USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station | RMRS-GTR-434-volume 2 | January 2024

Riparian, Aquatic, and Groundwater-Dependent Ecosystems in Southern Oregon and Northern California: An Assessment of Ecological Integrity to Inform Forest Plan Revision. Volume 2: Rogue River-Siskiyou National Forest

D. Max Smith, Laurel F. Martinez, Cynthia King, Taylor L. Pearson, Katelyn P. Driscoll

Smith, D. Max; Martinez, Laurel F.; King, Cynthia; Pearson, Taylor L.; Driscoll, Katelyn P. 2024. **Riparian, Aquatic, and Groundwater-Dependent Ecosystems in Southern Oregon and Northern California: An Assessment of Ecological Integrity to Inform Forest Plan Revision. Vol. 2: Rogue River-Siskiyou National Forest**. Gen. Tech. Rep. RMRS-GTR-434-vol. 2. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 162 p. https://doi.org/10.2737/RMRS-GTR-434-vol-2.

Abstract

This six-volume assessment provides information on the current conditions of riparian, aquatic, and groundwater-dependent ecosystems on the Rogue River-Siskiyou, Klamath, Six Rivers, Shasta-Trinity, and Mendocino National Forests of southern Oregon and northern California. We used peer-reviewed literature and national and regional-level data from the forests and their partners to evaluate the status of several key ecosystem characteristics. These characteristics are distribution, hydrologic regimes, water quality, connectivity, instream habitat quality, and riparian reserve condition for four different stream habitats (permanently flowing fish-bearing, permanently flowing nonfish-bearing, seasonally flowing fish-bearing, seasonally flowing nonfish-bearing); lakes, ponds, and reservoirs; and rare and unique riparian and aquatic habitats. We determined that roads, altered fire regimes, and climate change were major stressors to riparian, aquatic, and groundwater-dependent ecosystems on the national forests. The relative impacts of these stressors and the resistance and resilience of the focal ecosystems differed across the Five Forests cohort. Altered fire regimes and impacts from drought and climate change appear to be most pronounced in the southern reaches of the study area and projected hydrologic impacts of climate change are expected to be significant throughout the Cascades. Our results support the ecosystem assessment completed during the forest plan revision process and can help inform decision making related to restoration and maintenance of riparian, aquatic, and groundwater-dependent ecosystems across the Five Forests.

Keywords: forest plan, key ecosystem characteristic, riparian vegetation, flow regime, channel morphology, floodplain, natural range of variation

Cover: Top left—Chetco River in the Rogue-River Siskiyou National Forest, photographed in July of 2021. USDA Forest Service photo by Max Smith. Top right—Elk River in the Rogue-River Siskiyou National Forest, photographed in July of 2021. USDA Forest Service photo by Max Smith. Bottom center—Serpentine fen on Eight Dollar Mountain, near the Illinois River in the Rogue-River Siskiyou National Forest, photographed in December of 2022. California pitcher plants (*Darlingtonia californica*) are abundant in the foreground and background. USDA Forest Service photo by Max Smith.

All Rocky Mountain Research Station publications are published by U.S. Forest Service employees and are in the public domain and available at no cost. Even though U.S. Forest Service publications are not copyrighted, they are formatted according to U.S. Department of Agriculture standards and research findings and formatting cannot be altered in reprints. Altering content or formatting, including the cover and title page, is strictly prohibited.

Authors

D. Max Smith is a Research Associate with the Rocky Mountain Research Station at the Forestry Science Laboratory in Albuquerque, New Mexico. He completed a B.S. degree in wildlife biology at the University of Montana, Missoula, Montana, and an M.S. degree in zoology at the University of Oklahoma, Norman, Oklahoma.

Laurel F. Martinez is a Biological Science Technician with the Rocky Mountain Research Station at the Forestry Science Laboratory in Albuquerque, New Mexico. She completed a B.S. degree in environmental science with a minor in plant biology at the University of Vermont, Burlington, Vermont.

Cynthia King is a Biological Science Technician with the Rocky Mountain Research Station at the Forestry Science Laboratory in Albuquerque, New Mexico. She received a B.S. degree in environmental science with a minor in wildlife from New Mexico State University, Las Cruces, New Mexico and an M.S. in environmental management, with a graduate certificate in hydrology, from Portland State University, Portland, Oregon.

Taylor L. Pearson is a Biological Science Technician with the Rocky Mountain Research Station at the Forestry Science Laboratory in Albuquerque, New Mexico. She completed a B.S. degree in agriculture with a major in wildlife and minor in fisheries and aquatic sciences at Purdue University, West Lafayette, Indiana.

Katelyn P. Driscoll is a Research Ecologist with the Rocky Mountain Research Station at the Forestry Science Laboratory in Albuquerque, New Mexico. She completed a B.S. degree in biology with a minor in Spanish at Gonzaga University, Spokane, Washington and an M.S. degree in systems ecology at the University of Montana, Missoula, Montana.

Acknowledgments

We thank the Northwest Forest Planning Team of the USDA Forest Service Pacific Northwest and Pacific Southwest Regions for financial support to conduct this assessment. We are grateful to employees of the Northwest Forest Planning Team, including Steve Bachmann, Scott Peets, and Mary Friberg, as well as Greg Haywood for initial input, oversight and support of this project, and assistance in identifying goals, process, and reviews. We appreciate help from Steve Bachmann and Scott Peets for supplying data and reviewing early drafts of this report.

Contents

Abstract ii
Authors iii
Acknowledgments iii
INTRODUCTION 1
Background and Objectives 1
Study Area 1
ASSESSMENT FOR THE ROGUE RIVER-SISKIYOU NATIONAL FOREST—KLAMATH MOUNTAINS UNIT 2
Stressors 3
Climate Change 3
Dams and Diversions 4
Departure from Natural Disturbance Regimes 4
Drought 5
Invasive Species 6
Land-use Change 6
Livestock Grazing 8
Loss of Forest Cover 8
Mining 8
Pollution 10
Recreation 10
Roads 10
Vegetation Mortality 11
Ecosystems 12
Streams 12
Lakes, Ponds, and Reservoirs 59
Fens, Springs, and Vernal Pools 61
Interwatershed Connectivity 66
ASSESSMENT FOR THE ROGUE RIVER-SISKIYOU NATIONAL FOREST—CASCADES UNIT 70
Stressors 70
Climate Change 70
Dams and Diversions 71
Departure from Natural Disturbance Regimes 71
Drought 72
Invasive Species 73

Land-use Change 73
Livestock Grazing 75
Loss of Forest Cover 75
Mining 75
Pollution 76
Recreation 77
Roads 77
Vegetation Mortality 78
Ecosystems 78
Streams 78
Lakes, Ponds, and Reservoirs 123
Fens, Springs, and Vernal Pools 126
Interwatershed Connectivity 131
SUMMARY 134
REFERENCES 135
Appendix. Data for the Rogue River-Siskiyou National Forest 139

INTRODUCTION

Background and Objectives

We completed an assessment of riparian, aquatic, and groundwater-dependent ecosystems (GDEs) in fulfillment of an agreement between the Forest Service, U.S. Department of Agriculture Regions 5 and 6 Northwest Forest Planning Team and the Rocky Mountain Research Station. Our aim was to provide support during the process of revising management plans for national forests under the 2012 Planning Rule (36 CFR Part 219; USDA FS n.d.). We prepared this assessment to assist managers of five national forests in southern Oregon and northern California: the Rogue River-Siskiyou, Klamath, Six Rivers, Shasta-Trinity, and Mendocino National Forests (hereafter referred to collectively as the Five Forests). It is intended to enhance understanding of ecological conditions under their respective current plans and help identify needs-for-change to be addressed by the revised forest plan. Our methods meet planning rule requirements for a rapid assessment of ecological integrity—"the quality or condition of an ecosystem when its dominant ecological characteristics occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence"—that uses only existing information (USDA FS n.d.). As specified in the planning rule, we addressed structure, function, composition, and connectivity of terrestrial and aquatic ecosystems, along with drivers and stressors of key ecosystem characteristics (KECs). Study systems can cross administrative boundaries. For this reason, the planning rule uses an all-lands approach that requires consideration of how management actions that occur within the National Forest System (NFS) impact resources beyond the boundary and how conditions outside the national forest influence resources on NFS lands.

Study Area

This volume is the second in a six-volume series. In this volume we assess riparian, aquatic, and groundwater-dependent ecosystems (GDEs) for two geographic units of the Rogue River-Siskiyou National Forest (RRSNF). These units were defined by using physiographic provinces to divide the RRSNF into units classified by the Klamath Mountains and the Cascade Range. We evaluated and summarized KECs for habitats described in the Aquatic Conservation Strategy of the Northwest Forest Plan—permanently flowing fish-bearing (PFFB) streams, permanently flowing nonfish-bearing (PFNFB) streams, seasonally flowing fish-bearing (SFFB) streams, seasonally flowing nonfish-bearing (SFNFB) streams, lakes, ponds, and reservoirs—fens, springs, and vernal pools, at the scale of the geographic unit.

A brief history of human activity in the Five Forests planning area is presented in volume 1. Methods, conclusions, and appendixes pertaining to the Five Forests (Appendix A: data; Appendix B: data sources; Appendix C: maps of the distribution of ecosystem characteristics across the Five Forests; Appendix D: definitions of the watershed condition attributes and indicators discussed in these assessments) can also be found in volume 1. Please note that when we report data, percentages may not sum to 100 due to rounding error.

ASSESSMENT FOR THE ROGUE RIVER-SISKIYOU NATIONAL FOREST—KLAMATH MOUNTAINS UNIT

The Rogue River-Siskiyou National Forest (RRSNF)—Klamath Mountains unit contains 1.4 million acres, of which 1.3 million acres is in southwestern Oregon and 92,300 acres is in northern California. Thirteen level IV ecoregions are present within this unit (table A.1 in Appendix A in volume 1 of this series). Of this unit, 32 percent is classified as Coastal Siskiyous. These highly dissected mountains are between 600 and 5,300 feet in elevation and are characterized by mixed conifer forests (Thorson et al. 2003). Mean annual precipitation in the Coastal Siskiyous ranges from 70 to 130 inches and temperatures range from January minimums of 38 °F to July maximums of 76 °F. Streams in these areas tend to be high gradient. Soils are generally Inceptisols and Ultisols and geologic formations include colluvium, conglomerate, sandstone, and siltstone (Thorson et al. 2003).

Twenty-one percent of the RRSNF—Klamath Mountains unit is classified as the Inland Siskiyous ecoregion. These landscapes are highly dissected mountains characterized by mixed conifer forests (Thorson et al. 2003). Elevations in these areas range from 800 to 7,000 feet. Mean annual precipitation ranges from 25 to 70 inches and temperatures range from January minimums of 29 °F to July maximums of 86 °F. Streams tend to be high gradient. Soils are generally Alfisols and Ultisols and geologic formations include colluvium, granitic rocks, shale, and sandstone (Thorson et al. 2003).

Of this unit, 17 percent is classified as the Serpentine Siskiyous ecoregion. These highly dissected mountains are characterized by mixed conifer forests and montane chapparal (Thorson et al. 2003). Elevations range from 1,500 to 4,300 feet. Mean annual precipitation ranges from 45 to 120 inches and temperatures range from January minimums of 32 °F to July maximums of 82 °F. Streams tend to be perennial with high gradients. Soils are generally Alfisols and Inceptisols and geologic formations include colluvium, and ultramafic and related rocks (Thorson et al. 2003).

Twelve percent of the unit is classified as the Southern Oregon Coastal Mountains ecoregion. These dissected mountains are characterized by hemlock (*Tsuga* spp.) canopy, with salal (*Gaultheria shallon*), sword fern (*Polystichum* spp.), and vine maple (*Acer circinatum*; Thorson et al. 2003). Vegetation on wetter slopes and in riparian areas include California laurel (*Umbellularia californica*), western redcedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), grand fir (*Abies grandis*), red alder (*Alnus rubra*) in the canopy, salmonberry (*Rubus spectabilis*), and oxalis (*Oxalis* spp.). Elevations are between 0 and 4,000 feet. Mean annual precipitation ranges from 70 to 140 inches and temperatures range from January minimums of 36 °F to July maximums of 76 °F. Streams and rivers tend to be high gradient. Soils are generally Inceptisols and geologic formations include colluvium, siltstone, shale, sandstone, conglomerate, graywacke, granite, diorite, and serpentine (Thorson et al. 2003).

Eleven percent of the RRSNF—Klamath Mountains unit is classified as the Border High-Siskiyous ecoregion. These mountains are characterized by white fir (*Abies concolor*) and red fir (*Abies magnifica*) forests and some subalpine habitats (Griffith et al. 2016). Elevations range from 5,000 to more than 7,000 feet. Soil moisture regimes are xeric and soil temperature regimes are generally frigid, with some cryic at high elevations (Griffith et al. 2016).

The eight additional ecoregions present in the RRSNF—Klamath Mountains unit are Mid-Coastal Sedimentary, Northern Franciscan Redwood Forests, Rogue/Illinois/Scott Valleys, Western Klamath Low Elevation Forests, Western Klamath Montane Forests, Coastal Uplands, Oak Savanna Foothills, and Shasta Valley. Each occupies less than 5 percent of the unit.

Stressors

Climate Change

According to the Terrestrial Condition Assessment (TCA), none of the RRSNF—Klamath Mountains unit was in poor or very poor condition for climate exposure. This finding means that the changes in climate are unlikely to have impacted terrestrial ecological integrity within the unit (Cleland et al. 2017). Nevertheless, air temperatures in this unit have increased in all four seasons (table 1). Since 1900, annual precipitation has remained consistent or slightly increased throughout the Five Forests planning area (Loose et al. 2019), and these trends are expected to continue within this unit through 2100 (table 2). The timing of precipitation has changed over the last century, with substantial decreases in summer precipitation and increases in winter and spring snow and rainfall (table 1). Snowpack throughout the Five Forests has declined by up to 40 percent over the last 40 to 70 years (Loose et al. 2019; Siegel 2009; Sims et al. 2016c), and substantial reductions in April 1 snow water equivalent (SWE) and snow residence time are expected to occur within this unit by the end of this century (table 2). Snowmelt has shifted earlier by 15 to 40 days throughout the western United States since 1915 (Hamlet et al. 2005; Loose et al. 2019), and snowmelt-driven runoff in the same area has shifted 10 to 30 days earlier since the 1940s (Loose et al. 2019; Stewart et al. 2005).

