GRANDE RONDE
MODEL WATERSHED

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October 1, 2018

Independent Scientific Review Panel
Northwest Power and Conservation Council
851 S.W. Sixth Avenue, Suite 1100
Portland, Oregon 97204

Dear Panel Members,

We are pleased to submit the 25-year synthesis of the Grande Ronde Model Watershed (GRMW) and hope you find it satisfactory. Although this assignment might have been accepted begrudgingly, we have found value in taking the time to look at the road behind us, if for no other reason than to see if the dust has settled.

It is the nature of organizations like ours to engage in an endless cycle of plan, prioritize, plan, prioritize, and plan some more, often failing to review past actions with a critical eye. This shortcoming might not be as commonplace as I suspect, but having been engaged in the politics and science of this relatively new 'industry' for more than 20 years, I sense that it is not unique to GRMW. I am reminded that this synthesis encapsulates all my career with GRMW and so it is a personal reminder of some, but surely not all, of my own shortcomings.

If I may be presumptuous, I anticipate that other Umbrella organizations in the Columbia Basin will be tasked with a similar undertaking, and while I hope that our synthesis is not only what the Panel expected, but also can serve as a guide to those who will be preparing their own.

Since I am already being presumptuous, I would like to offer a couple of suggestions to the Panel when and if you assign similar tasks to others. Instead of prescribing a timeline that is virtually impossible to meet, allow a 6-9 month gestation period, with periodic check-ins for pre-determined content levels. The organic nature of a document like this that serves as an introspection gone public is to be valued, but leave few guesses about what should be included. Seek a balance of prescription and latitude.

Remember that we all have full time jobs already and that the organizations through which we get the vast majority of our financial support are not eager to fund work that was assigned to us by the Panel. We received no financial support from BPA or OWEB for the preparation of our synthesis. I was not able to ask staff members to set aside other work for more than a few hours at a time to work on the synthesis, yet there was the constant demand to provide materials and participate in review of sections for content, accuracy, even grammar. We asked a lot of our partners, those with whom we work directly on habitat restoration and those that work primarily in research, monitoring and modeling.

It is with a sigh of relief that we submit this synthesis, knowing that in a short time, we will begin anticipating the Panel's review and comments. Thank you for the opportunity, support and guidance.

Sincerely,

Jeff Oveson

Executive Director

GRANDE RONDE MODEL WATERSHED SYNTHESIS

1992-2016

Johanna Doty Sedell

Grande Ronde Model Watershed | La Grande, Oregon

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Introduction

The Model Watershed began with an assumption that a local citizens' group could be more effective at restoring the watershed habitat needed to improve salmon and steelhead populations than top-down, agency-led initiatives. In her 1996 application to BPA for funding, Patty Perry, then the organization's executive director, identified this underlying assumption, stating that the organization was testing the hypothesis that "[a] diverse citizen-based group can motivate fellow citizens and move forward with watershed restoration programs that measurably improve water quality, fish habitat, and [the] local economy" (P. Perry, 1996 BPA Fish and Wildlife Fiscal Year 1997 Proposal). She identified a single measurable objective: the "[a]dministration and development of watershed plans and projects to restore watershed function and improve salmonid production while maintaining a vigorous natural resource-based economy," an objective drawn directly from the organization's mission to "to develop and oversee the implementation, maintenance, and monitoring of coordinated resource management that will enhance the natural resources of the Grande Ronde River Basin." Constraints included social factors, such as the ability of the Board of Directors to commit to a shared vision, the ability of the organization to build trust with the community; ecological factors, such as the ability of "recommended measures" to have "positive effects upon fish habitat, water quality, and watershed health;" and links between watershed health and local economics.

In its twenty five-year history, the Grande Ronde Model Watershed has completed 248 projects, with a total of $32,391,030 invested in improvements to in-stream habitat, water quality, or uplands management. Researching the extent of restoration in the basin, Benge found that between 1994 and 2014, 4,449 sites received some sort of management action, and that 71 unique metrics were used in reporting documents to describe the work completed (2016). Those trying to quantify the impact of restoration on the basin will find, as Benge noted (citing work by Palmer and Allen, 2006), "[t]his can be challenging, as many stream restoration projects are implemented independently, with little coordination between agencies on the types of data collected" (2016). The purpose of this document is to summarize the work completed by the Grande Ronde Model Watershed to date, placing the work within the context of the evolution of the organization, planning documents, and research.

Reviewing the organization's work, the development of its role within the community, and the pressures facing native fish in the basin, five factors stand out as central to its success:

First, the presence of a long record of fisheries data, beginning with habitat surveys in the 1940s and continuing to the present with continued habitat surveys, data on fish populations, and data of fish use across the landscape. As the organization has evolved, these data have provided restoration practitioners with the ability to identify limiting factors, prioritize habitat restoration projects, and, in the future, determine the effectiveness of projects implemented. Second, the strong local leadership shown at the formation of the organization, which placed the Grande Ronde and Imnaha subbasin residents in a position to develop community-driven, rather than agency-driven restoration plans. Third, the organization received commitments from natural resource leaders, tribes, and the counties from the beginning. Leadership at the regional level connected the organization to those institutions and individuals charged with the responsibility of managing publicly owned natural resources or those encouraging sustainable development of privately owned natural resources. This strong foundation of gave the research community a reason to connect with the organization, as the value of data collection increases as it begins to inform on-the-ground changes. Fourth, the region supports local students pursuing careers in natural resources, resulting in the ability to hire professionals from the area. The organization has benefited from a talented group of staff members who grew up within the watershed's communities and maintain strong local connections. Finally, the availability of long-term funding from multiple sources leads to assurance amongst cooperators that contemplated watershed improvements are likely to be implemented. Replicating the organization's tools in another basin, such as the Atlas restoration planning tool or the adaptive management plan may not show the same level of success if any one of these factors is missing.

Early in the organization's history, work focused on implementing many projects in a short time frame, branding the organization with both funders and community members as a leader in watershed restoration. The organization quickly adopted planning documents to help prioritize restoration investments. Over time, the annual number of projects implemented has decreased, as the scale and complexity has increased, better targeting known limiting factors. In 2014, the Grand Ronde Model Watershed led the implementation of coordinated, landscape-wide planning and restoration through the development of the restoration Atlas, which now forms the core of adaptive watershed resource management in the basin. Over the next ten years, the Grande Ronde Model Watershed will lead the development of research-driven, coordinated efforts to address factors limiting salmon and steelhead production in the Grande Ronde headwaters and Catherine Creek, while leveraging developments in research to identify and respond to expanding conservation needs, particularly in the mainstem valley reaches of the Grande Ronde and those identified as priorities in the upcoming Wallowa County Atlas.

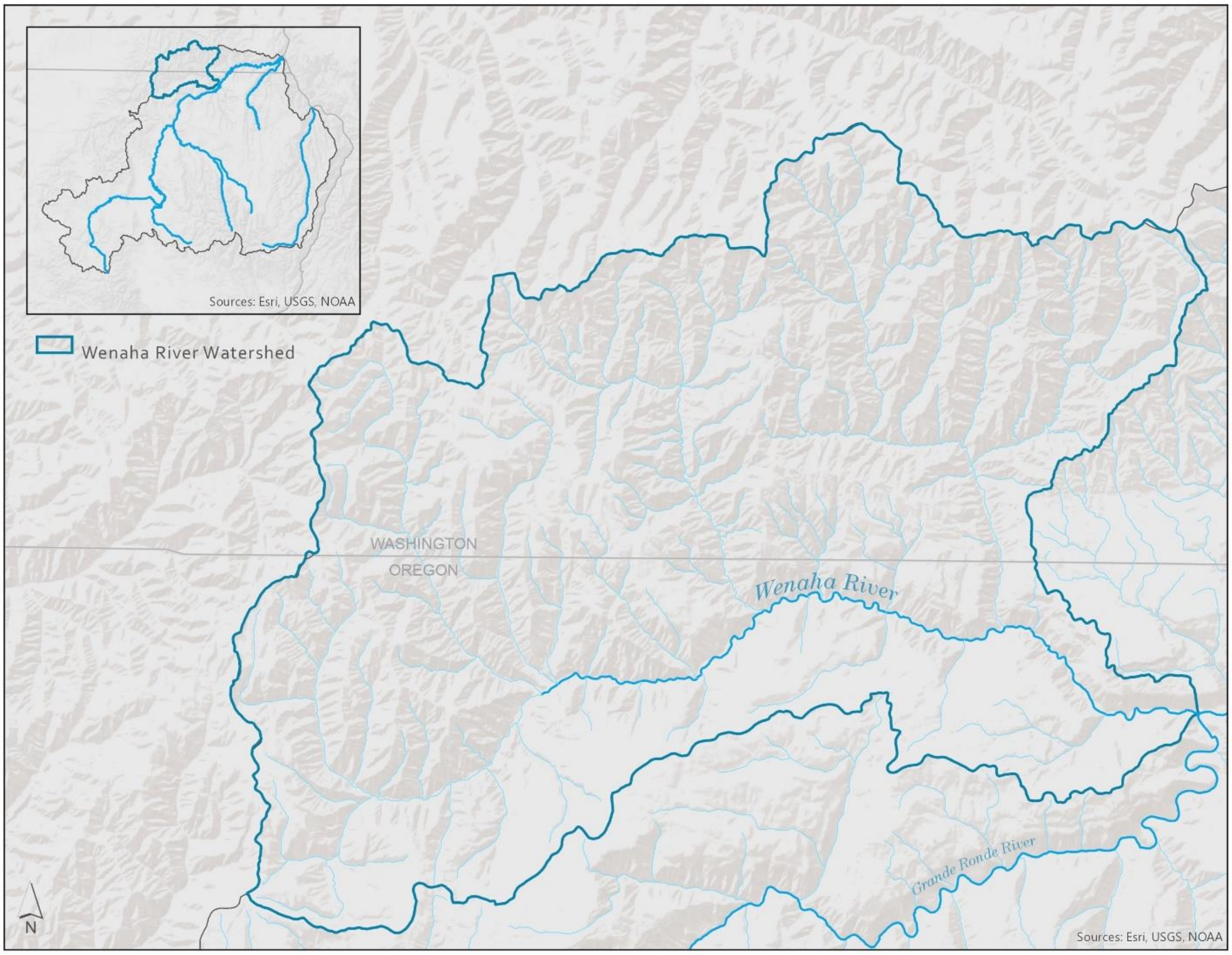
*GRMW Staff from left to right (**Top Row**): Jesse Steele, Connar Stone, Jeff Oveson, Coby Menton. (**Bottom Row**): Kayla Morinaga, Mary Estes, & Alex Towne.*

*GRMW Board Members & Alternates from left to right (**Top Row**): Nick Myatt, Tim Bailey, Norm Cimon, Kate Frenyea, Allen Childs, Larry Nall, Susan Roberts, Larry Cribbs. (**Bottom Row**): Dave Yost, Joe McCormack, Steve McClure, & Jed Hassinger. Board Members & Alternates not in photo: Donna Beverage, Jim Webster, Aaron Bliesner, Gene Hardy, Jim Lauman, & Jeff Yanke.*

Brief Geography and History of the Subbasins

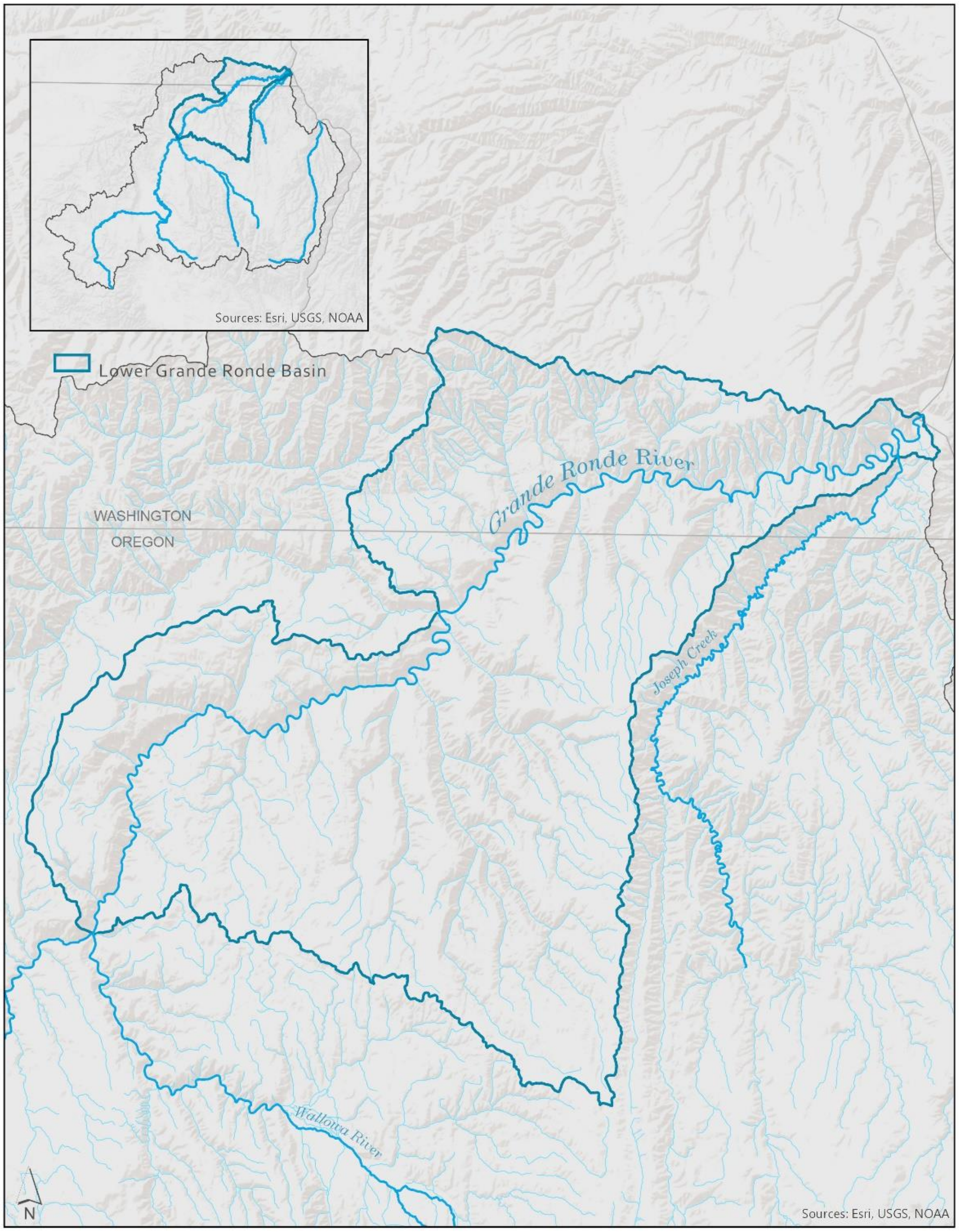
Map 1 Grande Ronde River Subbasin

The Grande Ronde River and its tributaries connect the peaks of the Wallowa and Blue Mountains of Eastern Oregon to the Snake and Columbia Rivers, and through them, to the Pacific Ocean. The continental climate of these Eastern Oregon ranges, which began as island arcs 200 million years ago, are moderated by the Cascade Range, which creates a rain shadow, and northern Rocky Mountain range, which tempers arctic winter extremes (Bryce and Omernik 1997). Marine air currents from the Columbia River Gorge also act to moderate the climate, lessening the effect of the Cascade rain shadow, as does elevation, with moisture increasing and temperature decreasing as elevation increases (Bryce and Omernik 1997). The 2004 Subbasin Plan identifies eight subbasins within the river system (Nowak 2004), with the location of headwaters, geology, and vegetation combining in ways that vary greatly from alpine wilderness to low elevation grasslands. See Gildemeister 1998 for a thorough review of the history of human use in the basin.



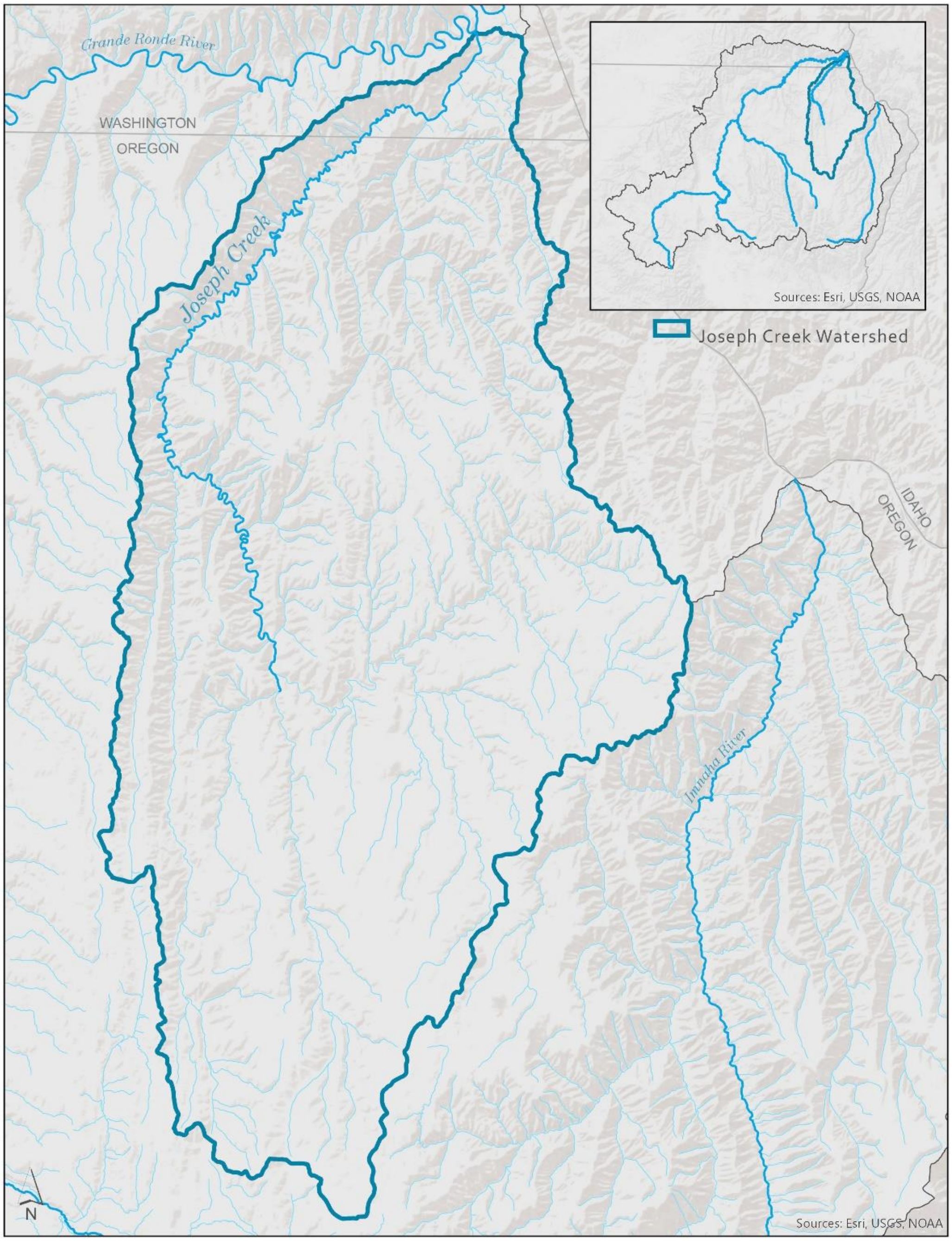
Map 2 Wenaha River Watershed

The Wenaha River drains an area of 296 square miles in the northern portion of the Grande Ronde basin, with its headwaters located in the Wenaha-Tucannon Wilderness. The 22 miles of river begin at an elevation of 4,500 feet, where up to five feet of snowfall can accumulate (USFS 2015), while at its lower elevation confluence with the Grande Ronde, winters are mild with precipitation averaging 10 to 20 inches annually (Bryce and Omernik 1997). Summers are characterized by high temperatures and limited precipitation (Bryce and Omernik 1997). The geology of the subbasin is dominated by the uplifting which created the Blue Mountains, and the Columbia River Basalt flows, which extend in some places to a depth of almost 5,000 feet (Swanson et al.1983). The Wenaha River flows from the Mesic Forest Zone and Canyon and Dissected Highlands ecoregions, characterized by mixed conifers and shrubs, to the Snake and Salmon River Canyons, characterized by shrubs, grasses, and some Ponderosa pine (Bryce and Omernik 1997). The Wenaha River has no diversions on public or private land and was designated a Wild and Scenic River in 1988 (USFS 2015). Fish Commission biologists surveyed the river in October of 1940, characterizing it as of moderate gradient, with “a large amount of suitable spawning area” (Parkhurst 1950). Because the Fish Commission biologists performed a more qualitative assessment on the Wenaha River, biologists did not repeat surveys in 1990 (Bruce McIntosh, ODFW Deputy Administrator - Inland Fisheries, personal communication). The 2004 subbasin assessment identified minimal disturbance in the Wenaha River and recommended maintaining protections as the only needed management action (Nowak).



Map 3 Lower Grande Ronde Watershed

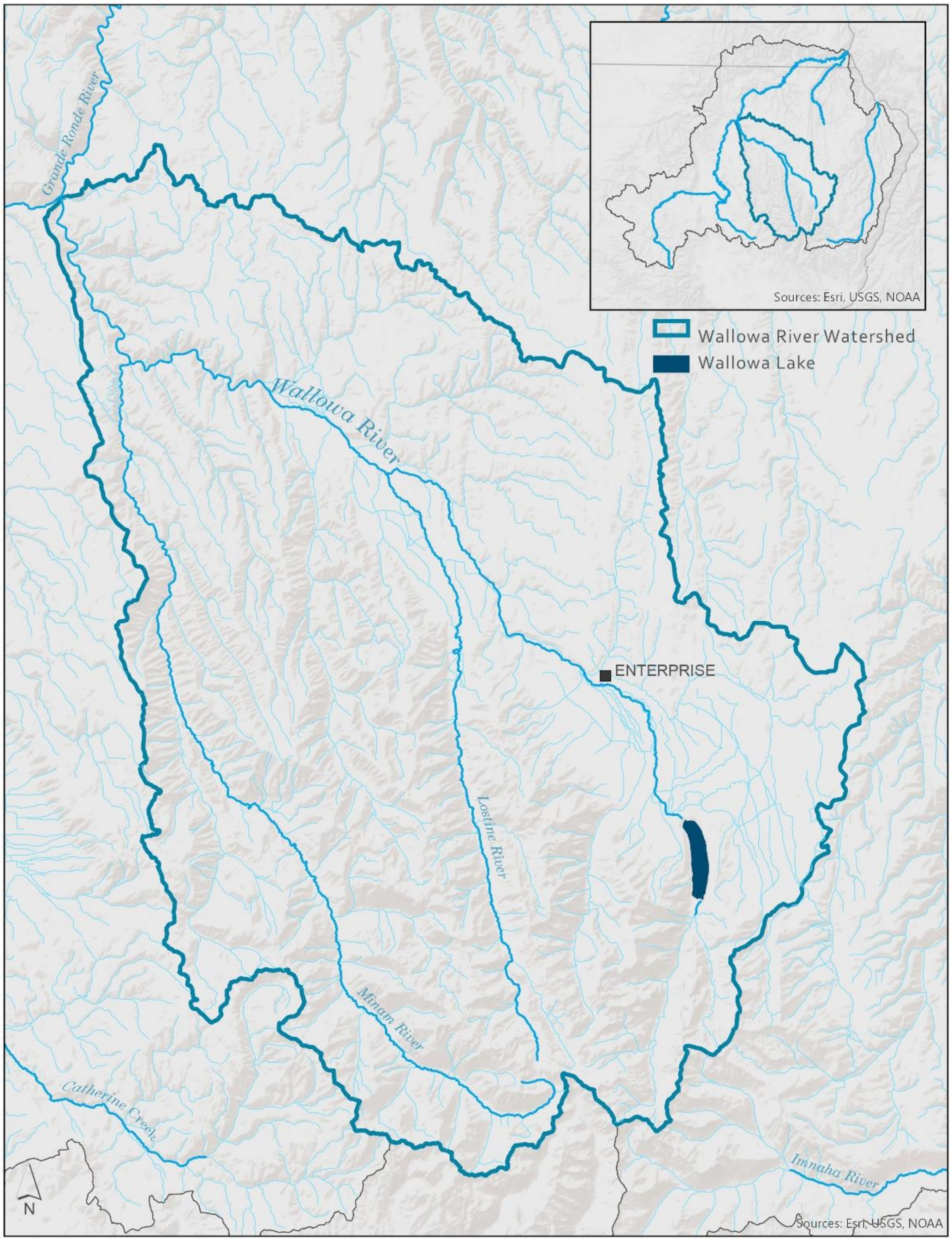
The confluence of the Grande Ronde and Wallowa Rivers mark the boundary of the Lower Grande Ronde basin, which straddles the borders of Oregon and Washington and drains about 1,400 square miles. The lower Grande Ronde River begins at an elevation of about 2000 feet and descends to an elevation of 830 feet at its confluence with the Snake River. The climate is hot and dry in the summer and mild in the winter. At higher elevations, Bryce and Omernik classify the vegetation as Canyons and Dissected Highlands (a mixture of conifers), giving way to Snake and Salmon River Canyons vegetation (Ponderosa pine, shrubs, and grasses) in lower elevations (1997). The river flows for nearly 90 miles through a steep canyon, which 1940-41 Fish Commission surveyors described as sparsely vegetated and "subject to rapid fluctuations in volume" (Parkhurst 1950). Surveyors found no barriers or diversions on the lower Grande Ronde, noting "numerous shallow riffle areas and an adequate number of resting pools" (Parkhurst 1950). While they felt that the lower Grande Ronde was "capable of supporting large runs" of salmon, they could not count spawning fish due to the turbidity of the water (Parkhurst 1950). A 1959 Fish Commission survey noted that while the vegetation contributed little stream shading, the stream was partially shaded by the topography of the canyon (Thompson et al. 1960). Throughout the lower Grande Ronde, 1959 surveyors found the river turbid, which they attributed to "irrigation, road construction, logging and gravel removal" (Thompson et al. 1960). Surveyors suggested that this portion of the Grande Ronde might be used for winter rearing (Thompson et al. 1960). The 2004 subbasin assessment identified this portion of the Grande Ronde as limited in large wood, although the authors noted that "large wood is not a major habitat component in this reach and likely never was" (Nowak 2004).



Map 4 Joseph Creek Watershed

Joseph Creek drains an area of 556 square miles in the northeast portion of the Grande Ronde basin, straddling the borders of Oregon and Washington, meeting the Grande Ronde River a few miles above its confluence with the Snake River. Headwater streams begin in elevations between 5,000 and 6,000 feet, with 15-40 inches of annual precipitation, descending to 900 feet in elevation at the confluence with the Grande Ronde, where the climate is much hotter and more arid (Bryce and Omernik 1997). Columbia River Basalt flows form the northern sections of the headwaters, with the creek entering a canyon where the tributaries form the mainstem (WCCPPG 2005). The southern headwater streams flow through lower gradient mixed forest and grasslands, becoming steeper and more incised as they approach the mainstem (WCNRAC 2014). Headwater stream vegetation is characterized by Blue Mountain Basin and Canyons and Dissected Highlands zones, with shrubs and grasses dominating in the Basin zones and mixed conifers in the highlands (Bryce and Omernik 1997). The Ponderosa pine, shrubs, and grasses of the Snake and Salmon River Canyons zone predominate in the lower elevations as Joseph Creek approaches its confluence with Grande Ronde River (Bryce and Omernik 1997). Close to 9 miles of the stream received a Wild and Scenic designation in 1988 (USFS 1993). The small unincorporated community of Paradise is located at the southwest of the watershed. The Upper Joseph Creek Watershed Assessment notes that Nez Pierce residents of the area managed the area for game and plant resources by frequently using fire to promote grasslands (2005). The Lower Joseph Creek Watershed Assessment attributes current conditions in the basin to "timber harvest, successful fire suppression, grazing, recreational hunting, combined with unplanned disturbances of wildfire, insect and disease, drought, and other weather climatic conditions" (WCNRAC 2014). Fish Commission biologists did not survey the creek in the 1940s, but noted "that it is of possible significant value to salmon" (Parkhurst 1950). In 1988, Noll et al. identified high stream temperatures in the summer due to low flows and reduced riparian vegetation; lack of instream habitat diversity, especially a loss of large wood; increased sediment loads and channel widening due to "over utilization by domestic livestock"; and winter icing which "reduces or eliminates available overwintering habitat," and "may also cause direct mortality of some fish" as well as anchor ice formation, which causes damage to the components of the stream habitat as conditions limiting salmon populations in the basin. The authors identified the need for fencing 113 stream miles, planting 60 stream miles, building of 46 instream structures, and placing of 49 off-site watering facilities (Noll et al. 1988). The 2004 Subbasin Plan identified sediment and temperature as concerns, recommending identifying and correcting sediment sources in the tributaries, protecting riparian habitat, and moving roads in the riparian areas (Nowak).

Wallowa River Watershed



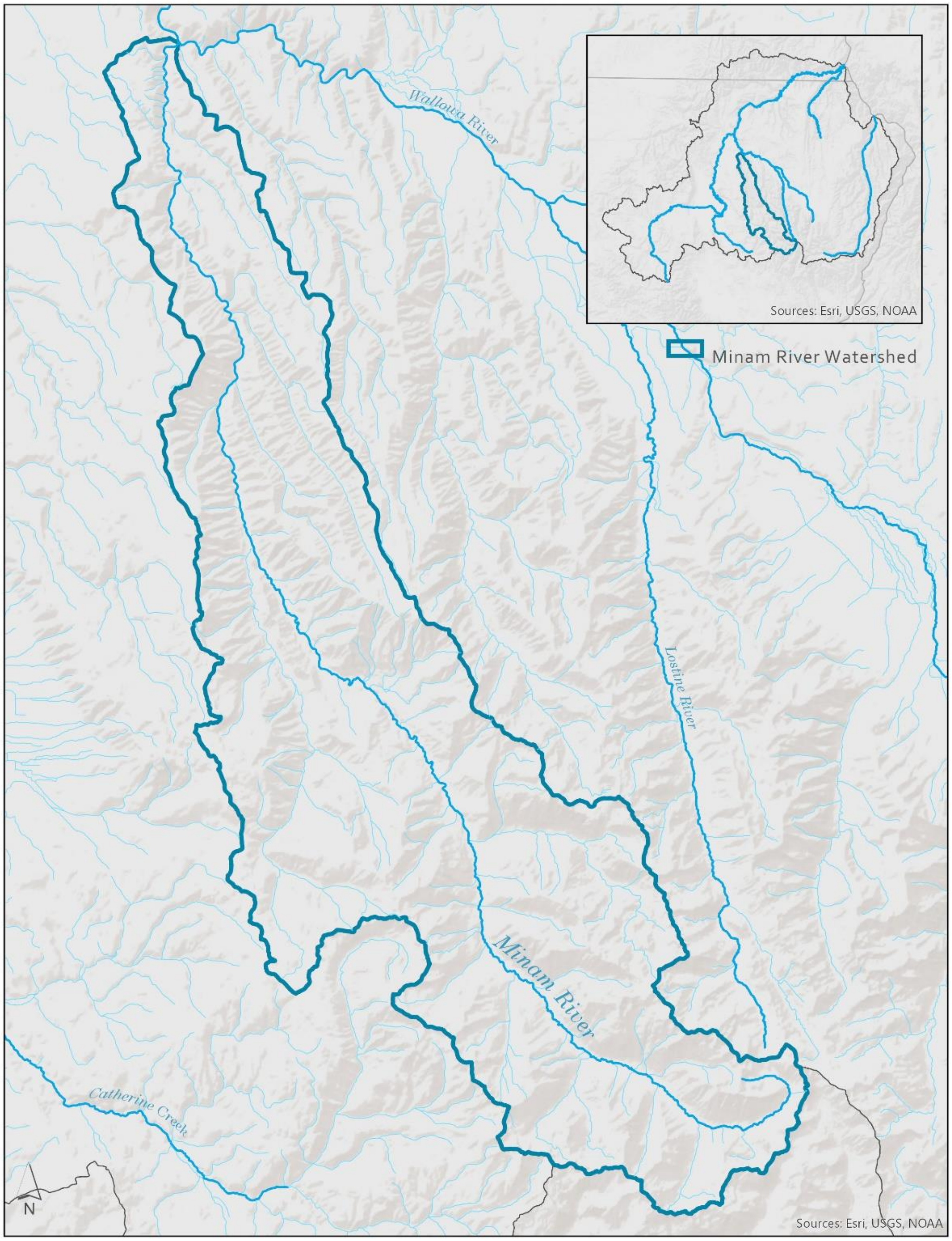
Map 5 Wallowa River Watershed

The Wallowa River, headwatered in the Eagle Cap Wilderness, drains an area of 950 square miles. Thompson et al. identified the Wallowa River "as the most important tributary of the Grande Ronde" due to "its drainage area and the production of anadromous fishes" (1960).

