Lewis River Bull Trout Recovery Monitoring and Evaluation:
Patches, Occupancy and Distribution

2006-2007 Progress Report

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Introduction

Bull trout (*Salvelinus confluentus*) were listed as threatened on November 1, 1999 (USFWS 1999). Previously, the Columbia River distinct population segment (DPS) of bull trout had been listed as threatened since June 10, 1998. Factors contributing to the listing of bull trout include range wide declines in distribution, abundance and habitat quality. Land and water uses that alter or disrupt habitat requirements of bull trout can threaten the persistence of the species. Examples of such activities include: water diversions, dams, timber extraction, mining, grazing, agriculture, nonnative fish competition and/or hybridization, poaching, past fish eradication projects, and channelization of streams. These threats are prevalent throughout the Columbia River basin (USFWS 2000, 2002a).

Two core areas have been identified within the Lower Columbia River and they are associated with the Lewis and Klickitat rivers. The Lewis Core Area includes the mainstem Lewis River and tributaries downstream to the confluence with the Columbia River (Figure 1), with the exclusion of the East Fork of the Lewis River (USFWS 2002b). Bull trout are currently known to occupy the Cougar, Pine, and Rush creek watersheds of the Lewis River.

While the current known occupancy of bull trout in the Lewis River subbasin appears to be limited to these three watersheds, it is possible that the historic distribution of the species within this subbasin was more widespread. Prior to the installation of three hydropower projects beginning in 1929, bull trout in the Lewis River subbasin exhibited a fluvial life history strategy (USFWS 2002b). When this life history strategy was lost due to migratory barriers from the hydropower projects, and habitat was inundated by the reservoirs behind the projects, it is probable that the distribution of bull trout in the subbasin was impacted. However, it is unknown with any degree of confidence how much of the habitat is suitable for bull trout spawning and early life rearing, how much is occupied, or how distribution may change with restoration and recovery. To address these uncertainties, the Bull Trout Recovery Monitoring and Evaluation Group (RMEG) have developed recommendations utilizing a template based on potential habitat for monitoring changes in occupancy and distribution of bull trout relative to recovery of the species.

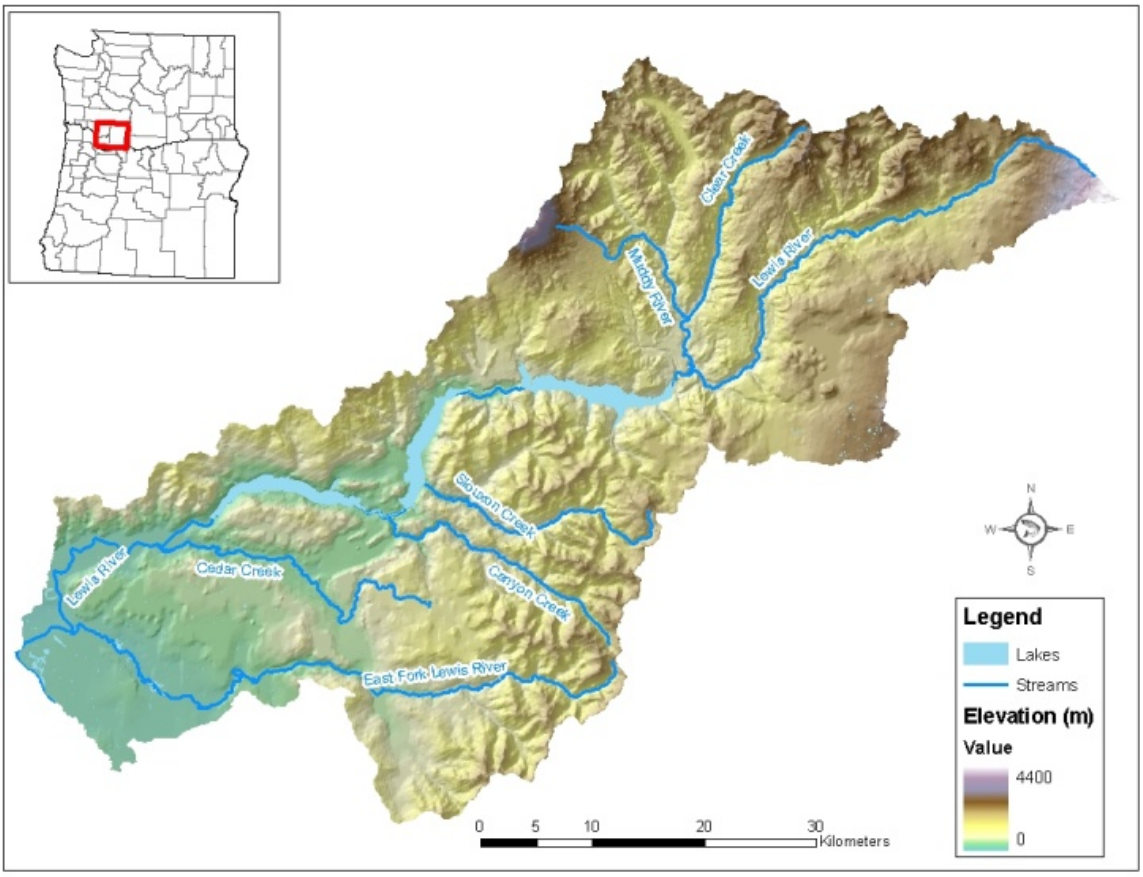

Figure 1: The Lewis River Subbasin.

Guidance from the Bull Trout RMEG (2008) recommends utilizing maximum annual stream temperature, stream size and catchment area as filters to begin to delineate potential bull trout habitat, or patches. Patches are potential areas that support bull trout spawning and early life rearing, and, therefore, are large enough to support biological populations. Many other factors summarized in Dunham and Rieman (1999) may also influence bull trout distribution (e.g., connectivity, stream gradient, geology, hydrologic regimes, presence of nonnative species, road density, solar radiation). However, maximum annual stream temperature (and the corresponding elevation) effectively dictates the range of this species (Rieman and McIntyre 1995) and patch size (catchment area) may be the most important factor determining the occurrence of bull trout populations (Dunham and Rieman 1999). Utilizing these three filters (information that most managers can readily acquire) provides the opportunity to apply and evaluate this approach as a tool for consistently delineating local population boundaries throughout the range of the species. This provides a standardized approach to developing a geographic template by which to assess bull trout status, including occupancy and distribution.

By researching the occupancy and distribution of bull trout within the Lewis River subbasin we can improve our understanding of this threatened species. This work established a quantitative baseline from which bull trout occupancy and distribution in

the Lewis River can be assessed. Implementation of this approach through a long-term monitoring program will provide data on trends in occupancy and distribution in the subbasin. This understanding will allow us to work towards restoration and recovery of bull trout populations within the Lower Columbia Recovery Unit as well as range wide.

The objectives of this project are to 1) apply RMEG guidance on monitoring bull trout occupancy and distribution in the Lewis River subbasin, 2) evaluate the application of RMEG guidance to provide feedback on utility of approach in other subbasins, and 3) quantitatively assess occupancy and distribution of bull trout in the Lewis River subbasin. Specific tasks for 2006 and 2007 are to delineate patches for the Lewis River subbasin, determine site-specific detection probability and assess bull trout occupancy in eight patches within the Lewis River subbasin.

Methods

Patch Delineation

The approach to describing bull trout patches in the Lewis River subbasin followed RMEG recommendations (RMEG 2008). Patches were identified using temperature:elevation relationships, stream order and determining catchment areas for subwatersheds that fall within the acceptable temperature and stream size thresholds.

