Draft Assessment
Forest Plan Revision

Aquatic, Wetland, and Riparian Ecosystems

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Aquatic, Wetland, and Riparian Ecosystems

Introduction

The biodiversity within aquatic, wetland, and riparian ecosystems rivals that of any other on earth. Not only are these ecosystems important to plant and animal species, but humans also rely on the many benefits they have to offer. In this report, ecological integrity (status and trend) is evaluated for these ecosystems. Ecological integrity assesses if key components are functioning properly according to reference versus managed conditions. Species specific assessments are contained in the At-risk Species Assessment report.

A variety of definitions exists for “aquatic, wetland, and riparian areas”. In this report, the term “aquatic” is tied to water and its related habitats and species. Aquatic species life cycles mostly depend on water. Streams, rivers, ponds, and lakes are considered surface waters. Soil-water and groundwater are considered subsurface waters which have complex interactions in sustaining surface waters and vice versa. Wetlands are where subsurface waters saturate soils for an extended period on an annual basis and may or may not include surface waters. Riparian areas are the vegetated transition between the aquatic and terrestrial environment.

The scale for this analysis is at the stream reach, watershed, national forest, and ecoregion levels. The Watershed Condition and Water Quality Assessment report include a description of the watershed hierarchical system. The Blue Mountains ecoregion, delineated by Omernik 1987 encompasses the Malheur, Umatilla, and Wallowa-Whitman National Forests, and the surrounding area.

Process and Methods

The primary sources of available, relevant information (36 CFR 219.6(a)(1)) for this assessment include annual Pacific Fish and Inland Fish Biological Opinion Monitoring Program reports (Saunders et al. 2023a, b, c), USDA Forest Service Aquatic Organism Passage Improvement dataset, and Climate Change Vulnerability and Adaptation in the Blue Mountains Region (Halofsky and Peterson 2017). It is assumed these sources used best available scientific information.

Monitoring data are typically collected at the site and reach scales (160 to 400 m stream lengths). Status and trend analyses are then extrapolated to the watershed scales, national forest, or ecoregion-level. Most aquatic, wetland, and riparian ecosystems will be assessed using the Pacific Fish and Inland Fish Biological Opinion Monitoring Program (PIBO-MP) reports on stream habitat conditions (Saunders, et al. 2023a, b, c). Stream habitat attributes in ‘managed’ watersheds are compared to ‘reference’ watersheds. Reference streams represent the most intact, properly functioning streams on the landscape (Roper et al. 2019) Appendix A contains maps of the PIBO-MP sites in the ecoregion (Figure 4) and larger monitoring network (Figure 5).

Physical habitat attributes include both instream and streambank measures to assess status and trends in aquatic and riparian ecosystems.

Table 1 lists the PIBO-MP stream habitat attributes. Landscape and climatic information were used to control for inherent differences across the broad monitoring network. Landscape covariates include catchment area, elevation, valley slope, reach gradient, drainage density, geologic type, and percent forested. The climatic covariate is average precipitation.

Table 1. Stream habitat attributes measured at monitoring sites. An * indicates fully analyzed.

Physical habitat attributes	Status	Trend
Total Index	*	*
Residual pool depth (m)	*	*
Percent pool habitat	*	*
Percent fine sediment (<6 mm diameter, in pool tails)	*	*
D50 (median substrate particle size)	*	*
Large Wood frequency (pieces /km)	*	*
Average bank angle (°)	*	*
Percent of bank with undercuts (bank angle <90°)		*
Bank stability (% bank covered with plants or rock)		*

The Pacific Fish and Inland Fish Biological Opinion Monitoring Program also provides evaluations of riparian vegetation conditions for both reference and managed sites. Plant species cover is sampled along streams and transects with a “wetland ratings” determined by relative abundance of indicator species. A statistical analysis compared managed versus reference sites for status and comparisons between measurement cycles to determine trends (Halofsky and Peterson USDA 2017).

The Blue Mountains Climate Change Vulnerability Assessment (Halofsky and Peterson 2017) used existing vegetation classifications to highlight the diversity and complexity of riparian areas. Types of riparian vegetation that were assessed include conifer-dominated, cottonwood-dominated, willow-dominated, other woody-dominated riparian areas, and herbaceous-dominated riparian areas. These vegetation types generally include two potential vegetation groups (warm or cold), divided into several potential vegetation types. Less common riparian and wetland vegetation communities include aspen species, subalpine, and alpine.

The Blue Mountains Climate Change Vulnerability Assessment (Halofsky and Peterson 2017) also assessed wetland and groundwater dependent ecosystems (GDEs). Information on the condition and distribution of wetlands and GDEs in the Blue Mountains is limited. Data from the Nature Conservancy, the National Hydrology Dataset, and the Oregon Wetlands was used to assess current conditions in the climate vulnerability assessment.

Current Management Direction

The Malheur, Umatilla, and Wallow-Whitman Forest plans (1990) have similar goals, objectives, and standards for managing aquatic ecosystems. They generally provide protection using riparian management areas; a minimum of 100 feet adjacent to streams, lakes, and wetlands, as well as the spatial extent of floodplains and riparian vegetation. The three Blue Mountains forest plans differ on management areas set aside for riparian area protection; the Malheur has a non-anadromous riparian (3A) and an anadromous riparian (3B) management area, the Umatilla has one riparian management area (C5), and the Wallowa-Whitman only has an anadromous management area (18). The Malheur and Umatilla have additional watershed-related management areas for municipal water supplies and fisheries.