Table 1—Deviation in mean (minimum, maximum) temperature and percentage change in mean (minimum, maximum) precipitation for each season in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Values were determined by the 2019 USDA Forest Service Terrestrial Condition Assessment (TCA; Cleland et al. 2017) using PRISM data as the mean departure of a recent 5 years from the historical record. The TCA uses an increase of 2 °F and a decrease of 10 percent as thresholds to identify land type associations that have experienced recent severe temperature or precipitation stress.

Season	Deviation in mean (minimum, maximum) temperature, °F	Percentage change in mean (minimum, maximum) precipitation
Winter	1.3 (0.6, 1.7)	10.7 (2.3, 17.4)
Spring	1.6 (1.3, 1.9)	7.9 (0.5, 16.6)
Summer	2.6 (2.1, 3.5)	-46.2 (-60.4, -39.7)
Fall	0.5 (0.2, 0.9)	-4.3 (-21.0, 9.5)

Table 2—Historical and projected annual precipitation, April 1 snow water equivalent, and snow residence time for the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data from the National Forest Climate Change Maps (USDA FS 2022).

Variable	Historical (1975–2005) mean (minimum, maximum)	Projected (2071–2090) mean (minimum, maximum)
Annual precipitation (inches)	96.1 (20.0, 165.5)	99 (20.7, 171.3)
April 1 snow water equivalent (inches)	0.9 (0, 27.3)	0.02 (0, 6.0)
Snow residence time (days)	5.7 (0, 85.0)	0.2 (0, 34.9)

Dams and Diversions

There were 0.7 diversions per square mile and four dams in this unit. Of the 1,567 diversions within the unit boundary, 1,031 occurred on NFS land. According to the WCF, 76 percent of watersheds were properly functioning for flow characteristics. These watersheds had primarily free-flowing rivers and streams, unmodified lakes, and no or limited groundwater withdrawals (Potyondy and Geier 2011). Nineteen percent of watersheds were classified as functional-at-risk for flow characteristics. Peak and base flows are maintained in these watersheds, but changes in the timing, rate of change, or duration (or combination thereof) of mid-range discharges have occurred. Five percent of watersheds were classified as impaired for flow characteristics, meaning hydrographs significantly departed from natural flow regimes.

Departure from Natural Disturbance Regimes

According to the TCA, 50 percent of the unit is in poor or very poor condition for fire deficit. These areas have not burned as frequently as projected by LANDFIRE's mean fire return interval. Data from the TCA were available through 2018. Since then, 1.3, 0.8, and 1.7 percent of this unit has burned at low, moderate, and high severity (table 3), respectively. According to the WCF fire regime condition class attribute, 22 percent of watersheds in this unit were properly functioning. In these areas, vegetation characteristics, fuel composition, fire frequency, and fire severity were within the natural range of variation (NRV) across most of the land. Vegetation in these areas offers good protection to soil and water resources (Potyondy and Geier 2011). Twenty-one percent of watersheds were classified as functional-at-risk. These areas have moderate departure from reference fire regimes across the majority of each watershed (Potyondy and Geier 2011). Vegetation in these watersheds was somewhat affected by abnormal fire patterns, resulting in less protection of soil and water resources. Fifty-seven percent of watersheds were impaired for Fire Regime Condition Class. These areas tend to experience periods of fuel accumulation followed by infrequent, intense, high-severity fires that lead to vegetation mortality and poor protection of soil and water resources (Potyondy and Geier 2011). In addition to departures in fire regime, the magnitudes of maximum flows and 1.5-year return interval floods are expected to increase by 2 to 4 and 4 to 6 percent by the 2040s, respectively (see the section "Hydrologic Regimes" for each stream type). Miller et al. (2017) suggest that streams experiencing an increase in peak flow of greater than 36 percent are very likely to be impaired. Increases in peak flow of less than 5 percent are likely to have minimum impacts (Miller et al. 2017).

Table 3—Percentage of the Rogue River-Siskiyou National Forest—Klamath Mountains unit burned at low, moderate, and high severity from 2012 through 2021. Data from the Rapid Assessment of Vegetation Condition after Wildfire composite burn index.

Year	Percentage burned at low severity	Percentage burned at moderate severity	Percentage burned at high severity
2012	0.1	0.1	<0.1
2013	<0.1	0.1	<0.1
2014	0.1	0.1	0.1
2015	0.4	0.4	0.2
2016	--	--	--
2017	4.8	3.5	3.5
2018	5.0	2.9	2.7
2019	--	--	--
2020	1.3	0.8	1.7
2021	--	--	--

-- Indicates no fire.

Drought

According to the TCA, none of this unit was in poor or very poor condition for drought. The Z-scores (values that represent a long-term deviation in annual moisture) were calculated by the TCA using moisture indices from 1900 to 2017 (Cleland et al. 2017; Koch et al. 2015; see figure C.2 in Appendix C in volume 1 of this series). This index indicates that conditions in this unit ranged from near normal to severe drought, with most of the unit experiencing mild to moderate moisture deficits (fig. 1).

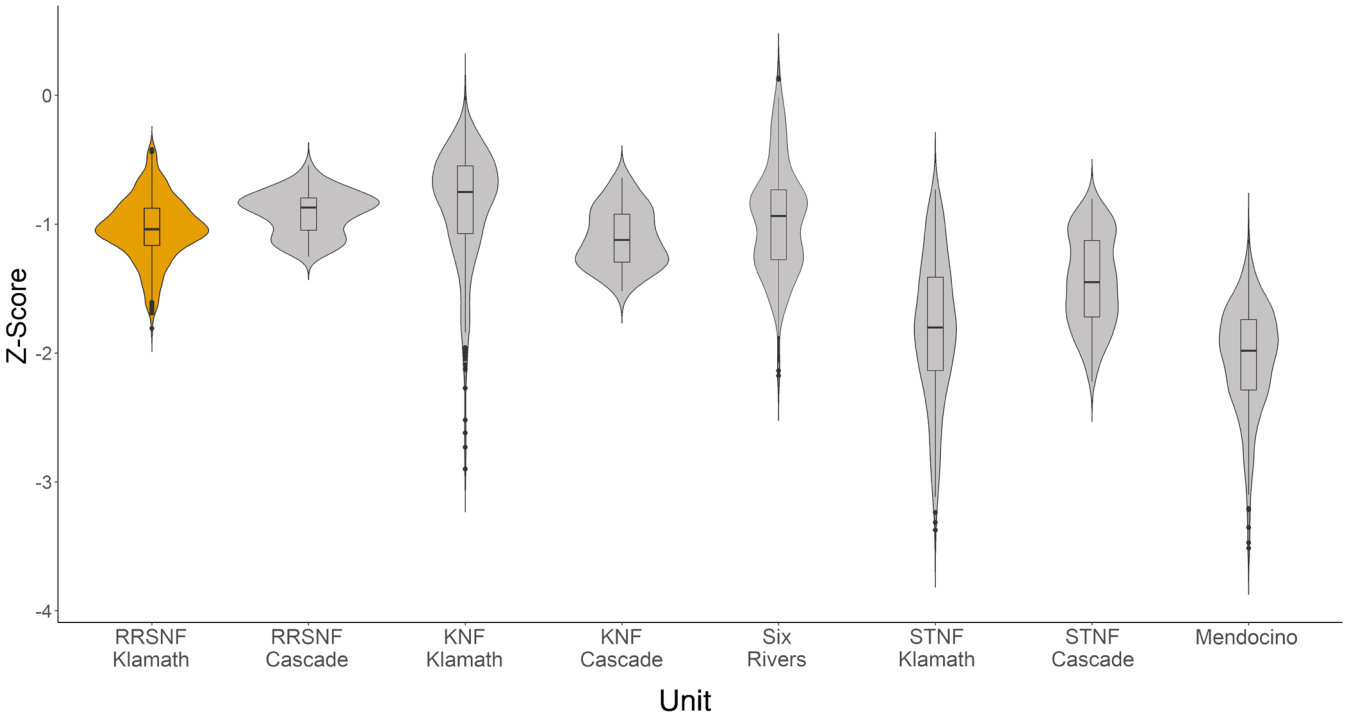

Figure 1—Violin and box plot displaying distribution, median, and quartile values of Z-scores for every 4 km pixel present within each study unit of the Five Forests cohort. Z-scores ranging from 0.5 to -0.5 indicate near-normal conditions, -0.5 to -1 indicate mild drought, -1 to -1.5 indicate moderate drought, -1.5 to -2 indicate severe drought, and -2 or less indicate extreme drought. KNF: Klamath National Forest; RRSNF: Rogue River-Siskiyou National Forest; STNF: Shasta-Trinity National Forest.

Invasive Species

During recent (2011–2019) visits to monitoring sites for the Aquatic and Riparian Ecosystem Monitoring Program (AREMP), invasive plants were observed in riparian areas. *Hedera helix* was observed at 1 site, *Lamiastrum galebdolon* was observed at 1 site, and *Rubus armeniacus* was observed at 19 sites. According to the WCF exotic and/or aquatic invasive species attribute, 74 percent of watersheds in this unit were properly functioning, 25 percent were classified as functional-at-risk, and one watershed was impaired. These findings mean that invasive species may be present in most watersheds in this unit, but that they have not greatly altered the condition of native species (Potyondy and Geier 2011).

Land-use Change

According to LANDFIRE data from 2016, 614 acres (0.04 percent) of the unit was classified as agriculture (fig. 2). We determined that 400 acres of agriculture occurred on NFS land, and the remaining 214 acres occurred on non-NFS lands within the unit. An additional 22,447 acres (1.6 percent) have been converted to development (fig. 2). Of these, 19,664 acres occurred on NFS land and the remaining 2,783 acres occurred on non-NFS lands within the unit. Conversion to agriculture and development has occurred within 4.0 percent of permanently flowing fish-bearing stream riparian reserves (RRs) within the administrative boundary, which includes some non-Forest Service lands. Conversion to agriculture and development also occurred within

1.5 percent of permanently flowing nonfish-bearing stream RRs, 1.4 percent of seasonally flowing fish-bearing stream RRs, and 1.9 percent of seasonally flowing nonfish-bearing stream RRs. Agricultural types are Western Cool Temperate Vineyard, Western Cool Temperate Close Grown Crop, Western Cool Temperate Row Crop, Western Cool Temperate Fallow/Idle Cropland, Western Cool Temperate Pasture and Hayland, and Western Cool Temperate Wheat. Seventy-two percent of developed land is classified as landscaped vegetation types, such as Western Cool Temperate Urban Deciduous Forest, 26 percent is roads, and 2 percent is other nonvegetated cover. Based on Miller et al. (2017), watersheds with less than 0.05 percent agriculture and less than 2.0 percent development rank among least-disturbed reference conditions.

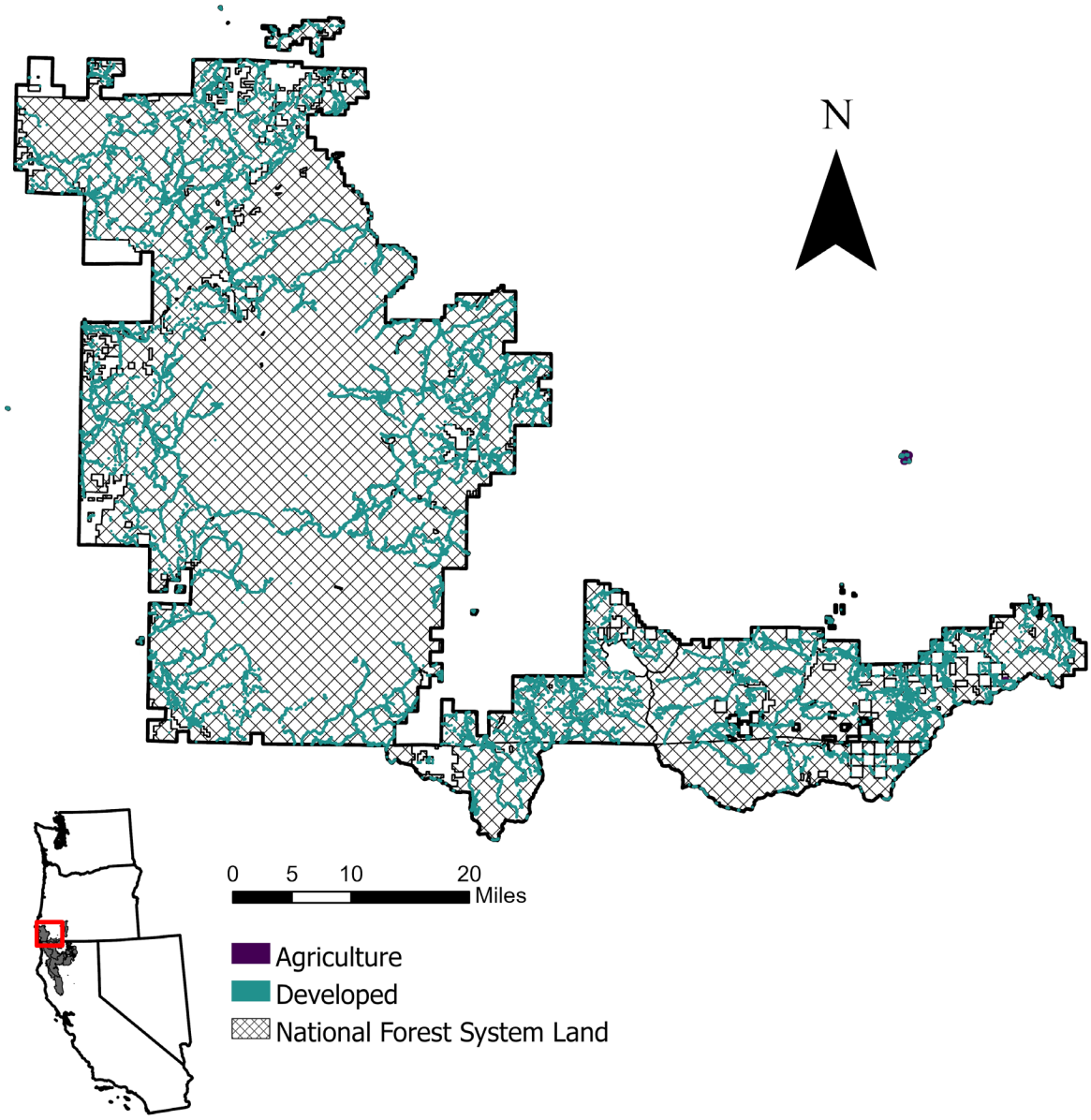

Figure 2—Agriculture and developed lands mapped by LANDFIRE within the Rogue River- Siskiyou National Forest—Klamath Mountains unit. Lower map shows location of study area within Oregon and California.

