

White Salmon River Basin: Lamprey Project

(NFWF Project #2006-0175-020)

Final Programmatic Report

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Introduction

The White Salmon River (WSR) is in southwest Washington in the Columbia River Gorge and it originates on Mount Adams (Figure 1). The U.S. Congress designated the WSR under both the Wild and Scenic Rivers Act and the Columbia Gorge National Scenic Area Act (NMFS 2009). The WSR basin is within lands ceded to the United States government by the Yakama Nation. Historically, the WSR supported Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, steelhead *O. mykiss*, coastal cutthroat trout *O. clarki*, bull trout *Salvelinus confluentus*, Pacific lamprey *Entosphenus tridentatus* and western brook lamprey *Lampetra richardsoni* populations (NPCC 2004). However, with the construction of Condit Dam in the early 1900's, anadromous fish production in the WSR declined drastically. After the destruction of the fish ladder by high flows in 1919, passage upstream of Condit Dam was blocked to all fishes (NMFS 2009). In addition, because of habitat loss and flow alteration caused by hydroelectric operations, little anadromous fish production occurs downstream of Condit Dam.

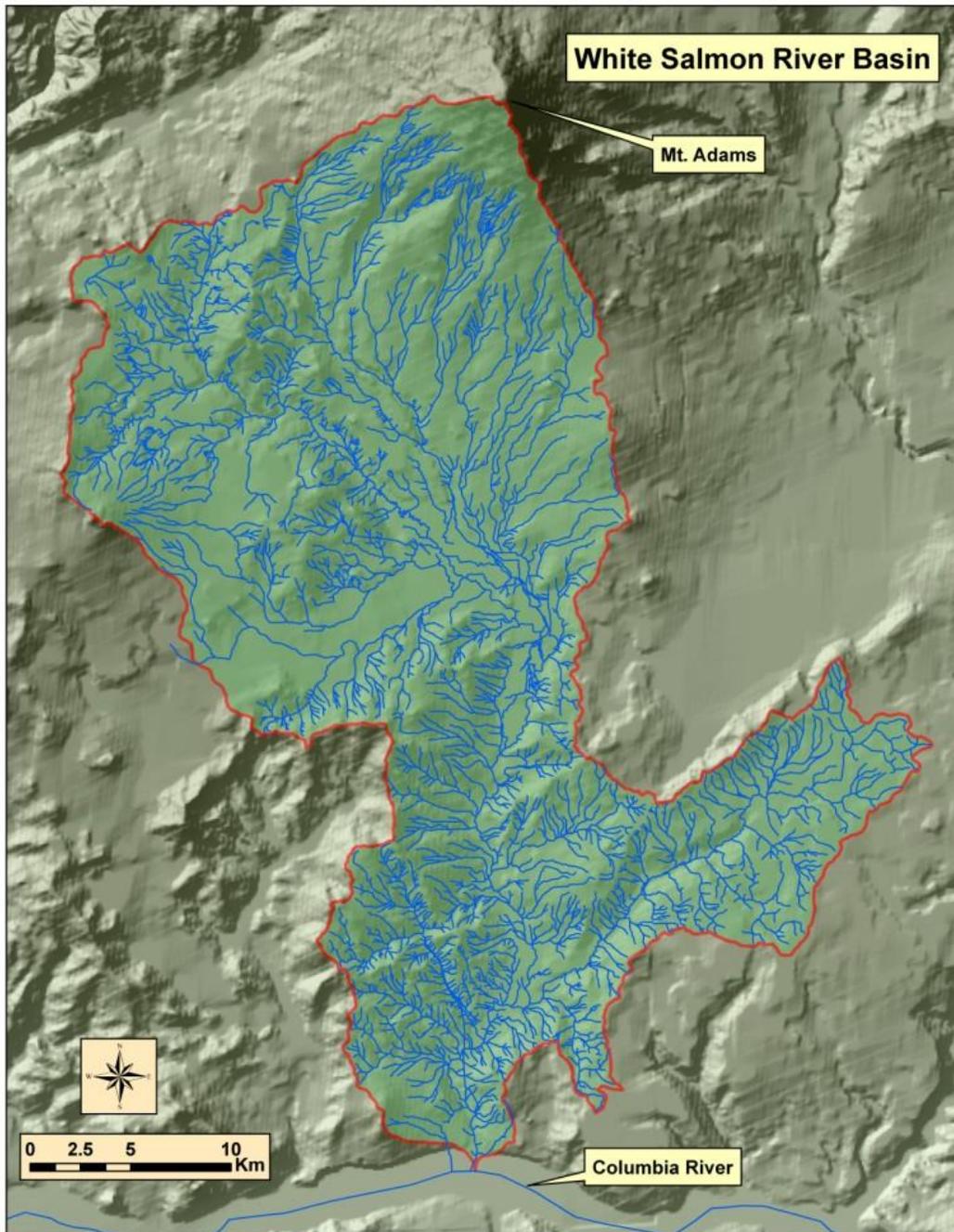


Figure 1. The White Salmon River basin, from its headwaters on Mount Adams to the Columbia River.

The Condit Hydroelectric Project, owned by PacifiCorp, includes 144-m long Condit Dam which is 38-m high, with a 38-m spillway. The 95 year-old project is located 5.3 km upstream from the confluence of the WSR and the Columbia River and is the only man-made

impoundment along the river's 72 km length. Condit Dam is scheduled to be removed in the fall of 2011 reconnecting historic fish spawning habitat to the mainstem of the Columbia River (NMFS 2009). The U.S. Fish and Wildlife Service has partnered with the Yakama Nation, the U.S. Geological Survey, the Washington Department of Wildlife, NOAA Fisheries and PacifiCorp to assess the impact that the removal of Condit Dam may have on fish populations and aquatic habitats in the WSR basin. The U.S. Fish and Wildlife Service has identified Pacific lamprey, bull trout, and coastal cutthroat trout as the highest priority species for restoration in the WSR basin (R.O. Engle, USFWS, personal communication).