All three forest plans were amended by two interim strategies to protect anadromous and non-anadromous fish-producing watersheds (referred to PACFISH/INFISH; USDA 1995/USDA and USDI 1995) in response to the potential listing under the Endangered Species Act of several anadromous and resident fish species in the Snake River and interior portions of the Columbia River basin. The strategies include measures intended to halt further degradation of the habitats of these species on Federal lands. Both strategies include:

- Designating riparian habitat conservation areas, managed for the benefit of aquatic and riparian-dependent species. Designated areas call for increasing the width from 100 feet for all water features to at least 150 feet for non-fish bearing perennial streams and lakes, and at least 300 feet for fish bearing streams.
- Identifying and increasing protection of watersheds supporting listed species in good condition or ones that could be restored.
- Standards and guidelines intended to modify or limit adverse effects of land management activities.
- Monitoring.

Subsequent biological opinions by the National Marine Fisheries Service and US Fish and Wildlife Service specified additional requirements for protecting and restoring aquatic and riparian habitats in National Forest system lands. Requirements include developing and implementing an area-wide monitoring strategy (USDA 2004) to track the effects of implementing the two strategies, and the development of a regionwide watershed and aquatic restoration strategy (latest version; USDA 2018). As a result, the PIBO monitoring program, interior Columbian Basin management strategy and Region 6 aquatic riparian conservation strategy were created

Existing Condition

Aquatic Ecosystems

Status and trends

For the Malheur National Forest, overall aquatic habitat is significantly departed from reference conditions at both the ecoregion and entire PIBO monitoring network (Table 2). Of the individual metrics, fine sediment, and median particle size (D50) were not significantly departed from reference stream but only at the ecoregion. The frequency of pools was significantly less than reference streams. Pools were also significantly shallower than desired. Large wood was less frequent than desired. Bank angle was less than desired as well.

The total index trend was stable in the Malheur meaning although the status is departed from reference, conditions are not worsening or improving (Table 2). This is due a combination of worsening and improving metrics. Pool frequency, fine sediment, and D50 metrics all trend away from reference (worsening) while large wood frequency, bank angle and undercut bank metrics trend towards reference (improving). Residual pool depth and bank stability did not have a significant trend (not improving or worsening).

Table 2. Summary of status and trend of Index scores in the Malheur National Forest.

Physical habitat attributes	Status	Trend
Total Index	Departed	Stable
Residual pool depth (m)	Departed	Stable
Percent pool habitat	Departed	Worsening
Percent fine sediment (<6 mm diameter, in pool tails)	Departed all, Within ecoregion	Worsening
D50 (median substrate particle size)	Departed all, Within ecoregion	Worsening
Large Wood frequency (pieces /km)	Departed	Improving
Average bank angle (°)	Departed	Improving
Percent of bank with undercuts (bank angle <90°)	na	Improving
Bank stability (% bank covered with plants or rock)	na	Stable

For Status: “Departed” means there is a statistically significant difference between managed and reference streams, “Within” means there is no statistically significant difference between managed and reference streams. For Trend: “Stable” means there is no statistically significant trend, “Worsening” means there is a statistically significant trend away from reference conditions, “Improving” means there is a statistically significant trend towards reference conditions.

Like the Malheur, overall aquatic habitat in the Umatilla National Forest is significantly departed from reference streams at both the ecoregion and all reference sites (Table 3). Of the individual metrics, at the ecoregion level fine sediment was within reference conditions. Pools were also significantly shallower than desired. The frequency of pools was significantly less than reference. The composition of streambed substrate, median particle size (D50) was significantly departed from reference. Large wood was less frequent than desired. Bank angle was less than desired as well.

The total index trend was stable in the Umatilla meaning although the status is departed from reference, conditions are not worsening or improving (Table 3). This is due to a combination of worsening and improving metrics. Fine sediment, D50, and bank stability all trend away from reference (worsening), while large wood frequency, bank angle, and undercut bank trend towards reference (improving). Residual pool depth and fine sediment did not have a significant trend (not improving or worsening).

Table 3. Summary of status and trend of Index scores in the Umatilla National Forest. For Status:

Physical habitat attributes	Status	Trend
Total Index	Departed	Stable
Residual pool depth (m)	Departed	Stable
Percent pool habitat	Departed	Stable
Percent fine sediment (<6 mm diameter, in pool tails)	Departed all, Within ecoregion	Worsening
D50 (median substrate particle size)	Within	Worsening
Large Wood frequency (pieces /km)	Departed	Improving
Average bank angle (°)	Departed	Improving
Percent of bank with undercuts (bank angle <90°)	na	Improving
Bank stability (% bank covered with plants or rock)	na	Worsening

"Departed" means there is a statistically significant difference between managed and reference streams, "Within" means there is no statistically significant difference between managed and reference streams. For Trend: "Stable" means there is no statistically significant trend, "Worsening" means there is a statistically significant trend away from reference conditions, "Improving" means there is a statistically significant trend towards reference conditions.