The Eagle Cap Mountains dominate the headwaters of the river, with the climate characterized by deep snowpack and a short growing season (Bryce and Omernik 1997), while the climate becomes more xeric at its confluence with the Grande Ronde, where precipitation averages 12 to 25 inches (NRCS 2006). The 1960 Fish Commission Report notes that "because of the great variance in elevation within the watershed, two periods of spring freshet normally occur" (Thompson et al.) A granitic core created by accretion formed the Eagle Cap Mountains (Bryce and Omernik 1997), with streams following fault lines along steep gradients (NRCS 2006). As the Wallowa river approaches its confluence with the Grande Ronde River, it crosses Columbia River Basalt flows (Bryce and Omernik 1997). Repeated glaciation formed the moraines cradling Wallowa Lake, located about 50 miles from the mouth of the river. Below the lake, the river flows for 30 miles through a valley, entering a canyon 20 miles in length between Dry Creek and the confluence with the Grande Ronde (Thompson et al. 1960). Bryce and Omernik characterized the vegetation zones as Subalpine in the headwaters, with meadows composed of green fescues and sedges, with lower elevations in the Mesic Forest (mixed conifers and shrubs), Blue Mountain Basin (mixed shrubs and grasses), meeting the Grande Ronde River in the Canyons and Dissected Highlands (mixed conifers) (1997).

The communities of Enterprise (incorporated in 1889, with a current population just under 2000); Joseph (incorporated in 1887, with a current population just over 1,000); Lostine (platted in the 19th century and incorporated in 1903, with a current population of 200); and Wallowa (incorporated in 1899 with a current population of 800) are within the Wallowa River subbasin. The 1940 Fish Commission surveyors identified numerous irrigation diversions and one power diversion which were "one of the chief causes for the depletion of the runs of salmon in the Wallowa . . . recognized as such in the annual reports of the Master Fish Warden of Oregon as early as the year 1901" (Parkhurst 1950). In the 1960 Fish Commission Report identifies irrigation withdrawals as the cause of low flows creating a passage barrier to migrating fish, noting that in some years the river was completely dewatered for a third of a mile below the town of Joseph (Thompson et al.). Construction of the dam at Wallowa Lake, first in 1916 with replacement structures at later dates, "resulted in the destruction of a large part of the run of blueback [sockeye] salmon that formerly ascended to Lake Wallowa, and the land-locking of the remainder" (Parkhurst 1950). These runs of sockeye salmon once supported a cannery at the lake, but currently only kokanee (the resident form) inhabit the lake and the stock is thought to have come from other areas (WC-NP 1999). The Wallowa County-Nez Perce recovery plan identifies fire suppression, channelization, irrigation water withdrawals, excess fine sediments, lack of "flushing flows" (that is, natural flow regime), high water temperatures, nutrients from feedlots entering the water column, lack of large wood, and insufficient pool to riffle ratios as concerns, but notes that since the original draft of the plan, all diversions are now screened (1999). In 2005, the NRCS identified "poor water quality due to streambank erosion, sediment, and loss of riparian vegetation; invasive, noxious weeds; lack of water for irrigation; and loss of wildlife habitat" as "major resource concerns," but noted a declining trend in soil loss from water erosion between 1982 and 1997. The Subbasin Plan identifies sediment, habitat diversity (reduced channel wetted widths from modification), poor riparian habitat, lack of wood, insufficient pools, lack of habitat diversity, stream temperature, predation, reduced flow, and road density as concerns (Nowak 2004).

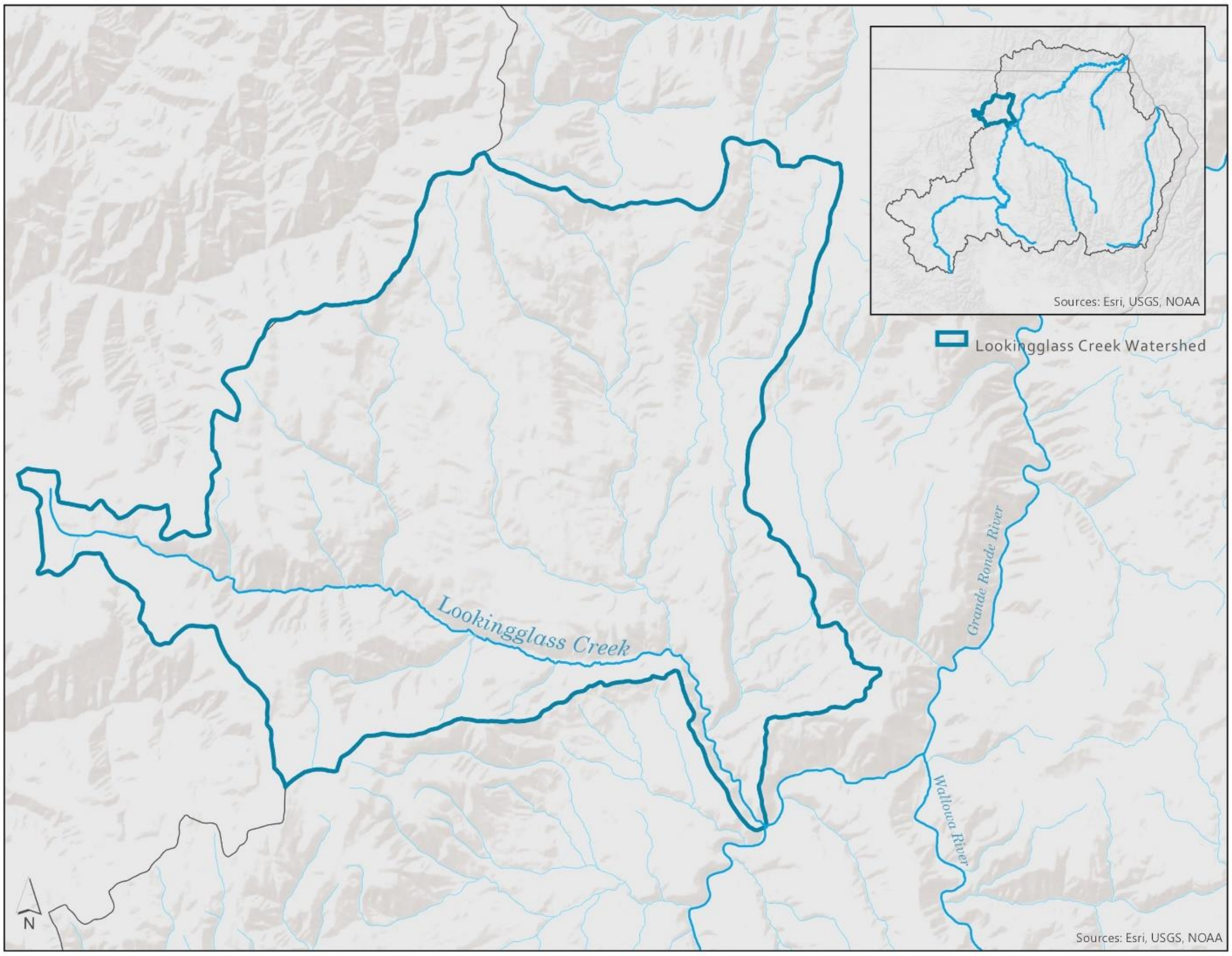
Minam River Watershed



Map 6 Minam River Watershed

While the Minam River is within the Wallowa River basin, it is treated separately in recovery planning because it hosts distinct populations of chinook and bull trout (Nowak 2004). The Minam River drains an area of 240 square miles. Mild summers and long, cold winters characterize the climate and the basin averages 270 inches of snow a year, with precipitation varying with elevation (Mast and Clow 2000). The underlying bedrock is composed of the granites of the Wallowa Batholith and the Columbia River Basalt flows (Mast and Clow 2000). The long, U-shaped valley through which the Minam River flows was once extensively glaciated, with glacial deposits on the walls and floor of the valley (Mast and Clow 2000). The headwaters support alpine meadows composed of green fescues and sedges (the Subapline Zone) and the river flows through the mixed conifers of the Mesic Forest Zone, the conifers and shrubs of the Wallowas-Seven Devils subregion, meeting the Wallowa River in the mixed conifers of the Canyons and Dissected Highlands (Bryce and Omernik 1997).

The watershed is sparsely populated, with the unincorporated community of Minam located at the confluence with the Wallowa River. The 1950 Fish Commission Report described the Minam River as having a moderate to fairly steep gradient “with numerous shallow riffles and an abundance of excellent spawning area[s] in the lower section, but few good resting pools (Parkhurst). In 1921, a 10-foot earthen dam at Minam Lake was built to store water for irrigation; water at the north end of the lake flows to the Lostine River and any water at the south end joins water from Blue Lake, flowing into the Minam River (Skovlin and McDaniel Skovlin 2011). Splash dams were used to transport logs in the 1920s (WC-NP 1999). The splash dam operated 4.5 miles above the Horse Ranch, and, although “partially blown out in 1939,” was identified as “a serious barrier to upstream migration” when surveyed between 1957 and 1959 (Thompson 1960). The 1960 Fish Commission Report identifies stream temperatures as “favorable” to fish, noting that temperatures “do not generally exceed 65 degrees in the principal spawning areas and 70 degrees near the mouth (Thompson). In 1988, 41.4 miles of the Minam River were designated as Wild and Scenic, all of which are located in the Eagle Cap Wilderness (USFS 1988). The 1999 Salmon Habitat Recovery Plan developed by Nez Perce and Wallowa County identified tree density due to past fire suppression, high water temperatures, and fine sediments as concerns. The 2004 subbasin plan identifies reduced wetted widths, reduced wood, and reduced riparian function as concerns (Nowak 2004).

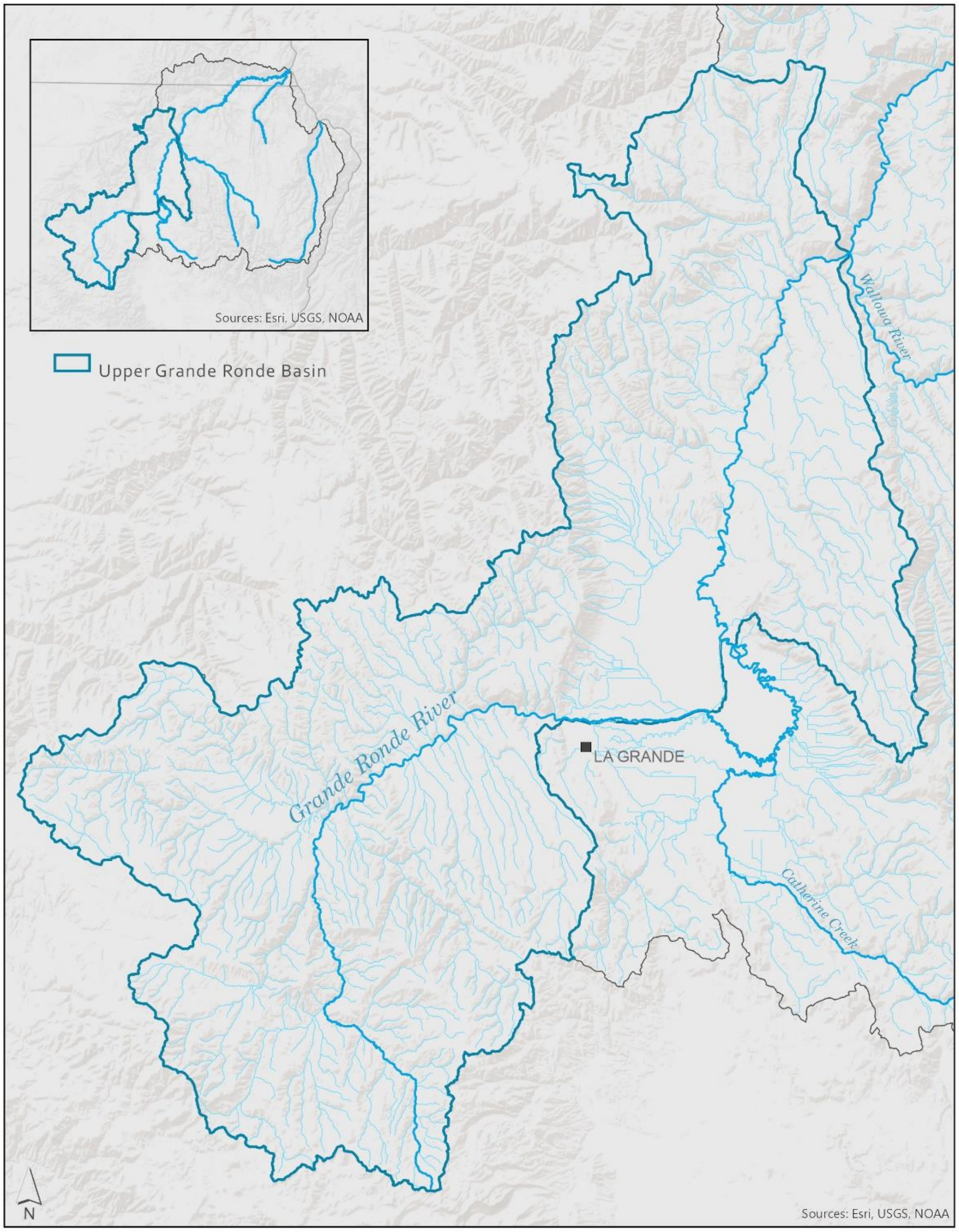


Map 7 Lookingglass Creek Watershed

Lookingglass Creek, headwatered in the Umatilla National Forest, drains an area of 95 square miles (Burck 1993). Langdon Lake forms the headwaters of Lookingglass Creek, at an elevation of 4,870 feet, and the stream flows east and south to its confluence with the Grande Ronde River near Palmer Junction at an elevation of 2,350 feet (Burck 1993). The climate of Lookingglass Creek is moderated by a maritime influence and the geology defined by Columbia River Basalt flows (Bryce and Omernik 1997). The vegetation is classified as Mesic Forest in the headwaters, characterized by mixed conifers and shrubs, and Canyons and Dissected Highlands at the confluence with the Grande Ronde, characterized by mixed conifers (Bryce and Omernik 1997).

The Lookingglass Creek drainage contains no population centers. Fish Commission biologists surveying the area in 1940 described the stream as moderate in gradient, “with numerous shallow riffles, good resting pools, and an abundance of excellent spawning area[s]" (Parkhurst 1950). They noted that "[t]he watershed is uninhabited, and there are no obstructions or water demands on the stream. Numerous springs along the course and in the headwaters assure a constant minimum flow" (Parkhurst 1950). The 1960 Fish Commission Report notes that agricultural activity is limited to grazing, but areas of the watershed were actively logged (Thompson et al.). In 1958, Fish Commission engineers blasted a 9-foot bedrock waterfall that was believed to be impairing fish access to spawning areas (Thompson 1960, Burck 1993). Portions of Little Lookingglass Creek were negatively affected by road construction along the stream and logging along the stream slopes in 1959 (Thompson et al. 1960). Surveyors also noted a beaver dam in the headwaters (Thompson et al. 1960).

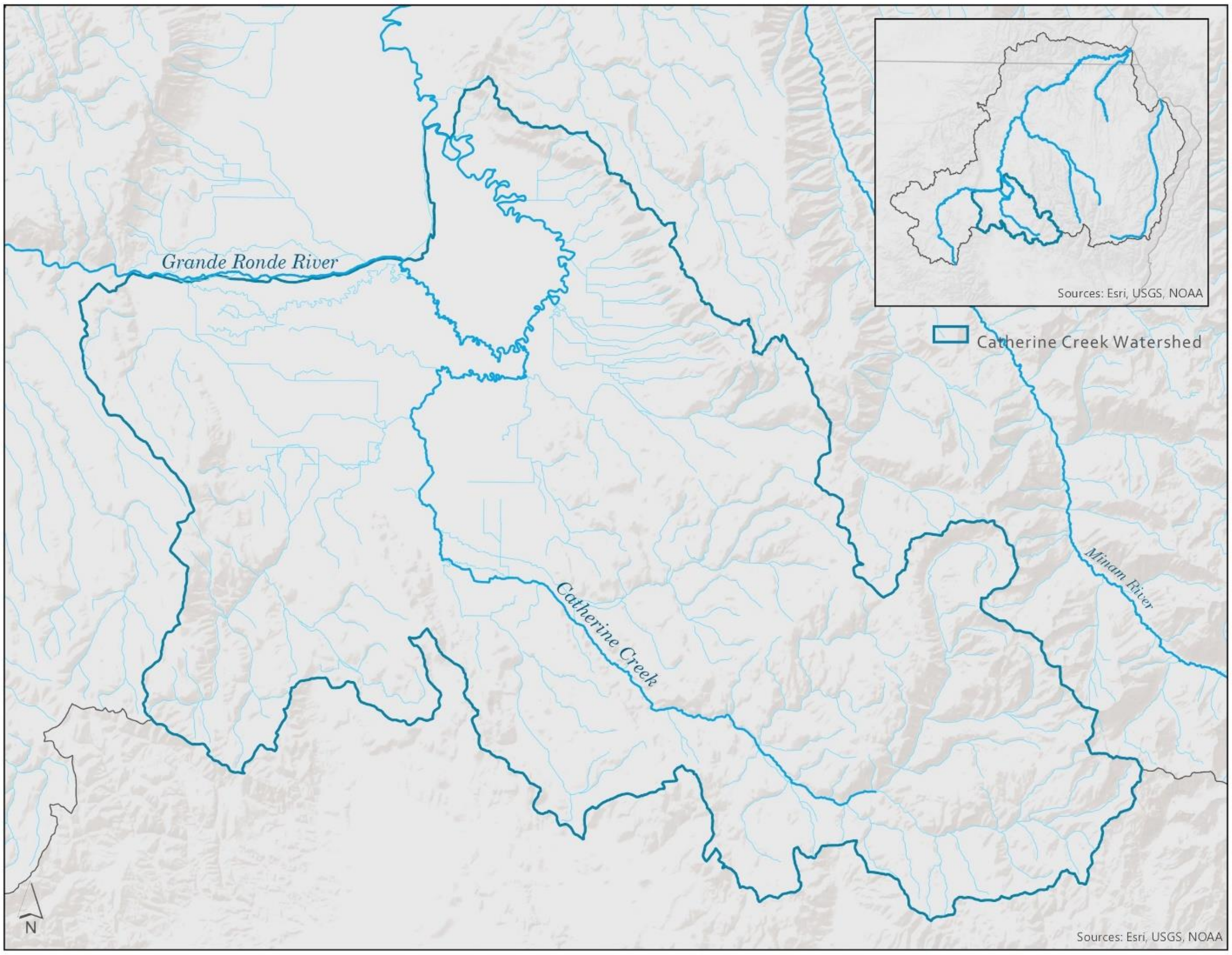
The Lookingglass Creek drainage contains no population centers. The Subbasin Assessment describes the stream as "one of the most pristine non-wilderness watersheds in the Grande Ronde River basin" (Nowak 2004). Factors detrimental to fish health are reduced wetted widths, reduced wood, poor riparian function, and sedimentation (Nowak 2004).



Map 8 Upper Grande Ronde Watershed

In the literature on the Grande Ronde basin, authors identify different geographic boundaries of the Upper Grande Ronde basin: at Meadow Creek (USFS et al. 1992), Perry (BoR 2014), La Grande (Parkhurst, 1950, Nowak 2004), or the confluence with the Wallowa River (Thompson 1960). For the purposes of this document, the Upper Grande Ronde subbasin refers to the Grande Ronde and its tributaries above Wallowa River, with Catherine Creek receiving separate consideration. The basin drains an area of roughly 1,650 square miles, with headwaters at an elevation of 7,000 feet in the southern end of the Blue Mountains (Thompson et al. 1960). The Cascade Range to the west creates a rainshadow, resulting in dryer conditions in this portion of the Blue Mountains, with the climate characterized by a short growing season with little summer precipitation and cold winters with significant snow accumulation in the headwaters (BoR 2014). Within the Grande Ronde valley, the climate varies, with drier conditions at the south end and more maritime influence at the east end (Bryce and Omernik 1997). The mountainous headwaters of the stream resulted from uplifting and faults, with primarily volcanic bedrock (BoR 2014). The Grande Ronde valley consists of gravels, silts, alluvial fans, and loess (Bryce and Omernik 1997). Mixed conifers dominate the mountain regions, with valleys vegetated by mixes of conifers, deciduous trees, and shrubs or mixes of grasses and forbs (USFS et al. 1992).

The Upper Grande Ronde is the most densely populated area in the subbasin, with the unincorporated community of Starkey settled in the 1870s; La Grande, incorporated in 1865 with a current population of 13,229; Imbler, incorporated in 1922 with a current population of 306; Summerville, incorporated in 1885 with a current population of 135; and Elgin, incorporated in 1891 with a current population of 1,718. Gold mining in the headwaters of the upper Grande Ronde began in 1870, with dredges used in the early 1900s (McIntosh et al. 1994). The Fish Commission biologists who surveyed the stream in 1940 describe the area 15 miles above Starkey, “the stream bed has literally been torn up by a gold dredge and deposited in conical mounds of gravel tailings. This upheaval continues for a distance of two miles upstream . . . the flow was entirely beneath the surface of the stream bed” (Parkhurst 1950). Signs of overgrazing appeared in the 1880s, with accounts of thousands of feral horses present in the area (Duncan (1998). McIntosh notes that while grazing of domestic animals declined over the 20th century, elk grazing may have increased (1994). Logging activities began in the 1880s, with splash dams operating on the Grande Ronde at Vey Meadows and Starkey and on Dark Canyon, Meadow, and Fly Creeks from the end of the 19th century through 1919 (McIntosh et al. 1994). Road and railroad construction throughout the basin constrains the channel and interferes with floodplain interactions (McIntosh et al. 1994). Stream channelization efforts conducted by various agencies shortened the length of streams in the basin, isolating them from their floodplains (McIntosh et al. 1994). Water rights were adjudicated in 1925 (BoR 2014); the Upper Grande Ronde River Anadromous Fish Habitat Protection, Restoration and Monitoring Plan states “resulted in a system that has substantially over-allocated available water resources” (1992). Descriptions from the Fish Commission biologists who surveyed the stream in 1940 indicate withdrawals for irrigation left the flow “imperceptible” in Island City, with 27 miles of flow greatly reduced by the State Ditch in the valley (Parkhurst). The survey identified numerous barriers and unscreened diversions, which “has undoubtedly contributed to the present depleted conditions of migratory fish” (Parkhurst 1950). The 1960 Fish Commission Report notes that in areas at the lower end of Elgin, little shade was available and erosion was a problem in this area as well as in areas upstream of La Grande (Thompson et al.). The extensive spawning grounds found near Elgin by the 1940 survey were silted over (Thompson et al.). Gravel removal near La Grande had widened the streambed, with “no definite channel” for a mile above Island City (Thompson et al.). McIntosh et al. found a 60 percent reduction in pool frequency between the 1940 survey and the 1990 survey (1994). The 2004 Subbasin Plan identifies sediment, flow, temperature, and reduced wetted widths as concerns, noting that “impacts of elevated temperature, sediment and habitat modification are widespread throughout the Upper Grande Ronde Watershed” (Nowak 2004).



Map 9 Catherine Creek Watershed

Catherine Creek drains an area of 402 square miles in the southern portion of the Grande Ronde basin, with the headwaters of the North Fork located in the Eagle Cap Wilderness and the headwaters of the South Fork located in the Wallowa-Whitman National Forest. The headwaters of Catherine Creek receive the highest amount of precipitation in the Grande Ronde basin, with precipitation greater than 50 inches, generally falling as snow, while 12-25 inches falls at the lower elevations where Catherine Creek joins the Grande Ronde River (Bach 1995). Most precipitation occurs as winter snow, with peak flows following snowmelt, while summers are hot and dry, with base flows occurring in August and September (BoR 2012). The geology underlying the Catherine Creek drainage is a collage of island arc terrane, old ocean sediments, metamorphic, and igneous rocks (Bryce and Omernik 1997), with basalt rock of the Grande Ronde Formation and glacial alluvium influencing groundwater and aquifer formation (BoR

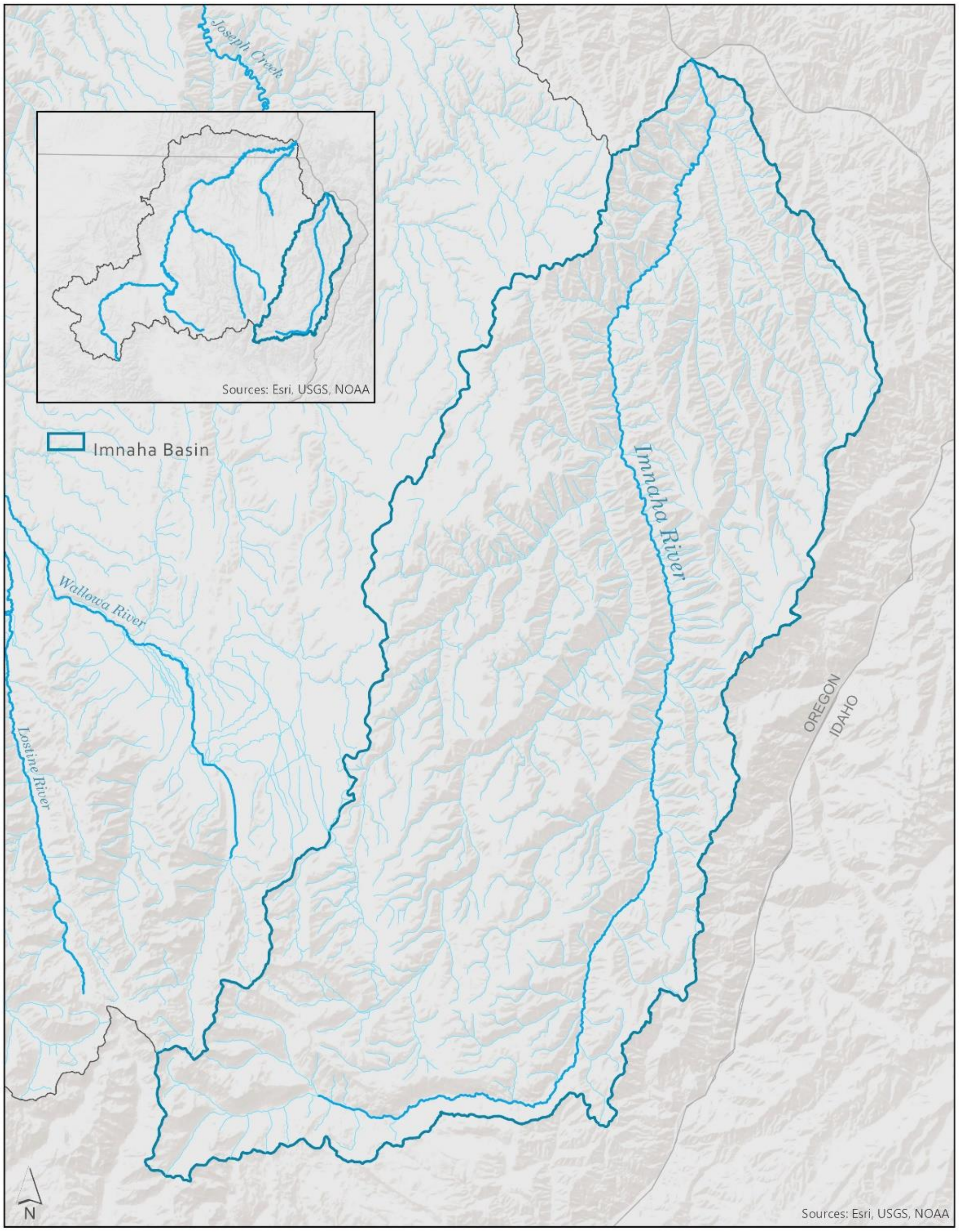
1997). Bryce and Omernik describe the vegetation of the region, which begins in the mixed conifer stands of the Mesic Forest Zone in the headwaters of North Fork Catherine Creek, the South Fork originating in the lower-elevation conifers of the Wallowa-Seven Devils Zone, and the two forks meeting in the mixed conifer, grass, and shrublands of the Blue Mountain Melange Zone (1997). Historically, Catherine Creek drained into Tule Lake, an estimated 20,000 acre lake and swamp area that stretched from present-day La Grande across the valley to Union and Cove (Duncan 1998). Beaver were common in the area.

Union, a town of about 2000 people, was established on Catherine Creek in 1878; Cove a town of about 200 located on Mill Creek, a major tributary of Catherine Creek, was settled in 1861 and incorporated as a city in 1904. Settlers constructed the first irrigation dam in 1861, establishing the first water rights on Catherine Creek (BoR 2012). Saw mills were established in Union and six miles up from the town in 1864, both with dams that acted as fish passage barriers (BoR 2012). Catherine Creek and the Grande Ronde River were used to transport logs (BoR 2012). In 1869, the three-mile Catherine Creek ditch was built, draining Tule lake and the surrounding marshland to allow for the expansion of agriculture (BoR 2012). Logging in the forests surrounding Catherine Creek began in 1928 (BoR 2012).

The 1941 fish commission surveyors Frey and Bryant found that only the lower 9 miles of Catherine Creek were accessible to fish at all times, with no suitable spawning areas in the first 15 miles of the stream, the first 12 due to the mud and sand bottom and miles12-15 due to siltation. Nineteen dams barred fish passage at low flows and several prevented fish passage even at high flows, while the 29 diversions limited flow in the lower reaches (Parkhurst 1950). Logging in the headwaters, stream temperatures due to low flows, and flash flooding (due to logging) were cited as reasons that “the former good run of chinook salmon into Catherine Creek has been greatly depleted,” with turbidity of the water making spawning counts difficult (Parkhurst 1950). The surveyors stated that “Under these conditions the stream is of little value in the production of salmon (Parkhurst 1950).

In 1948, flooding led to levee building, with additional revetments built following flooding the subsequent year (BoR 2012). In 1950, the authorization of the federal Flood Control Act led to additional levees and channelization (BoR 2012). In 1966, the La Grande District of ODFW’s annual report noted that channel relocation and straightening at the Union Experiment Station had led to “a complete change of spawning gravel location on Catherine

Creek over a period of several years . . . In 1957 many pools to 10 feet in depth were present in at least five miles of Catherine Creek upstream from the town of Union. These pools are now one and two feet in depth" (Sayre). By 1990, habitat surveys found a 67 percent decrease in pools on Catherine Creek, a 59 percent decrease in pools on the South Fork and a 43 percent drop on the North Fork (McIntosh et al.). Analysis by McIntosh et al. found that between 1941 and 1990, base discharge increased 25 percent, with peak flows occurring up to 30 days earlier (1990). The 2004 Subbasin Plan identifies reduced wetted widths, reduced wood, poor riparian function, sediment, flow, and temperature as key concerns (Nowak 2004).



Map 10 Imnaha River Watershed

The Imnaha subbasin drains an area of 850 square miles on the eastern side of the Eagle Cap mountains, flowing north to its confluence with the Snake River (Ecovista 2004). The 577 miles of stream (NRCS 2006) flow through terrain that varies in topography from the 10,000-foot peaks of the Eagle Caps through valleys and basalt canyons with steep walls (Ecovista

2004). The two forks, North and South, which comprise the headwater streams, flow through deep glacial troughs before meeting at approximately 5,500 feet in elevation (Thompson et al. 1960). Big Sheep Creek, draining the northeast of the Wallowa Mountains, flows 40 miles to its confluence with the Imnaha just above the town of the same name (Thompson et al. 1960). A temperate continental and dry climate characterizes the basin, with a diversity of microclimates determined by topography (Ecovista 2004). Higher elevations in the subbasin receive 60-75 inches of annual precipitation with a deep winter snowpack (Ecovista 2004), while lower elevations closer to the Snake River receive less than 9 inches (NRCS 2006). The geology is defined by the volcanic island arc that formed the Eagle Cap range and the subsequent flows of Columbia River basalt, the Imnaha basalt being "softer and more easily weathered than the Grande Ronde basalt" (Ecovista 2004). Six ecoregions comprise the plant communities, which range from the bunch grasses adapted to dry climates in the Palouse and Nez Perce Prairies—Warm Canyons and Dissected Uplands ecoregion to the subalpine forests of the Blue and Seven Devils Mountains (Ecovista 2004).