Whether and to what extent lamprey inhabit the WSR is unclear. Preliminary survey data of lamprey species in the WSR basin suggested that resident western brook lampreys (WBL) were rare above Condit Dam, while anadromous Pacific lampreys (PCL) may be locally extirpated (Rawding 2000). Pacific lampreys are limited by many of the same factors as salmon and steelhead, such as dam passage and habitat loss, and populations throughout the Columbia River Basin have declined to a remnant of their historical levels (Close 2002). While resident fish (i.e., *Cottidae*, *Salmonidae*) appear to be the primary inhabitants upstream of the dam (Rawding 2000), habitat surveys have suggested that there is suitable habitat both downstream and upstream of the dam for spawning and rearing of anadromous fish, including lampreys (NMFS 2009; C.W. Luzier, USFWS, personal communication).

The goal of this project is to evaluate how western brook and Pacific lamprey respond to the removal of Condit Dam. This phase of the project focused on quantitatively assessing the current status and distribution of lamprey species in the WSR prior to Condit Dam removal. This baseline data will facilitate comparisons of lamprey status and distribution, and habitat conditions after dam removal. Assessments of lamprey populations in the WSR basin before and

after removal of Condit Dam are imperative for evaluating the efficacy of restoration work and the need for further restoration to ensure long-term conservation of lamprey species. This project will inform efforts in the WSR basin, in particular, and efforts to reestablish Pacific lamprey in other basins. The specific objectives of this project were to: 1) identify areas in the WSR where Pacific lamprey would be likely to spawn, 2) determine the probability of detecting larval lampreys in an occupied watershed, 3) determine presence and distribution of Pacific lampreys and western brook lampreys before removal of Condit Dam, 4) determine if anadromous lampreys return to suitable spawning habitat after removal of Condit Dam, 5) determine the rate that anadromous lampreys may return after dam removal, and 6) determine whether Pacific lampreys become established in streams with western brook lamprey or streams without western brook lamprey. Objectives one, two and three are discussed in this annual report; objectives four, five, and six are proposed objectives that will be addressed after the removal of Condit Dam.

Methods

Sample Units

All watersheds in the WSR basin up to 3rd order in size (at 1:100,000 scale) were delineated as units of potential adult lamprey spawning and larval rearing (NMFS 2009; C.W. Luzier, USFWS, personal communication). These watersheds were defined as the sample unit for which we would evaluate lamprey occupancy. According to these criteria, a total of 21 viable sample units were identified in the WSR basin. Two additional areas, the White Salmon River mainstem below Condit Dam and Northwestern Lake (the area impounded by Condit Dam) were also included as sample units (Figure 2). Furthermore, we identified sample units in

the basin that represent relatively high probability of Pacific lamprey recolonization potential after the removal of Condit Dam as those with relatively high intrinsic potential to support anadromous steelhead spawning (D. Holzer, NOAA, personal communication; Figure 2).

Spawning of Pacific lamprey and steelhead overlaps, as they select similar sized substrates (Scott and Crossman 1973; Bjornn and Reiser 1991).

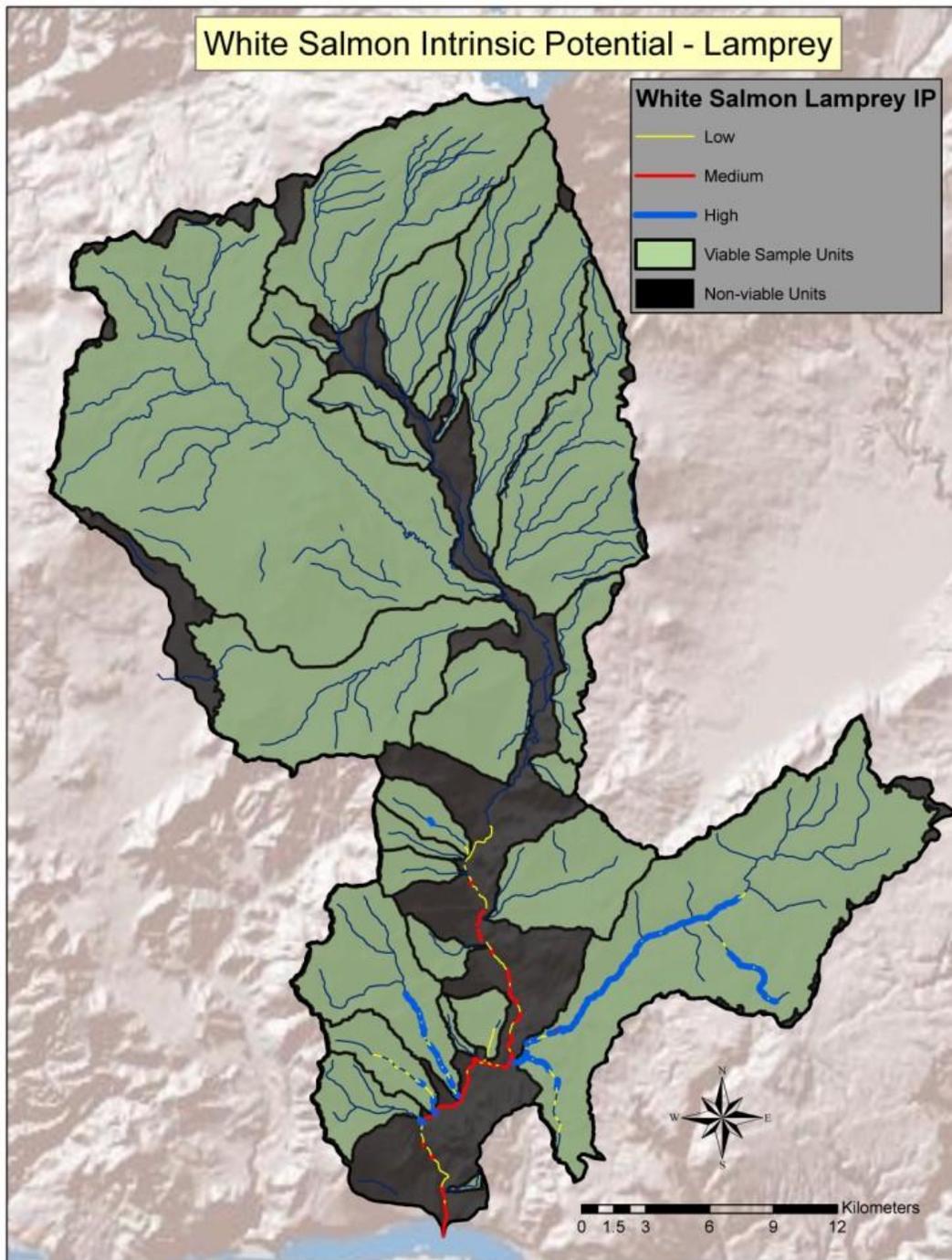


Figure 2. Sample units (n = 21) in the White Salmon River basin and intrinsic potential rankings for supporting Pacific lampreys. Rankings were generated for steelhead and applied here for Pacific lamprey. Non-viable units did not satisfy sample unit criteria.

