U.S. Fish and Wildlife Service

Bull Trout Distribution, Movements and Habitat Assessment in the Umatilla River Basin

FY 2014 Annual Report

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On the cover: *The Umatilla River near Stanfield, Oregon. Photograph by Paul Sankovich (FWS).*

The correct citation for this report is:

Sankovich, P. M., M. G. Barrows, and J. J. Skalicky. 2015. Bull trout distribution, movements and habitat use in the Umatilla River Basin. 2014 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.

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Funded by

U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office

authored by

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Final
2015

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BULL TROUT DISTRIBUTION, MOVEMENTS AND HABITAT USE IN THE UMATILLA RIVER BASIN

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Abstract

Abstract ─ The goal of the U.S. Fish and Wildlife Service's studies in the Umatilla River Basin is to provide information that can be used to develop recovery actions for bull trout *Salvelinus confluentus* listed as threatened under the Endangered Species Act. In 2014, our objectives were to 1) collect data and conduct a habitat assessment for use in a GIS-based recovery planning tool, 2) continue to monitor the movement and origin of any bull trout trapped at Three Mile Falls Dam (TMFD) on the lower Umatilla River, and 3) produce a briefing document for managers on the current state of our knowledge of bull trout in the Umatilla Basin, and some of the management questions that arise given that knowledge. Overall, the results from the habitat quality assessment accurately reflected the current physical conditions in the North Fork Umatilla and Umatilla rivers, with habitat conditions generally degrading progressively from the headwaters to the mouth of the Umatilla River. No bull trout were captured at TMFD in 2014, and none PIT-tagged there in previous years were detected in the Columbia River Basin. Based upon the available information, the long term prospects for the single local bull trout population in the Umatilla River Basin appear poor. Managers may soon need to consider whether to let nature take its course or begin an artificial propagation program.

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Introduction

Bull trout *Salvelinus confluentus* were officially listed as a threatened species under the Endangered Species Act (ESA) in 1998. The U.S. Fish and Wildlife Service (FWS) subsequently issued a Draft Recovery Plan (U.S. Fish and Wildlife Service 2002) which included a chapter for the Umatilla-Walla Walla Recovery Unit (Chapter 10). This chapter was updated in 2004 (U.S. Fish and Wildlife Service 2004) and is the current guide for recovery actions in the Umatilla Basin. The goal of bull trout recovery planning by the FWS is to describe courses of action necessary for the ultimate delisting of this species, and to ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout distributed across the species' native range (U.S. Fish and Wildlife Service 2004).

Bull trout in the Umatilla Basin exhibit two different life history strategies. Fluvial bull trout spawn in the headwaters and the juveniles rear there for one to four years before migrating downstream as subadults to larger main stem areas, and possibly to the Columbia River where they grow and mature, returning to their natal stream to spawn (Fraley and Shepard 1989). Downstream migration of subadults generally occurs during the spring, although it can occur throughout the year (e.g., Hemmingsen et. al. 2001). These migratory forms occur in areas where conditions allow for movement from upper watershed spawning streams to larger downstream waters that contain greater foraging opportunities (Dunham and Rieman 1999). Stream-resident bull trout also occur in the basin, completing their entire life cycle in the tributary streams where they spawn and rear. Resident and migratory forms of bull trout may be found living together for portions of their life cycle, but it is unknown if they can give rise to one another (Rieman and McIntyre 1993). Bull trout size is variable depending on life history strategy. Resident adult bull trout tend to be smaller than fluvial adult bull trout (Goetz 1989). Under appropriate conditions, bull trout regularly live to 10 years, and under exceptional circumstances, reach ages in excess of 20 years. They normally reach sexual maturity in four to seven years (Fraley and Shepard 1989; McPhail and Baxter 1996).

When compared to other North American salmonids, bull trout have more specific habitat requirements. The habitat components that shape bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (U.S. Fish and Wildlife Service 1998). Throughout their lives, bull trout require complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Watson and Hillman 1997). Juveniles and adults frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). McPhail and Baxter (1996) reported that newly emerged fry are secretive and hide in gravel along stream edges and in side channels. They also reported that juveniles are found in pools, riffles, and runs where they maintain focal sites near the bottom, and that they are strongly associated with instream cover, particularly overhead cover. Bull trout have been observed over-wintering in deep beaver ponds or pools containing large woody debris (Jakober et al. 1998). Habitat degradation and fragmentation (Fraley and Shepard 1989), barriers to migration (Rieman and McIntyre 1995), and reduced instream flows have all contributed to the decline in bull trout populations in the Columbia River Basin.

In summary, bull trout need adequate stream flows and temperatures and the corresponding habitat for each of the different life history functions at specific times of the year in order to persist. Habitat conditions must be adequate to provide spawning, rearing, and migration opportunities, cover, forage, seasonal movement, and over-wintering refuges.

The goal of the FWS studies in the Umatilla Basin is to develop information and analyses to assist in assessing the relative merit of potential action strategies in making progress towards meeting the requirements outlined in the Umatilla-Walla Walla chapter of the Draft Recovery Plan (U.S. Fish and Wildlife Service 2004) for the recovery and delisting of bull trout. Specifically, FWS studies were designed to address the following recovery plan objectives:

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and

- Conserve genetic diversity and provide opportunity for genetic exchange.

The habitat objective should be accomplished through a series of steps designed to restore and maintain suitable habitat conditions for all bull trout life history stages and strategies. The first step should consist of defining the physical conditions that comprise suitable bull trout habitat. The second step should be application of these habitat "criteria" to current conditions to determine the extent of the relevant stream that currently provides suitable habitat. The third step should consist of determination of the changes required to improve habitat in areas indicated in the recovery plan that do not currently provide suitable conditions. The fourth step should consist of implementing changes to restore and maintain suitable habitat conditions for all bull trout life history stages and strategies.

The genetic diversity objective should be accomplished by maintaining connectivity among local populations of bull trout to facilitate gene flow and genetic diversity. As the recovery plan discusses, connectivity consists of maintaining the fluvial component of each local population which includes providing conditions that allow fluvial adults to effectively move between spawning and wintering areas, and ensuring that movement of both fluvial adult and subadult bull trout can occur, at least seasonally, between local populations within each core area in the recovery unit. This includes establishing the physical conditions necessary for up- and down-stream fish passage, and providing a continuum of suitable physical habitat to ensure the persistence of fluvial life stages and provide the opportunity for genetic interchange between local populations and each core areas.

The approach the FWS used to plan studies in the Umatilla Basin consisted of the following steps:

- Identify information needed to assess if criteria for recovery objectives are being achieved;

- To that end, design and implement studies to describe bull trout distribution, movement, and seasonal habitat use patterns;

- Use this information and results from these studies to assist in guiding actions that will make progress towards bull trout recovery.

We previously described what was known about the abundance, distribution, and migratory patterns of bull trout and potentially limiting physical conditions in the Umatilla Basin when we initiated our study there in 2004 (Anglin et al. 2008). To summarize, at that time, the only viable population of bull trout appeared to occur in the North Fork Umatilla River, and it appeared to be relatively small. Telemetry studies had shown fluvial adult bull trout did not migrate extensively, remaining within the upper Umatilla River and the North Fork to complete their life cycle (Sankovich et al. 2003, 2004; Oregon Department of Fish and Wildlife [ODFW], unpublished report). Little was known about the movement and seasonal distribution of subadults, but the available evidence suggested they also were not prone to undertake extensive migrations. Five bull trout had been captured in a ladder at Three Mile Falls Dam (TMFD) in the lower Umatilla River at river kilometer (rkm) 6 between 1995 and 2004. These fish were 254 to 330 mm in fork length (FL), indicating they were either subadults or first-time maturing adults when captured. Thus, assuming these fish originated in the Umatilla Basin, it appeared at least a small number of subadults produced there continued to migrate to and use the lower Umatilla and Columbia rivers. Although there were human impacts to the upper basin due to development, agriculture, and forest management, the major impacts occurred in the lower basin where there were six irrigation dams and diversions and sections of the river were sometimes dewatered seasonally. Five of the diversion dams had ladders, but they were designed for passage of salmon and steelhead, and it was not known if bull trout could negotiate them. The remaining diversion dam was passable without a ladder, except during periods of low flow, which coincided with unsuitably high stream temperatures for salmonids.

Between 2004 and 2014, the conditions in the Umatilla Basin that held the potential to negatively impact bull trout remained relatively unchanged. The population in the North Fork appeared to be small and stable or declining based on redd counts and mark-recapture abundance estimates (Budy et al. 2004, 2005, 2006, 2007, 2008, 2009; P.M.S., unpublished data). Because fluvial adult bull trout migrations had been studied previously and subadult migrations remained largely undescribed, we chose to focus on the latter when we began our study. Through 2009, we used a combination of trapping, snorkeling, telemetry, and fixed PIT tag detection sites to determine the subadult population was small and individuals exiting the North Fork (i.e., individuals migrating as subadults for the first time) remained within the upper 40 km of the Umatilla River during their first summer in it. We also determined some of these subadults and older subadults rearing in the upper Umatilla River undertook staged downstream migrations, for example, emigrating from the North Fork in spring and rearing in the Umatilla River for several months before again initiating downstream migration in fall. We observed no subadults utilizing the heavily impacted lower river. As a result, we were unable to describe the timing of use, seasonal distribution, and movement of subadults in the lower river and determine how subadults might be negatively affected by conditions there. Meeting those objectives seemed unlikely given the small size of the subadult population and the apparently low frequency with which subadults migrated to the lower river; therefore, in 2010, we transitioned to identifying potential bull trout spawning and rearing areas in the basin by conducting a patch analysis (FWS 2008) to begin to resolve uncertainty about the number and distribution of local populations. In 2010 and

2011, we collected water temperature data throughout the Umatilla Basin for use in the patch analysis, conducted the analysis to identify patches, and visited those we were unfamiliar with to eliminate any having no or insufficient stream flow. This process lead to the identification of seven patches, only one of which (the North Fork Umatilla River) was known to support a bull trout population. In 2012, we conducted bull trout occupancy surveys in five of the six remaining patches (the sixth was not sampled due to time constraints) and found no bull trout in any of them. Based on those findings and our professional judgment regarding the likelihood of the unsampled patch (Johnson Creek) supporting bull trout, we concluded the North Fork Umatilla River was the only stream in the basin likely supporting a viable bull trout local population.

Although our life history investigations were focused on subadult bull trout, larger, presumably mostly first-time maturing adults (all but one of 11 were between 300 and 400 mm FL) continued to be trapped occasionally at TMFD after we began our study, and we took advantage of this by tagging and collecting genetic samples from eight of them (those that could be handled under suitable stream temperatures) to identify their origin and fill in gaps in our knowledge of bull trout movement and distribution. We found all of these fish originated outside the Umatilla Basin, in the Walla Walla or Tucannon basins. A portion successfully negotiated the dams and ladders in the lower Umatilla River, and there was no indication the movements of the remainder were impeded by the dams and ladders. One individual, from the Walla Walla Basin, migrated onto the spawning grounds in the North Fork Umatilla River and was there during the spawning period, providing evidence for biological connectivity between populations in adjacent basins.

In addition to collecting stream temperature data for the patch analysis, we have been collecting existing data on other habitat conditions in the Umatilla River since 2010. This effort was undertaken so we can relate physical conditions in and along the river to what is known about bull trout movements and distribution to identify potential limiting factors and provide information useful in the development, implementation, and evaluation of recovery actions.

In 2014, we had three objectives. The first was to continue work initiated in 2013 to construct a GIS-based recovery planning tool that describes current physical and hydrologic conditions in the Umatilla Basin and how they relate to spatial and temporal patterns of bull trout distribution and movement. This tool is intended to be a database of information that will link to relevant recovery actions to assist Ecological Services in moving forward with implementation of the Umatilla-Walla Walla Recovery Unit plan. Our specific objective in 2014 was to conduct a bull trout habitat quality assessment for the Umatilla and North Fork Umatilla rivers, and incorporate the results from that assessment in the GIS-based recovery planning tool. Our second objective was to continue to monitor the movement and origin of any bull trout trapped at TMFD. This included any bull trout trapped in 2014 and those trapped and tagged in previous years. Our third objective was to produce a briefing document for managers on the current state of our knowledge of bull trout in the Umatilla Basin, and some of the management questions that arise given that knowledge.

