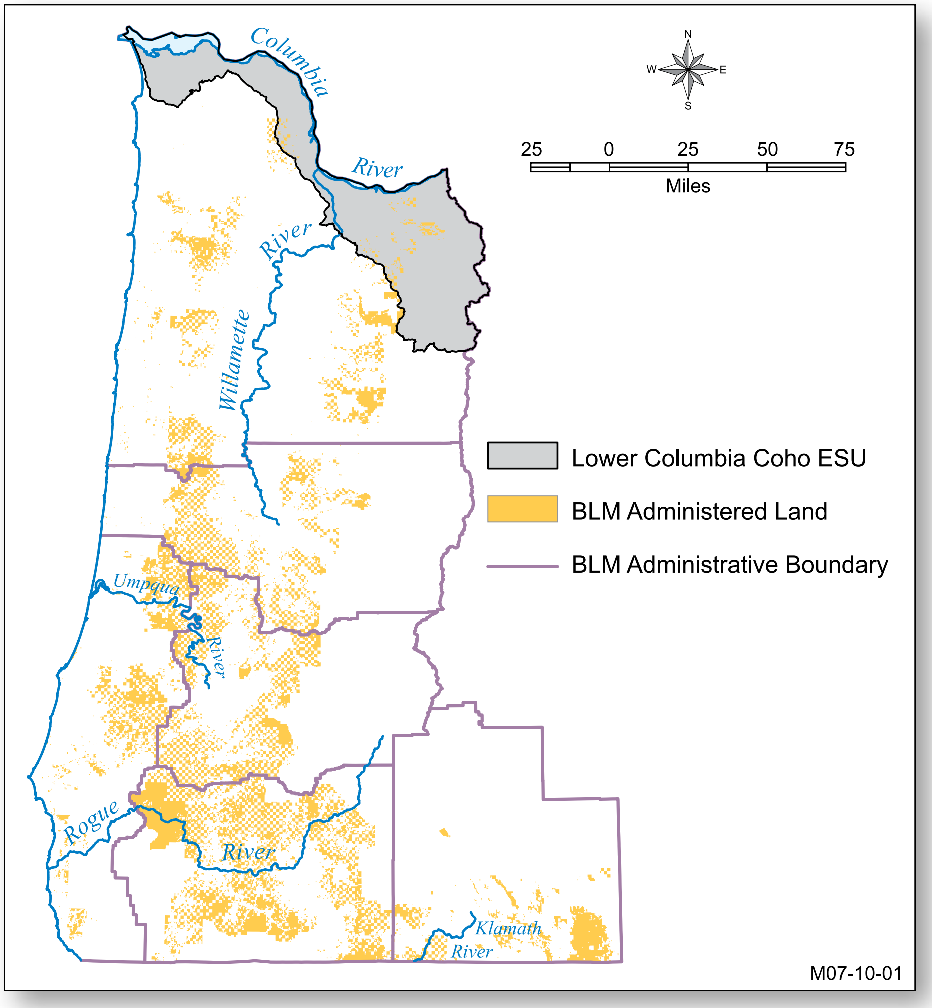


Figure J-6. Lower Columbia River Coho Salmon Evolutionary Significant Unit Within The Planning Area

Key Limiting Factors Identified For the Lower Columbia River Coho Populations

Limiting factors outside BLM's control are not listed here. The following limiting factors, and their level of threat to the Lower Columbia River Coho ESU, were identified in the 2006 Pacific Coastal Salmonid

Restoration Fund Report to Congress:

- Degraded Habitat – *Floodplain Connectivity and Function*
- Degraded Habitat – *Channel Structure and Complexity*
- Degraded Habitat – *Water Quality*
- Degraded Habitat – *Riparian Areas and LWD Recruitment*
- Degraded Habitat – *Stream Substrate*
- Degraded Habitat – *Stream Flow*

Status of Critical Habitat

Critical habitat has not been designated for the Lower Columbia River Coho Salmon ESU.

Lower Columbia River Steelhead Distinct Population Segment

Status of the Species (Myers et al. 2006, ODFW 2007)

Life History

The Lower Columbia River Steelhead DPS has two distinct life history strategies; summer- and winter-run timing. Winter steelhead are typically found west of the Cascades, and summer steelhead are most common east of the Cascades. Steelhead exhibit extensive diversity in life history traits, particularly run timing, spawn timing, and juvenile life histories. In Oregon, winter steelhead are found in the Western Cascades strata (Clackamas, Sandy) and the Columbia Gorge strata (Lower and Upper Gorge, Hood), while summer steelhead are found in the Columbia Gorge strata (Hood). Winter steelhead in the coast strata are not listed under the Endangered Species Act.

There is considerable overlap in the life history patterns of winter and summer steelhead. Each rears in freshwater for 1-4 years prior to emigrating to the ocean where they spend 1-4 years before returning to their natal streams to spawn. The primary difference between summer and winter steelhead is the timing of their return. Summer steelhead return between May and October, holding until the following year where they spawn from January to June. Winter steelhead return between December and May and spawn from February to June. Winter steelhead tend to spawn later than summer steelhead, but there is overlap in the timing of spawning. Unlike salmon, steelhead are capable of being repeat spawners, although the rate of repeat spawning is low (5-10%).

Populations

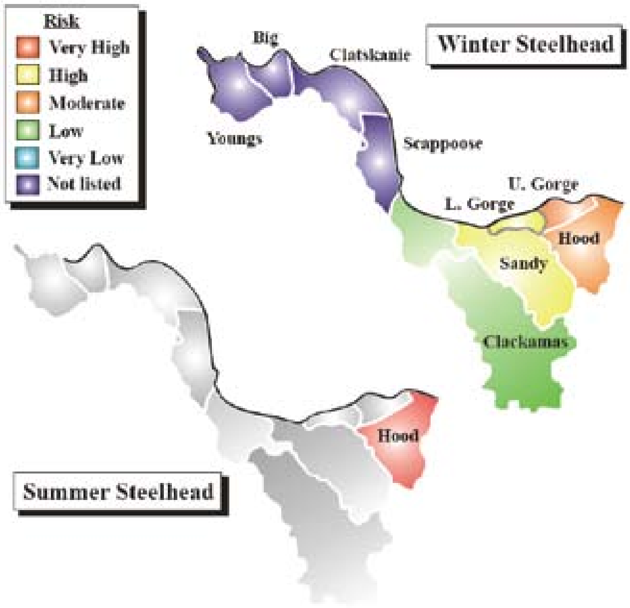
Three of the six populations are estimated to be at high or very high risk of extinction. See *Figure J-7 (Extinction risk determinations for the Lower Columbia River Steelhead DPS)*. The Clackamas and Hood winter steelhead populations have the lowest risks and the Sandy and Lower Gorge winter steelhead and Hood summer steelhead populations have the highest risks. The Upper Gorge and Hood winter steelhead populations are at moderate risk. This is a reflection of the low abundance and productivity scores. While the Sandy winter steelhead population was rated at high risk, due to low abundance and productivity scores, recent population trends (last 10 years) suggest that the primary threat to abundance and productivity (high hatchery fish stray rates) has been reduced to very low levels (<10%).

Status and Distribution

The Lower Columbia River Steelhead Distinct Population Segments were federally listed as threatened in March of 1998 by the National Marine Fisheries Service. Recovery planning for this DPS is in progress.

Figure J-7. Extinction Risk Determinations For The Lower Columbia River Steelhead DPS

Population	Overall Extinction Risk
Winter Steelhead	
Youngs	**Not Listed**
Big	**Not Listed**
Clatskanie	**Not Listed**
Scapoose	**Not Listed**
L. Gorge	**High**
U. Gorge	**Moderate**
Sandy	**High**
Hood	**Moderate**
Clackamas	**Low**
Summer Steelhead	
Hood	**Very High**



The following are the summary of factors contributing to the decline of Lower Columbia River Steelhead (NMFS 1996) (factors in bold are those that BLM can influence).

- Hatchery introgression
- Habitat blockages
- **Logging**
- Eruption of Mt. Saint Helens
- Hydropower Development
- Predation
- Harvest

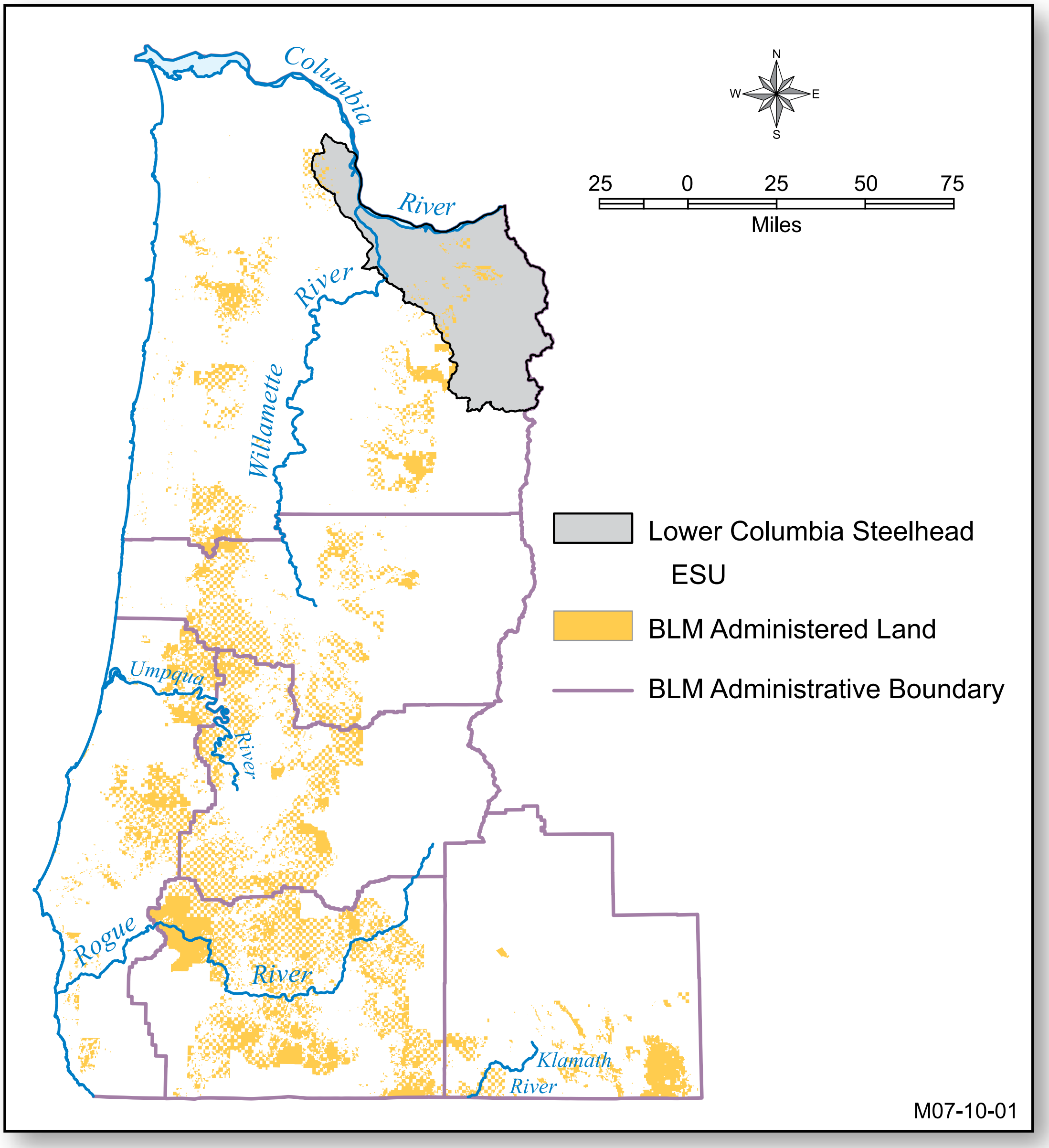
The BLM-administered land within the planning area comprises less than 1% of the DPS. There are 1,099 stream miles in this DPS occupied by the Lower Columbia River steelhead, with 44 of the miles on BLM-administered land. See *Table J-4 (Distribution of Lower Columbia River steelhead salmon in DPS and on BLM-administered Lands within the planning area)* and *Figure J-8 (Lower Columbia steelhead evolutionary significant unit within the planning area).*

Table J-4. Distribution Of Lower Columbia River Steelhead Salmon In DPS And On BLM-Administered Lands Within The Planning Area

District and Ownership		Acres in DPS	Steelhead Miles in DPS (Plan Area)	Critical Habitat Miles (Entire DPS)
Salem District	**BLM**	34,911	44	13
	Other	1,234,391	1,055	945
Total	**BLM**	34,911 (1%)	44	13
	All*	3,244,050	1,099	957

*All includes acres in ESU outside planning area.

FIGURE J-8. LOWER COLUMBIA STEELHEAD EVOLUTIONARY SIGNIFICANT UNIT WITHIN THE PLANNING AREA



Key Limiting Factors Identified For the Lower Columbia River Steelhead Populations

Limiting factors outside BLM's control are not listed here. The following limiting factors and their level of threat to the Lower Columbia River Steelhead DPS were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress:

- Degraded Habitat – *Floodplain Connectivity and Function*
- Degraded Habitat – *Channel Structure and Complexity*
- Degraded Habitat – *Water Quality*
- Degraded Habitat – *Riparian Areas and LWD Recruitment*
- Degraded Habitat – *Stream Substrate*
- Degraded Habitat – *Stream Flow*
- Degraded Habitat – *Fish Passage*

Status of Critical Habitat

Critical habitat was designated in September of 2005. There are 13 miles of critical habitat on BLM-administered lands in this DPS. See *Figure J-9 (Lower Columbia River steelhead critical habitat in entire DPS and on BLM-administered lands within the Western Oregon Plan Revision area)* and *Figure J-10 (Lower Columbia River steelhead CHART streams and watersheds).*

Figure J-9. Lower Columbia River Steelhead Critical Habitat Within The Western Oregon Plan Revision Area

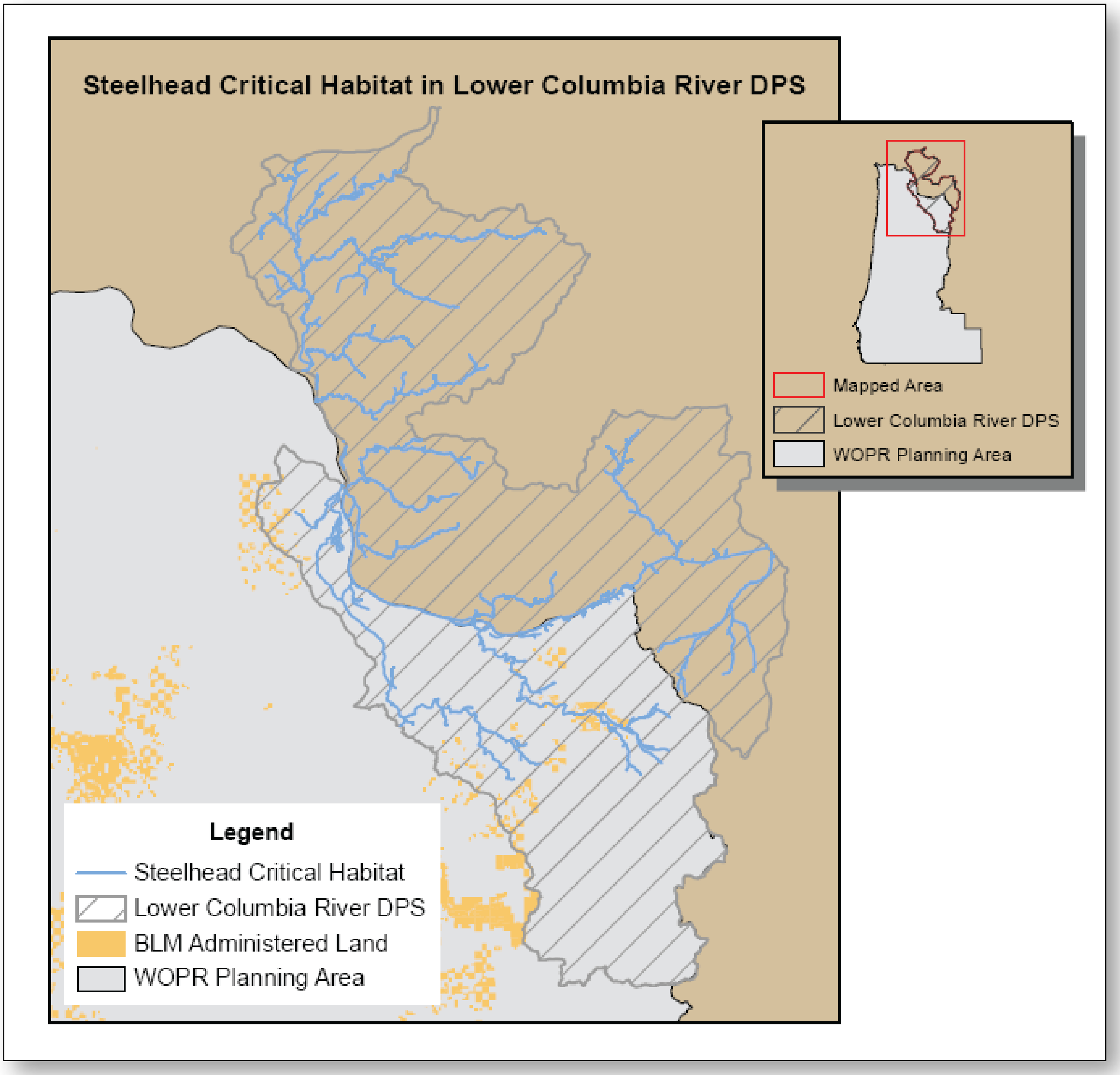
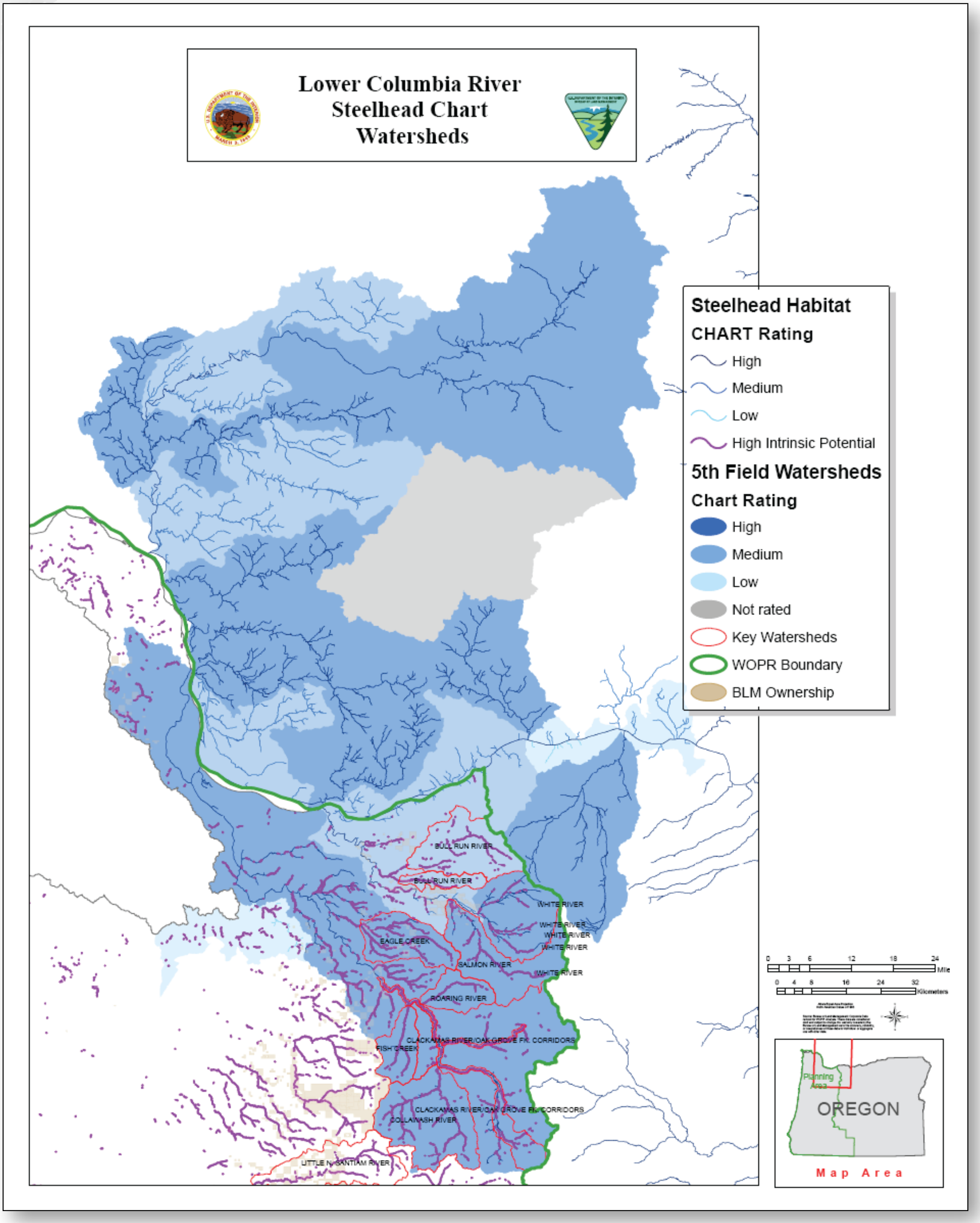