Sample Framework

In each sample unit, randomly selected, spatially-balanced 50 m sample reaches were delineated using the Generalized Random Tessellation Stratified (GRTS) method (Stevens and Olsen 2004). On average, one 50 m reach was selected every 0.5 km of stream. The GRTS method assigns a hierarchical order to the selected 50 m reaches within a watershed which is used as an unbiased method of ranking the priority of reaches for sampling. In this study, low numbered reaches within each watershed were designated as the highest priority for sampling (Figure 3). The reaches were sampled in non-sequential order, generally beginning with the reach lowest in the watershed and moving upstream. Sampling for larval lampreys was conducted using an AbP-2 backpack electrofisher (ETS Electrofishing, Verona, WI). If a given reach in a sample unit could not be electrofished (e.g., dewatered or inaccessible), the reach was omitted from the sample unit and the next highest priority reach was added. This technique maintained the spatial balance and randomization of sample reaches. When two lampreys differing by more than 20 mm in TL (of the same species) were captured in a reach, the sample unit was considered occupied (additional reaches in that unit were not sampled).

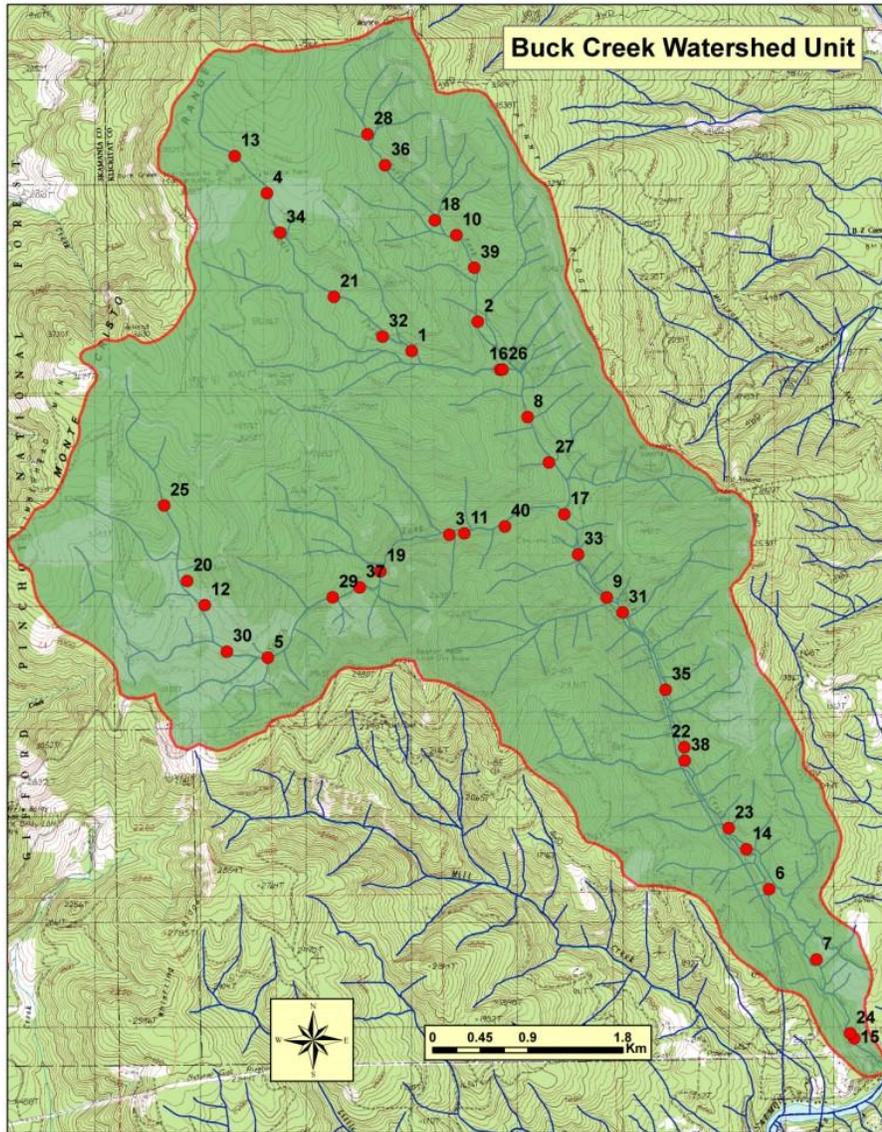


Figure 3. An example of a sample unit (Buck Creek) and randomly selected, spatially-balanced 50-m sample reaches as generated with the GRTS method. Reaches 1-21 were the highest priority and were generally electrofished beginning with the lowest in the watershed (i.e., reach 15) and moving upstream.

2007

The 21 highest priority, feasible reaches in Buck Creek and Trout Lake Creek were sampled for larval lampreys using a backpack electrofisher (Figure 4). Results of this larval lamprey sampling effort were used to calculate larval lamprey detection probability (DP) in an occupied sample unit, that is, one known to contain larval lampreys. In turn, this DP information

was used to determine the number of reaches necessary to conduct a probabilistic evaluation of larval lamprey occupancy in subsequent sample units (i.e., unknown occupancy; see Peterson and Dunham 2004). Sampling of Rattlesnake Creek to determine occupancy by larval lampreys began in 2007 as well (completed in 2009).