Study Area

The Umatilla Basin encompasses an area of approximately 6,579 km^2. Its headwaters drain the west slope of the Blue Mountains in northeastern Oregon (Figure 1). The Umatilla River flows for approximately 144 km before entering the Columbia River at rkm 465. The North Fork Umatilla River is approximately 16 km long. Habitat conditions generally degrade progressively from the headwaters downstream to the mouth the Umatilla River.

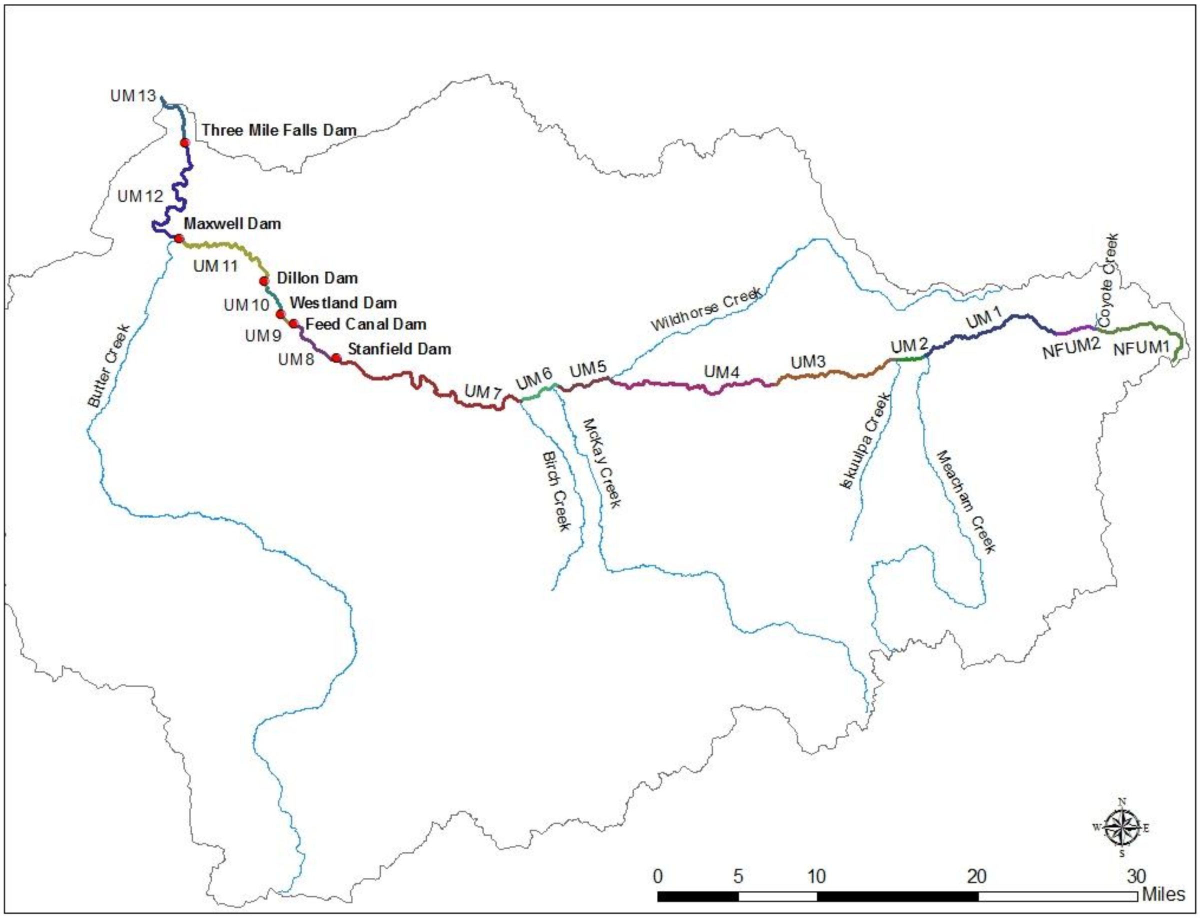

Figure 1. Location of study reaches in the Umatilla and North Fork Umatilla rivers, and major tributaries to, and diversion dams in, the Umatilla River.

Methods

Bull Trout Habitat Quality Assessment

To conduct the bull trout habitat quality assessment, we followed the methods described by Schaller et al. (2014), which is a macro-level assessment conducted in a GIS. Briefly summarized, we divided the Umatilla and North Fork Umatilla rivers into reaches (Table 1) containing fairly uniform habitat conditions that differed from habitat conditions in adjacent reaches. We identified the reaches based on channel modifications, land uses, stream gradient, elevation, and the location of major tributaries and irrigation dams (Appendix A, Table 1). Habitat quality was assessed in relation to two life stages (adult and subadult) and eight strategies or activities exhibited by those life stages: adult spawning; juvenile rearing, foraging and growth; fluvial adult upstream migration; adult foraging and maintenance; fluvial adult downstream migration; fluvial subadult downstream migration; fluvial subadult upstream migration; and fluvial subadult rearing, foraging, and growth. A model was developed to calculate a monthly habitat quality score (HQS) for each stream reach and life stage, strategy, or action. The model was based on eleven habitat variables: surface flow, groundwater, water temperature, passage impediments, channel modification, riparian zone, stream gradient, elevation, land use, geology and sinuosity. These habitat variables were assigned a rating factor for each month and reach, and the rating factors were adjusted by a weighting factor to reflect each variable's relative importance. The weighting factors were developed using an Analytical Hierarchal Process method adapted from Saaty (2008). Each HQS was calculated as:

$$HQS = (HV_1 \text{ x } WF_1) + (HV_2 \text{ x } WF_2) +\ldots+ (HV_{11} \text{ x } WF_{11}),$$

where HV = habitat variable and WF = weighting factor. We rated habitat quality as poor, low, fair, good, or high if the habitat quality score was $\leq$1.8, >1.8 and $\leq$2.6, >2.6 and $\leq$3.4, >3.4 and $\leq$4.2, or >4.2 and $\leq$5, respectively. The lowest habitat quality score possible was 1 and the highest was 5; thus, the five ratings each spanned 0.8 scoring units.

Movement and Origin of Bull Trout Captured at Three Mile Falls Dam

Personnel from the Confederated Tribes of the Umatilla Indian Reservation and ODFW annually operate a fish trap in the east bank ladder at TMFD. We supplied them with the equipment needed to PIT tag and collect genetic samples from any bull trout captured in the trap, but none were captured in 2014.

To monitor the movement of bull trout PIT tagged at TMFD in previous years (n = 8), we queried the Pacific States Marine Fisheries Commission's PTAGIS data base to determine if those bull trout were detected at any PIT tag detection sites in the Columbia River Basin. The detection site of primary interest on the Umatilla River was Feed Canal Dam, at rkm 45. Detection of fish there would indicate successful passage through all of the dams in the lower river, except for Stanfield Dam. Two routes of passage at Feed Canal Dam—a ladder and a notch in the dam—were outfitted with PIT tag antennas. Fish may also pass the dam by jumping it, but this appears to occur infrequently (B. Duke, ODFW, personal communication), so detection efficiency, although unassessed, presumably was high.

Results

Bull Trout Habitat Quality Assessment

Adult spawning.--Modeled scores indicated that during the spawning period (mid-August through October) high quality spawning habitat is present in only NFUM1 and NFUM2 in

Table 1. Habitat reaches in the Umatilla and North Fork Umatilla rivers.

	Boundaries		Length
Reach	Upstream	Downstream	(km)
NFUM1	N.F. Umatilla River headwaters	Coyote Creek	13.1
NFUM2	Coyote Creek	mouth of the N.F. Umatilla River	4.2
UM1	mouth of the N.F. Umatilla River	Meacham Creek	17.9
UM2	Meacham Creek	Iskuulpa Creek	3.5
UM3	Iskuulpa Creek	Moonshine Creek	15.3
UM4	Moonshine Creek	Wildhorse Creek	18.8
UM5	Wildhorse Creek	McKay Creek	7.2
UM6	McKay Creek	Birch Creek	4.6
UM7	Birch Creek	Stanfield Dam	26.1
UM8	Stanfield Dam	Feed Canal Dam	7.1
UM9	Feed Canal Dam	Westland Dam	1.7
UM10	Westland Dam	Dillon Dam	4.4
UM11	Dillon Dam	Maxwell Dam	15.6
UM12	Maxwell Dam	Three Mile Falls Dam	18.7
UM13	Three Mile Falls Dam	mouth of the Umatilla River	5.9

October (Appendix B, Table 1). Spawning habitat was rated as good in those reaches in August and September. Spawning habitat also was rated as good in UM1 during the spawning period. All of the remaining reaches were rated as having good, fair, or low quality spawning habitat.

Juvenile rearing, foraging and growth.--Within the only juvenile bull trout rearing area in the Umatilla River Basin (the North Fork Umatilla River [NFUM1 and NFUM2]) the quality of juvenile rearing, foraging, and growth habitat was rated as high or good during May-October and good throughout the remainder of the year (Appendix B, Table 2). Habitat quality also was rated as high or good in UM1 throughout the year. Habitat quality in the remaining reaches generally was rated as good or fair, but it was rated as low in UM5 in July and in and downstream from UM2 in July and August.

Fluvial adult upstream migration.--The quality of habitat for fluvial adult upstream migration generally was rated as high or good throughout the year in and upstream from UM4 (Appendix B, Table 3). Habitat quality generally was rated as high or good during the period of fluvial adult upstream migration (spring and summer) between UM5 and UM9 (inclusive). Habitat quality was rated as low in and downstream from UM10 in July and August.

Adult foraging and maintenance.--The quality of habitat for adult foraging and maintenance was rated as high in NFUM1 and NFUM2 in May-October and UM1 in May-November, and as good in those reaches the remainder of the year (Appendix B, Table 4).

Habitat quality was rated as good or fair throughout the year in most of the remaining reaches. Habitat quality was rated as low in and downstream from UM10 in July and August.

Fluvial adult downstream migration.--The quality of habit for fluvial adult downstream migration generally was rated as high or good during the period of adult downstream migration (fall and early winter)(Appendix B, Table 5). Habitat quality was rated as fair in and downstream from UM10 in September and good or high in October-December.

Fluvial subadult downstream migration.--The quality of habitat for fluvial subadult downstream migration was rated as high or good throughout the year in and upstream from UM4 (Appendix B, Table 6). Downstream from UM4, habitat quality generally was rated as high or good, but it was rated as fair or low in some reaches and months.

Fluvial subadult upstream migration.--The quality of habitat for fluvial subadult upstream migration was rated as high or good throughout the year in and upstream from UM4 (Appendix B, Table 7). Downstream from UM4, habitat quality generally was rated as good, but it was rated as fair or low in and downstream from UM10 in July-September and fair in UM9 in July and August.

Fluvial subadult rearing, foraging, and growth.--The quality of habitat for fluvial subadult rearing, foraging, and growth was rated as high or good throughout the year in and upstream from UM3 (Appendix B, Table 8). Habitat quality generally was rated as good or fair downstream from UM3. In July and August, habitat quality in and downstream from UM10 was rated as low.

Movement and Origin of Bull Trout Captured at Three Mile Falls Dam

No bull trout were captured at TMFD in 2014, and none of the eight bull trout PIT tagged at TMFD in 2007-2013 were detected in the Columbia River Basin in 2014. A bull trout PIT tagged on the Walla Walla River in 2011 and detected at TMFD in 2012 also was not detected in the Columbia River Basin in 2014.

Briefing Document on Umatilla Basin Bull Trout

The briefing document was completed and is included in Appendix C.

Discussion, Conclusions and Management Implications

Bull Trout Habitat Quality Assessment

Overall, the results from the habitat quality assessment accurately reflect the current physical conditions in the North Fork Umatilla and Umatilla rivers. The highest quality habitat for bull trout spawning and early rearing is in the North Fork Umatilla River, consistent with the model results. The North Fork, which flows through a wilderness area, contains two of the three reaches (the other being UM1) rated as having good or high quality habitat during all months of the year for each of the bull trout life stages, strategies, and actions we identified. As we have described previously (Anglin et al. 2008), and as the model results indicated, habitat conditions in the Umatilla River generally degrade heading downstream from the headwaters to the confluence with the Columbia River. Although habitat quality was low at certain times of the year in the lower Umatilla River, habitat restoration efforts should not necessarily be focused there. High stream temperatures in the Umatilla River, including its upper reaches, may be the most important factor limiting bull trout production (see Appendix C). Thus, restoration efforts that increase the amount of summer habitat available to bull trout in the upper Umatilla River presumably would be more beneficial and of higher priority.