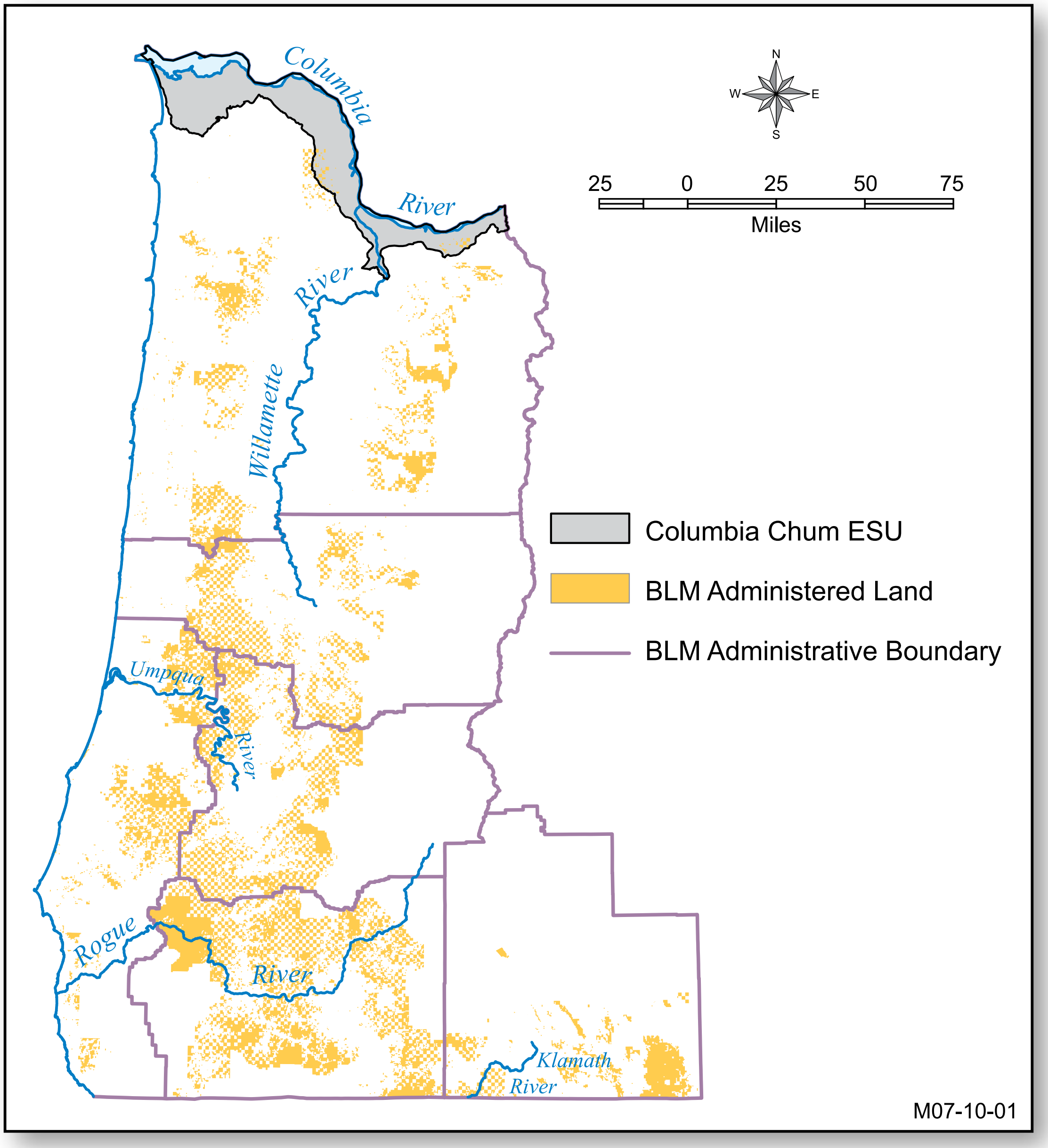
Figure J-10. Lower Columbia River Steelhead CHART Streams And Watersheds



Columbia River Chum Salmon Evolutionary Significant Unit

Chum salmon spawn on the Oregon side of the lower Columbia Gorge in the Multnomah area, but are absent from other populations in the Oregon portion of the Columbia River Evolutionary Significant Unit. With the exception of the lower Columbia Gorge population, Columbia River chum salmon are considered extirpated, or nearly so, in Oregon. The Columbia River Chum salmon do not occur on BLM-administered lands within the western Oregon revision planning area (NOAA 2005). Within the planning area, Columbia River chum salmon do not occur on BLM-administered lands. See *Figure J-11* (*Chum salmon evolutionary significant unit within the planning area*).

Figure J-11. Chum Salmon Evolutionary Significant Unit Within The Planning Area



Upper Willamette River Chinook Salmon Evolutionary Significant Unit

Status of the Species (Myers et al. 2006)

Life History

The geography and ecology of the Willamette Valley is considerably different from surrounding areas. Historically, the Willamette Falls offered a narrow temporal window for upriver migration, which may have promoted isolation from other Columbia River stocks (Myers et al. 1998). Chinook in this ESU exhibit a diverse array of life histories including 1) downstream migration through the lower reaches of tributaries and the Willamette/Columbia as late winter/early spring fry; 2) fall to early winter oceanward migration by fingerlings; and 3) late winter to spring oceanward migration by yearlings.

Populations

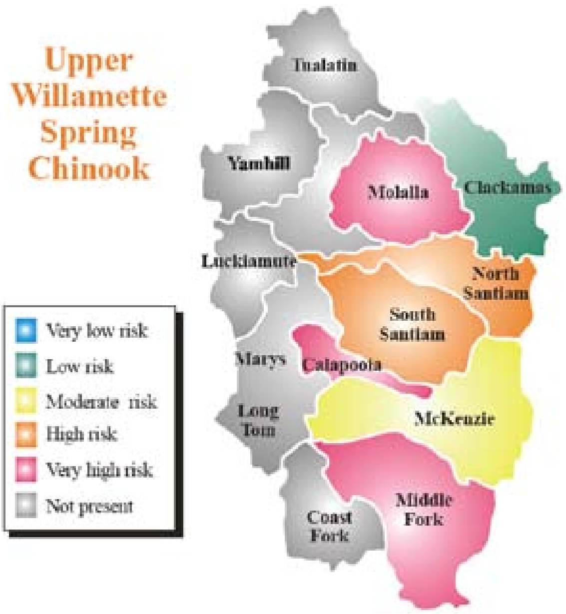
The Upper Willamette ESU historically supported large numbers (perhaps exceeding 275 thousand fish) of spring Chinook salmon returning to six river basins: the Clackamas, situated immediately downstream from Willamette Falls; and the Molalla; the Santiam; the Calapooia; the McKenzie; and the Middle Fork Willamette; all located upstream from Willamette Falls *(UWRC Recovery Plan 2007)*.

These basins all drain the Cascade Range from the east. Upper Willamette Chinook run timing is viewed as an adaptive response to flow conditions at Willamette Falls prior to laddering of the falls. The majority of the run ascends Willamette Falls in April, May, and June; passage over the falls regularly tapers off in July *(UWRC Recovery Plan 2007)*. Supported by the six above noted river basins, the Upper Willamette ESU consists of seven historical populations: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and Middle Fork Willamette *(UWRC Recovery Plan 2007)*.

Based on a review of extinction risk scores assigned by the Lower Columbia/Upper Willamette technical review team, five of seven populations of Upper Willamette Chinook are considered to be at a very high risk of extinction and the Upper Willamette Chinook ESU, as a whole, is at high risk of extinction *(UWRC Recovery Plan 2007)*. See *Figure J-12 (Extinction risk determinations for the Upper Willamette River Chinook ESU)*.

FIGURE J-12. EXTINCTION RISK DETERMINATIONS FOR THE UPPER WILLAMETTE RIVER CHINOOK ESU

Population	Overall Extinction Risk
Clackamas	Low
Mollala	Very High
North Santiam	Very High
South Santiam	Very High
Calapooia	Very High
McKenzie	Moderate
Middle Fork	Very High
ESU Overall Classification	High



Status and Distribution

The Upper Willamette River Chinook Salmon Evolutionarily Significant Unit was federally listed as threatened in March of 1999 by the National Marine Fisheries Service. Recovery planning for this ESU is in progress.

The following are the summary of factors contributing to the decline of Upper Willamette Chinook Salmon (70 FR 37160) (factors in bold are those that BLM can influence).

- **Habitat blockages**
- Hatchery introgression
- Urbanization
- **Logging**
- Hydropower Development
- Harvest

The Upper Willamette River Chinook ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries, above Willamette Falls, Oregon (64 FR 14208; March 24, 1999). The BLM-administered land within the planning area comprises less than 7% of the ESU. There are 1,570 stream miles in this ESU occupied by the Upper Willamette River chinook, with 43 of the miles on BLM-administered land. See *Table J-5 (Distribution of Upper Willamette River chinook ESU and on BLM-administered lands within the planning area)* and *Figure J-13 (Upper Willamette River chinook ESU within the planning area).*

Key Limiting Factors Identified For the Upper Willamette River Chinook Populations

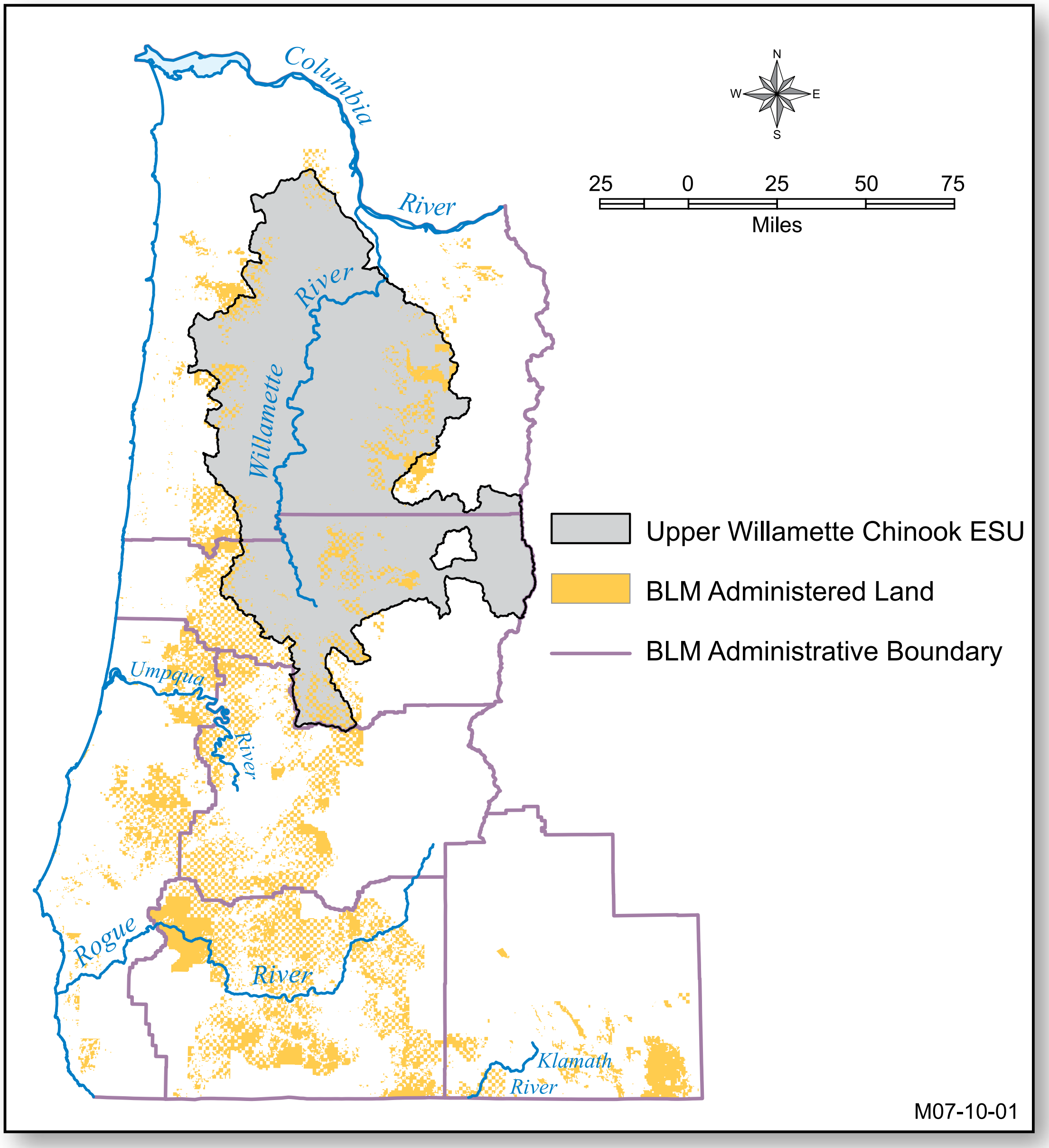
Limiting factors outside BLM's control are not listed here. The following limiting factors, and their level of threat to the Upper Willamette River chinook ESU, were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress:

- Degraded Habitat – *Floodplain Connectivity and Function*
- Degraded Habitat – *Channel Structure and Complexity*
- Degraded Habitat – *Water Quality*
- Degraded Habitat – *Riparian Areas and LWD Recruitment*
- Degraded Habitat – *Fish Passage*

Table J-5. Distribution Of Upper Willamette River Chinook In ESU And On BLM-administered Lands Within The Planning Area

District and Ownership		Acres in ESU	Chinook Streams in ESU (Miles in Plan Area)	Critical Habitat Miles (Entire ESU)
Salem District	**BLM**	185,230	29	35
	Other	3,054,863	1,060	934
Eugene District	**BLM**	153,542	14	0
	Other	1,480,715	424	0
Roseburg District	**BLM**	806	0	0
	Other	754	0	0
Total	**BLM**	339,578 (7%)	43	35
	All	4,875,910	1,570	1,004

Figure J-13. Upper Willamette River Chinook Evolutionary Significant Unit Within The Planning Area



Status of Critical Habitat

Critical habitat was designated for the Upper Willamette River Chinook ESU in July of 2005. There are 35 miles of critical habitat on BLM-administered lands in this ESU. See *Figure J-14 (Upper Willamette River chinook critical habitat within the Western Oregon Plan Revision area)* and *Figure J-15 (Upper Willamette River chinook CHART streams and watersheds).*

Figure J-14. Upper Willamette River Chinook Critical Habitat Within The Western Oregon Plan Revision Area

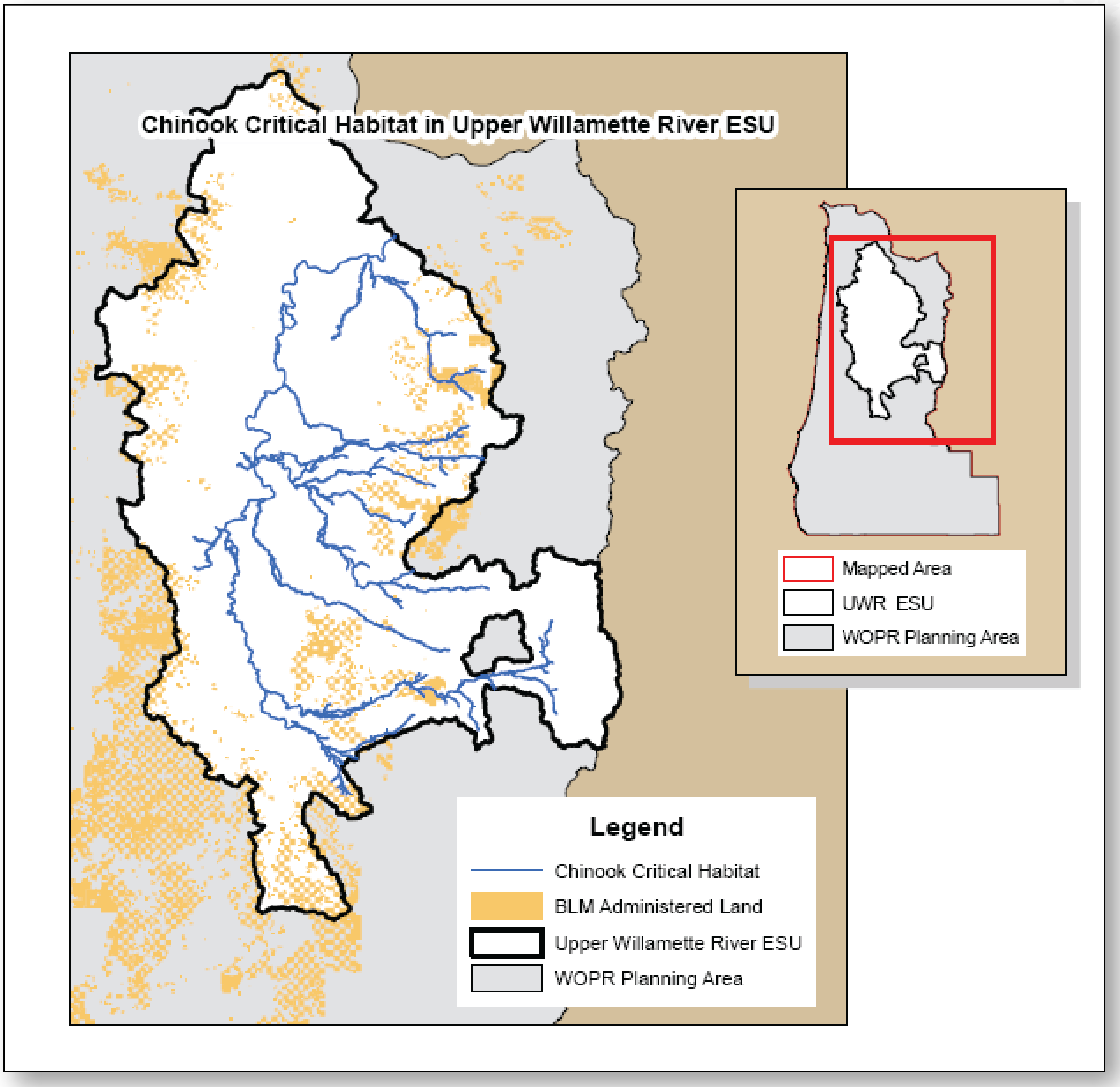
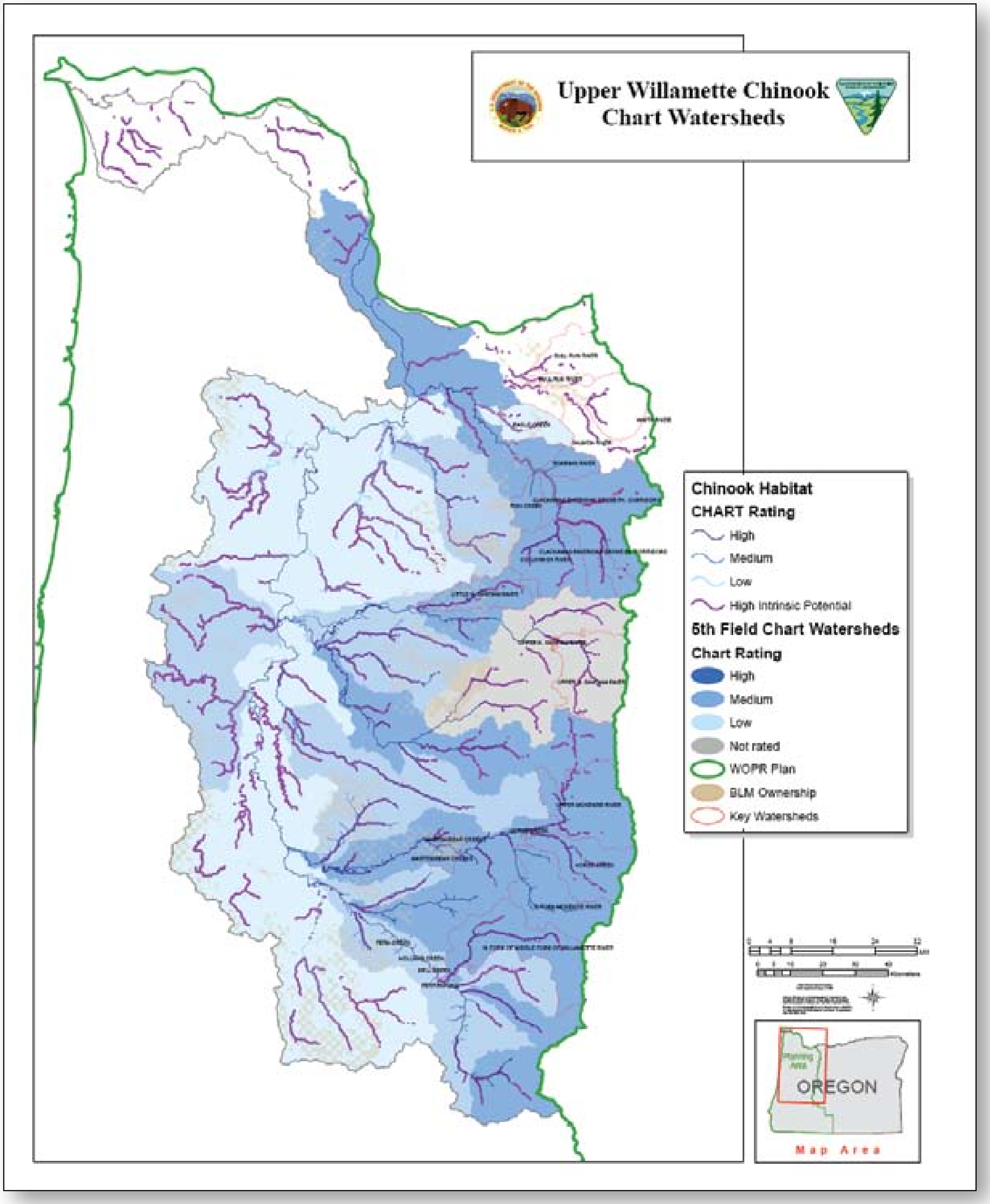


Figure J-15. Upper Willamette River Chinook CHART Streams And Watersheds



Upper Willamette River Steelhead Distinct Population Segment

Status of the Species (Myers et al. 2006, UWR Draft Recovery Plan 2007)

Life History

Only one run (winter-run) of steelhead historically was found in the Willamette above the Falls. The Upper Willamette steelhead ESU historically supported a large number (over 200 thousand) of late-run, native, winter steelhead returning to three river basins: the Molalla; the Santiam; and the Calapooia; all located upstream from Willamette Falls. These basins all drain the Cascade Range from the east. Willamette River tributaries that drain the Coast Range from the west (West Side Tributaries) represent an area of intermittent use by steelhead, which may be important for recovery, but are not classified as historical independent populations. Upper Willamette steelhead run-timing is viewed as an adaptive response to flow conditions at Willamette Falls prior to laddering of the falls. The majority of the run ascends Willamette Falls in late March and April; spawning typically occurs from April to early June. Unlike the Upper Willamette Chinook, which are sexually immature upon return to natal streams, Upper Willamette (native) winter steelhead enter freshwater and ascend to their natal basins as sexually mature fish and spawn rather quickly after reaching the spawning grounds. Supported by the three above noted river basins, the Upper Willamette Steelhead ESU consists of four historical populations: Molalla, North Santiam, South Santiam, and Calapooia; all four continue to support native late-run steelhead. Genetic analysis indicates a close affinity between winter steelhead populations in the North and South Santiam, Molalla, and Calapooia rivers. Natural- or hatchery-produced summer and early-run winter steelhead are genetically distinct from late-run native steelhead.