Similarly, overall aquatic habitat in the Wallowa-Whitman National Forest is significantly departed from reference streams at local, ecoregion, and all reference sites. At all levels, fine sediment and D50 was within reference conditions (Table 4). The remaining indices are significantly departed from reference streams. Pools were significantly shallower than desired. The frequency of pools was significantly less than reference. Large wood was less frequent than desired. Bank angle was less than desired as well.

Unlike the other two forests, the total index on the Wallowa-Whitman was trending away from reference (worsening). This is due to four metrics, including pool percent, fine sediment, D50, and bank angle all trending away from reference (worsening) while only one metric, large wood frequency trends towards reference (improving) (Table 4). Residual pool depth, undercut bank, and bank stability did not have a significant trend (not improving or worsening).

Table 4. Summary of status and trend of Index scores in the Wallowa-Whitman National Forest.

Physical habitat attributes	Status	Trend
Total Index	Departed	Worsening
Residual pool depth (m)	Departed	Stable
Percent pool habitat	Departed	Worsening
Percent fine sediment (<6 mm diameter, in pool tails)	Within	Worsening
D50 (median substrate particle size)	Within	Worsening
Large Wood frequency (pieces /km)	Departed	Improving
Average bank angle (°)	Departed	Worsening
Percent of bank with undercuts (bank angle <90°)	na	Stable
Bank stability (% bank covered with plants or rock)	na	Stable

For Status: “Departed” means there is a statistically significant difference between managed and reference streams, “Within” means there is no statistically significant difference between managed and reference streams. For Trend: “Stable” means there is no statistically significant trend, “Worsening” means there is a statistically significant trend away from reference conditions, “Improving” means there is a statistically significant trend towards reference conditions.

Summary

On all three Blue Mountains national forests, the status of fine sediment and median particle sizes (D50) were mostly within reference conditions. However, trends in these two metrics are moving away from the desired conditions (worsening). This may be due to recent wildfires resulting in sediment pulses into the systems. Trends in pool frequency is decreasing (worsening), except in the Umatilla. Recent flood events could also be driving this trend.

Of all the trends only large wood frequency was improving in the Blue Mountains national forests. Improved large wood frequency may increase pool depth, although pool depth is stable in all three national forests. However, interaction with large wood and pool depth are complex, influenced by precipitation patterns and streamflow over the monitoring period (Roper et al. 2019). The three streambank related metrics were mostly stable or improving across the Blue Mountains, except for bank angle on the Wallowa-Whitman and bank stability on the Umatilla. Again, precipitation and streamflow conditions during the monitoring period could influence these trends.

It is important to note that the Blue Mountain forests and ecoregion only have five and nine percent of the PIBO reference streams, respectively. Most of these reference streams are in wilderness at high elevations with higher precipitation than managed sites. Although physical and climatic variables are used to normalize results across all locations of the PIBO monitoring programs there are inherent issues with having only 18 reference streams to compare with 40 to 66 managed streams per national forest.

Aquatic Restoration

The Blue Mountains national forests have completed many aquatic habitat restoration projects over the last two decades. Almost 150 fish passage barriers have been replaced with larger culverts, bridges, or retrofitted. About 50 fish passage barriers were fully removed from closed or decommissioned roads. There are still many fish passage barriers that need to be remediated in the future. See figure 1 for details.

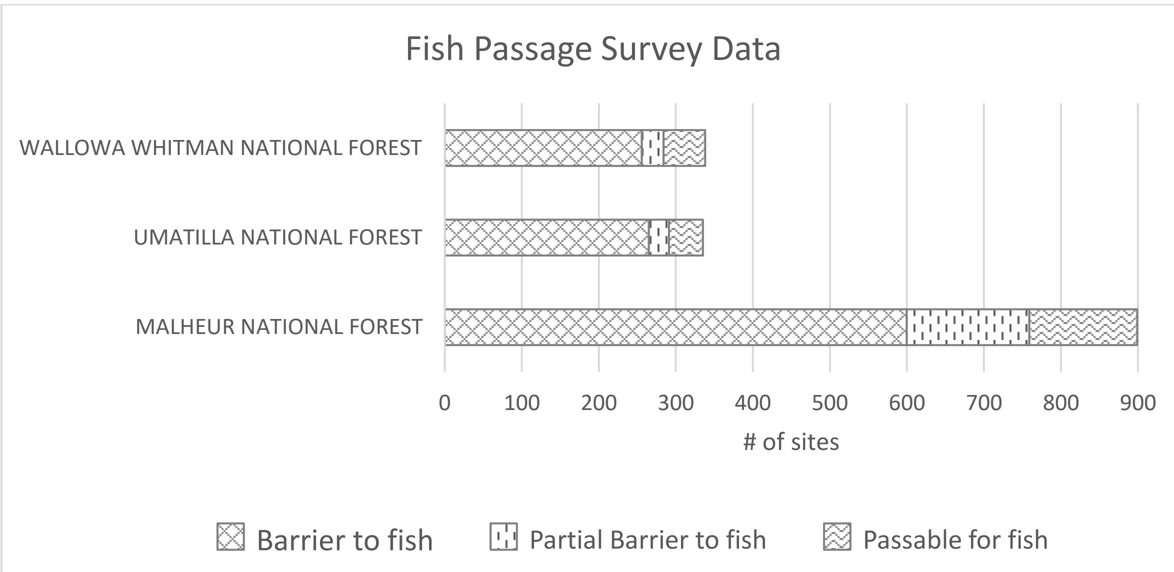

Figure 1. Summary of fish passage barrier survey data in the Blue Mountains National Forests.