Adult spawning.--The only known bull trout local population in the Umatilla Basin resides in the North Fork Umatilla River (Sankovich and Anglin 2013). Bull trout spawning in the North Fork occurs throughout its lower 9 km but is concentrated between Coyote Creek (rkm 4) and Woodward Creek (rkm 9). Bull trout spawning activity in the North Fork has been documented from mid-August to late October (P.M.S., unpublished data). Results from the spawning habitat assessment, which indicated spawning habitat quality is high or good in NFUM1 (upstream from Coyote Creek) in September and October, were consistent with our knowledge of where and when most bull trout spawn in the North Fork. The more sporadic spawning that occurs between the mouth of the North Fork and Coyote Creek is consistent with the rating of spawning habitat in that reach as high or good in September and October. Since the North Fork flows through a wilderness area, there are no opportunities for managers to improve spawning habitat in the North Fork.

Juvenile rearing, foraging and growth.--As with adult spawning, juvenile rearing, foraging and growth in the Umatilla Basin is known to occur only in the North Fork Umatilla River (Sankovich and Anglin 2013). Within the North Fork, juvenile rearing, foraging and growth is concentrated between Coyote and Woodward creeks but occurs downstream to the mouth (Budy et al. 2009; PMS, unpublished data). The model results (ratings of high or good throughout the year) were consistent with the known distribution of juveniles. As with spawning habitat, there are no opportunities for managers to improve juvenile rearing, foraging, and growth habitat in the North Fork since it flows through a wilderness.

Fluvial adult upstream migration.--Fluvial adult bull trout from the Umatilla Basin have been shown to migrate between wintering habitat in the upper Umatilla River and spawning habitat in the North Fork Umatilla River (Sankovich et al. 2003, 2004; ODFW, unpublished report). Extensive use of the lower Umatilla River has not been documented, but there have been occasional observations of bull trout in the lower river (USFWS 2002). Fluvial adult bull trout originating outside of the Umatilla Basin also have been observed occasionally in the lower river (Sankovich and Anglin 2008, 2011, 2013; Small et al. 2012). Some of these individuals have migrated into the upper Umatilla and North Fork Umatilla rivers (Sankovich and Anglin 2008, 2011). Fluvial adults from within and outside the Umatilla Basin migrate upstream in in the Umatilla River in spring and early summer. Those from within the basin generally enter the North Fork in July (Sankovich 2002; 2003). Some individuals (presumably immature adults) may migrate upstream but remain in the upper Umatilla River throughout the summer and part or all of the fall spawning season (Sankovich et al. 2003). The model results indicated the quality of habitat for fluvial adult upstream migration in the upper Umatilla River is high or good, largely due to there being no passage impediments, only minor water withdrawals, and suitable stream temperatures during the migration period. Although fluvial adults originating within the Umatilla Basin appear for the most part to not use the lower Umatilla River, managers nevertheless should be concerned with conditions there. The restricted seasonal distribution of the fluvial adults may be a consequence of human impacts to the lower river (Starcevich et al. 2010, 2012), and improving conditions there could broaden the fluvial adult distribution and increase the opportunities for foraging and connectivity. It could also increase the opportunities for connectivity for out-of-basin individuals that enter the Umatilla River. The model results indicated habitat quality downstream from Westland Dam (UM10 through UM13) was low in July and August, largely due to decreased surface flows, increased water temperatures, and passage impediments. There may be little managers can do to address the former two issues in the short term given the available water supply and broad scale of the impacts creating the increased water temperatures. However, managers should consider conducting passage evaluations at each of the diversion dams. We have demonstrated fluvial adult-sized bull trout are capable of passing upstream through the dams (Sankovich and Anglin 2008, 2011), but formal passage evaluations have not been conducted, and whether passage conditions are optimal for bull trout remains unknown.

Adult foraging and maintenance.--As noted above, fluvial adult bull trout are distributed throughout the upper Umatilla River during winter, begin moving upstream in spring, and either remain in the upper Umatilla River or enter the North Fork in summer (Sankovich et al. 2003, 2004; ODFW, unpublished report). Fluvial adult bull trout return downstream to their wintering sites in fall or winter. They feed throughout the year during their seasonal movements. Based on the model results, the quality of adult foraging and maintenance habitat is high or good upstream from the mouth of Iskuulpa Creek (UM3), which is the area within which most fluvial adult bull trout migrate seasonally. Fluvial adult bull trout presumably used the lower Umatilla River with more frequency historically, before habitat conditions there were degraded. If Umatilla Basin bull trout increase in abundance, the lower river may once again become important as a foraging and maintenance area for fluvial adults. The model results indicate foraging and maintenance habitat generally is only in fair condition downstream from Iskuulpa Creek during months (fall – spring) when fluvial adults would use that area. Thus, that is an area where managers might consider restoring habitat in the future.

Fluvial adult downstream migration.--Fluvial adult bull trout migrate downstream out of the spawning grounds in the North Fork Umatilla River in September and October and winter in the upper Umatilla River (Sankovich et al. 2003, 2004; ODFW, unpublished report). No permanent barriers to downstream migration exist in the North Fork Umatilla or Umatilla rivers, although there may be some passage issues at Three Mile Falls Dam (USFWS 2002). The model results indicate the quality of habitat for the downstream migration of fluvial adults is generally high or good, which is consistent with existing conditions. The only low quality rating occurred in the lower river (UM11) in July, when bull trout are not present due to unsuitably high stream temperatures.

Fluvial subadult downstream migration.--Subadult bull trout migrate downstream out of the North Fork Umatilla during all months of the year, but primarily during spring, with a lesser peak in fall (Sankovich and Anglin 2006, 2007, 2008, 2009, 2010, 2011). No permanent barriers to downstream migration exist in the North Fork Umatilla or Umatilla rivers, although there may be some passage issues at Three Mile Falls Dam (USFWS 2002). The model results indicate the quality of habitat for the downstream migration of subadults is generally high or good, which is consistent with existing conditions. The only low quality rating occurred in the lower river (UM11) in July, when bull trout are not present due to unsuitably high stream temperatures.

Fluvial subadult upstream migration.--Upstream migration of subadult bull trout in the Umatilla River has not been documented. If subadults do migrate upstream, they likely do so to avoid increasing water temperatures in June through August, as occurs in the neighboring Walla Walla River Basin (Schaller et al. 2014). There are no permanent barriers to upstream migration and only minor diversions in the upper Umatilla River, and this is reflected in the model results (HQ indices of high or good). Upstream passage of subadults at the irrigation dams in the lower river has not been evaluated. The ladders were designed for adult salmon and steelhead, and it is not known if they are suitable for passage of subadults. If they are not, the model results for the likely period of subadult upstream migration in the reach of river downstream from Stanfield Dam (HQ indices ranging from good to low) may be inaccurate, and habitat conditions may actually be poor. Managers should consider conducting passage evaluations for both subadult and (as noted above) adult bull trout at the diversion dams.

Fluvial subadult rearing, foraging, and growth.--The seasonal distribution of subadult bull trout in the Umatilla Basin is not well documented. The combined evidence suggests their seasonal distribution is similar to that of fluvial adults, with the subadults perhaps making slightly greater use of the lower Umatilla River (Sankovich and Anglin 2007, 2008, 2009; P.M.S, unpublished data). Based on the model results, the quality of subadult rearing, foraging, and maintenance habitat is high or good upstream from the mouth of Iskuulpa Creek (UM3), which is the area within which most subadults likely migrate seasonally. As with the fluvial adults, subadults presumably used the lower Umatilla River with more frequency historically, and the lower river might once again become important as rearing, foraging, and growth habitat for subadults if their numbers increase in the future. During the colder months of the year, when stream temperatures are suitable for bull trout in the lower river, the model results indicated habitat conditions were only fair. Thus, as we noted above with respect to fluvial adult foraging and maintenance, that is an area where managers might consider restoring habitat in the future.

Acknowledgements

This study was funded by the U.S. Fish and Wildlife Service. David Hines of the U.S. Fish and Wildlife Service produced Figure 1 in this report.

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Appendix A, Table 1. Umatilla River Basin reach delineation matrix.

Reach	RK	Major Tributaries	Major Diversions	Channel Modification	Land Use	Elevation	Stream Gradient	Geology
NFUM1	164			None	Forested	High	High	Uplands
	163			None	Forested	High	High	Uplands
	162			None	Forested	High	High	Uplands
	161			None	Forested	High	High	Uplands
	160			None	Forested	High	High	Uplands
	159			None	Forested	Fairly High	High	Uplands
	158			None	Forested	Fairly High	High	Uplands
	157			None	Forested	Fairly High	High	Uplands
	156			None	Forested	Fairly High	High	Uplands
	155			None	Forested	Medium	High	Uplands
	154			None	Forested	Medium	High	Uplands
	153			None	Forested	Medium	High	Uplands
	152			None	Forested	Medium	High	Uplands
	151			None	Forested	Medium	High	Uplands
NFUM2	150	Coyote Cr. (RK 150.88)		None	Forested	Medium	High	Uplands
	149			None	Forested	Medium	High	Uplands
	148			None	Forested	Medium	High	Uplands
	147			None	Forested	Medium	High	Uplands
UM1	146	N.F. Umatilla R. (RK 146.73)		Minimal	Forested	Medium	High	Uplands
	145			Minimal	Forested	Medium	High	Uplands
	144			Minimal	Forested	Medium	High	Uplands
	143			Minimal	Forested	Medium	High	Uplands
	142			Minimal	Agriculture - Pasture Land	Fairly Low	High	Uplands
	141			Minimal	Forested	Fairly Low	High	Uplands
	140			Minimal	Forested	Fairly Low	High	Uplands
	139			Minimal	Forested	Fairly Low	High	Uplands
	138			Minimal	Forested	Fairly Low	High	Uplands

	137			Minimal	Forested	Fairly Low	High	Uplands
	136			Minimal	Agriculture - Pasture Land	Fairly Low	High	Uplands
	135			Minimal	Forested	Fairly Low	High	Uplands
	134			Minimal	Forested	Fairly Low	High	Uplands
	133			Minimal	Forested	Fairly Low	High	Uplands
	132			Minimal	Forested	Fairly Low	High	Uplands
	131			Minimal	Agriculture - Pasture Land	Fairly Low	High	Uplands
	130			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Uplands
	129			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Uplands
UM2	128	Meacham Cr. (RK 128.83)		Moderate	Agriculture - Pasture Land	Fairly Low	Fairly High	Uplands
	127			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Uplands
	126			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Uplands
UM3	125	Iskuulpa Cr. (RK 125.29)		Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	124			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	123			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	122			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	121			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	120			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	119			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	118			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	117			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	116			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	115			Minimal	Agriculture - Row Crop	Fairly Low	Fairly High	Foothills
	114			Minimal	Agriculture - Row Crop	Fairly Low	Fairly High	Foothills
	113			Minimal	Agriculture - Row Crop	Fairly Low	Fairly High	Foothills
	112			Minimal	Agriculture - Row Crop	Fairly Low	Fairly High	Foothills
	111			Minimal	Agriculture - Row Crop	Fairly Low	Fairly High	Foothills
UM4	110			Minimal	Agriculture - Pasture Land	Fairly Low	Medium	Foothills
	109			Minimal	Agriculture - Row Crop	Fairly Low	Medium	Foothills
	108			Minimal	Agriculture - Row Crop	Fairly Low	Medium	Foothills
	107			Minimal	Agriculture - Row Crop	Fairly Low	Medium	Foothills