In general, resident and anadromous life histories of resident rainbow and anadromous steelhead are considered components of a population unless they have been isolated reproductively from each other because of life history differences or long-standing natural barriers. For example, rainbow trout in the McKenzie River have been identified as genetically distinct from winter steelhead in the upper Willamette Steelhead ESU.

The life history of native steelhead exhibits considerable variability. Juveniles most often overwinter in freshwater for two winters before migrating to the ocean during the spring; however, they may migrate to the ocean after spending one to four winters in freshwater, typically in higher elevation and gradient headwater streams. Most adults return to spawn after spending two summers in the ocean, but a small proportion of a brood may return after spending one, three, or four summers in the ocean. Steelhead may spawn more than once, returning to the ocean between spawning periods.

Populations

After a decade in which overall abundance (from Willamette Falls count) was near the lowest levels on record, adult returns for 2001 and 2002 were higher; with similar levels to those in the 1980s.

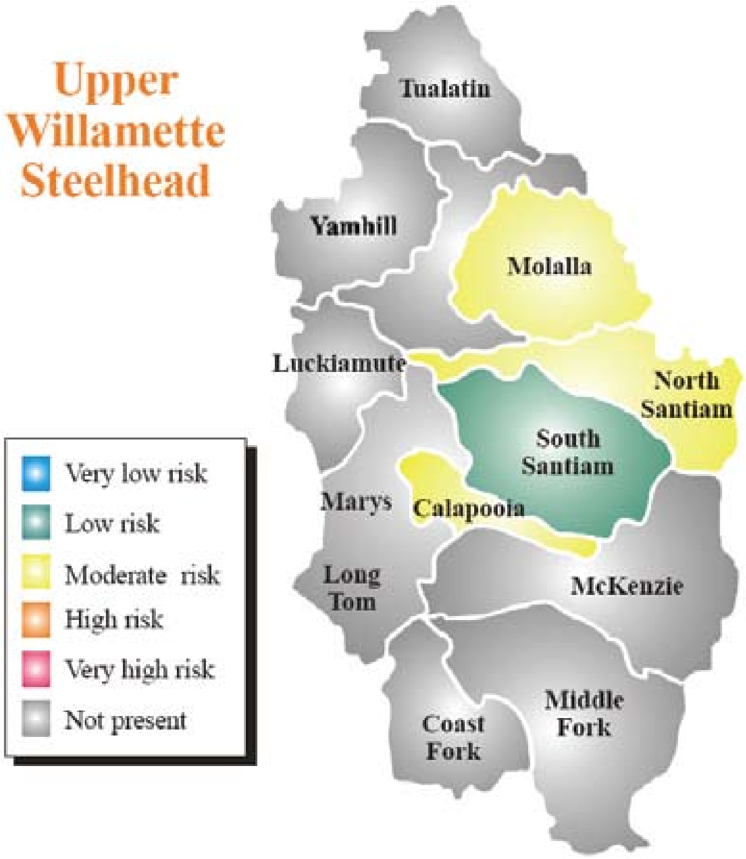
Three of the populations are estimated to be at moderate risk of extinction. See *Figure J-16 (Extinction risk determinations for the Upper Willamette River Steelhead DPS).*

Status and Distribution

The Upper Willamette River Steelhead Distinct Population Segments were federally listed as threatened in March of 1999 by the National Marine Fisheries Service. Recovery planning for this DPS is in progress.

Figure J-16. Extinction Risk Determinations For The Upper Willamette River Steelhead DPS

Population	Overall Extinction Risk
Molalla	Moderate
North Santiam	Moderate
Calapooia	Moderate
South Santiam	Low



The following are the summary of factors contributing to the decline of Upper Willamette Steelhead (NMFS 1996) (factors in bold are those that BLM can influence).

- Urbanization
- Habitat blockages
- **Logging**
- Predation
- Harvest
- Agriculture

The BLM-administered land within the planning area comprises approximately six percent of the DPS. There are 2,086 stream miles in this DPS occupied by the Upper Willamette River steelhead; with 80 of the miles on BLM-administered land. See *Table J-6 (Distribution of Upper Willamette River steelhead salmon in DPS and on BLM-administered lands within the planning area)* and *Figure J-17 (Upper Willamette River steelhead evolutionary significant unit within the planning area).*

Table J-6. Distribution Of Upper Willamette River Steelhead Salmon In The DPS And On BLM-Administered Lands Within The Planning Area

District and Ownership		Acres in ESU	Steelhead Miles in ESU (Plan Area)	Critical Habitat Miles (Entire ESU)
Salem District	**BLM**	178,281	80	42
	Other	2,711,622	1913	1,018
Eugene District	**BLM**	8,707	<1	0
	Other	228,444	93	79
Total	**BLM**	186,988 (6%)	80	42
	All	3,127,055*	2,086	1,139

*All includes acres in DPS outside planning area.

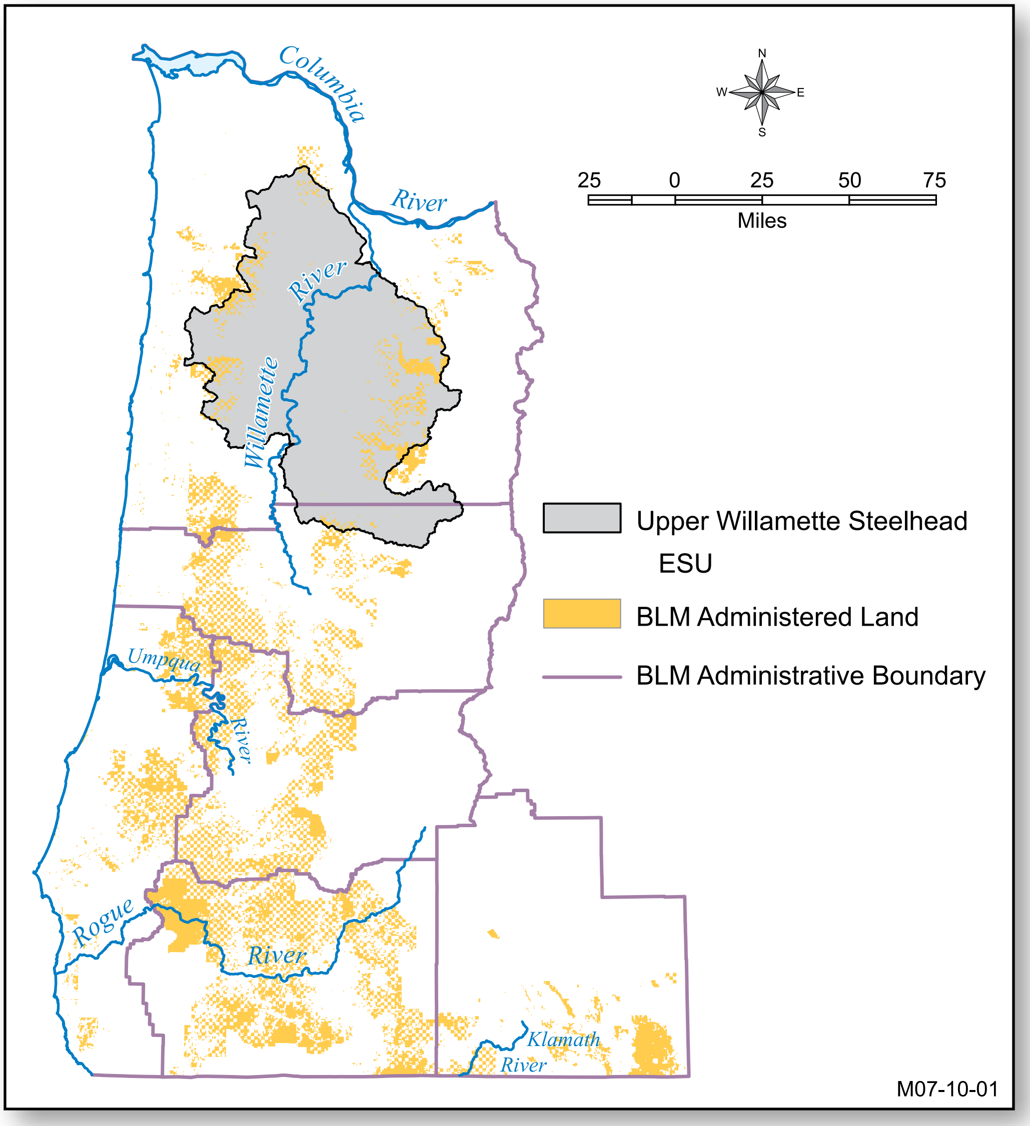


Figure J-17. Upper Willamette River Steelhead Evolutionary Significant Unit Within the Planning Area

Key Limiting Factors Identified For the Upper Willamette River Steelhead Populations

Limiting factors outside BLM's control are not listed here. The following limiting factors, and their level of threat to the Upper Willamette River DPS, were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress:

- Degraded Habitat – *Floodplain Connectivity and Function*
- Degraded Habitat – *Channel Structure and Complexity*
- Degraded Habitat – *Riparian Areas and LWD Recruitment*
- Degraded Habitat – *Stream Flow*
- Degraded Habitat – *Fish Passage*

Status of Critical Habitat

Critical habitat was designated July of 2005. There are 42 miles of critical habitat on BLM-administered lands in this DPS. See *Figure J-18 (Upper Willamette River steelhead critical habitat in entire DPS and on BLM-administered lands within the Western Oregon Plan revision area)* and *Figure J-19 (Upper Willamette River steelhead CHART streams and watersheds).*

Figure J-18. Upper Willamette River Steelhead Critical Habitat In The Entire DPS And On BLM-Administered Lands Within The Western Oregon Plan Revision Area

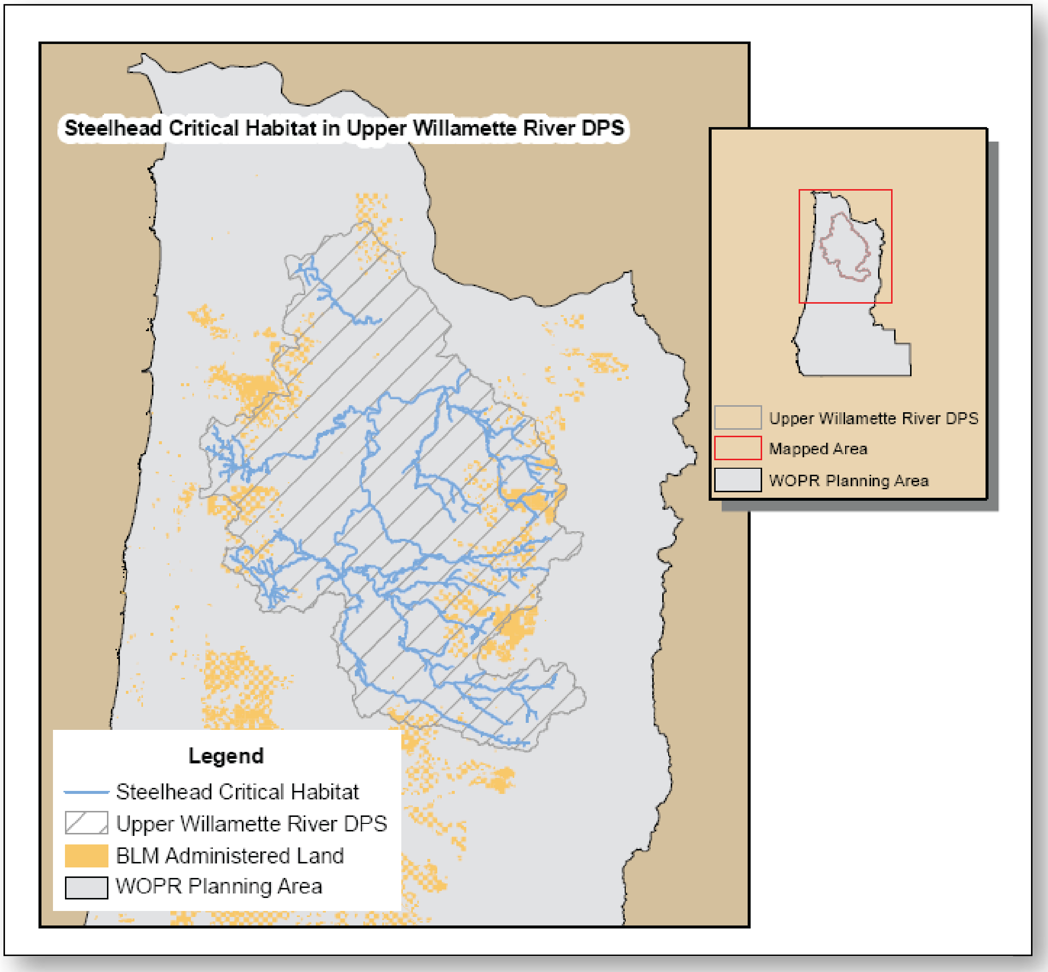
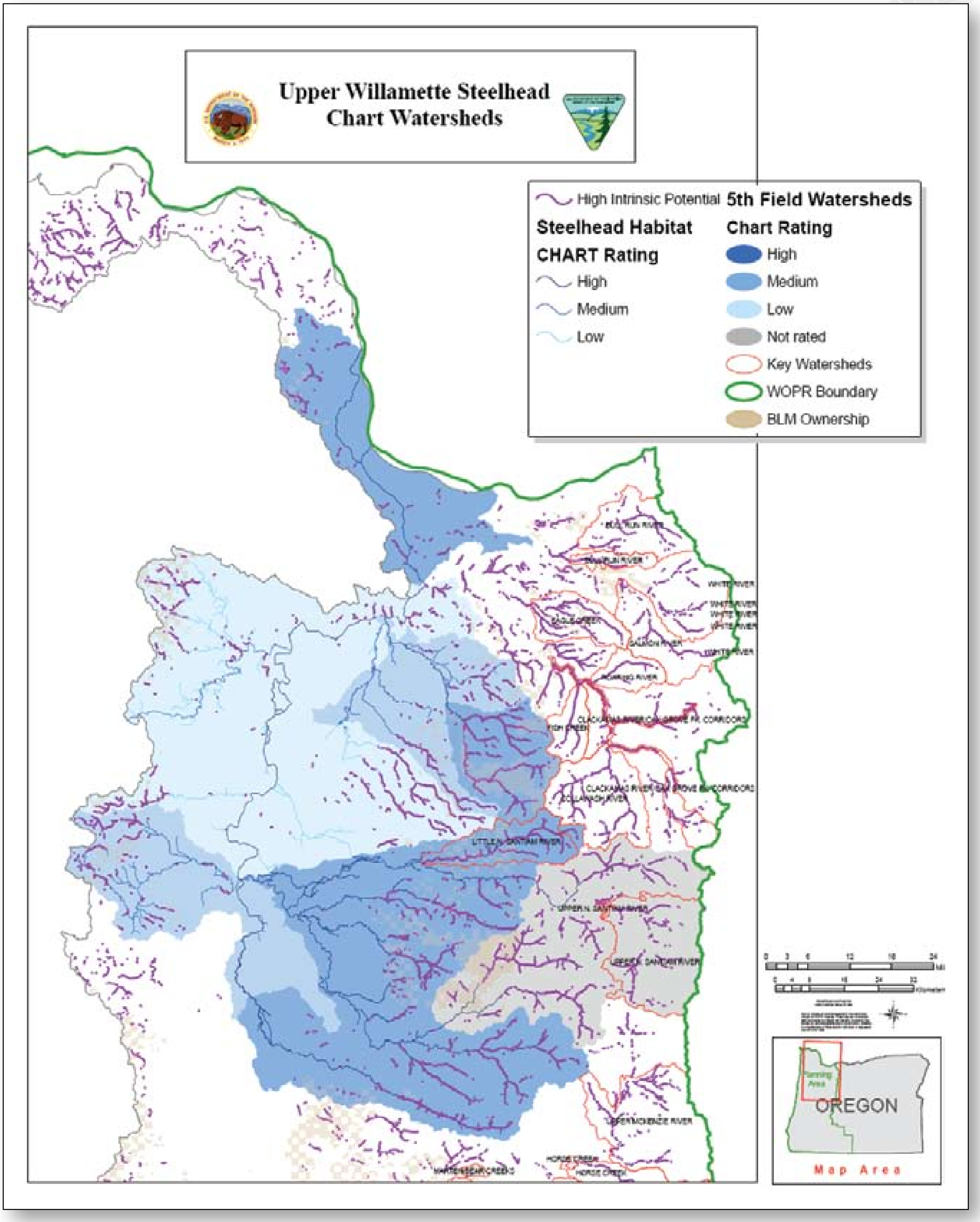


Figure J-19. Upper Willamette River Steelhead CHART Streams And Watersheds



Oregon Coast Coho Evolutionary Significant Unit

Status of the Species (Oregon Coast Conservation Plan 2007)

Life History

Coho from this ESU are present in the ocean from northern California to southern British Columbia, but the bulk of the ocean harvest of coho from this ESU would be expected to be off the Oregon coast. The vast majority of coho migrates as juveniles through estuaries to the ocean after spending one winter in freshwater and then spends two summers in the ocean before returning to spawn as 3-year old adults in the autumn and winter. Coho salmon normally spawn in relatively small tributaries with moderate to low gradient stream reaches and, as adults, return to spawning areas close to where they were hatched. Juvenile coho salmon migrate to the ocean as smolts in the spring, typically from late April, May, and early June. As smolts, coho may be present in estuaries for a period of weeks to perhaps a month during their migration to the ocean. Oregon Coast coho tend to make relatively short ocean migrations.

Populations

The Oregon Coast coho ESU includes naturally produced coho salmon in 56 populations, as defined by the National Oceanic and Atmospheric Administration (NOAA) Technical Recovery Team (Lawson et al. 2004.) Coho salmon are widely distributed in large and small Oregon Coastal river basins in this ESU and were historically well distributed in Oregon tributaries to the Columbia River. Coho were the most abundant salmon species in rivers of the Oregon Coast Coho ESU and were the most numerous species in commercial and recreational catches off the Oregon coast during the 1950s through the 1970s. Coho salmon have declined to historically low levels since the 1950s. However, returns of spawning coho to the Coast coho ESU since 2000 have been higher than decadal averages since the 1950s. This improvement is primarily related to two factors: 1) harvest related mortality in ocean fisheries has decreased from levels of over 80% to levels generally less than 15 percent, and 2) marine survival improved from the very low levels observed during the 1990s.

The Technical Recovery Team identified 56 coho populations as components of the ESU; 21 are classified as functionally or potentially independent and 35 are classified as dependent populations. See *Table J-7 (Conclusions from the 2005 Oregon Coast Coho Assessment viability analysis for Oregon Coast coho at the population, strata, and ESU level).*

Status and Distribution

The Oregon Coast Coho ESU was listed as threatened in February of 2008.

The BLM-administered land within the planning area comprises 16 percent of the ESU. There are 6,470 stream miles in this ESU occupied by the Oregon Coast Coho Salmon within the planning area, with 673 of the miles on BLM-administered land. See *Table J-8 (Distribution of Oregon Coast coho salmon in ESU and on BLM-administered lands within the planning area)* and *Figure J-20 (Oregon Coast coho salmon evolutionary significant unit within the planning area).*

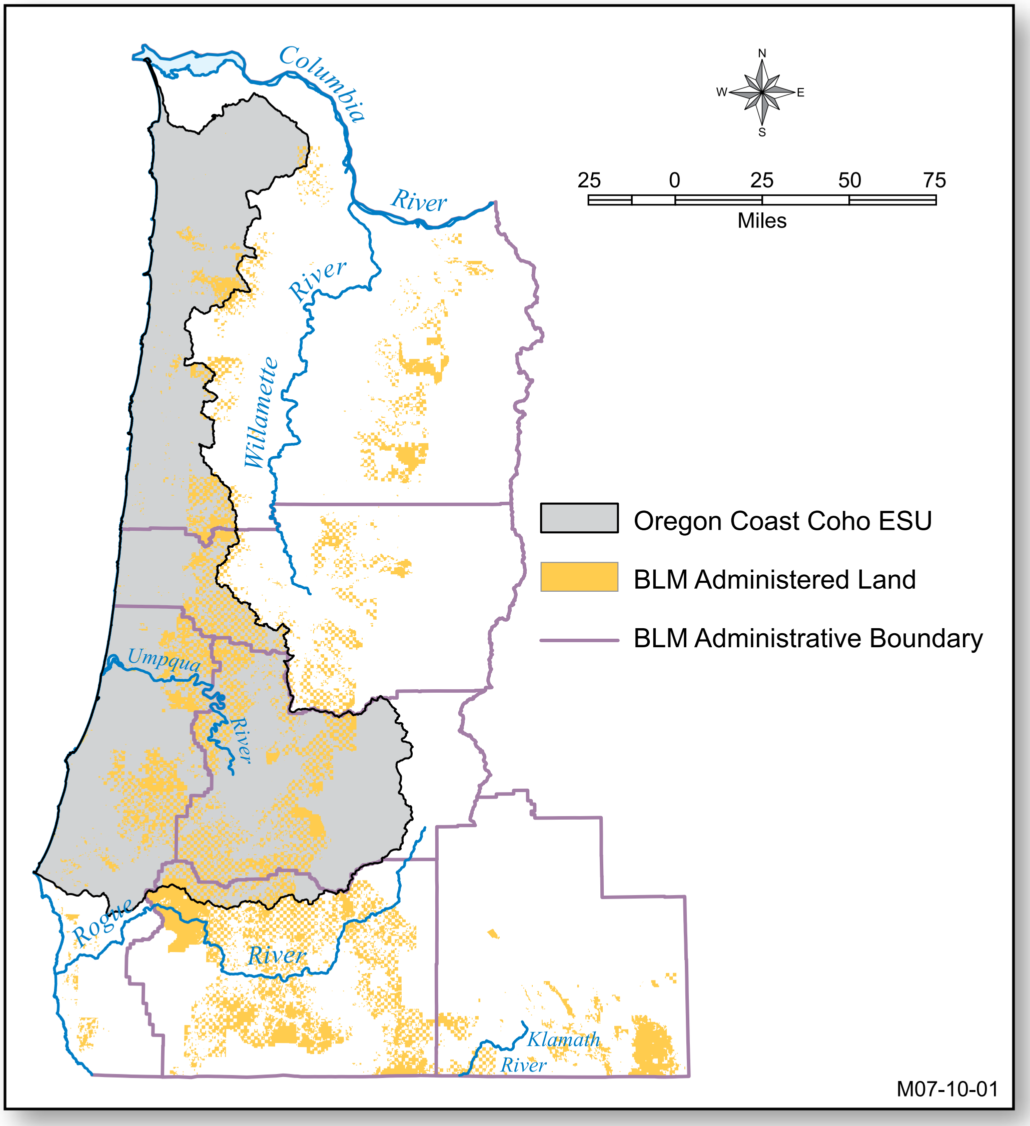
Table J-7. Conclusions From The 2005 Oregon Coast Coho Assessment Viabililty Analysis For Oregon Coast Coho At The Population, Strata, and ESU Level