Livestock Grazing

Of this unit, 17 percent was within a grazing allotment. The WCF classified rangeland vegetation condition in 99 of the 145 total watersheds present in this unit. Of the rated watersheds, the WCF indicates 99 percent of watersheds were properly functioning for rangeland condition. In these watersheds, rangelands have the capacity to capture, store, and safely release water from rainfall, runoff, and snowmelt. These watersheds limit the redistribution and loss of soil resources, including nutrients and organic matter (Potyondy and Geier 2011). One watershed was classified as functional-at-risk. Rangelands in this watershed had suffered a reversible loss in function. These areas were vulnerable to irreversible degradation (Potyondy and Geier 2011). No watersheds were classified as impaired for rangeland vegetation condition.

Loss of Forest Cover

According to the WCF loss of forest cover attribute, 42 percent of watersheds were properly functioning. Less than 5 percent of NFS land in these watersheds contained cut-over, denuded, or deforested land that could contribute to increased erosion and sediment supply or alter stream temperature (Potyondy and Geier 2011). Eighteen percent of watersheds were classified as functional-at-risk, meaning between 5 and 15 percent of NFS land within the watershed was cut over, denuded, or deforested. Forty percent of watersheds were classified as impaired, meaning more than 15 percent of NFS land was cut over, denuded, or deforested. Eight percent of the unit was located within timber harvest projects that happened between 1939 and 2017. Less than 1 percent of the RR area was within a timber harvest or stand treatment project since 1994. Most of the timber projects that have occurred within the Five Forests planning area under the Northwest Forest Plan have been thinning or selection cuts. The most extensive treatment type in the RRSNF—Klamath Mountains unit was commercial thinning, which affected 1 percent of the RR area. Stand clearcuts affected 0.1 percent. In recent decades, timber harvest has become less of a driver for change in the loss of forest cover attribute as large, uncharacteristic wildfire has become increasingly common (Steve Bachmann, USDA Forest Service, Yreka, CA, personal communication, June 28, 2021). Since 2013, 37 percent of this unit was within wildfire-burned area perimeters, and 8 and 8 percent of the unit was burned at moderate and high severity, respectively. Thirty-five percent of the RR area was within burned-area perimeters of fires that occurred between 2013 and 2020.

Mining

There were 901 mines located in this unit and 266 acres impacted (fig. 3). Nearly all mines are historical and not active (Steve Bachmann, USDA Forest Service, Yreka, CA, personal communication, July 13, 2021). Most mines were classified as prospect pits. Open pit mines impacted more acres than other mining activities.

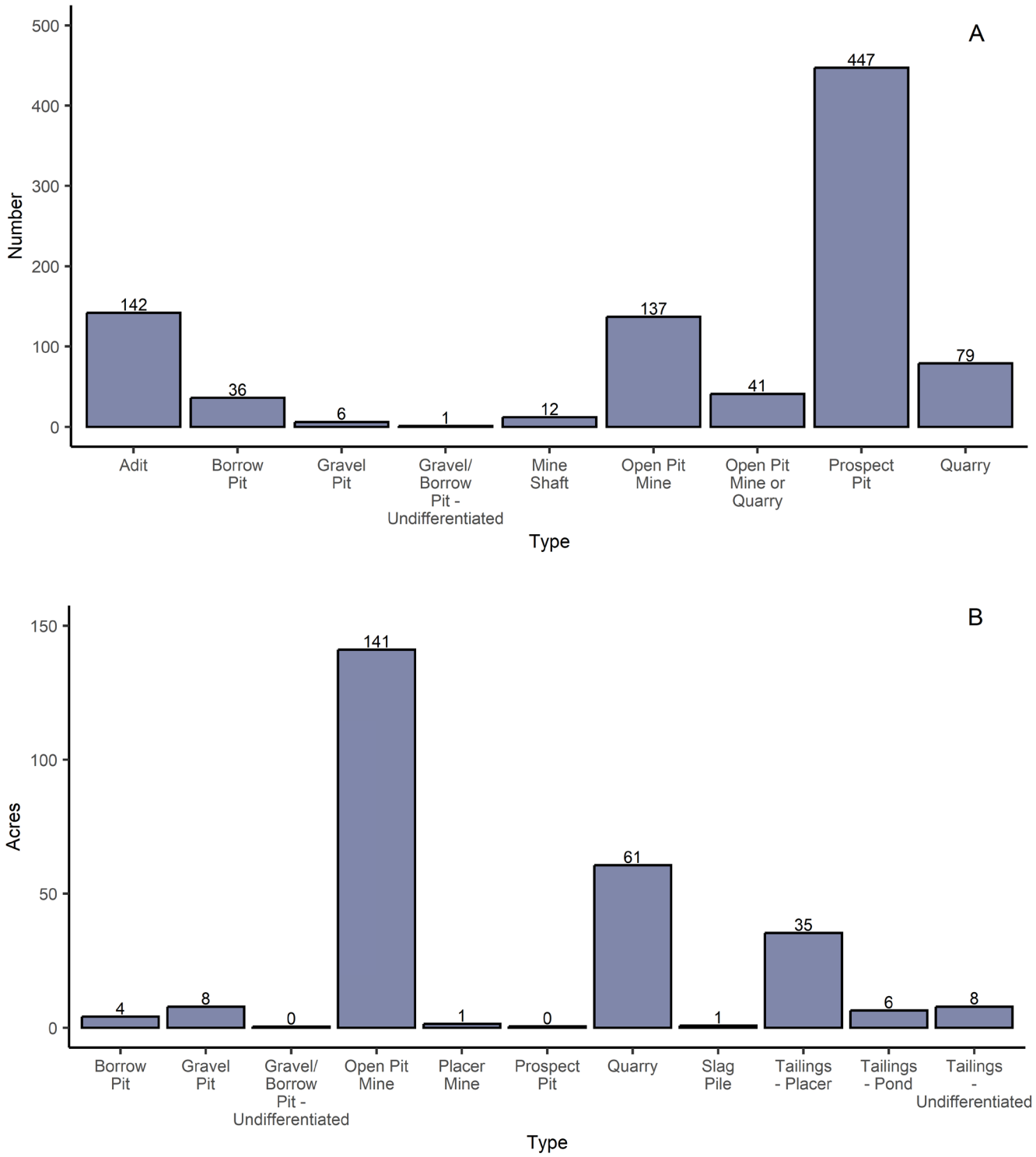

Figure 3—(a) Number of different types of mines and (b) acreage impacted by mining activities in the Rogue River-Siskiyou National Forest—Klamath Mountains unit.

Pollution

According to the TCA Pollution Indicator, 27 percent of this unit was in poor or very poor condition. This indicator considers acid and nitrogen deposition (figs. C.3, C.4) and ozone exposure. Based on the WCF soil contamination attribute, 85 percent of watersheds were properly functioning. Atmospheric deposition of sulfur or nitrogen (or both) in these watersheds is more than 10 percent below the terrestrial critical load and there are no substantial areas of soil contamination. Fifteen percent of watersheds were rated functional-at-risk, meaning atmospheric deposition of sulfur or nitrogen is 0 to 10 percent below the terrestrial critical load and there are only limited areas of soil contamination. No watersheds were rated as impaired.

Recreation

This unit had 0.3 trail mile per square mile. See the section "Roads" below for information on the application of best management practices (BMPs) for trails. There were 245 recreation sites (0.1 sites per square mile) in this unit. Most of these sites were trailheads and campgrounds (fig. 4).

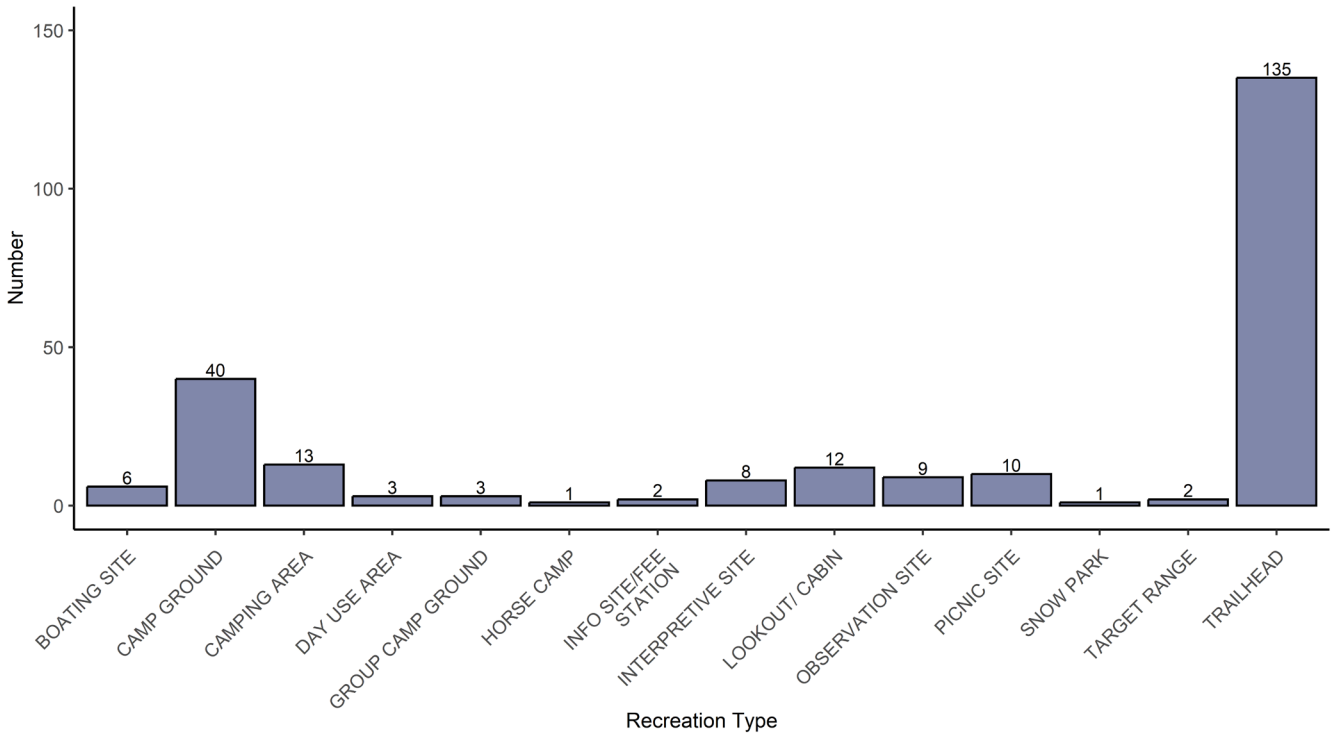

Figure 4—Number of different recreation site types within the Rogue River-Siskiyou National Forest—Klamath Mountains unit.

Roads

There were 1.3 road miles per square mile in this unit and 1.2 road miles per square mile within RRs. According to the TCA, 59 percent of the unit was in poor or very poor condition for road density, suggesting roads have impacted terrestrial ecological integrity in most of

the unit. According to the WCF roads and trails condition indicator, 50 percent of watersheds in this unit were properly functioning. Hydrologic regimes within these watersheds were largely unimpacted by the density and distribution of roads and trails (Potyondy and Geier 2011). Forty-two percent of watersheds were rated as functional-at-risk, meaning there was moderate probability that the hydrologic regime was substantially altered by road density or distribution. The remaining 9 percent of watersheds were classified as impaired; there was high probability that density and distribution of roads had contributed to substantial hydrologic alterations. According to the WCF, 26 percent of watersheds were properly functioning for road and trail maintenance; that is, best management practices (BMPs) for maintenance of drainage features are applied to more than 75 percent of roads, trails, and water crossings in the watershed. Seventy-one percent of watersheds were rated functional-at-risk for road and trail maintenance, indicating that BMPs for maintenance of drainage features are applied to between 50 and 75 percent of roads, trails, and water crossings in the watershed. For the 3 percent of watersheds that were classified as impaired for road and trail maintenance, BMPs for maintenance of drainage features are applied to less than 50 percent of roads, trails, and water crossings in the watershed. Eighty-three percent of watersheds were properly functioning for mass wasting, meaning few roads were on unstable landforms and there was no danger of large quantities of debris being delivered to the stream channel. Nine percent of watersheds were in functional-at-risk condition for mass wasting; some roads were on unstable landforms, and there was moderate evidence of active movement. In these watersheds, there was some danger of delivery of large quantities of debris to the stream channel. Nine percent of watersheds were classified as impaired for mass wasting, indicating most roads were on unstable landforms subject to mass wasting. In these watersheds, there was extensive evidence of active movement, and delivery of large quantities of debris to the stream was a primary concern.

Vegetation Mortality

Of this unit, 2 and 3 percent was impacted by tree mortality between 2009 and 2013 and between 2014 and 2018, respectively (fig. 5). The WCF insects and disease attribute indicates that 77 percent of watersheds were properly functioning, meaning less than one-fifth of forested land was at imminent risk of abnormally high levels of tree mortality due to insects and disease. Eleven percent of watersheds were rated functional-at-risk; that is, between 20 and 40 percent of forested land had an imminent risk of abnormally high tree mortality due to insects and disease. Twelve percent of watersheds were impaired, meaning more than 40 percent of forested land had imminent risk of abnormally high tree mortality due to insects and disease.