	106			Minimal	Agriculture - Row Crop	Fairly Low	Medium	Foothills
	105			Minimal	Agriculture - Row Crop	Fairly Low	Medium	Foothills
	104			Minimal	Agriculture - Row Crop	Fairly Low	Medium	Foothills
	103			Minimal	Agriculture - Pasture Land	Fairly Low	Medium	Foothills
	102			Minimal	Agriculture - Row Crop	Fairly Low	Medium	Foothills
	101			Minimal	Agriculture - Pasture Land	Fairly Low	Medium	Foothills
	100			Minimal	Agriculture - Pasture Land	Fairly Low	Fairly High	Foothills
	99			Minimal	Agriculture - Pasture Land	Low	Fairly High	Foothills
	98			Moderate	Agriculture - Pasture Land	Low	Fairly High	Foothills
	97			Moderate	Agriculture - Pasture Land	Low	Fairly High	Foothills
	96			Moderate	Agriculture - Pasture Land	Low	Fairly High	Foothills
	95			Moderate	Urban Development	Low	Fairly High	Foothills
	94			Moderate	Urban Development	Low	Fairly High	Foothills
	93			Moderate	Urban Development	Low	Fairly High	Foothills
	92			High	Urban Development	Low	Fairly High	Foothills
UM5	91	Wildhorse Cr. (RK 91.24)		High	Urban Development	Low	Fairly High	Foothills
	90			High	Urban Development	Low	Medium	Foothills
	89			High	Urban Development	Low	Medium	Foothills
	88			High	Urban Development	Low	Medium	Foothills
	87			High	Urban Development	Low	Medium	Foothills
	86			High	Urban Development	Low	Medium	Foothills
	85			High	Urban Development	Low	Medium	Foothills
UM6	84	McKay Cr. (RK 84.05)		High	Urban Development	Low	Medium	Foothills
	83			High	Agriculture - Pasture Land	Low	Medium	Foothills
	82			High	Agriculture - Pasture Land	Low	Medium	Foothills
	81			High	Agriculture - Pasture Land	Low	Medium	Foothills
	80			High	Agriculture - Row Crop	Low	Fairly Low	Foothills
UM7	79	Birch Cr. (RK 79.58)		High	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	78			High	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	77			Moderate	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	76			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills

	75			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	74			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	73			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	72			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	71			Moderate	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	70			Moderate	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	69			Moderate	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	68			Moderate	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	67			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	66			Moderate	Agriculture - Pasture Land	Low	Fairly Low	Foothills
	65			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	64			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	63			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	62			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	61			Moderate	Agriculture - Row Crop	Low	Fairly Low	Foothills
	60			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	59			Moderate	Agriculture - Pasture Land	Low	Low	Foothills
	58			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	57			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	56			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	55			Moderate	Agriculture - Pasture Land	Low	Low	Foothills
	54			Moderate	Agriculture - Row Crop	Low	Low	Foothills
UM8	53		Stanfield Dam (RK 53.44)	Moderate	Agriculture - Pasture Land	Low	Low	Foothills
	52			Moderate	Agriculture - Pasture Land	Low	Low	Foothills
	51			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	50			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	49			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	48			Moderate	Agriculture - Row Crop	Low	Low	Foothills
	47			Moderate	Agriculture - Row Crop	Low	Low	Foothills
UM9	46		Feed Canal Dam (RK 46.36)	Moderate	Agriculture - Row Crop	Low	Low	Foothills
	45			Moderate	Agriculture - Row Crop	Low	Low	Foothills

UM10	44		Westland Dam (RK 44.67)	Moderate	Agriculture - Row Crop	Low	Low	Foothills
	43			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	42			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	41			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
UM11	40		Dillon Dam (RK 40.23)	Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	39			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	38			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	37			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	36			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	35			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	34			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	33			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	32			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	31			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	30			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	29			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	28			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	27			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	26			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	25			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
UM12	24	Butter Cr. (RK 24.44)	Maxwell Dam (RK 24.61)	Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	23			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	22			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	21			Moderate	Agriculture - Row Crop	Low	Low	Low Lands
	20			Moderate	Agriculture - Row Crop	Low	Fairly Low	Low Lands
	19			Moderate	Agriculture - Row Crop	Low	Fairly Low	Low Lands
	18			Moderate	Agriculture - Row Crop	Low	Fairly Low	Low Lands
	17			Moderate	Agriculture - Row Crop	Low	Fairly Low	Low Lands
	16			Moderate	Urban Development	Low	Fairly Low	Low Lands
	15			Moderate	Urban Development	Low	Fairly Low	Low Lands
	14			Moderate	Urban Development	Low	Fairly Low	Low Lands

	13			Moderate	Agriculture - Row Crop	Low	Fairly Low	Low Lands
	12			Moderate	Agriculture - Row Crop	Low	Fairly Low	Low Lands
	11			Moderate	Agriculture - Row Crop	Low	Fairly Low	Low Lands
	10			Moderate	Agriculture - Row Crop	Low	Medium	Low Lands
	9			Moderate	Agriculture - Row Crop	Low	Medium	Low Lands
	8			Moderate	Agriculture - Row Crop	Low	Medium	Low Lands
	7			Moderate	Agriculture - Row Crop	Low	Medium	Low Lands
	6			Moderate	Agriculture - Row Crop	Low	Medium	Low Lands
UM13	5		Three Mile Dam (RK 5.9)	Moderate	Agriculture - Row Crop	Low	Medium	Low Lands
	4			Moderate	Agriculture - Row Crop	Low	Medium	Low Lands
	3			High	Agriculture - Row Crop	Low	Medium	Low Lands
	2			Moderate	Urban Development	Low	Medium	Low Lands
	1			Moderate	Urban Development	Low	Medium	Low Lands

Appendix B, Table 1. Monthly habitat quality scores and indices for bull trout spawning habit in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	4.30	4.30	4.30	4.56	4.56	3.99	3.74	3.74	3.99	4.51	4.25	4.30
NFUM2	4.22	4.22	4.22	4.48	3.96	3.91	3.65	3.65	3.91	4.43	4.43	4.22
UM1	4.12	4.12	4.12	4.12	3.86	3.80	3.80	3.80	3.80	3.80	4.06	4.12
UM2	3.97	3.97	3.97	3.97	3.45	3.65	3.39	3.39	3.65	3.91	3.91	3.97
UM3	3.94	3.94	3.94	3.94	3.68	3.62	3.36	3.36	3.36	3.62	3.88	3.94
UM4	3.79	3.79	3.79	3.79	3.27	3.21	3.21	3.21	3.21	3.47	3.73	3.79
UM5	3.46	3.46	3.46	3.46	2.94	2.88	2.88	2.88	2.88	3.14	3.40	3.46
UM6	3.53	3.53	3.53	3.01	3.01	2.95	2.95	2.95	2.95	3.21	3.47	3.53
UM7	3.68	3.68	3.68	3.16	3.16	3.35	3.09	3.09	3.35	3.35	3.61	3.68
UM8	3.75	3.75	3.75	3.23	3.23	3.17	3.17	3.17	3.17	3.43	3.69	3.75
UM9	3.63	3.63	3.63	3.11	3.11	3.05	2.84	2.84	2.94	3.31	3.57	3.63
UM10	3.69	3.47	3.47	2.95	2.95	2.89	2.25	2.25	2.57	3.37	3.63	3.69
UM11	3.90	3.17	3.17	3.12	3.12	2.85	1.99	1.99	2.31	3.32	3.32	3.90
UM12	3.69	3.47	3.47	2.95	2.95	2.89	2.25	2.25	2.57	3.37	3.63	3.69
UM13	3.43	3.69	3.17	3.17	2.69	2.89	1.99	1.99	2.52	3.10	3.36	3.43

HQ Index
High
Good
Fair
Low
Poor

Appendix B, Table 2. Monthly habitat quality scores and indices for juvenile rearing, foraging and growth habitat in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	3.73	3.73	3.73	4.02	4.31	4.27	4.56	4.56	4.27	4.27	3.98	4.02
NFUM2	3.64	3.64	3.64	3.92	4.21	4.17	4.46	4.46	4.17	4.17	3.88	3.92
UM1	3.56	3.56	3.56	3.56	4.14	4.59	4.30	4.30	4.30	4.59	4.30	3.56
UM2	3.37	3.37	3.37	3.37	4.24	4.11	3.82	3.82	4.11	4.11	4.11	3.37
UM3	3.43	3.43	3.43	3.43	4.01	4.17	3.59	3.59	3.88	4.46	4.17	3.43
UM4	3.16	3.16	3.16	3.16	3.73	3.60	3.03	3.32	3.60	4.18	3.89	3.16
UM5	2.71	2.71	2.71	2.71	3.58	3.16	2.58	2.87	3.16	3.74	3.45	2.71
UM6	2.80	2.80	2.80	3.38	3.38	3.25	2.96	2.96	3.25	3.54	3.54	2.80
UM7	2.99	2.99	2.99	3.57	3.57	3.73	3.15	3.44	3.73	3.73	3.73	2.99
UM8	3.13	3.13	3.13	3.71	3.71	3.58	3.29	3.29	3.58	3.87	3.87	3.13
UM9	2.96	2.96	2.96	3.54	3.54	3.41	3.03	3.03	3.36	3.70	3.70	2.96
UM10	3.11	2.89	2.89	3.47	3.47	3.34	2.53	2.53	3.08	3.85	3.85	3.11
UM11	3.59	3.37	3.37	3.88	3.59	3.24	2.21	2.21	2.77	3.75	4.04	3.59
UM12	3.11	2.89	2.89	3.47	3.47	3.05	2.24	2.53	3.08	3.85	3.85	3.11
UM13	3.00	3.00	3.29	3.29	3.07	3.23	2.13	2.13	2.89	3.45	3.45	3.00

HQ Index
High
Good
Fair
Low
Poor

Appendix B, Table 3. Monthly habitat quality scores and indices for fluvial adult upstream migration habitat in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	4.03	4.03	4.03	4.20	4.20	4.16	4.52	4.16	4.16	4.16	3.99	4.03
NFUM2	3.98	3.98	3.98	4.16	4.16	4.12	4.47	4.12	4.12	4.12	4.12	3.98
UM1	3.82	3.82	3.82	3.82	4.00	4.17	4.70	4.70	4.52	4.17	4.17	3.82
UM2	3.69	3.69	3.69	3.69	3.87	4.39	4.22	4.22	4.39	4.04	4.04	3.69
UM3	3.66	3.66	3.66	3.66	3.84	4.36	4.18	4.18	4.18	4.36	4.00	3.66
UM4	3.58	3.58	3.58	3.58	4.11	4.10	3.92	3.92	4.10	4.28	3.92	3.58
UM5	3.14	3.14	3.14	3.14	3.67	3.66	3.49	3.49	3.66	3.84	3.49	3.14
UM6	3.21	3.21	3.21	3.74	3.74	3.73	3.56	3.73	3.73	3.91	3.56	3.21
UM7	3.43	3.43	3.43	4.13	3.96	4.30	3.95	3.95	4.30	4.13	3.77	3.43
UM8	3.47	3.47	3.47	4.18	4.18	3.99	3.81	3.99	3.99	4.17	3.81	3.47
UM9	3.45	3.45	3.45	4.16	4.16	3.97	3.41	3.41	3.78	4.15	3.79	3.45
UM10	3.42	3.15	3.15	3.85	3.85	3.67	2.37	2.37	3.20	4.12	3.77	3.42
UM11	3.67	3.39	3.39	4.02	4.20	3.74	2.16	2.34	3.00	4.37	3.84	3.67
UM12	3.42	3.15	3.15	3.85	3.85	3.67	2.37	2.37	3.20	4.12	3.77	3.42
UM13	3.15	3.33	3.33	3.33	3.40	3.75	2.27	2.27	3.21	3.85	3.49	3.15