The watershed improvement tracking database provides trends in watershed improvements completed on an annual basis. Figure 2 and Figure 3, illustrate aquatic and riparian restoration work that has occurred over the last fifteen years. These figures only use the aquatic and riparian activity classes from the watershed improvement tracking dataset. It is likely that all improvements made over the last two decades just haven't shown up in the response reaches due to a century of disturbances.

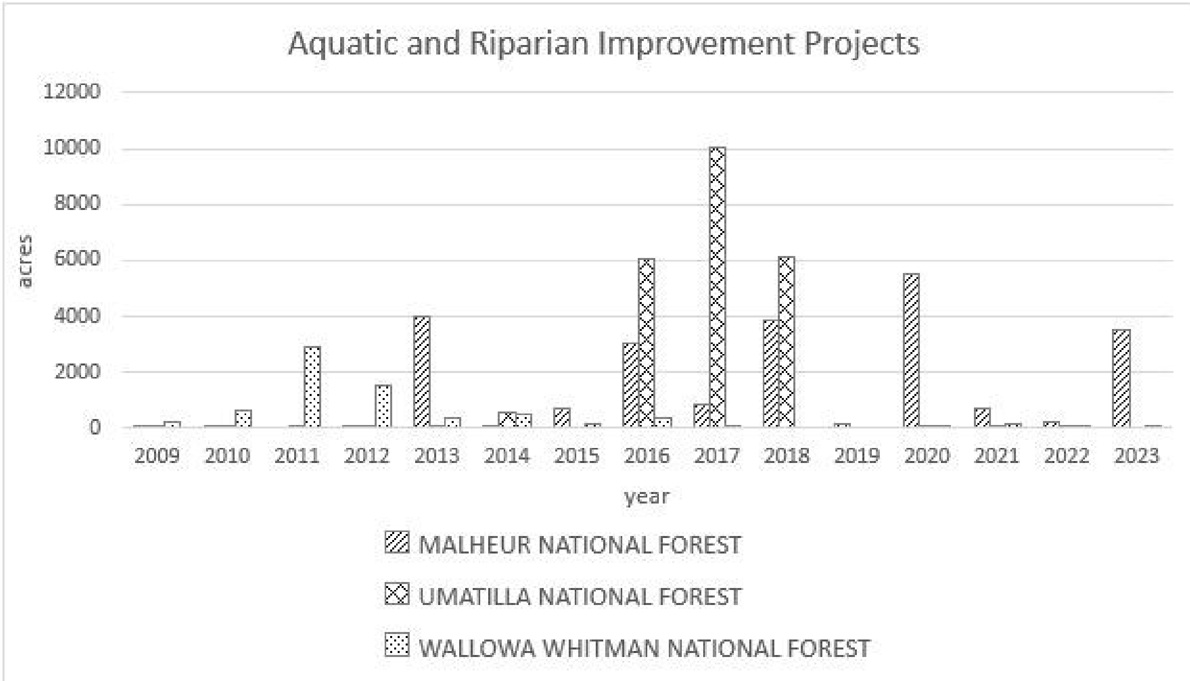

Figure 2. Summary of aquatic and riparian habitat improvement projects reported in acres.