ESU Criteria Conclusion	Geographic Stratum	Stratum Criteria Conclusion	Populations	Populations Criteria Conclusions
Pass	Northern	Pass	Necanicum	Pass
			Nehalem	Fail
			Tillamook	Fail
			Nestucca	Pass
	North-Central	Pass	Salmon	Fail
			Siletz	Fail
			Yaquina	Pass
			Beaver	Pass
			Alsea	Fail
			Siuslaw	Pass
	Umpqua	Pass	Lower Umpqua	Pass
			Mid Umpqua	Pass
			North Umpqua	Fail
			South Umpqua	Pass
	Lakes	Pass	Siltcoos	Pass
			Tahkenitch	Pass
			Tenmile	Pass
	South-Central	Pass	Coos	Pass
			Coquille	Pass
			Floras	Pass
			Sixes	Fail

Table J-8. Distribution of Oregon Coast Coho Salmon in ESU and on BLM-administered Lands Within the Planning Area

District and Ownership		Acres in ESU	Coho Miles in ESU (Plan Area)	Critical Habitat Miles (Entire ESU)
Salem District	BLM	151,071	80	83
	Other	1,919,642	2,288	2,354
Eugene District	BLM	137,246	139	151
	Other	468,687	679	751
Roseburg District	BLM	424,967	201	197
	Other	1,676,855	1,145	1,109
Coos Bay District	BLM	295,595	221	231
	Other	1,502,448	1,578	1,661
Medford District	BLM	82,689	32	30
	Other	133,789	107	94
Total	BLM	1,091,568 (16%)	673	693
	All	6,792,989	6,470	5,970

FIGURE J-20. OREGON COAST COHO SALMON EVOLUTIONARY SIGNIFICANT UNIT WITHIN THE PLANNING AREA



Key Limiting Factors Identified for the Oregon Coast Coho ESU

Limiting factors outside BLM's control are not listed here. The following limiting factors, and their level of threat to the Oregon Coast Coho ESU, were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress:

- stream complexity
- water quality

Status of Critical Habitat

Critical habitat was designated February of 2008. There are 693 miles of critical habitat on BLM-administered lands in this ESU. See *Figure J-21 (Oregon Coast coho critical habitat in the entire ESU and on BLM-administered lands within the Western Oregon Plan Revision area)* and *Figure J-22 (Oregon Coast coho CHART streams and watersheds).*

FIGURE J-21. OREGON COAST COHO CRITICAL HABITAT IN THE ENTIRE ESU AND ON BLM-ADMINISTERED LANDS WITHIN THE WESTERN OREGON PLAN REVISION AREA

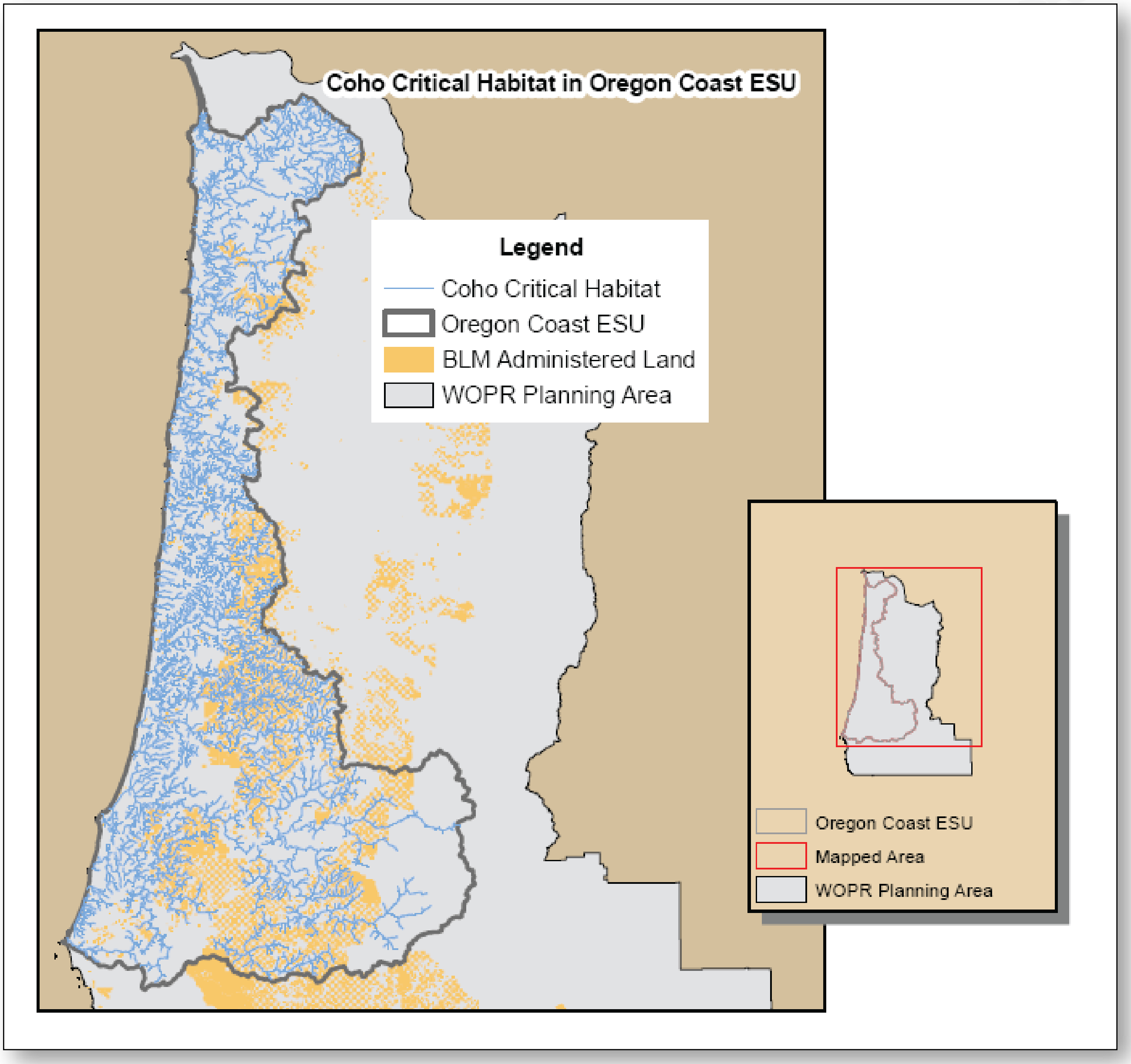
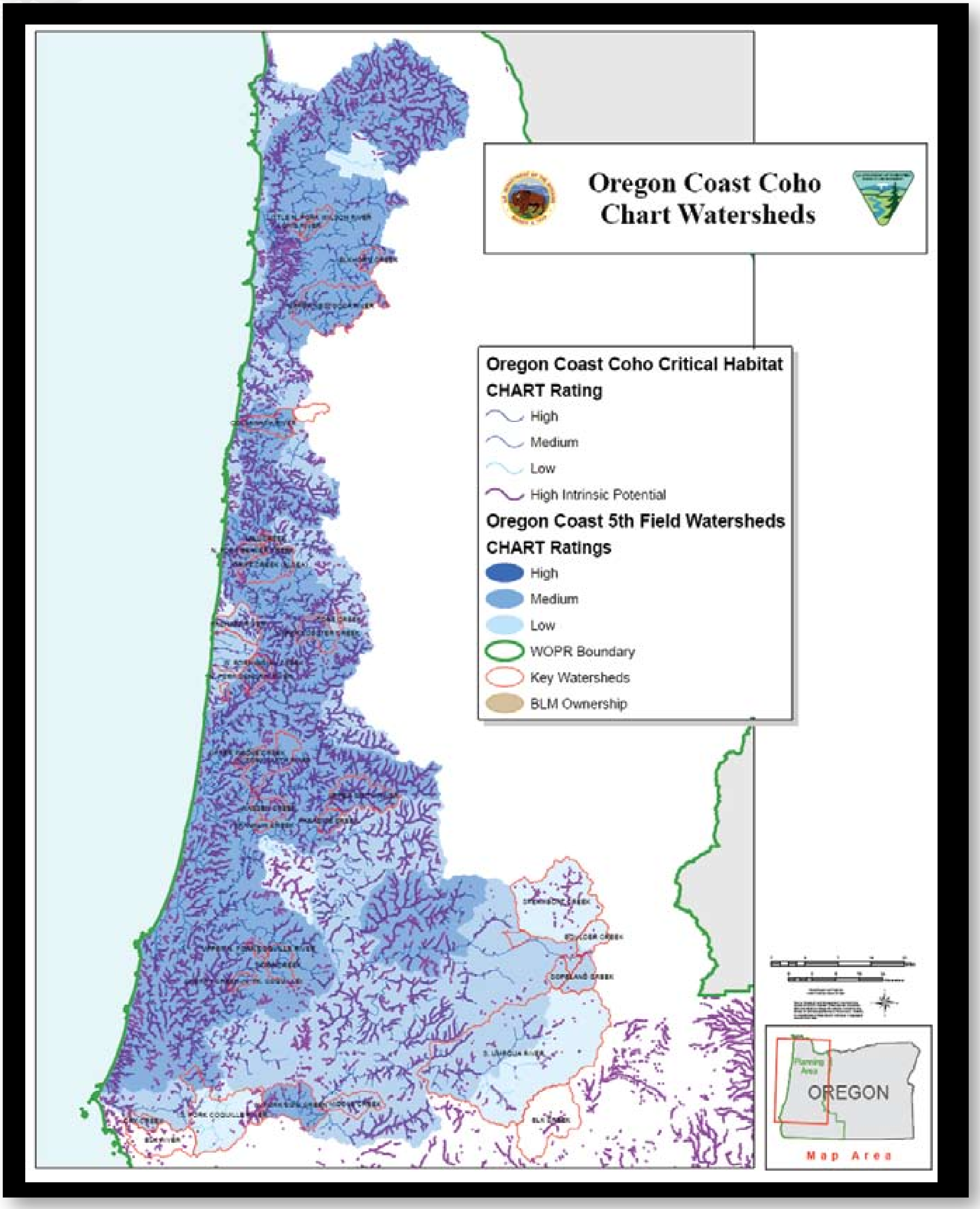


Figure J-22. Oregon Coast Coho CHART Streams and Watersheds



Southern Oregon/Northern California Coast Coho Salmon Evolutionary Significant Unit

Status of the Species

Life History

The Southern Oregon/Northern California Coast coho ESU (SONCC) includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California (62 FR 24588; May 6, 1997). The majority of coho migrates as juveniles through estuaries to the ocean after spending one winter in freshwater and then spend two summers in the ocean before returning to spawn as 3-year old adults in the autumn and winter. Coho salmon normally spawn in relatively small tributaries with moderate to low gradient stream reaches and, as adults, return to spawning areas close to where they were hatched. Juvenile coho salmon migrate to the ocean as smolts in the spring, typically from late April, May, and early June. As smolts, coho may be present in estuaries for a period of weeks to perhaps a month during their migration to the ocean.

Populations

The SONCC coho ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. Three artificial propagation programs are considered to be part of the ESU: the Cole Rivers Hatchery (Oregon Department of Fish and Wildlife (ODFW), Trinity River Hatchery, and Iron Gate Hatchery coho programs.

The estimated historical abundance of the SONCC coho ESU is 150,000. The recent mean abundance is 5,170, which is the highest such abundance since 1980. However, this estimated abundance is derived from the only reliable time series of adult abundance for the naturally spawning component of the SONCC coho ESU – the Rogue River population in southern Oregon. The California portion of the ESU is characterized by a paucity of data, with only a few available spawner indices and presence-absence surveys. Less reliable indices of spawner abundance in several California populations exist, and suggest flat or declining trends. Relatively low levels of observed presence in historically occupied coho streams (32–56 percent from 1986 to 2000) indicate continued low abundance in the California portion of this ESU.

Three rivers have hatchery populations and natural populations that are depressed throughout the range of the ESU. Although extant populations reside in all major river basins within the ESU, there are concerns about the loss of local populations in the Trinity, Klamath, and Rogue River systems. The high hatchery production in these systems may mask trends in ESU population structure and pose risks to ESU diversity. The overall ESU trend since the time of listing or first review shows that productivity has remained unchanged, and population abundance has remained unchanged.

The following are the summary of factors contributing to the decline of Southern Oregon / Northern California Coho Salmon (70 FR 37160) (factors in bold are those that BLM can influence).

- **Habitat blockages**
- Historic Flooding
- Predation
- **Water Diversion/extraction**
- Poaching
- Agriculture
- Hatchery introgression
- **Logging**
- Harvest
- **Mining**

Status and Distribution

The Southern Oregon/Northern California Coast coho salmon Evolutionarily Significant Unit was federally listed as threatened in May of 1997 by the National Marine Fisheries Service. Recovery planning for this ESU is in progress.

The BLM-administered land within the planning area comprises 6 percent of the ESU. Within the planning area, there are 1,242 stream miles in this ESU occupied by Southern Oregon/Northern California Coast coho; with 128 of the miles on BLM-administered land. See *Table J-9 (Distribution of Southern Oregon/ Northern California Coast coho salmon in ESU and on BLM-administered lands within the planning area)* and *Figure J-23 (Southern Oregon/Northern California Coast coho salmon ESU).*

Figure J-23. Southern Oregon/Northern California California Coast Coho Salmon ESU

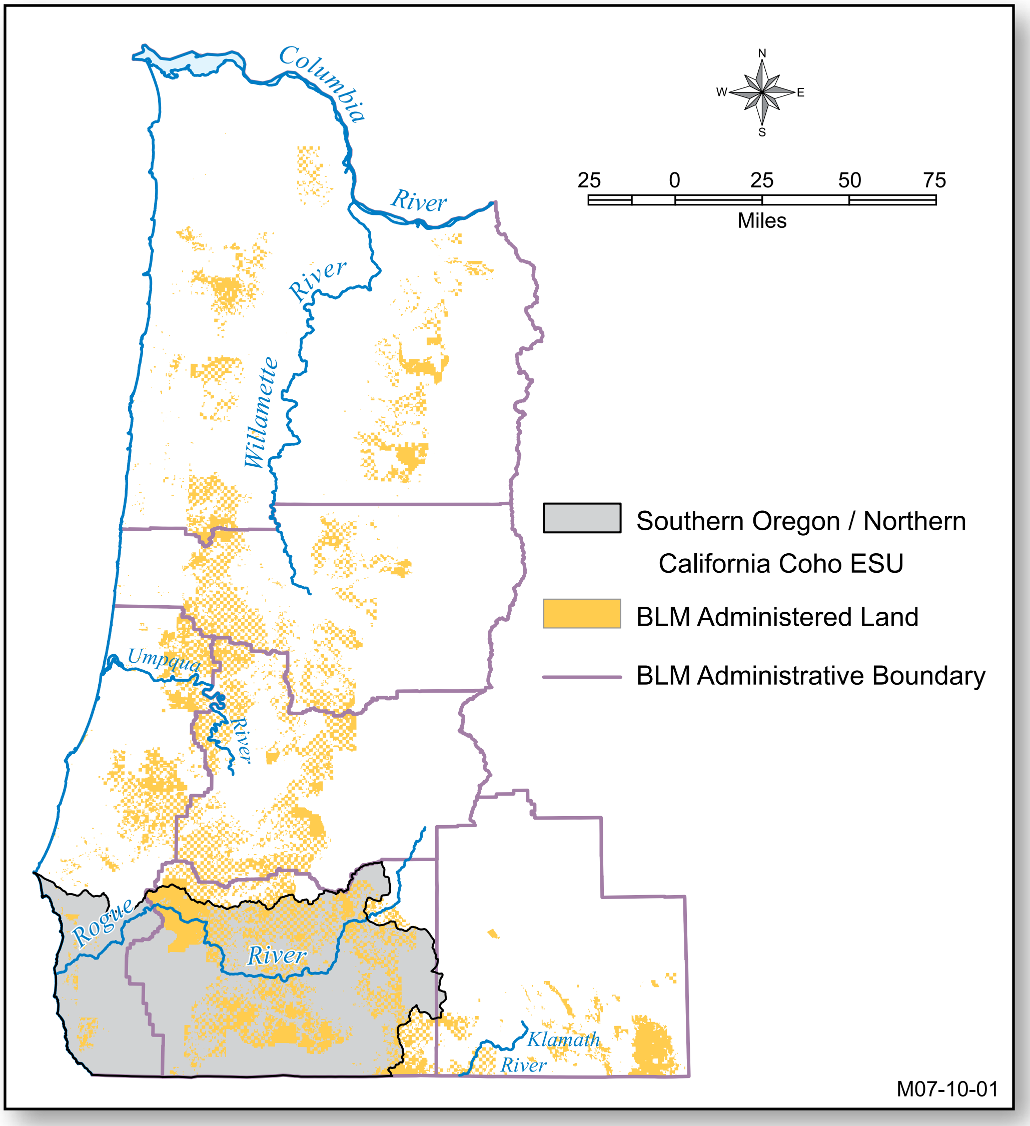


Table J-9. Distribution Of Southern Oregon/Northern California Coast Coho Salmon ESU And On BLM-Administered Lands Within The Planning Area

District and Ownership		Acres in ESU	Coho Miles in ESU (Plan Area)	Critical Habitat Miles (Entire ESU)
Roseburg District	BLM	222	0	Not Available
	Other	561	0	Not Available
Coos Bay District	BLM	26,622	2	Not Available
	Other	788,370	316	Not Available
Medford District	BLM	706,610	126	Not Available
	Other	1,847,492	926	Not Available
Klamath Falls Resource Area	BLM	838	0	Not Available
	Other	12,020	0	Not Available
Total	BLM	734,292 (6%)	128	Not Available
	All	11,538,731	1,242	Not Available

Key Limiting Factors Identified For the Southern Oregon / Northern California Coho ESU (NOAA SW Regional Office 2008)

Limiting factors outside BLM's control are not listed here. The following limiting factors, and their level of threat to the Oregon Coastal Coho ESU, were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress:

- Degraded Habitat - *Floodplain Connectivity & Function*
- Degraded Habitat - *Channel Structure & Complex*ity
- Degraded Habitat - *Riparian Areas & Large Woody Debris Recruitment*
- Degraded Habitat - *Stream Substrate*
- Degraded Habitat - *Stream Flow*
- Degraded Habitat - *Water Quality*
- Degraded Habitat - *Fish Passage*

Status of Critical Habitat

Critical habitat was designated in May 1999. Critical habitat for this ESU includes all waterways, substrate, and adjacent riparian zones below longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). The GIS data is not available for critical habitat distribution in this ESU.

Shortnose and Lost River Suckers

Status of Species (USFWS 1993)

Life History

Lost River and shortnose suckers are large, long-lived and omnivorous suckers that generally spawn in rivers or streams and then return to the lake. Both sucker species have a limited geographic range, and are endemic to the Upper Klamath Basin of Northern California and Southern Oregon. However, both species have separate populations that spawn near springs in Upper Klamath Lake. Lost River suckers from Upper Klamath Lake can be up to 43 years old. Lost River suckers are one of the largest sucker species and may obtain a length of up to 1 meter in total length. Sexual maturity for suckers in Upper Klamath Lake occurs between the ages of 6 to 14 years, with most maturing at age 9, with most growth in Upper Klamath Lake occurring mainly during the first 8 to 10 years of life. Both species of suckers are lake dwelling but spawn in tributary streams or springs. For stream spawning populations, shortnose and Lost River suckers begin their spawning migration into the Williamson and Sprague Rivers in late March or early April, with spawning activity often continuing well into May. Larval Lost River and shortnose suckers usually spend relatively little time in tributary streams and migrate back to the lake shortly after swim up.

Populations

Early records indicate that Lost River and Shortnose suckers were once widespread and abundant in the upper Klamath Basin of Oregon and California (USFWS website). Currently, the Lost River sucker occupies only a fraction of its former range and is restricted to a few areas in the Upper Klamath Basin, such as the drainages of Upper Klamath Lake, Tule Lake, and Clear Lake (USFWS website).

Declining population trends for both species were noted as early as the mid-1960s, but the severity of the population declines was not evident until the early 1980s. The adult sucker monitoring program (USGS) information on the current status of sucker populations in the Upper Klamath Basin indicates there has been no significant recruitment into the adult population in the last few years (USGS).

Status and Distribution

The Lost River and Shortnose Suckers were federally listed as endangered July of 1988 by the U.S. Fish and Wildlife Service. Recovery Plans for these fish species were completed in March of 1993. Critical habitat was proposed in 1994 (Federal Register 59:61744).

Section 4(c)(2)(A) of the Endangered Species Act requires a review of listed species at least once every 5 years. The U.S. Fish and Wildlife Service completed a comprehensive review of the Lost River sucker and the shortnose sucker in 2007 (USFWS 2007). After completing the five-year status review, the U.S. Fish and Wildlife Service found the Lost River Sucker not in immediate danger of extinction because populations have persisted and stabilized following mortality events and because significant habitat restoration efforts have been completed and are planned for the future. Additionally, because a reproducing population of Lost River Suckers is also found in Clear Lake, the U.S. Fish and Wildlife Service believes this population redundancy further reduces the imminence of extinction. While the U.S. Fish and Wildlife Service does not believe Lost River Sucker is currently at imminent risk of extinction, the U.S. Fish and Wildlife Service does believe that Lost River Suckers are at risk of becoming endangered within the foreseeable future due to the continuing threat of water quality related die-offs in Upper Klamath Lake. According to the Endangered Species Act, a threatened species means “any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” This definition most accurately describes the current status of the Lost River Suckers; therefore, the U.S. Fish and Wildlife Service recommended that Lost River Sucker be down-listed to threatened. However, since the 5-year review was completed the U.S. Fish and Wildlife Service has not taken any final agency action (i.e., Federal Register Notice) that downgrades the listing to "threatened."