HQ Index

High

Good

Fair

Low

Poor

Appendix B, Table 4. Monthly habitat quality scores and indices for adult foraging and maintenance habitat in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	3.89	3.89	3.89	4.15	4.40	4.37	4.37	4.37	4.37	4.37	4.12	4.15
NFUM2	3.81	3.81	3.81	4.07	4.32	4.29	4.29	4.29	4.29	4.29	4.04	4.07
UM1	3.73	3.73	3.73	3.73	4.24	4.35	4.60	4.60	4.35	4.35	4.35	3.73
UM2	3.55	3.55	3.55	3.55	4.06	4.17	4.17	4.17	4.17	4.17	4.17	3.55
UM3	3.58	3.58	3.58	3.58	4.08	4.19	3.94	3.94	4.19	4.19	4.19	3.58
UM4	3.35	3.35	3.35	3.35	3.85	3.96	3.46	3.46	3.96	3.96	3.96	3.35
UM5	2.83	2.83	2.83	2.83	3.34	3.45	2.95	2.95	3.45	3.45	3.45	2.83
UM6	2.94	2.94	2.94	3.44	3.44	3.55	3.05	3.30	3.55	3.55	3.55	2.94
UM7	3.17	3.17	3.17	3.93	3.68	4.04	3.54	3.79	4.04	3.79	3.79	3.17
UM8	3.29	3.29	3.29	4.04	4.04	3.90	3.40	3.65	3.90	3.90	3.90	3.29
UM9	3.17	3.17	3.17	3.93	3.93	3.78	3.12	3.12	3.70	3.78	3.78	3.17
UM10	3.25	3.02	3.02	3.78	3.78	3.64	2.53	2.53	3.34	3.86	3.86	3.25
UM11	3.72	3.50	3.50	3.72	3.97	3.61	2.28	2.53	3.09	4.08	3.83	3.72
UM12	3.25	3.02	3.02	3.78	3.78	3.39	2.53	2.53	3.34	3.86	3.86	3.25
UM13	3.10	3.10	3.36	3.36	3.14	3.50	2.39	2.39	3.17	3.47	3.47	3.10

HQ Index

- High
- Good
- Fair
- Low
- Poor

Appendix B, Table 5. Monthly habitat quality scores and indices for fluvial adult downstream migration habitat in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	4.14	4.14	4.14	4.54	4.74	4.71	4.51	4.51	4.71	4.71	4.51	4.54
NFUM2	4.06	4.06	4.06	4.46	4.66	4.63	4.42	4.42	4.63	4.63	4.42	4.46
UM1	3.93	3.93	3.93	3.93	4.53	4.47	4.47	4.47	4.47	4.47	4.67	3.93
UM2	3.78	3.78	3.78	3.78	4.18	4.32	4.12	4.12	4.32	4.52	4.52	3.78
UM3	3.75	3.75	3.75	3.75	4.35	4.28	4.08	4.08	4.08	4.28	4.48	3.75
UM4	3.63	3.63	3.63	3.63	4.03	3.97	3.77	3.77	3.97	4.17	4.37	3.63
UM5	3.20	3.20	3.20	3.20	3.60	3.53	3.33	3.33	3.53	3.73	3.93	3.20
UM6	3.28	3.28	3.28	3.68	3.68	3.61	3.41	3.61	3.61	3.81	4.01	3.28
UM7	3.48	3.48	3.48	3.88	3.88	4.01	3.81	3.81	4.01	4.01	4.21	3.48
UM8	3.53	3.53	3.53	3.93	3.93	3.87	3.67	3.87	3.87	4.07	4.27	3.53
UM9	3.48	3.48	3.48	3.88	3.88	3.82	3.45	3.45	3.82	4.02	4.22	3.48
UM10	3.47	3.21	3.21	3.61	3.61	3.55	2.66	2.66	3.28	4.01	4.21	3.47
UM11	4.11	3.84	3.84	3.91	3.91	3.58	2.43	2.63	3.05	4.04	4.04	4.11
UM12	3.47	3.21	3.21	3.61	3.61	3.55	2.66	2.66	3.28	4.01	4.21	3.47
UM13	3.61	3.61	3.81	3.81	3.34	3.48	2.75	2.75	3.28	3.74	3.94	3.61

HQ Index

- **High**
- **Good**
- **Fair**
- **Low**
- **Poor**

Appendix B, Table 6. Monthly habitat quality scores and indices subadult downstream migration habitat in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	4.04	4.04	4.04	4.51	4.75	4.72	4.48	4.48	4.72	4.72	4.48	4.51
NFUM2	3.98	3.98	3.98	4.46	4.69	4.66	4.42	4.42	4.66	4.66	4.42	4.46
UM1	3.82	3.82	3.82	3.82	4.53	4.43	4.43	4.43	4.43	4.43	4.66	3.82
UM2	3.68	3.68	3.68	3.68	4.16	4.29	4.06	4.06	4.29	4.53	4.53	3.68
UM3	3.66	3.66	3.66	3.66	4.38	4.27	4.03	4.03	4.03	4.27	4.51	3.66
UM4	3.55	3.55	3.55	3.55	4.02	3.92	3.68	3.68	3.92	4.15	4.39	3.55
UM5	3.08	3.08	3.08	3.08	3.56	3.45	3.21	3.21	3.45	3.69	3.93	3.08
UM6	3.16	3.16	3.16	3.63	3.63	3.53	3.29	3.53	3.53	3.77	4.00	3.16
UM7	3.37	3.37	3.37	3.85	3.85	3.98	3.74	3.74	3.98	3.98	4.22	3.37
UM8	3.43	3.43	3.43	3.91	3.91	3.80	3.56	3.80	3.80	4.04	4.28	3.43
UM9	3.41	3.41	3.41	3.89	3.89	3.78	3.37	3.37	3.78	4.02	4.26	3.41
UM10	3.37	3.16	3.16	3.64	3.64	3.53	2.70	2.70	3.32	3.98	4.22	3.37
UM11	4.14	3.93	3.93	3.91	3.91	3.59	2.54	2.78	3.17	4.04	4.04	4.14
UM12	3.37	3.16	3.16	3.64	3.64	3.53	2.70	2.70	3.32	3.98	4.22	3.37
UM13	3.57	3.57	3.81	3.81	3.36	3.49	2.83	2.83	3.25	3.70	3.94	3.57

HQ Index
High
Good
Fair
Low
Poor

Appendix B, Table 7. Monthly habitat quality scores and indices for fluvial subadult upstream migration habitat in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	4.73	4.73	4.73	4.73	4.73	4.69	4.69	4.69	4.69	4.69	4.69	4.73
NFUM2	4.68	4.68	4.68	4.68	4.68	4.65	4.65	4.65	4.65	4.65	4.65	4.68
UM1	4.53	4.53	4.53	4.53	4.53	4.69	4.69	4.69	4.69	4.69	4.69	4.53
UM2	4.40	4.40	4.40	4.40	4.40	4.56	4.36	4.36	4.56	4.56	4.56	4.40
UM3	4.36	4.36	4.36	4.36	4.36	4.52	4.12	4.12	4.32	4.52	4.52	4.36
UM4	4.27	4.27	4.27	4.27	4.27	4.23	3.83	3.83	4.23	4.43	4.43	4.27
UM5	3.86	3.86	3.86	3.86	3.86	3.81	3.42	3.42	3.81	4.01	4.01	3.86
UM6	3.86	3.86	3.86	3.86	3.86	3.81	3.42	3.42	3.81	4.01	4.01	3.86
UM7	4.13	4.13	4.13	4.13	4.13	4.29	3.89	4.09	4.29	4.29	4.29	4.13
UM8	4.18	4.18	4.18	4.18	4.18	4.13	3.74	3.93	4.13	4.33	4.33	4.18
UM9	4.14	4.14	4.14	4.14	4.14	3.77	3.37	3.37	3.93	4.30	4.30	4.14
UM10	4.11	3.84	3.84	3.84	3.84	3.80	2.35	2.35	3.36	4.27	4.27	4.11
UM11	4.17	3.89	3.89	4.17	4.17	3.85	2.13	2.33	3.14	4.33	4.33	4.17
UM12	4.11	3.84	3.84	3.84	3.84	3.60	2.35	2.35	3.36	4.27	4.27	4.11
UM13	3.87	3.87	3.87	3.87	3.59	3.75	2.30	2.30	3.38	4.02	4.02	3.87

HQ Index

High

Good

Fair

Low

Poor

Appendix B, Table 8. Monthly habitat quality scores and indices for fluvial subadult rearing, foraging, and growth habitat in fifteen reaches in the North Fork Umatilla and Umatilla rivers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NFUM1	3.85	3.85	3.85	3.85	4.11	4.08	4.35	4.35	4.08	4.08	3.82	3.85
NFUM2	3.76	3.76	3.76	3.76	4.03	4.00	4.26	4.26	4.00	4.00	3.73	3.76
UM1	3.64	3.64	3.64	3.64	3.91	4.29	4.55	4.55	4.29	4.29	4.02	3.64
UM2	3.48	3.48	3.48	3.48	4.01	4.12	4.12	4.12	4.12	3.86	3.86	3.48
UM3	3.49	3.49	3.49	3.49	3.76	4.14	3.87	3.87	4.14	4.14	3.87	3.49
UM4	3.30	3.30	3.30	3.30	3.83	3.94	3.41	3.41	3.94	3.94	3.68	3.30
UM5	2.79	2.79	2.79	2.79	3.33	3.44	2.91	2.91	3.44	3.44	3.18	2.79
UM6	2.88	2.88	2.88	3.41	3.41	3.53	3.00	3.26	3.53	3.53	3.26	2.88
UM7	3.11	3.11	3.11	3.90	3.64	4.02	3.49	3.75	4.02	3.75	3.49	3.11
UM8	3.20	3.20	3.20	4.00	4.00	3.85	3.32	3.58	3.85	3.85	3.58	3.20
UM9	3.13	3.13	3.13	3.93	3.93	3.78	3.10	3.10	3.71	3.78	3.51	3.13
UM10	3.16	2.95	2.95	3.75	3.75	3.60	2.51	2.51	3.32	3.80	3.54	3.16
UM11	3.42	3.22	3.22	3.69	3.95	3.60	2.30	2.56	3.11	4.07	3.80	3.42
UM12	3.16	2.95	2.95	3.75	3.75	3.33	2.51	2.51	3.32	3.80	3.54	3.16
UM13	2.81	2.81	3.07	3.07	3.13	3.51	2.42	2.42	3.17	3.45	3.19	2.81

HQ Index
High
Good
Fair
Low
Poor

Appendix C. Summary report of the current state of our knowledge of bull trout in the Umatilla Basin.

Bull Trout in the Umatilla Basin

Introduction

When the Draft Bull Trout Recovery Plan was issued in 2002 and revised for the Umatilla-Walla Walla recovery unit in 2004, limited information was available on the abundance, distribution, and life history of bull trout and the factors limiting them in the Umatilla Basin. Since 2004, the U. S. Fish and Wildlife Service's Columbia River Fisheries Program Office has investigated these topics to provide information required to properly plan, implement, and monitor recovery efforts. Here, we combine our findings and those from other entities into a condensed summary of the current state of our knowledge of bull trout in the Umatilla Basin, and highlight some management questions that arise as a result of those findings.

Number and Distribution of Bull Trout Local Populations

The revised Draft Bull Trout Recovery Plan lists two local populations of bull trout in the Umatilla Basin, the upper Umatilla River (including the North Fork and South Fork Umatilla rivers) and the North Fork Meacham Creek local populations. Only the North Fork Umatilla River was known to support a viable local population of bull trout when the recovery plan was written. The South Fork Umatilla River and North Fork Meacham Creek were included based on infrequent observations of bull trout or redds attributed to them in those streams in the recent past. Questions remained not only as to whether the South Fork Umatilla River and North Fork Meacham Creek actually supported bull trout local populations, but also whether other streams might, given rigorous surveys had not been conducted throughout the Umatilla Basin.

To address these questions, we conducted a "patch analysis" (USFWS 2008) to identify areas (patches) in the Umatilla Basin that hold the potential to support bull trout spawning and early rearing. We subsequently visited the patches that were identified to determine whether base stream flow within them was sufficient to support bull trout, and conducted bull trout occupancy surveys in patches with sufficient stream flow. We assessed spawning habitat during the occupancy surveys to identify patches that, if unoccupied, might be capable of supporting bull trout spawning in the future.

We identified 24 bull trout patches and determined seven had sufficient stream flow to support bull trout (Figure 1). We conducted occupancy surveys in five of those seven patches, excluding the North Fork Umatilla River because it was known support a local bull trout population, and Johnson Creek because of time constraints and the minimal likelihood of bull trout being present there given the narrow width and shallow depth of the reach of stream within the patch.

We found no bull trout in the patches sampled during the occupancy surveys. Thus, it appears there is currently only one bull trout local population in the Umatilla Basin, and it is in the North Fork Umatilla River. Bull trout spawning in the North Fork is restricted currently to a 5-mile reach and is concentrated in an approximately 2.5-mile reach.