Digital Elevation Models (DEMs, 10 m resolution) were acquired for each quadrangle in the Lewis River subbasin from the University of Washington (GIS at Earth Space and Science, http://duff.ess.washington.edu/data). The quadrangles were appended to one another to construct a single Lewis River subbasin DEM. A 1:100k resolution stream layer for the Lewis River subbasin was acquired from the National Hydrography Dataset web site (http://nhd.usgs.gov).

A maximum instantaneous annual stream temperature of 16^{o}C was used as the threshold to identify the lowest boundary of a stream segment that is likely to support bull trout populations. Temperature data was acquired from water quality monitoring conducted from 1996-2003 on the Gifford Pinchot National Forest (GPNF 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003). The maximum instantaneous annual stream temperature for various stream locations in the Lewis River subbasin were determined for the overall time period. In other words, if one year of monitoring occurred at a location, then the maximum temperature from that year was used. If several years of monitoring occurred at a location, then the highest maximum temperature achieved over all years was used. Geographic coordinates (UTM NAD 83) were determined for all stream locations used and elevation was determined using the constructed Lewis River subbasin DEM. Temperature:elevation relationships were investigated using linear regression analysis and resulted in determination of an elevation threshold above which the maximum annual stream temperature would not be expected to exceed 16^{o}C. If a statistically significant temperature:elevation relationship did not exist for the entire subbasin, linear regression was conducted on smaller portions of the subbasin representing discrete geographic areas until a statistically significant relationship resulted.

Patch delineation was conducted using ArcGIS. Watersheds were initially delineated by eliminating all areas that fell below the 16^{o}C temperature:elevation threshold. Then, all remaining areas in which the stream size was larger than a 3rd order (at a 1:100,000 scale) were eliminated. Finally, any remaining watersheds that were

smaller than 400 hectares were eliminated, resulting in the final patch delineation (areas supporting bull trout spawning and early life rearing) for the Lewis River basin.

Sample Framework

The determination of sample sites was done using a random, spatially-balanced design (Generalized Random-Tesselation Stratified, GRTS, design; Stevens and Olsen 2004). Sample sites were identified on a 1:100 k stream layer using Program R (Gentleman and Ihaka, 1996) at a density of 1 UTM coordinate every 500 m, which translated to a sample reach that went from that point upstream for 50 m.

Site-Specific Detection Probability

Site-specific detection probability (SSDP), or the probability of detecting a species where they are known to occur, was determined for bull trout in the Lewis River. This was accomplished by sampling 16 reaches in one patch (Pine 5) that was known to be occupied. The SSDP was determined as the proportion of reaches in which bull trout were detected. That proportion was used to estimate SSDP for all patches in the basin. This allowed us to estimate the number of reaches per patch that must be sampled to quantify the probability that bull trout are not present in a patch (unoccupied) if they are not detected in any reach sampled. The SSDP was applied to a model developed by RMEG (2008).

To facilitate potential evaluation in the future of the relationship between various habitat variables and SSDP, habitat measurements were collected from the study reach. The gradient of each sampling site was measured using a hand-held clinometer. Gradient was measured and recorded twice at each site, from the top of the reach to the middle, and again from the middle to the bottom of the reach. The eye level height of the person sighting the gradient was measured against the person standing downstream. One surveyor stood level with the water's edge upstream and measured the percent gradient against the second surveyor standing downstream at level with the water's edge.

Transects were flagged along the thalweg at every 10 m mark from 0 to 50 m. Channel dimensions were then measured along each of the six designated transects within the 50 m sampling reach. For each transect, measurements were completed for the wetted width, maximum depth along the transect line, and depth recordings at a ¼, ½, and ¾ marks across the wetted width. Total length of the reach measured along the bank was also recorded as an index of sinuosity.

Within each reach, large woody debris (LWD) was categorized and counted. Only pieces of wood directly within the channel or within 1 m of the water's surface were considered. Wood was classified into four categories: LWD > 10 cm in diameter and > 3 m in length, LWD > 60 cm in diameter and > 10 m in length, root wads and LWD piles (aggregates of > 4 pieces of wood together) were quantified within each reach.

The number, type and size of undercut banks were measured along both sides of the sampling reach. Undercuts were defined as areas under boulders, banks, wood, or bedrock along the stream bank that were > 5 cm deep, > 10 cm in length, and > 5 cm in height (e.g., PIBO; Kershner et al. 2004). Only undercuts within 0.5 m of the stream surface were considered.

Occupancy and Distribution

Sampling was conducted in each reach using backpack electrofishing. Each 50 m reach was sampled from the downstream to the upstream boundary. All fish encountered were captured and identified. Bull trout length and mass were documented to facilitate size class determination. The patch was considered occupied (by a population) if two age classes (as determined by size classes > 30 mm difference in fork length) of bull trout were captured in any combination of one or more reaches within a patch. Since, both bull trout and brook trout (*Salvelinus fontinalis*) may inhabit these watersheds and hybridization between the two could occur, *Salvelinus* species were carefully scrutinized for distinguishing features (e.g., vermiculation, black markings on fins, halos) before identification (Holton and Johnson 1996). All fish captured were released alive within the sampled reach.

Results

Patch Delineation

A statistically significant relationship between temperature and elevation did not exist for the subbasin as a whole. Temperature:elevation relationships were quantitatively evaluated in four distinct geographic areas of the Lewis River subbasin (Upper Lewis, Clear, Muddy and East Fork/Canyon/Siouxon). Linear regression provided the best fit for each dataset. The Upper Lewis provided the only statistically significant relationship (Figure 2). However, the results indicated a similar temperature:elevation relationship in three of the drainages (Upper Lewis, Clear and East Fork/Canyon/Siouxon). Therefore, these three drainages were combined. The result was a statistically significant linear relationship (Figure 3). The temperature:elevation relationship at the 16^{o}C threshold in the Muddy River was significantly different and this drainage was evaluated separately. The resulting relationship, suggested that maximum stream temperature does not exceed 16^{o}C in the Lewis River (excluding the Muddy River watershed) at elevations of 570 m or greater. For the Muddy River, the equivalent elevation was 1230 m or greater. Application of this information to the Lewis River subbasin identified 502 subwatersheds that could potentially support bull trout based on temperature alone (Figure 4a). Applying the stream order filter to these subwatersheds resulted in one of them being split into six subwatersheds for a total of 507 (Figure 4b). Applying the final patch size filter resulted in the identification of 33 patches in the Lewis River subbasin. These patches ranged in size from 515 to 11,905 hectares (Figure 4c).