The final rule listing the Lost River and Shortnose suckers as endangered species included the following factors for their decline (Federal Register 53:27130-27134) (factors in bold are those that BLM can influence):

- damming of rivers
- dredging and draining of marshes
- water diversions
- hybridization, competition and predation by exotic species
- Insularization of habitat
- **water quality problems associated with timber harvest, removal of riparian vegetation, livestock grazing, and agricultural practices** (A shift toward hyper-eutrophication in Upper Klamath Lake has been documented (Miller and Tash 1967, Vincent 1968) and is considered by the Service to be a probable cause for the decline of Lost River and shortnose suckers and a major limiting factor in recovery of the species (USDI 1993). Tule Lake, lower portions of the Lost River, Lake Ewauna, and the upper Klamath River also have severe water quality problems associated with hypereutrophication. Over-harvest and chemical contamination also may have contributed to the decline (USDI 1993).

The BLM-administered land within the planning area comprises 1% of the range. There are 225 stream miles occupied by the Lost River Sucker; with 10 of the miles on BLM-administered land**.** There are 303 miles occupied by the Shortnose sucker; with 50 of the miles on BLM-administered land. See *Table J-10 (Distribution of Lost River and Shortnose Suckers on BLM-administered lands within the planning area)* and *Figure J-24 (Fifth-field watersheds in the range of Lost River and Shortnose Suckers within the Western Oregon Plan Revision area*).

Status of Critical Habitat

Critical habitat was proposed in 1994, but not finalized.

Conservation Measures and Recovery

The interim objective is to establish at least one stable refugial population with a minimum of 500 adult fish for each unique stock of both Lost River and shortnose suckers (USDI 1993). A list of recovery "tasks" for BLM administered-lands are included in the recovery plan. See *Table J-11* (*Recovery "tasks" listed in the sucker recovery plan for BLM [USDI 1993]).*

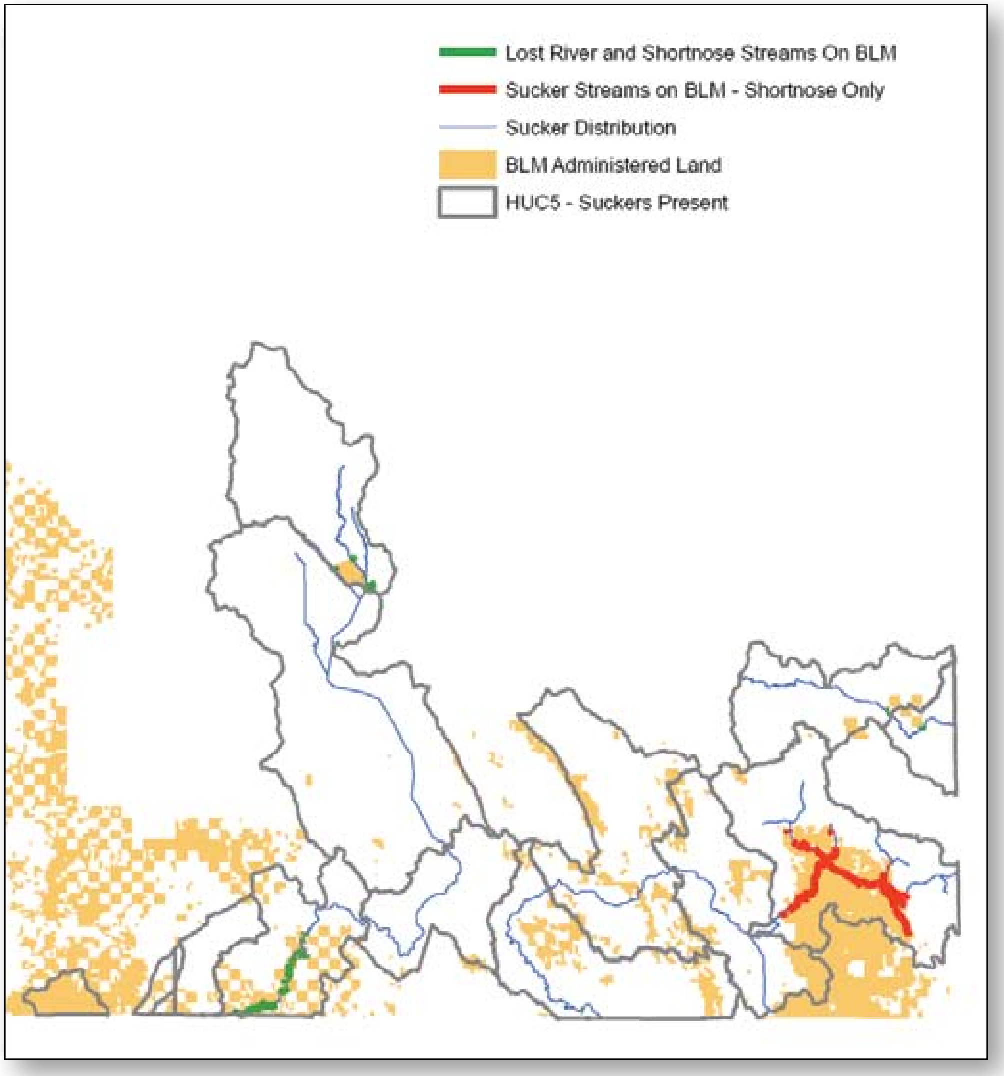
Table J-10. Distribution Of Lost River And Shortnose Suckers On BLM-Administered Lands Within The Planning Area

District and Ownership		Acres in Range of the Species	Lost River Sucker Miles in the Planning Area	Shortnose Sucker Miles in the Planning Area
Medford District	**BLM**	14,632	0	0
	Other	6,296	0	0
Klamath Falls Resource Area	**BLM**	145,246	10	50
	Other	1,058,990	215	253
Total	**BLM**	159,878 (1%)	10	50
	All	11,225,164	225	303

Table J-11. Recovery "Tasks" Listed In The Sucker Recovery Plan For BLM

	BLM Recovery Tasks for the Suckers
1.	Determine distribution and abundance of suckers in Gerber Reservoir and small reservoirs in the Lost River system.
2.	Determine habitat requirements of suckers in Upper Klamath Lake.
3.	Develop and implement a plan to monitor habitat and water quality conditions for all populations.
4.	Identify and secure riparian land parcels for rehabilitation.
5.	Develop and implement riparian management unit rehabilitation plans.
6.	Identify land parcels for wetland rehabilitation.
7.	Secure, develop and implement areas for pilot wetland rehabilitation projects.
8.	Develop and implement a long-term plan for wetland rehabilitation.
9.	Develop and implement a plan to reduce impacts of otter upland management practices such as forestry, grazing, and farming.
10.	Investigate alternative ways to balance water demands for Clear Lake.
11.	Develop and implement a plan to secure adequate water levels and flows for stable sucker populations in Clear Lake.

Figure J-24. Fifth-Field Watersheds In The Range Of Lost River And Shortnose Suckers Within The Western Oregon Plan Revision Area



Bull Trout

Status of the Species (USFWS 2002)

In the planning area, there are seven miles of bull trout on BLM-administered lands in the Lower McKenzie River fifth-field watershed of the Eugene District BLM. There are no bull trout streams on BLM-administered land in any other bull trout DPS (or District) within the planning area.

Life History

Bull trout have more specific habitat requirements than most other salmonids. Bull trout are found in colder streams and require colder water than most other salmonids for incubation, juvenile rearing, and spawning. Spawning and rearing areas are often associated with cold-water springs, groundwater infiltration, and/or the coldest streams in a watershed. Bull trout exhibit both resident and migratory life-history strategies. Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. Migratory bull trout spawn in tributary streams where juvenile fish rear one to four years before migrating to either a lake (afluvial form), river (fluvial form) or in certain coastal areas, to saltwater (anadromous). Resident and migratory forms may be found together, and either form may give rise to offspring exhibiting either resident or migratory behavior. The size and age of bull trout at maturity depends upon life-history strategy. Resident fish tend to be smaller than migratory fish at maturity and produce fewer eggs. Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. Repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented.

Populations

Bull trout are native throughout the Pacific Northwest. In Oregon, bull trout were historically found in the Willamette River and major tributaries on the west side of the Oregon Cascades, the Columbia and Snake Rivers and major tributaries east of the Cascades, and in streams of the Klamath basin. Currently, most bull trout populations are confined to headwater areas of tributaries to the Columbia, Snake, and Klamath rivers. In the Columbia River Basin, bull trout historically were found in about 60 percent of the basin. They now occur in less than half of their historic range. Populations remain in portions of Oregon, Washington, Idaho, Montana and Nevada.

Status and Distribution

The Bull Trout (Columbia River) Distinct Population Segment was federally listed as threatened in June of 1998 by the U.S. Fish and Wildlife Service. Critical habitat has not been designated on federal lands. A draft recovery plan was completed in October of 2002. The Klamath DPS also occurs in the planning area; however, there are no occupied stream miles on BLM-administered lands.

While bull trout occur over a large area, their distribution and abundance has declined and several local extinctions have been documented. Many of the remaining populations are small and isolated from each other, making them more susceptible to local extinctions.

The BLM-administered land within the planning area comprises 3.3% of the DPS's. There are 606 stream miles in the DPS occupied by the bull trout; with 7 of the miles on BLM-administered land. See *Table J-12 (Distribution of Bull Trout in DPS and on BLM-administered lands within the planning area)* and *Figure J-25* (*Bull trout distribution on BLM-administered lands within the Western Oregon Plan Revision area).* All of the bull trout stream miles on BLM-administered lands occur within the Lower McKenzie River fifth-field watershed. There are 165,080 acres in the watershed; of which 25,891(16%) acres are on BLM-administered lands.

Table J-12. Distribution Of Bull Trout In The DPS And On BLM-Administered Lands In The Planning Area

District and Ownership		Acres in DPS	Acres in Lower McKenzie River Watershed	Bull Trout Miles in DPS (Plan Area)
Eugene District	BLM	53,277	25,981	7
	Other	1,545,637	139,099	269
Total	BLM	53,277 (3.3%)	25,981	7
	All	1,545,637	165,080	606

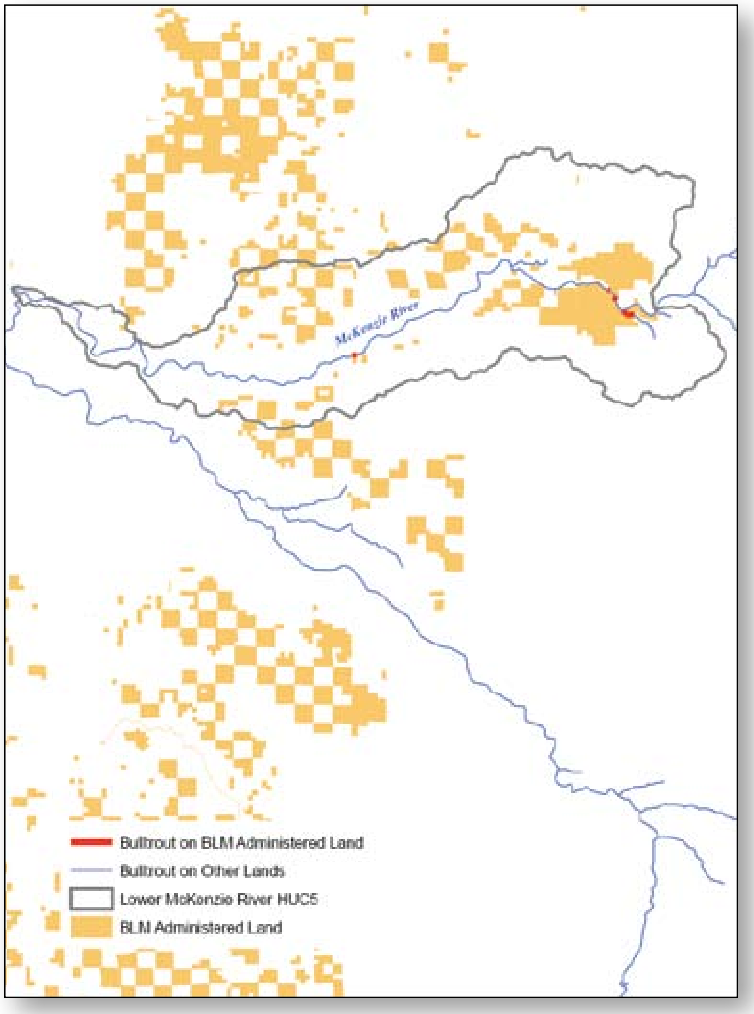


Figure J-25. Bull Trout Distribution On BLM-Administered Lands Within The Western Oregon Plan Revision Area

Conservations Measures and Recovery

The Willamette River Recovery Unit is the only recovery unit within the planning area where bull trout occur on BLM-administered lands.

Five management components were identified for bull trout conservation on federal lands for planning, designing, and implementing management actions within bull trout recovery units (USDI 2002). According to the recovery plan, federal land management agencies should consider these five components when analyzing potential effects of their plans or actions on bull trout (USDI 2002).

A list of recovery "tasks" for BLM administered-lands are included in each of the Recovery Plan Units. See *Table J-13* (*Recovery plan conservation measures for bull trout).*

Table J-13. Recovery Plan Conservation Measures For Bull Trout

BLM Recovery Task For Willamette Recovery Unit
1. Coordinate bull trout recovery monitoring in the Willamette River basin with the monitoring program for the Oregon Plan for Salmon and Watersheds.
2. Participate in efforts by local and regional (basin-wide) watershed groups and others to accomplish site-specific protection and restoration activities.
Source: USDI 2002

Oregon Chub

Oregon chub are endemic to the Willamette River Valley of western Oregon. Although information is scarce, historically, the Oregon chub likely existed throughout the lower elevations of the Willamette River valley. The current distribution is limited to approximately 20 naturally occurring populations and four reintroduced populations (Santiam River, Middle Fork Willamette River, Coast Fork Willamette River, McKenzie River, and several tributaries to the Main stem Willamette River downstream of the Coast Fork/Middle Fork confluence). Almost all of the populations are small and isolated and do not occur on BLM-administered lands within the WOPR planning area.

Recovery Planning

Draft recovery plans for the Willamette/Lower Columbia River chinook, coho, chum, and steelhead are currently available on the National Marine Fisheries Service website. Recovery plans for Lost River and Shortnose suckers are available on the U. S. Fish and Wildlife Service website.

Modeling

Wood Delivery Model

Introduction

The large wood delivery model is a spatially explicit, Geographic Information System-based wood recruitment model developed for this analysis to determine the potential large wood contribution to fish-bearing streams from BLM-administered lands. The potential wood contribution is determined to all streams over entire channel networks, including wood recruitment processes for channel-adjacent tree fall, mass wasting, and channel migration. Model inputs are digital elevation and forest cover, with detailed forest stand tables specifying stem density, size, and mortality rates for each size class in each stand type. Outputs are calculated wood recruitment rates to each delineated stream reach and rates of wood supply to channels from each DEM cell. Calculated rates are referenced to input stand characteristics and represent the mean annual wood contribution to channels from the specified conditions over time. For each given spatial distributions of stand types, the outputs are summarized to compare wood recruitment by different processes, pieces and stream size, ownership, and scales, under different management scenarios.

Assumptions and Methods

See the *Fisheries Planning Criteria* in this appendix for detailed information about assumptions and methodology.

Source Data for Modeling

See the *Fisheries Planning Criteria* in this appendix for detailed information about analysis steps and the source data used in the modeling.

General Description of Methodology

This model is used to evaluate the relative effect of different management alternatives on aquatic habitat was to examine potential differences in the rate of wood recruitment to stream channels among the alternatives considered. Wood comes to streams via a variety of processes (Bilby and Bisson 1998) with rates that vary in space and time. Three processes were evaluated:

- trees in riparian areas that die and fall into streams (e.g., Sobota et al. 2006)
- wood carried by landslides and debris flows to streams (e.g., Reeves et al. 2003)
- trees that fall into streams because of bank erosion and channel migration (Latterell and Naiman 2007)

Several factors govern the rate at which wood is supplied to channels by each of these processes. Of primary importance are the number and size of trees available for recruitment to the channel. The spatial distribution of stand types determines in large part the rate at which wood inputs to the channel will occur, and changes in stand characteristics over time determine the degree to which recruitment rate changes over time. Hence, modeled wood recruitment rates depend explicitly on outputs from the OPTIONS scheduling model and the ORGANON stand growth model that OPTIONS uses.

The OPTIONS output files for the wood delivery model contains the WPR_ID for every resultant GIS polygon for each alternative. The OPTIONS output files for the wood delivery model were derived from State of Forest (SOF run at 5-year intervals along with and Activity and Volume files for the duration of the run. From these files, treatment activity and harvest history were tracked for each WPR_ID (management polygon). For each WPR_ID the stand attributes over time were extracted from an Index Lookup Table containing OGRANON Stand Table information. An Index Lookup Table was compiled from ORGANON Guide and Treatment Curves. This table contains the ORGANON summary of stand-level information for All Possible Treatments. These data include live and dead tree statistics, harvested TPA (trees per acre) and average height by 1-inch diameter class split into conifer and hardwood groupings. Entries were complied for all possible combinations of commercial harvest entries. These All Possible Treatments are the potential combinations of OPTIONS modeled commercial harvest entries. For example, a particular Species Group and Productivity Class modeled to potentially receive 2 CTs (Commercial Thinnings) will have five different treatment combinations:

- No harvest modeled
- No CTs, RH (Regeneration Harvest) only
- First CT only with RH
- Second CT only with RH
- First and Second CTs with RH

The wood delivery model input data is generated based on the OPTIONS output files. For each WPR_ID, the activity history is derived and the corresponding 'all treatment' curve is identified. Structure Stage is calculated, the latest treatment is stored within the report and, based on the age of the WPR_ID at the corresponding 5yr interval, the stand parameters are looked up from the Index Lookup Table and also saved within the wood delivery model report. The OPTIONS model uses stand attributes derived from the FOI (Forest Operations Inventory) and the CVS inventory along with stand-level growth and management projections developed with the ORGANON model. The OPTIONS output files for the wood delivery model report derives the activity history for each individual WPR_ID. With this, the appropriate “All Possible Treatments” curve was identified from a crosswalk table. Then, based on the age of the WPR_ID, the corresponding 5-year interval was selected for that curve from the Index Lookup Table and the ORGANON-derived stand parameters were added to the report. The Stand Structure was calculated for the stand at that point in time, and that along with the latest OPTIONS treatment are saved within the Wood Delivery Model Report for each WPR_ID for every 5-year report interval.

Topography also poses a primary control on wood recruitment rates, particularly for landslide and debris-flow recruitment. Basin topography determines the locations where different recruitment processes occur and so affects the spatial pattern of recruitment rates. Because topography (in our model) does not change over time, it has no effect on temporal changes in recruitment rate. The wood delivery model focused on recruitment, not on in-stream wood abundance. The two are intimately related, because the amount of wood in a stream system depends on the accumulation of recruited wood over time, minus wood lost to decay. Several factors complicate estimates of wood abundance. Because wood can persist in a stream for many years, wood abundance depends explicitly on the temporal sequence of recruitment events. Moreover, wood can be carried downstream and redeposited by fluvial processes. The sequence of storms, which drive recruitment events, and floods, which redistribute wood, can create large temporal and spatial variability in wood abundances within a channel system (Benda et al. 2003). To avoid these complicating factors, and to greatly simplify the modeling tasks, the model focused solely on estimating recruitment rates for a specified spatial distribution of stand types, and did not attempt to model wood abundances over time and space. Changes in estimated recruitment rates among alternatives provide one metric to assess the relative influence of different management alternatives on aquatic habitat.

For all of the modeled processes, wood inputs are associated with distinct events, with potentially long intervals with little or no wood recruitment. A frequency distribution of recruitment rates (e.g., in number of pieces per year) for any specified portion of a channel network is highly skewed, with little or no inputs most of the time, and large inputs some of the time (Benda et al. 2003). The mean of this frequency distribution is determined to apply as a measure of wood recruitment potential. Mean recruitment rate provides a measure to assess differences in recruitment potential for the different spatial distribution of stand characteristics predicted with the OPTIONS model under each of the proposed management alternatives. However, differences in mean recruitment rate between processes can be difficult to interpret, because of differences in the frequency distribution of recruitment events. Wind and rain may cause dead or dying trees in riparian zones to topple, so that storms may trigger wood inputs to a stream reach from riparian zones every few years to decades; landslides or debris flows may deposit wood in a reach only every few centuries (May and Gresswell 2004). The relationship between mean recruitment rate and the frequency of recruitment events can differ dramatically between processes. Likewise, the volume of wood delivered in a single recruitment event may differ dramatically between recruitment processes. These differences in the frequency of occurrence, and the volume of wood involved with a single occurrence, hinder direct comparison of recruitment rates among processes. Hence, differences in mean recruitment rate between alternatives must be evaluated independently for each modeled process.

Different algorithms and data are required for each recruitment process. To estimate inputs from mortality of riparian trees, the following were determined:

- The number and location of dead or dying trees that may fall. These are estimated from the outputs of the ORGANON stand growth model used by OPTIONS. For each stand type, a tree list is used that provides the density (in stems per acre) of trees that have died (over a five-year time step) by species (conifer and hardwood) and size (diameter) class. It was assumed that all dead trees fall during the next time step
- The slope gradient at each tree location (trees on steeper slopes are more likely to fall in a downslope direction than trees on less steep slopes). This is calculated from the 10-m DEM.
- The location of falling trees relative to the channel edge. Channel-edge locations are based on channel centerlines traced using flow-paths derived from the DEM, with channel width estimated using regional regressions to drainage area (Castro and Jackson 2001, Clarke et al. 2008).
- The probability that a falling tree intersects the channel. This probability is derived from an empirical probability density function for fall direction (Sobota et al. 2006) together with the location of all channel edges within a distance less than or equal to the tree height.
- The diameter of the tree bole where it intersects the channel. Tree boles were approximated as a cone, with a diameter-at-breast-height (using a breast height of 1.4 meters) based on the size class for the tree (from the tree lists) tapering linearly to zero at the tree height.

The digital elevation model (DEM) is used as a spatial reference. Streams are traced from the DEM (Clarke et al. 2008) and stand-type polygons are referenced to DEM cell boundaries. Channel-edge segments are defined where traced channel edges (centerline plus a buffer of one half the estimated channel width) cross DEM cells. For each channel segment, DEM point is found within a tree height of the segment to calculate the probability that: a) a tree within that stand is dead (and ready to fall), and b) if a tree at that point falls, it hits the channel segment.