We assessed spawning habitat at 60 to 96 sites within the patches where the occupancy surveys were conducted (Table 1). None of the patches contained ample spawning habitat. Spring Creek contained the most, but stream temperatures measured during the occupancy surveys indicated it may be too warm to support bull trout, despite what the results from the patch analysis indicated. Buck Creek might hold the greatest potential to support bull trout. It contained the second highest amount of spawning habitat and has been confirmed to be cold enough to support bull trout spawning and early rearing. Notably, North Fork Meacham Creek and the South Fork Umatilla River contained little to no spawning habitat.

Abundance of Bull Trout in the North Fork Umatilla River

The abundance of adult bull trout in the North Fork Umatilla River is low. Redd counts in the North Fork rose from 29 in 1994 to 144 in 1999, but have declined more or less steadily since then (Figure 2). An average of only 22 redds has been counted annually over the past ten years. Researchers from Utah State University estimated fewer than 25 migratory adult bull trout (individuals >370 mm fork length) were present in the North Fork each summer in 2003-2008 (Figure 3). Abundance estimates of bull trout ≤370 mm fork length, which could have been resident juveniles, migratory juveniles, resident adults, or combinations thereof, ranged from 504 to 3,114 each summer (Figure 3). Since 2004, all of the redds in the North Fork have been the size of those made by migratory females. Thus, there appears to be either no, or a very small, resident component to the population. Prior to 2004, resident-sized redds were often observed (T. Bailey, ODFW, personal communication).

Production of subadult bull trout from the North Fork Umatilla River also appears to be low. Of 530 bull trout that were <300 mm fork length (i.e., that were presumably not migratory adults) when PIT tagged in the North Fork in 2003-2009, only 47 (9%) were subsequently observed emigrating past a detection site at the mouth of the North Fork (UM1)(Figure 4). Another 4 (0.1%) passed UM1 undetected and were detected at a detection site approximately 10 miles downstream (UM2)(Figure 4).

Movement and Distribution of Migratory Bull Trout

Personnel from ODFW studied the migrations of adult bull trout in the Umatilla Basin in 1998-99 and 2002-03 (ODFW, unpublished report; Sankovich et al. 2003, 2004). The movements of the bull trout in those studies were restricted relative to those of migratory adult bull trout in systems with less land and water use impacts than in the Umatilla River (Starcevich et al. 2010, 2012). All but one of the migratory adult bull trout in the Umatilla River overwintered within its upper 24 miles (Figure 5), and none utilized the lower Umatilla River or Columbia River.

Since 1995, 17 bull trout have been trapped in the east bank ladder at Three Mile Falls Dam (TMFD) on the lower Umatilla River (Figure 6). They ranged from 250 to 510 mm in fork length and at that size were likely migratory adults. In 2004-2013, we tagged nine bull trout captured at TMFD. Five were outfitted with radio and PIT tags and four, only with PIT tags. Each of the five radio-tagged bull trout continued migrating upstream after being released above TMFD, and all but one successfully passed the diversion dams in the lower river (Figure 6). The individual that did not pass all of the diversion dams arrived relatively late at TMFD, was recovered as a mortality, and may have succumbed to unsuitable stream temperatures. One of the radio-tagged bull trout migrated onto the spawning grounds in the North Fork Umatilla River (Figure 6) and was present there during the bull trout spawning period. Another migrated to the upper Umatilla River, where it was either legally harvested by a tribal member or poached (its radio tag was located in a trailer park in Pendleton a few days after being located in the upper Umatilla River). The two remaining radio-tagged bull trout were last observed downstream from McKay Creek in the cold water plume created by hypolimnetic water releases from McKay Reservoir. To date, the bull trout outfitted only with PIT tags have not been detected at any detection sites in the Umatilla River or Columbia River basins.

The presence of bull trout at TMFD may not be an indication that at least some North Fork Umatilla River bull trout use the lower Umatilla River or Columbia River. Genetic analyses indicated none of the bull trout tagged at TMFD originated in the Umatilla Basin (Figure 6)(Small et al. 2012). Seven were from the adjacent Walla Walla Basin, and one was from the Tucannon Basin. The genetic sample from an individual captured in 2013 has not yet been analyzed.

In 2006-2008, we radio-tagged 69 subadult bull trout captured in spring in a screw trap just below the mouth of the North Fork Umatilla River. Like the migratory adults in the ODFW studies, the subadults did not undertake extensive migrations (Figure 7). Those that moved downstream after their release remained within the upper 23 miles of the Umatilla River. Some apparently were making local rather than directed downstream movements when captured, since they moved upstream after being released (Figure 7).

Genetics of North Fork Umatilla River Bull Trout

Bull trout in the North Fork Umatilla River are genetically different from other bull trout populations (Spruell et al. 2003; Ardren et al. 2011), but there are no data indicating they are more unique than other bull trout populations (P. DeHaan, USFWS, personal communication). North Fork Umatilla River bull trout had a single mtDNA haplotype, which was the most common one observed among the 75 populations Ardren et al. (2011) analyzed, and they possessed no unique microsatellite loci (P. DeHaan, USFWS, personal communication). Bull trout in the North Fork Umatilla River were most similar to other populations in the mid-Columbia and Snake River regions.

Potential Limiting Factors

Under current conditions, the primary factor limiting the production of North Fork Umatilla River bull trout is likely high stream temperatures that restrict bull trout to a small area in the North Fork Umatilla River, and perhaps the upper Umatilla River, in summer. Over the past ten years, stream temperatures meeting the US EPA's criteria for bull trout spawning and rearing have only existed in the North Fork Umatilla River (Figure 8). The high stream temperatures are due largely to past land uses in the upper main stem and its two major tributaries outside the North Fork Umatilla wilderness area, the South Fork Umatilla River and Meacham Creek. Logging and grazing in these tributary basins and grazing and wood removal along the upper main stem have led to the various problems associated with those practices (e.g., loss of riparian habitat and pools, earlier and less prolonged runoff). The upper main stem and Meacham Creek have also been affected by the construction and maintenance of roads and a railroad in their floodplains (e.g., dikes and levees have been built and the streams have been channelized).

The Future of Bull Trout in the Umatilla Basin

The prospects of Umatilla Basin bull trout appear poor. The one remaining local population is small, isolated, and seasonally restricted to a limited area. A decades-long restoration effort would be required to increase the amount of habitat in the Umatilla River with suitable temperatures for bull trout. Given these facts, some relevant management questions arise: 1) How likely is it that North Fork Umatilla River bull trout will persist long enough to benefit from habitat restoration efforts (if such efforts are ever undertaken)? 2) Should managers simply let nature take its course, or should some type of intervention--in the form of artificial production--be attempted? and 3) If artificial production is attempted, what strategy should be employed (e.g., translocation, captive rearing, or captive breeding)?

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Table 1. Number of sites where spawning habitat was assessed within patches, and the number (and percentage) of those sites that contained suitable spawning habitat.

Patch	Number of sites	Number with suitable habitat (%)
Buck Cr.	96	6(6.3)
Spring Cr.	87	8(9.2)
Shimmiehorn Cr.	72	3(4.2)
SF Umatilla R.	72	0(0.0)
NF Meacham Cr.	60	1(1.7)

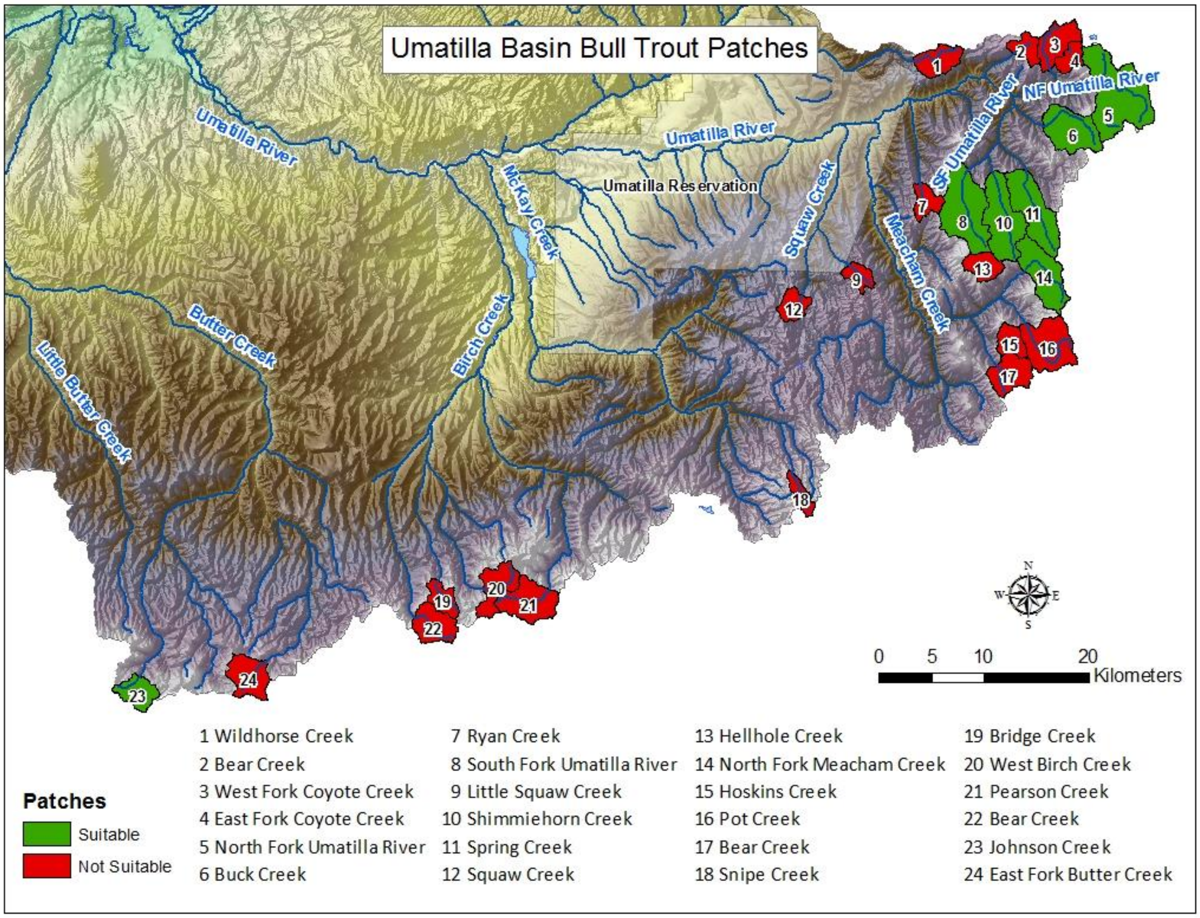


Figure 1. Bull trout patches in the Umatilla Basin identified through a "patch analysis" (USFWS 2008). Patches determined through reconnaissance surveys to have sufficient (Suitable) and insufficient (Not Suitable) stream flow to support bull trout are shown.

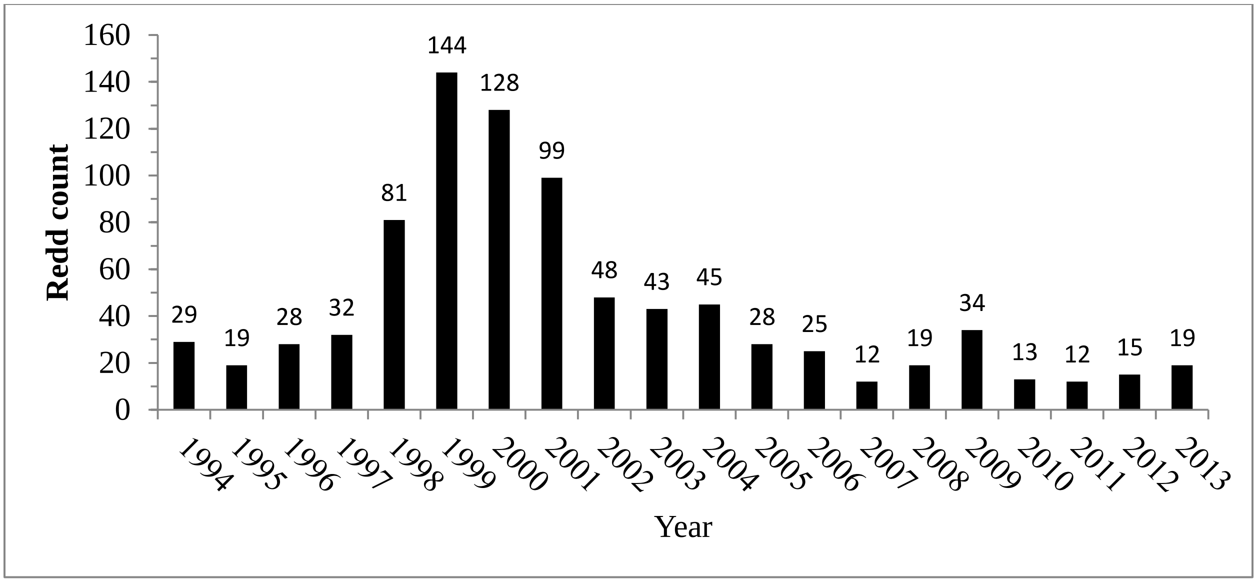


Figure 2. Bull trout redd counts in the North Fork Umatilla River in 1994 - 2013.