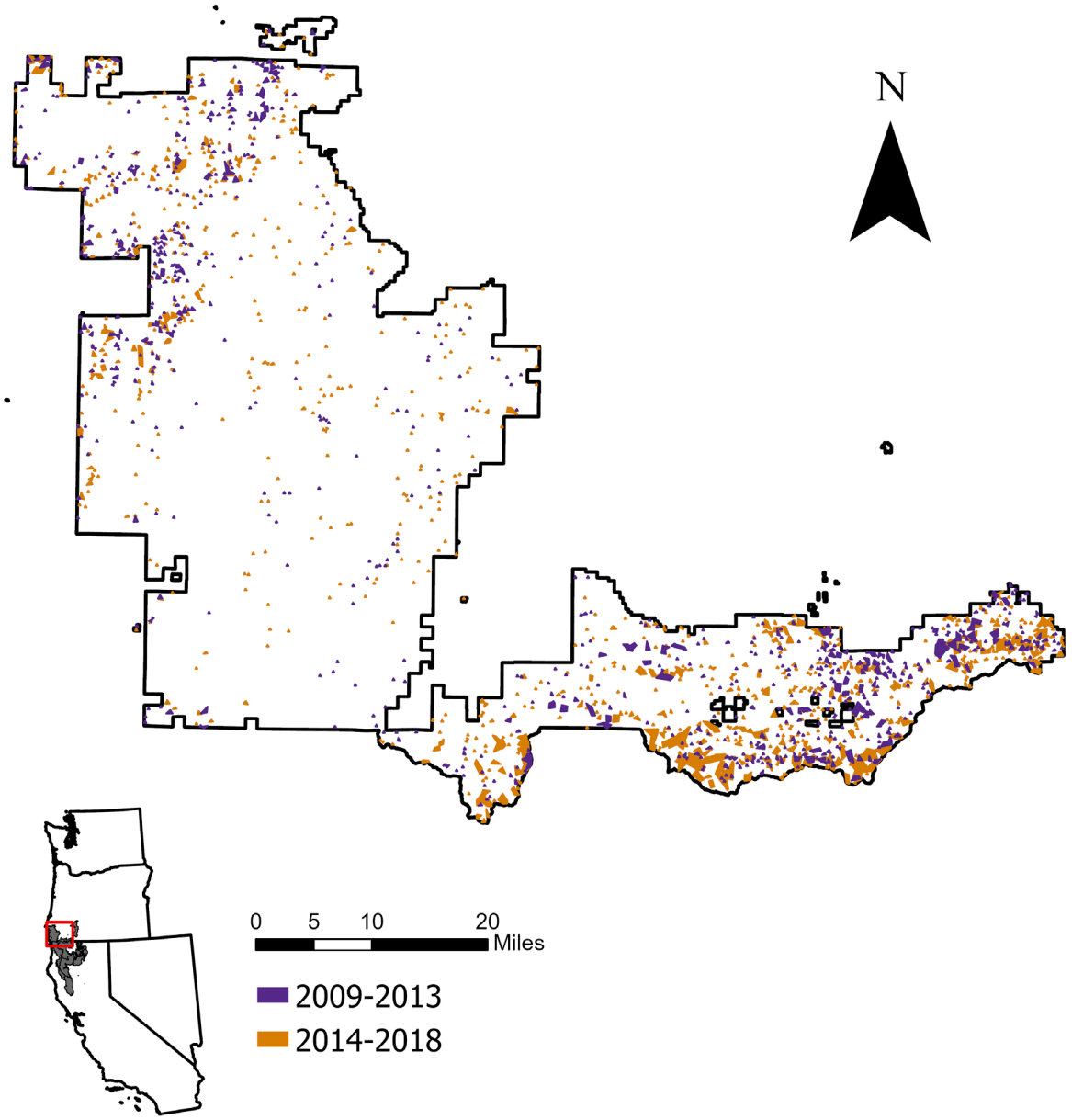

Figure 5—Tree mortality on the Rogue River-Siskiyou National Forest—Klamath Mountains unit mapped by the USDA Forest Service Forest Health Assessment and Applied Sciences Team for two time periods. Lower map shows location of study area within Oregon and California. Data from the Terrestrial Condition Assessment.

Ecosystems

Streams

The National Hydrography Dataset mapped 6,850 total miles of streams within the administrative boundary of the RRSNF—Klamath Mountains unit. Of the miles mapped, 6,270 occurred on NFS land. Of streams on NFS land, 21 percent were classified as permanently flowing fish-bearing streams, 59 percent were permanently flowing nonfish-bearing streams, less than 1 percent were seasonally flowing fish-bearing streams, and 20 percent were

seasonally flowing nonfish-bearing streams (fig. 6). According to Loose et al. (2019), streams within the Five Forests planning area have moderate to high sensitivity to climatic and anthropogenic stressors and to changes in disturbance regimes.

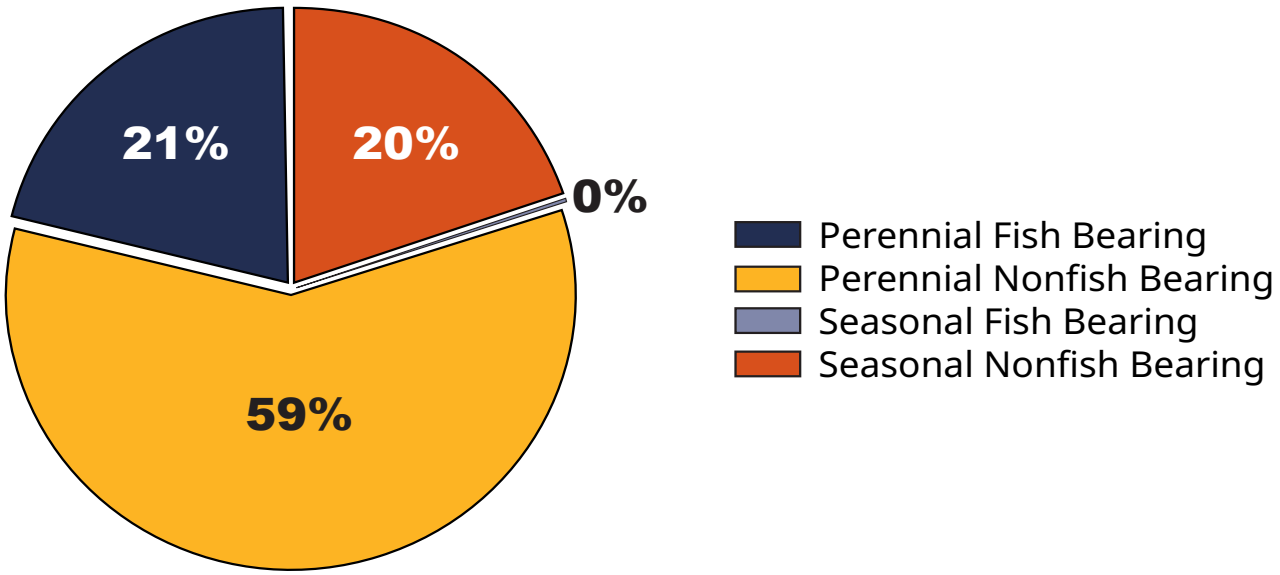

Figure 6—Relative proportions of stream types present in the Rogue River-Siskiyou National Forest—Klamath Mountains unit.

Management Status

The RRSNF—Klamath Mountains unit contains potential spawning and rearing habitat for the Federally threatened Oregon Coast evolutionarily significant unit of coho salmon and the Southern Oregon and Northern California Coasts evolutionarily significant unit of coho salmon. Potential habitat is also present for the Oregon Coast distinct population segment for steelhead, the Klamath Mountains Province distinct population segment of steelhead, the Oregon Coast evolutionarily significant unit of Chinook salmon, and the Southern Oregon/Northern California evolutionarily significant unit of Chinook salmon. Potential habitat is present for other threatened and sensitive species including Pacific lamprey and Pacific eulachon (table 1 in the Appendix in this volume; also see appendix table 1 for scientific names of fauna).

Watersheds in this unit either are protected or receive special management considerations under several land-use designations. Late successional reserves (LSRs) compose 44 percent of the unit, key watersheds (KWs) 38 percent, and congressional reserves 19 percent. An additional 10 percent is within adaptive management areas and 2 percent is within administratively withdrawn areas. Streams are also buffered by RRs, which make up 21 percent of the unit.

Intrinsic Potential

Intrinsic potential was quantified for streams in 36 eight-digit hydrologic unit code (HUC8) watersheds that overlap with the Five Forests planning area. The RRSNF—Klamath Mountains unit contains streams with high intrinsic potential (HIP) for Chinook salmon, coho salmon, and steelhead (fig. 7). There are 546 stream miles classified as HIP for steelhead, 58 miles for Chinook salmon, and 46 miles for coho salmon. Of the 11 HUC8 watersheds overlapping this

unit, 6 have streams with HIP within the unit. The Illinois River watershed has the greatest length of streams with HIP for Chinook salmon, coho salmon, and steelhead (appendix table 3). This habitat is largely accessible and unobstructed by dams outside of the study unit or by culverts, bridges, and other barriers within the unit (fig. 8). Across species, 38 to 46 percent of HIP stream miles are within KWs and 38 to 54 percent are within LSRs (appendix table 2).

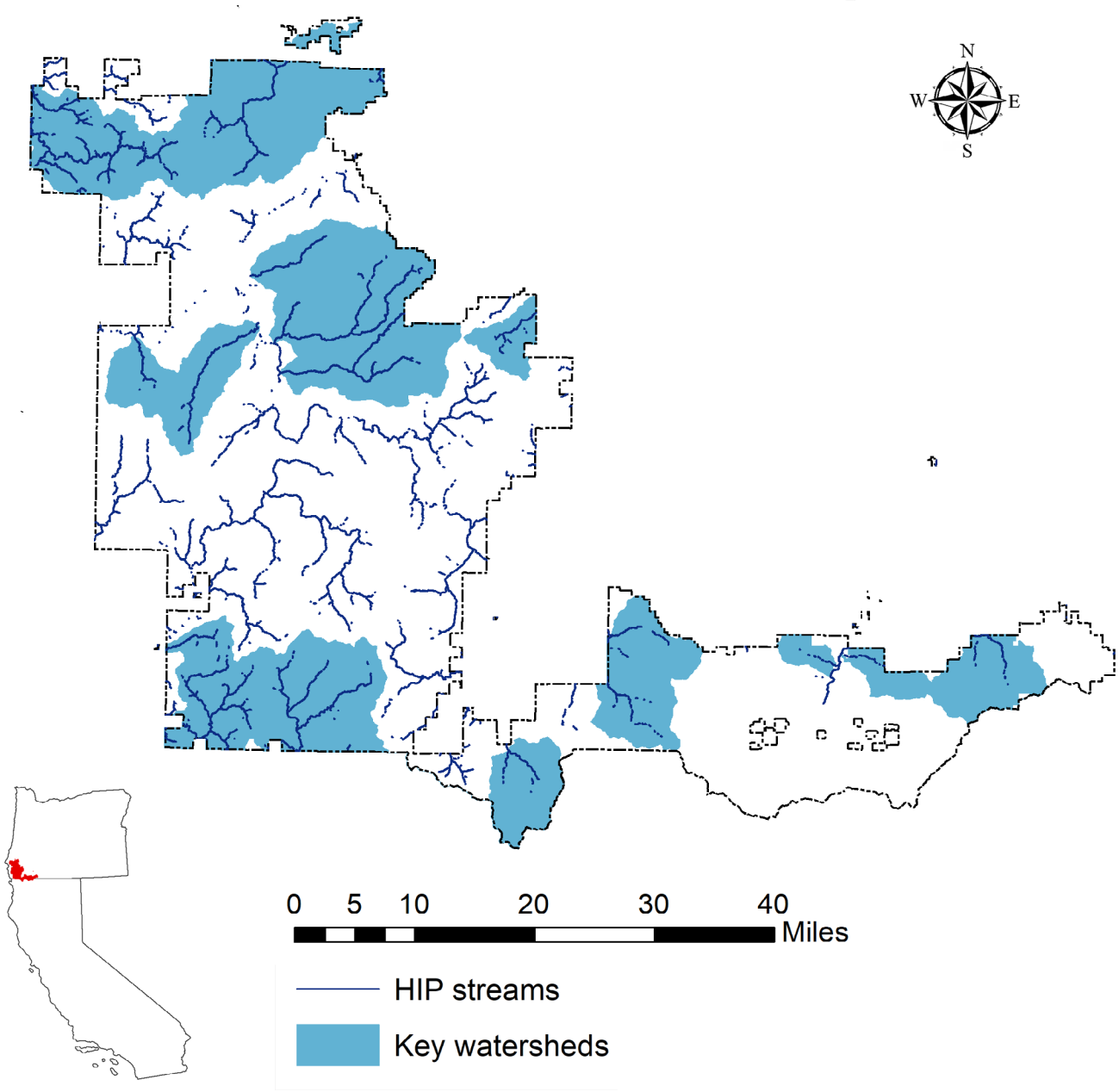

Figure 7—Distribution of key watersheds and streams with high intrinsic potenital (HIP) for salmon and steelhead in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Lower map shows study area within Oregon and California.