This calculation is repeated for every DEM point and integrated to the probabilities over all DEM cells. This gives the probability that a tree falls into the channel segment. This is repeated for all channel segments and for all tree species and size classes, summing results by piece-size classes for each segment. This procedure provides the annual probability for wood recruitment from each DEM cell and the annual probability of recruitment to each channel segment. These probabilities are interpreted as average rates. For example, if the calculated annual probability for input of wood to a reach is 0.1, it is interpreted as a recurrence interval of 10 years; that is, one piece every ten years, or an average rate of 0.1 pieces per year. The results are then summed over specified sets of reaches (e.g., all BLM-owned, fish-bearing reaches in a fifth-field hydrologic-unit-code basin).

To estimate wood inputs from debris flows, the following were determined:

- The locations of potential debris flow tracks, and the recurrence interval for debris flows that traverse each track. Debris-flow locations were estimated using empirical topographically driven models (Miller and Burnett 2007, 2008) calibrated to landslide data from throughout the plan area and to debris-flow tracks mapped by the Oregon Department of Forestry following the large 1996 storms (Robison et al. 1999). Recurrence intervals are based on data for low-order channels in the Coast Range reported by May and Gresswell (2004), who estimate a recurrence interval for debris flows to ~3rd order channels of about 350 years.
- The number of live and dead trees available along the debris-flow track. These values are obtained from the tree lists output by OPTIONS. The DBH of each tree is used as the diameter for the recruited piece of wood.
- The number of pieces contributed (per year) by dead trees from adjacent areas falling into the track. This number is estimated using the same procedure described above for riparian recruitment to stream channels.
- The probability for debris flow scour and deposition along each potential track, based on data from the 1996 storm study (Miller and Burnett 2008, Robison et al. 1999).
- The average width of a debris-flow track, set to 6 meters based on data in Robison et al. (1999).

To estimate the number of pieces of wood carried to a stream channel by a potential debris flow, the number of trees available along the track within each DEM cell traversed by the track is summed, and multiplied by the probability that a debris flow will traverse the cell. If the stem density for the stand indicates (on average) 10 trees per 10-meter DEM cell, 6 of these will be incorporated into a 6-meter-wide debris flow. If the estimated recurrence interval for a debris flow to traverse the cell is 500 years, that gives 6 trees recruited (into the debris flow) every 500 years, or 0.012 trees per year. These values along all potential debris flow tracks are summed. To estimate the proportion of the accumulated wood that is deposited (on average, for all the debris flows that may traverse each cell), the proportional downslope decrease is determined in debris flow probability. If the probability decreases by 1% from one cell to the next, 1% of the accumulated wood is left in the cell.

In some cases, a large proportion of the wood carried by debris flows is not from the current stand, but has been excavated from wood deposited in previous debris-flow deposits (May 2002). To estimate debris-flow recruitment rate from a specified spatial distribution of stand types, it is important to account for the incorporation of wood from this stand into future debris flows. This is an estimated probability that a debris flow encounters wood deposited from a previous debris flow based on the recurrence interval. The probability that a future debris flow encounters a deposit containing wood from this stand is estimated as one minus the probability that no debris flows had occurred over the recurrence interval for debris flows to that cell, i.e., $1 – (1\text{-}1/R)^R$, where R is the recurrence interval in years. For values of R exceeding 100 years, this equation has a nearly constant value of 0.63; hence, we estimate a 63% probability (on average) that a future debris flow will encounter wood from this year's forest stands. However, over recurrence intervals of this length, any wood that is not buried in the deposit will likely be completely decayed. Benda and Dunne (1997) estimate from field observations that approximately 70% of debris-flow deposit volume resides in fans and terraces; hence we assume that 70% of the available wood is buried in these fans and terraces. This argument suggests that about 44% (0.63*0.7) of the deposited wood is available to future debris flows.

The modeling provides an estimate of the rate at which wood from the specified forest stands may be carried by debris flows to stream channels. The resulting value is a function of estimated debris flow recurrence intervals and wood availability. The model calibration accounts for regional differences in topographic controls on landslide susceptibility, but not for climatically and geologically controlled differences in landslide rate. Likewise, the debris-flow runout model is calibrated only to data from the Siuslaw basin in the Coast Range province (Miller and Burnett 2008). Hence, differences in basin- or region-wide average debris-flow recruitment rates reflect differences in topography and, primarily, differences in modeled stem density. Because there is no data to reliably estimate regional differences in average landslide rate, the calculated debris-flow wood recruitment rates undoubtedly suffer systematic errors that differ from province to province. However, because the errors are systematic, relative differences calculated for debris-flow recruitment rate between alternatives is indicative of the relative difference in actual recruitment rates. Therefore, these procedures provide a reliable measure of the relative difference in debris-flow wood recruitment between management alternatives, but the magnitude of these rates cannot be reliably compared to the magnitude calculated for other recruitment processes, or between regions.

Observational evidence indicates that landslide rate and the extent of debris flow runout vary with forest stand characteristics (Miller and Burnett 2007, 2008). For simplicity and to reduce modeling uncertainty, the debris flow probabilities in the analysis were modeled using a uniform non-forested land cover, with the resulting probability values multiplied by a constant value to give an average 350-year recurrence interval for debris flows to 3rd order channels for the basins studied by May and Gresswell (2004). This approach removed the effects of management on modeled debris flow probability, so that differences in calculated wood recruitment rates between alternatives and over time solely reflect differences in the amount of wood available to debris flows. Depending on the modeling approach and landslide inventory data source, the effects of forest-cover vary; which is why a uniform non-forested land cover was used to compare alternatives based on wood availability.

However, this strategy masks the effects of management on landslide potential. Therefore, these effects are modeled for three watersheds in the plan area to demonstrate the influence of forest-cover over time on landslide susceptibility. The potential wood contribution is shown using two different landslide data sets to demonstrate the variability of results for each data set used.

The magnitude of modeled wood recruitment rates vary between different landslide models. It is likely that every data set would give somewhat different results since the relative landslide rates would depend on the sequence of storms. For this, two data sets are used to show the both the variance between models and the effects of forest-cover on landslide susceptibility over time. The first data set is based on air photo landslide inventories over the entire WOPR planning area (Model 1). The second data set is based on the landslide inventory that was collected by the Siuslaw National Forest following the 1996 storm. The modeled recruitment rates were “normalized” by dividing all values by the results under the No Harvesting reference analysis at 2006. The results show how the predicted magnitude changes over time and gives the ability to compare the results using different data sets directly.

The results for each model were also “normalized” relative to the landslide density under un-forested conditions, so the difference between the models depends solely on the degree of change among different forest-cover classes.

The results under the Proposed RMP do not account for the No Harvest areas within the Riparian Management Area. The results should not be used to evaluate alternatives, but rather, to see the implications that differences in forest cover imply for the results.

Figures J-26 through J-28 show the potential wood contribution from debris flow sources relative to the No Harvesting reference analysis at 2106 from the contribution under the No Harvesting reference analysis at 2006, in the Upper Molalla River, Eagle Creek, and Upper Smith River watersheds for Model 1, Model 2, and with uniform non-forested land cover).

When debris flow probabilities are dependant on the spatial distribution of forest types over time, the results change depending on the degree to which the forest type influences landslide susceptibility over time. Under Model 1, there is a substantial reduction in landslide susceptibility between 0-10 year stands and the 10-100 year stands, with a smaller difference between the 10-100 and >100 year stands. In Model 2, there is a smaller difference between the 0-10 and 10-100 year stands, and a larger difference between the 10-100 and >100 year stands.

Model 1 shows that the potential wood contribution would change the results between alternatives. For example, Alternatives 2 and 3 provide less wood than Alternative 1 and Alternative 3 provides less than Alternative 2; the opposite of the results found using the uniform non-forest cover. This occurs because landslide susceptibility decreases in older forests. Using a static debris flow from a uniform non-forest cover, the results reflect the amount of wood “available” for debris flow recruitment over time based on the amount and size of trees available. When landslide susceptibility is based on forest cover, the results reflect both the amount of wood available and the imposed effect of forest cover on debris flow recurrence intervals. When different landslide raters are used from different data sets (Model 1 and Model 2), the ratios are different between forest types which gives different results. For example, under Model 1, the relative difference in landslide density between forest types is smaller (densities in older forests were 30% of those in stand establishment forests).

These results demonstrate how the influences of forest cover on landslide susceptibility influences debris-flow recruitment. Patterns of modeled recruitment rate over time and the potential wood recruitment to streams differs between models and watersheds. Model 2 is more similar to the results using a uniform forest cover than Model 1. This occurs because the 10-100 year landslide density in Model 2 is closer to that applied under the uniform scenario. Under Model 1, debris flow probabilities are generally reduced by age class, which consequently reduces the modeled debris-flow recruitment rate and reduces the proportion of debris flow wood contribution from the harvest land base and increases the amount of wood contribution from the riparian management area. Thus, Model 1 would show a greater wood contribution from alternatives with a more extensive riparian management area.

Based on these scenarios, utilizing the uniform forest cover for the analysis gives the best representation, with the least amount of uncertainty, in determining the amount of wood available under each alternative over time; since the modeled debris flow recruitment rate is based on 1) topographic controls on debris flow locations, and 2) the amount of wood available for debris flow recruitment.

To estimate wood inputs from channel migration, the following was determined:

1. Channel migration (or bank erosion) rates. Due to the great variety of unquantified controlling factors, channel migration rates are not estimated. Rather, the floodplain area potentially susceptible to occupation by the channel is identified. This is done using the DEM, flagging all cells within 5 bankfull depths above the channel elevation (along flow lines to a channel cell). Then the assumption that a constant 0.01 probability for any point on the delineated floodplain to be occupied by the channel is used (e.g., every point on the floodplain is assessed by the channel on average once every century).
2. The number of live and dead trees available to be recruited by channel migration into the channel. Stem densities obtained from OPTIONS are multiplied by the delineated floodplain area.

FIGURE J-26. POTENTIAL WOOD CONTRIBUTION FROM DEBRIS FLOW SOURCES RELATIVE TO NO HARVESTING REFERENCE ANALYSIS IN THE UPPER MOLALLA WATERSHED

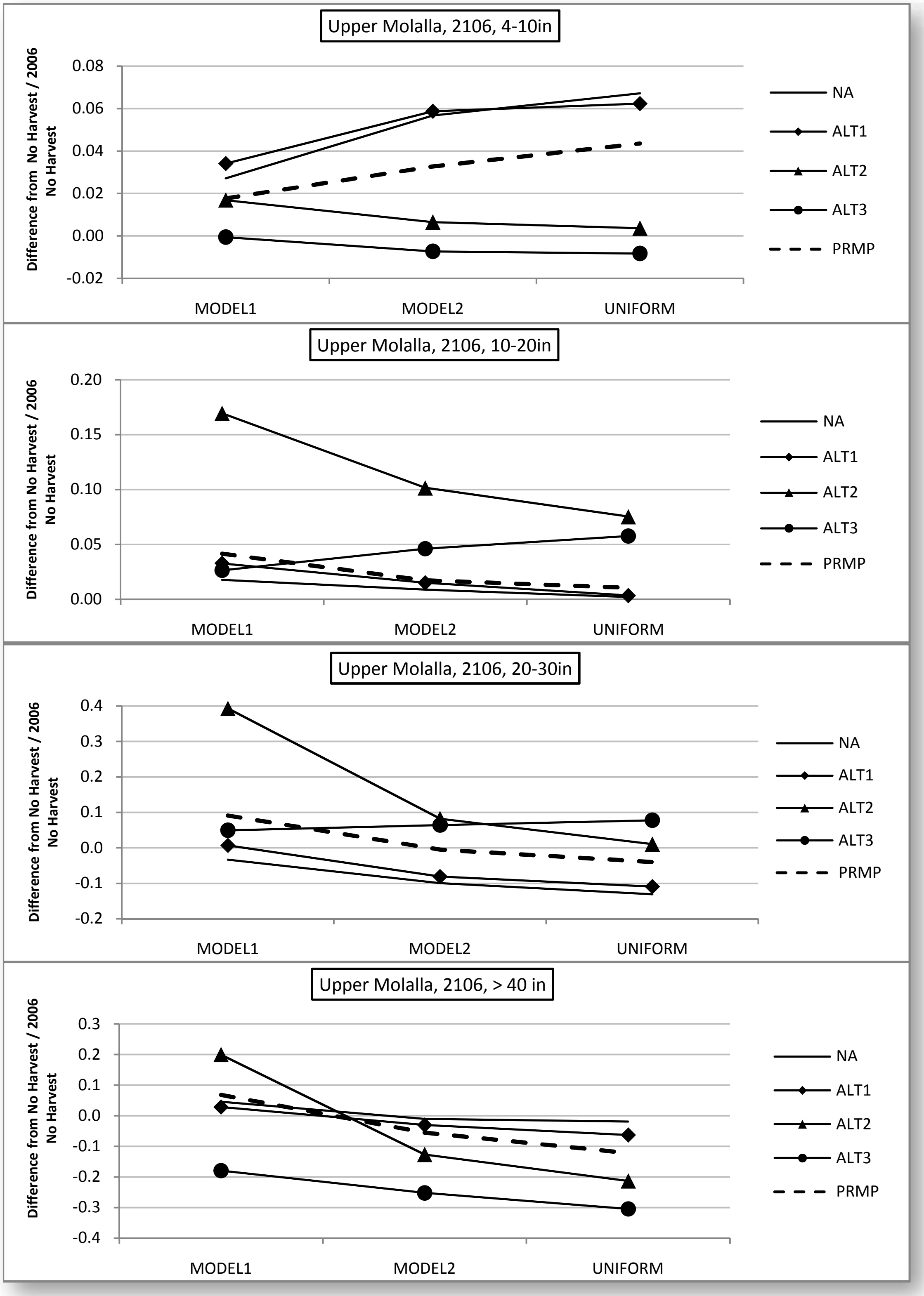


Figure J-27. Potential Wood Contribution From Debris Flow Sources Relative To No Harvesting Reference Analysis In The Upper Smith River Watershed

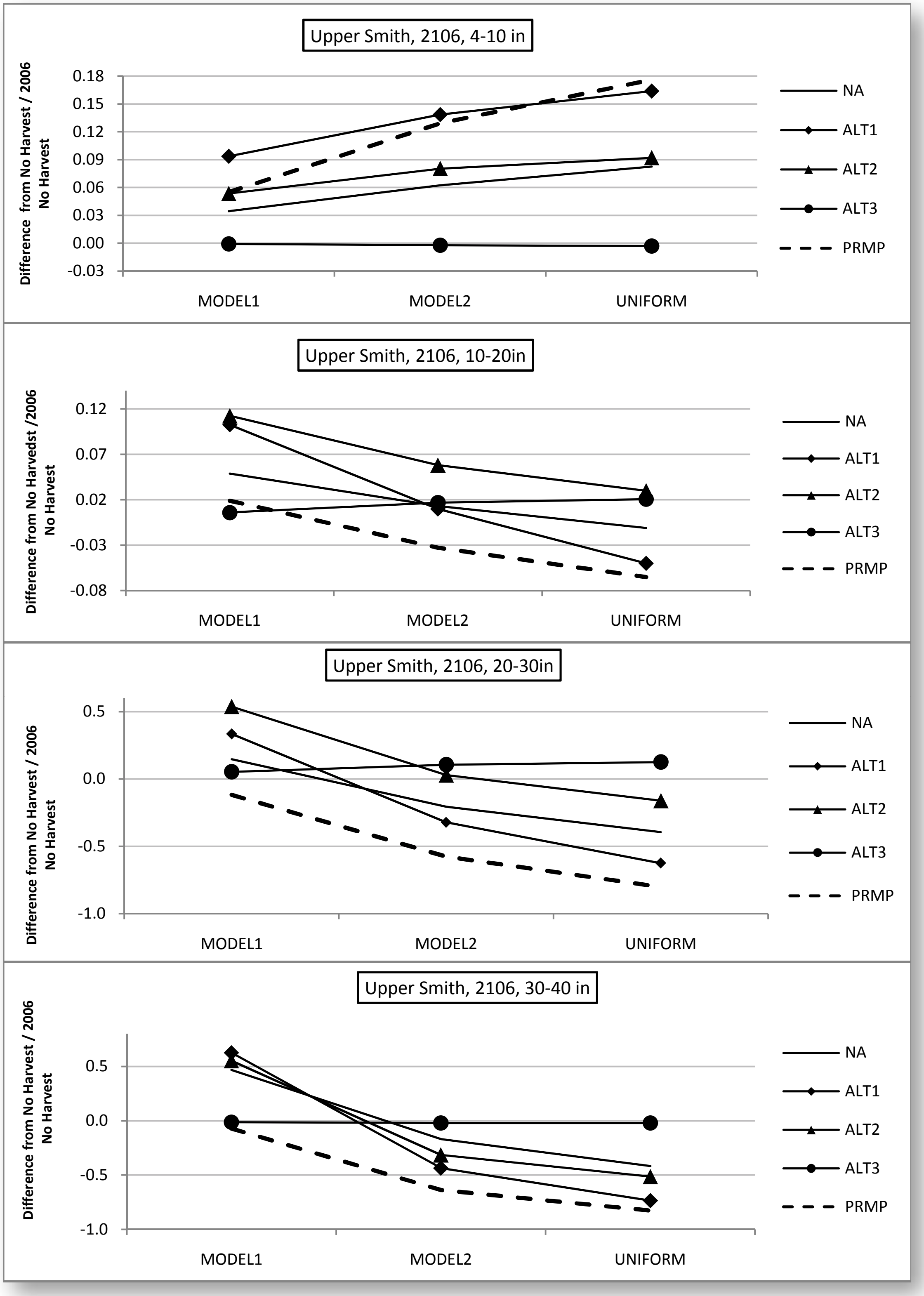
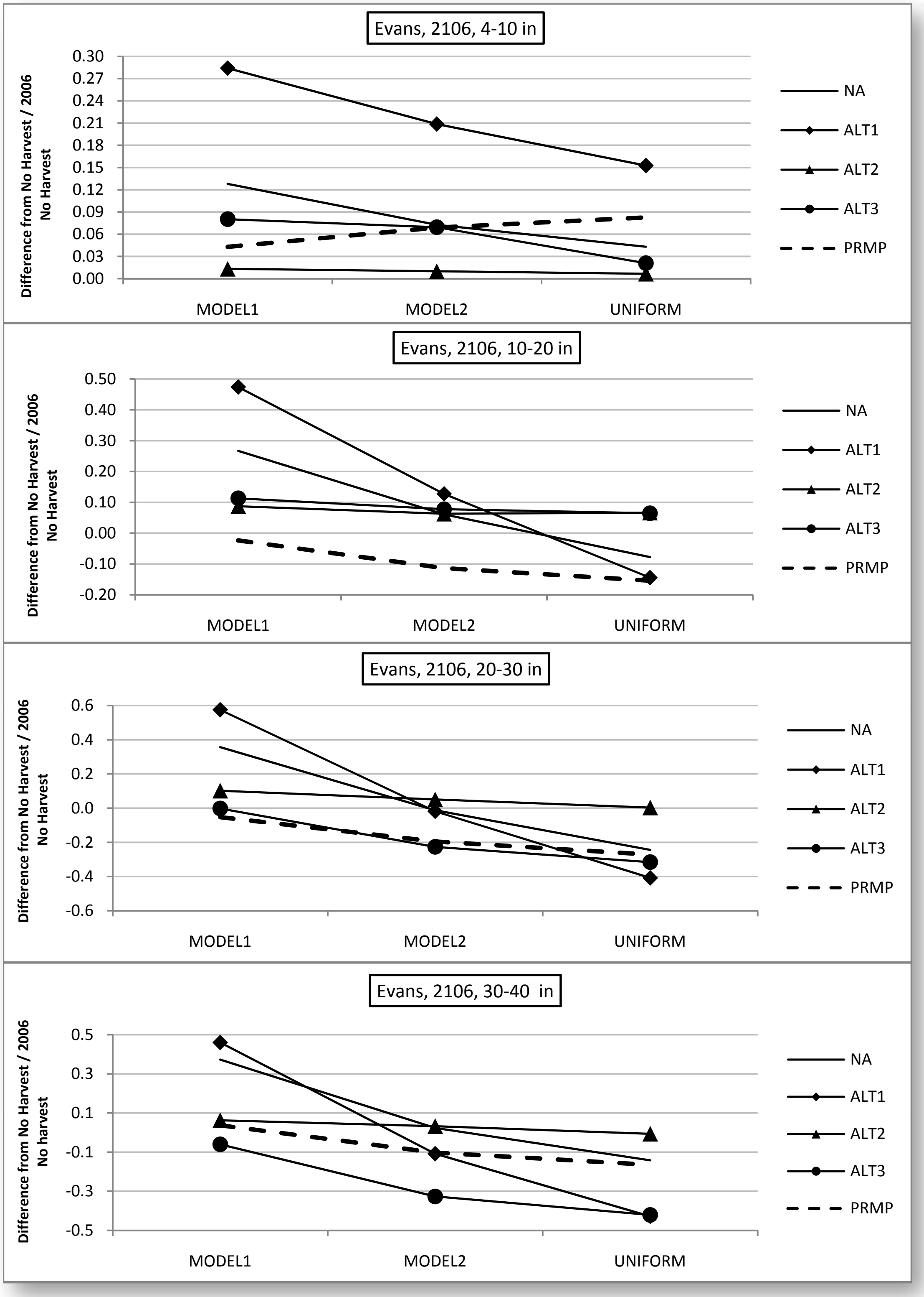


Figure J-28. Potential Wood Contribution From Debris Flow Sources Relative To No Harvesting Reference Analysis In The Evans Creek Watershed



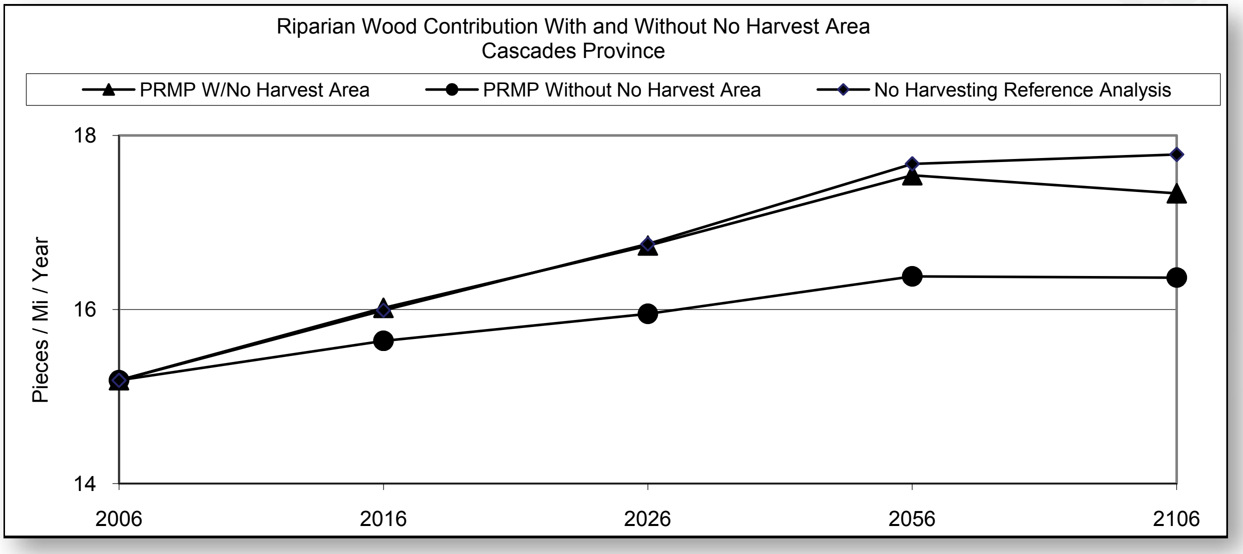
This procedure provides a relative measure of the wood available for recruitment by channel migration across DEM-delineated flood plains. For each of these three recruitment processes, the number of pieces recruited to channels by piece size class is tracked (based on diameter of the bole where it intersects the channel edge for riparian recruitment and the DBH of standing trees for debris flow and channel migration recruitment). Piece lengths are not estimated; hence there are no estimates of wood volume. The results provide a means to compare potential effects of the management alternatives on relative wood recruitment rates to channels. Recruitment by piece size is tracked, so that these effects can be evaluated relative to the size of the channels receiving the wood: the minimum diameter for wood capable of providing a habitat function varies with channel size. Recruitment rates for stream-width classes in terms of either functionally sized or key (> 20 inches diameter) pieces are then reported.