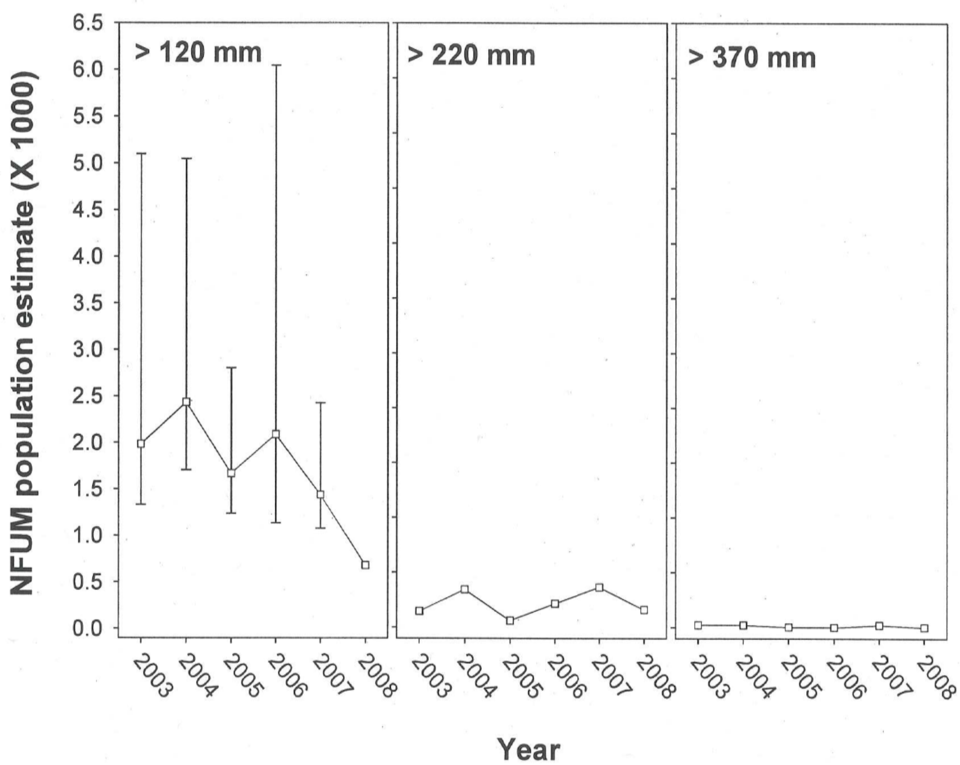
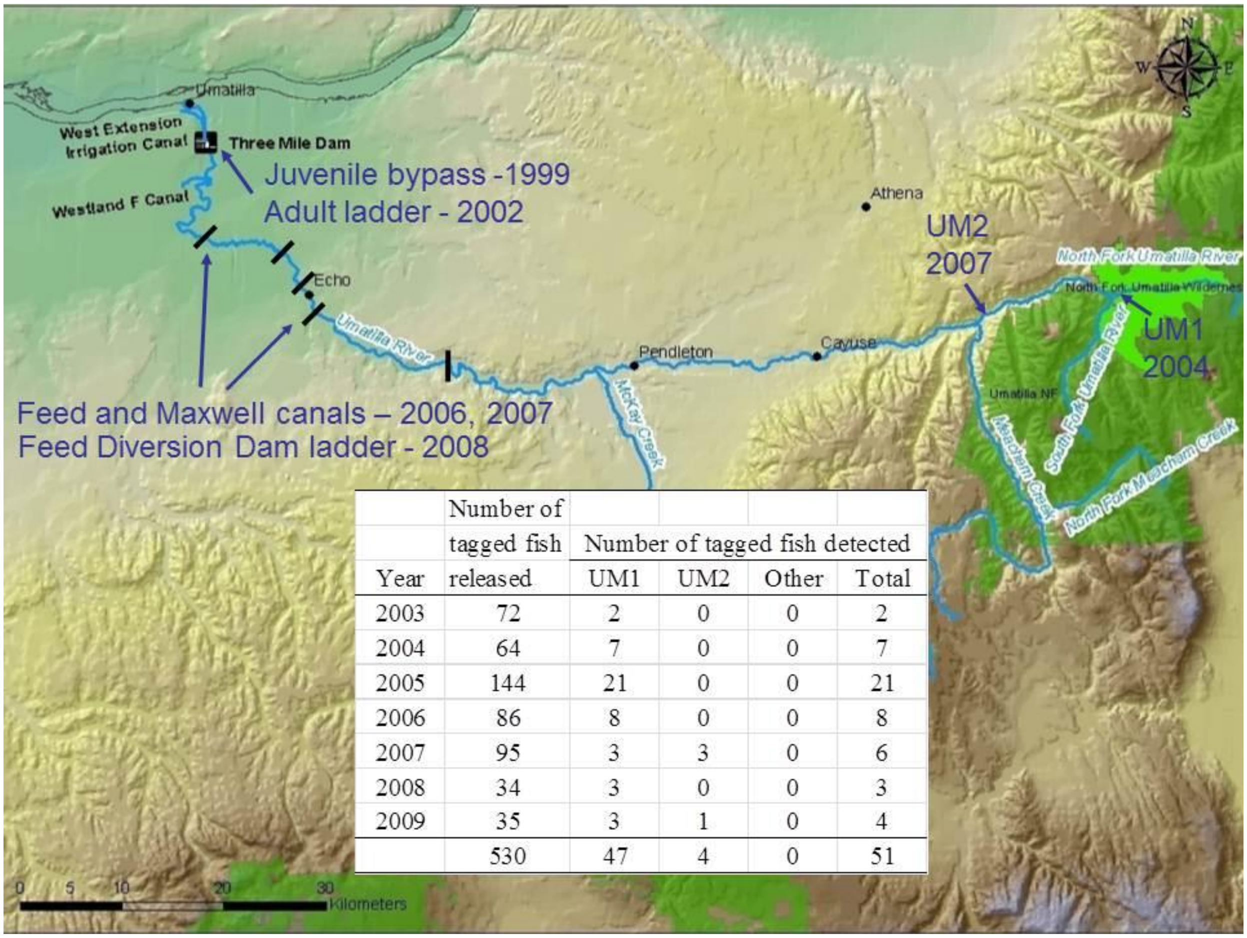


Figure 3. Abundance estimates of bull trout in three size classes (>120 mm and ≤220 mm, >220 mm and ≤370 mm, and >370 mm) in the North Fork Umatilla River (NFUM) in summer 2003-2008. Reproduced from Budy et al. (2009).



Year	Number of tagged fish released	Number of tagged fish detected			
		UM1	UM2	Other	Total
2003	72	2	0	0	2
2004	64	7	0	0	7
2005	144	21	0	0	21
2006	86	8	0	0	8
2007	95	3	3	0	6
2008	34	3	0	0	3
2009	35	3	1	0	4
	530	47	4	0	51

Figure 4. Location and year of installation of PIT tag detection sites in the Umatilla and North Fork Umatilla rivers, the number of PIT-tagged bull trout released in the North Fork Umatilla River in summer 2003-2009, and the number of unique (first-time) detections of those fish at the various detection sites. Only bull trout <300 mm at tagging are included.

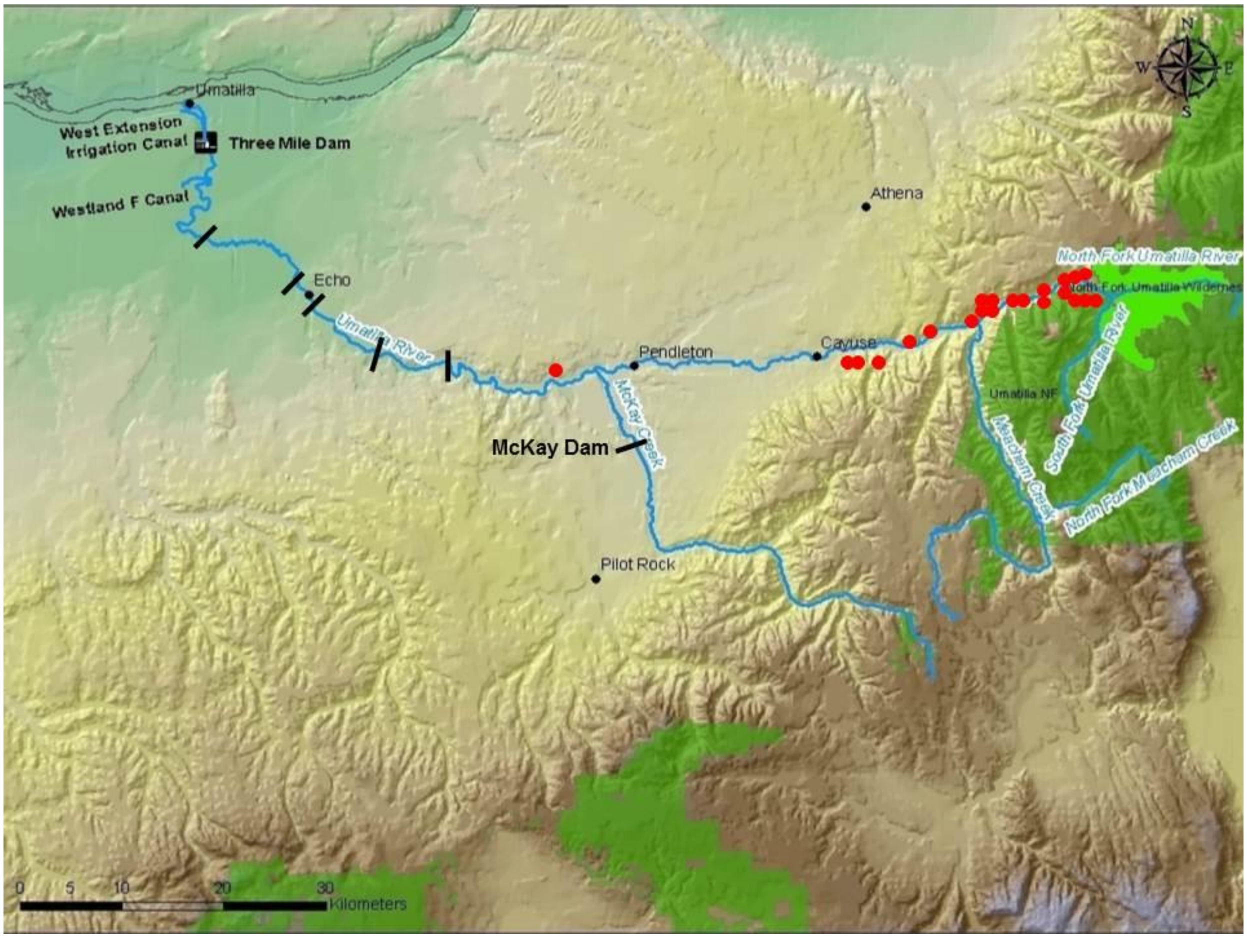
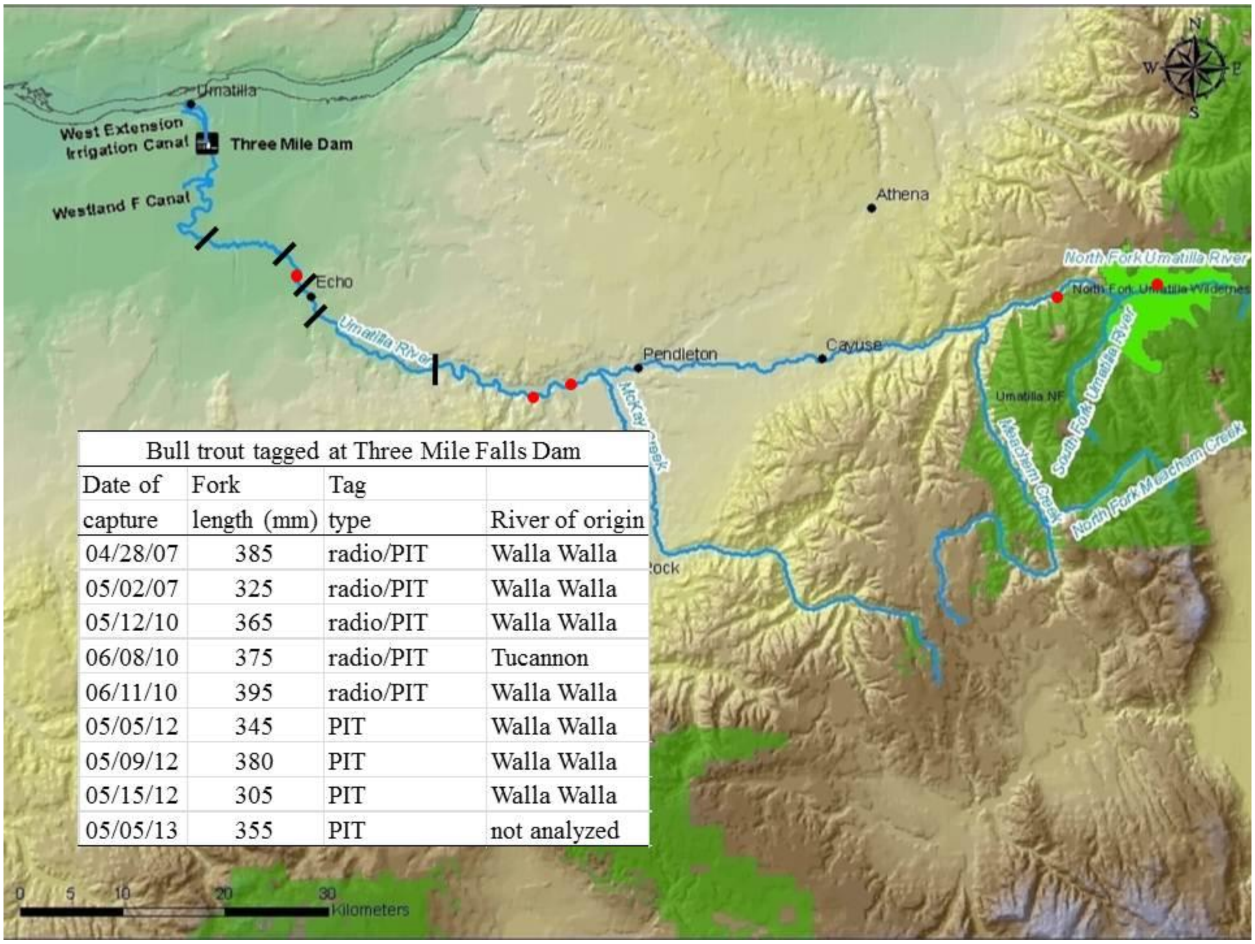