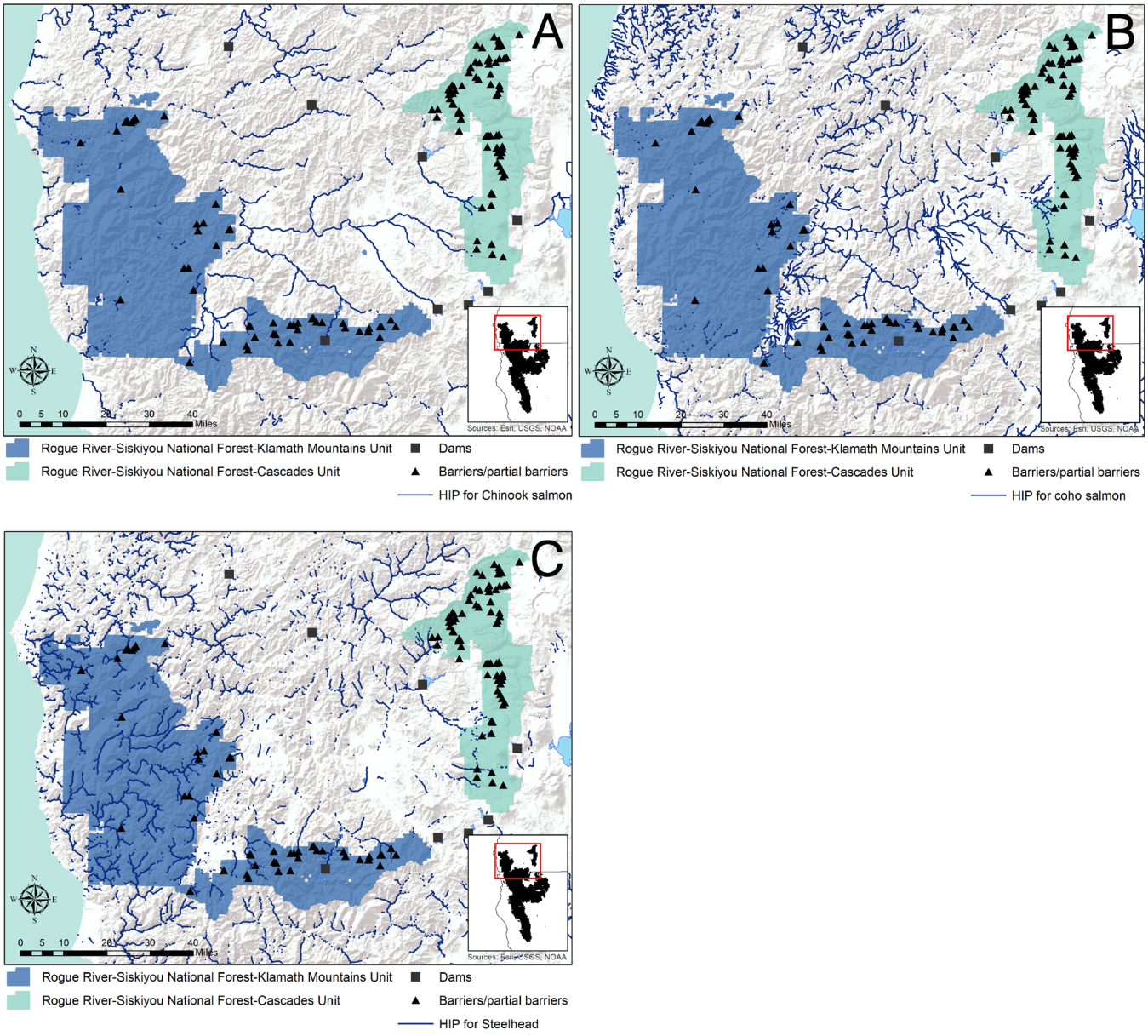

Figure 8—Distribution of streams with high intrinsic potential (HIP) for (a) Chinook salmon, (b) coho salmon, and (c) steelhead on the Rogue River-Siskiyou National Forest. Dams and other barriers to fish passage are also depicted. Inset maps show location of study areas within Oregon and California.

Permanently Flowing Fish-Bearing Streams

Distribution

There are 1,490 miles of permanently flowing fish-bearing streams within the administrative boundary of the RRSNF—Klamath Mountains unit (fig. 9). Of these, 1,340 miles are on NFS land. Riparian reserves associated with these streams cover 87,500 acres within the administrative boundary (78,700 acres on NFS land), or 6 percent of the unit (fig. 9). According to data from the Forest Service Bioregional Assessment (BioA), permanently flowing fish-bearing streams and their RRs are evenly distributed throughout this unit (fig. 10). According to the WCF, dams and

diversions have had limited impacts on hydrologic regimes; 4 percent of watersheds containing permanently flowing fish-bearing streams are classified as impaired for flow characteristics (table 4). Drought has not been significant in this unit, and small percentages of RRs have been converted by development and agriculture. Therefore, the distribution of permanently flowing fish-bearing streams is likely to be intact in this unit.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 1,088 miles of permanently flowing fish-bearing stream habitat in the RRSNF—Klamath Mountains unit. Flow metrics modeled for 1977 through 2006 indicated that 91 percent (988 miles) of permanently flowing fish-bearing streams in this unit had early, rainfall-dominated runoff (fig. 11). The remaining 9 percent (100 miles) had intermediate runoff timing. No late, snowfall-dominated runoff systems was present in this habitat. A shift in runoff timing is likely to occur; a transition to earlier runoff in many historically intermediate reaches is expected by the 2040s (fig. 11). A projected 82 percent reduction in the extent of reaches with intermediate runoff timing suggests that climate change is likely to contribute to altered hydrologic regimes by mid-century (table 5).

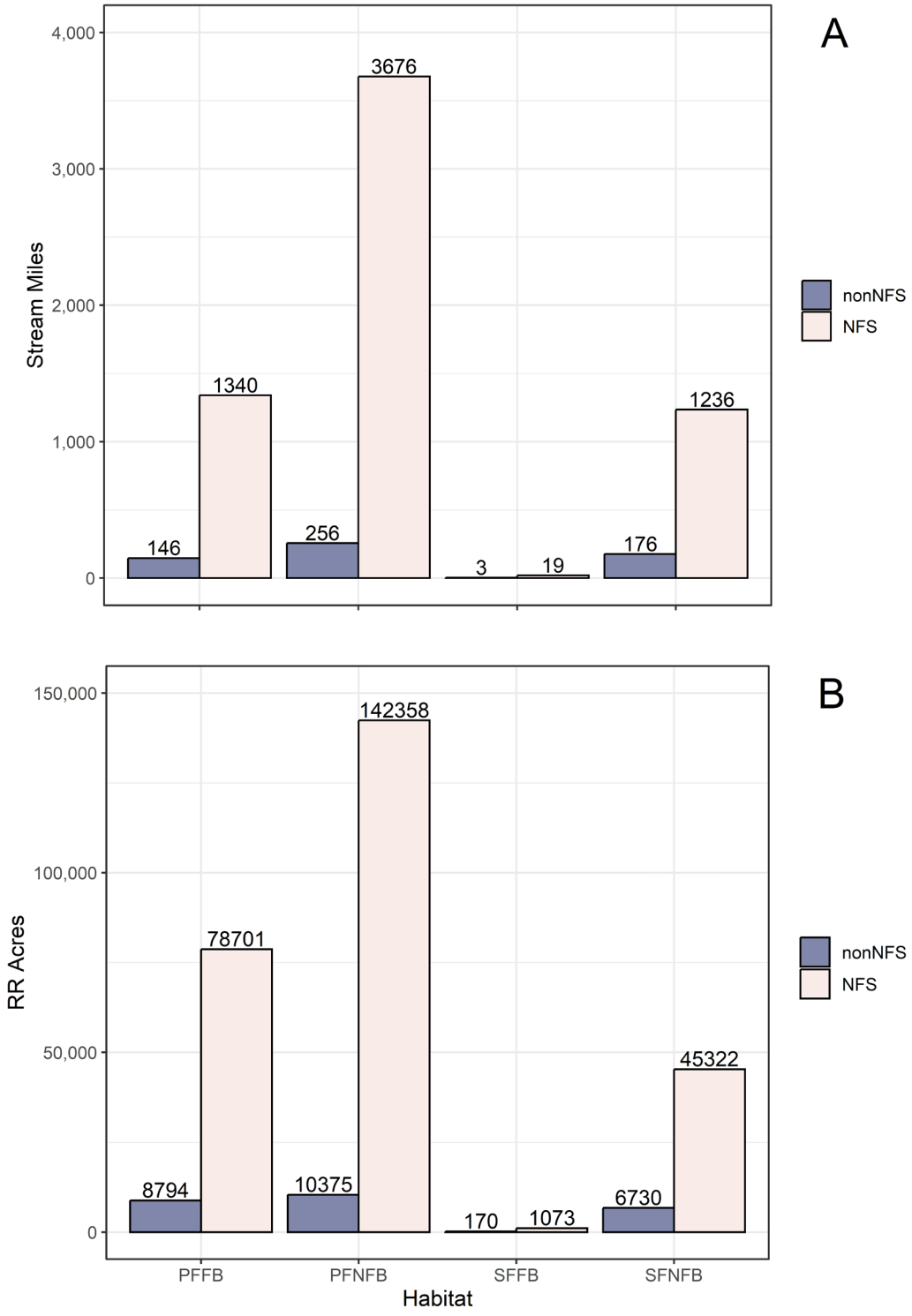

Figure 9—(a) Total stream miles and (b) riparian reserve acres associated with the four stream habitat types in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. NFS: National Forest System; RR: riparian reserve; PFFB: permanently flowing fish-bearing; PFNFB: permanently flowing nonfish-bearing; SFFB: seasonally flowing fish-bearing; SFNFB: seasonally flowing nonfish-bearing.

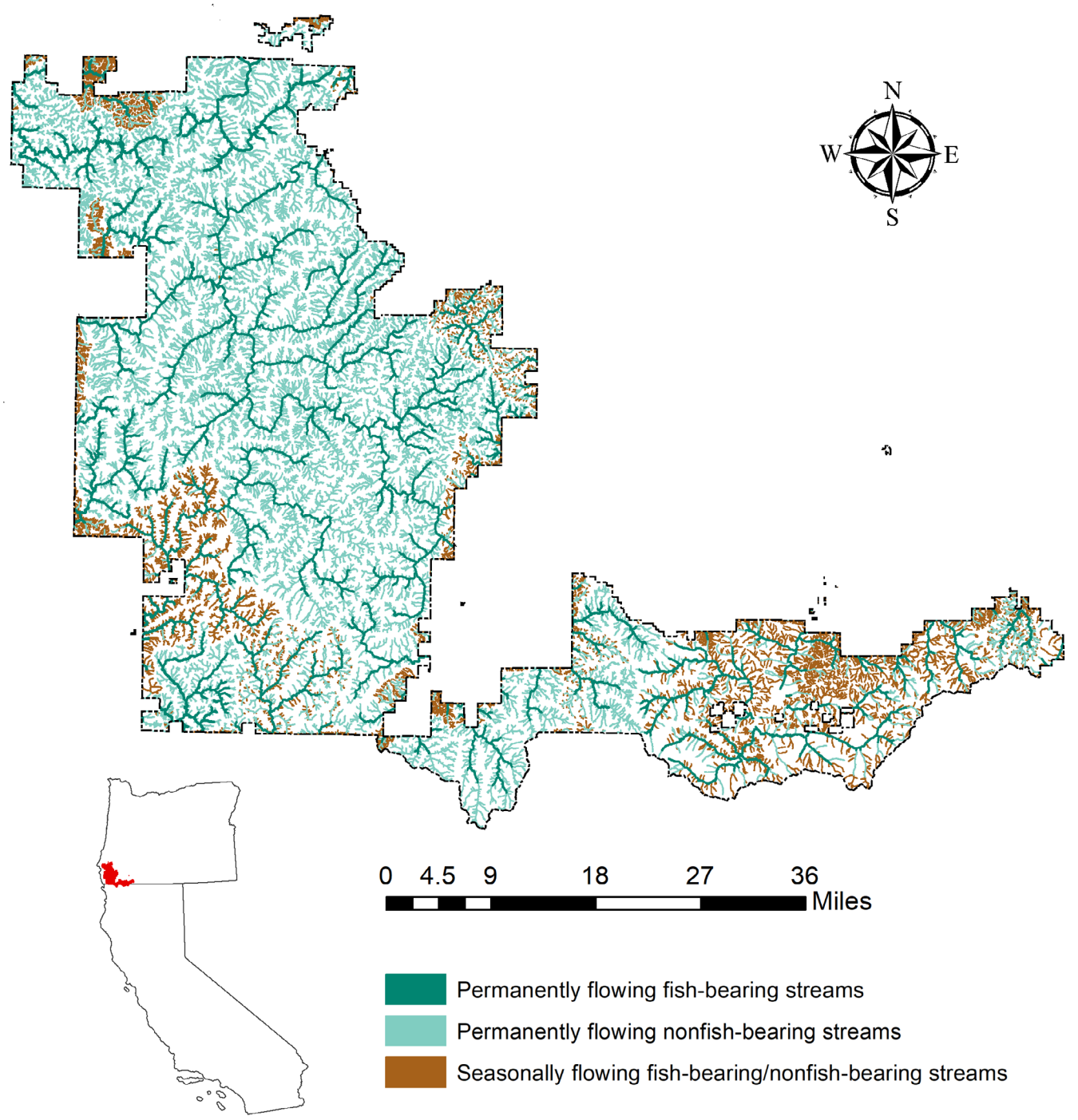

Figure 10—Distribution of riparian reserves associated with streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Lower map shows location of study area within Oregon and California.

Table 4—Percentage of the 93 watersheds with permanently flowing fish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Klamath Mountains unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	26	72	2
Exotic and/or aquatic invasive species attribute	73	26	1
Fire regime condition class attribute	14	22	65
Flow characteristics attribute	73	23	4
Habitat fragmentation attribute	77	23	0
Insects and disease attribute	76	10	14
Large woody debris attribute	26	53	22
Loss of forest cover attribute	44	15	41
Mass wasting attribute	97	3	0
Open road density attribute	58	40	2
Proximity to water attribute	13	76	11
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	17	83	0
Road and trail maintenance attribute	17	81	2
Roads and trails condition indicator	57	40	3
Soil contamination attribute	84	16	0
Water quality indicator	44	31	25
Water quality problems attribute	54	15	31

[a] Rangeland vegetation condition rated in 69 watersheds.