Nez Perce tribes began grazing horses in the mid-eighteenth century, making use of the canyon lowlands and introducing cattle around 1850 (Ecovista). Oregon trail migrants first settled in the unincorporated community of Imnaha in 1878, which grew rapidly in the late 19th century. Although the rugged terrain precluded extensive development, European settlers established farms and ranches, primarily in valley and riparian areas, with grazing expanding into remote regions (Ecovista 2004). The region once supported six separate school districts, but the population declined rapidly in the first 40 years of the 20th century, with only one district serving the region (Ecovista 2004). Sheep grazed the area heavily, with declines in pasture quality leading to fine sediments muddying streams and competition between stock growers for adequate forage (Ecovista 2004). The 1990s saw a series of land use regulation changes that reduced the number of animals grazed and eliminated sheep grazing due to concerns over interactions between domestic and big horn sheep (Ecovista 2004).

Cultivation of crops in the region began with the Nez Perce, who controlled weedy species to encourage khouse, camas, and huckleberries (Ecovista 2004). Early European settlers practiced subsistence farming in valley bottoms which supported irrigation, which expanded to include feed crops as the livestock industry expanded (Ecovista 2004). The region continues to produce barley, wheat, and hay; fine sediment inputs and withdrawals for irrigation affect water quality, with large withdrawals on Big and Little Sheep Creeks (Ecovista 2004).

While the remoteness of the Imnaha basin and its rugged terrain limited population growth, the need to connect natural resource commodities to markets led to road building, sections of which have had negative consequences for streams (Ecovista 2004). Fish Commission surveyors in the 1950s noted that road construction about 15 miles above the town of Imnaha created a "serious barrier" that was later "rectified" (Thompson et al. 1960). Road building along the floodplain and unstable areas has led to the introduction of fine sediments through road failures, landslides, and runoff, streams have been channelized, riprap has been installed, and riparian areas have been reduced or eliminated (Ecovista 2004). The USFS began reducing and relocating roads in the 1990s (Ecovista 2004).

Timber extraction remained at a subsistence level, supporting the needs of farmers, ranchers, and the short-lived Eureka mine until the connection of Enterprise by railroad allowed commercial harvest (Ecovista 2004). Water quality problems arose with the introduction of heavy tractor skidders in the 1930s and 1940s, as the weight of the machinery compacted moist soils along draws (Ecovista 2004). Timber management methods led to a reduction in diversity and overstocking, with a shift towards mixed age classes to promote recreation and wildlife in the 1970s (Ecovista 2004).

In 1960, stream surveyors reported that

> [t]he Imnaha watershed is in a generally good condition, especially in the upper half of the stream. Conifers, rock outcroppings, and grasses dominate the slope cover above Summit Creek while below here the timber recedes and grasses and rocks are predominant. Bank vegetation consists of conifers and brush on the upper one-third of the stream, and in the lower two-thirds, deciduous trees gradually replace the evergreens in a downstream progression. [Thompson et al. 1960]

Overall, "[g]ood pools are frequent and numbers of pools and shallows are well-balanced" (Thompson et al. 1960). Annual spawning ground surveys, begun in 1948, suggested that "this is probably the most consistently productive chinook salmon stream in Eastern Oregon" (Thompson et al. 1960). The results of the survey and data from ten years of spawning ground surveys led participants in the project to argue that "careful consideration be given to the introduction of fall-spawning chinook into the lower Imnaha . . . If only the 10- mile section from the town of Imnaha to Horse Creek is considered as a production area, a potential of over 600 redds can be calculated from the amount of stream bottom estimated to be suitable for spawning in that area" (Thompson et al. 1960). Entrainment of fish into irrigation ditches was not a problem on the mainstem, with surveyors noting that "All observed ditches diverting water from the Imnaha River are screened" (Thompson et al. 1960). The report also noted the presence of woody debris although at the time of the survey, log jams were considered barriers to passage that should be removed. The surveyors found 21 "small to medium-sized" log jams in the Big Sheep Creek basin; some of these were attributed to ongoing logging operations (Thompson et al. 1960).

However, Big Sheep Creek and its tributaries, Little Sheep and Camp Creeks, were found to have less optimal conditions. Surveyors reported that "[i[rrigation practices on Big Sheep Creek and on tributaries, Little Sheep and Camp Creeks, are at the point of being harmful to fish life" (Thompson et al. 1960). Along with the naturally steep gradient on a three-mile section of Upper Big Sheep Creek, a diversion dam for the Wallowa Valley Improvement Canal prevented some upstream migration, while during the summer, the low flows created below the dam created a passage barrier, with "the entire flow of Big Sheep Creek (an estimated 40 c.f.s.) . . . being diverted, except for a slight leakage of less than 1 c.f.s." (Thompson et al. 1960). In addition, two log and gravel diversions created barriers on Big Sheep Creek two miles above the mouth of Little Sheep Creek and of eleven diversions, five operated without screens (Thompson et al. 1960). Low flows and high water temperatures in spawning and holding areas were noted on Big Sheep Creek, with surveyors recording a water temperature of "72°F. at Coyote Creek near the lower limit of the known spring chinook spawning area" (Thompson et al. 1960). The surveyors identified water diversions for irrigation and "removal of watershed vegetation" as the primary contributors to the flow and temperature problems on the Big Sheep drainage, noting

> During the irrigation season, ground- water inflow and the flows of a few small tributaries located below the diversion are often the sole sources of water in the spawning areas of Big Sheep Greek. Since Little Sheep Crock also supplies water to the Wallowa Valley irrigation system, flow conditions during the irrigation season are somewhat similar on this stream. Briefly, it appears that warm water conditions once probably typical only the lower reaches of these streams, have

invaded former cool water habitat utilized by spawning salmon and steelhead. [Thompson et al. 1960].

Despite these problems, Big Sheep Creek supported runs of spring chinook salmon and steelhead, with "substantial numbers" making use of spawning areas on Big Sheep Creek at the time of 1960 Fish Commission Report (Thompson et al. 1960). More recently, much of the stream network has been 303d listed for temperature (Ecovista 2004). Fires, timber management, livestock grazing, and pasture creation contribute to erosion hazards, particularly on Big Sheep Creek and the middle and lower reaches of Little Sheep Creek, as well as on Lick Creek (Ecovista 2004). Although habitat remained impaired, Sausen, reporting on bull trout population monitoring in 2007, identified the Imnaha bull trout as "one of the strongholds" due to the presence of multiple age classes, fluvial and resident life histories, an anadromous prey base, a migratory corridor to the Snake River, and the dispersal of the species throughout the available habitat, with the caveat that the Big Sheep Creek population posed a special concern.

In the 2004 *Imnaha Subbasin Plan*, Ecovista identified the primary limiting factors for spring/summer and fall chinook, steelhead, and bull trout as low flows and fine sediments. High stream temperatures were identified as a primary limiting factor for spring/summer chinook, bull trout, and steelhead (Ecovista 2004). Poor riparian conditions were a primary limiting factor for spring/summer chinook and steelhead (Ecovista 2004). Lack of habitat diversity was a primary limiting factor for spring/summer chinook and fall chinook (Ecovista 2004). High flows were also identified as a factor limiting productivity for bull trout and steelhead (Ecovista 2004). Productivity was further hampered by low populations for spring/summer chinook and steelhead, while obstructions limited bull trout productivity (Ecovista 2004). In the supplement to the plan, Ecovista notes that channel modification also limits production of spring/summer chinook and steelhead, "act[ing] cumulatively to affect streamflow regime, riparian development, and habitat diversity" (Ecovista 2004).

Ecovista used the Qualitative Habitat Assessment (QHA) model, developed by Mobrand Biometrics Inc., to rank and prioritize recommended restoration actions for each species of concern, as well as an aggregate prioritization for benefit to both spring chinook and bull trout (Ecovista 2004). The rankings were separated into those that were spatially common and those that were geographically isolated (Ecovista 2004). The key spatially common limiting factors were, in order of ranking, high stream temperatures, low flows, and fine sediments, while the spatially linked limiting factors were "population connectivity, legacy effects from land use activities impacting channel form and stability, and thermal and organic pollutants" (Ecovista 2004). The authors identified Big Sheep Creek subbasin (including Little Sheep Creek) as the priority basin, as "habitat-based factors are most limiting to multiple focal species and where restoration activities would be most beneficial" (Ecovista 2004).

Ecovista recommended "the restoration of non-functional riparian zones, maintenance/protection of functional riparian zones, ameliorating grazing impacts, reduction of consumptive water uses, restoration of natural floodplain processes, [and] restoration of channel form" to address high water temperatures (2004). To improve flow conditions, Ecovista recommended two approaches: working with water users to improve efficiency and reduce the need for withdrawals, while also enhancing riparian, floodplain, and wetland areas to restore the natural hydrograph (2004). To address fine sediments, "riparian management, upland vegetation management, access management, floodplain restoration, and hydro-modification" were recommended (Ecovista 2004). Ecovista recommended continued monitoring to determine the extent of habitat used by focal species, combined with the mapping and removal of passage barriers (2004). Five strategies were identified to address channel form and diversity: using rock weirs to elevate the streambed in downcut areas, reconfiguring roads in areas where these limit floodplain interactions, bioengineering to restore width to depth ratios and sinuosity, placing rootwads or large woody debris in conjunction with riparian planting in areas where both riparian and channel health are concerns, and restoring areas where headcuts are a concern to prevent upstream progression (Ecovista 2004). Ecovista included a review of available water quality information, which showed that apart from thermal pollution, none of the subbasins had been found to exceed state standards for chemical or nutrient contamination but noted that "localized problems with chemical and organic pollutants have been reported in some portions of the subbasin" (2004). Water quality monitoring to identify sources and impacts was recommended, with restoration efforts focusing first on spawning and rearing areas and then expanding to migratory corridors (Ecovista 2004).

Development of the Grande Ronde Model Watershed

In 1986, Governor Neil Goldschmidt convened a meeting of "irrigators, environmentalists, rangeland experts, and legislators" to develop cooperative solutions to "water management problems" (Office of the Governor 1989). The following year, the Governor and legislature instituted the Governor's Watershed Enhancement Board (GWEB) and a $500,000 fund for watershed projects (Office of the Governor 1989). GWEB borrowed the concept of local volunteers and local matching funding from ODFW's Salmon and Trout Enhancement Program (STEP) (Office of the Governor 1989). The state provided technical assistance and invited "any person or group" to apply for funding for "projects that [i]mprove groundwater storage by keeping watersheds healthy; [u]se volunteers to work on watershed projects; [p]romote the benefits of better watersheds; [or p]romote natural methods to restore streambanks, adjacent lands, and nearby uplands" (Office of the Governor 1989).

Governor Barbara Roberts, who succeeded Goldschmidt, expanded the community-driven approach to developing watershed projects, creating the Grande Ronde Model Watershed in April of 1992, one of three model watersheds in Oregon. The Northwest Power Planning Council had identified the need for a coordinated approach to restoration that drew on local participation in the 1992 Strategy for Salmon. The Council advocated a "locally based, bottom-up, voluntary approach for protection and improvement of habitat on private lands," using a "coordinated resource management approach" that "brings together local landowners and key interests in a facilitated forum to identify goals for improving and managing lands" (Northwest Power Planning Council 1992).

In the first report to the Power Planning Council, Patty Perry, the organization's second Executive Director, states that "the Commissions from Union and Wallowa Counties determined that a grass-roots, locally based effort working to coordinate existing local, state and federal programs could effectively maintain, enhance, and restore the watershed" (1997). The Commissioners of Union and Wallowa Counties appointed the Grande Ronde Model Watershed Board, with members meeting for the first time in June of 1992 (Duncan 1998). Perry describes the Board as "a diverse group of interests with the common vision of a healthy watershed" (1997). Union County Commissioner John Howard chaired the Board, with Ellen Morris Bishop, a geologist "representing environmental interests" serving as vice chair (Duncan 1998). Perry describes the Board make up as "include[ing] stock-growers, farmers, Native American tribes, environmental groups, elected officials, and public lands, community, forestry, and fish & wildlife representatives" (1997).

Duncan notes criticism that the Board was “heavily weighted toward local economic interests” and that “the governor’s office was openly critical of board makeup” (1997). Despite the apparent homogeneity of the Board, the original participants describe the process of developing the organization as a difficult one. In a 2002 article in the local paper, Union County Commissioner Steve McClure states, “there were days when that group could not agree on anything, except to meet again . . . I remember saying to John [Howard], 'You might as well give up. This isn't going to work’” (Linker 2002). In the same interview, Howard says, “There was the trust factor . . . Both sides some thought we weren't moving fast enough; others thought we were moving too fast. The goal was to bring people together” (Linker 2002). He adds, “We wanted to be proactive, rather than reactive . . . There was quite a bit of coaching going on a lot of sideline work. By the second year the group began to jell” (Linker 2002).

Duncan also describes a rocky beginning: in 1993, the Oregon legislature awarded $10 million to the model watershed programs, with $4 million spent in the Grande Ronde along with a team of technical experts from the state (1998). Perry describes the initial organizational goals as “creating partnerships and developing missions, goals, and objectives.” Duncan relates that tensions arose between the Board and the state technical experts regarding the approach to project development: should the organization focus on assessing conditions in the watershed and developing planning documents or begin developing projects on the ground immediately (1998)? Because the initial model for watershed investments included reviews by both Oregon Water Resources Department and the new Strategic Water Management Group, “unnecessary ‘top down-bottom up’ procedural arguments ensued” as projects approved by the Board and state field team moved through the review process (Duncan 1998). At the same time the organization acted as a liaison between technical staff and the local community, it also worked to coordinate actions amongst “local, state, tribes, and federal natural resource agencies” through “monthly round table discussion[s]” (Perry 1997).

In addition to cost sharing from landowners and baseline support from BPA and the Oregon Watershed Health Program, Perry lists partnerships that were crucial to the organization’s early success:

> The Bureau of Reclamation has contributed $230,000 in staff support, technical assistance, research grants, and consultation since project inception. Oregon Watershed Health Program has provided $35,000 in

> staff support and $3 million for project implementation. The Wallowa-Whitman National Forest has provided technical assistance, and to the extent feasible, aligned their planning operations, water analysis, and watershed restoration efforts with those of the GRMWP. The Natural Resources Conservation Service, Union and Wallowa Soil and Water Conservation Districts, and state agencies (ODF, ODFW, DEQ), contribute staff planning support and project management. Oregon Water Resources Department and Oregon Department of Agriculture provided computer systems. [1997.]

The participation of the Nez Perce and Confederated Tribes of the Umatilla was also crucial in the formation of the Board, with representatives of each tribe serving as members. Both tribes collaborated with state and federal agencies in the development of the 1992 Upper Grande Ronde River anadromous fish habitat protection, restoration and monitoring plan; the Nez Perce worked with the Wallowa County Commissioners to develop a salmon habitat recovery plan in 1993 (revised in 1999).

In 1994, the Grande Ronde Model Watershed Board sought a science-based tool "for prioritizing restoration actions in the basin that would promote effectiveness and accountability" (Mobrand et al. 1995). A team of experts familiar with the basin met in workshop settings from May to December of 1994 to review existing data and develop a plan that was based on current science and "empower[ed] local communities to identify their own problems and select appropriate solutions within the larger context of what is beneficial for the watershed" (Mobrand et al. 1995). The group worked with the Ecosystem Diagnosis and Treatment (EDT) method developed by Lichatowich, Mobrand, Lestelle, and Vogel in 1995, focusing on spring chinook as an indicator species for determining the health of the watershed (Mobrand et al. 1995).

EDT uses medical metaphors to describe historical and current ecological conditions, to establish causes for declines in the species selected for analysis, and to develop a range of alternatives to address the causes of those declines. The workshop participants began with a Patient-Template Analysis, attempting to define habitat conditions present in the basin before 1880, which served as the Template (Mobrand et al. 1995). Spring chinook were chosen as the diagnostic species. Using "available information about current environmental conditions within the watershed and what is known or inferred about the effect of these conditions on survival and distribution," the workshop participants developed an assessment of the Patient (Mobrand et al. 1995). Workshop participants ranked fourteen "descriptive attributes of environmental quality," assigning a score for each factor contributing to the productivity of spring chinook (Mobrand et al. 1995).

Comparing the Template with current watershed conditions, the workshop participants developed a diagnosis and were also able to develop a range of possible future conditions (Mobrand et al. 1995). The analysis showed "that major changes have likely occurred in spring chinook productivity within the Grande Ronde watershed between historic and current conditions," with productivity "appear[ing] to have declined substantially for portions or all of each life stage that occurs in these waters" (Mobrand et al. 1995). Similar patterns were found for Catherine Creek (Mobrand et al. 1995). The participants found "major changes" from perceived historical conditions to current watershed conditions throughout the basin, "with the effects of channel stability, flow, habitat type diversity, sediment load, temperature, riparian condition, and predators to have generally increased the most" (Mobrand et al. 1995). The change in temperature seemed to be the biggest factor in decreasing the productivity of spring chinook (Mobrand et al. 1995).

The diagnosis also took into account the diverse life histories possible for spring chinook, finding that the "reductions combine such that composite productivity across the entire life cycle is often less than one returning adult per parent spawner" (Mobrand et al. 1995). Analysis determined that early migrants were "the most productive pattern under Template conditions;" for those fish "migrating seaward before winter, survival from egg to smolt would have been higher relative to the other patterns" (Mobrand et al. 1995). Maintaining this life history pattern and the habitat associated with it was identified as "vital to safeguard the population from further decline" (Mobrand et al. 1995). The next priorities established focus on maintaining or restoring life histories in decline or which are no longer expressed in the basin (Mobrand et al. 1995).

The next step in the EDT planning process is to develop a list of "reasonable alternative actions" based upon the diagnosis (Mobrand et al. 1995). The environmental attributes identified by workshop participants as negatively affecting spring chinook populations inform the Treatment Alternatives, coordinated by strategies that form a "comprehensive, large-scale marshaling and allocation of resources" across the basin (Mobrand et al. 1995). Within the overall strategy for the watershed, multiple organizations and individuals could propose treatment alternatives (Mobrand et al. 1995). Each proposed action should be analyzed on its ability to promote a positive change in the environmental attributes as it is linked to life history diversity and productivity and contextualized by factors that range from economic objectives to recreational (Mobrand et al. 1995). With this information, the Board adopted a matrix to evaluate and prioritize projects.

Within the organization's first five years, it had developed and funded 111 projects addressing "fish passage structures/irrigation diversion improvements, riparian and rangeland management/off-stream water development, water quality (sediment & erosion reduction), water quantity, and fish habitat" (Perry 1997). The organization also produced a series of assessments during that time, including action plans for the Grande Ronde operations, Bear Creek, Indian Creek, Lostine River, and Big and Little Sheep Creeks. When the Independent Scientific Review Panel (ISRP) reviewed the Model Watershed in 1998, it praised the organization's "good track record of success," noting that projects were "well described." Reviewers requested more detail on monitoring and evaluation and questioned the need for and effectiveness of proposed large-scale noxious weed control (ISRP 1998).

Program Evolution

Initially, the Wallowa Whitman National Forest acted as the Board's fiscal agent. After the Board formed the Grande Ronde Model Watershed Foundation and incorporated as a nonprofit, the organization became its own fiscal agent, contracting staffing out to Eastern Oregon University (for the Executive Director and Wallowa County Coordinators positions) and to Union County for all other staffing. Contracting the payroll to EOU and the County both saves the organization in payroll costs and allows for the leveraging of human resource expertise (for instance, establishing employment policy and annual reviews) beyond the scope of other similarly sized organizations. Over the past 25 years, the Grande Ronde Model Watershed's annual budget has ranged from a low of $382,656[1] to a high of $3,755,235, with average annual spending of $1,295,641. Administrative spending, which includes staff spending for program delivery, has followed the general trend of the overall budget, averaging 36 percent of the annual

[1] In 2003, the BPA revised accounting and budgeting policy, essentially eliminating the 2003 implementation budget and leading to the cancellation of several small projects.

budget. Most monitoring and outreach spending, such as the publishing of *Ripples* is also grouped within administrative spending, as human resources constitute the bulk of these expenses. In 2010, the organization expanded its staffing, leading to an increase in administrative spending.

Each year, a Certified Public Accountant (CPA) conducts an audit and prepares financial statements. Beginning in fiscal year 2017, a separate CPA prepares a financial report based on those financial statements at the request of BPA—in the past, due to the organization's size, the independent reporter was considered unnecessary, and the same firm prepared both the statements and the reports. The Board's Finance Committee reviews the audit's findings with the CPA each year.

The evolving requirements of funders has shaped the organization's spending. While weed control projects were initially a priority for the Board, after 2005, no new projects were awarded funding in this category as BPA one of the organization's primary funders, determined that weed control efforts were not part of mandated mitigation spending. Prior to 2007, Grande Ronde Model Watershed did not lead the implementation of projects; rather, the organization solicited projects and awarded funding to partners and landowners. In 2007, BPA asked the Grande Ronde Model Watershed to develop and implement projects in house. The Board solicited an engineer of record by a request for proposals, selecting Anderson Perry to complete design work. In 2012, NPCC and BPA determined that project implementation by the Grande Ronde Model Watershed created a conflict of interest, so the organization returned to its role as the lead entity coordinating and funding restoration in the basin.

The Grande Ronde Model Watershed engages in public education and outreach to four different groups: youth, community members, landowners, and other watershed councils. In the beginning, the organization focused on tours, presentations, news media, and landowner meetings to further its mission. In 1997, just five years after its inception, the Grande Ronde Model Watershed led nine tours (including one for attended by then-Secretary of the Interior Bruce Babbitt), gave ten presentations, produced four articles for natural resource publications, held two meetings for landowners engaged in project development, and engaged in 20 other outreach activities, ranging from salmon presentations to local high schoolers to a radio feature with former Senator Mark Hatfield discussing a restoration project. Grande Ronde Model Watershed staff have led or participated in outdoor school activities, free fishing days, Ladd

Marsh Wildlife Refuge Youth Days, FFA, Stewardship Days and salmon walks to promote understanding of watershed science and natural resource management amongst area youth. Arts for All (sponsored by Art Center East, a local nonprofit), Bird-a-Thon, Arbor Day tree giveaways, watershed festivals, and litter/graffiti removal work parties have helped connect community members to the organization. The Grande Ronde Model Watershed staff have helped further the effectiveness of watershed councils across the state through participation in the Oregon Network of Watershed Councils, by offering expertise and sharing outreach materials, and by mentoring and supporting the work of other watershed councils' staff. Staff have also served on OWEB Rules Advisory Committees focused on strategic planning, outreach, and application development, as well as outreach to elected officials at the state and national level.

The Grande Ronde Model Watershed began publishing a quarterly circular appearing in local papers, *Ripples*, in April of 2005. The first edition, with the motto "Rivers Uniting Neighbors," featured a cover article introduced the concept of a watershed and explained that through it the organization sought to "bring news to our communities about the Grande Ronde watershed . . . highlight[ing] the activities that are occurring within the community to help improve our watershed." The first edition contained an invitation to participate in a river clean up, an update on returning salmon runs, an update on collaborative planning efforts in Wallowa County, an interview with Board member Pat Wortman, updates on projects implemented at Ladd Marsh and a road relocation project at McIntyre Creek, hints for protecting water quality in the home, and links for educators on natural resources. By leveraging local expertise at partner organizations, the organization developed a high-quality newsletter that has kept the basin informed of its work for 13 years.

Development of Atlas

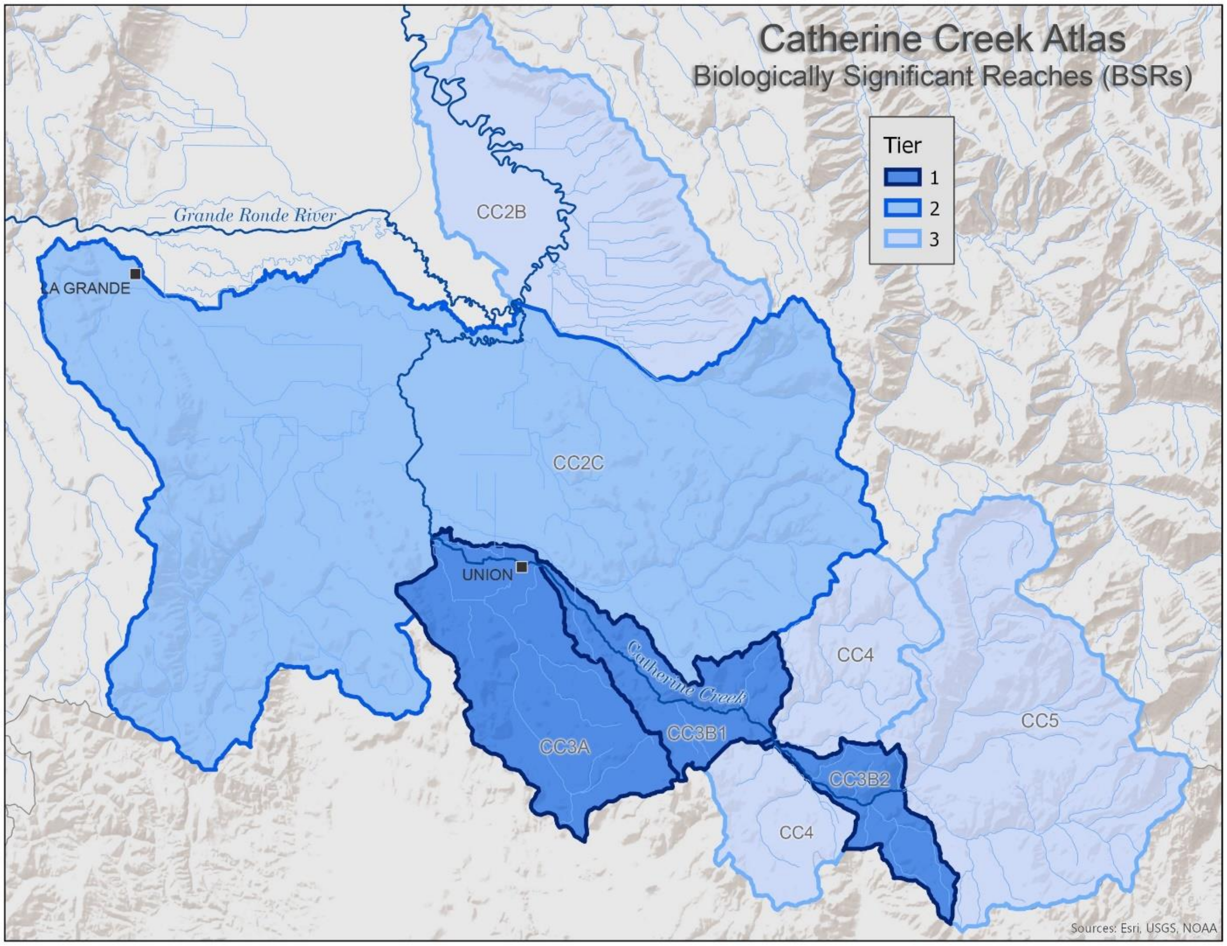
The Spring 2013 issue of *Ripples* announced a new effort by the Grande Ronde Model Watershed begun in November 2012 to promote the accuracy and transparency of investments in habitat restoration and to further efforts "to more clearly define habitat restoration priorities and identify opportunities to integrate habitat restoration efforts with current land use" (Oveson). Rather than creating a new planning document, the Atlas team assembled by Grande Ronde Model Watershed worked with existing data and planning documents to develop a GIS engine for project prioritization and appropriate restoration activities. At completion, Atlas would allow Grande Ronde Model Watershed and its partners to identify "appropriate types of restoration actions in strategically defined locations to address key limiting factors" based on data collected in the basin; implement "focused restoration within key reaches containing habitat for ESA listed species" rather than annually selecting highest priority projects from a portfolio of current restoration project opportunities (i.e., transitioning from a process in which willing partners proposed projects that were evaluated for likelihood to effect positive change to limiting factors to a process in which the restoration opportunities are identified and landowner cooperation is then sought); and create "collaborative, focused, and biologically beneficial restoration projects" that build on the history of interagency collaboration in the basin (Tetra Tech 2017). At its core, Atlas is a bank of maps and data including "local fish species limiting factors, life history requirements, biologically significant reaches (BSRs), habitat restoration opportunities, and conceptual habitat restoration opportunity maps consistent with local geomorphology" (Tetra Tech 2017). This bank of information supports "a scoring and ranking matrix of project opportunities and associated site maps that were collectively developed and evaluated by local and regional experts who participated on committees throughout its development" (Tetra Tech 2017). Because the Atlas structure is built to incorporate new data and to accommodate changing knowledge of restoration processes, it supports the adaptive management of the basin's watershed resources. As the value of the products Atlas offers became clear, a second Atlas process began in the Wallowa subbasin, with construction of projects informed by Atlas expected to begin in 2018.

Eleven organizations contributed to the TAC, along with Grande Ronde Model Watershed staff and Tetra Tech contractor Vance McGowan. Agency staff from BPA, BOR, CTUIR, CRITFC, NOAA, ODFW, USFWS, and USFS, Nez Perce fisheries biologists, and a project leader from the Fresh Water Trust contributed data and analysis to guide Atlas development and implementation. Along with the wealth of expertise, the participants brought a willingness to work across agency boundaries towards a shared vision of landscape-level habitat restoration to support the recovery of anadromous fish species in the basin.

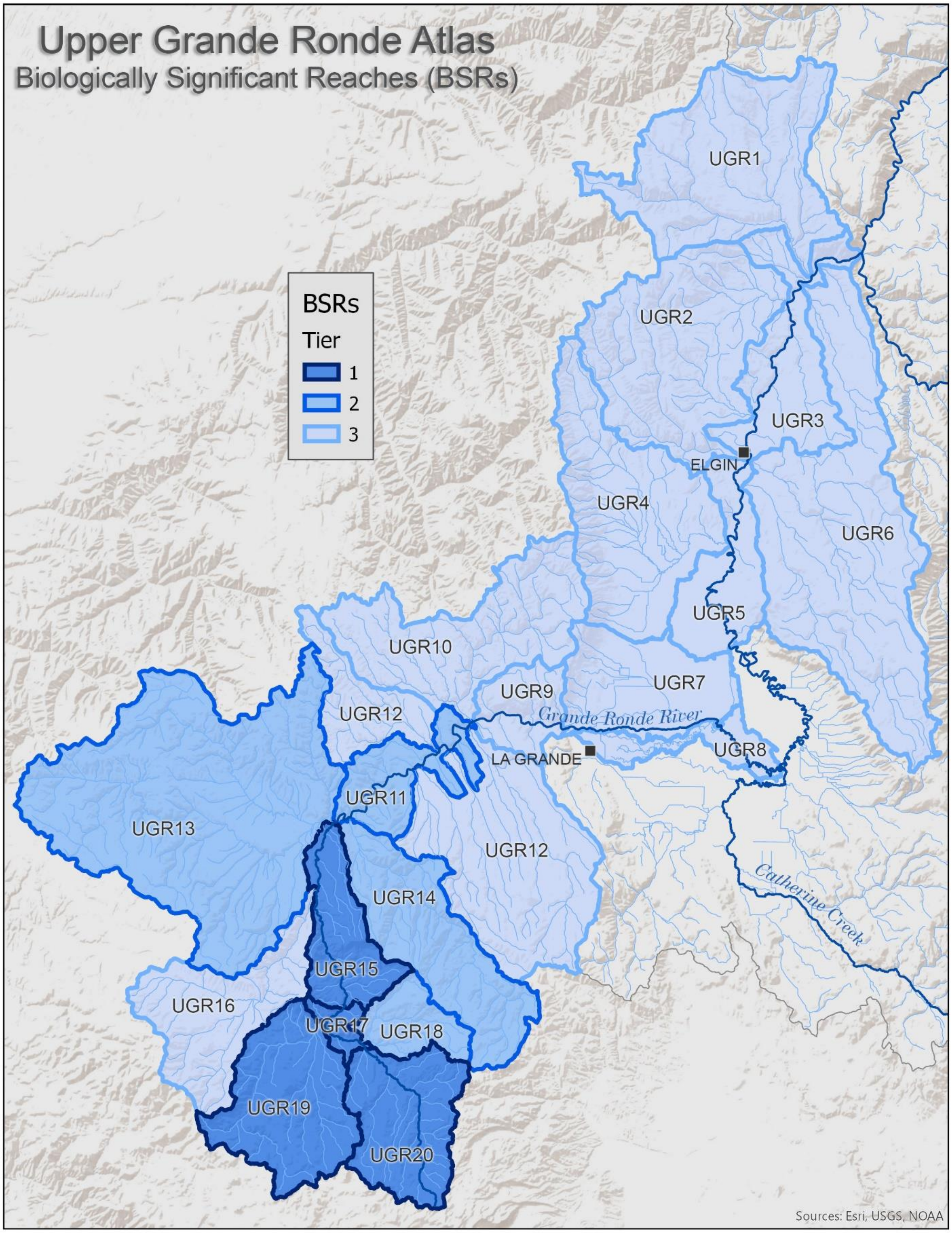
The TAC used flood inundation zones, bathymetry data, surface waters framework, and stream layers to develop the hydrography-hydrology layer of Atlas (Tetra Tech 2017). Total Maximum Daily Load (TMDL) 303d listings, point sources of pollutants, existing stream temperature data (thermographs and forward-looking infrared sensing [FLIR]) and predicted temperature data based on modeling, gage stations, and water right points of diversion (including seniority and quantity) informed the water quality and quantity layer (Tetra Tech 2017). The fish and fish habitat layers incorporate data from the Oregon Department of Fish and Wildlife aquatic habitat inventories project, fish life history (smolt outmigrants, radio telemetry, and redd counts), EDT reaches, fish barrier, hatchery facility, StreamNet (utilization for spawning, rearing and migration areas), Columbia River Habitat Monitoring Program (CHaMP), and Columbia River Inter-tribal Fish Commission (CRITFC) (Tetra Tech 2017).