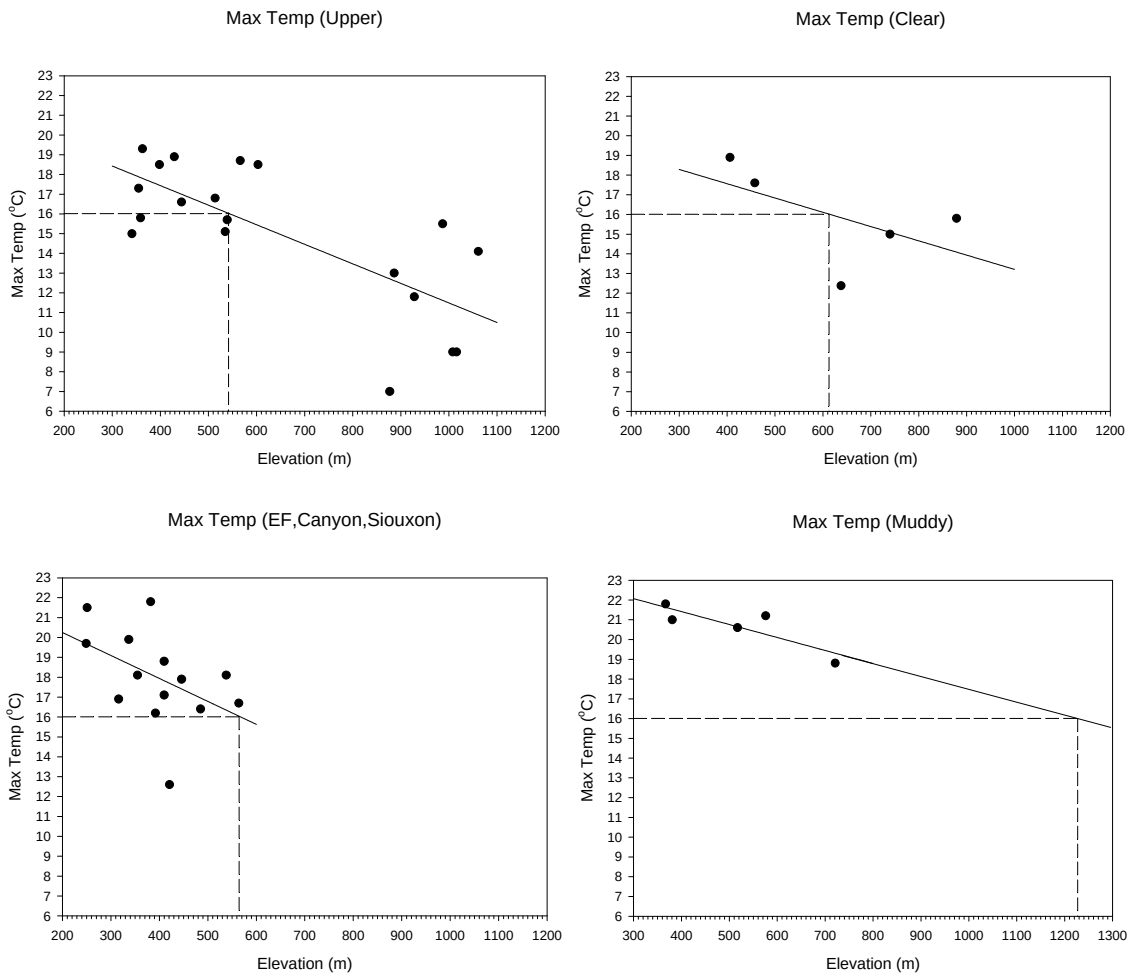

Figure 2. Linear regression analysis results for four distinct geographic areas in the Lewis River subbasin.

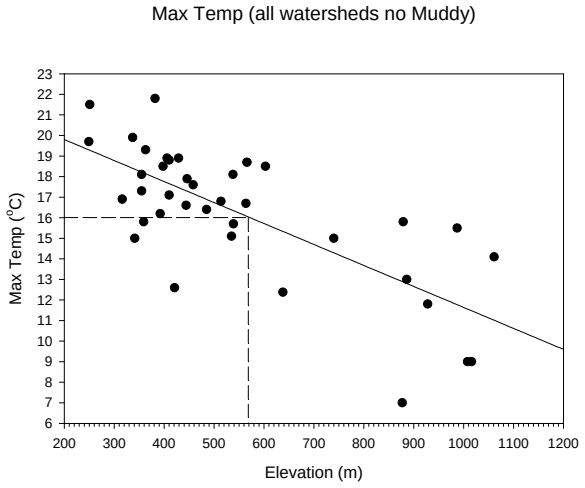

Figure 3. Linear regression analysis results for Lewis River (excluding the Muddy River) in Lewis River subbasin.

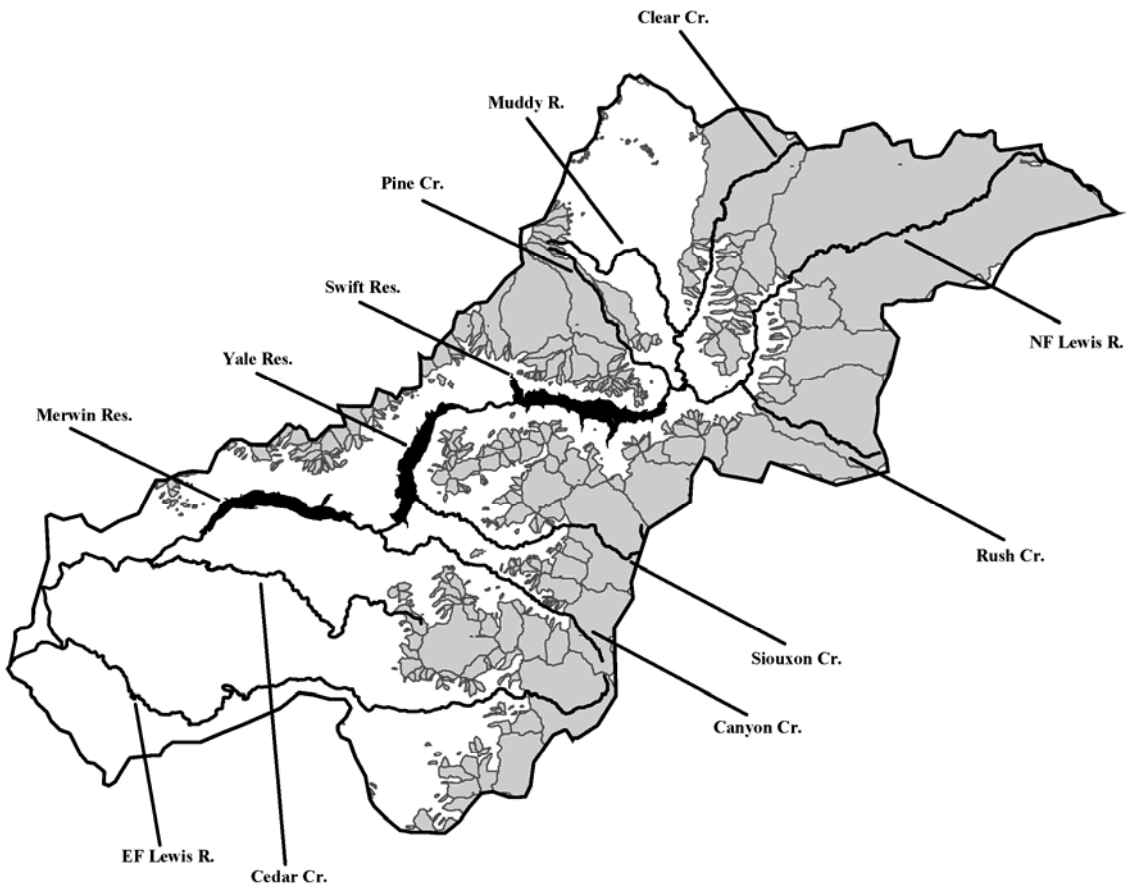

Figure 4a. Lewis River subbasin bull trout patches (n=502) identified by temperature:elevation.