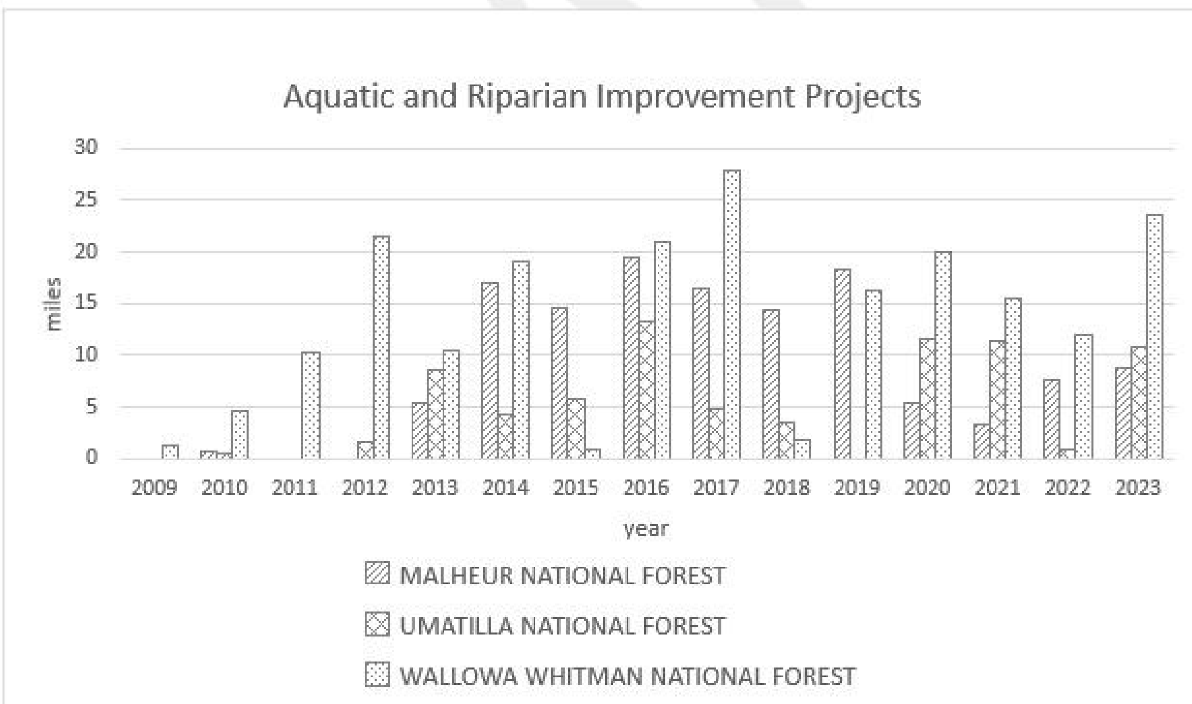

Figure 3. Summary of aquatic and riparian habitat improvement projects reported in miles. In most cases projects did not report both acres and miles, meaning the results summarized in tables 2 and 3 are additive not duplicative.

Wetland and Riparian Ecosystems

Vegetation conditions

Conifer-dominated riparian areas

Conifer-dominated riparian communities are very common in the Blue Mountains national forests. These areas are important microclimates, provide wildlife habitat, and large wood source areas. The "cold riparian forest" potential vegetation group (Powell et al. 2007) includes several potential vegetation types with dominant conifer species such as subalpine fir, Engelmann spruce, and lodgepole pine (see "Terrestrial Ecosystems Report"). The "warm riparian forest" potential vegetation group includes several potential vegetation types with dominant conifer species such as Douglas-fir or grand fir, and less commonly western white pine. These vegetation types typically occur at higher elevations, mostly along smaller streams, and in steeper valley bottoms.

Impacts to conifer-dominated riparian areas primarily include past timber harvest, fire exclusion, grazing, road building, and mining. Wildfire, insects and disease, landslides, and debris flows are common natural disturbances. In some locations, channel incision and decreasing soil moisture have resulted in ponderosa pine becoming more prevalent in lower elevation riparian areas.

Cottonwood-dominated riparian areas

Black cottonwood is a common deciduous tree species present along a variety of valley types in the Blue Mountains, ranging from confined, steep-gradient valleys to more open, low-gradient valleys. These areas are considered "warm riparian forest" potential vegetation groups all dominated by cottonwood overstory, with understory of willow (*Salix spp.*) or alder (*Alnus spp.*) (Powell et al. 2007). European settlers often inhabited these areas due to water proximity and lower gradient valley bottoms that are easily converted to cattle pasture. Stream channel alterations, water diversions, tree removal, and grazing have all impacted cottonwood and associated willow, alders, and aspen.

Willow-dominated riparian areas

Willow-dominated riparian areas are most extensive at mid to lower elevations but are found across all elevation ranges. Willows provide for increased bank stability and sediment storage, stream shade, organic matter, and wildlife habitat. The less prevalent "cold riparian shrub" potential vegetation group occurs at higher elevations or cold air drainage at lower elevations (Powell et al. 2007). The more prevalent potential vegetation group called "warm riparian shrub" are also called the "alluvial bar" willow group. The historic removal of American beaver (*Castor canadensis Kuhl*) in streams throughout North America whose dam building practices maintained higher water tables has severely influenced stream channels and the distribution of willows (Halofsky and Peterson 2017). However, studies suggest American beaver were infrequent in the Blue Mountains (Swanson, et al. 2010) because of the lack of suitable habitat. Stream diversions lowering the water table in these areas has also resulted in species composition shifting to more drought-tolerant species.

Other woody-dominated riparian areas

The Blue Mountains have a variety of tree and shrub dominated riparian areas due to geographic location, complex geology, and varied stream channel forms. Within the previously discussed "warm riparian forest" group there are nine potential vegetation types dominated by red and white alder (Powell et al. 2007). In drier sites, there is a "low soil moisture riparian shrub" group with numerous potential vegetation types and species that occur across a range of valley bottoms and steep canyons. In a "warm riparian shrub" group there are many different potential vegetation types mostly dominated by mountain alder, as well as Sitka alder, water birch, dogwoods, and currant (Powell et al. 2007).

In locations where groundwater levels have lowered, willow-dominated groups have been converted to the more drought tolerant woody-dominated groups particularly shrubby cinquefoil, currant, and common snowberry. As with the cottonwood and willow dominated groups, they have also been affected by livestock and native ungulate browsing, and agricultural uses.

Herbaceous-dominated riparian areas

Several herbaceous-dominated wetland and riparian plant associations have been identified in the Blue Mountains over a wide elevation range (Crowe and Clausnitzer 1997). Many of these are in meadows, mostly dominated by sedge species. In addition, many plant associations and community types occur along shaded streams or springs. Herbaceous-dominated riparian areas typically occur in more open valley bottoms, usually along low-gradient stream segments.