The TAC used the assembled data to define the timing of fish presence for Chinook salmon, steelhead, and bull trout and the life history stages (adult migration, spawning, incubation/emergence, juvenile summer rearing, juvenile winter rearing, and juvenile emigration) for stream reaches within the Upper Grande Ronde (Tetra Tech 2017). Chinook salmon life histories were used for Catherine Creek, with the assumption that restoration work promoting Chinook salmon would also benefit steelhead and bull trout (Tetra Tech 2017). The data allowed the team to identify reaches as high (immediate need of action), medium (of long-term importance), or low (existing conditions minimally affect fish use) priorities based on current fish use for each life history stage (Tetra Tech 2017). This information, combined reaches defined by previous planning documents enabled the TAC to identify biologically significant reaches:[2] "stream reaches with similar fish use and limiting factors" (Tetra Tech 2017). Ten biologically significant reaches comprise Catherine Creek, while twenty have been identified in the Upper Grande Ronde (for the purposes of Atlas, the Upper Grande Ronde begins above the Wallowa confluence and extends to the headwaters) (Tetra Tech 2017).

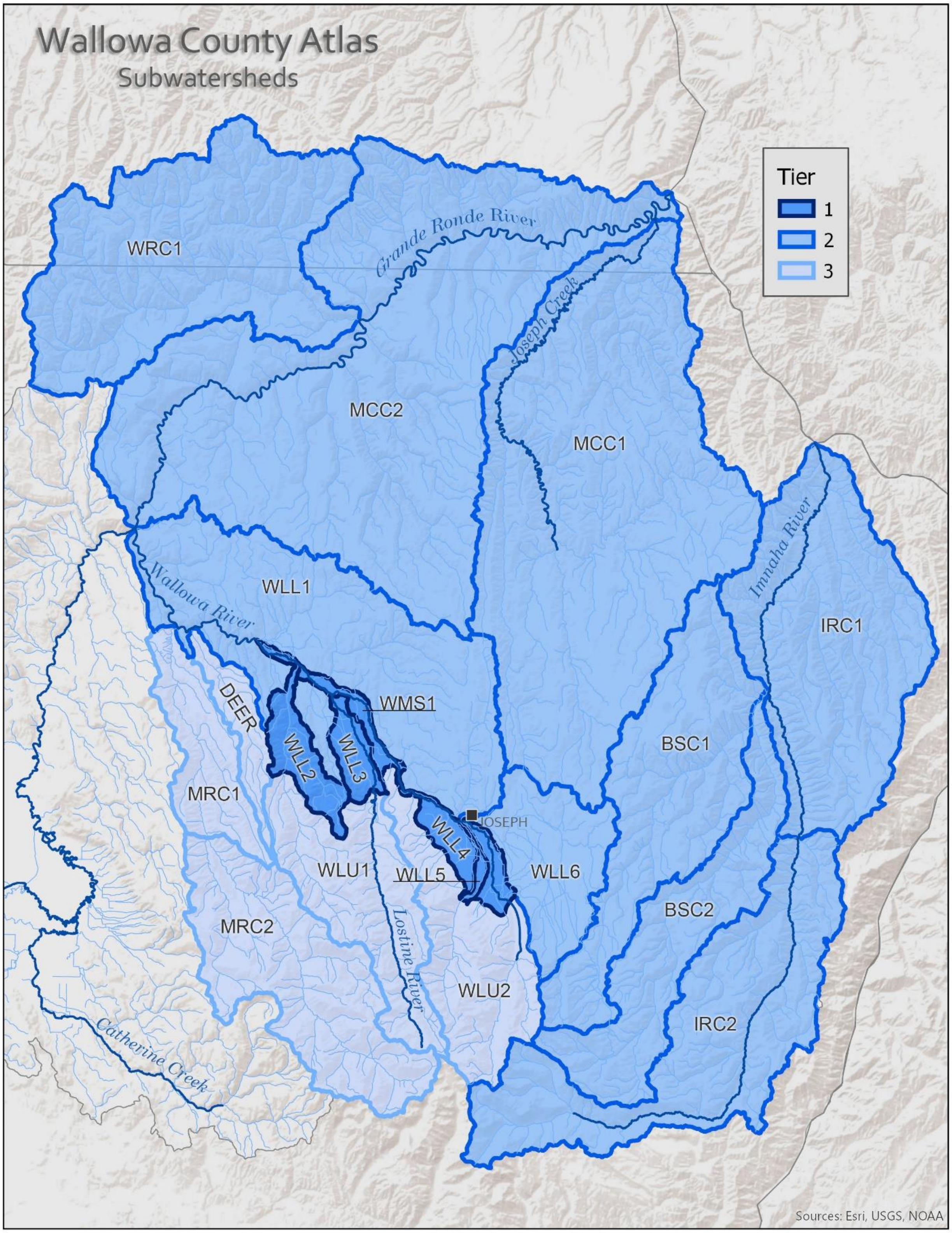
[2] The Wallowa Atlas uses the term subwatersheds rather than biologically significant reaches.



Map 11 Biologically Significant Reaches in the Catherine Creek Watershed



Map 12 Biologically Significant Reaches in the Upper Grande Ronde Watershed



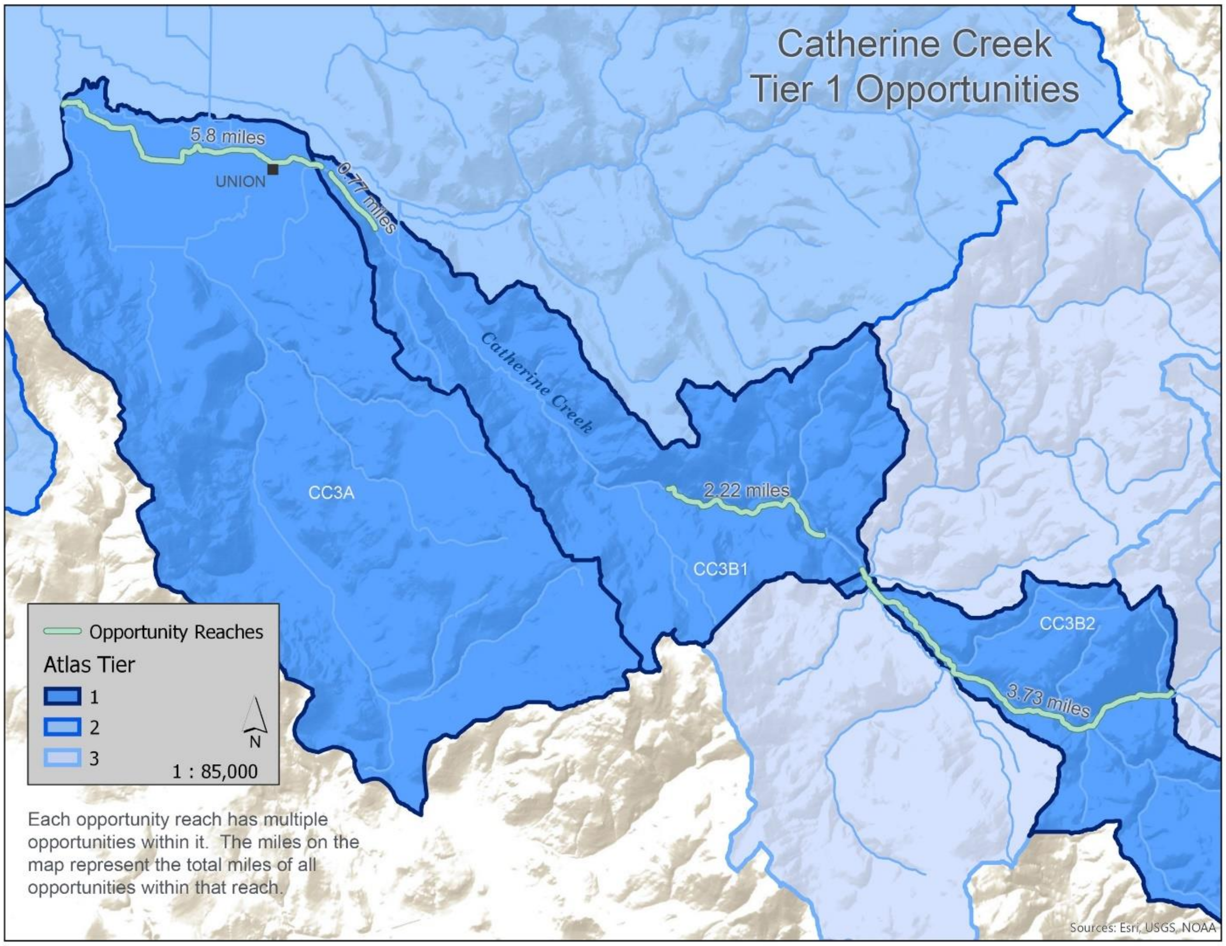
Map 13 Subbasins by Tier in the Wallowa River Watershed

The TAC ranked limiting factors for the two subbasins, using those identified by the National Marine Fisheries Service in 2013 for Catherine Creek (Tetra Tech 2017). In its 2013 draft plan, the National Marine Fisheries found that "[f]our interrelated limiting factors primarily reduce the viability of the Snake River spring/summer Chinook and steelhead populations: excess fine sediment, water quality (primarily temperature), water quantity (primarily low summer flows), and habitat quantity/diversity (primarily limited pools and large wood)," and that "[m]any stream reaches suffer from impaired riparian conditions and loss of floodplain connectivity" (NMFS 2013). The National Marine Fisheries Service limiting factors informed the Upper Grande Ronde Atlas limiting factors, but the TAC used additional limiting factors to promote a multi-species approach (Tetra Tech 2017). The TAC ranked the limiting factors (high, medium, or low) "based on current fish use from empirical data, published research evidence, or local knowledge" (Tetra Tech 2017).

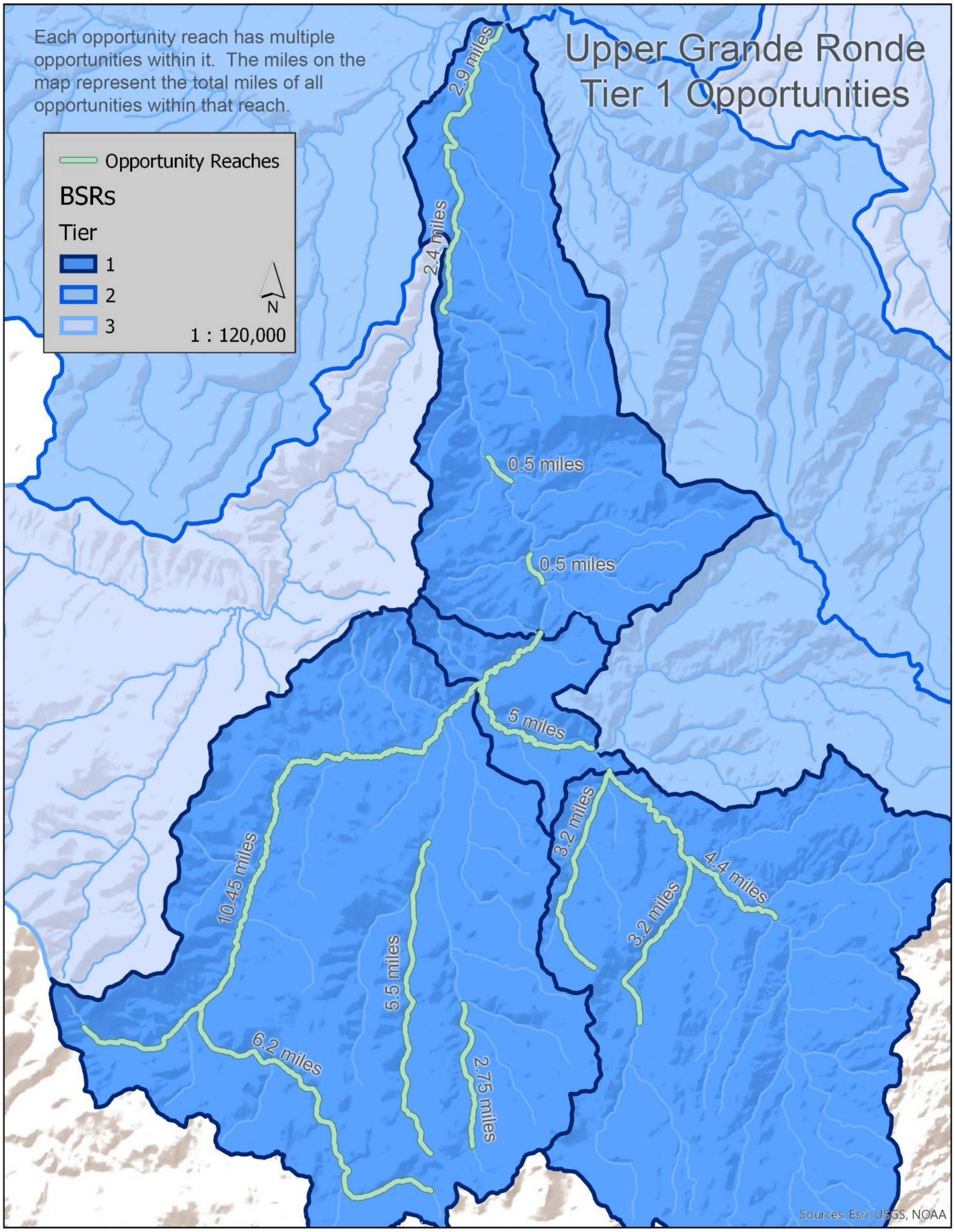
To ensure that proposed restoration actions address the limiting factors effecting fish currently using each reach, the TAC developed Restoration Activity Worksheets. The TAC identified 36 actions that were grouped into 10 categories (water or land preservation, channel modification, floodplain reconnection, side or off-channel habitat restoration, riparian restoration, fish passage, nutrient supplementation, in-stream structures and large wood, bank restoration/removal of armoring, and water quality or quantity impacts) (Tetra Tech 2017). The restoration actions received rankings for immediate impact on current fish use and long-term impact based on future use. To receive a high ranking, actions need "to provide immediate benefits to key life stage use" (immediate) or "to benefit species and life stage use in the future" (long-term, based on future fish use) (Tetra Tech 2017). Actions that would provide a benefit for in the future or that should be implemented as part of a combined program with other actions received a ranking of medium (Tetra Tech 2017). Actions that could not show a potential positive effect on current or future fish populations received an "N/A" ranking (Tetra Tech 2017). The TAC developed a map of future restoration opportunities using the ranked actions and biologically significant reaches (Tetra Tech 2017).

To identify the reaches where restoration will be most beneficial to listed fish, the TAC developed three tiers of priority for both subbasins (Tetra Tech 2017). Four principles, based on work by Beechie et al. 2008 and Roni et al. 2002 guided the development of the priority tiers: "[b]uild from existing production areas," focus on "areas with critical species and life stages present," focus on areas with a geomorphic potential for change, and focus on areas where the current habitat condition will respond to change (Tetra Tech 2017). Oregon Department of Fish and Wildlife supplied adult salmonid redd waypoint data and juvenile salmonid spatial and temporal distribution data to support tier development (Tetra Tech 2017; E. Sedell, ODFW Project Leader - Grande Ronde Steelhead and Habitat Monitoring, personal communication). In addition, Oregon Department of Fish and Wildlife's HabRate limiting factors model of CHaMP data was used to develop qualitative rankings of current habitat conditions (Tetra Tech 2017; E. Sedell, personal communication). Finally, a current temperature score was assigned using Columbia River Intertribal Fish Commission's temperature model and Chinook data as well as the U.S. Bureau of Reclamation's FLIR data (Tetra Tech 2017).

To prioritize restoration opportunities within each biologically significant reach, the TAC developed an opportunity prioritization based on five categories; while these serve as a guide for prioritizing, the ranking was not intended to be an absolute (Tetra Tech 2017). The following factors guide the ranking: the tier of the reach (I, II, III), the severity and number of limiting factors addressed, the likelihood of addressing immediate and long-term habitat conditions, the designation of "full restoration, partial restoration, or simply short-term habitat restoration based on Beechie et al. (2010)," and in Catherine Creek, the effects of water rights on downstream flow (Tetra Tech 2017). Additional factors added to the initial prioritization ranking include the active or passive nature of the restoration action; including restoration actions in Tier II and III areas that "may not provide immediate benefits for focal fish species, but may provide an opportunity for experimental techniques that may provide refuge habitat until root causes of low fish survival are determined;" and a feasibility ranking based on the perceived willingness of the landowner to participate in a restoration action (Tetra Tech 2017).



Map 14 Tier 1 Restoration Opportunities in the Catherine Creek Watershed



Map 15 Tier 1 Opportunities in the Upper Grande Ronde Watershed

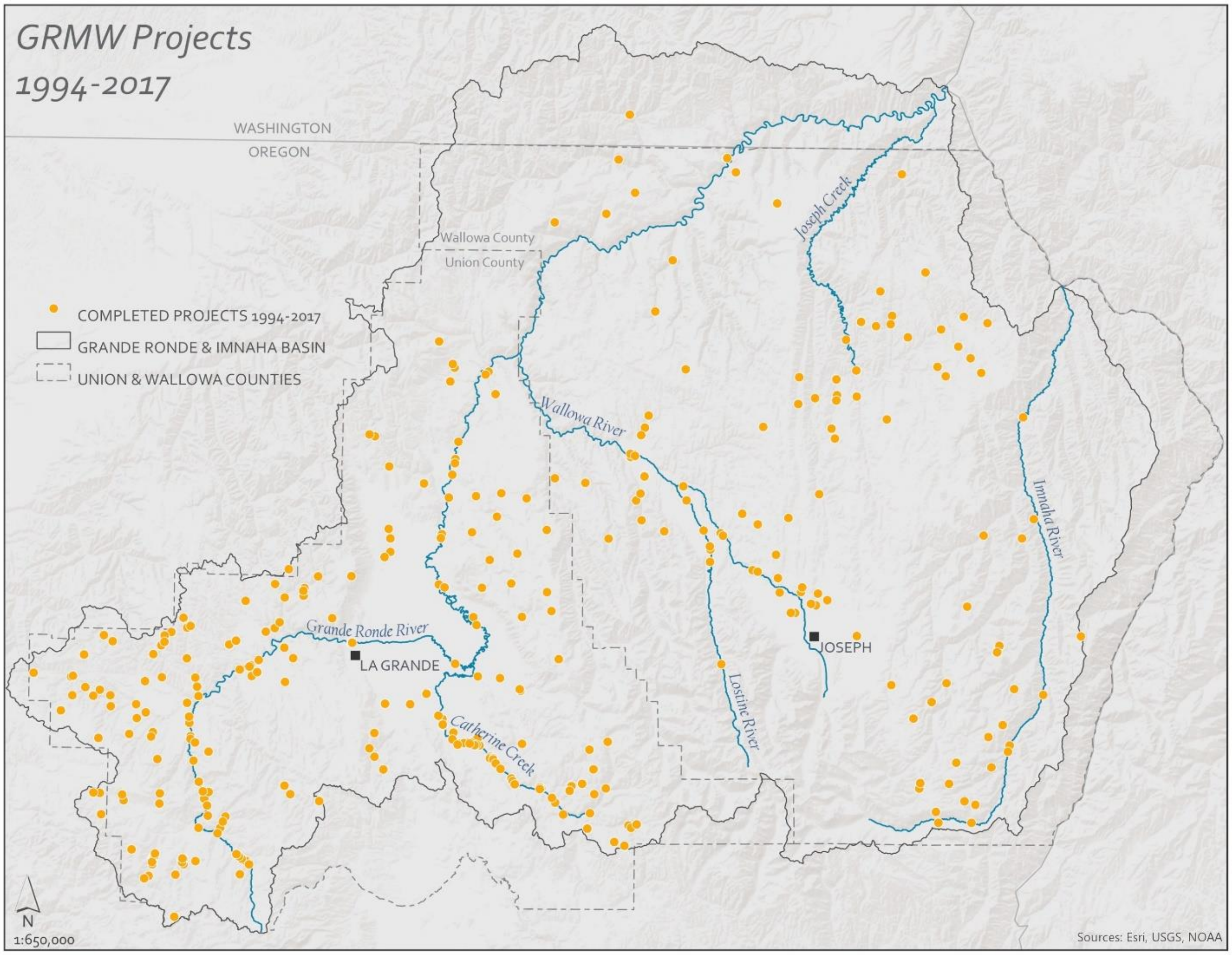
The Atlas Implementation Team (IT) meets monthly to review project opportunities and assign project leads, members chosen from the IT most likely to work effectively with the landowners or agencies within prospective project areas. Monthly meetings also provide an opportunity for the IT to review progress reports and work within subgroups to provide design critiques. While Atlas originally employed a spreadsheet matrix to review opportunities, the IT now has an online format that allows members to easily update information and comment on opportunities. The Model Watershed solicits projects twice a year; meetings at these times focus on reviewing prospective projects. While Atlas provides a gross-level plan for restoration, the IT refines the objectives at specific project sites, incorporating greater detail as the needs and willingness of landowners allow. Project implementers work with the IT to balance the ideal with the on the ground and social reality, ultimately determining whether or not a project can be developed that meets both ecological and landowner goals. At the prospectus stage, a discrete restoration opportunity identified in Atlas may be broken into multiple components—or multiple opportunities might be combined into a single project; a one to one correspondence between Atlas opportunities and projects does not exist. Following project implementation, the IT conducts site visits to review the degree to which project implementation was in keeping with design specifications. As Atlas matures, the IT will also identify monitoring goals and measurable objectives as part of the review of project proposals. Because Atlas includes a fish periodicity table for each BSR, it provides a tool for planning the appropriate timing to determine fish use at project sites. The Model Watershed will act as the coordinator of project monitoring: identifying goals and objectives and ensuring the implementation of monitoring across the basin.

Limber Jim: An Example of Project Development through Atlas

Atlas established a general progression for projects on National Forest land. While the Upper Grande Ronde has already been a focus for restoration for several decades, Atlas revealed the need for new objectives: larger-scale projects focusing on floodplain connectivity in areas within and adjacent to current chinook spawning and rearing domains offer the highest potential to improve chinook populations. Partners from USFS approached the IT with a proposal for work on Limber Jim Creek, a steelhead stream in the Upper Grande Ronde identified as a Tier 2 BSR. The IT reviewed the proposal and offered feedback, agreeing that the project would be worthwhile to pursue. The Model Watershed asks project proposers to use Stepwise, an online application process that walks the applicant through a series of questions that help the IT determine the relationship between the proposed project and Atlas restoration priorities and actions. The USFS submitted a project prospectus that addressed the required Stepwise information. After further review by the IT, the focus of the project shifted from a series of wood structures similar to those that had been used in the past—large wood placed to create in-stream habitat—to channel-spanning pieces that would encourage the inundation of the floodplain. A subgroup of IT members formed to further refine the project, working with an engineer from BPA, Sean Welch. The subgroup developed a new design incorporating large members to span the channel as well as smaller wood and slash to be woven into the structure, mimicking beaver dams that would have been in the area historically. The USFS project lead and Welch reported on the progress of the design periodically; when the proposal was submitted for formal review, little time was needed because the team had been engaged throughout the development process at monthly meetings.

The Model Watershed approved the project following the IT approval and the project was built the summer of 2017. Along with wood placements, one mile of forest road was recontoured, and 3.2 miles were closed. Large boulders were placed to define access for recreational vehicles at three dispersed camp sites. One culvert was removed on the South Fork of Limber Jim and two culverts were replaced, one on the North Fork and one on the main stem of Limber Jim. Plantings included 4,500 seedlings and 10,000 cuttings. Because of the interest the project generated, the IT made multiple site visits. While the USFS Restoration Program Manager places wood by “feel,” drone imagery used to provide data for a review of the project as built and the design showed that the implemented project met the objectives of the design, although some of the structures were located in variance to the design. While the channel spanning logs raised fish passage concerns for some on the IT, spawning ground surveyors found a steelhead redd above the project site and several hundred juvenile Chinook parr from summer snorkel surveys throughout the project site in 2018 (E. Sedell, personal communication).

Summary and Review of Restoration Actions



Map 16 Grande Ronde Model Watershed Projects 1994-2017

Projects Completed under the Operations-Action Plan

From 1994 to 2005, the *Grande Ronde Model Watershed Program Operations-Action Plan* provided the framework for the development of project goals. (The Power and Conservation Council Subbasin Plan was completed in 2004; however, projects did not begin going on the ground under these guidelines until 2006 due to the lag time between project solicitation, design, and implementation.) While the Action Plan identified the limiting factors for each watershed, the Grande Ronde Model Watershed Technical Committee used a Restoration Project Priority Matrix to rank individual projects. Projects that maintained or enhanced existing high-quality habitat in salmon and bull trout biodiversity areas received the highest priority. Comprehensive approaches to limiting factors received higher priority ranking than those that addressed limiting factors without promoting a comprehensive approach. Additional emphasis was given for criteria such as low cost, quick completion, strong leverage of funding, diversity in support, or the ability of the project to offer additional education or research opportunities. The Grande Ronde Model Watershed completed 172 projects (including monitoring, technical assistance, and feasibility studies) between 1994 and 2005, an investment of $14,420,059. The average total cost (including all organizational costs) per project was $83,838. No projects were implemented in the Wenaha, Minam, or Lookingglass watersheds. The Upper Grande Ronde and Catherine Creek watersheds saw the highest number of projects implemented, with the fewest implemented in the Imnaha and Joseph watersheds. Joseph Creek projects were more likely to be implemented in headwater streams on private land, rather on the main stem, much of which is canyon land designated Wild and Scenic. Projects addressing streambank erosion were the most commonly implemented projects, while projects to reduce winter icing were the least commonly implemented

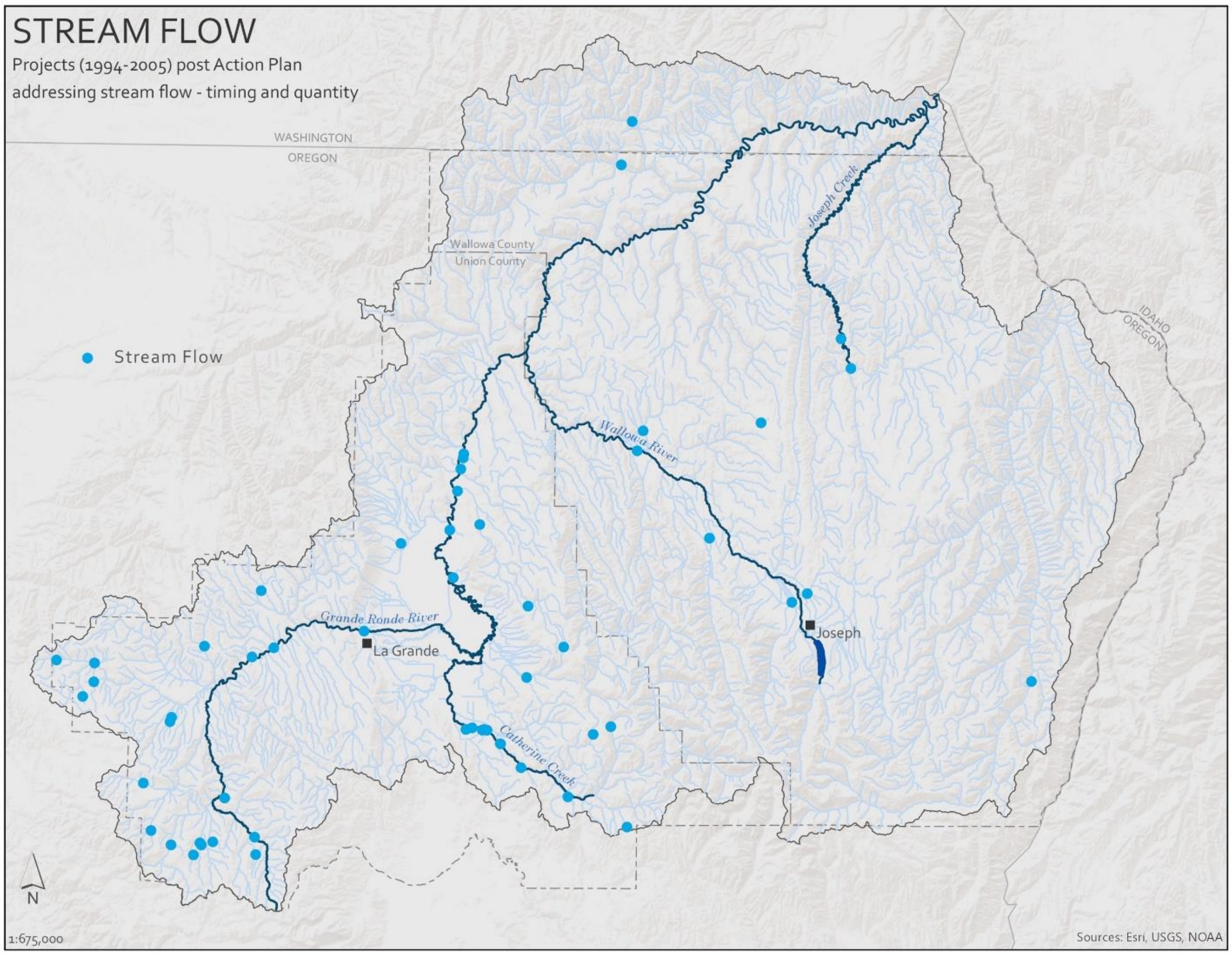
Stream Flow Timing and Quantity

The 1994 Action Plan identified five concerns related to stream flow and the timing of high flows: tree density and transpiration; roads and logging that have compacted soils or reduced vegetation; minimum flows, and future demands for water. In stands lacking optimal density, proscribed burns, thinning, and planting are recommended. Mitigating impacts of roads, trails, wildlife, and livestock was recommended to avoid runoff and improve infiltration, including relocation of roads outside of riparian areas. Improving or protecting minimum flows would be accomplished through planting or protecting riparian cover; limiting precipitation-intercept-evaporation and preserving snow pack shading through management of tree density; limiting the diversion of irrigation water to other basins; purchasing or negotiating water from water right holders during low flows; improving irrigation efficiency; studying impoundments; filing instream water rights; developing wells; identifying water savings measures for canals; and creating wetlands for water storage.

Watershed	Flow Quantity	Riparian Conditions
Upper Grande Ronde	21	62

Catherine Creek	8	12
Wallowa River	6	13
Lower Grande Ronde	2	9
Imnaha River	1	4
Joseph Creek	2	11

Table 1 Projects Addressing Stream Flow and Timing 1994-2005



Map 17 Projects Addressing Streamflow, 1994-2005

Forty projects addressed low streamflow, through habitat improvements, irrigation modifications, or a combination of both. The bulk of these projects were implemented between 1996 and 1999. One hundred eleven projects addressed riparian conditions. The majority of projects improving flow were located in the Upper Grande Ronde and Catherine Creek, with sites more likely to be located on tributary streams than on mainstems.