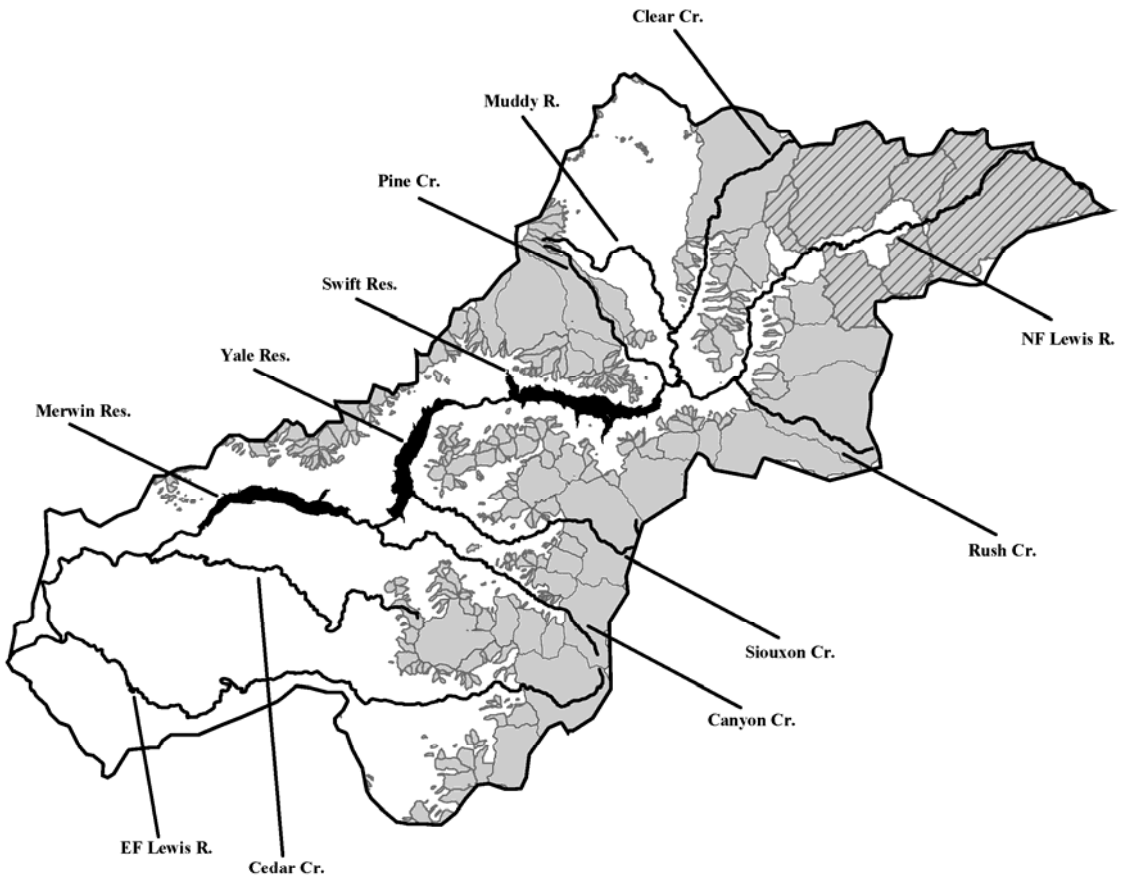

Figure 4b. Lewis River subbasin bull trout patches (n=507) identified by temperature:elevation and stream order. Six patches with cross hatch are the new patches identified using the stream size filter.

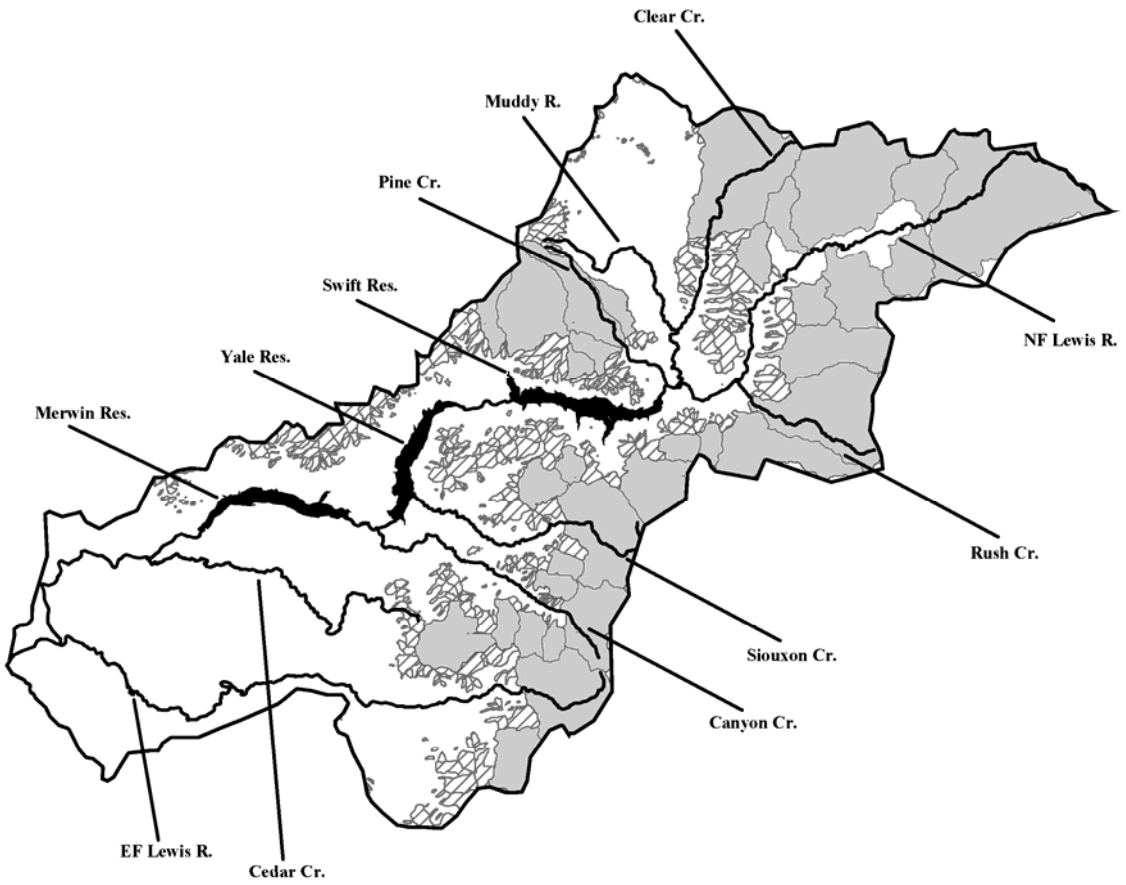

Figure 4c. Lewis River subbasin bull trout patches (n=33), in grey, identified by temperature:elevation, stream order, and patch size. Areas with cross hatch were previously identified as potential patches but dropped due to small size.

SSDP

Field work to determine SSDP in the Lewis River subbasin occurred on August 31, 2006, in conjunction with the *Salvelinus confluentus* Curiosity Society annual meeting. Six field crews completed surveys in 16 reaches within the Pine5 patch (Figure 5), a patch known to be occupied by bull trout (USFWS 2002b). Bull trout were captured at 6 of the 16 sites (Table 1, Figure 6), yielding an SSDP of 37.5%. Given this SSDP applied to the model developed by RMEG (2008; Figure 7), if 3, 5, or 7 reaches were sampled within a patch and no bull trout were detected, the probability that bull trout occupied that patch would be less than 0.20, 0.10, or 0.05, respectively. Brook trout, a bull/brook hybrid, coastal cutthroat trout and *O. mykiss* were captured within the patch as well (Figure 6). Electrofishing effort across all reaches sampled averaged 573 seconds per site. Habitat data as described in methods was also collected during this effort (Table 2).

Table 1. Sites surveyed for determination of SSDP and species found in 2006.