Across all elevations, many meadows have long-lasting impacts from livestock use (Kauffman et al. 2004). As with other riparian groups the effects of grazing, water diversion, and stream alterations have favored more drought tolerant species, including invasive plants.

Riparian and wetland aspen plant communities

Stands of quaking aspen are relatively uncommon in the Blue Mountains region; most are less than three acres in extent. Riparian and wetland aspen communities are mostly associated with herbaceous species in meadows, followed by common snowberry and other tall shrubs (Swanson et al. 2010). Aspen plant communities have been affected by fire exclusion and browsing by native ungulates and livestock. Conifers are encroaching into aspen communities due to fire exclusion and herbivory. Aspen stands are declining, with little to no regeneration, and are susceptible to insects and diseases (Swanson et al. 2010). The Terrestrial Ecosystems report assessed aspen stands in more detail.

Subalpine and alpine riparian areas and wetlands

Many subalpine and alpine plant associations have been identified, including willow species, low shrubs, sedges, and forbs (Wells 2006). These are mostly located in glacial valleys, headwater springs, and fens. Although subalpine and alpine riparian areas have been affected by many of the same uses as other riparian vegetation types (e.g. livestock and ungulate browsing, historic road building and mining, recreation) they are typically in better condition than low-elevation areas.

Wetland and Riparian Vegetation Monitoring

The condition of wetland and riparian ecosystems greatly differs depending on location within the watershed, valley configuration, and past and current land use. Wetland and riparian ecosystems at low to mid elevations are the most altered by previously described land use practices. Wetland and riparian ecosystems that occur in lower elevation, more open, gentle valley bottoms are inherently more impacted than higher elevation, confined, conifer-dominated riparian areas. Wetlands and riparian ecosystems impacted by land use are more vulnerable to natural disturbances like flooding or wildfire.

An analysis of riparian vegetation data in the climate vulnerability assessment found significantly lower total cover and woody cover for managed sites relative to reference sites. The analysis also found higher invasive species cover and lower ratings for wetland integrity. Woody cover appears to be increasing slightly at both managed and reference sites, while invasive species cover has been decreasing. There is a trend in the wetland index decreasing at managed sites. In general, trends in wetland and riparian vegetation needs more monitoring and research.

Wetland Inventories

According to the Oregon Wetlands database about 42 to 51 percent of the mapped wetlands in the Blue Mountains national forests are classified as riverine (stream-associated riparian wetlands). The Blue Mountains national forests also have palustrine wetlands (forested and non-forested upland wetlands) and lacustrine wetlands (wetlands along lake shores). The Malheur National Forest has the most total area of palustrine wetlands compared to the Wallowa-Whitman National Forest, which has the most total area of lacustrine and riverine wetlands.

Groundwater-Dependent Ecosystems

Springs

Currently, there are over 5,000 springs mapped in the Blue Mountains national forests. The Malheur National Forest has the most mapped springs (53 percent), compared to the Wallowa-Whitman (35 percent), and Umatilla (12 percent). Springs play an important role in delivering cooler water and supplementing stream flows throughout the summer. Springs can also provide relatively warmer water during winter months. It is likely that most streams and rivers in the Blue Mountain are partially groundwater dependent.

Fens

Fens are believed to occupy less than one percent of the Blue Mountains national forests yet contribute substantially to biodiverse ecosystems. Perennially saturated fens provide important habitat for invertebrate and amphibian species. Fens are underlain by organic soils and are mostly occupied by sedge species. Several herbaceous-dominated plant associations can also occur in fens.

Current groundwater dependent ecosystem conditions

Groundwater dependent ecosystems have not been thoroughly mapped throughout the Blue Mountains national forests. Surveys in the Malheur and Wallowa-Whitman National Forests strategically selected sites based on disturbance, land management, water withdrawals and other high values areas. The Umatilla National Forest's surveys were related to grazing allotments and watersheds of concern. About half of the groundwater dependent ecosystems inventoried showed adverse impacts to soils and vegetation composition from water diversions and related human activities as well as ungulate browsing.

Climate Change

Climate change will have far-reaching effects on aquatic, wetland, and riparian ecosystems (Halofsky and Peterson 2017). Extreme climate events are expected to occur more often, with associated impacts on ecological disturbance increasing. Anticipated reduction in amount and duration of snowpack will alter peak flow timing, reduce summer low flows, and, as air temperatures increase, result in increased stream temperatures, all which will impact aquatic habitats. Abundance and distribution of at-risk species will be affected, although impacts will differ by site as a function of both stream temperature changes and compounding stressors from nonnative fish species. Expected increases in wildfire intensity may mobilize more sediment to streams, increase peak flows, destabilize stream channels, and raise water temperature by removing stream shade.

Wetland and riparian areas are vulnerable to increased air temperature, reduced snowpack, and altered hydrology. Primary effects include decreased establishment, growth, and cover of important riparian tree species, which may be displaced by more drought-tolerant species in some locations (Halofky and Peterson 2017) (see “Climate Change Report”). Reduced groundwater discharge will shrink areas of saturated soil, perennial springs will transition to ephemeral springs, ephemeral springs will decline, all impacting aquatic species (Halofky and Peterson 2017).