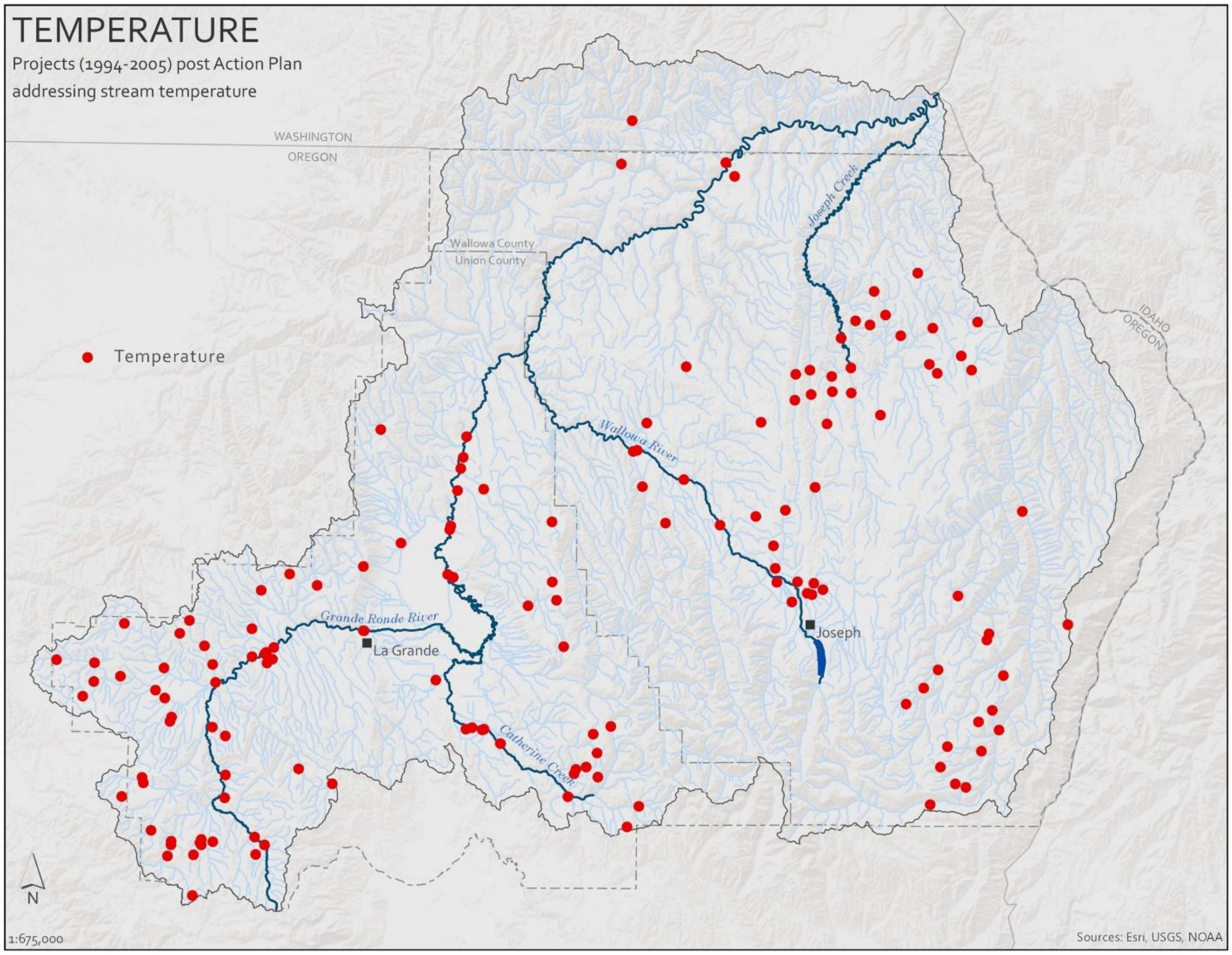
Temperature

The Oregon Department of Environmental Quality adopted its current temperature standard in 2003 (OAR 340-041-0028): the seven-day-average maximum temperature of streams providing salmon and steelhead spawning habitat shall not exceed 13 Celsius degrees during spawning; streams providing rearing habitat and serving as a migration corridor shall not exceed 18 Celsius degrees; and streams providing a migration corridor shall not exceed 20 Celsius degrees. In addition, OAR 340-041-0028 states that "these water bodies must have coldwater refugia that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body."

The Action Plan identified five strategies for reducing stream temperatures: increasing riparian shading, protecting or increasing spring flows, planting conifers in riparian areas to provide cover in winter, increasing flow quantity, and limiting surface irrigation return flows. In addition to riparian protection or enhancement measures, NOAA's 2016 proposed recovery plan for Snake River salmon and steelhead recommends providing "mitigation for declining summer flows by protecting and restoring wetlands, floodplains, and other landscape features that store water." Citing work by P. Roni and T. Beechie (2013), the recovery plan also recommends "that increasing floodplain connectivity, restoring stream flow regimes, and restoring incised channels to provide stream complexity (including through beaver reintroduction) are the actions most likely to ameliorate stream flow and temperature changes and increase habitat diversity and population resilience."

Watershed	Flow Quantity	Riparian Conditions	Stream Complexity
Upper Grande Ronde	21	62	35
Catherine Creek	8	12	12
Wallowa River	6	13	11
Lower Grande Ronde	2	9	3
Imnaha River	1	4	4
Joseph Creek	2	11	8

Table 2 Projects Addressing Stream Temperature, 1994-2005



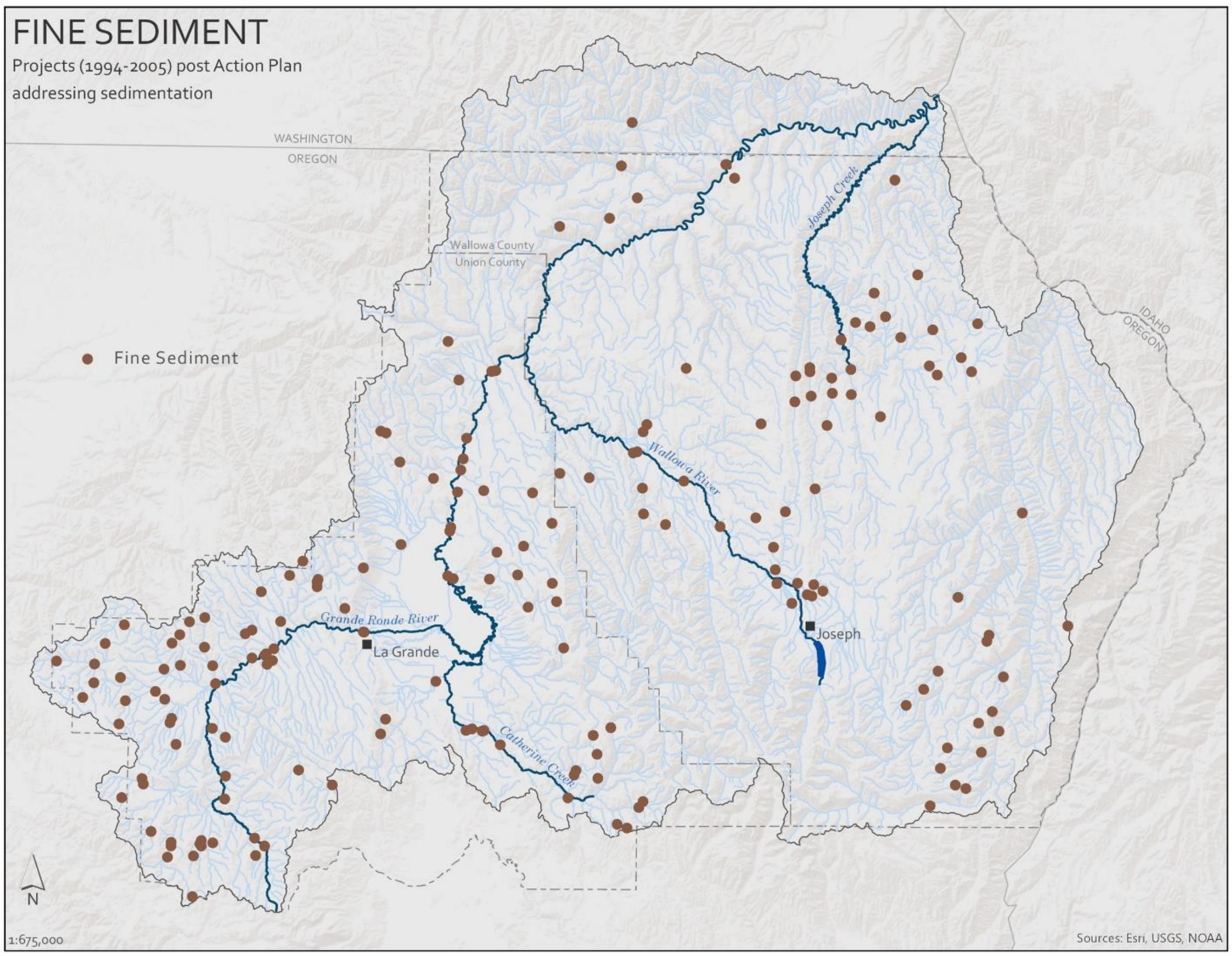
Eighty-five projects addressed stream temperatures. Projects attempted to lower stream temperatures by increasing stream length, removing or modifying dikes, creating or improving pool habitat, plantings, fencing, and building exclosures. The bulk of these projects were implemented between 1996 and 2001. One hundred eleven projects addressed riparian conditions. Projects to improve stream temperatures were implemented in each watershed, with sites located more frequently on tributary streams rather than the main stem.

Fine Sediment

The 1994 Action Plan identified land uses including roads, recreation, forestry, and agricultural and livestock management as possible sources of fine sediments in the basin. Recommended actions to reduce fine sediment impacts focused on protecting and restoring width to depth ratios; planting filter strips along roads and feedlots; relocating or eliminating roads; switching to lighter skidding equipment or better controlling skidding operations; fencing streams and providing watering alternatives for livestock; managing camping and trails to lighten impacts to fisheries; avoiding excess flows in irrigation canals; and managing forests to reduce fuel density.

Watershed	Fine Sediment	Streambank Erosion	Riparian Conditions
Upper Grande Ronde	63	62	62
Catherine Creek	12	14	12
Wallowa River	13	13	13
Lower Grande Ronde	9	9	9
Imnaha River	4	4	4
Joseph Creek	11	12	11

Table 3 Projects Addressing Fine Sediment, 1994-2005



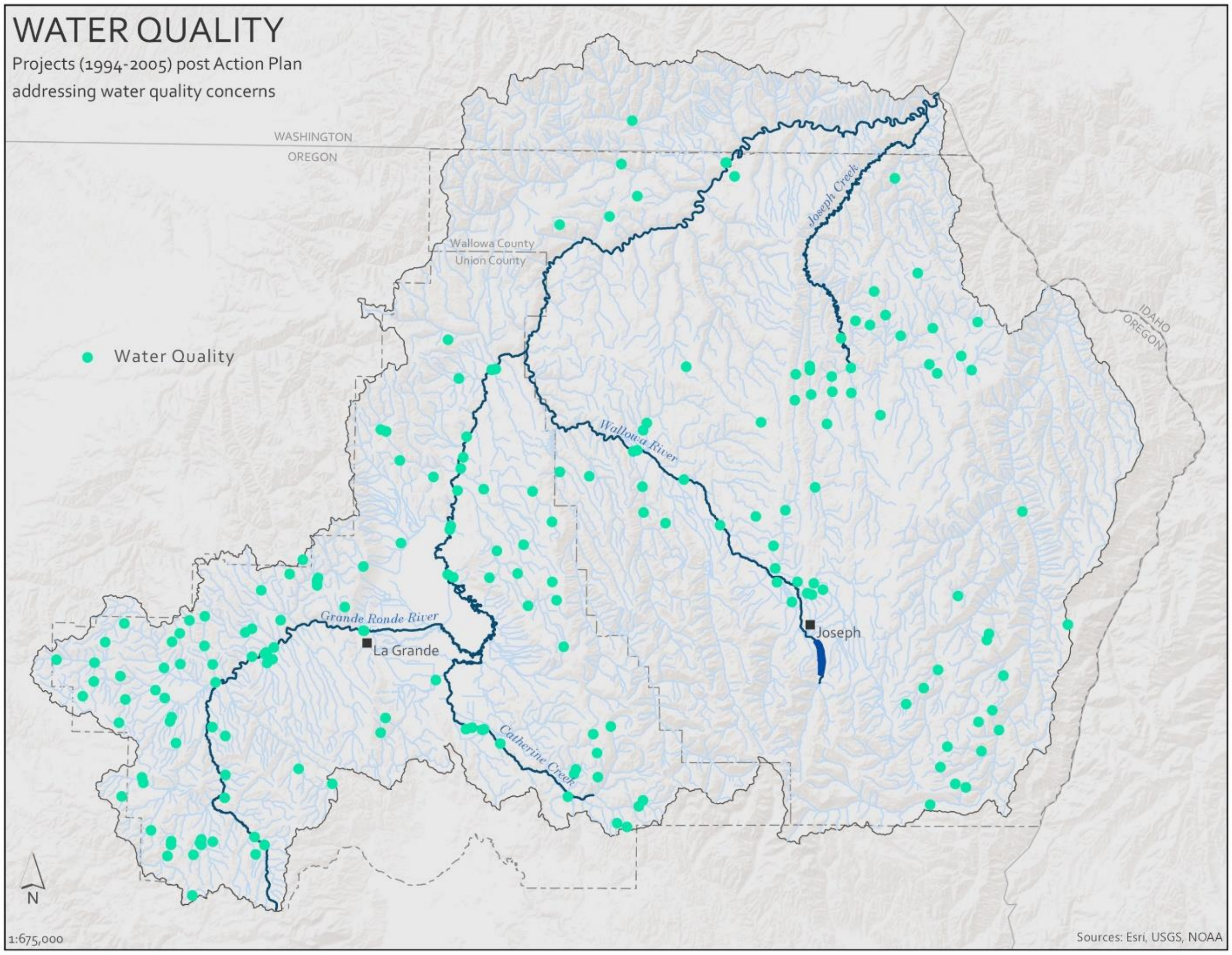
One hundred twelve projects addressed fine sediment. Projects sought to improve sediment conditions by increasing stream length, dike removing or modifying dikes, modifying habitat, plantings, creating or improving livestock watering sites, relocating, obliterating, or other otherwise improving roads, and through fencing. The bulk of these projects were implemented between 1996 and 2001. Projects addressing fine sediment were implemented most often in the Upper Grande Ronde and Catherine Creek, with sites located more frequently on tributary streams rather than the main stem.

Other Water Quality Concerns

Noxious weed control, irrigation returns, trash, human waste and sewer systems, herbicides and pesticides, municipal and industrial chemicals, and excess nutrients were also identified as concerns.

Watershed	Water Quality
Upper Grande Ronde	63
Catherine Creek	12
Wallowa River	13
Lower Grande Ronde	9
Imnaha River	4
Joseph Creek	11

Table 4 Projects Addressing Water Quality, 1994-2005



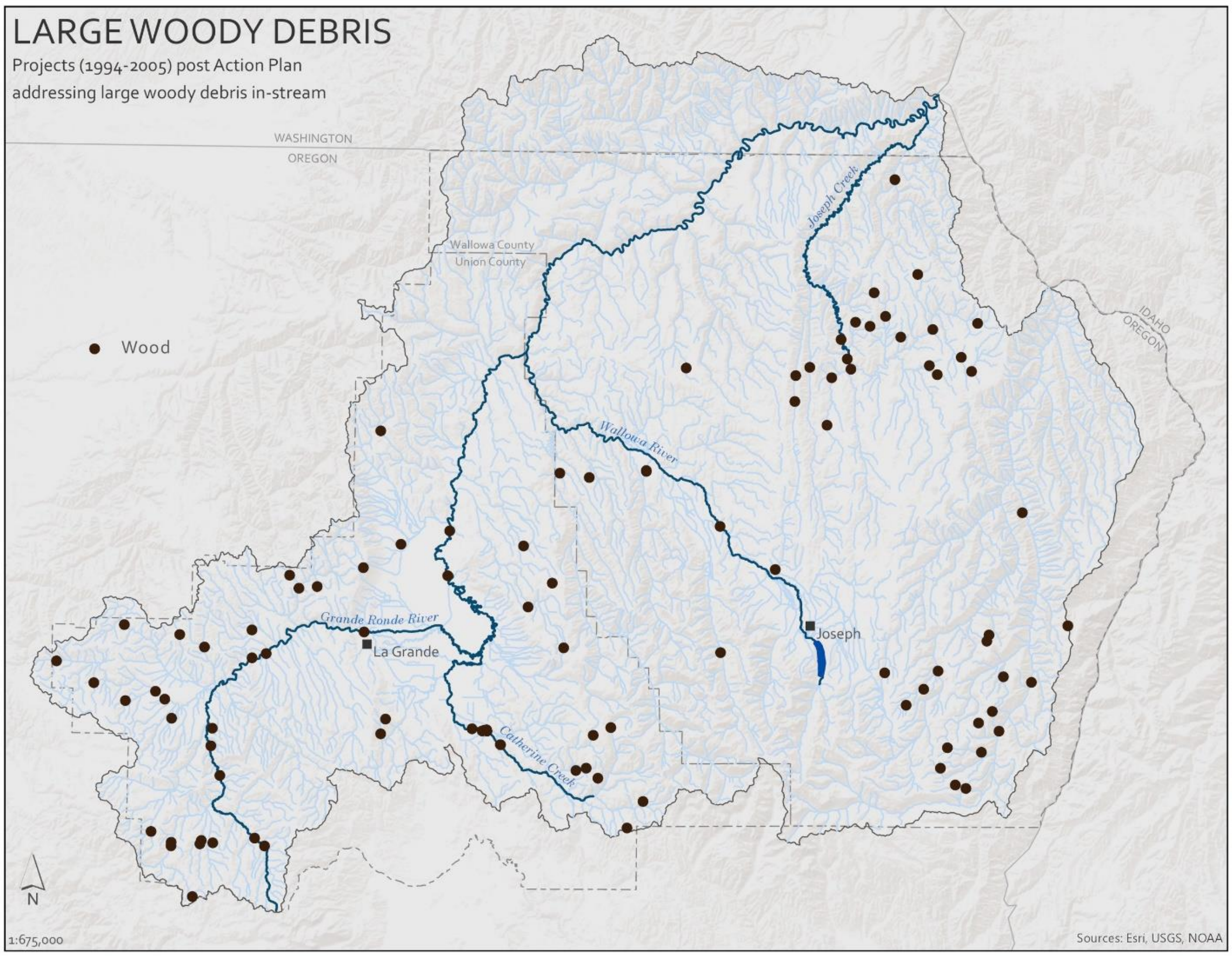
In addition to the projects addressing fine sediment (which are assumed to also address other water quality concerns), 16 additional projects were implemented to improve water quality. Each of these were seeding projects, implemented between 1996 and 2005. Projects addressing water quality were implemented most often in the Upper Grande Ronde and Catherine Creek, with sites located more frequently on tributary streams rather than the main stem. Because urban water quality issues have been less of a concern for the basin, sites are located outside of urban areas.

Large Wood

The 1994 Action Plan identified three strategies for addressing the shortage of woody debris in streams: "add/preserve large woody debris in streams, other permanent structures such as boulders or concrete, [and] plac[ing] woody debris or large boulders to direct water to spawning gravel."

Watershed	Large Wood
Upper Grande Ronde	27
Catherine Creek	9
Wallowa River	6
Lower Grande Ronde	1
Imnaha River	4
Joseph Creek	8

Table 5 Projects Addressing Lack of Large Wood, 1994-2005



Fifty-five projects addressed shortages of large wood in streams; three of those projects included an increase in stream length. The bulk of these projects were implemented between

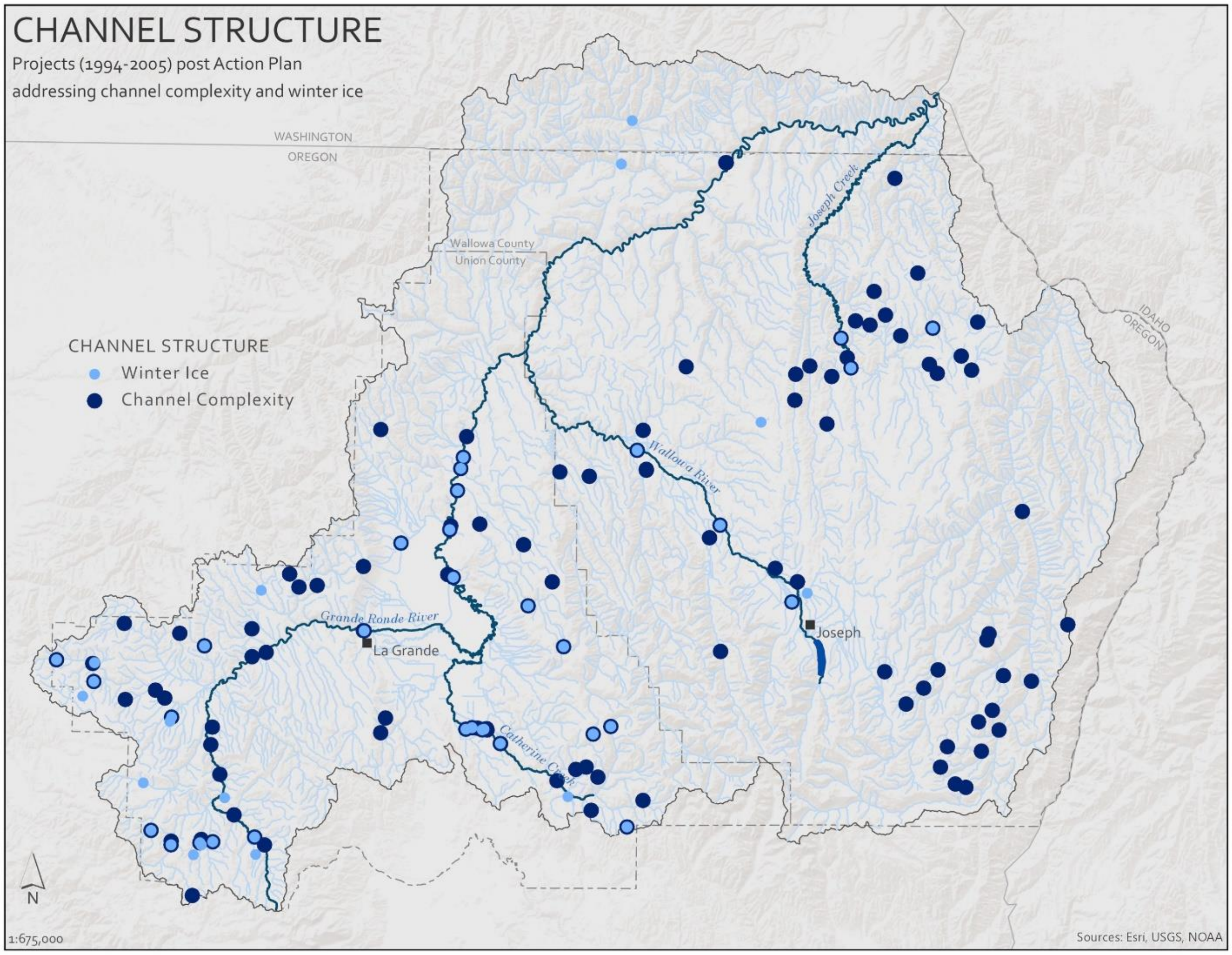
1996 and 2001. Projects to improve stream temperatures were implemented in each watershed, with sites located more frequently on tributary streams rather than the main stem.

Channel Structure and Winter Ice

Along with the preservation or addition of large wood in the stream channel, the 1994 Action Plan recommends prohibiting further channelization; avoiding building in floodplains; developing mitigation strategies for necessary channelization or bank protection; developing hardened fords for machinery and livestock use; avoiding high flows that erode banks; retaining large trees along banks to break up or slow ice dams; dynamiting smaller ice flows before these "get bad;" anchoring wood or providing other structures to form pools in steeper gradient streams; and placing boulders or other concrete structures to direct water.

Watershed	Winter Ice	Pool Formation	Large Wood
Upper Grande Ronde	17	33	27
Catherine Creek	4	12	9
Wallowa River	4	11	6
Lower Grande Ronde	2	2	1
Imnaha River	0	4	4
Joseph Creek	3	8	8

Table 6 Projects Addressing Channel Structure and Winter Ice, 1994-2006



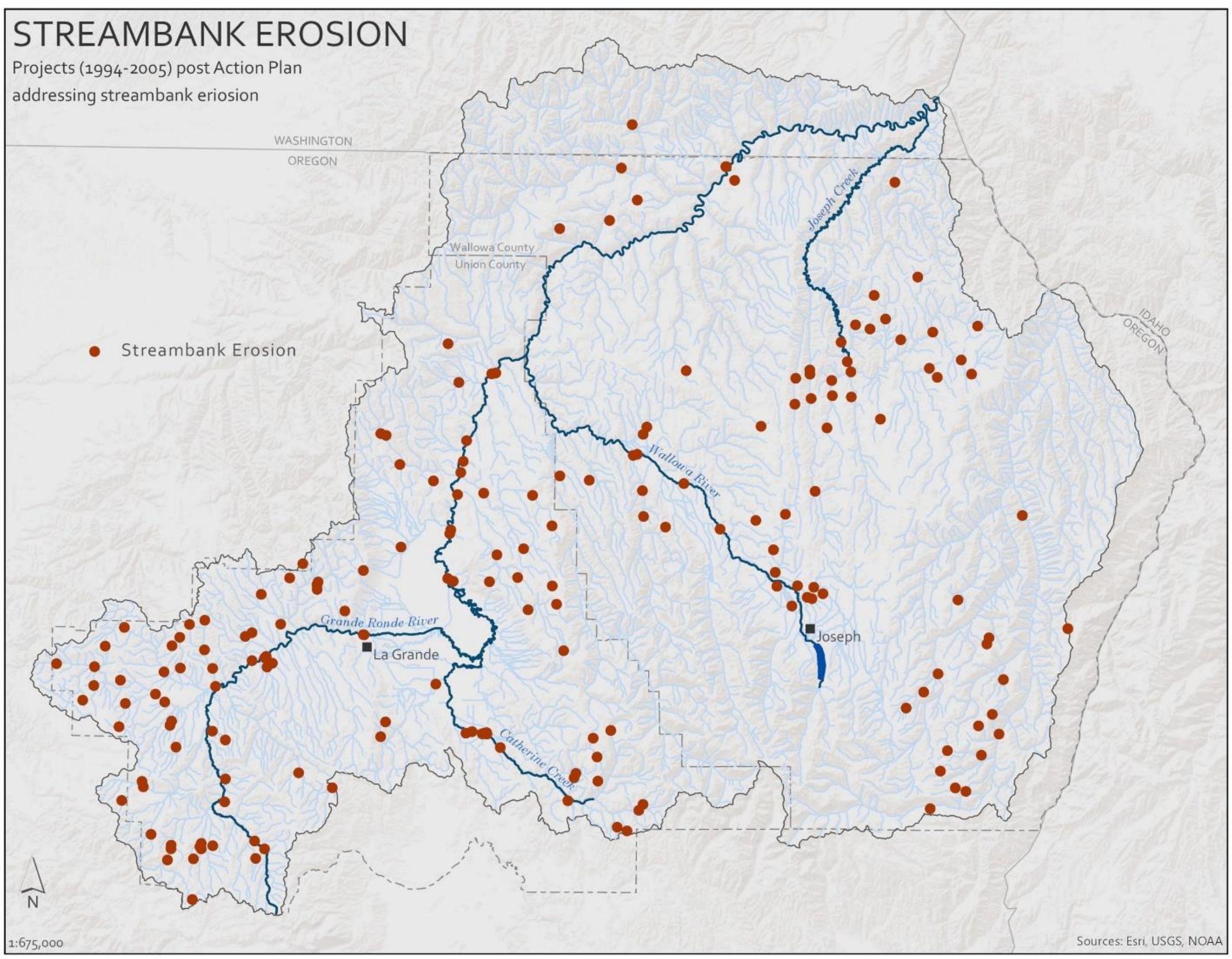
Thirty projects addressed winter icing in streams; three of those projects included an increase in stream length and the remaining 27 relied on habitat improvements. The bulk of these projects were implemented in 1996 and 1997. An additional 70 projects attempted to improve or create pools; seven included the construction of pools, six included boulder placements, 29 included engineered log jams or other wood placements, 35 included the construction of rock structures, and 44 through a combination of stream treatments. (No unique project included wood placement that did not either address winter ice or the formation of pools.) Projects addressing winter ice and channel complexity were located throughout the basin, primarily on tributary streams.

Streambank Erosion

Although the 1994 Action Plan identifies streambank erosion as an issue negatively effecting streams in the basin, no specific actions are recommended for addressing it, although activities recommended for other concerns, such as enhancing riparian conditions or placement of log structures might also address localized erosion concerns.

Watershed	Streambank Erosion	Riparian Conditions	Large Wood
Upper Grande Ronde	62	62	27
Catherine Creek	14	12	9
Wallowa River	13	13	6
Lower Grande Ronde	9	9	1
Imnaha River	4	4	4
Joseph Creek	12	11	8

Table 7 Projects Addressing Streambank Erosion, 1994-2005



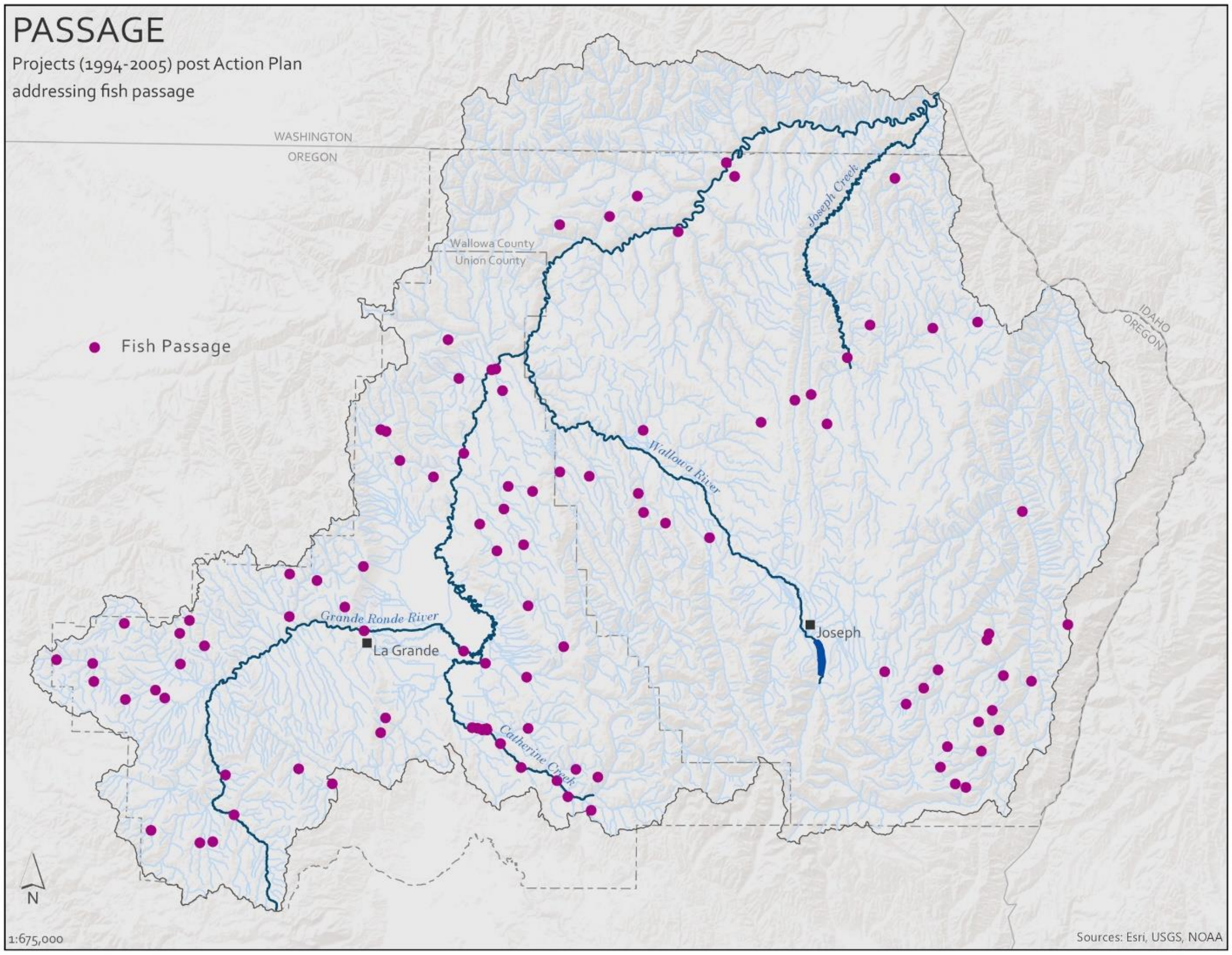
One hundred fourteen projects addressed streambank erosion. Projects addressed erosion through increases in stream length, dike removal or modification, boulder placements, engineered log structures, habitat enhancements, plantings and seeding, creation or improvement of livestock watering sites, road relocations, obliterations, or other improvements, and through fencing (upland fences, riparian fences, and exclosures). The bulk of these projects were implemented in 1996 and 2000. These projects were located throughout the subbasin, primarily on tributary streams.

Unscreened Diversions and Fish Passage

The 1994 Action Plan recommended monitoring and removing log jams and excess woody debris; modifying diversions to improve passage; and educating swimmers to encourage passage through swimming hole dams. The installation, monitoring, and maintenance of screens was recommended at all irrigation diversions and returns; fish screens are handled by the ODFW fish screen shops at John Day and Enterprise.

Watershed	Fish Passage
Upper Grande Ronde	34
Catherine Creek	14
Wallowa River	7
Lower Grande Ronde	6
Imnaha River	4
Joseph Creek	5

Table 8 Projects Addressing Fish Passage, 1994-2005



Seventy projects addressed fish passage. The majority of passage projects focused on improving road crossings, including road obliterations and relocations. Four fish ladders were constructed, and twelve projects addressed stream diversions. These projects were located throughout the subbasin, primarily on tributary streams; however, in the Catherine Creek Basin, the bulk of the projects were located on the mainstem.