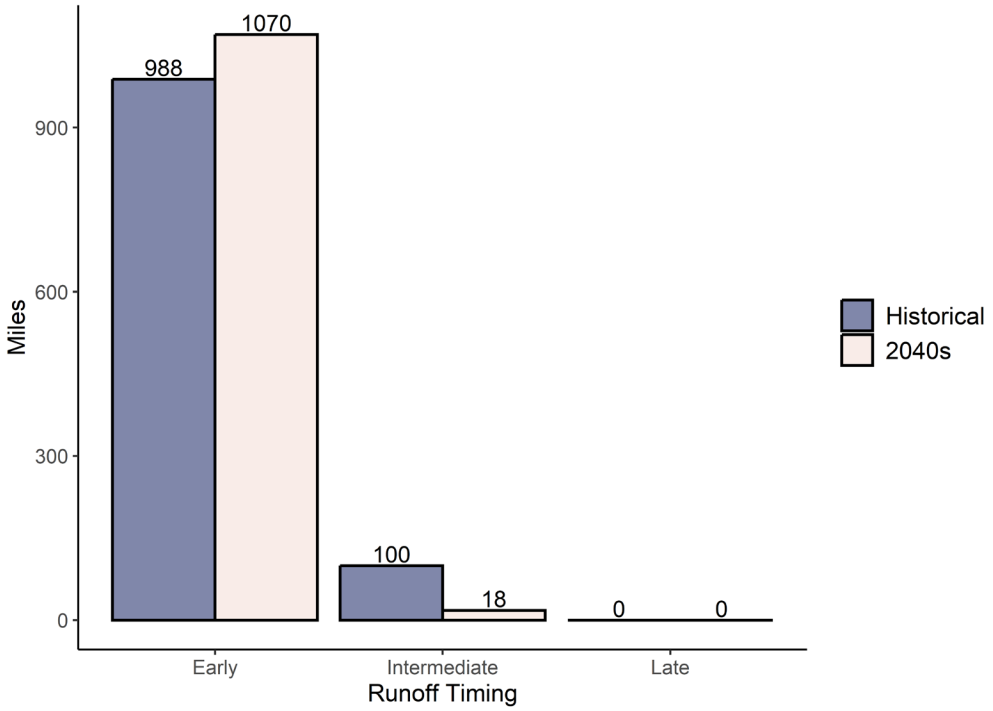

Figure 11—Total length (miles) of permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 5—Flow metrics modeled for permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	988 miles	1,070 miles	+8
	Extent of intermediate, transient runoff systems	100 miles	18 miles	-82
	Extent of late, snowmelt-dominated runoff systems	0 miles	0 miles	--
Magnitude	Average summer daily flow (June 1–September 30)	118 cfs[a]	95 cfs	-20
	Average August daily flow	70 cfs	67 cfs	-5
	Average baseflow index	0.09 cfs	0.09 cfs	-2
	Average 1.5-year return interval flood	5,409 cfs	5,628 cfs	+4
	Average maximum modeled flood	17,327 cfs	17,956 cfs	+4
Duration	Average daily flow	506 cfs	505 cfs	-0.3

[a] cfs: cubic feet per second.
-- Indicates no change.

The magnitudes of high and low flows in permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit are expected to change by mid-century (table 5). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of average 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to substantially change between the historical period and mid-century (table 5), flow duration is likely to be impacted by shifts in the timing and amount of runoff. Because runoff timing is likely to occur earlier, the magnitude of 1.5-year return interval floods is expected to increase, and the magnitude of summer baseflows is likely to decrease, we expect that permanently flowing fish-bearing streams in this unit are Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 3). Some of the land in this unit has been converted to agriculture and development. The amount of development may be large enough in some watersheds to have localized impacts on hydrology. The TCA indicates that drought and climate change have not had significant impacts in the unit. Of the 981 diversions located within permanently flowing fish-bearing streams, 572 were on NFS land. In addition to these diversions, a single dam (Spalding Pond dam on Soldier Creek) was also located within permanently flowing fish-bearing streams. According to the WCF, these structures have had limited impacts on hydrologic regimes, with 4 percent of watersheds containing this stream habitat classified as impaired for flow characteristics (table 4). The WCF also suggests that hydrologic impacts of roads, livestock grazing, and timber harvest on permanently flowing fish-bearing streams are likely to be limited, but that altered wildfire regimes and loss of forest cover may have contributed to substantial changes in hydrology in many watersheds (table 4). Based on these results, we estimate hydrology of these habitats is likely to have been altered. Current trends in temperature and precipitation (see the section "Stressors" on page 3), projected changes in snowpack (see the section "Stressors"), and modeled flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be further impacted by projected changes in climate.

Water Quality

Water temperatures appear to be increasing in permanently flowing fish-bearing streams of the RRSNF—Klamath Mountains unit (fig. 12a). According to the Northwest Stream Temperature (NorWeST) model, the median August stream temperature between 1993 and 2011 for these habitats was 59.4 °F. The median August stream temperature between 2002 and 2011 was 59.5 °F (fig. 12b). Stream temperatures are expected to increase further by mid- and late century, with modeled median August stream temperatures of 61.7 °F by the 2040s and 63.3 °F by the 2080s (fig. 12b). Of the 1,340 miles of permanently flowing fish-bearing stream habitat in this unit, 305 miles appear on California's 303(d) list of impaired waters due to temperature.

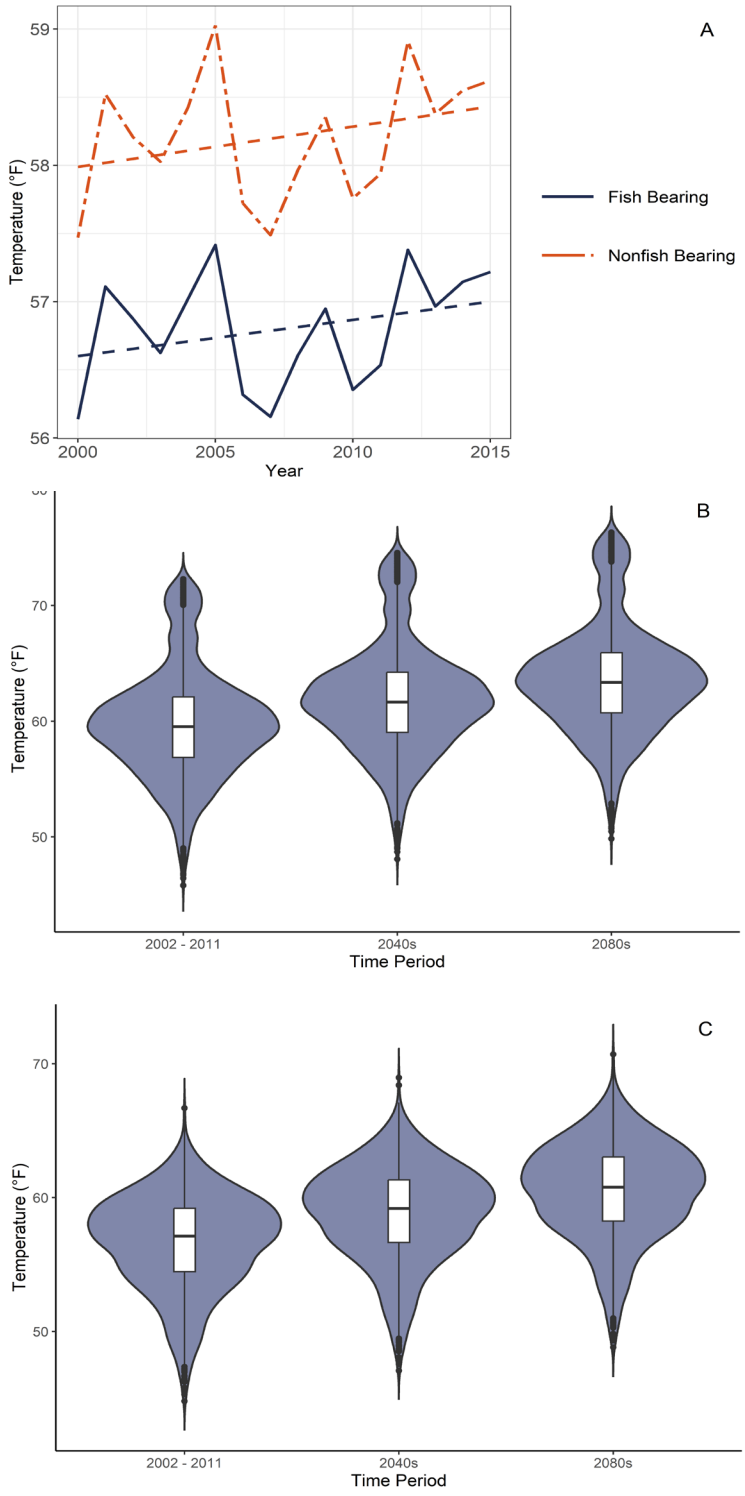

Figure 12—For the Rogue River-Siskiyou National Forest—Klamath Mountains unit: (a) modeled median August stream temperature and trend line from 1993 to 2015 for permanently flowing streams; (b) distribution of modeled mean August stream temperature values in reaches of permanently flowing fish-bearing streams for historical and future periods; (c) distribution of modeled mean August stream temperature values in reaches of permanently flowing nonfish-bearing streams for historical and future periods. Data from the NorWeST model.

According to output from the U.S. Geological Survey's Spatially Referenced Regression On Watershed attributes (SPARROW) model, permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit receive suspended sediment loads primarily from forested and urban lands, including roads (fig. 13). The largest source of total nitrogen is atmospheric deposition. These streams also receive relatively large nitrogen loads from nitrogen fixation by red alder trees, as well as runoff from scrublands, grasslands, and urban lands, including roads (fig. 13). The largest source of phosphorus to permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit is weathering of upland geology. In addition to natural phosphorus loading from geologic sources, these streams also receive relatively large inputs of phosphorus from urban lands, including roads (fig. 13). In general, incremental sediment and nutrient loads are low throughout this unit, with limited reaches exposed to large incremental or accumulated loads (table 6; figs. C.5–C.40). Of the 1,340 miles of permanently flowing fish-bearing streams present in this unit, 13 miles appear on the 303(d) list due to pH and less than 1 mile is listed for sedimentation.

Permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to stressors that can impact water quality, including altered fire regimes, loss of forest cover, land-use change, and pollution (see the section "Stressors" on page 3). The TCA indicates a departure from natural fire regimes in half of the unit, and most watersheds containing permanently flowing fish-bearing streams are classified as impaired by the WCF fire regime condition class attribute (table 4). Loss of forest cover, driven primarily by wildfire, is likely to impact these habitats, with nearly half of watersheds containing permanently flowing fish-bearing streams classified as impaired (table 4). These stressors are likely to interact with warming air temperatures and contribute to an overall increase in stream temperatures. Nearly one-quarter of permanently flowing fish-bearing streams in this unit are on the 303(d) list due to temperature. Development, including roads, may impact water quality in localized areas, but the WCF suggests that roads are generally maintained and that mass wasting is limited in watersheds with these stream habitats (table 4). Permanently flowing fish-bearing streams in this unit receive suspended sediment, nitrogen, and phosphorus from natural sources, but also are likely to receive inputs from largely human-generated atmospheric deposition and urban lands, including roads (fig. 13). Additionally, the TCA indicates more than one-quarter of this unit is significantly impacted by pollution, including nitrogen deposition. Nevertheless, the WCF suggests no watersheds containing this habitat type are impaired due to extensive areas of soil contamination and less than one-third of watersheds have extensive water quality problems such as excessive sediment or nutrients (table 4). Twenty-four percent of permanently flowing fish-bearing streams are listed as impaired. Riparian and wetland vegetation may improve the resistance of permanently flowing fish-bearing streams to stressors, as most watersheds containing this habitat are classified as functional-at-risk for riparian/wetland vegetation condition (table 4). Based on these results, it appears that water quality in permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit is likely to have been impacted by loss of forest cover and other water quality problems such as excessive sediment or nutrients. We estimate that water quality in these streams is likely to have been altered.

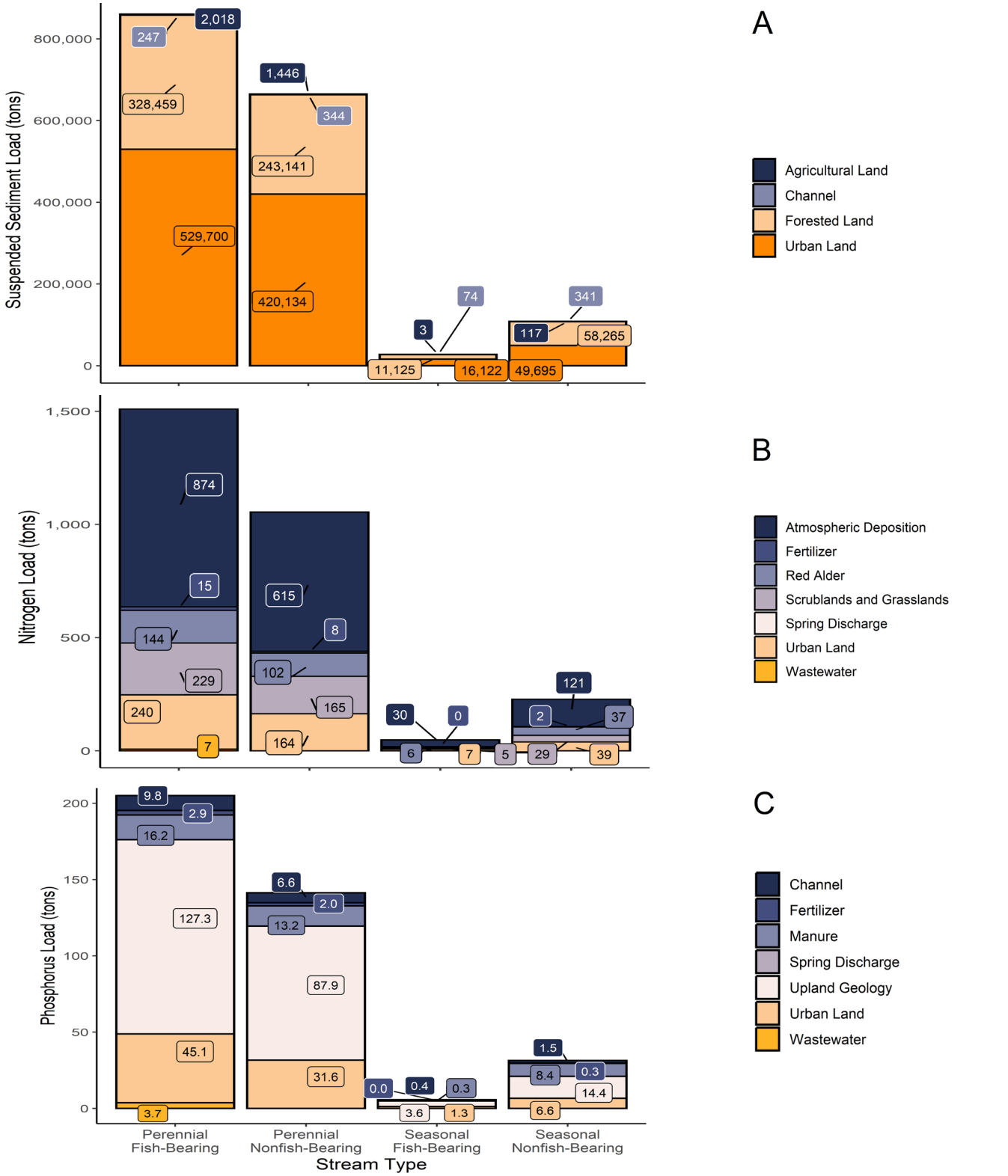

Figure 13—Incremental suspended sediment (a), total nitrogen (b), and total phosphorus loads (tons) (c) for streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data from the U.S. Geological Survey's SPARROW model.