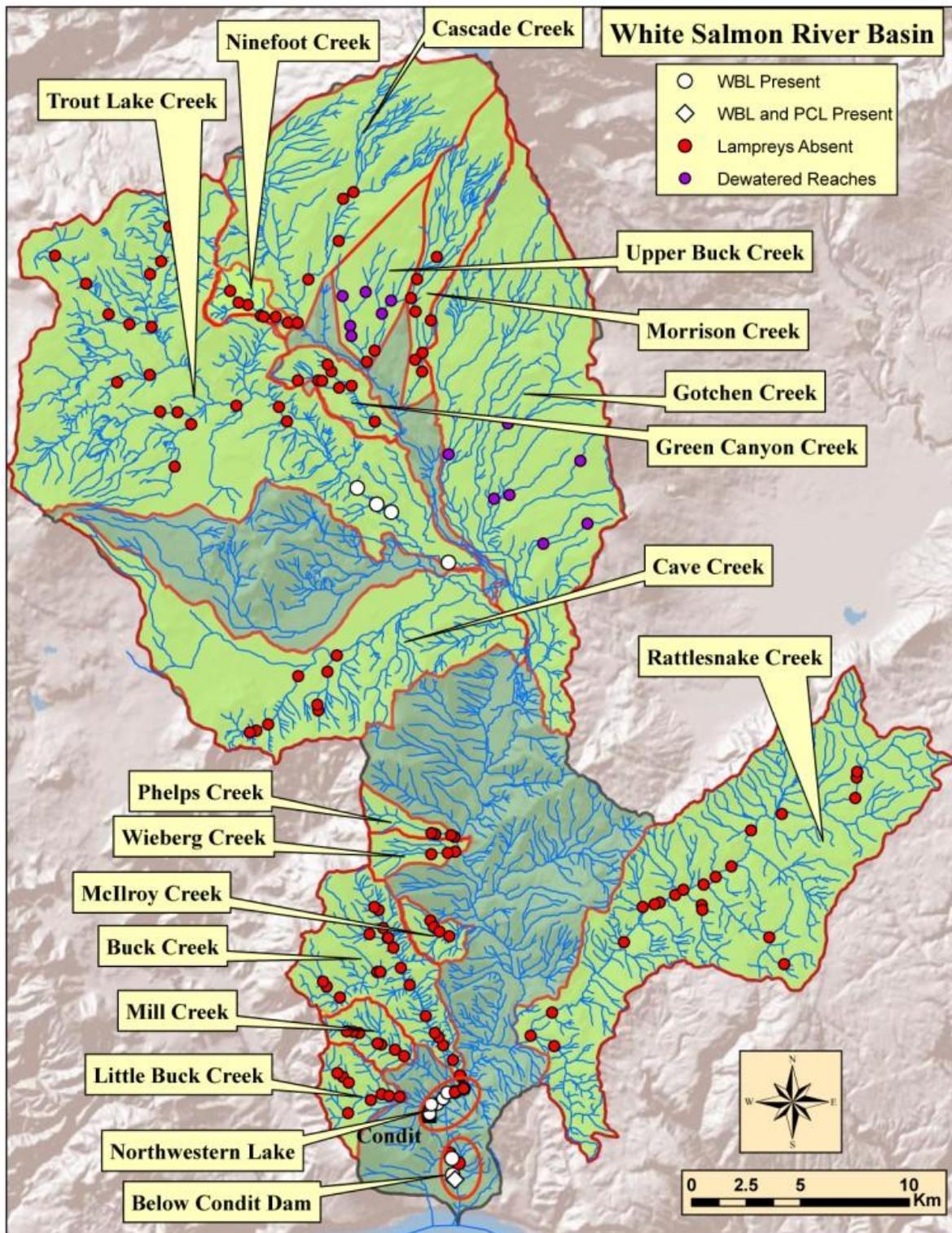


Figure 4. Sample units in the White Salmon River basin where electrofishing sampling was conducted. Larval and adult western brook lampreys were captured in four reaches on Trout Lake Creek and at six sites in Northwestern Lake. Below Condit Dam, larval western brook lampreys were captured at three sites and larval Pacific lampreys at one site.

The White Salmon River mainstem below Condit Dam was also sampled for larval lampreys with a backpack electrofisher (Figure 5). This area of the river was largely within a steep canyon and was accessed using an inflatable raft launched at the Condit Dam powerhouse. We floated the river to the Highway 14 bridge near the mouth of the Columbia River. The raft was stopped at several locations where potentially suitable larval rearing habitat was encountered and river margins of wadeable depth were electrofished. A total of five sites were sampled below Condit Dam.