Figure 5. Downstream-most (i.e., winter) location of migratory adult bull trout radio tagged on the Umatilla River in 1998 and 2002.



Bull trout tagged at Three Mile Falls Dam			
Date of capture	Fork length (mm)	Tag type	River of origin
04/28/07	385	radio/PIT	Walla Walla
05/02/07	325	radio/PIT	Walla Walla
05/12/10	365	radio/PIT	Walla Walla
06/08/10	375	radio/PIT	Tucannon
06/11/10	395	radio/PIT	Walla Walla
05/05/12	345	PIT	Walla Walla
05/09/12	380	PIT	Walla Walla
05/15/12	305	PIT	Walla Walla
05/05/13	355	PIT	not analyzed

Figure 6. Date of capture, fork length, tag type, and river of origin of nine bull trout tagged and released above Three Mile Falls Dam in 2007-2013. The upstream-most location of the five radio-tagged bull trout are indicated by red dots.

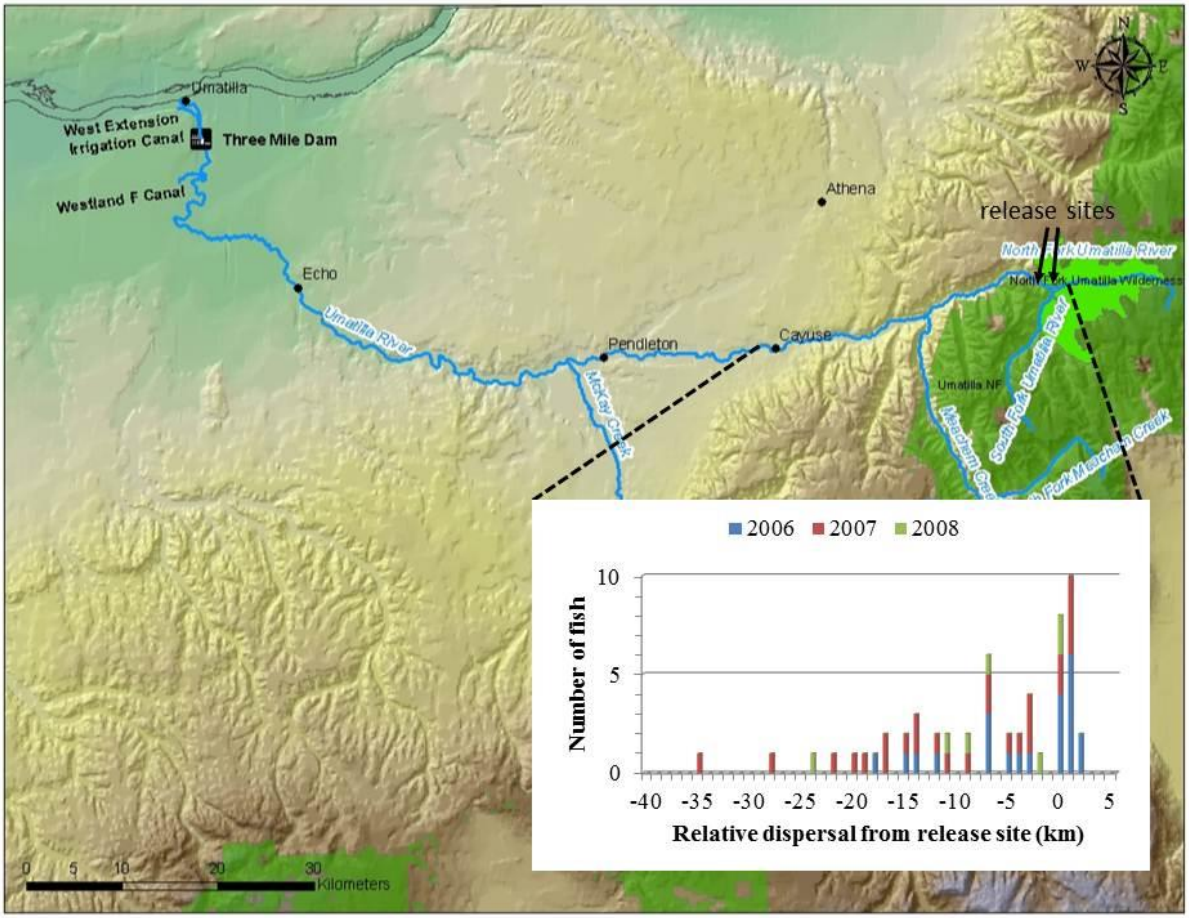


Figure 7. Relative dispersal of radio-tagged subadult bull trout after being released at sites in the upper Umatilla River and lower North Fork Umatilla River.

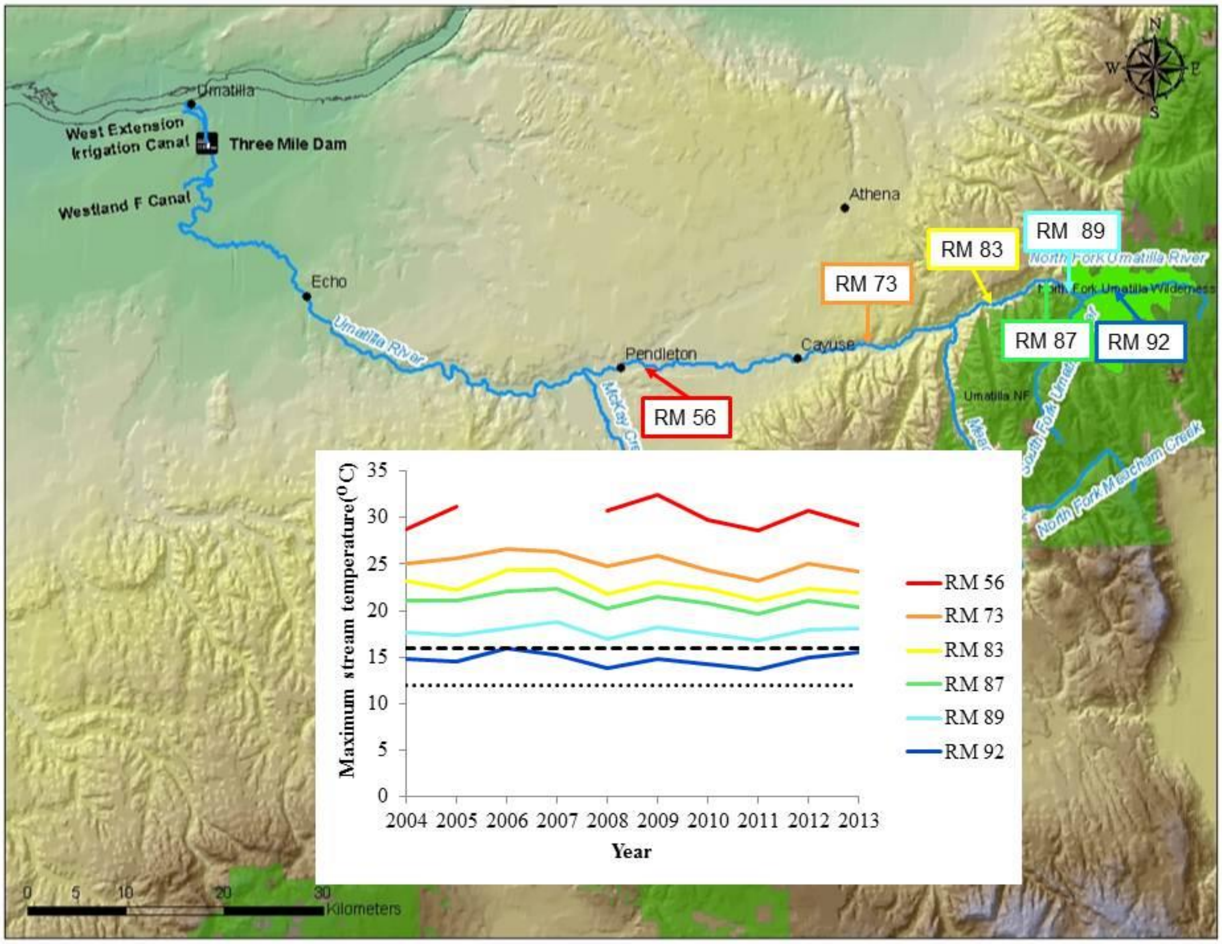


Figure 8. Maximum stream temperatures between river mile (RM) 56 on the Umatilla River and RM 92 on the North Fork Umatilla River in 2004-20013. River miles are continuous from the mouth of the Umatilla River into the North Fork of the Umatilla River. The North Fork enters the Umatilla River at RM 89.4. The dashed lines indicate the US EPA criteria for maximum stream temperatures in bull trout rearing (lower line) and migratory (upper line) habitat. Stream temperatures meeting the criterion for bull trout rearing exist in the North Fork Umatilla River, but upstream from the temperature monitoring site at RM 92.

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