Lostine River/Sheep Ridge Diversion Fish Passage Improvement. Sponsor: GRMW. Funders: BPA, Landowners. Completed: 2012. Photos by Coby Menton (GRMW). Wallowa/Lostine Subbasin. Pre-project photos left (Aug 2012), post-project right (Sept 2012).

Beaver Creek Reservoir, immediately upstream of this project, is controlled by a diversion structure owned by the City of La Grande, OR and located on USDA Forest Service land. By providing fish passage, access to more than 12 miles of high quality habitat was gained. The extreme gradient of this reach of Beaver Creek called for challenging design in order to meet fish passage criteria. This project was funded by numerous partners, including OWEB and BPA, the City of La Grande, and Oregon Water Resources Department. Photo by Connar Stone (GRMW).

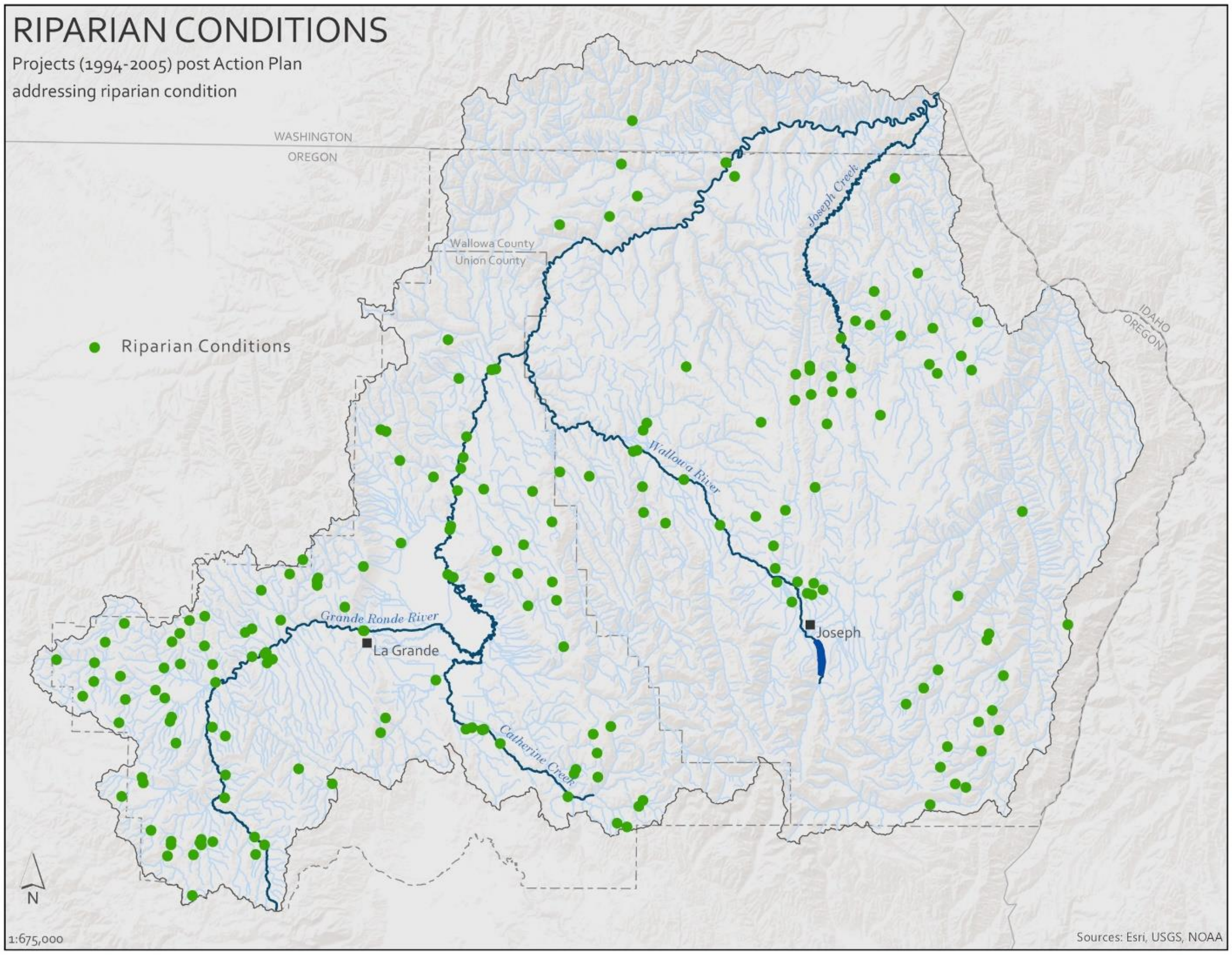
Habitat Requirements

The 1994 Action Plan recommended the preservation and restoration of riparian vegetation to improve fish habitat. In addition, promoting the habitat conditions needed for prey; closing some streams and educating sports fishers; moving or providing alternate recreational opportunities; and living with or providing alternate food sources for predators such as bull trout and blue herons were recommended.

Watershed	Riparian Conditions	Stream Complexity
Upper Grande Ronde	62	35
Catherine Creek	12	12
Wallowa River	13	11
Lower Grande Ronde	9	3

Imnaha River	4	4
Joseph Creek	11	8

Table 9 Projects Addressing Habitat Conditions, 1994-2005



One hundred eleven projects addressed riparian habitat conditions. Projects attempted to improve riparian conditions through creating, removing, or modifying dikes, increasing stream length, plantings and seeding, creating or improving stock watering facilities, changing road infrastructure (road obliteration, relocation, or other improvements) and fencing. These projects were located throughout the subbasin, primarily on tributary streams; however, in the mid-valley reaches of the Grande Ronde, some projects were located on the mainstem. Seventy-three projects addressed stream channel habitat and complexity, through barrier removal, increases in stream length, boulder placements, pool creation, engineered log structures or large wood placements, and construction of rock structures.

Projects Completed Under the 2004 Subbasin Plan

While the 1994 Action Plan offered the Model Watershed Board guidance on needed actions to improve in-stream conditions throughout the basin, EDT offered a framework which began prioritizing restoration actions that incorporated the specific habitat needs of listed fish species at different life history stages that were identified as currently lacking in eight subbasins. Rather than a simple comparison of what had changed from historic conditions at each stream site, the 2004 Subbasin Plan tried to offer the Board a guide to implementing projects that would produce a positive effect on the life stages in which greatest mortality or lowest productivity were concerns—for instance, increasing spawning habitat or creating improved rearing conditions. However, the Subbasin Plan notes that "[t]he previously established 'focus' areas, and corresponding limiting factors, are not substantially different than limiting factors identified by the current EDT analysis" (Nowak 2004); that is, while the plan incorporates a new analysis of fish-fish habitat and population dynamics, the limiting factors and focal areas identified in the 1994 Action Plan are comparable to those guiding restoration work under the 2004 Subbasin Plan. The 2004 Subbasin Plan also offers more ambitious strategies for improving stream channel dynamics, including restoring historic stream channels, and new strategies for improving flow, such as re-establishing beaver populations.

The 2004 Subbasin Plan recommended developing restoration objectives for four parameters: channel conditions, sediment reduction, riparian function, and low flows (Nowak). In addition, the 2004 Subbasin Plan establishes goals for terrestrial restoration and conservation in ponderosa pine forests and woodlands, quaking aspen and curleaf mountain mahogany communities, eastside grasslands, wetlands, mid- to high-elevation conifer forests, and conservation goals for Rocky Mountain elk (Nowak). Along with priority restoration goals, the 2004 Subbasin Plan also identifies appropriate restoration actions to support the recovery of listed fish populations. While goals and strategies are outlined, the 2004 Subbasin Plan does not offer measurable objectives (i.e. stream miles of riparian habitat needing rehabilitation) for these limiting factors.

In addition to guidance on project selection and implementation, the Subbasin Plan also outlined a monitoring and evaluation program to promote better understanding of how fish populations changed as a result of restoration activities and changes in fish population management strategies. The Subbasin Plan recommended that project-level monitoring "reflect the approaches being developed within the comprehensive state, tribal initiatives, and federal pilot projects (Wenatchee, John Day, and Upper Salmon), and the top down framework and considerations being developed by PNAMP [the Pacific Northwest Aquatic Monitoring Partnership]" (Nowak 2004).

Seventy-six projects were implemented under the guidance of the subbasin plan. The total organizational cost during these years was $17,970,971, an average $236,460 per project. The average cost per project increased $152,623 per project. No projects were implemented in the Wenaha, Minam, or Lookingglass watersheds. The Upper Grande Ronde and Catherine Creek watersheds saw the highest number of projects implemented, with the fewest implemented in the Wenaha and Lower Grande Ronde watersheds. Projects addressing hydromodification were the most commonly implemented projects, while projects to improve streamflow were the least commonly implemented. While 85 projects attempted to address stream temperature under the earlier action plan, only 18 projects addressed stream temperature following the adoption of the Subbasin Plan. Streambank erosion, the most commonly addressed factor in projects implemented under the action plan, was dropped as a priority category under the Subbasin Plan, although between 2005 and 2016, fine sediment was addressed by 44 projects.

Projects Addressing Channel Conditions

The 2004 Subbasin Plan establishes a goal for channel conditions: a diversity of channel types and a distribution of habitats "that are as close as possible to the historic distribution of these two variables within the subbasin" (Nowak). The recommended strategies to achieve this goal are "improve[ing] the density, condition and species composition of riparian vegetation through planting, seeding, grazing management and improved forest management practices," "reconstruct[ing] channelized stream reaches to historic or near-historic form and location where appropriate and feasible," "[remov[ing] or relocate[ing] channel confinement structures such as draw-bottom roads and dikes where appropriate and feasible," using forestry best management practices to maintain existing large woody debris inputs to streams; adding large wood, "[r]econnecting] channels with floodplain or historic channels where appropriate and feasible," and "[i]nstall[ing] in-channel structures (LWD, boulders, rock structures) as appropriate to improve habitat complexity in the short term" (Nowak 2004).

The Wallowa River, Minam River, Lookingglass Creek, Catherine Creek, and the Middle Grande Ronde are identified in the plan as lacking adequate habitat diversity. Thirty-eight projects addressed habitat diversity, primarily in the Upper Grande Ronde and Catherine Creek. Projects increased habitat diversity by creating new freshwater habitat, placing rootwads and log structures, increasing channel length, increasing side channels, adding spawning gravel, constructing pools, adding boulders, and removing or modifying dikes.

The Lower Grande Ronde, Wallowa River, and Minam River are identified in the plan as providing deficient habitat for listed fish due to hydromodifications. Fifty-two projects addressed hydromodifications, primarily in the Upper Grande Ronde and Catherine Creek. Projects addressed hydromodifications by creating new habitat, breaching or removing dikes in riparian areas, improving road infrastructure through bridge construction, culvert removal or replacement, installing fish ladders, eliminating barriers to allow upstream passage, increasing channel length, increasing side channels, creating pools, replacing diversion structures, and by constructing rock or boulder structures.

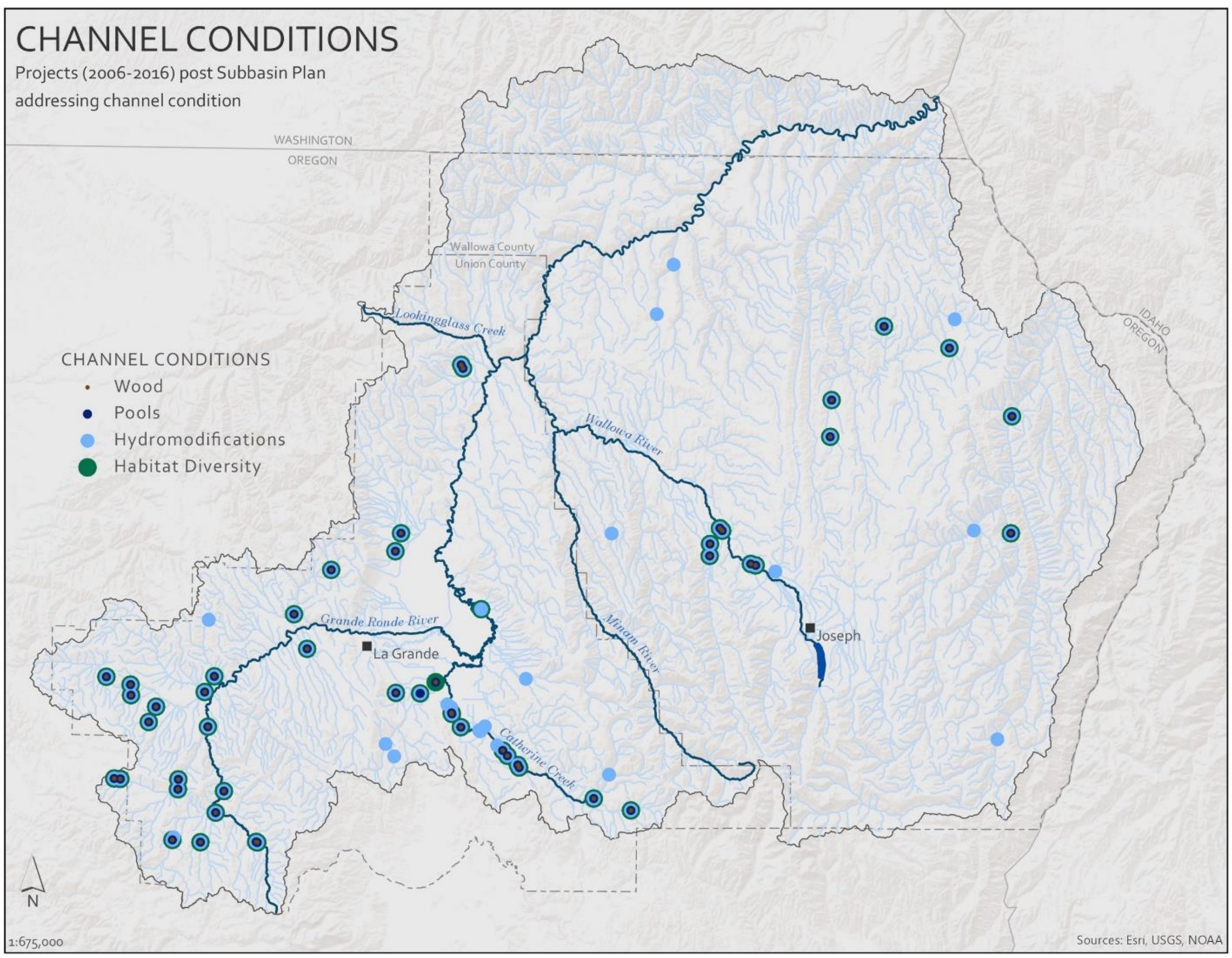
The Wallowa River and Minam River are identified in the plan as deficient in pools. Thirty-seven projects addressed the shortage of pools, primarily in the Upper Grande Ronde and Catherine Creek. Projects addressed the shortage of pools by installing wood structures, log jams, and rootwads, increasing channel length, building pools, and placing rock structures.

The Lower Grande Ronde, Wallowa River, lower Minam River, and Upper Grande Ronde are identified in the plan as deficient in wood. Thirty-six projects addressed the shortage of wood, primarily in the Upper Grande Ronde and Catherine Creek. Projects addressed the shortage of wood in streams using anchored individual log structures, logjam structures (these were installed either for bank stability or for habitat complexity, or for both purposes, depending on the site), rootwad structures, and large woody debris placements.

Watershed	Habitat Diversity	Hydromodifications	Pools	Wood
Wenaha	0	0	0	0

Lower Grande Ronde	0	1	0	0
Joseph Creek	1	2	1	1
Wallowa River	6	8	6	6
Minam River	0	0	0	0
Lookingglass Creek	0	0	0	0
Catherine Creek/Middle Grande Ronde	10	18	10	9
Upper Grande Ronde	21	23	20	20

Table 10 Projects Addressing Channel Conditions, 2006-2016



Map 18 Projects Addressing Channel Complexity, 2006-2016

6 Ranch Project II. Sponsor: GRMW. Funders: BPA, OWEB, USFWS. Completed: 2016. Wallowa Subbasin. Photos by Connar Stone (GRMW)

Projects Addressing Sediment Conditions

The 2004 Subbasin Plan establishes the goal of “a distribution of sediment type and size structure that is appropriate for the channel type, geology and ecoregion, recognizing that the distribution will also vary in time in response to natural disturbance factors” for sediment conditions (Nowak). The 2004 Subbasin Plan recommends “identifying sediment sources;” closing or relocating roads; “[i]mprov[ing] drainage, install culverts, surface,” on remaining roads that contribute sediment; changing grazing strategies, reducing, or eliminating grazing in riparian areas; using off-site water development or herding to reduce grazing impact; planting native riparian species where habitat is limited; “[s]tabiliz[ing] active erosion sites, where appropriate, through integrated use of wood structures (limited use of rock if necessary) and vegetation reestablishment;” restoring natural channels and promoting floodplain interactions;

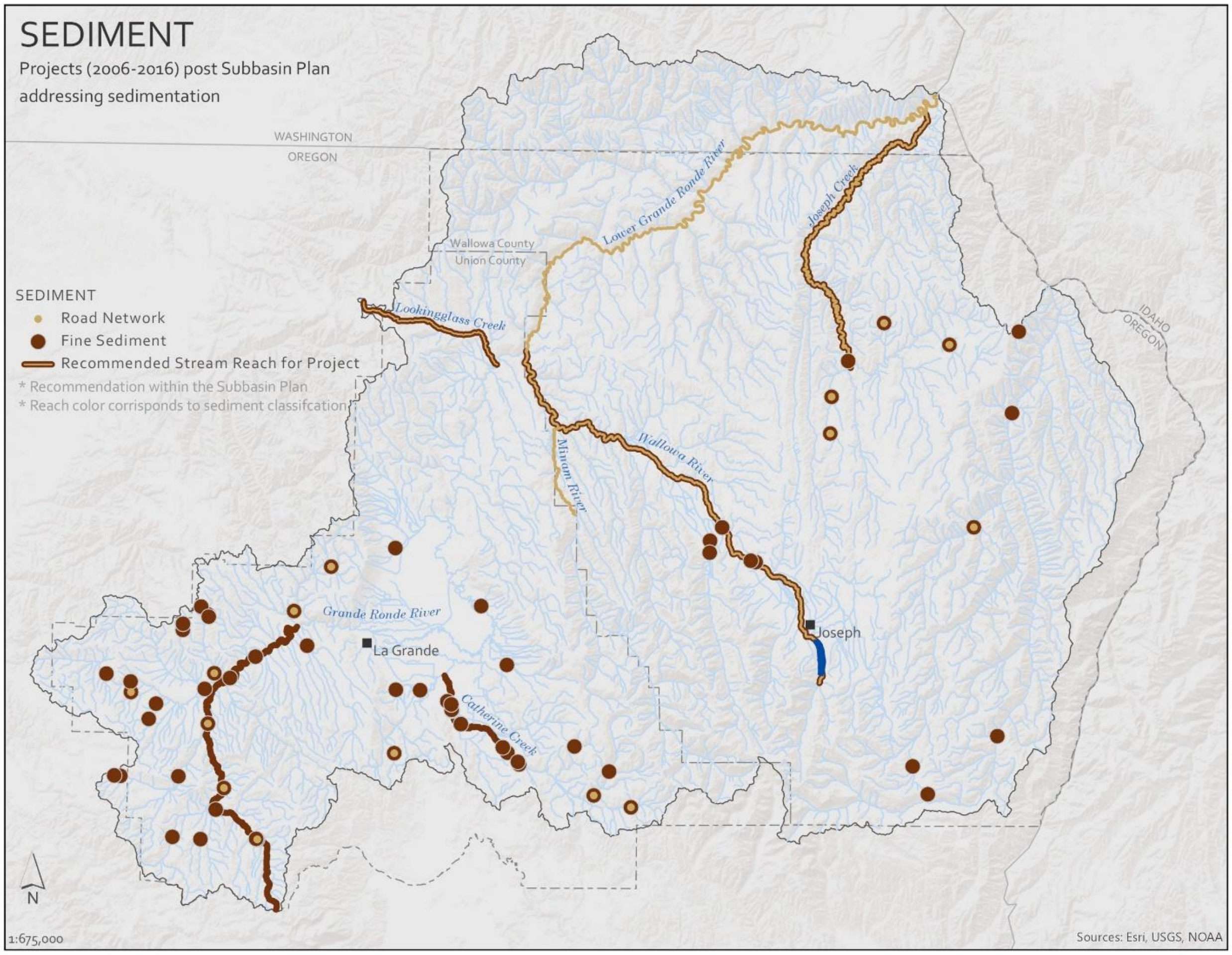
encouraging participation of landowners in conservation incentive programs; promoting agricultural conservation measures such as minimum, integrated noxious weed management, and “construct[ion] of wetlands and filter strips for livestock feedlots and irrigation return flows” (Nowak).

Roads are identified in the plan as a limiting factor in the Lower Grande Ronde, Joseph Creek, the Wallowa River, and the lower Minam River. Eight projects addressed the road network, with projects primarily located in the Upper Grande Ronde and Catherine Creek watersheds. Projects addressed the road network through improving or decommissioning roads, recontouring roads located in riparian areas, relocating roads, and blocking roads in riparian areas. While projects addressing the road network often fell outside the Subbasin Plan recommendations, the high road density across the National Forest lands in the subbasin has been a long-standing concern.

Sediment is identified in the plan as a limiting factor in the Lower Grande Ronde, Joseph Creek, Wallowa River, Lookingglass Creek, Middle Catherine Creek, and Upper Grande Ronde. Forty-four projects addressed sediment, with projects primarily located in the Upper Grande Ronde and Catherine Creek watersheds. Projects addressed sediment through fencing, installing stock watering facilities, stabilizing banks with log structures, rootwads, or boulder structures, improving or decommissioning roads, removing or modifying dikes, seeding, and planting.

Watershed	Roads	Sediment
Wenaha	0	0
Lower Grande Ronde	0	0
Joseph Creek	1	2
Wallowa River	0	6
Minam River	0	0
Lookingglass Creek	0	0
Catherine Creek/Middle Grande Ronde	2	13
Upper Grande Ronde	5	23

Table 11 Projects Addressing Sediment Conditions, 2006-2016



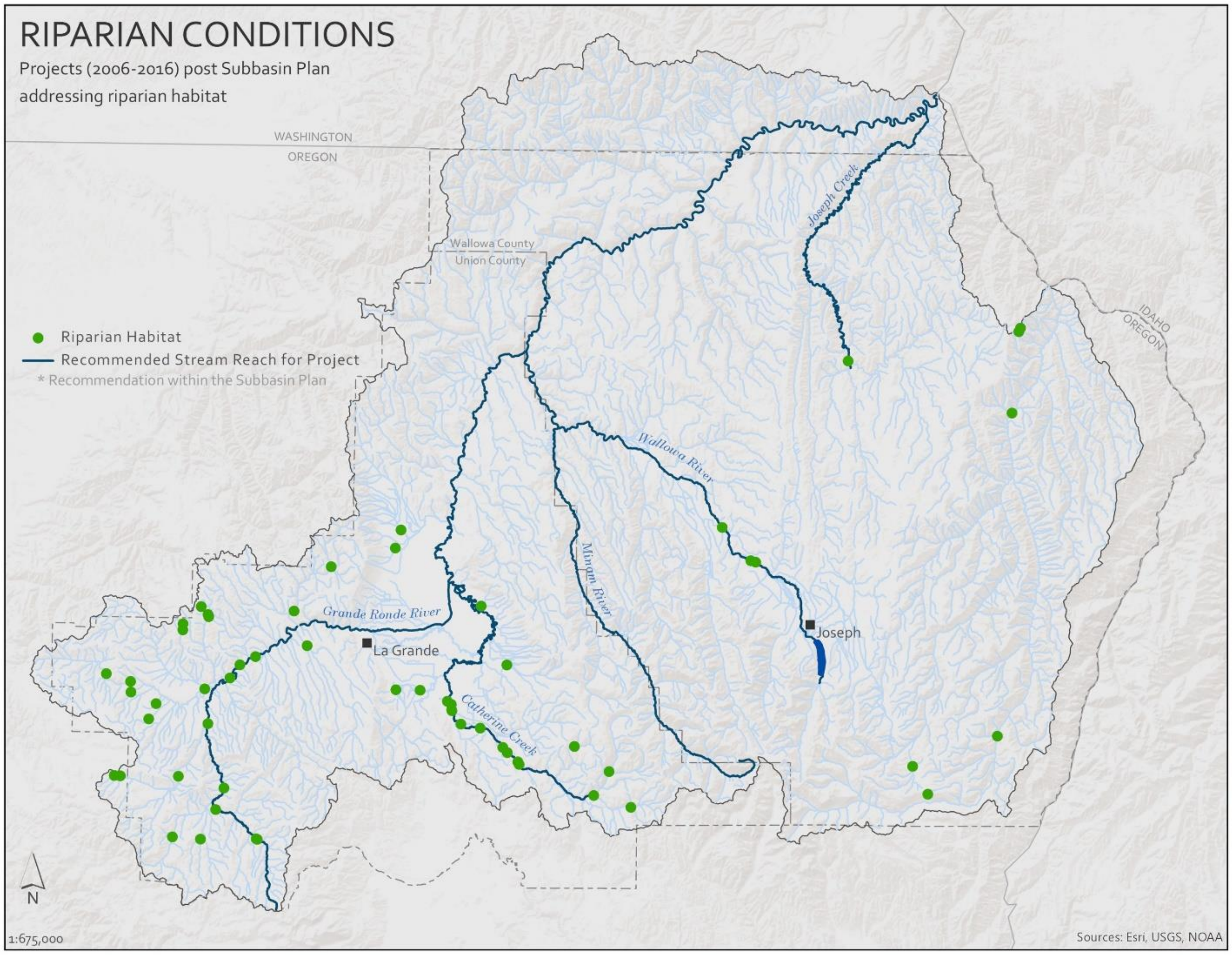
Projects Addressing Riparian Conditions

The 2004 Subbasin Plan establishes the goal of riparian communities that reflect a diversity of species, size, and structure "appropriate for the channel type and ecoregion," noting "that the distribution will also vary in time in response to natural disturbance factors for sediment conditions" (Nowak). In addition to the strategies for riparian habitat listed above, the 2004 Subbasin Plan recommends the relocation of recreation facilities located in riparian areas (Nowak).

Riparian habitat is identified in the plan as a limiting factor in the Lower, Middle, and Upper Grande Ronde, Joseph Creek, the Wallowa River, the Minam River, and Catherine Creek. Forty-three projects addressed riparian habitat, primarily in the Upper Grande Ronde and Catherine Creek watersheds. Projects addressed riparian habitat concerns by creating new freshwater habitat, breaching or removing dikes located in riparian areas, fencing riparian areas, installing alternative stock watering sources, removing, relocating, scarifying, or recontouring roads located in riparian areas, constructing exclosures, extending buffer strips in agricultural areas, and planting and seeding riparian areas. In the Wallowa and Catherine Creek watersheds, projects were more likely to be located on the mainstem, while in the Upper Grande Ronde, projects were located on the mainstem and tributary streams.

Watershed	Riparian Habitat
Wenaha	0
Lower Grande Ronde	0
Joseph Creek	1
Wallowa River	5
Minam River	0
Lookingglass Creek	0
Catherine Creek/Middle Grande Ronde	13
Upper Grande Ronde	24

Table 12 Projects Addressing Riparian Conditions, 2006-2016



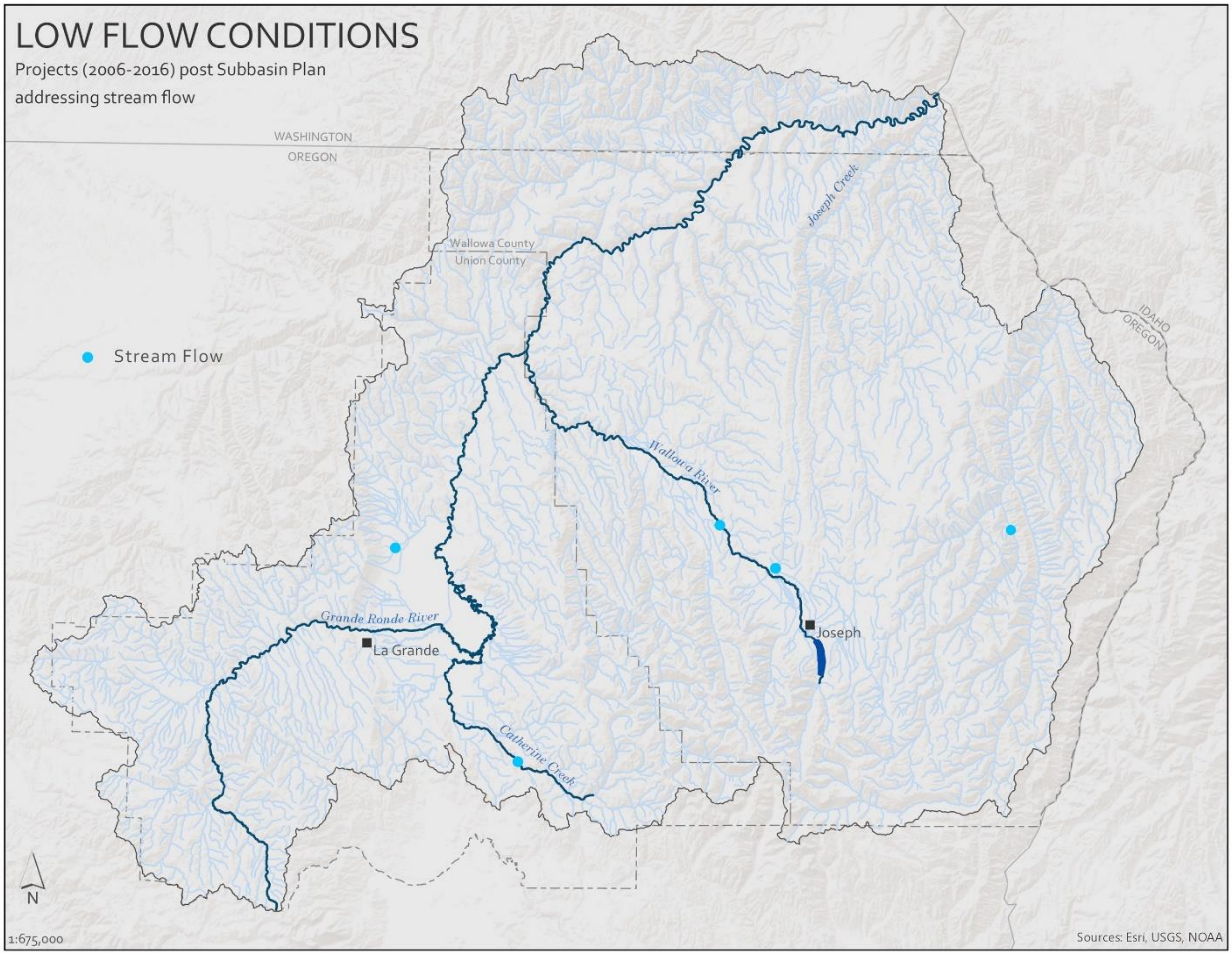
Projects Addressing Low Flow Conditions

The 2004 Subbasin Plan establishes the goal of "enhance[ing] low flow conditions such that they mimic the natural hydrograph to the extent possible, given the limitations posed by agriculturally dependent water use in the region" (Nowak). The 2004 Subbasin Plan recommends identifying stream reaches where agricultural water withdrawals create low flows; improving riparian function to increase storage ability; restoring beaver populations; re-establishing wetlands and wet meadows that existed historically; returning tree density and species diversity to historic conditions to improve hydrologic function; establishing the feasibility of storage facilities to improve late-season flows; reducing irrigation needs through an "integrated program" focused on improving and promoting irrigation efficiency, consolidating points of diversion, and purchasing or leasing water rights for instream use; developing alternatives to water-intensive crops; and reducing withdrawals by limiting appropriation to "valid water rights quantities" (Nowak).

The Wallowa River, Catherine Creek, and the Middle and Upper Grande Ronde are identified in the plan as deficient in flow. Four projects addressed flow, two in the Wallowa watershed, one in the Upper Grande Ronde watershed, and one in the Catherine Creek Watershed. Stream flows were improved by installing metering devices, eliminating withdrawals, and constructing spring-fed channels.