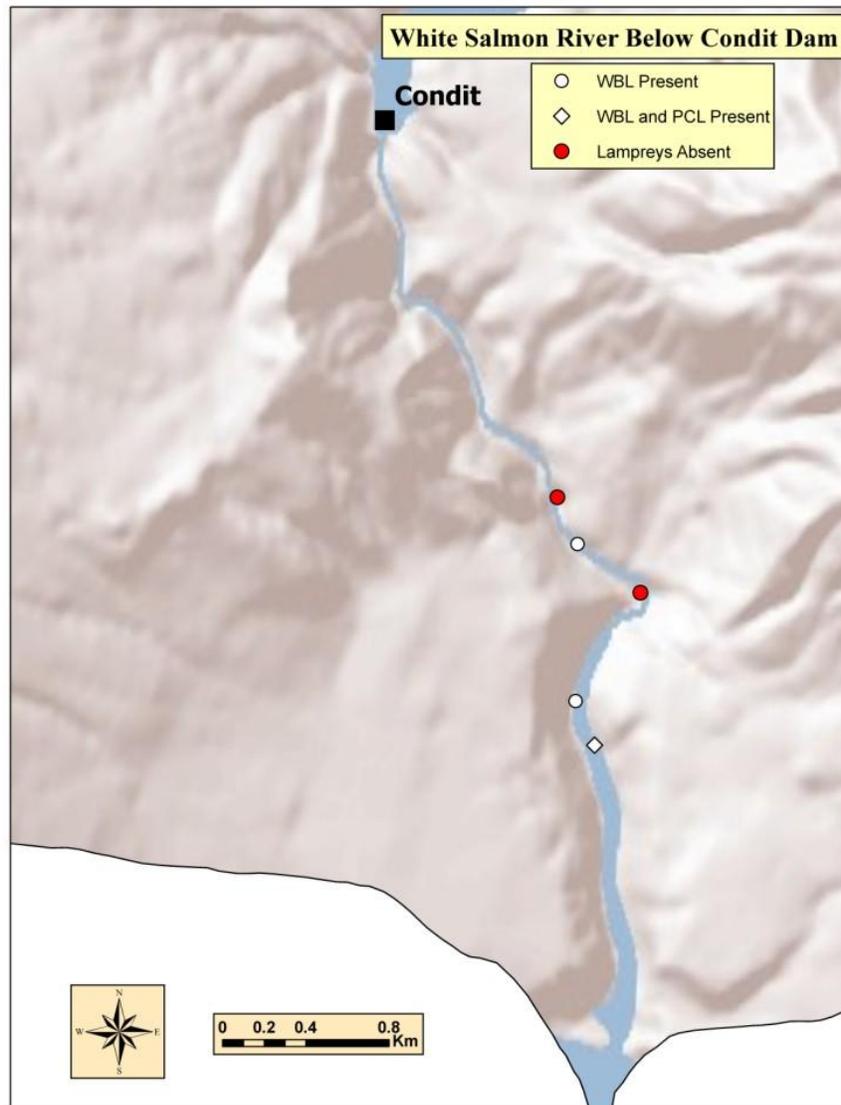


Figure 5. Sample sites on the White Salmon River below Condit Dam in 2007. In 2009 and 2010, only the lowest site (white diamond) was sampled.

2008

To determine occupancy by larval lampreys, randomly selected 50 m reaches (i.e., the highest priority reaches) were electrofished in the Little Buck Creek, Mill Creek, and Morrison Creek sample units (Figure 4).

2009

To determine occupancy by larval lampreys, randomly selected 50 m reaches (i.e., highest priority reaches) were electrofished in Phelps Creek, Wieberg Creek, Gotchen Creek and Upper Buck Creek sample units (Figure 4). Additional reaches within the Rattlesnake Creek unit were sampled to complete the 21 highest priority reaches in this unit (Figure 4). The White Salmon River mainstem below Condit Dam was again electrofished for larval lampreys in 2009 as described above (Figure 5).

2010

To determine occupancy by larval lampreys, randomly selected 50 m reaches (i.e., the highest priority reaches) were electrofished in Green Canyon Creek, Cave Creek, Ninefoot Creek, Cascade Creek and McIlroy Creek. The White Salmon River mainstem below Condit Dam was again electrofished for larval lampreys in 2010 as described above (Figure 5).

Northwestern Lake

Northwestern Lake, a reach of the White Salmon River impounded by Condit Dam, was also sampled to assess larval lamprey occupancy within the approximately 3.2 km long lake (Figure 6). Eight randomly selected, spatially-balanced sample sites along the thalweg of Northwestern Lake were delineated using the GRTS method as described above (Stevens and Olsen 2004). The sites ranged from immediately above Condit Dam, upstream to the confluence with Buck Creek (Figure 3, Figure 6). Sample sites in Northwestern Lake were accessed by boat and sampled using a boat-mounted deepwater electrofisher (Bergstedt and Genovese 1994; Jolley et al. 2010), specifically designed for capturing larval lampreys in lentic habitats. Electrofishing methods and electrofisher settings were the same as those used in Jolley et al. (2010).