Table 6—Median (minimum; maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0; 10,449)	0 (0; 30)
	Forest land	664 (0.1; 431,137)	123 (0; 3,881)
	Agricultural land	0 (0; 26,242)	0 (0; 495)
	Urban land (including roads)	195 (0; 485,826)	17 (0; 14,721)
Total nitrogen	Scrublands and grasslands	0.36 (0; 446)	0.05 (0; 2.96)
	Atmospheric deposition	1.84 (0; 1,043)	0.37 (0; 9.50)
	Urban land (including roads)	0.47 (0; 486)	0.06 (0; 3.69)
	Spring discharge	0 (0; 0)	0 (0; 0)
	Red alder trees	0 (0; 75.3)	0 (0; 10.1)
	Fertilizer and manure applied to crop lands	0 (0; 103)	0 (0; 0.94)
	Wastewater treatment discharge	0 (0; 616)	0 (0; 4.51)
Total phosphorus	Urban land (including roads)	.09 (0; 53.0)	0 (0; 0.50)
	Wastewater treatment discharge	0 (0; 152)	0 (0; 2.51)
	Fertilizer and manure applied to crop lands	0 (0; 6.42)	0 (0; 0.10)
	Manure from grazing cattle applied to rangeland	0 (0; 52.7)	0 (0; 0.94)
	Weathering of upland geology	0.23 (0; 146)	0.04 (0; 0.96)
	Channel	0.2 (0; 52.2)	0 (0; 0.12)
	Spring discharge	0 (0; 0)	0 (0; 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

Connectivity

Stream connectivity can be disrupted by dams and diversions, but most watersheds containing permanently flowing fish-bearing streams have primarily free-flowing rivers with no or minor alterations from natural hydrographs. See the section "Hydrologic Regimes" on page 16 for more information on the number of diversions in this habitat and their impact as indicated by the WCF flow characteristics attribute. According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 4).

Fish passage data from AREMP show that there were 143 culverts in or bridges crossing permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit. Of these structures, 37 were full barriers, 53 structures were passable, 7 were partial barriers, and 46 structures had no data regarding passability. The AREMP functional stream network classified 1,060 miles of permanently flowing fish-bearing streams in this unit. According to this dataset, 2 percent of these streams were blocked by a barrier culvert somewhere downstream. One percent of stream miles were above a partial barrier. Eight percent were above a passable culvert. Twenty-nine percent were above an open bridge or a structure with no data regarding passability. Finally, 60 percent of permanently flowing fish-bearing streams in this unit had no culvert or bridge downstream.

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the channel in most watersheds containing permanently flowing fish-bearing streams (table 4). According to the WCF roads and trail maintenance attribute, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in most watersheds containing this stream habitat (table 4).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the center of flow mass date for these streams was February 14. The center of flow mass is expected to shift earlier, with February 11 calculated as the mean date for the 2040s (fig. 14). Mean summer baseflows are likely to continue declining, with a 20 percent reduction in average summer daily flow from June 1 to September 30 expected by the 2040s (see the section "Hydrologic Regimes" on page 16). Earlier runoff and reduced summer baseflows may contribute to longitudinal fragmentation in this habitat. The magnitude of 1.5-year return interval floods is expected to increase by 4 percent, potentially increasing lateral connectivity by mid-century (see the section "Hydrologic Regimes").

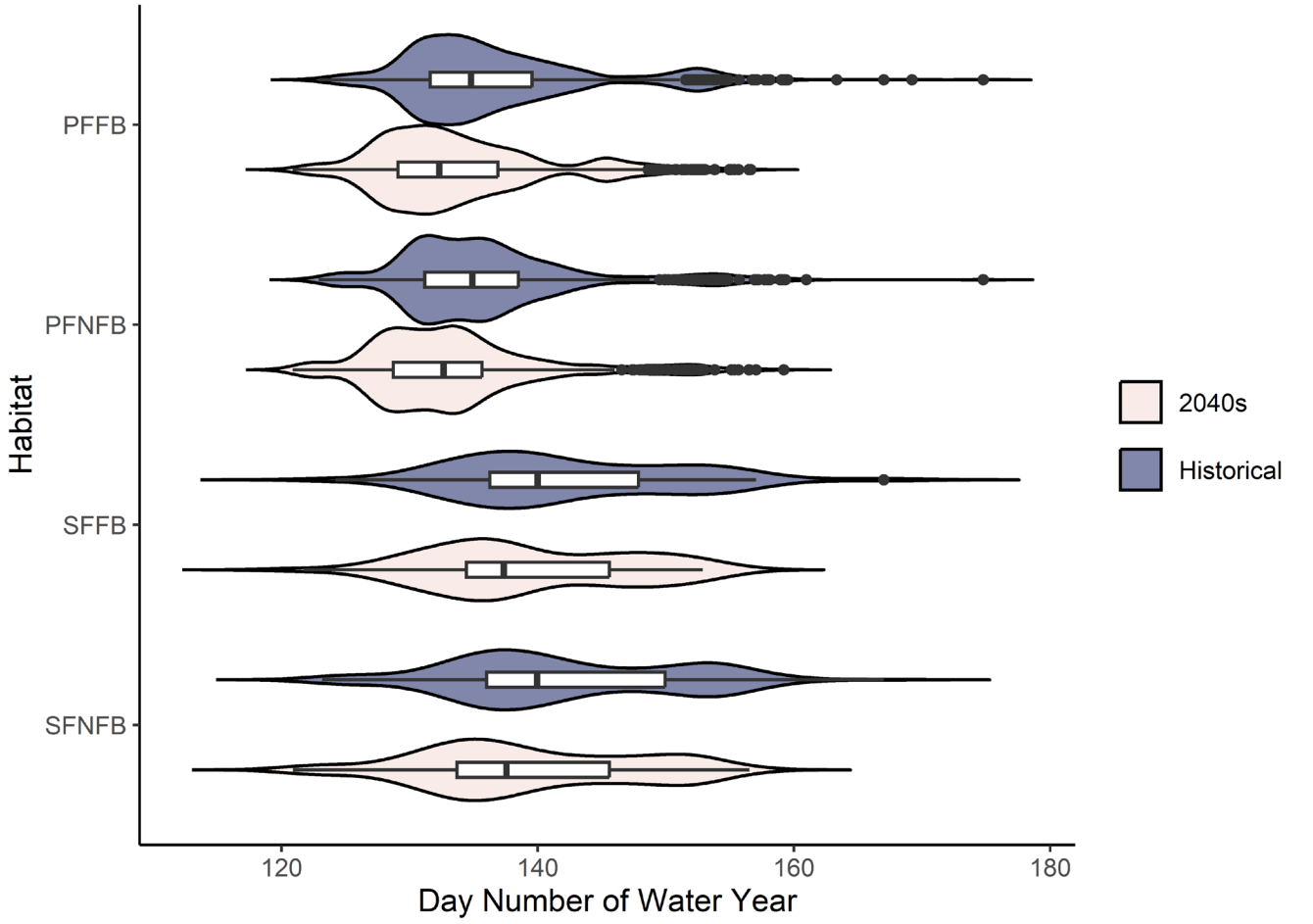

Figure 14—Distribution of modeled center of flow mass dates for stream habitats in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data from the Western U.S. Stream Flow Metrics dataset. Day 120 = January 29; day 180 = March 30. PFFB: permanently flowing fish-bearing; PFNFB: permanently flowing nonfish-bearing; SFFB: seasonally flowing fish-bearing; SFNFB: seasonally flowing nonfish-bearing.

The median August stream temperature between 2002 and 2011 was 59.5 °F (fig. 12b), according to the NorWeST model. Stream temperatures are expected to increase by mid- and late century (see the preceding section, "Water Quality" on page 21). Stream temperatures were reported at 22 AREMP sampling sites within permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit between 2013 and 2017. The average 7-day maximum temperature at these sites was 70.5 °F. Based on AREMP stream temperature thresholds and modeled mean August stream temperatures from 2002 through 2011, 61 percent of total modeled stream miles exceeded 59 °F, and 42 percent exceeded 60.8 °F (fig. 12b). Fragmentation of permanently flowing fish-bearing streams due to temperature is likely to increase by the end of this century (fig. 15).

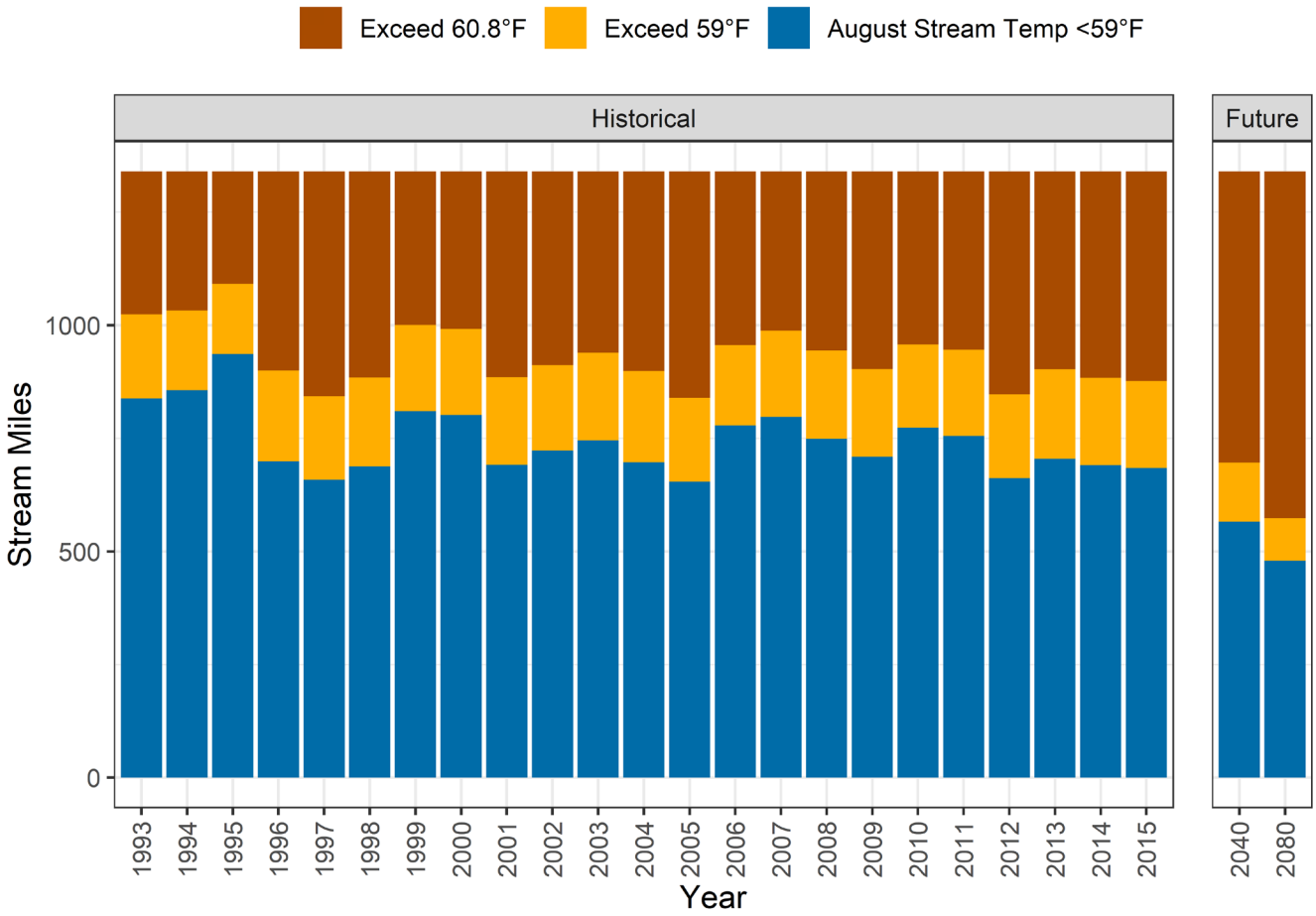

Figure 15—Total length (miles) of permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit that have mean August stream temperature less than 59 °F, exceeding 59 °F, and exceeding 60.8 °F from 1993 to 2015 and for future periods. Data from the NorWeST model.

According to the WCF attribute, habitat fragmentation is not a serious concern in most watersheds containing permanently flowing fish-bearing stream habitat (table 4). Additionally, the WCF channel shape and function attribute indicates there is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain in most watersheds with this habitat type present (table 4).

Permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to limited stressors that impact connectivity (see the section "Stressors" on page 3). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. The AREMP functional stream network dataset estimates that 97 percent of these habitats are unobstructed by downstream barriers. According to NorWeST stream temperature data, many reaches of permanently flowing fish-bearing streams are likely to experience temporary fragmentation due to warm stream temperatures during the summer months. Nevertheless, both the WCF habitat fragmentation attribute and channel shape and function attribute indicate watersheds containing these habitats exhibit longitudinal and lateral connectivity in most stream reaches.

Based on these results, we estimate connectivity of permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit is likely to be high. Connectivity in these systems is likely to be vulnerable to projected climate impacts, including warming stream temperatures and reduced summer flows, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Instream Habitat Quality

There are 14 miles of permanently flowing streams designated as critical habitat for the Oregon Coast evolutionarily significant unit of coho salmon within this unit in the Sixes River watershed. Approximately 28 percent of this critical habitat is within a KW. There are fewer than 1 permanently flowing stream miles of critical habitat for this evolutionarily significant unit within the Coquille River watershed in this unit. Critical habitat for the Southern Oregon and Northern California Coasts evolutionarily significant unit of coho salmon has been designated in the Applegate, Chetco, Illinois, Lower Rogue, and Smith watersheds. Data showing the extent of this habitat are unavailable. There are 59 miles of permanently flowing fish-bearing stream habitat with HIP for Chinook salmon, 46 miles for coho salmon, and 546 miles for steelhead (appendix table 2).