Watershed	Flow	Riparian Habitat
Wenaha	0	0
Lower Grande Ronde	0	0
Joseph Creek	0	1
Wallowa River	2	5
Minam River	0	0
Lookingglass Creek	0	0
Catherine Creek/Middle Grande Ronde	1	13
Upper Grande Ronde	1	24

Table 13 Projects Addressing Low Flow Conditions, 2006-2016



Map 19 Projects Addressing Low Flow Conditions, 2006-2016

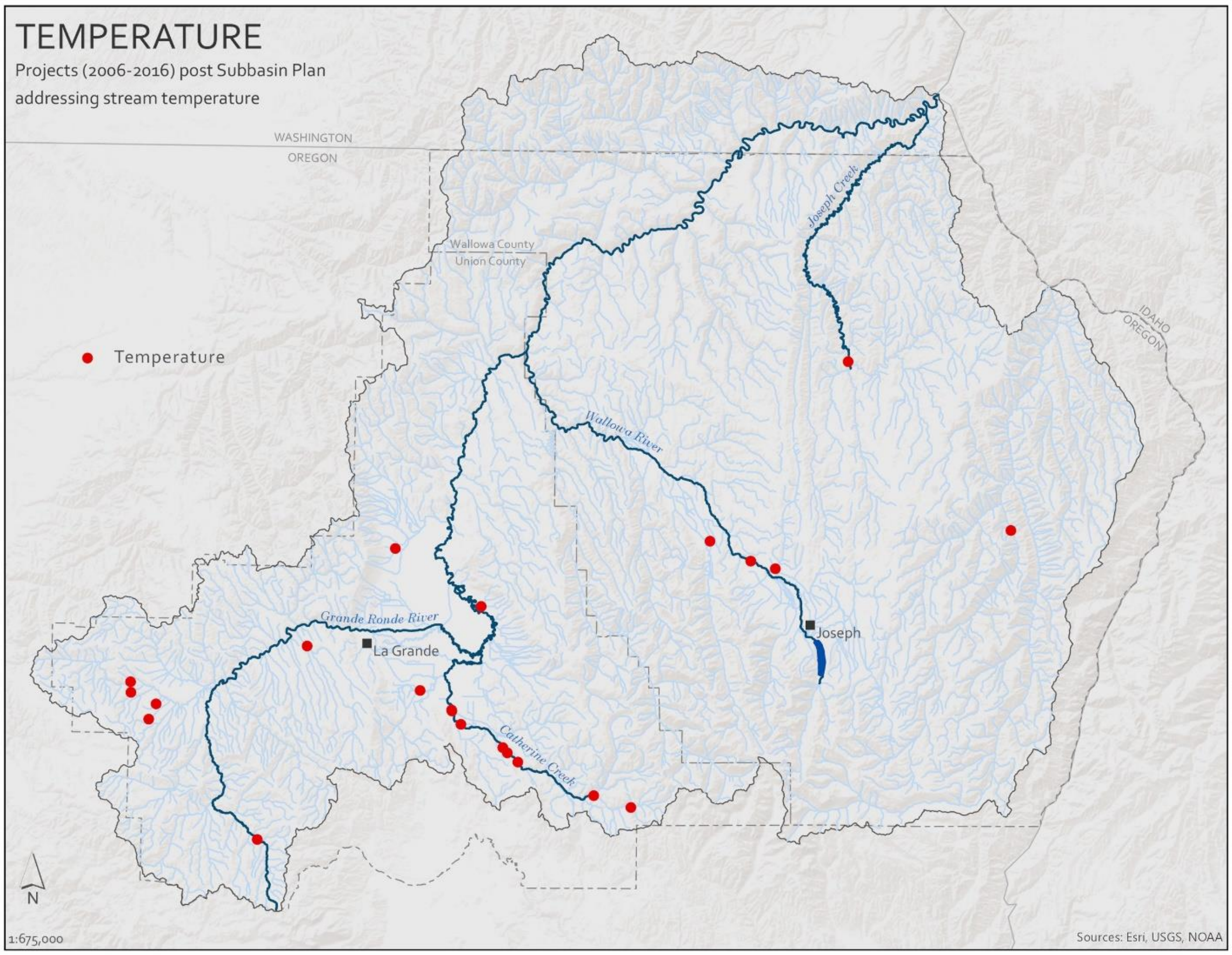
Projects Addressing Temperature

The 2004 Subbasin Plan states that stream temperatures are "largely function of riparian condition and/or low flows;" no specific strategies are given for reducing stream temperatures, rather, projects that address riparian function or low flows are assumed to promote lower stream temperatures (Nowak 2004).

Temperature is identified as a limiting factor on Joseph Creek, the Wallowa River, Middle Catherine Creek, and the Upper Grande Ronde. Eighteen projects addressed stream temperatures, with the majority located on the Upper Grande Ronde and Catherine Creek watersheds. Projects addressed stream temperature by conserving flow, removing or modifying dikes, creating pools, planting, and increasing channel length. In the Catherine Creek watershed, projects were primarily located on the mainstem, while in the Upper Grande Ronde, projects were primarily located on tributary streams.

Watershed	Temperature	Riparian Habitat
Wenaha	0	0
Lower Grande Ronde	0	0
Joseph Creek	1	1
Wallowa River	3	5
Minam River	0	0
Lookingglass Creek	0	0
Catherine Creek/Middle Grande Ronde	7	13
Upper Grande Ronde	7	24

Table 14 Projects Addressing Stream Temperature, 2006-2016

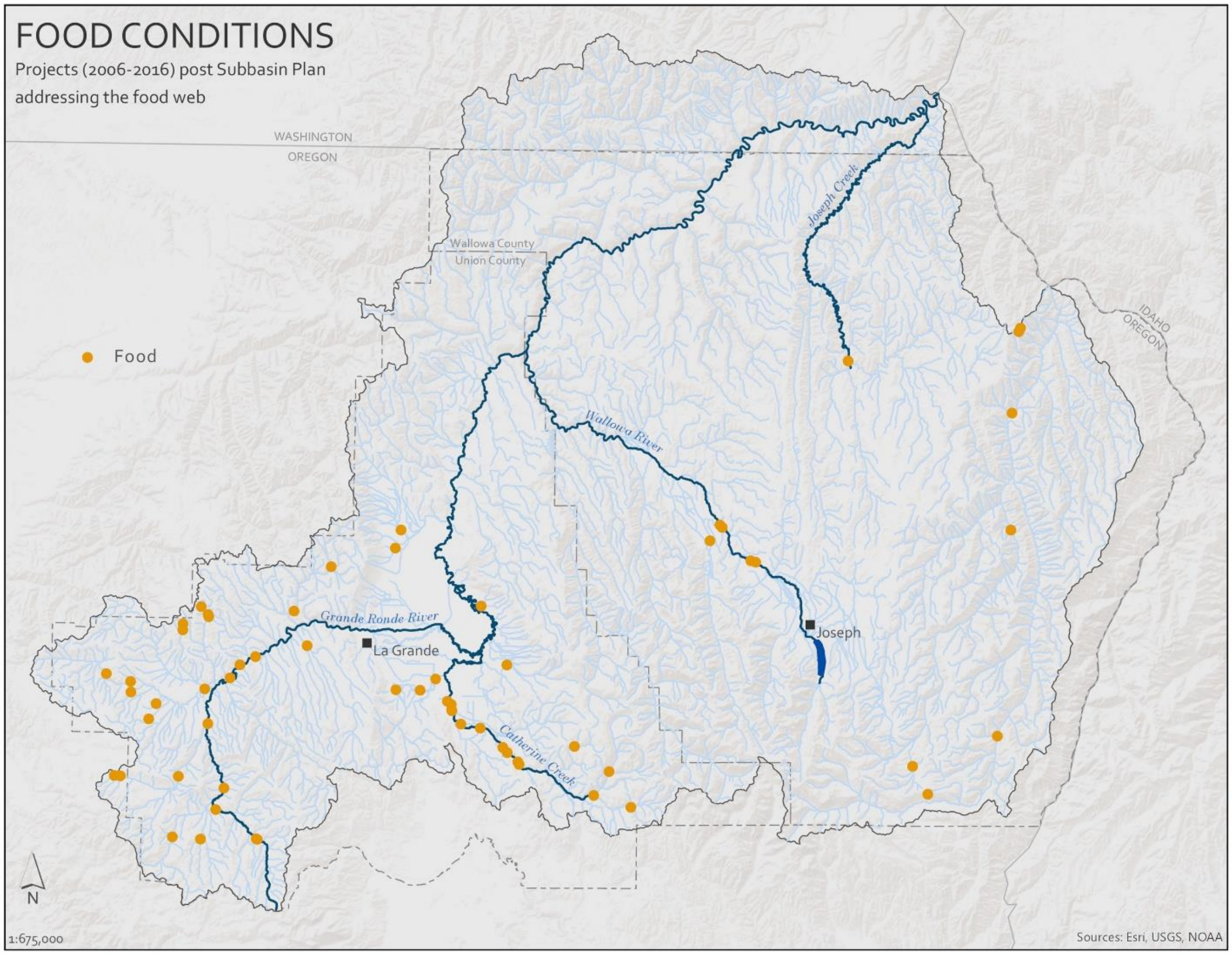


Projects Addressing Food Web Conditions

The Wallowa River, Catherine Creek, and the Middle Grande Ronde are identified in the plan as providing deficient amounts of prey for listed fish. Forty-six projects address the food web, with the bulk of those projects located in the Upper Grande Ronde and Catherine Creek. Projects addressed the food web by installing fencing and exclosures, stabilizing banks with wood structures, logjams or individual logs, increasing stream complexity with wood structures, logjams, or individual logs, adding large woody debris, and planting or seeding. Projects were located on both mainstem and tributary streams.

Watershed	Food Web
Wenaha	0
Lower Grande Ronde	0
Joseph Creek	1
Wallowa River	7
Minam River	0
Lookingglass Creek	0
Catherine Creek/Middle Grande Ronde	14
Upper Grande Ronde	24

Table 15 Projects Addressing the Food Web, 2006-2016



Projects Addressing Other Limiting Factors

Hatchery fish are identified in the 2004 Subbasin Plan as a limiting factor for steelhead in Catherine Creek and the Middle Grande Ronde; management of hatchery fish is the responsibility of Oregon Department of Fish and Wildlife, the Nez Perce, the Confederated Tribes of the Umatilla, and the Lower Snake Compensation Program. Pathogens are identified in the 2004 Subbasin Plan as a limiting factor for steelhead in Catherine Creek; identification and management of fish pathogens is the responsibility of Oregon Department of Fish and Wildlife. Predation is identified in the 2004 Subbasin Plan as a limiting factor for steelhead in the Wallowa River and Catherine Creek and for chinook in the Lower Lostine and Mid-Wallowa Rivers; although Oregon Department of Fish and Wildlife is responsible for managing populations of non-native predators, projects sponsored by the Grande Ronde Model Watershed that increase fish cover may also reduce losses to predation.

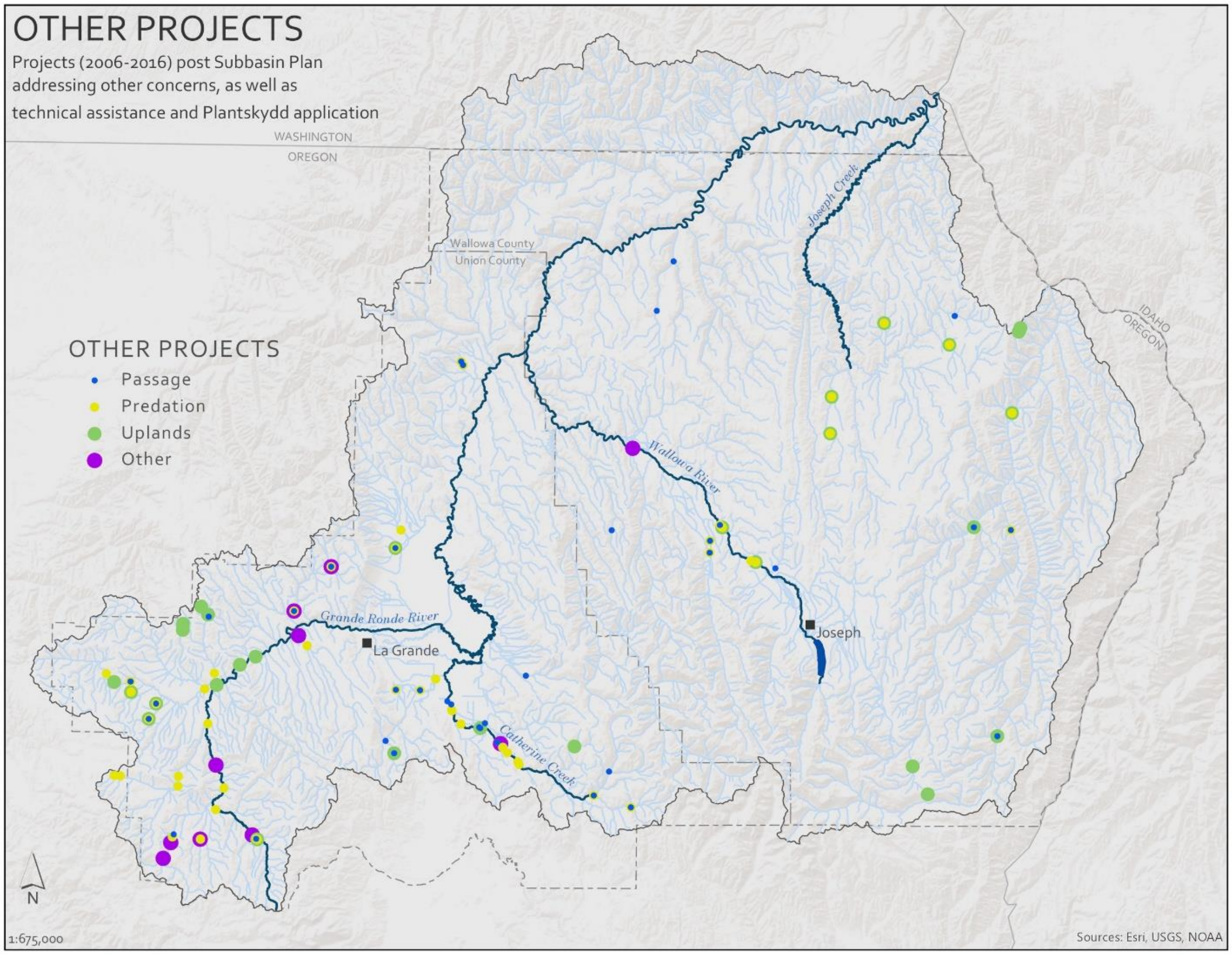
Twenty-seven projects addressed fish passage, with projects primarily located in the Upper Grande Ronde and Catherine Creek watersheds. Fish passage was addressed by removing barriers, constructing fish ladders, installing culverts, and otherwise increasing access to upstream habitat.

Thirty-seven projects addressed predation, with projects primarily located in the Upper Grande Ronde and Catherine Creek watersheds. Predation was addressed by installing individual logs, logjam structures, rootwad structures, and large woody debris, creating pools, and planting to increase cover.

Seventeen projects addressed upland concerns, with projects primarily located in the Upper Grande Ronde and Catherine Creek watersheds. Upland concerns were addressed by creating alternative stock watering devices, fencing, improving or decommissioning roads, treating weeds, redirecting recreation users, and seeding.

Watershed	Passage	Predation	Uplands	Other
Wenaha	0	0	0	
Lower Grande Ronde	1	0	1	
Joseph Creek	1	1	1	
Wallowa River	5	6	5	1
Minam River	0	0	0	
Lookingglass Creek	0	0	0	
Catherine Creek/Middle Grande Ronde	12	10	12	1
Upper Grande Ronde	8	20	8	8

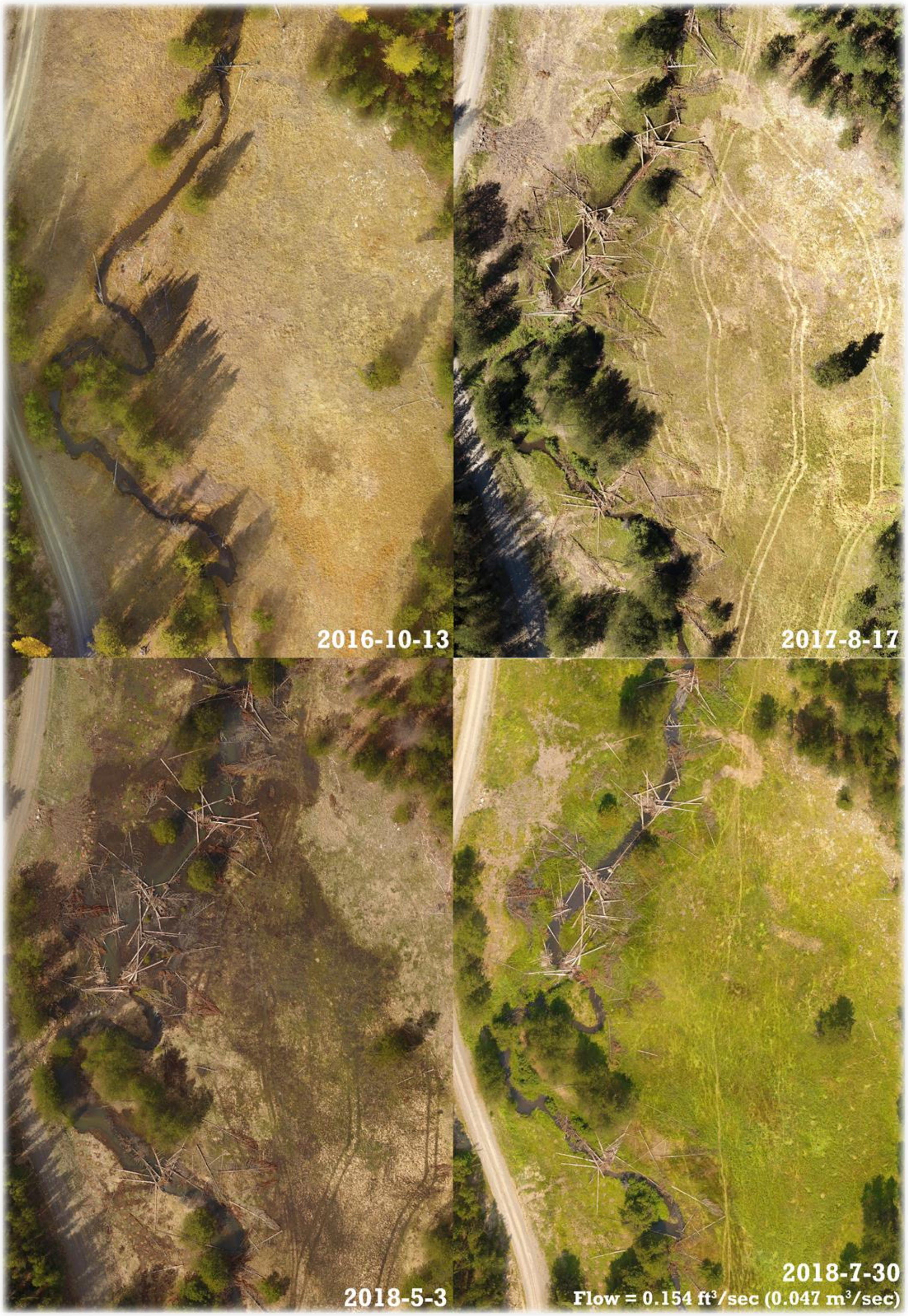
Table 16 Projects Addressing Other Concerns, 2006-2016



Projects Completed under Atlas

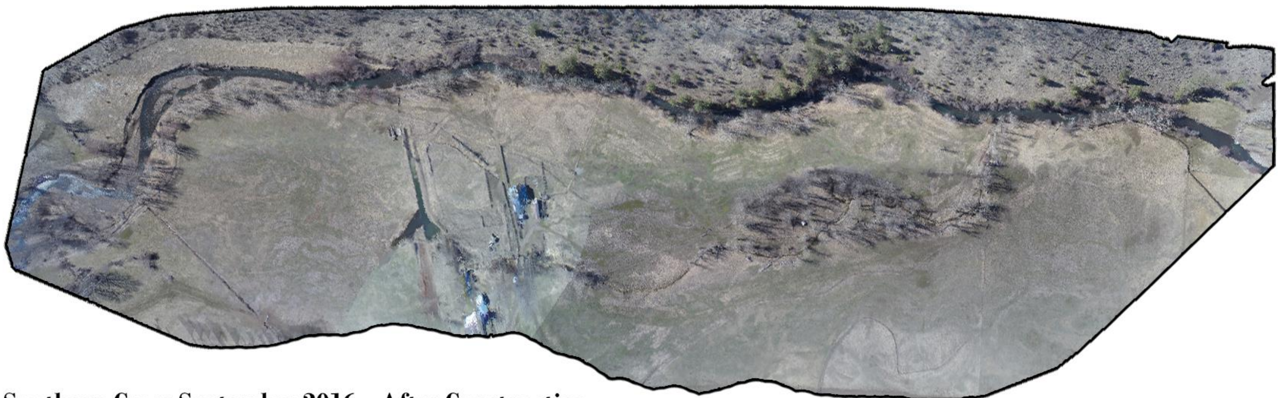
Biologically Significant Reaches

Atlas identifies biologically significant reaches within the Catherine Creek and the Upper Grande Ronde subbasins, with restoration priorities assigned in three tiers. Ten biologically significant reaches were identified in Catherine Creek and twenty in the Upper Grande Ronde. Within the Catherine Creek subbasin, two reaches were identified as Tier I priorities: CCC3a and CCC3bl. Within the Upper Grande Ronde subbasin, three reaches were identified as Tier I priorities: UGR-15, UGR-17, and UGR-19. Atlas identified 73 total project opportunities for Catherine Creek, with 28 projects in Tier I sites. Atlas identified 184 project opportunities in the Upper Grande Ronde, with 25 Tier I sites. Construction of the first of these projects began in 2017.



Limber Jim Creek, Sponsor: USFS, Funders: BPA, USFS, Completed: 2017, Upper Grande Ronde Subbasin, Photo Credit: Connar Stone (GRMW). Limber Jim Creek aerial photographs taken before and after restoration showing wood additions and riparian plantings. Within one year of implementation by the Forest Service the floodplain was wetter throughout the summer months and an increase in late summer green-up was evident.

Southern Cross April 2015 - Before Construction



Southern Cross September 2016 - After Construction

CC 44 Southern Cross. Sponsor: CTUIR. Funders: BPA, CTUIR. Completed: 2016. Photos by Connar Stone (GRMW), Catherine Creek Subbasin. Photos demonstrate the new sinuous and complex channel that replaced the previously channelized section of Catherine Creek as well as the difference in technology gathering strategies to produce high resolution orthomosaics.

CC 44 Southern Cross. Sponsor: CTUIR. Funders: BPA, CTUIR. Completed: 2016. Photos by Connar Stone (GRMW), Catherine Creek Subbasin. Bottom photo shows recently constructed main and side channels during low flows. Upper photo demonstrates floodplain and side channel activation at higher flows.

A tributary to the Upper Grande Ronde and an important steelhead stream, Rock Creek is on private land. Prior to restoration, Rock Creek exhibited high width to depth ratio and was incised throughout most of its length. CTUIR Habitat Program, working with the landowner, improved sinuosity and floodplain connection as well as narrowing the channel. This project was funded primarily by BPA and will be completed in 2019. Photos by Connar Stone (GRMW).

Dry Creek Aiwohi Cisco. Sponsor: USWCD. Funders: BPA, USWCD, OWEB. Completed: 2018. Photos by Aaron Bliesner (USWCD), Willow Creek Subbasin. Top photo shows pre-project conditions; incised channel with actively eroding banks. Bottom photo shows post-project conditions; a new sinuous channel with large woody debris and complex pools. Site will be seeded with native grasses and planted with riparian woody species.

Analysis of Past Restoration Actions

Offering an analysis of the effectiveness of the Grande Ronde Model Watershed's projects is beyond the scope of this analysis. Particularly in the early years of the organization, little or no baseline data may have been collected prior to project implementation. Most project-specific monitoring relied on photo points taken annually as funding allowed or as required by funders. Even compiling metrics to showcase the organization's accomplishments is difficult: over time, the language describing project metrics has evolved as has project implementation.

Yesterday's engineered wood structure might be today's large woody debris placement. Benge's 2016 Master's work included compiling all of the metrics for restoration projects across the subbasin. His compilation includes geographic information for the project sites, which will allow Model Watershed staff working with researchers at CRITFC to identify Model Watershed projects and extract the project metrics. In addition, CRITFC researchers may use the information Benge compiled along with CHaMP data to investigate whether or not habitat modifications can be identified through the monitoring data collected.

While the effectiveness of the Model Watershed's projects remains unexamined, some observations can be drawn from the material currently available. As the organization matured, site selection became more focused, with the Upper Grande Ronde and Catherine Creek watersheds receiving an increasing proportion of projects over time. Following the adoption of the Subbasin Plan, Wallowa County project implementation decreased. Twenty-eight projects were completed under the organization's original Action Plan (between 1994 and 2005), while only 15 projects were implemented in Wallowa County after the Subbasin Plan. A shift has also occurred from primarily site-specific projects to the implementation of projects treating streams at the reach-level. This has coincided with an increase in project spending as project complexity has grown. Over time, project development has evolved. The organization began by addressing limiting factors on an opportunistic basis. This shifted to the development of projects focusing limiting factors in high priority geographic regions and is now entering a new phase focused on addressing the factors limiting fish production and survival in areas within or adjacent to known fish use. Finally, as the organization has matured, project implementation has ceased to be treated in isolation; as the organization moves forward, implementation will dovetail with fisheries research and habitat monitoring at both the project and landscape level.

Implementing Adaptive Management in the Grande Ronde Basin

The Grande Ronde Model Watershed enjoyed a series of rapid successes in completing both projects and watershed plans, with the 1998 ISRP reviewers describing the application for funding for fiscal year 1999 as "a very good watershed council proposal," noting that "The project appears to have a good track record of success, with a technical advisory committee" (ISRP 98-1A). However, the following year ISRP reviewers requested the development of plan that included "implement[ion of] an evaluation procedure for its subbasin-wide impacts," one which included a discussion of “how local priorities match regional priorities” and “develop[ed] a protocol for integrated monitoring and evaluation among the projects” (ISRP 99-2). Calls for the organization to adopt an adaptive management plan continued, with a 2017 ISRP review of all of the watershed management organizations finding a lack of progress toward “program-scale adaptive management and in development and application of a strategic ecological approach for ‘ridgetop to valley bottom’ whole watershed restoration” (ISRP 2017-2). In addition, organizations engaged in restoration are unable to “describe the status and trends of habitat or fish populations at a landscape scale in a way that could be linked to habitat restoration activities” (ISRP 2017-2).

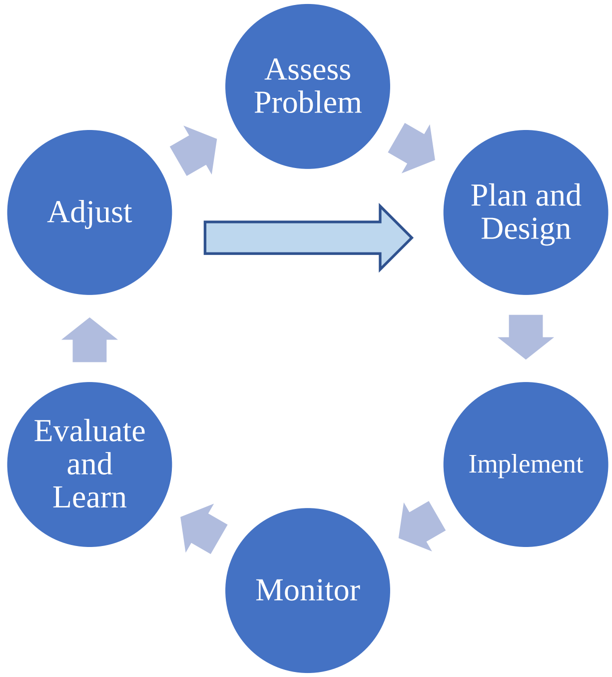
What the ISRP envisioned for the Model Watershed was a data-driven approach to restoration, adjusting dynamically to new information about fish populations and restoration practices through an experimental design. The ISRP identified four factors inhibiting adoption of an adaptive management approach: “quantitative objectives with explicit timelines that are expressed in terms of expected (hypothesized) improvements in habitat (outcomes) or Viable Salmonid Population (VSP) parameters,” “appropriate monitoring, access to monitoring data, and an explicit plan for evaluating and documenting outcomes,” “an additional technical capacity beyond what currently exists for some umbrella projects,” and improved documentation of outcomes, such as reporting that “identif[ies] lessons learned, and share[s] knowledge via public engagements, targeted workshops, and peer-reviewed publications” (ISRP 2017-2).

An additional challenge, not mentioned by the ISRP, may be the fundamental shift in the identity of the organization that the adaptive management program requires: from a social experiment to an ecological one. As the Model Watershed has grown as an organization, it has demonstrated its ability to engage partners and the community in constructive planning toward shared watershed goals. Over time, the number of projects completed annually has decreased while the scale and complexity has dramatically increased, and the role of the organization has evolved to focus on collaborative project coordination rather than implementation. With the growing sophistication of the organization’s projects and the positive response from community and partners, the opportunities for restoration continue; however, the necessity for accountability, the desire to achieve landscape-level change, and the need to understand the level of response from fish populations has grown correspondingly. The development of Atlas formed the catalyst for the adoption of a clearly articulated adaptive management plan: data-driven objectives, strong monitoring plans, and a diverse technical capacity are united within a social framework that encourages the sharing of lessons learned and the incorporation of new information.

A 1997 report from the ISRP underscores the importance of adaptive management:

> The adaptive management approach . . . offers the region a means to integrate new knowledge and experimentation into the applied effort of salmon recovery and maintenance of the Columbia River ecosystem. There is a fine balance to be struck in drafting a plan that has sufficient flexibility to accommodate a realistic need for ongoing fine tuning, but which still is concrete and specific enough to provide meaningful guidance. Designing efficient management experiments, and conducting the monitoring to obtain timely and conclusive results from the experiments, will be crucial to the success of this adaptive approach. [From ISRP 97-1 Report of the Independent Scientific Review Panel for the Northwest Power Planning Council.]

The TAC built Atlas using the data available for fish populations, fish use, and known limiting factors across the basin. The BSRs stratify the basin geographically into high, medium, and low tiers for restoration priority. The restoration actions link current assumptions about restoration to specific actions, for instance, the belief that building healthy, diverse riparian communities in currently degraded areas will promote the expansion of fish populations into new habitat. While Atlas offers a data-driven approach that prioritizes restoration through explicit hypotheses about the watershed—the concrete and specific guidance, it also creates an iterative social process for drawing and sharing conclusions and for integrating new information—the flexibility and ability to accommodate fine-tuning.