Patch	Site	Sample Date	Salmonid Species	Non-Salmonid Species
Pine 5 Creek	2	8/31/2006	Bull Trout	-
	4	8/31/2006	Brook Trout	-
	5	8/31/2006	Bull Trout, Cutthroat Trout	-
	7	8/31/2006	Bull Trout	-
	8	8/31/2006	Bull Trout, Cutthroat Trout	-
	9	8/31/2006	Brook Trout	-
	10	8/31/2006	-	-
	12	8/31/2006	-	-
	14	8/31/2006	Bull/Brook Hybrid, Brook Trout	-
	15	8/31/2006	Brook Trout	-
	16	8/31/2006	Cutthroat Trout	-
	19	8/31/2006	Bull Trout	-
	20	8/31/2006	Bull Trout, Cutthroat, *O. mykiss*	-
	22	8/31/2006	Brook Trout, Cutthroat Trout	-
	23	8/31/2006	-	-
	24	8/31/2006	Brook Trout	-

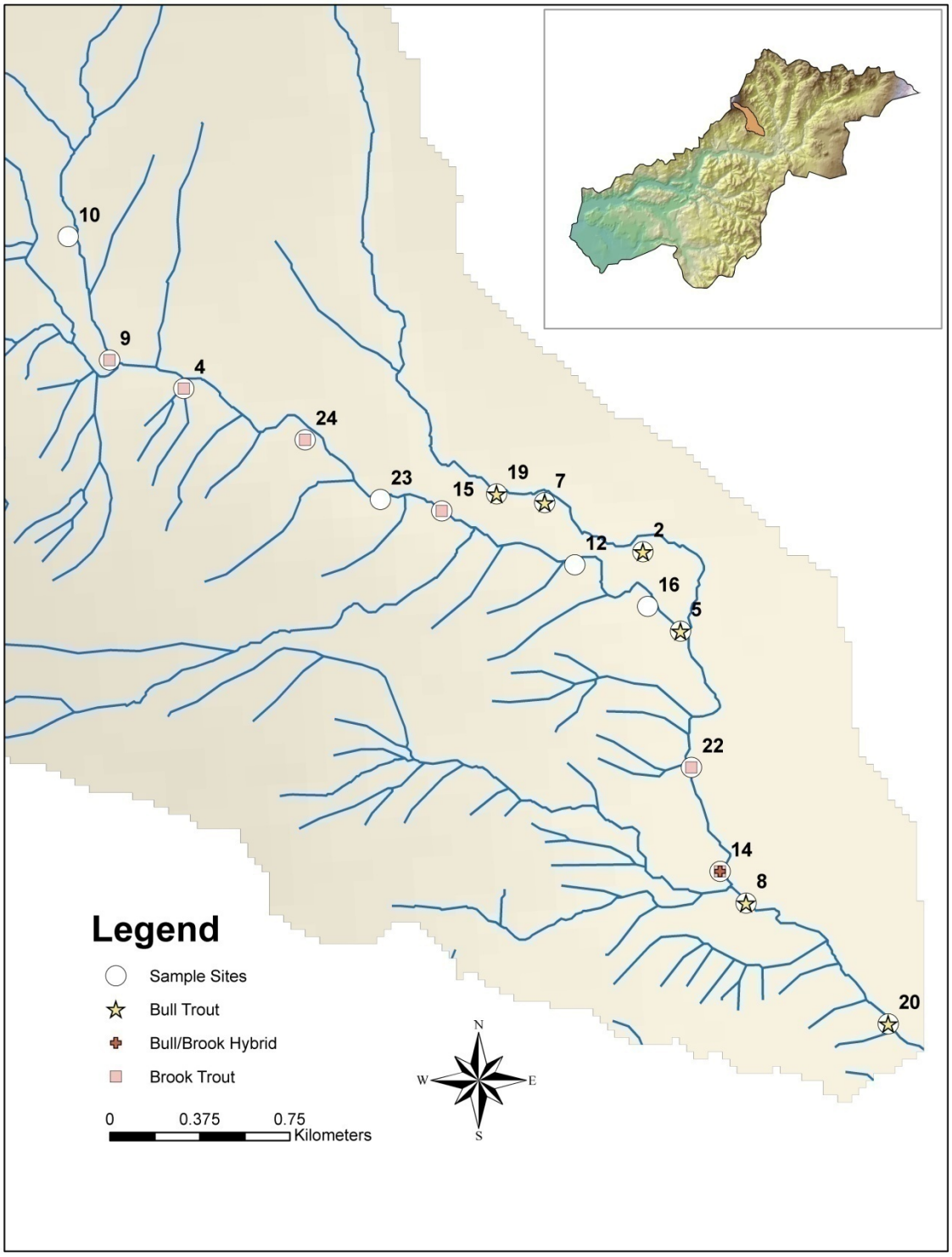

Figure 6. Pine 5 patch reaches sampled in 2006. Legend indicates species collected and sites sampled which correspond to a reach number on the map.

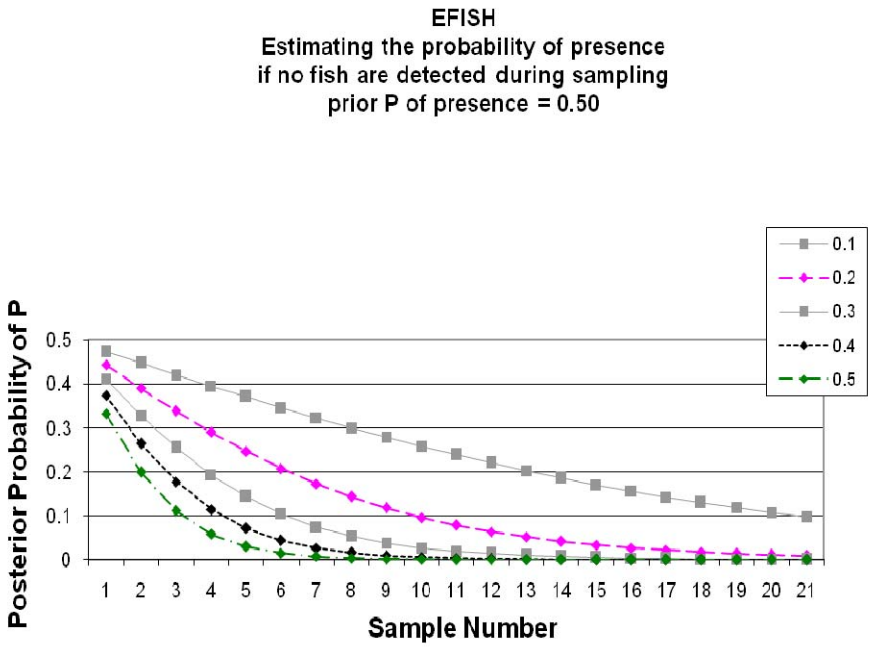

Figure 7. The relationship between the probability of bull trout presence in a patch (posterior probability of P) if no bull trout are detected and the number of reaches sampled. The curves represent various SSDPs ranging from 0.10 – 0.50.

Table 2. Habitat data collected in the Pine5 patch in 2006.