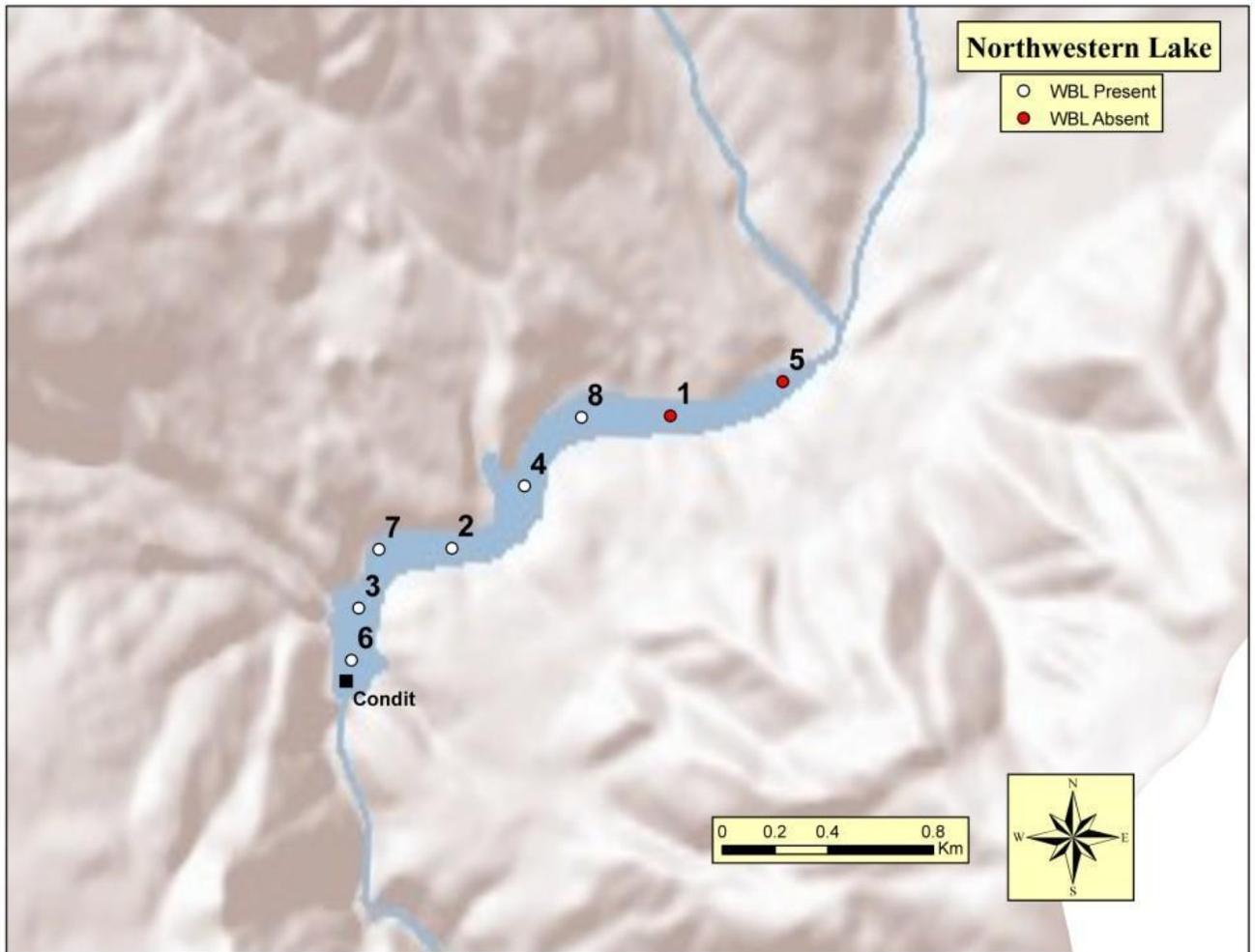


Figure 6. Sample sites in Northwestern Lake using a deepwater electrofisher.

Field Protocol

Sample reaches were accessed on foot (except in Northwestern Lake) using GPS units loaded with sample reach UTM coordinates for navigation. Once a sample reach was located, a 50 m stream reach was measured and flagged. Water temperature and conductivity were recorded in each reach. The reach was electrofished using an AbP-2 backpack electrofisher. Power output settings for the AbP-2 were adapted from Weisser and Klar 1990 (Table 1). We spent relatively more time within each reach electrofishing areas of preferred larval lamprey rearing habitat

where depositional silt and sand substrates are dominant (henceforth Type I habitat, Slade et al. 2003). Relatively less time was spent electrofishing areas with hard bedrock and boulder substrates. All larval lampreys observed were captured and placed in buckets containing stream water.

Table 1. AbP-2 electrofisher power output settings used when sampling for larval lampreys.

	Bursted Pulse Primary Wave Form	Standard Pulse Secondary Wave Form
Voltage (v)	125	125
Pulse Frequency (Hz)	4	30
Duty Cycle (%)	25	25
Burst Pulse Train	3 on:1 off	-

Biological data was collected from a maximum of 25 larval lampreys at each sample reach. Lampreys were removed from the holding bucket, anesthetized in a solution of tricaine methanesulfonate (MS-222), identified to species (WBL, PCL, or lamprey spp.) according to caudal pigmentation (Goodman et al. 2009) and classified according to developmental stage (i.e., ammocoete, macrophthalmia, or adult). Lampreys were measured (TL in mm) and weighed (wet weight in g) and caudal fin tissue was collected from subsample of up to 10 lampreys per site for genetic analysis to confirm species identification. Lampreys were placed in a recovery bucket of fresh stream water and released into the stream after resuming normal swimming behavior.

Results

2007

Electrofishing sampling of three sample units, Buck Creek, Trout Lake Creek, and Rattlesnake Creek was conducted in 2007 (Table 2, Figure 4). Five sites on the White Salmon River mainstem below Condit Dam were also sampled (Table 3, Figure 5). In Buck Creek, 21

reaches were sampled and no larval lampreys were captured in any of the sample reaches (Figure 4). In Trout Lake Creek, larval western brook lampreys ($n = 80$) and adult western brook lampreys ($n = 2$) were captured at four of the 21 reaches sampled (Table 2). Lampreys ranged in size from 59 mm to 130 mm TL (mean = 86 mm, SE \pm 2mm). The four sites where lampreys were captured were in approximately the lower fourth of the Trout Lake Creek watershed, within approximately 9 km of the confluence with the White Salmon River (Figure 4). In Rattlesnake Creek, no larval lampreys were captured at three sample reaches (Figure 4). Reach-specific DP of larval lamprey in Trout Lake Creek (the only unit known to be occupied) was 0.19. Accordingly, the estimated minimum level of sampling effort to be 80% certain that larval lampreys are absent when undetected, was eight sample reaches per unit (see Peterson and Dunham 2003; Jolley et al. 2010).

Table 2. Sample units in the White Salmon River basin in 2007, 2008, and 2009, 2010.

Sample unit	Year	Number Reaches visited	Number Reaches sampled	Number Dewatered reaches	Number Occupied reaches	Est. Prob. of Occupancy
Buck Creek	2007	21	21	0	0	< 0.02
Trout Lake Creek	2007	21	21	0	4	1.00
Rattlesnake Creek	2007	3	3	0	0	< 0.35
Little Buck Creek	2008	8	8	0	0	< 0.20
Mill Creek	2008	7	7	0	0	< 0.20
Morrison Creek	2008	8	5	3	0	< 0.30
Phelps Creek	2009	4	4	0	0	0.30
Wieberg Creek	2009	3	3	0	0	< 0.35
Gotchen Creek	2009	7	0	7	0	-
Upper Buck Creek	2009	8	2	6	0	< 0.40
Rattlesnake Creek (revisted)	2009	18	18	0	0	< 0.05
Rattlesnake Creek (total)	2007, 2009	21	21	0	0	< 0.02
Green Canyon Creek	2010	8	8	0	0	<0.20
Cave Creek	2010	8	8	0	0	<0.20
Ninefoot Creek	2010	8	8	0	0	<0.20
Cascade Creek	2010	4	4	0	0	0.30
McIlroy Creek	2010	4	4	0	0	0.30

In 2007, 26 lampreys were captured at three of five sites sampled below Condit Dam.

Lampreys were a mix of larval western brook lampreys (n = 19), adult western brook lampreys (n = 5) and larval Pacific lampreys (n = 2; Table 3, Figure 5). Lampreys ranged in size from 58 mm to 142 mm TL (mean = 108 mm, SE ± 4 mm).

Table 3. Sites sampled on the White Salmon River mainstem below Condit Dam and in Northwestern Lake above Condit Dam.