Conifer-dominated riparian areas will be more susceptible to drought, wildfire, and insect infestations (Halofky and Peterson 2017). Cottonwood and willow-dominated riparian areas are expected to decrease in extent due to anticipated changes in frequency and magnitude of peak flows and lowering water table. Other woody-dominated riparian areas will likely increase in some areas, displacing mesic species with more drought-tolerant species.

Herbaceous-dominated and aspen riparian areas are likely to shrink in extent due to decreased water availability. Sedge species are expected to be replaced by more drought-tolerant grass species and invasive species. Riparian and wetland aspen plant communities will likely continue to decrease in extent and vigor due to decreased water availability. Some isolated populations of aspen may be extirpated because of altered hydrology.

Climate-induced changes in groundwater-surface water interactions could impact stream baseflows, wetlands and other groundwater dependent ecosystems. Changes in groundwater-surface water interactions will vary depending on location within the watershed and stream system. Small, unconfined aquifers dependent on shorter time scales for renewal may respond rapidly in contrast to larger, deeper confined aquifers with nonrenewable groundwater projected to have a slower response.

Groundwater dependent ecosystems in igneous and metamorphic rocks may not be as vulnerable to changes in temperature and precipitation regimes since they typically are recharged during large infrequent precipitation or snowmelt events (Halofky and Peterson 2017). However, groundwater dependent ecosystems in sedimentary or basalt may be more sensitive to altered climate since they are recharged more frequently. This is because igneous and metamorphic rocks that exhibit lower permeability and porosity, have lower volume groundwater discharges to groundwater dependent ecosystems than sedimentary or basalt rocks.

For fens, peat accumulation will be influenced by increasing temperatures and changes in hydrologic regime. Soil aeration and organic matter oxidation tend to increase as groundwater levels lower. However, accumulation and maintenance of peat depends on stable conditions. As water tables lower, shifts in fens species composition could occur since wetland species respond to slight changes in water table elevation (Halofky and Peterson 2017).

Key Findings

Overall aquatic, wetland, and riparian ecosystems in the Blue Mountains national forests are departed from reference conditions. Fine sediment and median substrate particle sizes are mostly within reference conditions but are trending away from reference conditions, likely due to recent wildfires and flooding events. Large wood frequency in streams is trending towards reference conditions, as well as many of the streambank indicators. The Blue Mountains national forests have increased the pace and scale of fish passage, stream habitat, and riparian restoration treatments in the last two decades. Groundwater dependent ecosystems need more research and monitoring to determine trends. Climate change will have far-reaching effects on aquatic, wetland, and riparian ecosystems, including changes in timing of and reductions in snowpack and summer peak flows along with increases in stream temperatures.