It is important when evaluating and interpreting these model results to consider the factors included and not included in the models. The most available data was used to characterize three key recruitment processes; and the data is sufficient to provide a relative index of management effects for each process, but are insufficient to estimate relative rates between processes. The mean annual rates of wood input that we calculate reflect the average of a right-skewed distribution of values, and the degree of skew differs between processes, with higher skew for debris-flow delivery of wood. Recruitment of wood from riparian mortality and bank erosion probably occurs more frequently than recruitment from debris flow. For a given rate, the longer the time between events, the greater is the quantity of wood delivered with each event. Within a fifth-field HUC, riparian mortality probably provides some wood every year, whereas debris flows may provide wood only a few years out of every decade. For a 100-m reach, riparian inputs may occur every decade (depending on stand conditions), whereas debris flows may occur only every few centuries (depending on adjacent topography and forest disturbance).

The model does not include other disturbance-driven wood recruitment processes. Other simulation models suggest that fire-killed trees can provide a substantial source of wood (Benda et al. 2003). Disease and insect infestations can dramatically increase rates of riparian tree mortality (Bragg 2000). Blowdown, particularly along the outer edge of riparian buffers, can substantially increase rates of riparian recruitment (Liquori 2006, Martin and Grotefendt 2007). These factors are also sensitive to management influences. No-harvest area within riparian areas, for example, while providing a greater number of dead trees for recruitment to the channel than a thinned stand, may also result in increased fuel loading along riparian corridors, with consequent increases in fire potential. Likewise, the stand-growth modeling does not resolve distinct riparian stand types, which may in some areas experience more frequent disturbance than upland stands, with consequently greater density of hardwood species in riparian zones (Nierenberg and Hibbs 2000, Pabst and Spies 1999).

Modeled wood recruitment rates from riparian mortality are sensitive to the stand conditions specified for channel-adjacent zones, as we found when a no-harvest area was added within the riparian management area. See *Figure J-29 (Riparian wood recruitment rates with and without no-harvest buffer in the Cascades Province)*.

Figure J-29. Riparian Wood Recruitment Rates With And Without No-Harvest Buffer in The Cascades Province



Intrinsic Potential Model

Intrinsic potential is a scientific, topographical approach used to determine the potential of a stream to provide high-quality habitat for salmonids. Comprehensive information on the location of stream reaches with the greatest potential to provide high-quality habitat for salmonids was generally missing for the planning area. The intrinsic potential of stream channels to provide high-quality rearing habitat was modeled for juvenile coho salmon (*Oncorhynchus kisutch*), juvenile steelhead (*O. mykiss*), and juvenile chinook salmon (*O. tshawytscha*). The initial research was conducted in the Coastal Landscape Analysis and Modeling Study (CLAMS) and was expanded for coho, steelhead and chinook on all ownerships within the planning area.

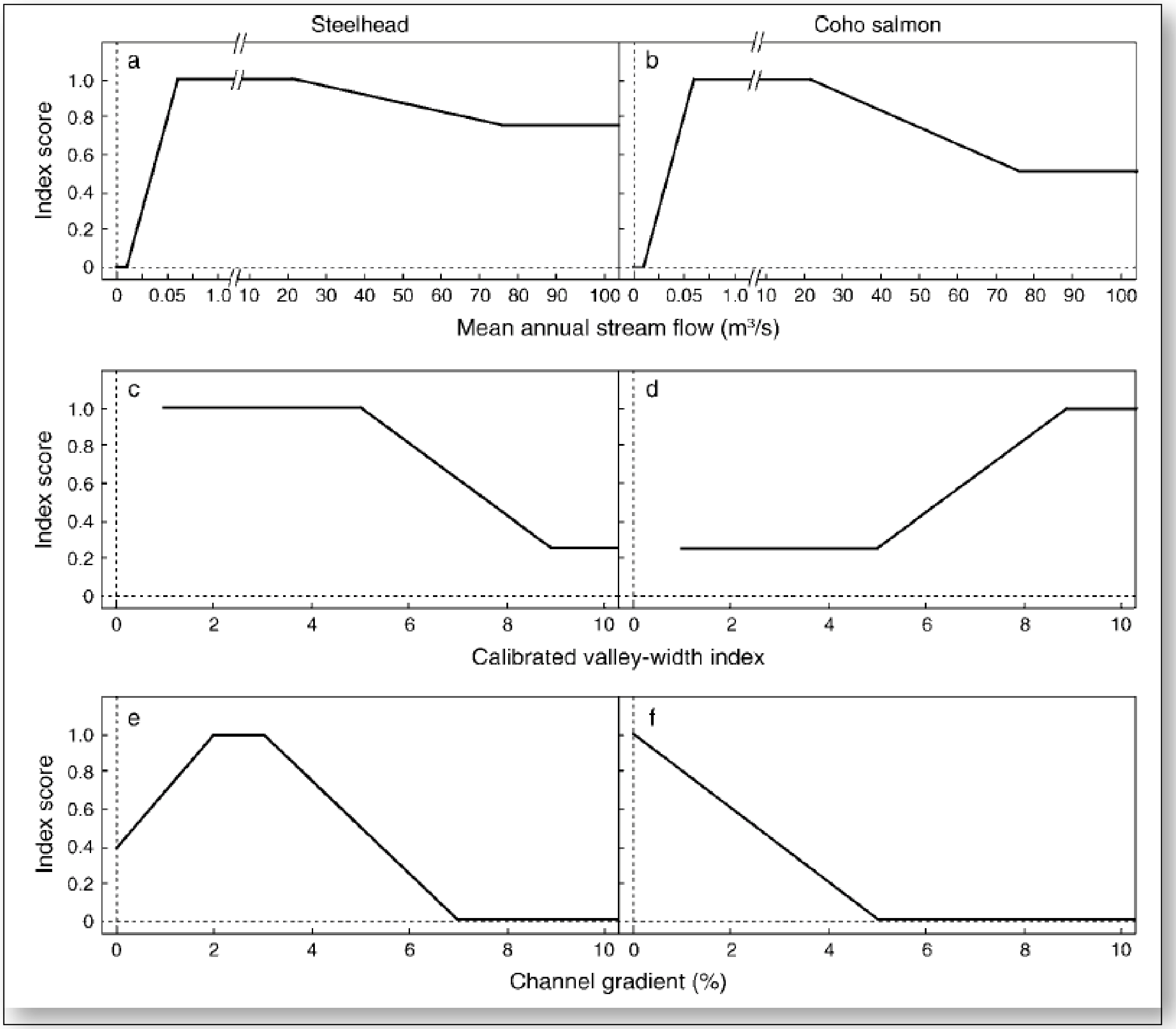
Spatial models were developed that estimate the potential of streams to provide high- quality rearing habitat for coho, steelhead and chinook. The calculated metric, termed intrinsic potential, reflects species-specific associations between fish use and persistent stream attributes; stream flow, valley constraint, and stream gradient.

The intrinsic potential for each stream reach was modeled independently for juvenile steelhead, coho, and chinook salmon from stream attributes of mean annual stream flow, valley constraint, and channel gradient. These attributes were produced in conjunction with the digital stream network from 10-m digital elevation models (DIGITAL ELEVATION MODELs) (Miller 2003). The stream network output was in an ArcView shape file format and then imported into ArcInfo (version 8.3; ESRI, Redlands, California, USA) for all subsequent processing. Stream attribute values were translated into index scores for each species as shown in *Figures J-30* and *J-31*.

The index scores were based on empirical evidence from published studies regarding the relationship between a stream attribute and juvenile fish use. The index scores for chinook were developed for this EIS and have not been peer-reviewed or published.

Following the most commonly applied approaches for modeling habitat suitability (Morrison et al. 1998 and Vadas and Orth 2001 in Burnett et al *in press*), intrinsic potential for each stream reach was calculated by multiplying the un-weighted species-specific index scores together and then taking the geometric mean

Figure J-30. Examples Of Relationship Between Values Of The Three Stream Attributes And The Index Scores Used To Calculate Intrinsic Potential For Steelhead and Coho



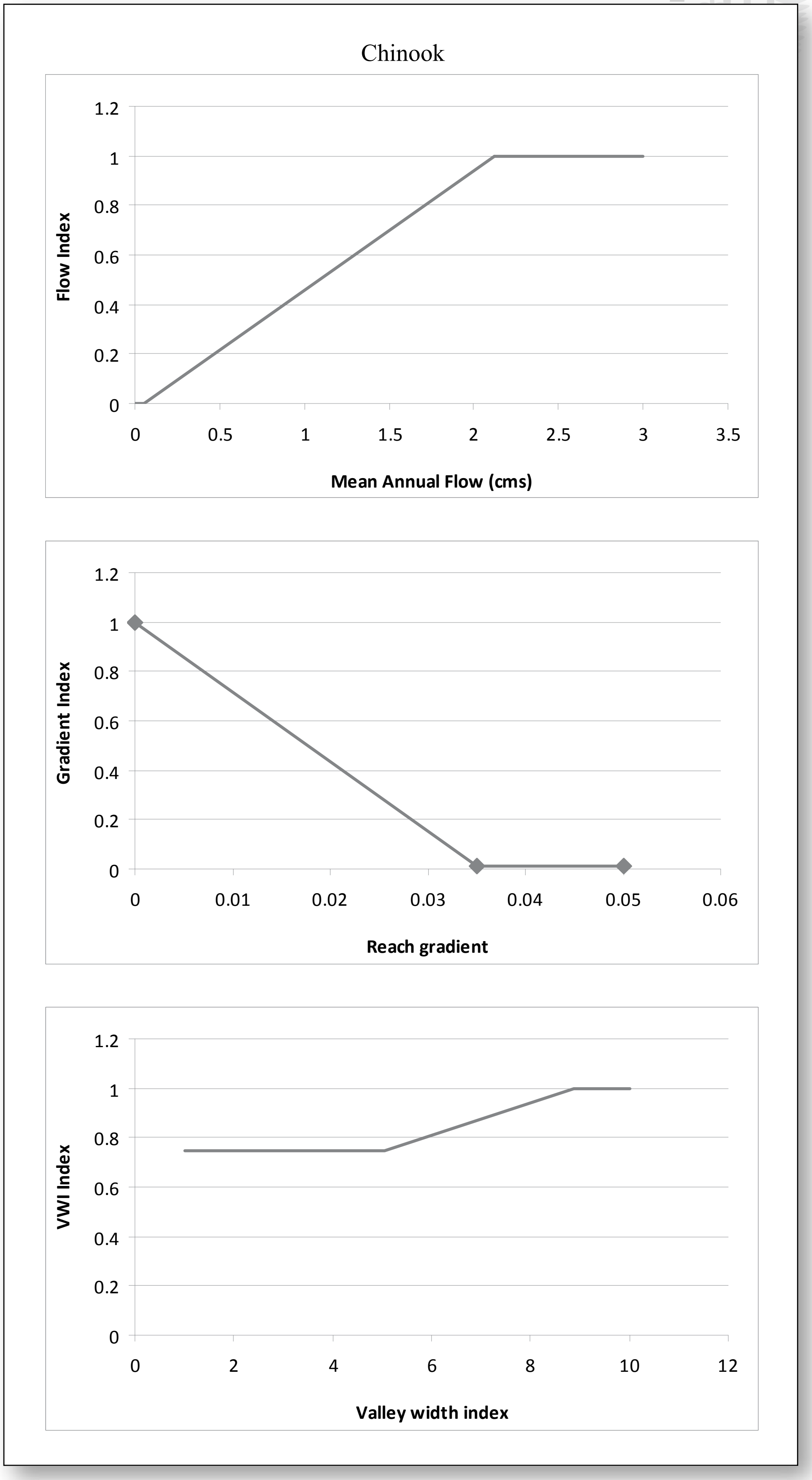


FIGURE J-31. EXAMPLES OF RELATIONSHIP BETWEEN VALUES OF THE THREE STREAM ATTRIBUTES AND THE INDEX SCORES USED TO CALCULATE INTRINSIC POTENTIAL FOR CHINOOK of the product. This approach reflects the assumption that the three stream attributes are of approximately equal importance and only partially compensatory, and that the smallest index score has the greatest influence on the intrinsic potential. The index scores and intrinsic potential can range from zero to one; larger values indicating a greater potential for providing high-quality rearing habitat. Stream reaches were classified with a high species-specific intrinsic potential when the calculated value was 0.75. Intrinsic potential is reported for a species only below naturally occurring barriers to migrating adults (Burnett et al. in press).

Fisheries Planning Criteria

Analytical Question 1

How would the potential large wood contribution and small functional wood contribution to fish-bearing and non-fish-bearing stream channels on BLM-administered lands and non-BLM-administered lands in forested landscapes vary by alternative?

Analytical Assumptions

Large woody debris (large wood) are coniferous or deciduous logs, limbs, or root wads that intrude into a stream channel.

Depending on stream size, woody material of all sizes from tiny fragments to intact trees can function in stream systems.

Woody debris is considered "functional" if it is pool-forming (Beechie et al. 2000) relative to stream size. See *Table J-14*.

Because decay rate and probability of displacement are a function of size, larger pieces have a greater influence on habitat and physical processes in stream channels than small pieces (Dolloff and Warren 2003). For this analysis, trees greater than 20 inches in diameter are considered large wood and the contribution to stream channels is tracked independently from smaller "functional" woody debris.

Wood enters stream channels from chronic and episodic events (Bisson et al. 1987).

Large wood source areas across the landscape that have a higher probability of delivering wood to stream channels include areas from:

- trees in riparian areas that die and fall into streams (e.g., Sobota et al. 2006)
- wood carried by landslides and debris flows to streams (e.g., Reeves et al. 2003)
- trees that fall into streams because of bank erosion and channel migration (Latterell and Naiman 2007)

Table J-14. Functional Piece Size And Stream Channel Widths

Stream Width	Functional Wood Diameter
15 feet	4.5 inches
20 feet	6.0 inches
30 feet	9.0 inches
40 feet	12.0 inches
50 feet	15.0 inches
>50 feet	>20 inches: large wood or "key piece"

Source: Beechie et al.2000

Several factors govern the rate at which wood is supplied to channels by each of these processes. Of primary importance are the number and size of trees available for recruitment to the channel. The spatial distribution of stand types determines in large part the rate at which wood inputs to the channel will occur, and changes in stand characteristics over time determine the degree to which recruitment rate changes over time. Modeled wood recruitment rates depend explicitly on outputs from the OPTIONS scheduling model and the ORGANON stand growth model that OPTIONS uses.

Topography is a primary control on wood recruitment rates, particularly for landslide and debris-flow recruitment. Basin topography determines the locations where different recruitment processes occur and so affects the spatial pattern of recruitment rates.

Because topography (in the model) does not change over time, it has no effect on temporal changes in recruitment rate.

Wood inputs are associated with distinct events, with potentially long intervals with little or no wood recruitment. A frequency distribution of recruitment rates (e.g., in number of pieces per year) for any specified portion of a channel network is highly skewed, with little or no inputs most of the time, and large inputs some of the time (Benda et al. 2003).

Mean recruitment rate provides a measure to assess differences in recruitment potential for the different spatial distribution of stand characteristics predicted with the OPTIONS model under each of the proposed management alternatives.

Wind and rain may cause dead or dying trees in riparian zones to topple, so that storms may trigger wood inputs to a stream reach from riparian zones every few years to decades; landslides or debris flows may deposit wood in a reach only every few centuries (May and Gresswell 2004).

The relationship between mean recruitment rate and the frequency of recruitment events can differ dramatically between processes. Likewise, the volume of wood delivered in a single recruitment event may differ dramatically between recruitment processes.

The maximum potential large wood contribution reflects a maximum biological potential, and does not necessarily reflect average historic conditions.

The average historic conditions at the province scale ranged from 79% in a mature & structurally complex structural stage class in the Coast Range and West Cascades Provinces to 45% in a mature & structurally complex structural stage class in the Eastern Cascades Province.

At the individual fifth-field watershed scale, the variability in historic amounts of mature & structurally complex structural stage class would have been extremely high, likely with long periods of time in which the watershed was nearly all in the mature & structurally complex structural stage class (Wimberley et al. 2000). These periods of time in which a fifth-field watershed would be nearly all in the mature&structurally complex structural stage class, which would correspond to the maximum large wood contribution calculated in the model, would represent the maximum potential for large wood delivery.

The model output of potential large wood contribution is an estimate of the potential wood contribution to stream channels over time based on forested stand conditions and tree availability, but is not meant to be a prediction of actual instream conditions at a specific point in time.

Debris flow source areas for wood are widely distributed, but most of the wood accumulated by debris flows is scoured from low-order channels.

Debris flow inputs to fish-bearing streams occur at these low-order channel junctions.

Analytical Methods and Techniques

Step 1

Use Stand Table information to determine number of stems, density, height and diameter of the live and standing dead trees by 10-inch diameter class for conifer and hardwood at each reporting point. Reports account for management activities and stand growth and mortality.

1) Obtain stand table information on live and dead trees by species type. The abundance of live and dead trees is sensitive to management activities. For this analysis, detailed information about these activities is provided by WOPR unit from the OPTIONS model. However, since OPTIONS utilizes and reports stand average information, it methods were adopted to determine the stand table information for each WOPR unit at each reporting period.

   In the OPTIONS model, each WOPR is uniquely managed based on the hierarchy of management assumptions and objectives. The application of these assumptions and objectives create a dynamic modeling process that affects the sequence and timing of stand level treatments, this sequence cannot be forecast outside of the OPTIONS model. However, based on the OPTIONS modeling framework it was possible to define the entire range of possible treatment combination based on modeling group, site index and treatment timing and intensity, which were modeled in ORGANON to create to create individual stand tables

2) Consolidate large set of ORGANON stand tables into a single Index Table for every combination of modeling group, species group, site index and treatment timing and intensity. Determine detailed stand table information for each WOPR unit by reviewing the sequence of OPTIONS treatment details and then referring to the corresponding ORGANON data in the Index Table.

3) Use All Possible Treatment Yield Curve Crosswalk Table (ACT2CVS_XWALK).
   This table identifies which treatment yield curve to use to obtain the required stand characteristics and index values for the large wood analysis report. The treatment yield curve is identified based on the current alternative, management regime, species, site productivity class, and treatment age.

4) Use Index Value Lookup Table (INDX_LKUP)
   This table is an Alternative based lookup table containing projected stand characteristics and index values for each treatment yield curve. Some of the index values available include:
   - Stand characteristics: age, basal area, TPA, QMD, height, volume, crown ratio, canopy closure, relative density, SDI, CV, DDI,
   - TPA by 10" diameter classes for live and dead trees by Conifer and hardwood: # of trees in 0" to 9", 10" to 19", 20" to 29", 30" to 39", greater than or equal to 40"
   - Average height by 10" diameter classes for live and dead trees by Conifer and hardwood: weighed height by TPA in 0" to 10", 11" to 20", 21" to 30", 31" to 40", greater than 40"
   - Average diameter by 10" diameter classes for live and dead tree by conifer and hardwood: weighted diameter by TPA in 0" to 10", 11" to 20", 21" to 30", 31" to 40", greater than 40"

5) Use OPTIONS Run Files to post-process an OPTIONS run. The following OPTIONS run files are required:
   - OPTIONS data files (.DBF, .DBS, .SPG, .SIC)
   - OPTIONS run files (.DEF, .DEV, .RUN, .I, .II., .V)

Step 2

For each Alternative:

1) Using ORGANON, generate the possible treatment stand tables based on the Alternative's management regime definitions. Create the Crosswalk Table to identify which stand table to reference for a particular treatment combination.

2) Based on the Crosswalk Table, pre-process each treatment stand table to generate the index values that will be used to in the large wood analysis. Create the Index Table to identify which index values to use for a particular treatment stand table.

3) Initialize a Large Wood Report Table by listing for each WOPR unit the OPTIONS inventory values for forest type (forest, non-forest, road), initial management regime, species group, site productivity class and area.

For each forested WOPR unit in the Large Wood Report Table:

4) Set initial conditions:
    - Initial Structural Stage and legacy (based on OPTIONS inventory structural stage)
    - Plant Series/Retention Zone (based on OPTIONS inventory)
    - NSO Variance: based on plant series, species group and habitat definition
    - Flag for MOCA and SHRUB areas
    - GTR (green tree retention) flag for LSMA and additional GTR Areas

5) Based on the OPTIONS run results, build the WOPR unit Activity History Table including harvest activities and state of the forest years in chronological order. Record the stand management regime, species group, site productivity and age at which these actives occur. This history table represents the changes in stand characteristics over time.