		Pine 5 Creek (2006)															
Site		2	4	5	7	8	9	10	12	14	15	16	19	20	22	23	24
Date		8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31	8/31
Time Start		1055	1030	1115	1220	1236	1205	1330	1425	1440	1200	1225	1330	1055	1210	1320	1425
Time End		1145	1105	1207	1310	1310	1230	n/a	1445	1530	1220	1305	1420	1115	1305	1341	1455
Temperature (°C)		6.5	6.0	7.3	6.5	7.8	8.5	8.5	8.4	7.0	n/a	7.6	6.5	8.9	7	n/a	n/a
Conductivity (µs)		90	40	40	90	n/a	35	40	40	n/a	n/a	40	90	92	n/a	n/a	n/a
Large Woody Debris	**# >3m L >10cm D**	1	2	13	1	0	0	0	1	2	4	10	4	1	4	7	3
	LWD Piles	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0
	# >10 m L >60 cm D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average Depth (m)		0.59	0.26	0.25	0.61	0.59	0.10	0.11	0.31	0.38	0.69	0.26	0.53	0.49	0.49	0.60	0.78
Average Wetted Width (m)		7.1	5.8	6.6	6.3	9.3	1.3	1.7	6.8	13.4	5.62	5.5	8.9	9.9	9.8	n/a	5.4
% Undercut		18.8	12.5	12.6	19.4	6.9	4.9	4.85	14.3	16.3	14.5	12.7	19.6	9.9	34.2	12.1	5.8

Occupancy and Distribution

Field work in the Lewis River subbasin occurred on August 31, 2006 and from July 17 through August 30 of 2007. Seven reaches in each of seven patches (Big Creek, Chickoon Creek, Clear1 Creek, Curly Creek, Miller Creek, Tillicum Creek, and Unnamed Trib. 9; Figure 8) were completed in 2007 for a total of 49 reaches (Table 3). No bull trout were collected in any of these patches. Other salmonid species found throughout the patches included *O. mykiss*, brook trout, and cutthroat trout. Habitat data collected reflected stream complex channel morphology, varying quantity and type of cover (undercutting, LWD), relatively high water temperature, high gradient and moderate conductivity (Table 4). Electrofishing efforts for all reaches sampled in 2007 averaged 207 seconds per site.

The Big Creek patch had habitats ranging from a low gradient meadow to waterfalls near the confluence with the Lewis River. The average water temperature for this patch was 11.2°C (range 8.8 – 15.9). Reach 1 was not sampled because it was inaccessible. Reach 9 was located 40 m downstream of a waterfall. Several more waterfalls were further downstream before Big Creek joined the Lewis River. Brook trout and *O. mykiss* were present within this patch.

The average water temperature of the Chickoon Creek patch was 12.5° C (range 9.7 – 15.6). Site 6 was not sampled due to inaccessibility. No salmonid species were found in this patch.

The Clear1 patch average water temperature was 10.6°C (range 8.6 – 13.0). The patch had many steep, confined valleys with sheer granite cliffs preventing the sampling of sites 6 and 7. Site 4 was dry. Brook Trout were found at sites 2 and 3.

The average water temperature in the Curly Creek patch was 9.3°C (range 6.2 – 13.1). There were many dry sites located on Outlaw Creek (1, 4, 5, 8, 9, 10, 13, and 14). Site 3 was upstream of a high gradient boulder and bedrock channel that ran dry downstream at a road crossing. Brook trout occupy this patch.

The average water temperature of the Miller Creek patch was 12.0°C (range 8.8 – 13.6). Site 3 was not sampled due to inaccessibility. No salmonids were present in this patch.

Tillicum Creek had an average water temperature of 9.9°C (range 6.7°-12.4°). Site 6 was not sampled because it was dry. Site 7 was not sampled due to inaccessibility. Coastal cutthroat trout and *O. mykiss* were present in this patch.

The Unnamed Trib 9 Patch had the highest average water temperature of any patches sampled in 2007 (14.1°C; range 9.9 – 17.6). Site 4 was located above a 15m waterfall and below a 3m waterfall. No salmonid species were found in this patch.

Barriers were documented in all patches sampled in 2007. The location of barriers at or below the most downstream extent of six of these patches (Big Creek, Chickoon Creek, Curly Creek, Miller Creek, Tillicum Creek, and Unnamed Trib. 9) make it unlikely that bull trout will naturally (re)colonize any of these patches. Furthermore, the lack of bull trout in the Chickoon Creek and Tillicum Creek patches, located above the Lower Lewis River Falls on the mainstem NF Lewis River, suggest that bull trout do not currently occupy any of the six remaining patches above those falls yet to be sampled. This information was incorporated into the current patch structure that was revised following the 2007 field season (Figure 9).

Table 3. Patches, reaches, dates sampled, species found in 2007.

Patch	Reach	Sample Date	Salmonid Species	Non-Salmonid Species
Big Creek	2	8/9/2007	Brook Trout	-
	4	8/9/2007	*O. mykiss*	-
	5	8/9/2007	Brook Trout	Frog
	6	8/14/2007	-	-
	8	8/7/2007	-	Frog
	9	8/10/200	Brook Trout, *O. mykiss*	-
	10	8/14/2007	-	-
Chickoon Creek	1	8/8/2007	-	-
	2	8/8/2007	-	Frog, Salamander
	3	8/2/2007	-	Tadpoles, Salamander
	4	8/2/2007	-	Tadpoles, Salamander
	5	8/2/2007	-	-
	7	8/2/2007	-	Frog
	8	8/8/2007	-	-
Clear1 Creek	1	7/24/2007	-	Tadpoles
	2	7/18/2007	Brook Trout	-
	3	7/18/2007	Brook Trout	-
	5	7/24/2007	-	Frog
	8	7/19/2007	-	-
	9	7/18/2007	-	-
	10	7/18/2007	-	-
Curly Creek	2	8/17/2007	Brook Trout	-
	3	8/16/2007	Brook Trout	-
	6	8/24/2007	-	-
	7	8/17/2007	Brook Trout	-
	11	8/24/2007	-	-
	12	8/21/2007	Brook Trout	-
	15	8/28/2007	-	Salamander
Miller Creek	1	8/15/2007	-	-
	2	8/15/2007	-	-
	4	8/16/2007	-	-
	5	8/15/2007	-	Tadpoles
	6	8/16/2007	-	-
	7	8/15/2007	-	-
	8	8/15/2007	-	Tadpoles
Tillicum Creek	1	8/29/2007	-	-
	2	8/29/2007	-	Salamander
	3	8/28/2007	-	-
	4	8/29/2007	-	Dicamptodon
	5	8/28/2007	Cutthroat Trout	-
	8	8/29/2007	*O. mykiss*	-
	9	8/30/2007	-	-
Unnamed Trib. 9	1	7/25/2007	-	Frog, Salamander
	2	7/25/2007	-	Frog
	3	8/1/2007	-	-
	4	7/31/2007	-	-
	5	7/25/2007	-	-
	6	7/25/2007	-	Frog, Salamander
	7	8/1/2007	-	-