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Appendix A - Maps

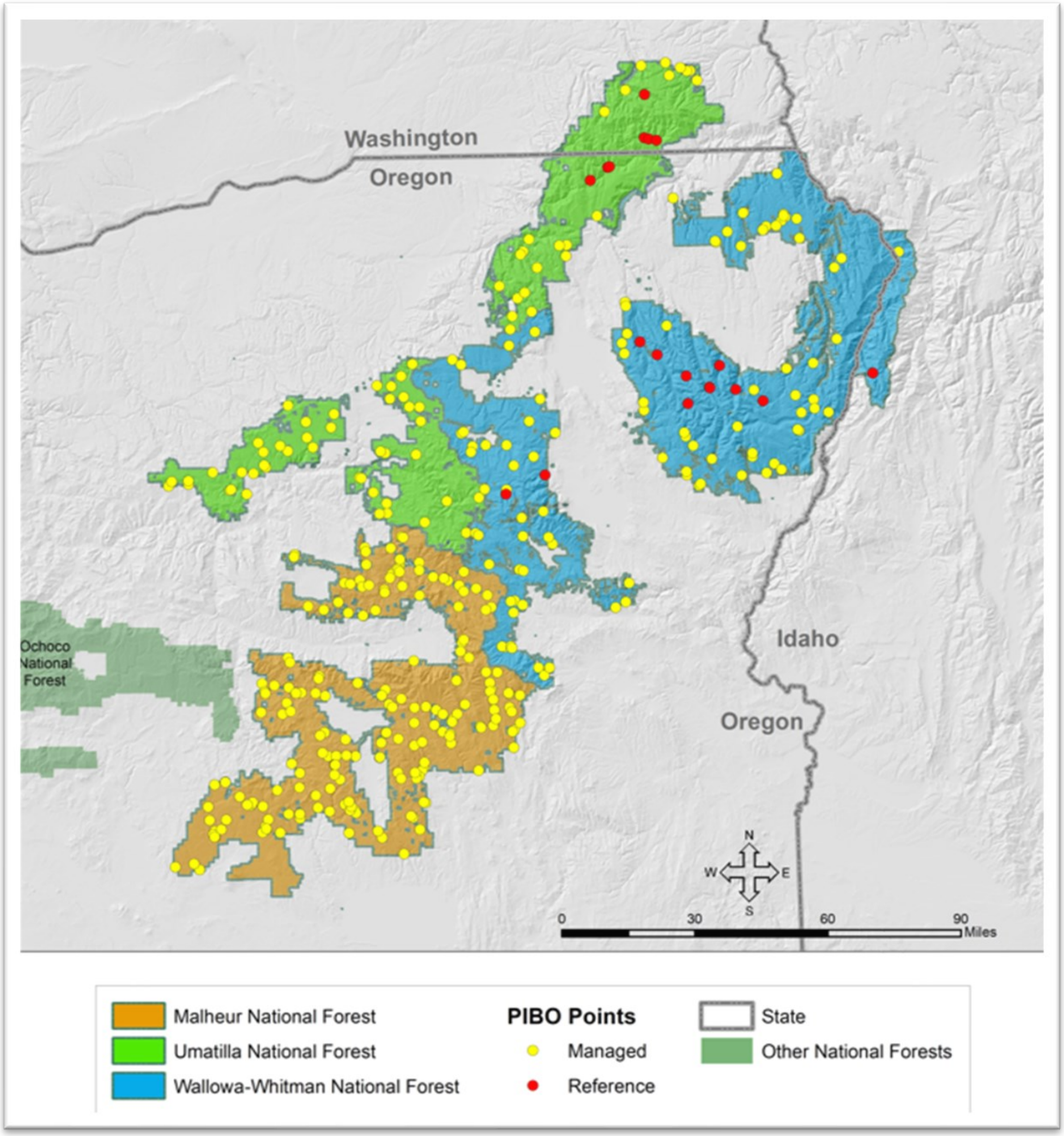

Figure 4.Pacific fish and inland fish biological opinion monitoring points within planning area.

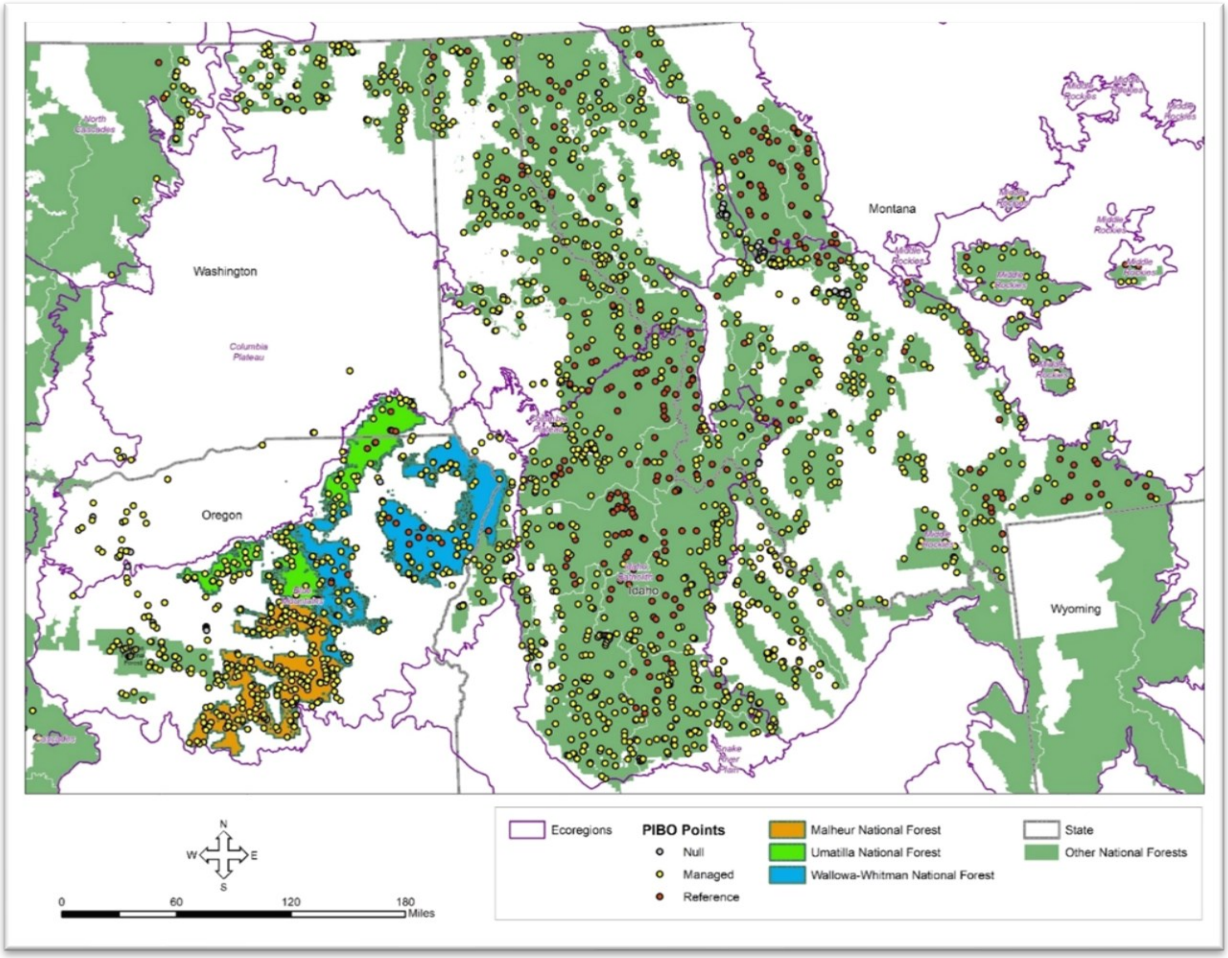

Figure 5. A map of all pacific fish and inland fish biological opinion monitoring points.