For each Activity in the Activity History:

6) Determine the current thinning treatment combination, partial harvest condition and legacy based on the type of activity completed.
    - For Regeneration Harvest: reset thinning treatment combination, reset partial harvest conditions, re-evaluate legacy for each management scenario.
    - For Selection Harvest: reset thinning treatment combination, set partial harvest condition, re-evaluate legacy
    - For Commercial Thinning: set thinning treatment combination based on thinning age and thinning sequence, no change to partial harvest condition or legacy.

7) Set activity stand table reference from Crosswalk Table based on the treatment combination.

8) Retrieve stand characteristics and index values from Index Table based on stand table reference.

9) Calculate Structure Stage Classification based on index values and structural stage definition.

10) Update Report Table with Structural Stage and stand table values such as TPA, average HT and DBH for live and dead trees by conifer and hardwood in 10" diameter classes for each reporting year.

Step 3

The following analytical technique is a spatially explicit, Digital Elevation Model and Geographic Information System-based wood recruitment model developed for this analysis to determine the potential wood contribution to streams from BLM-administered lands. Outputs are calculated wood recruitment rates to each delineated stream reach and rates of wood supply to channels from each DEM cell in the planning area.

1) Identify fish-bearing and non-fish-bearing stream channels. Trace stream channel locations inferred from flow routing indicated by DEM, based on flow directions defined for every DEM point (e.g. Tarboton 1997), and upslope contributing calculated for all flow paths. Determine fish-bearing and non fish-bearing stream channels with Western Oregon Plan Revision Geographic Information System stream fish distribution layer.

2) Estimate wood inputs from mortality of riparian trees. Determine:
    - The number and location of dead or dying trees that may fall. These are estimated from the outputs of the ORGANON stand growth model used by OPTIONS. For each stand type, generate tree list that provides density (in stems per acre) of trees that have died (over a five-year time step) by species (conifer and hardwood) and size (diameter) class. Assume all dead trees fall during the next time step.
    - The slope gradient at each tree location (trees on steeper slopes are more likely to fall in a downslope direction than trees on less steep slopes), calculated from the 10-m DEM.
    - The location of falling trees relative to the channel edge. Channel-edge locations are based on channel centerlines traced using flow-paths derived from the DEM, with channel width estimated using regional regressions to drainage area (Castro and Jackson 2001; Clarke et al. 2008).
    - The probability that a falling tree intersects the channel. This probability is derived from an empirical probability density function for fall direction (Sobota et al. 2006) together with the location of all channel edges within a distance less than or equal to the tree height.
    - The diameter of the tree bole where it intersects the channel. Tree boles are approximated as a cone, with a diameter-at-breast-height (using a breast height of 1.4 meters) based on the size class for the tree (from the tree lists) tapering linearly to zero at the tree height.
    - Reference stand-type polygons to DEM cell boundaries. Channel-edge segments are defined determine where traced channel edges (centerline plus a buffer of one half the estimated channel width) cross DEM cells. For each channel segment, find every DEM point within a tree height of the segment and calculate the probability that a) a tree within that stand is dead (and ready to fall), and b) if a tree at that point falls, it hits the channel segment.
    - Repeat this calculation for every DEM point and integrate the probabilities over all DEM cells to determine the probability that a tree falls into the channel segment.
    - Repeat for all channel segments and for all tree species and size classes, summing results by piece-size classes for each segment to determine the annual probability for wood recruitment from each DEM cell and the annual probability of recruitment to each channel segment.
    - Interpret these probabilities as average rates. For example, if the calculated annual probability for input of wood to a reach is 0.1, we interpret this as a recurrence interval of 10 years; that is, one piece every ten years, or an average rate of 0.1 pieces per year.

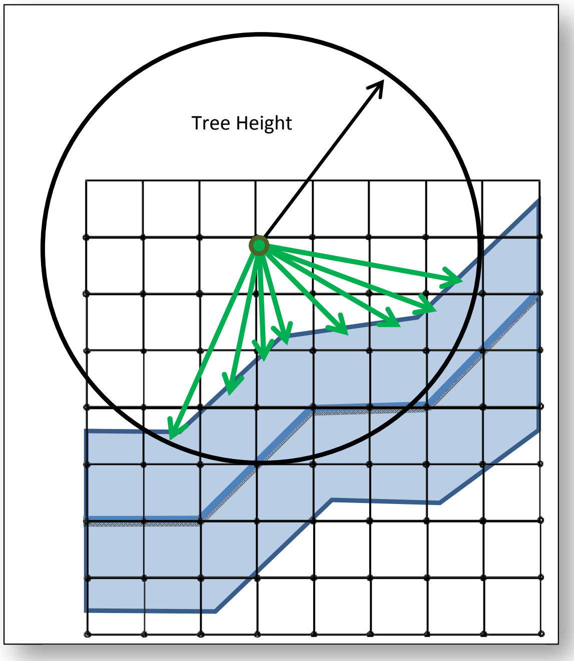
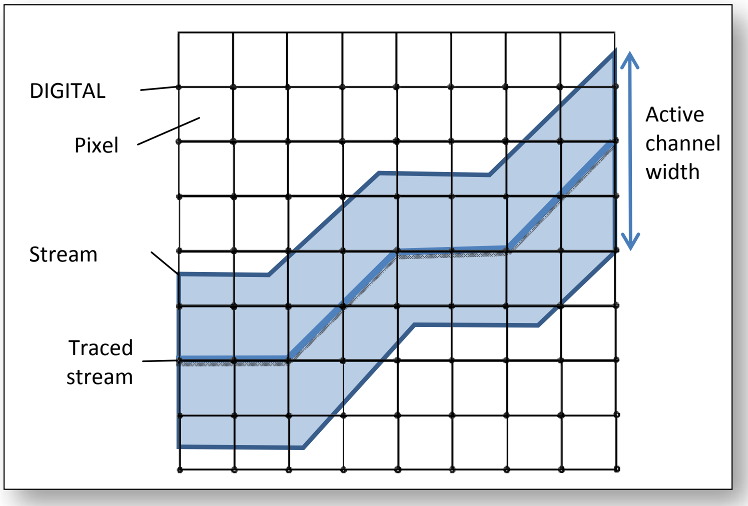


Figure J-32. Calculating Tree Height Relative to Channel Edge

Figure J-33. Calculating Probability That Trees Will Intersect The Channel



3) Estimate wood inputs from debris flows. Determine:
    - The locations of potential debris flow tracks, and the recurrence interval for debris flows that traverse each track. Estimate debris-flow locations using empirical topographically driven models (Miller and Burnett 2007, 2008) calibrated to landslide data from throughout the plan area and to debris-flow tracks mapped by the Oregon Department of Forestry following the large 1996 storms (Robison et al. 1999). Recurrence intervals are based on data for low-order channels in the Coast Range reported by May and Gresswell (2004), who estimate a recurrence interval for debris flows to ~3rd order channels of about 350 years.
    - The number of live and dead trees available along the debris-flow track, obtained from the tree lists output by OPTIONS. Use the DBH of each tree as the diameter for the recruited piece of wood.
    - The number of pieces contributed (per year) by dead trees from adjacent areas falling into the track. This number is estimated using the same procedure described above for riparian recruitment to stream channels.
    - The probability for debris flow scour and deposition along each potential track, based on data from the 1996 storm study (Miller and Burnett 2008; Robison et al. 1999).
    - The average width of a debris-flow track set to six meters based on data in Robison et al. (1999).

To estimate the number of pieces of wood carried to a stream channel by a potential debris flow:

- Sum the number of trees available along the track within each DEM cell traversed by the track, and multiply this value by the probability that a debris flow will traverse the cell. If the stem density for the stand indicates (on average) 10 trees per 10-meter DEM cell, 6 of these will be incorporated into a 6-meter-wide debris flow. If the estimated recurrence interval for a debris flow to traverse the cell is 500 years, that gives 6 trees recruited (into the debris flow) every 500 years, or 0.012 trees per year.
- Sum these values along all potential debris flow tracks.

- To estimate the proportion of the accumulated wood that is deposited (on average, for all the debris flows that may traverse each cell), determine the proportional downslope decrease in debris flow probability. If the probability decreases by 1% from one cell to the next, 1% of the accumulated wood is left in the cell.
- In some cases, a large proportion of the wood carried by debris flows is not from the current stand, but has been excavated from wood deposited in previous debris-flow deposits (May 2002). To estimate debris-flow recruitment rate from a specified spatial distribution of stand types, account for the incorporation of wood from this stand into future debris flows. Estimate the probability that a debris flow encounters wood deposited from a previous debris flow based on the recurrence interval. The probability that a future debris flow encounters a deposit containing wood from this stand is estimated as one minus the probability that no debris flows had occurred over the recurrence interval for debris flows to that cell, i.e., $1 - (1\text{-}1/R)^R$, where R is the recurrence interval in years. For values of R exceeding 100 years, this equation has a nearly constant value of 0.63; hence estimate a 63% probability (on average) that a future debris flow will encounter wood from this year's forest stands. However, over recurrence intervals of this length, any wood that is not buried in the deposit will likely be completely decayed. Benda and Dunne (1997) estimate from field observations that approximately 70% of debris-flow deposit volume resides in fans and terraces; hence assume that 70% of the available wood is buried in these fans and terraces. This suggests that about 44% (0.63*0.7) of the deposited wood is available to future debris flows.

Observational evidence indicates that landslide rate and the extent of debris flow runout vary with forest stand characteristics (Miller and Burnett 2007, 2008). For simplicity, model debris flow probabilities using a uniform non-forested land cover, with the resulting probability values multiplied by a constant value to give an average 350-year recurrence interval for debris flows to 3rd order channels for the basins studied by May and Gresswell (2004). This removes the effects of management on modeled debris flow probability, so that differences in calculated wood recruitment rates between alternatives and over time solely reflect differences in the amount of wood available to debris flows. However, this strategy masks the effects of management on landslide potential. Therefore, these effects are examined for a subset of basins in the plan area, for the appendix.

4) Estimate wood inputs from channel migration. Determine:
    - Channel migration (or bank erosion) rates. Due to the great variety of un-quantified controlling factors on channel migration rates, identify the floodplain area potentially susceptible to occupation by the channel. Use the DEM, flagging all cells within 5 bankfull depths above the channel elevation (along flow lines to a channel cell). Assume a constant 0.01 probability for any point on the delineated floodplain to be occupied by the channel (e.g., every point on the floodplain is assessed by the channel on average once every century).
    - The number of live and dead trees available to be recruited by channel migration into the channel.
    - Multiply the stem densities obtained from OPTIONS by the delineated floodplain area to derive a relative measure of the wood available for recruitment by channel migration across DEM-delineated flood plains.

5) Estimate relative wood contribution across all ownerships:
    - Use Interagency Vegetation Mapping Project (IVMP) data to determine stand information on non-BLM administered lands.
    - Use simplified structural stage stand type data (Stand Establishment, Young, Mature and Structurally Complex, and Non-Forest) for BLM and non-BLM administered lands.
    - Follow Steps 1-3 to determine relative wood contribution by ownership.

Analytical Conclusion

Compare alternatives in terms of potential large wood and small functional wood contribution for the entire planning area and by province.

Data Display

Summarize results over specific sets (BLM, non-BLM, large wood, small functional wood, fish-bearing, non-fish-bearing, land use allocation, piece/size and stream size, plan-wide and by province, by wood contribution source). Graph format potential wood contribution over time compared to current condition and no harvest reference analysis for large wood and small functional wood.

Data Needs

- Ownership, by watershed
- Stream miles, by ownership
- Fish distribution
- OPTIONS growth and yield detailed stand data (In grid format)
- 10-meter Digital Elevation Models
- Land use allocation spatial data.

Analytical Question 2

How will changes in sediment delivery to stream channels affect fish under each alternative?

Analytical Assumptions

Salmonids have the ability to cope with some level of sediment at various life stages.

In gravel-bed streams, persistent infiltration of fine sediment into gravel reduces survival of salmonid eggs and fry (Hall and Lantz 1969, Everest et al. 1987, Sullivan et al. 1987).

Fine sediments (sand, silt, and clay at less than 2 mm) enter and leave river channels naturally, but increased suspended sediment (turbidity) and sedimentation (embeddedness) can adversely affect fish (Anderson et al. 1996).

The timing of the sediment inputs relative to the biological vulnerability of each fish species is more important than the absolute quantity of sediment.

Once sediment enters the channel, downstream routing and effects on fish habitat are determined by channel morphology, quantity and size of sediment, and frequency and magnitude of flow events (Swanston 1991).

Predicting sediment delivery to streams is difficult due to both the extreme variability in site conditions and in the variables leading to accelerated erosion. It is difficult to quantify or accurately predict the indirect effects sediment delivery will have on fish habitat (such as sedimentation of gravel interstices, channel aggradation and widening, and increased suspended sediment load).

Thresholds beyond general levels at which lethal and sub-lethal effects have not been well established in terms of the levels of sediment delivery that would cause impairment to fish at the scale of this analysis.

Suttle and co-authors suggest there is no threshold below which fine sediment is harmless to fish, and the deposition of fine sediment in the stream channel, even at low concentrations, can decrease the growth of salmonids (Suttle et al. 2004). It is not possible to describe quantitative changes in sub-lethal effects under the alternatives over time at this scale of analysis. Therefore, this analysis focuses on the sediment levels that would affect fish survival. This analysis assumes that every 1% increase in fine sediment from management activities would result in a 3.4% decrease in fish survival (Cederholm et al. 1981).

Like the watersheds used in the Cederholm study, existing fine sediment levels in watersheds in the planning area are generally not currently above background rates. The assumption is based on the current condition of fine sediment in streams within the planning area on BLM-administered lands.

For this analysis, sediment yields are calculated at a fifth-field scale and expressed as tons per square mile per year. Since this output (tons/square mile/year) cannot be directly equated to a percent embeddedness, using the assumption above (>1% increase above natural levels) provides the ability to utilize a relative increase to evaluate the effects of fine sediment delivery on fish species at the watershed scale for each alternative.

Analytical Methods and Techniques

Step 1

Determine increase in fine sediment to stream channels for each alternative . For each fifth-field watershed, use results from sediment analysis to assess impacts to fish.

Analytical Conclusions

Rank alternatives, showing changes in sediment delivery. For each fifth-field watershed, outcome will be displayed as a table formatted for each alternative:

<u>Outcome A</u>: Changes in sediment delivery to stream channels would not increase above 1% of base rates; and would not affect fish habitat.

<u>Outcome B</u>: Changes in sediment delivery to stream channels would increase above 1% base rates and decrease fish survival.

Analytical Question 3

How will changes to stream temperature affect fish under each alternative?

Analytical Assumptions

Salmonids are a beneficial use and their needs are included in water quality temperature standards.

If water quality temperature standards are not met, an increase in stream temperature could harm fish.

Water temperatures affect the biological cycles of aquatic species and are a critical factor in maintaining and restoring healthy salmonid populations. See *Table J-15* for temperature standards for species within the plan area (ODEQ 2004).

Table J-15. Temperature Standards For Species Within The Western Oregon Plan Revisions Area

Species	*Seven-Day Average Maximum Temperature Standard* (Degrees Fahrenheit)
Salmon and steelhead	55.4
Salmon and trout rearing and migration	64.4
Lahontan cutthroat trout or Redband trout	68.0
Bull trout spawning and juvenile rearing	53.6

Analytical Methods and Techniques

Step 1

Use output from stream temperature analysis, fish distribution, and temperature standards.

Analytical Conclusions

Rank alternatives displaying how each alternative meets shade targets or contributes to an increase in stream temperature.

Data Display

Table display of data.

Analytical Question 4

How will changes in peak flows within stream channels affect fish under each alternative?

Analytical Assumptions

Channel forming flow is a series of naturally occurring discharges that result in channel morphology close to the existing channel.

Extreme flood flows can cause large-scale effects on channel morphology and fish habitat. The runoff volume from these storms can overwhelm the hydrologic effects of vegetation management and roads (Harr 1981).

More frequently occurring flows, such as those with a 1.5-year to 2-year return interval, are generally the dominant channel forming flows in stable natural streams (Grant et al. 2008). For steep mountain streams and for this analysis, the 2-year, 24-hour peak flow is used to simulate a channel forming flow (Lisle 1981). Water available for runoff in rain-on-snow areas is estimated as an incremental change compared to this reference flow.

When 5-year, 24-hour flows (10%-20% above 2-year 24-hour flow) begin to occur at the 2-year, 24-hour frequency, stream channels can become unstable, effect channel morphology and increase streambank erosion (Harr 1992).

Whether susceptibility to peak flow increases result in fish egg mortality depends on watershed and stream-specific characteristics and the timing of peak flow increases, making it impossible to make a reasonable prediction of the precise effects on fish from peak flow increases under each alternative over time. For example, streambed scour that would result in egg mortality would generally occur in lower gradient stream channels with gravel and sand-bed substrates, and would not typically occur within cascade and step-pool stream types (Grant et al. 2008).

On BLM-administered lands within the planning area, eighty percent of the streams are stream types where increases in peak flows would not cause streambed scour.

Increases in peak flow susceptibility would result in adverse effects on fish only if all of the following conditions would occur in concert: a storm that would increase flow would occur during the time period a subwatershed would be susceptible; the increase in flows would occur in pool/riffle streamtypes with gravel-bed and sand substrates; and the increase in flows would occur when fish would be spawning.

Analytical Methods and Techniques

Step 1

Determine percentage increase of peak flow by alternative.

For each sixth-field:

- Use output from Hydrology peak flow analysis to determine if peak flows would increase in frequency from a 2-year 24-hour flow, to a 5-year 24-hour flow.

Analytical Conclusions

Rank alternatives by amount of susceptible watersheds compared to No Harvesting reference analysis and Intensive Management on Most Commercial Timber Lands reference analysis showing peak flow changes, by sixth-field watersheds.

Analytical Question 5

How will aquatic restoration affect fish under each alternative?

Analytical Assumptions

Increasing habitat complexity in streams with high priority fish populations or occupied high intrinsic potential streams would be more effective in improving habitat complexity in those streams with a greater potential to support salmonids than others.

Intrinsic potential for streams is the stream's inherent ability to provide high quality rearing habitat for salmonids.

The species specific relationship between habitat value and mean annual discharge reflects that coho salmon are thought to rear primarily small to mid-size streams (Sandercock 1991 and Rosenfeld et al. 2000 in Burnett et al, 2007); that juvenile steelhead generally use a somewhat broader range of stream sizes (Meehan and Bjornn 1991 and Benke 1992 in Burnett et al. 2007); and that juvenile chinook rear in medium to larger rivers (Healy 1991).

Species specific relationships between value of juvenile rearing habitat and channel gradient reflect that: 1) coho and chinook salmon predominate in the lowest gradient reaches while steelhead predominate in reaches of 2-3%; and 2) fish density decreases with increasing channel gradient beyond the optimum up to a maximum of 7% for coho salmon and 10% for steelhead (Burnett et al. 2007) and up to a maximum of 5% for chinook salmon (Burnett 2001), which also encompasses gradients where adult chinook salmon spawn (Montgomery et al. 1999).

Species specific relationships between habitat value and channel constraint reflect that densities of chinook salmon and coho salmon tend to be greater in unconstrained than in constrained reaches (Burnett 2001) but that juvenile steelhead may avoid unconstrained reaches (Burnett 2001).

Step 1

Determine location of High Intrinsic Potential Streams for coho, chinook and steelhead.
This technique is a topographically-based modeling approach that was used to assess the intrinsic potential of stream channels to provide high quality habitat for salmonids developed by Burnett, 2003 for coho salmon, chinook salmon and steelhead trout for all lands in the Western Oregon Plan Revision planning area. Spatial models were developed that estimate the potential of streams to provide high-quality rearing habitat for coho, steelhead and chinook.

The calculated metric, termed intrinsic potential reflects species-specific associations between fish use and persistent stream attributes; stream flow, valley constraint, and stream gradient.

Intrinsic potential is calculated as:

$$I.P. = (MD * CG * VC)^{1/3}$$

Where:
MD = Mean Annual Discharge
CG = Channel Gradient
VC = Valley Constraint

And:
High (>.75)
Medium (.5-.75)
Low (<.5)

Mean Annual Discharge

- Calculate mean annual discharge as a function of drainage area derived from 10m DEM data and average annual precipitation from PRISM (Parameter-elevation Regressions on Independent Slopes Model) using the equation developed for Western Oregon.

Channel Gradient

- Calculate channel gradient from 10m DEM generated by interpreting contour lines from USGS 7.5-minute quadrangles.
- Calculate the mean percent reach gradient from points of known elevation wherever a contour line crosses the modeled stream and the estimated length of the channel between the points.

Valley Constraint

- Derive channel constraint from the relationship between channel form in Oregon Department of Fish and Wildlife ODFW) stream surveys and modeled valley width index (VWI), a ration of valley floor width to active channel width (ACW).

- Approximate valley floor width from the 10m DEM as the length of a transect intersecting valley walls above the channel at a height that varies with bankfull depth.
- Model ACW from ODFW data and mean annual discharge.

Model intrinsic potential for each stream reach independently for juvenile steelhead, coho, and chinook salmon from stream attributes of mean annual stream flow, valley constraint, and channel gradient.

Produce attributes in conjunction with the digital stream network from 10-m digital elevation models (Miller et al. 2003).

Import stream network output from ArcView shape file format into ArcInfo (version 8.3; ESRI, Redlands, California, USA) for HIP processing.

Translate stream attribute values into index scores for each species See *Figures J-30* and *J*-31 earlier in this appendix.

- Following the most commonly applied approaches for modeling habitat suitability (Morrison et al. 1998 and Vadas and Orth 2001 in Burnett et al, 2007), calculate intrinsic potential for each stream reach by multiplying the un-weighted species-specific index scores together and then taking the geometric mean of the product.
- This approach reflects the assumption that the three stream attributes are of approximately equal importance and only partially compensatory, and that the smallest index score has the greatest influence on the intrinsic potential.
- The index scores and intrinsic potential can range from zero to one; larger values indicate a greater potential for providing high-quality rearing habitat. Stream reaches are classified with a high species-specific intrinsic potential when the calculated value is >0.75.
- Overlay all fish barriers (GIS data layer) and calculate intrinsic potential for species only below naturally occurring barriers to migrating adults. (Burnett et al. 2007).

Analytical Conclusions

Compare alternatives in terms of amount and location of restoration compared to current condition.

Data Display

Table and map format.

Data Needs

- Ownership, by watershed
- Stream miles, by ownership
- Fish distribution