Sample Location	Site #	Year	Larval WBL	Adult WBL	Larval PCL
Below Condit Dam	1	2007	0	0	0
Below Condit Dam	2	2007	2	1	0
Below Condit Dam	3	2007	0	0	0
Below Condit Dam	4	2007	3	1	0
Below Condit Dam	5	2007	14	3	2
Below Condit Dam	5	2009	22	0	0
Below Condit Dam	5	2010	N/A	0	5
Northwestern Lake	1	2009	0	0	0
Northwestern Lake	2	2009	1	0	0
Northwestern Lake	3	2009	4	0	0
Northwestern Lake	4	2009	1	0	0
Northwestern Lake	5	2009	0	0	0
Northwestern Lake	6	2009	1	0	0
Northwestern Lake	7	2009	6	0	0
Northwestern Lake	8	2009	1	1	0

2008

Electrofishing sampling of three sample units, Little Buck Creek, Mill Creek, and Morrison Creek, was conducted in 2008 (Table 2, Figure 4). In Little Buck Creek, eight reaches were sampled and no larval lampreys were captured (Figure 4). In Mill Creek, seven reaches were sampled and no larval lampreys were captured (Figure 4). One additional reach in Mill Creek was inaccessible and was not sampled. In Morrison Creek, eight reaches were sampled and no larval lampreys were captured (Figure 4). The area below Condit Dam was not sampled in 2008.

2009

Electrofishing sampling of the Phelps Creek, Wieberg Creek, Gotchen Creek and Upper Buck Creek sample units was conducted in 2009 (Table 2, Figure 4). Additional reaches in Rattlesnake Creek were sampled, totaling 21 over a two year period (Table 2, Figure 4). In

Phelps Creek, no larval lampreys were detected in four reaches sampled (Figure 4). At approximately river kilometer (RKM) 2 of Phelps Creek a series of three waterfalls 3-5 m in height was encountered that was presumed to be a barrier to lamprey migration. Continued sampling upstream of the waterfalls was not conducted. Similarly, in Wieberg Creek no lampreys were detected in three reaches sampled (Figure 4). At approximately RKM 1.5 of Wieberg Creek a waterfall of approximately 25 m in height was reached that was presumed to be a barrier to lamprey migration. Continued sampling upstream of the waterfall was not conducted. The seven sites visited in Gotchen Creek were completely dewatered (Figure 4). These sites were low in the watershed and suggested that all or most of the watershed was dewatered. As such, no other feasible sites were available for additional sampling and water was not available to support lamprey. Similarly, in Upper Buck Creek, six of eight sites visited were dewatered. Two sites with water (likely intermittent flow) were electrofished and no lampreys were detected (Figure 4). At Rattlesnake Creek 18 reaches were sampled and no larval lampreys were detected (Figure 4).

In Northwestern Lake, larval western brook lampreys ($n = 14$) and adult western brook lampreys ($n = 1$) were captured at 75% (six of eight) of the sites sampled using a deepwater electrofisher (Table 3, Figure 6). Lampreys ranged in size from 82 mm to 138 mm TL (mean = 101 mm, SE \pm 4 mm).

Below Condit Dam, one sample site was electrofished and 22 larval western brook lampreys were captured (Table 3, Figure 5). Lampreys ranged in size from 34 mm to 140 mm TL (mean = 99 mm, SE \pm 7 mm).

2010

Electrofishing sampling of the Green Canyon Creek, Cave Creek, Ninefoot Creek, Cascade Creek and McIlroy Creek sample units was conducted in 2010 (Table 2, Figure 4). In Green Canyon Creek, Cave Creek and Ninefoot Creek, no larval lampreys were detected in any of the eight reaches sampled in each creek. In Cascade Creek and McIlroy Creek, no larval lampreys were detected in any of the four reaches sampled in each creek.

Below Condit Dam, numerous larval western brook lampreys were captured, but were not enumerated. Additionally, five potential larval Pacific lampreys (size range 57 mm to 91 mm TL) were captured. Morphological identification of lamprey larvae less than 60 mm is difficult and unreliable (Goodman 2009). As a result, fin clips were collected from these lampreys for future genetic confirmation of the species.

Discussion

Lampreys are not widely distributed in the WSR. Western brook lamprey distribution in the WSR basin was limited to the mainstem of the WSR both above and below Condit Dam and one tributary. Of the 15 sample units electrofished for lampreys above Condit Dam (Northwestern Lake and 14 tributaries), western brook lampreys were detected in only two units (13%): Northwestern Lake (the mainstem WSR impounded by the dam) and Trout Lake Creek (Figure 7). Pacific lampreys are unable to pass above Condit Dam and thus, as an anadromous species, were found in the WSR mainstem below the dam only. However, suitable habitat for adult lamprey spawning as well as Type I larval rearing habitat was present in each of the 14 tributaries sampled and does not appear to be a factor limiting lamprey distribution in the WSR basin. Western brook lamprey, a resident species, also had an unexpectedly limited distribution above Condit Dam. Restricted distribution of WBL above Condit Dam is likely being influenced

by physical migration barriers and stream flow. Waterfalls that are presumed barriers to fish (i.e., salmon) migration are found throughout the White Salmon River and its tributaries (NMFS 2009). Both Wieberg and Phelps Creeks have waterfalls at their mouths where they enter the White Salmon River and all sample reaches in these units were above these falls. In addition, waterfalls occur at approximately RKM 1.5-2.0 on the two creeks and likely further restrict resident fish movements within them.