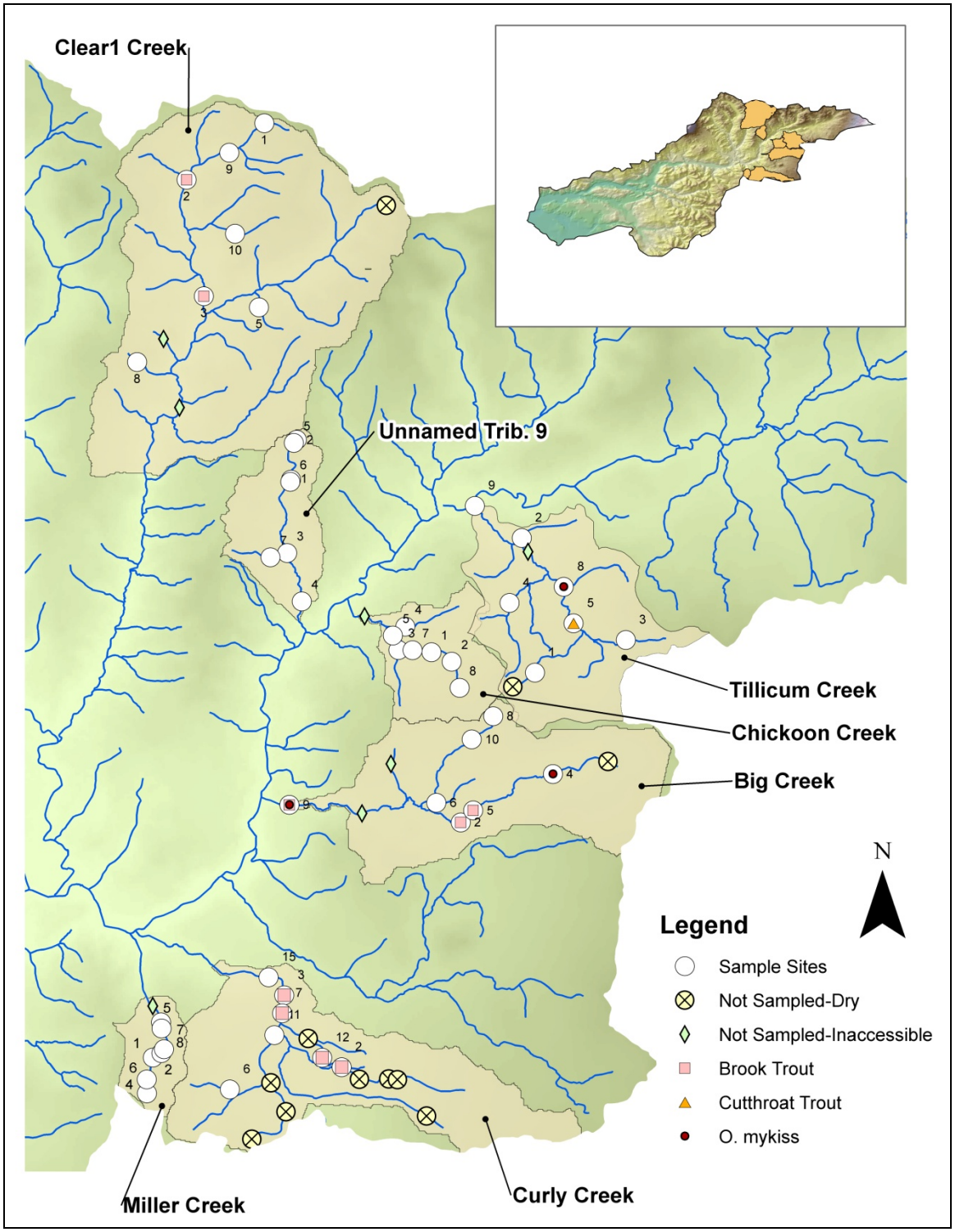

Figure 8. Patches sampled in 2007 (Big Creek, Chickoon, Clear1, Curly, Miller, Tillicum, and Unnamed Trib. 9). Legend indicates fish species collected and sites sampled which have a corresponding reach number on the map.

Table 4: Habitat data collected in the Lewis River subbasin.

		Big Creek (2007)							Chickoon Creek (2007)						
Reach		2	4	5	6	8	9	10	1	2	3	4	5	7	8
Date		8/9	8/9	8/9	8/14	8/7	8/10	8/14	8/8	8/8	8/2	8/2	8/2	8/2	8/8
Time Start		1439	1205	1546	1507	1505	1139	1315	1133	1331	1153	1537	1345	1028	1537
Time End		1522	1220	1627	1524	1515	1223	1334	1209	1358	1239	1604	1426	1105	1556
Temperature (°C)		12.5	9.0	12.5	15.9	9.2	10.7	8.8	11.4	11.0	12.8	15.6	14.6	12.6	9.7
Conductivity (µs)		45.0	44.3	37.2	57.2	33.5	41.2	37.2	35.5	32.2	38.0	86.8	41.8	45.2	28.1
Bank Length		46.4	43.8	45.0	45.0	40.5	49.3	49.9	49.6	48.6	49.0	42.2	49.4	46.5	45.7
Thalweg Length		50	50	50	50	50	50	50	50	50	50	50	50	50	50
Pools		Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	N	Y	N
Clinometer Average (%)		0.0	0.0	1.0	1.5	2.0	1.0	0.8	40.0	4.0	19.6	11.4	4.4	2.6	6.0
Large Woody Debris	**# >3m length >10cm diameter**	17	0	7	2	16	6	14	15	7	38	10	4	29	3
	LWD Piles	3	0	0	0	0	1	2	3	1	6	1	1	3	0
	# >10 m in length >60 cm diameter	6	0	3	1	5	3	6	10	6	7	4	6	6	6
	# Root Wads	2	0	0	0	0	2	2	1	0	4	0	0	3	2
Average Depth (m)		1.19	1.73	0.75	1.32	0.55	1.32	0.40	0.48	0.21	0.55	0.25	0.25	0.55	0.19
Average Wetted Width (m)		6.48	3.75	4.5	1.45	1.75	10.7	3.93	4.28	2.72	3.90	4.17	4.05	3.12	0.88
% Undercut		88	16	22	86	25.3	3.8	40.5	4.5	14.3	37.1	2.3	11.3	1.95	26.8

		Clear1 Creek (2007)							Curly Creek (2007)						
Reach		1	2	3	5	8	9	10	2	3	6	7	11	12	15
Date		7/24	7/18	7/18	7/24	7/19	7/18	7/18	8/17	8/16	8/24	8/17	8/24	8/21	8/28
Time Start		1225	1600	1500	1558	1020	1215	1045	1128	1552	1222	0946	1246	1205	1228
Time End		1312	1615	1535	1628	1110	1258	1119	1209	1643	1243	1033	1320	1337	1316
Temperature (°C)		8.6	12.9	13.0	9.6	10.6	10.6	8.7	6.8	10.4	11.0	6.2	13.1	8.1	10.0
Conductivity (µs)		31.3	34.0	37.3	36.8	27.6	36.3	33.0	63.6	44.5	23.3	38.8	33.2	46.6	40.9
Bank Length		49	58	48.3	51.0	50.5	49.5	58.2	45.4	49.0	46.0	48.4	48.8	46.7	49.2
Thalweg Length		50	50	50	50	50	50	50	50	50	50	50	50	50	50
Pools		Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	N
Clinometer Average (%)		3.2	5.0	1.2	12.8	8.8	8.2	31.8	1.8	2.0	3.0	3.0	2.5	3.5	1.8
Large Woody Debris	**# >3m length >10cm diameter**	7	9	18	10	19	3	9	37	1	8	7	1	8	4
	LWD Piles	0	0	3	1	1	0	2	4	0	1	0	0	0	1
	# >10 m in length >60 cm diameter	5	5	13	7	10	1	7	8	0	1	3	0	15	2
	# Root Wads	0	1	1	1	0	0	0	3	0	0	1	0	0	0
Average Depth (m)		0.32	0.77	1.26	0.38	0.14	0.28	0.29	1.03	1.28	0.17	0.88	0.64	0.93	0.98
Average Wetted Width (m)		2.30	7.25	1.25	2.73	2.33	3.67	2.55	5.15	8.9	2.18	7.51	4.43	4.42	5.93
% Undercut		22.2	63.9	6	25.6	11.8	31.9	20.8	51.7	15.6	64.1	30.7	0	26.0	16.6

Table 4: Habitat data collected in the Lewis River subbasin (cont.)