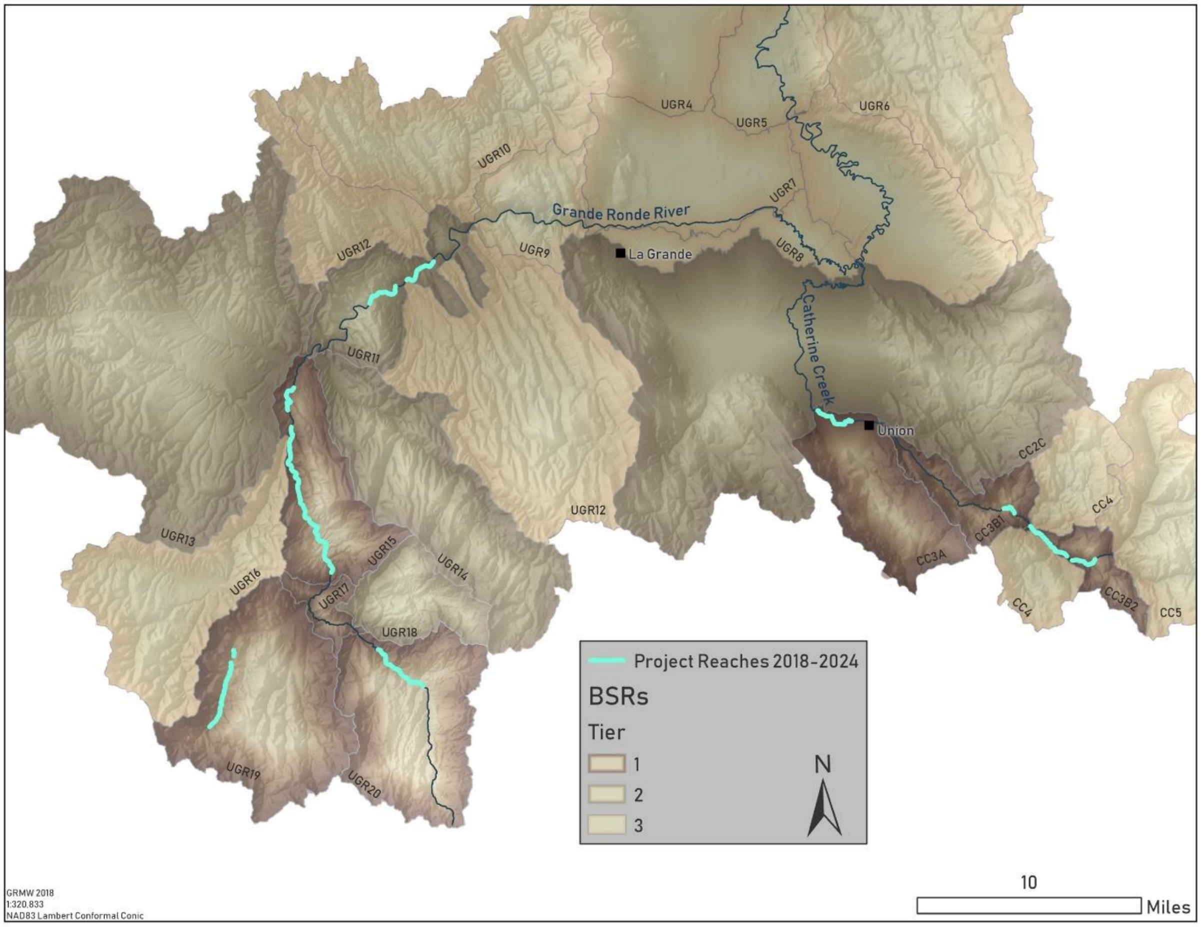


After reviewing different models of adaptive management, the Model Watershed staff developed a cycle drawn from both Williams 2008 and Bouwes, Bennett, and Wheaton 2016. Williams describes the relationship between scientists and managers as complementary: "bi-directional support with an overall goal of reducing uncertainty and improving management" as the defining feature of adaptive management (2008). Williams identifies six conditions that warrant the use of adaptive management: "a problem important enough that management actions must be taken," the ability to identify "clear and measurable objectives," adequate flexibility in management "to allow adaptations as understanding accumulates through time," the "potential to improve management performance by reducing uncertainty," the availability of monitoring to diminish uncertainties, and "a sustained commitment by stakeholders and managers" (2008). Williams stresses the importance of stakeholder involvement, from the development of objectives and management alternatives through the collection and analysis of monitoring data (2008). Each of these conditions exists in the basin: declining populations of anadromous fish and bull trout requiring sustained management, objectives drawn from recovery documents and current research within the region, a range of management options to choose from in restoring stream habitats, a desire within the restoration community to determine the most effective options to improve the performance of restoration actions, the potential for strong monitoring programs for habitat and fish populations, and an enthusiastic stakeholder group connected to the broader community by the Model Watershed Board.

Planning and Design

From its inception, the Model Watershed Board sought a clear articulation of the factors limiting fish populations within the basin. A series of watershed assessments have guided restoration work within the basin. Atlas drew on these documents and data from the research community to assess the problem: continuing declines in target fish populations despite decades of stream restoration. As the TAC reviewed existing fish and habitat data, a list of assumptions about where to work (BSRs) and what work to accomplish (restoration actions) formed. Over the next twenty years, the goal of the organization is to complete all of the opportunities identified for Tier I BSRs in Atlas. This would restore 55.4 miles of stream habitat in the Upper Grande Ronde watershed and 12.3 miles in the Catherine Creek watershed. NOAA and ODFW researchers are currently evaluating the uplift expected from these restoration actions.

As these goals are addressed at the project level, quantitative objectives linked to monitoring metrics will be included in the Stepwise process. These objectives will help ensure that the effectiveness of new restoration actions can be measured following restoration and that expected outcomes for habitat can be calculated. The combined data will allow sponsors access to previous habitat data, previous restoration work at the site, and Atlas objectives. As the project moves to implementation and monitoring, the database (currently in production) will capture corrective actions or project changes taken by the project sponsor, creating a record of lessons learned to analyze at the annual State of the Science meeting and to apply to future projects.



Map 20 Planned Restoration in the Grande Ronde Basin 2018-2024

Implementation and Monitoring

As project implementation continues, the Model Watershed will take the lead in coordinating habitat monitoring throughout the basin. In the past, the Model Watershed was able to rely on a robust habitat monitoring program implemented by its partners, CHaMP. With the elimination of CHaMP following the 2016 field season, access to monitoring data is in jeopardy. The Model Watershed now requires the submission of measurable monitoring objectives as part of the Stepwise project solicitation process; these objectives will guide pre- and post-implementation monitoring at the project level, with the assumption that these data will also contribute to the understanding of landscape-level effectiveness. The Model Watershed will also work with ODFW to ensure that Aquatic Inventory surveys rotate throughout the subbasin to capture habitat change over time. The anticipated monitoring database will employ internal links back to Stepwise, the Project Database and to Atlas, so that all information related to a project, from pre-restoration data to project results, can be used to estimate the uplift expected from restoration work. Existing survey, monitoring reports, or links that draw conclusions from individual efforts can be attached to a specific project as well.

Sheep Creek. Sponsor: USFS. Funders: BPA, USFS. Completed: 2016. Upper Grande Ronde Sub Basin. Photo Credit: Connar Stone (GRMW). Sheep Creek was poorly aligned to the entrance of an undersized culvert beneath National Forest Road 5160 (before – bottom image 2016-7-14). The culvert was replaced with a precast concrete bridge that can withstand highs flows, relieving impacts to the banks and additional scour (after – top image 2018-5-3). An earlier large wood project (to the left in photos), upstream of the culvert replacement project was successful in creating some hydraulic interaction with LWD, but did not result in better floodplain connectivity. Review of the project by Atlas partners concluded that the wood was oversized and placed so that interaction with flow was not as effective as it could have been. An additional project, slated for implementation beginning in 2019, is designed to cause inundation of the floodplain, increase lateral bank storage of water, and aggrade the channel bottom.

Evaluation and Adjustment

At the organizational and landscape level, the adaptive management cycle will undergo an annual audit for evaluation and learning at the Model Watershed's State of the Science meeting. The Model Watershed staff, Atlas partners, and TAC develop the meeting agenda, which includes a review of restoration projects completed during the previous year, a review of conceptual projects pursued during the previous year, a summary of what has been learned through project implementation and monitoring, and the incorporation of new research that can inform project development, prioritization, or implementation. The agenda also leaves room for a discussion between the IT and TAC regarding an update of Atlas scoring matrices based on new data or other research. Beginning in 2019, an Adaptive Management Subbgroup will meet at the end of the State of the Science meeting to review work at the landscape level (how well the organization is addressing known limiting factors and how emerging science should be incorporated) and at the project level (what lessons learned over the past year should be incorporated into new projects and how well emergent science is being incorporated). This creates a self-critical process, extending from the site level, to the BSR level, to the stream, and to the landscape. An Extended State of the Science meeting is planned every five years to analyze the outcomes of the previous five years of project implementation within the context of the most recent data and science. At this time, the IT and TAC will determine whether or not Atlas requires an update to identify and score new restoration opportunities or the scoring matrices. Active participation by the Independent Scientific Review Panel at the extended meetings could challenge both the Model Watershed and the research community to ever-higher levels of achievement.

Integrating New Research into the Adaptive Management Plan: 2018 State of the Science

The 2018 State of the Science meeting began with a summary of projects completed in 2017 and projects slated for implementation in 2018 and 2019. Researchers presented on topics including food web investigations, life cycle modeling, factors limiting survival of overwintering Chinook and spring emigrating Chinook, and hydrologic modelling of the Grande Ronde Valley. As a result of the presentations and associated discussions, two work groups formed: the first to follow up on potential updates to Atlas as a result of new information on fish populations in the Grande Ronde Valley and the second to continue development of the Model Watershed's adaptive management plan using Atlas objectives and life cycle modeling.

An Oregon State University graduate student, Matt Kaylor, presented research on the release of marine nutrients into the Upper Grande Ronde watershed. As anadromous fish populations have declined, a correlating decrease in marine-derived nutrients reaching the basin is also assumed to have occurred. In 2016, an OSU team found low levels of nitrate and phosphate across the Upper Grande Ronde above the town of Perry. Based on this finding, Kaylor felt that a carcass addition study could help determine if additional nutrients might lead to an increase in juvenile fish size and a corresponding increase in survival. In August of 2017, steelhead carcasses were added at three locations paired with three upstream controls; the three sites were selected to span a range of stream temperatures and fish assemblages. Fish growth rates, fish diet, biofilm chlorophyll a, stable isotopes, and benthic invertebrates were measured to determine if carcasses increased growth and, if so, through what pathway. A "bottom-up" pathway, the release of nutrients into the stream environment, did reveal itself in one pair by the increase in biofilm, but the primary pathway appeared to be direct consumption—a 24 percent increase in fish length through the direct consumption of eggs and tissue. Research will continue at four sets of control and treatment sites in 2018; however, the preliminary findings suggest that restoring rearing habitat may also require direct manipulation of food web elements to improve fish fitness.

NOAA researchers Tom Cooney and Rishi Sharma presented on the chinook lifecycle model developed by the NOAA team that employs a family of matrix models to explore more than twenty years of data on fish populations. The model combines spawner to smolt migrant dynamics, tributary habitat conditions, in-basin hatchery effects, ocean survival scenarios, hydropower corridor survivals, climate scenarios, mainstem harvest, and marine predation to explore where management actions could create an uplift in the Grande Ronde and Catherine Creek populations. Cooney and Sharma have now standardized rearing estimates across the populations using Aquatic Inventory Survey parameters for rearing habitat. The longer fish remain in the basin before emigrating, the less likely they are able to survive long enough to be counted at the Lower Granite Dam. While spring outmigrants exhibit no significant relationship to density, those that overwinter before emigrating show lower rates of survival. Survival amongst these fish increases as a function of length, which indicates that length can be used as a surrogate for survival. Increasing populations requires two tracks: increasing the carrying capacity by increasing pool density while simultaneously increasing productivity by expanding spawning habitat. By calculating the post-implementation pool equivalent area of a restoration site, the life cycle model can estimate a derived response in fish returns. In the future, as new data identifies a new limiting factor, the life cycle model can be used to calculate a new derived fish response.

Cooney and Sharma stressed that when viewed within the context of climate change, the need to restore chinook spawning habitat becomes even more acute. The model indicates the need to increase spawning habitat at the same time that a changing climate further reduces the habitat suitable for spawning. In the Upper Grande Ronde, 95 percent of spawning habitat is located upstream of Fly Creek, leaving redds between Sheep Creek and Fly Creek vulnerable to climate change unless the implemented projects mitigate predicted increases in stream temperature. Most parr rear upstream of Vey Meadows. Summer temperatures and summer parr capacity act as the primary bottlenecks for survival: increasing the number of pools adequate for rearing will improve fish survival rates. Climate models for Catherine Creek show higher temperatures moving upstream less quickly; downstream projects on Catherine Creek have more potential for improving fish survival. Life cycle modelling combined with climate change predictions will help Atlas partners determine where to place projects, how to tailor projects to mitigate life cycle bottlenecks, and how to estimate increases in survival as a result of completed projects.

ODFW researcher Scott Favrot presented on his work investigating juvenile survival in the basin, which he conducted with Brian Jonasson, recently retired from ODFW. The initial research question guiding the investigation was a desire to know where Catherine Creek Chinook overwinter; the research expanded to include the Upper Grande Ronde. Overwintering Chinook from both streams show lower rates of survival than populations from the Lostine and Minam Rivers. Using radio tags, crews were able to identify the specific reaches used by overwintering fish. In the fall, fish moved quickly as they sought lower stream reaches. Deep water with low velocity offers the best overwintering habitat but may not be available. Fish sought the lowest velocity available, in areas where wood and boulders provided cover. Fish stayed close to cover, typically located near banks. Using kernel density estimation to explore the data, areas of use were similar between fall and winter and were associated with beaver dams located on the mainstem of the river.

Not all Chinook overwinter in their natal streams. Of those that emigrate in spring, the fish that pass Lower Granite Dam exhibit high rates of return—an outmigrant that survives as far as the dam is highly likely to complete its lifecycle and return. Smolts experience a high rate of mortality within the Grande Ronde Valley. Favrot's team wanted to identify where in the valley spring emigrants are being lost. Radio tagging revealed not just where fish mortality occurred, but when. Chinook experienced high mortality throughout Catherine Creek—no single reach could be addressed to improve survival. Data from Upper Grande did not replicate Catherine Creek mortality patterns: instead, as rates of migration slow, mortality increases. Favrot hypothesizes that fish are responding to novel water signals. As fish enter the valley, their rate of migration speeds up as they experience each introduction of water from tributaries. Larger fish are fit enough to respond to these cues and emigrate, but many loiter in the valley in order to obtain smolting size. This loitering behavior puts pre-smolt emigrants at high risk for mortality, as passing rapidly through the valley to Lower Granite Dam seems to be key for survival. Favrot believes the key to reducing mortality in the valley reaches will be to synchronize the environmental and physiological cues. For managers, projects that increase fitness before smolting, such as creating juvenile rearing nurseries below and just downstream of natal areas and restoring missing food web components such as adult carcasses may reduce the loitering of fish in the valley.

Improving survival odds for fish that loiter in the valley may require more drastic intervention, including the re-examination of Atlas priorities. Currently, the State Ditch re-routes the Grande Ronde River so that it joins Catherine Creek near Alicel Lane. At the confluence, water flows upstream at Catherine Creek during Grande Ronde River peak flows. Restoring the historic confluence of Catherine Creek and the Grande Ronde would almost eliminate the surge of backwater emigrating fish must fight before leaving the valley and may provide the novel water signal needed to keep smolts moving downstream. Creating floodplain nurseries within the upper portions of the Grande Ronde Valley may allow smaller fish to reach smolting size. Currently the valley portions of the Grande Ronde and Catherine Creek are low priorities due to the combination of "distance from current production areas and their highly degraded habitat" (Tetra Tech 2017). The TAC left open possibility for work in these areas through "Ecological Nodes," which they defined as a

> smaller geographic area within a lower ranked (Tier 2 or Tier 3) biologically significant reach (BSR) that may have significant fish use based on close proximity to known spawning habitat, refuge habitat (thermal refugia, hiding cover, or available floodplain), or important tributary junctions. Restoration work in these areas may not provide immediate benefits for focal fish species, but may provide an opportunity for experimental techniques that may provide refuge habitat until root causes of low fish survival are determined. [Tetra Tech 2017.]

Favrot's data on mortality may suggest that researchers have enough evidence on fish mortality to reposition the valley's ranking within the BSR priorities.

Mike Knutson, an engineer with BoR, elaborated on the hydrologic problems created by the State Ditch. Compared to historical conditions, Catherine Creek experiences more frequent, higher duration, and more expansive backwatering. The lower 10 miles of the creek experience the greatest effect. When simulating historic conditions, when Catherine Creek reached its confluence with the Grande Ronde near the city of Cove, modeling showed fewer backwatering events and a shorter duration for each event. Knutson identified two management implications: due to irrigation dam management and levees, Grande Ronde water exits the valley more quickly than historically and offers poor habitat, while Catherine Creek operates as a slackwater reservoir with low water velocity and limited floodplain habitat available.

Following these presentations, Tim Bailey, District Fish Biologist with ODFW, led a discussion on the historic confluence of the Grande Ronde and Catherine Creek. Participants explored concerns about the potential of restoring the confluence: Is enough known about mortality in the valley to justify seeking community support for such a project? Would returning the Grande Ronde to its historic channel offer benefits to landowners experiencing declining well levels? Would work in the valley take place at the expense of more immediate needs in the headwaters, given limited budgets? If one must be prioritized, which offers the greatest return on investment in fish populations? Based on the life cycle model, Cooney stressed the need to continue work that increased spawning and rearing habitat adjacent to current areas of productivity. The discussion ended with an agreement to form a subgroup of the TAC to explore the implications of Favrot's research and Knutson's hydrologic modeling.

Vision for the Future: Research and Restoration

Climate Change Resilience

In a recently published article, Dan Isaak and his coauthors examined the effects of estimated stream temperature warming on distribution of sockeye salmon and brown and rainbow trout. Using historic stream and air temperature records for the northwest and estimated future trends, they found that an increase of 1.0°C in stream temperatures (expected to occur by midcentury), would lead to an 8 percent decrease in the total length of stream habitat able to support the modeled species (Isaak et al. 2018). When more drastic predictions of warming were modeled, they found a decrease of 18-31 percent, noting that "rivers with optimal temperatures where trout densities are likely to be highest decreased more rapidly—by 16% for a 1.0°C increase, by 33% for a 2.0°C increase, and by 50% for a 3.0°C increase" (Isaak et al. 2018). In addition, while they noted "relatively small decreases in thermally suitable habitat were predicted for Washington's rivers," Oregon and northern California would experience the largest decreases in thermally suitable habitat" (Isaak et al. 2018). Casey Justice and a team of biologists working for the Columbia River Inter-Tribal Fish Commission found a similarly bleak outlook for native fish when modeling the effects of climate change in the Grande Ronde: median increases of 2.7 °C and 1.5 °C in the Upper Grande Ronde and Catherine Creek, respectively (Justice et al. 2017).

Current stream temperatures further problematize fisheries conservation in the context of climate change projections. In the Lower Grande Ronde, all streams, a total of 533.6 miles, have been 303(d) listed for temperature (ODEQ 2010). In the Upper Grande Ronde, thirty-eight stream segments were included on Oregon's 1998 303(d) list, with 92% of the stream network exceeding 64°F (ODEQ 2000). The TMDL prepared in 2000 noted that temperatures change rapidly in the upper 30 miles of the river, with summer temperatures on the mainstem below Meadow Creek to the Wallowa River confluence at Rondowa exceeding 75°F (ODEQ 2000). FLIR temperature profiles revealed "[a]lmost no cold-water 'refugia' areas" for either Grande Ronde River and Catherine Creek after stream temperatures warmed: "[o]nce the mainstem has heated to mid-70°F in the Grande Ronde River, it remains at a relatively warm temperature throughout the remaining 80 river miles to the Wallowa River confluence" (ODEQ 2000). Only the headwater reaches, 4.9 percent of the Upper Grande Ronde and 29 percent of Catherine Creek had summer water temperatures below 64°F (ODEQ 2000).

Along with rising stream temperatures, climate change projections raise concerns about changes in stream flows. Isaak et al., citing work by Ashfaq et al. 2016 and Rupp et al. 2017, note that higher-resolution models reveal "increases in rain-shadow areas and smaller future precipitation increases and sometimes decreases in mountainous areas" (2018). Citing work by Hamlet and Lettenmaier (1999), Isaak et al. add this "is especially true in river basins with the greatest snowpack contributions where trends toward earlier melt and runoff are very likely to continue reducing summer flows" (2018). Under these climate change scenarios, flows in the Grande Ronde basin are likely to be lower, with higher stream temperatures.

Isaak et al. identify 2015 as a possible typical year in the future; in 2015, Columbia River temperatures exceeded 21°C in June and remained elevated levels 2–4°C above monthly averages for 3–4 consecutive weeks, with mass mortality occurring upstream of Bonneville Dam (2018). The range of suitable habitat will contract, with isolated pockets of resident trout taking advantage of coldwater refugia (Isaak et al. 2018). With higher stream temperatures, the expansion of warm water predators, combined with difficulties in growth and disease resistance, will reduce the survival of trout species (Isaak et al. 2018, citing Lawrence et al. 2014; Rubenson and Olden 2017; Hari et al. 2006; Ayllon et al. 2013). Isaak et al. predict salmon species to follow a similar shift in habitat as they seek cooler waters during alevin and parr stages, but note that "annual migrations provide additional complexities" (2018). Returning adults may shift the timing of migration, potentially spending less time in the ocean, exhibiting lower energy reserves and completing the migration less often (Isaak et al., 2018, citing Crozier et al. 2011 and Cooke et al. 2004).

Isaak et al. (2018) offer the following suggestions for management:

> Restoration efforts to cool rivers might include minimization of flow diversions (Elmore et al. 2015), increasing shade provided by riparian vegetation (Cristea and Burges 2010; Johnson and Wilby 2015), reconnecting rivers to floodplains to enhance habitat diversity (Beechie etal. 2013), and increasing channel roughness to encourage more water exchange between the channel and cooler hyporheic flows (Arrigoni et al. 2008; Nichols and Ketcheson 2013). More aggressive measures have also been discussed, such as excavating deep pools adjacent to warm rivers to access cool groundwater or the construction of wingwalls upstream of cold tributary inflows to limit mixing and create microrefugia (Kurylyk et al. 2015).

Restoration modeling within the context of climate change completed by Justice et al. (2017) indicates that riparian restoration could reduce "the percentage of the stream network with peak summer water temperatures above 16 °C from 93% to 73% in the U[pper] G[rande] R[onde] B[asin], and from 70% to 48% in the C[atherine] C[reek] B[asin]." The team predicts that riparian restoration combined with reductions in the wetted width would lower median water temperatures in the Upper Grande Ronde Basin by 6.5 °C and 3.0 °C in Catherine Creek (Justice et al. 2017). The combined restoration effort would produce a predicted increase in fish abundance of 590 percent in the Upper Grande Ronde Basin and percent in Catherine Creek (Justice et al. 2017). The authors point out that their work assumes that the full length of the stream network could be restored, and that the benefits of riparian restoration will occur immediately; however, their modeling does indicate long-term benefits with substantial increases in fish abundance, leading them to "emphasize the urgent need for a targeted and aggressive restoration strategy which includes riparian restoration as a key component" (Justice et al. 2017).

While work by Isaak et al. and many others indicate the dire conditions facing fish as a result of climate change, the work by Justice and the Columbia River Intertribal Fish Commission biologists (TAC members) indicate that an aggressive approach to restoration can help mitigate the effects of climate change and conserve the basin's fisheries. As members of the TAC, their work helped guide the development of Atlas restoration actions and priorities: over the next 6 years, 28.5 miles of riparian restoration and 5 projects targeting stream narrowing are planned. In addition, 11 projects that will improve connections between streams and associated floodplains and 12 projects increasing channel roughness (both identified by Isaak et al. as potential management strategies to mitigate climate change) are anticipated.

Management of Nonnative Species

Jim Ruzycki, program director for ODFW's East Region, noted that the need for assessment of nonnative species exists, especially in the valley reaches of the Grande Ronde (personal communication). An understanding of the presence and distribution of problematic predatory introduced species and diseases is needed, particularly to understand juvenile salmonid mortality. The Grande Ronde Model Watershed could support ODFW through community outreach, especially to gain access to the river from landowners and to support anger education.

Toxics in the Grande Ronde Basin

Past and current land uses suggest that toxics could be affecting fish populations: gold mining in headwater streams may have included the use of mercury to amalgamate ore; wastewater from municipal treatment plants and septic tanks could introduce pharmaceuticals and other endocrine disrupters; use of pesticides and herbicides to control pests and weeds in forests, agricultural, and residential areas as well as along right of way; and permitted wastewater from area mills could introduce toxins into the water column (Julann Spromberg, Northwest Fisheries Science Center Fisheries Biologist, personal communication). (The small size of the communities in the basin suggest that storm water runoff is less likely to be a primary factor in the introduction of toxins to waterways.) DEQ staff sampled for toxins at three sites in the Upper Grande Ronde in 2011, each on the mainstem (ODEQ 2015). While Atlas does not currently address toxics, the adaptive management framework encourages adjustment of goals and objectives as new data emerge. While current budgets do not allow for toxics monitoring by the Model Watershed or its partners, additional funding targeting toxics monitoring in the basin would fill a data gap and could lead to the development of mitigation efforts if a problem were identified. ODEQ's statewide report on toxics recommended expanding both the geographic coverage of the previous sampling effort and the parameters analyzed (ODEQ 2015).

During the DEQ sampling efforts in 2011, arsenic, barium, iron, and manganese were detected at each site, but none of the samples exceeded DEQ aquatic life criteria (ODEQ 2015). The highest sampling site was at Hilgard State Park, considerably downstream from headwaters and the locations of historic mining activities.

Municipal wastewater facilities that discharge treated water into soil or simulated wetlands filter out pharmaceuticals and other endocrine disrupters; however, facilities that discharge directly into streams are potential sources of contaminants (J. Spromberg, personal communication). The 2011 sampling effort used coprostanol as a biomarker for the presence of fecal waste; the ratio of cholesterol to coprostanol indicated that humans and other animals (cattle and birds, for example) are the likely source of the coprostanol found (ODEQ 2015). Twenty-eight components of pharmaceuticals and personal care products were analyzed in the same sampling cycle, with sulfatmethoxazole (an antibiotic) and bis (2-ethylhexyl) adipate (used in cosmetics, hydraulic fluid, and other products) were detected at the site north of Elgin; no guidelines exist for these chemicals (ODEQ 2015). A vitellogenin study could help determine whether or not endocrine disrupters are inhibiting fish populations (J. Spromberg, personal communication). Male fish and juveniles should never produce vitellogenin, the protein that spurs egg yolk production in mature female fish. Sampling fish downstream of wastewater treatment plants would identify whether or not these toxins are a concern; if not, then wastewater treatment is probably functioning adequately in the basin. Positive results would indicate the need for additional study.

Because of the history of agriculture in the basin, both legacy contaminants such as DDT and currently registered agricultural chemicals could inhibit fish productivity (J. Spromberg, personal communication); however, the 2011 sampling efforts did not include an analysis of legacy pesticides. Herbicides are applied along right of ways, particularly with power infrastructure and roads. Sampling efforts in 2011 detected bromacil, diuron and hexazinone, three herbicides currently registered for use at a sampling site north of Elgin on highway 82; these were detected during the spring sampling event but did not exceed EPA aquatic life benchmarks (ODEQ 2015). Bromacil is listed for use on brush management on non-cropland, suggesting the possibility that rights of way may be a source of this chemical (ODEQ 2015). Carbamates, copper, and organophosphates can interfere with the olfactory senses of fish, reducing their ability to imprint, find food, and detect predators. As research has already raised the question of the ability of Grande Ronde fishes to detect and respond to novel waters, additional work on the presence of these toxins may be needed. Mitigation practices such as encouraging riparian hedgerow buffers of 20-30 feet to intercept sprays will help reduce future impacts. Misapplication by homeowners could be addressed through annual outreach at retail outlets to ensure appropriate use and disposal and to introduce less toxic alternatives.

Other probable areas where toxins may enter the water column include chemicals used for forestry, including herbicides and fire retardants, and permitted industrial discharges (J. Spromberg, personal communication). Timber mills are the primary industrial dischargers in the basin, with dioxin and chemicals used to produce plywood being potential concerns. Sampling efforts in 2011 did not include PCBs, flame retardants, dioxins, furans, or inorganic arsenic (ODEQ 2015).

Influence of Upland Conditions

The current upland influence regional biologists are interested in investigating is the role lodgepole thinning might play in changing evapotranspiration rates (J. Ruzycki, personal communication). Removal of juniper has led to in-stream and floodplain responses in some regions; some researchers are interested in exploring if similar results could be achieved in the Blue Mountains through lodgepole thinning.

Life Cycle Modeling to Support Recovery Efforts

Current efforts by NOAA to model the life cycles of listed fish benefit from twenty years of data available in the Grande Ronde basin (Tom Cooney, research biologist with the NOAA Fisheries' Northwest Fisheries Science Center, personal communication). Life cycle modeling examines the statistical probability of a fish's survival at each point in its life cycle and for multiple life histories; for example, how likely is it that a fish will survive from parr to smolt in its natal stream? Modeling efforts begin with data for spawning and returning adults for each year in a twenty-year series. The data are scaled to a measure of available habitat for spawning and rearing—the total amount of current habitat available for fish use. The model factors in year to year ocean survival as year to year returns are most influenced by ocean effects, as well as estuary conditions near natal streams and the plume of fresh water from natal streams into the ocean. The effects of different harvest schemes and different hydropower management schemes are also evaluated.

The resulting model allows researchers to identify the current amount of smolt production in the Grande Ronde basin and estimate potential gains to productivity based on incremental restoration of highest priority areas. Sampling and monitoring efforts have identified areas that are below production potential for smolts and are close to current spawning areas; stream reaches currently used for spawning or immediately above and below those reaches offer the most potential for immediate population gains and should be prioritized for restoration. Rather than trying to identify pre-disturbance conditions and re-create an idealized vision of what habitat conditions may have been, restoration efforts instead should address whatever factors currently inhibit fish production in these reaches: channel loss, stream structure, channel pattern, flow, or riparian cover.

In the Grande Ronde basin, stream temperatures and lack of pool habitat are the biggest limiting factors for listed fish. Restoration actions will not lead to immediate improvements in habitat; for instance, five years after a tree planting effort, perhaps only a twenty percent improvement in habitat conditions will be achieved. Because of the lag between action and benefit, short-term strategies to preserve fish populations, such as planting native brood stock, continue to be necessary alongside long-term restoration actions. Efforts by Tom Cooney to model fish response to habitat restoration actions assume that a five-year increment is needed to see a response in fish populations; that fish find and use restored habitat; that the same fluctuations due to ocean conditions and hydropower management continue; and also accounts for time for trees to grow. Cooney's research demonstrates that restoration practitioners must think strategically about actions but should also realize that positive changes really *are* possible: thoughtful planning and implementation of habitat restoration can lead to the recovery of naturally sustainable fish populations in the Grande Ronde basin.

To achieve recovery of these populations, fish data collection, habitat data collection, implementation of habitat actions need to work together to inform lifecycle models. Atlas itself is informed by life cycle models: the tiers in Atlas lead to prime candidate actions for improvement. Atlas demonstrates a segue from an old approach to implementing restoration to a new, strategic approach. The EDT paradigm compared current conditions to historic, concentrating on changes from historical conditions; the Model Watershed solicited projects and project sponsors proposed the candidate actions. The end result was an array of actions that might be good but did not add up to enough to achieve quick gains in fish population numbers. The new approach the Atlas TAC has developed asks: where can the Grande Ronde Model Watershed receive the greatest return in population increases for each restoration investment? How should these actions be sequenced? This requires the design of a research, monitoring, and evaluation program that is more spatially designed: what do we expect to get, action type by action type? What is the measurable larger-scale fish response to these actions?

Novel Approaches and New Technology

Ruzycki identifies reducing stream temperature and providing solar insulation as the most important goal for the Upper Grande Ronde, with projects that increase shading and improve the morphology of stream channels as most beneficial, while for Catherine Creek, addressing juvenile survival in the valley reaches is the primary goal, with research needed to identify limiting factors (personal communication). He believes that the best tool will be fully functional lifecycle models, offering implementers a predictive tool to guide restoration actions. The ability to investigate whether one action offers more benefit than another action, for example, adding wood versus reducing stream temperature, will help allocate restoration investments more effective. He also believes eDNA may offer tools for determining presence/absence of nonnatives, and hopes to see additional work in marine nutrient cycling.

Conclusion

In 2016, the Grande Ronde Model Watershed coordinated ten projects, with a total cost of $1,526,518, including administration. This budget allowed the organization to replace seven culverts and one diversion, test a browse deterrent along 7.5 miles of stream, fence 1.5 miles of stream, and actively restore 4.34 miles of stream. Removing the $54,766 cost of the browse deterrent study, one could estimate restoration costs at about $252,012 a stream mile for 2016. If the restoration work required along the 67.7 miles of Tier I sites is comparable in nature to the work performed in 2016, then approximately $17,061,235 will be needed over the next six years ($2,843,539 each fiscal year) to complete restoration objectives in Tier I geography.

In addition to the monetary costs of restoration, the Model Watershed will need the continued support of project partners and funders, with strong support from the fisheries research community. The organization will also face new outreach challenges: while the past 25 years have often focused on lands primarily used for timber and grazing, research into limiting factors in the valley reaches will require strong support from field crop producers. Temporal challenges also face the organization: dwindling native fish stocks require immediate action, leaving little time to plan for recovery, while the demographics of the research and conservation community mean that over the next six years, retirements will begin to challenge the institutional knowledge of restoration practitioners.

The Model Watershed possesses a unique set of strengths that will help it meet the challenges of addressing restoration needs across the subbasin: the long-standing fisheries data to inform restoration actions, strong support amongst both residents and community leaders, continued commitments from natural resource leaders, a talented staff with strong local ties, and the continued support from a diverse group of funders. These strengths helped shift the organization from site-base projects that developed as opportunities arose to strategic, data-driven projects that seek to restore ecological processes across the landscape. In the years ahead, the Model Watershed will benefit from the additional tools provided by restoration Atlases for the Grande Ronde, Catherine Creek, and Wallowa County as well as the continued dialectic between the research community and implementers built into the organization’s adaptive management plan. Continued commitment from Model Watershed supporters will help conserve the subbasin’s native fish stocks. The tools and approach taken by the Model Watershed offer a path toward community-driven restoration for other basins also seeking to protect and conserve native fishes.

GRMW wishes to thank the many partners both in and out of our basin who provided data and other content. We look forward to many more years working together to restore fish habitat and watershed health.

Respectfully Submitted by Grande Ronde Model Watershed. October 1, 2018.

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