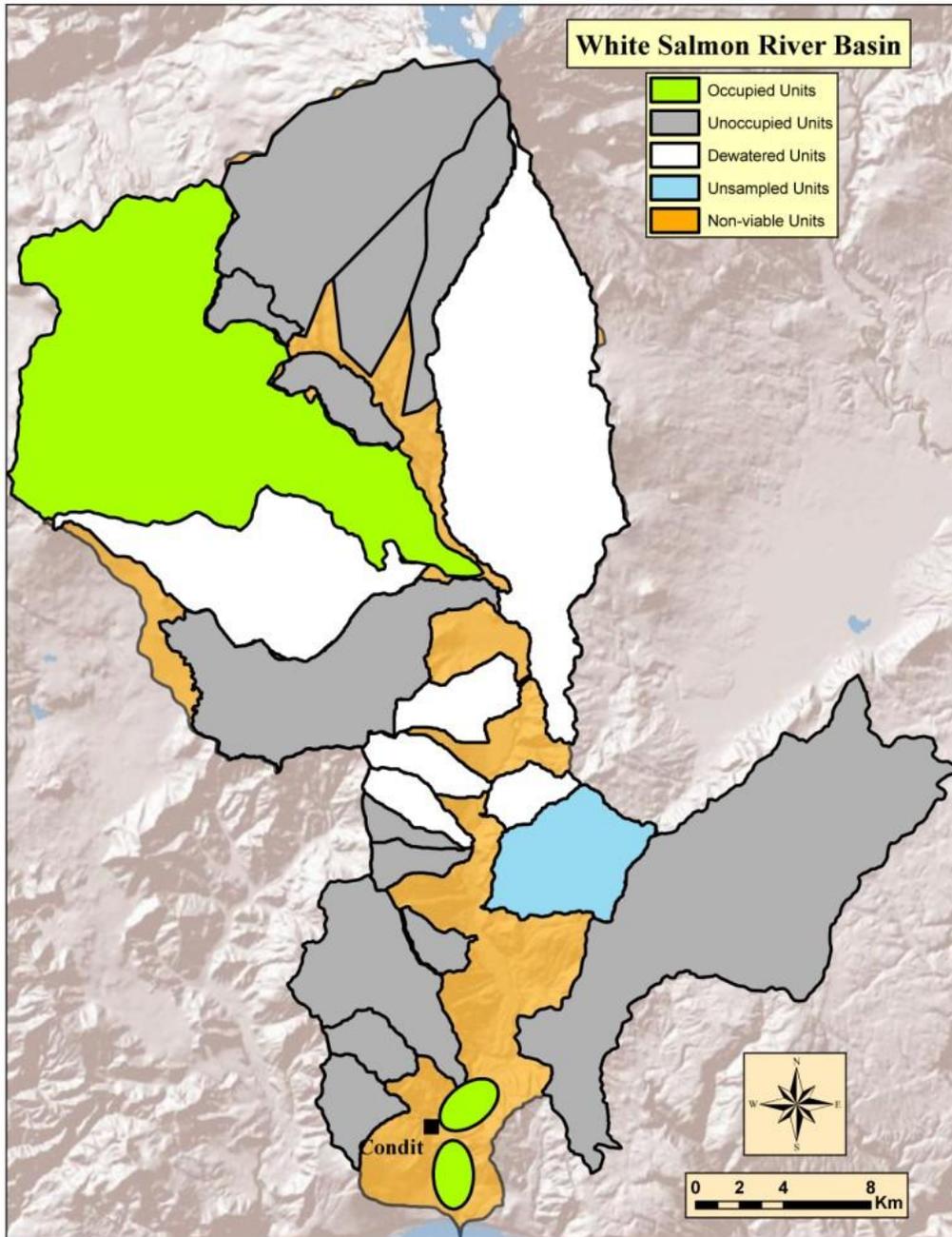


Figure 7. Status of the 21 tributary sample units (plus Northwestern Lake and the White Salmon River below Condit Dam) as of August, 2010. Units in green are occupied by lampreys, while lampreys are absent from gray units. Units in white were completely dewatered and not sampled. The unit in blue was not sampled due to lack of access to private property. Areas of orange were not viable units according to the sample unit selection criteria.

Rattlesnake Creek, a large WSR tributary with high lamprey intrinsic potential (D.

Holzer, NOAA, personal communication; Figure 2), also contains multiple barrier waterfalls

(NMFS 2009). A waterfall located at RKM 2.4 is thought to be a barrier to all salmonids except steelhead and possibly coho salmon (NMFS 2009), and may be a barrier to lampreys. A larger double falls (~25 m in height) at RKM 17.1 is a complete barrier to all fish migration (NMFS 2009). Of the 21 reaches sampled for lampreys in Rattlesnake creek, two reaches were located downstream from the waterfall at RKM 2.4 and 19 sample reaches were located between the falls at RKM 2.4 and RKM 17.1. No lampreys were detected in these 21 reaches. While barriers are likely restricting western brook lamprey distribution in the Rattlesnake Creek unit, the absence of larval lampreys in the two sample reaches below the falls at RKM 2.4 suggests that other factors may be limiting western brook lamprey occupancy in Rattlesnake Creek.

Low summer stream flow conditions likely influenced lamprey distribution in the WSR basin. Two sample units (Morrison Creek and Upper Buck Creek) located in the upper portion of the WSR basin were extensively dewatered during sampling in August. Additional sample units in the basin were completely dewatered and sampling was not conducted in these units (n = 6; Figure 7). Stream flow in much of the WSR basin is primarily the result of snowmelt runoff and many tributaries are ephemeral (NPCC 2004). It is likely the dewatered sample units we visited are dry annually during summer and fall and not occupied by larval lamprey.

The White Salmon River mainstem below Condit Dam is occupied by both larval western brook and Pacific lampreys and, presumably, adults of both species also spawn in this reach. The removal of Condit Dam may allow for upstream movement by adults of both species within the WSR basin and lead to recolonization of Pacific lampreys in the basin above Condit Dam. Adult Pacific lampreys returning to areas in the WSR basin above the dam may be restricted by the factors limiting distribution of western brook lampreys, such as barrier waterfalls and intermittent flow conditions. Recolonization of Pacific lampreys may occur then, at a minimum,

in areas currently occupied by western brook lamprey (i.e., the WSR mainstem and lower reaches of some tributaries). However, robust adult Pacific lampreys can use their sucker mouths to climb natural barriers that restrict movement of other fishes (Kostow 2002). For example, adult Pacific lampreys routinely pass Willamette Falls on the Willamette River. The climbing ability of Pacific lampreys may allow them to access regions of the WSR that are inaccessible to and not occupied by western brook lampreys. Thus, the full potential of the WSR basin to support Pacific lampreys is not known but may be greater than for western brook lampreys. Future monitoring after the removal of Condit Dam is planned to address the remaining objectives to investigate recolonization of the WSR basin by Pacific lampreys.

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