		Miller Creek (2007)							Tillicum Creek (2007)						
Reach		1	2	4	5	6	7	8	1	2	3	4	5	8	9
Date		8/15	8/15	8/16	8/15	8/16	8/15	8/15	8/29	8/29	8/28	8/29	8/28	8/29	8/30
Time Start		1558	1500	1230	1204	1153	1259	1419	1050	1109	1218	1250	1410	1258	1054
Time End		1612	1520	1247	1233	1204	1312	1456	1130	1157	1300	1340	1500	1340	1130
Temperature (°C)		13.0	12.1	8.8	12.6	10.6	13.6	13.3	8.3	10.9	6.7	10.8	9.5	10.7	12.4
Conductivity (µs)		25.1	26.0	29.3	25.4	24.4	25.0	27.5	30.0	80.3	57.0	33.2	53.5	51.0	54.2
Bank Length		48.2	46.4	46.4	45.7	44.5	49.0	48.0	47.3	47.9	46.3	47.3	48.6	50.6	49.1
Thalweg Length		50	50	50	50	50	50	50	50	50	50	50	50	50	50
Pools		Y	Y	N	Y	Y	Y	N	N	N	Y	N	Y	N	Y
Clinometer Average (%)		4	3	5	1.3	3	1.5	2.5	6.5	8.3	13.0	3.0	3.0	2.5	2.0
Large Woody Debris	**# >3m length >10cm diameter**	22	50	5	13	20	10	4	7	15	15	21	9	4	1
	LWD Piles	3	7	1	1	2	1	1	1	1	2	3	1	0	0
	# >10 m in length >60 cm diameter	3	14	1	5	10	5	3	1	6	4	1	3	2	1
	# Root Wads	2	7	0	2	3	0	1	0	1	0	0	0	0	1
Average Depth (m)		0.24	0.28	0.14	0.33	0.10	0.65	0.20	0.47	0.29	0.69	0.64	0.57	0.80	0.86
Average Wetted Width (m)		2.27	2.02	1.40	3.42	1.67	3.33	2.10	2.05	1.87	4.12	3.23	7.37	5.48	8.68
% Undercut		2.5	56.5	39.7	56.1	50.5	18.1	19.5	18.8	37.6	18.2	34.3	0	2.7	20

		Unnamed Trib. 9 (2007)						
Reach		1	2	3	4	5	6	7
Date		7/25	7/25	8/1	7/31	7/25	7/25	8/1
Time Start		1107	1343	1433	1245	1430	1003	1206
Time End		1151	1418	1502	1325	1452	1038	1255
Temperature (°C)		10.1	17.6	14.9	16.7	16	9.9	13.5
Conductivity (µs)		24.0	26.3	29.9	31.1	26.3	25.9	24.6
Bank Length		49.7	50.9	45.4	45.0	n/a	40.9	48.2
Thalweg Length		50	50	50	50	50	50	50
Pools		Y	N	Y	Y	Y	Y	Y
Clinometer Average (%)		15.8	5.4	6.4	17.4	17.4	3.0	4.6
Large Woody Debris	**# >3m length >10cm diameter**	7	0	4	4	12	5	8
	LWD Piles	1	0	2	0	0	0	3
	# >10 m in length >60 cm diameter	3	2	5	3	1	3	22
	# Root Wads	0	0	0	0	0	1	1
Average Depth (m)		0.45	0.40	0.76	0.63	n/a	0.30	0.27
Average Wetted Width (m)		2.33	1.00	3.92	5.17	n/a	4.55	2.15
% Undercut		18.2	1.2	16.8	2.0	0.5	30.8	5.6

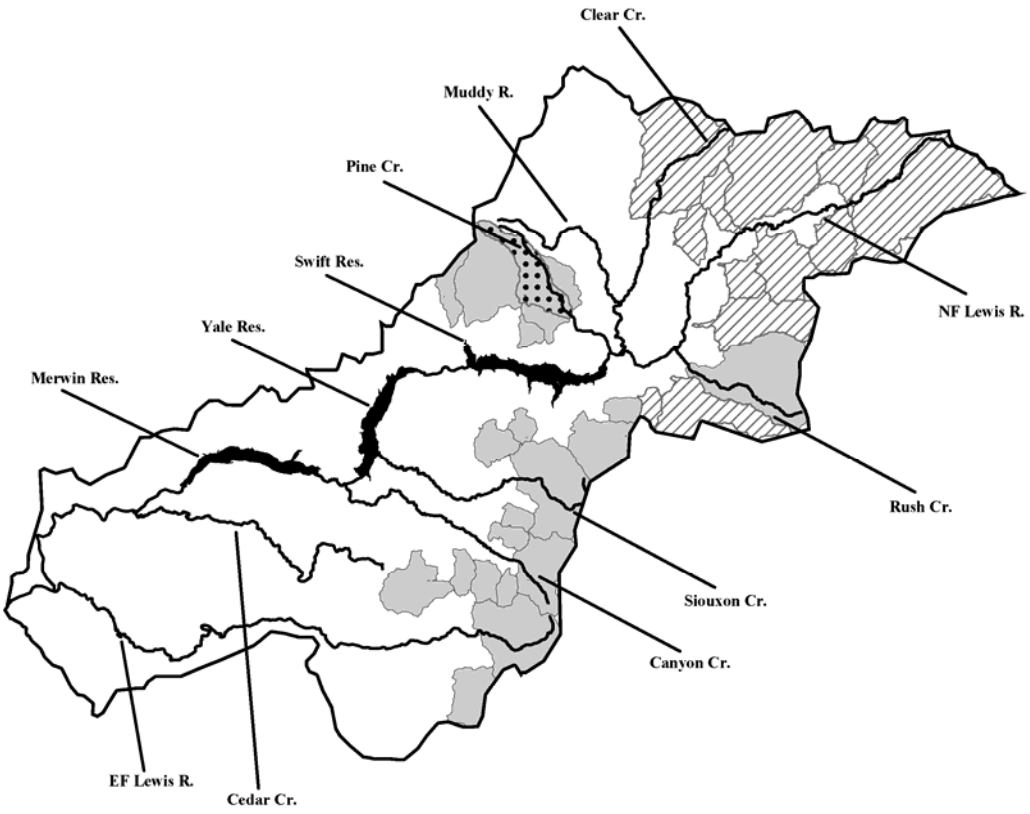

Figure 9. The Lewis River subbasin patch structure following the 2007 field season. Grey patches with dots are occupied by bull trout, white patches with cross hatch are not occupied by bull trout, and grey patches have not been sampled.

Findings

- RMEG guidance can be applied in a straightforward manner to generate bull trout patches when certain information (e.g., temperature monitoring data, GIS coverage) is readily available.
- SSDP suggested sampling seven sites within a patch can yield a probability of < 0.05 that were bull trout were present if not detected.
- Sampling in the eight designated patches resulted in an observation of bull trout in one patch. Thus, we conclude that 12.5% (1 of 8) of the Lewis River subbasin patches sampled through 2007 were occupied by bull trout.
- Work in 2008 will focus on continuing to assess occupancy of remaining patches in the Lewis River subbasin. By expanding the number of sampled sites within a occupied patch, species distribution within the patch can be better documented.
- Bull trout are known to be in Rush Creek below a barrier (USFWS 2002b). However, the occupied part of this stream for the most part lies outside the patch boundary. This suggests that additional considerations to determining bull trout areas of spawning and early life rearing (patches) may exist, or be necessary, in certain geographic areas (e.g., where adfluvial populations of bull trout utilize large reservoirs for rearing).

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