The presence of instream wood was measured at 55 AREMP sampling sites along permanently flowing fish-bearing streams. Sampling sites contained instream wood in four size classes and wood jams were present at 22 percent of sites (appendix table 6). According to the WCF, large woody debris is present but recruited into the system at less-than-natural rates in more than half of watersheds containing this habitat type (table 4).

Data from gradient nearest neighbor (GNN) models indicate that as of 2017, trees and snags in RRs have the potential to provide shade and down wood to streams. Mean tree canopy cover was estimated to be 45 percent for conifers and 36 percent for hardwoods in RRs. Mean tree density was estimated to be 49.4 stems per acre for live trees between 9.8 and 19.7 inches in diameter, 15.4 stems per acre for live trees 19.7 inches or greater in diameter, 7.7 stems per acre for snags between 9.8 and 19.7 inches in diameter, and 3.2 stems per acre for snags 19.7 inches or greater in diameter (appendix table 8). Spatial data from the Forest Service indicate 6 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1939 and 2021 and 0.4 percent of the area was within projects completed since 1994. From 2013 through 2020, 36 percent of RR area was within wildfire-burned area perimeters. These fires likely increased the short-term supply of instream wood. Additional sources of wood, including permanently flowing and seasonally flowing nonfish-bearing tributaries, should be considered as well (see the section “Riparian Reserves Condition” for each of these stream types). The preceding results suggest that instream wood is present in moderate amounts in multiple size classes, and there is potential for recruitment of multiple size classes of wood from RRs. This potential has not been affected by recent timber harvest but is likely to have been influenced by recent wildfires.

Fish passage data from AREMP indicate that 97 percent of permanently flowing fish-bearing streams in this unit are unobstructed by downstream full or partial barriers. Additionally, no watersheds containing this habitat type are classified as impaired by the WCF habitat

fragmentation attribute. See the preceding section, "Connectivity" on page 26, for more information.

According to the WCF, channels in most watersheds containing permanently flowing fish-bearing stream habitat in this unit maintain width-to-depth ratios within NRV and vertical stability except in places where riparian vegetation has been disturbed, between 5 and 25 percent of the channels have widened, channel degradation or aggradation (or both) has occurred in relatively small sections of the network, and downcutting has disconnected some channels from their floodplain (table 4).

Hydrologic regimes are likely to continue shifting; large declines in summer baseflow and small increases in bankfull flows are expected by mid-century (see the section "Hydrologic Regimes" on page 16). According to the WCF flow characteristics attribute, most watersheds containing this habitat have primarily free-flowing rivers and streams, with no or minor alterations from natural hydrologic conditions (table 4). According to NorWeST stream temperature data, most stream reaches maintain mean August stream temperatures that support cold-water fish (see the section "Connectivity" on page 26). Stream temperatures are expected to increase by mid-century (see the preceding section, "Water Quality" on page 21). According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 4).

Permanently flowing fish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to stressors that may impact the quality of instream habitat, including roads, loss of forest cover, and departure from natural fire regimes (see the section "Stressors" on page 3). According to the TCA, roads have impacted terrestrial ecological integrity in more than half of the unit, but the WCF suggests roads have had less effect on watershed function. Loss of forest cover has significantly impacted many watersheds containing permanently flowing fish-bearing streams. Finally, the TCA and WCF indicate altered fire regimes are likely to have impacted terrestrial ecological integrity and watershed function in most of the unit. It appears that large woody debris is present but recruited at less-than-natural rates, and that stream channel degradation has occurred in small sections of these streams. Based on these results, it is likely that instream habitat in permanently flowing fish-bearing streams has been impacted by departure from natural fire regimes. We estimate that instream habitat quality is likely to have been altered.

Riparian Reserves Condition

Five percent of the area within RRs associated with permanently flowing fish-bearing streams is classified by LANDFIRE as existing riparian vegetation. This vegetation is patchily distributed in narrow canyons and valleys of the RRs (fig. 16). The area classified as potential riparian vegetation is greater (14 percent), indicating that riparian extent has likely departed from historical conditions as a result of conifer encroachment, stream modifications, or other changes.

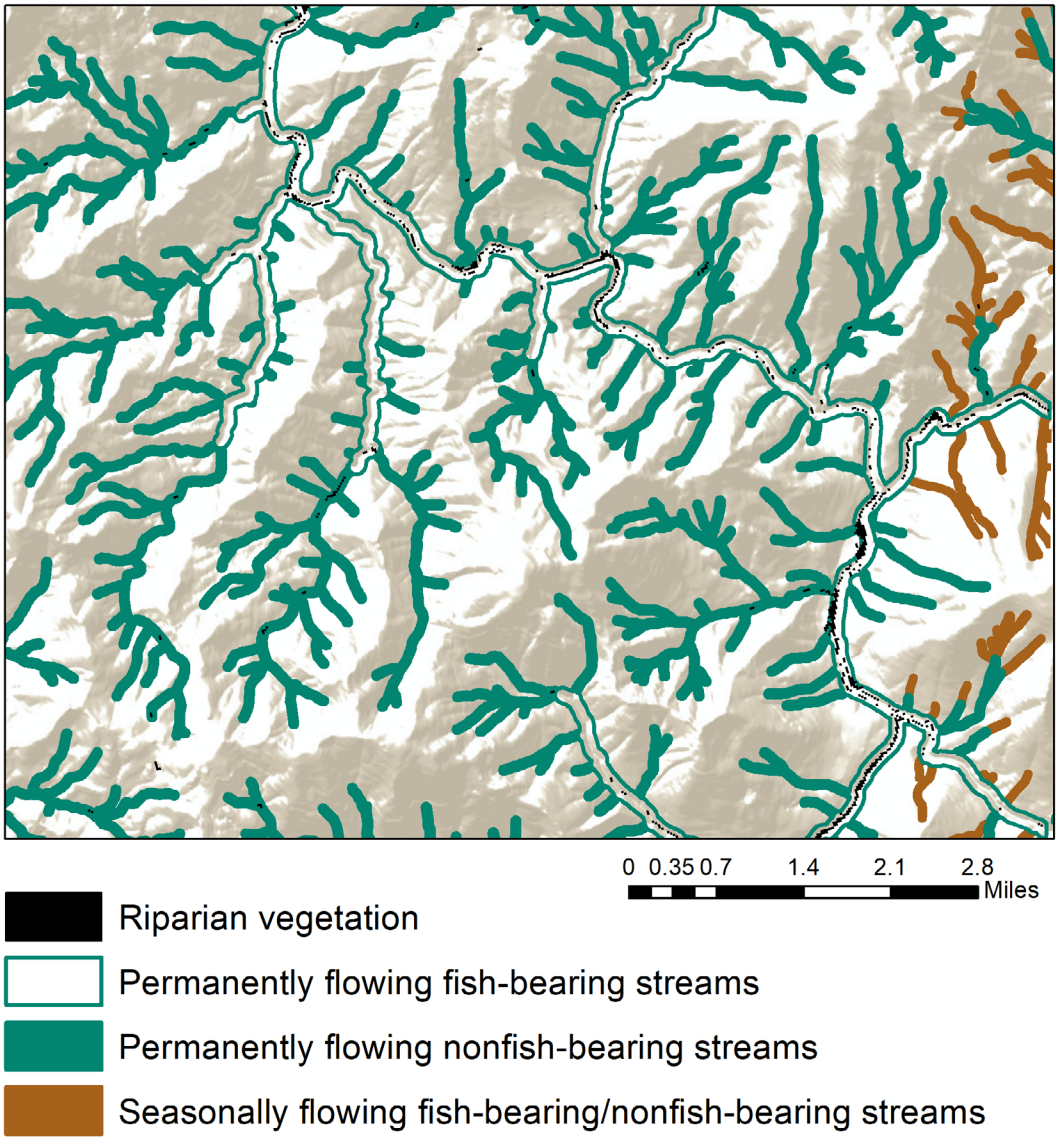

Figure 16—Example of LANDFIRE existing vegetation classification, showing extent of riparian vegetation within riparian reserves associated with each stream type in the Rogue River-Siskiyou National Forest—Klamath Mountains unit.

Of the vegetation in RRs classified by LANDFIRE as riparian, 83 percent is forest or woodland (appendix table 7). Woody riparian species include willows (*Salix* spp.), bigleaf maple, red alder, white alder (*Alnus rhombifolia*), Port Orford Cedar (*Chamaecyparis lawsoniana*), Oregon ash (*Fraxinus latifolia*), and California laurel. Output from GNN models classified 34 percent of RR area in 2017 as conifer forest, 33 percent as mixed conifer/hardwood forest, and 17 percent as hardwood forest. The most abundant forest types in RRs, such as *Pseudotsuga menziesii* and *Pseudotsuga menziesii*/*Notholithocarpus densiflorus*, are dominated by early- to mid-successional tree species (appendix table 11). Forest types with late successional (*Pseudotsuga menziesii*/*Abies grandis*) co-dominants are present as well.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is greater than 120 years, basal-area weighted mean diameter is greater than 19.7 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl and marbled murrelet (appendix table 1). The presence of down wood and snags benefits Siskiyou Mountain salamander, harlequin duck, purple martin, fisher, Pacific marten, and other vertebrates (appendix table 1). If down wood, snags, or large trees are near streams, they contribute to habitat quality for Chinook salmon, coho salmon, steelhead, and other fishes.

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 78 percent was upland vegetation with historically short (≤35 years) fire return intervals. Thirteen percent of the vegetation, most of which is along streams, is a combination of riparian and upland species with longer (35–200 years) fire return intervals (fig. 17). Nine percent of the vegetation is classified as having a very long (>200 years) fire return interval. Most of this vegetation is within RRs in the northern portion of the unit (fig. 18). From 2013 through 2020, 36 percent of RR area was within wildfire-burned area perimeters. According to data from the Global Forest Change project (GFC), these fires caused forest loss in 10 percent of the RR area. Spatial data from the Forest Service indicate 6 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1939 and 2021 and 0.4 percent of the area was within projects completed since 1994.

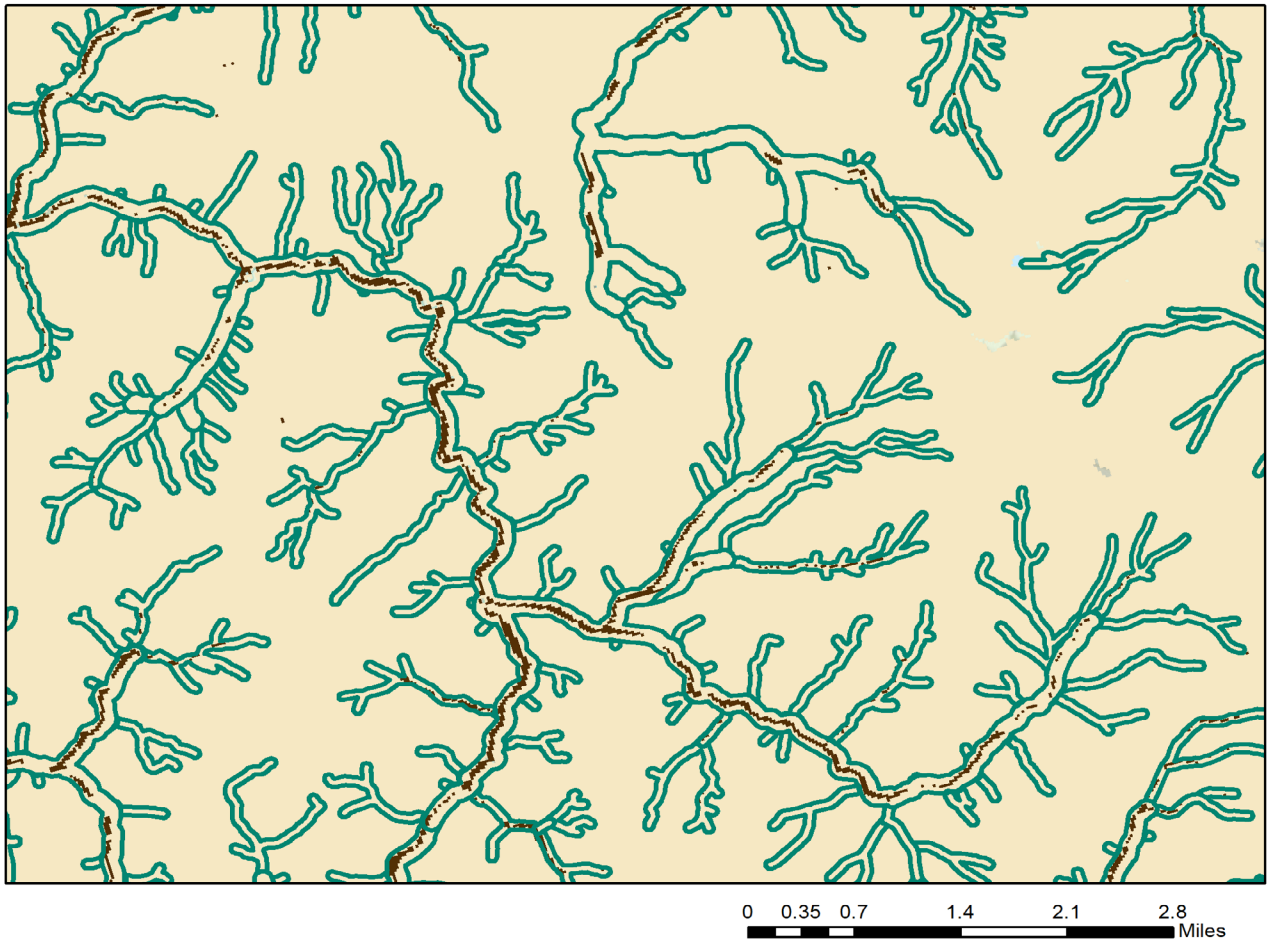

Figure 17—Example of LANDFIRE fire regime group classification, showing extent of vegetation classified as fire regime group I (fire return interval ≤35 years) and fire regime group III or IV (fire return interval 35–200 years). This map depicts vegetation within and outside of riparian reserves in the Rogue River-Siskiyou National Forest—Klamath Mountains unit.

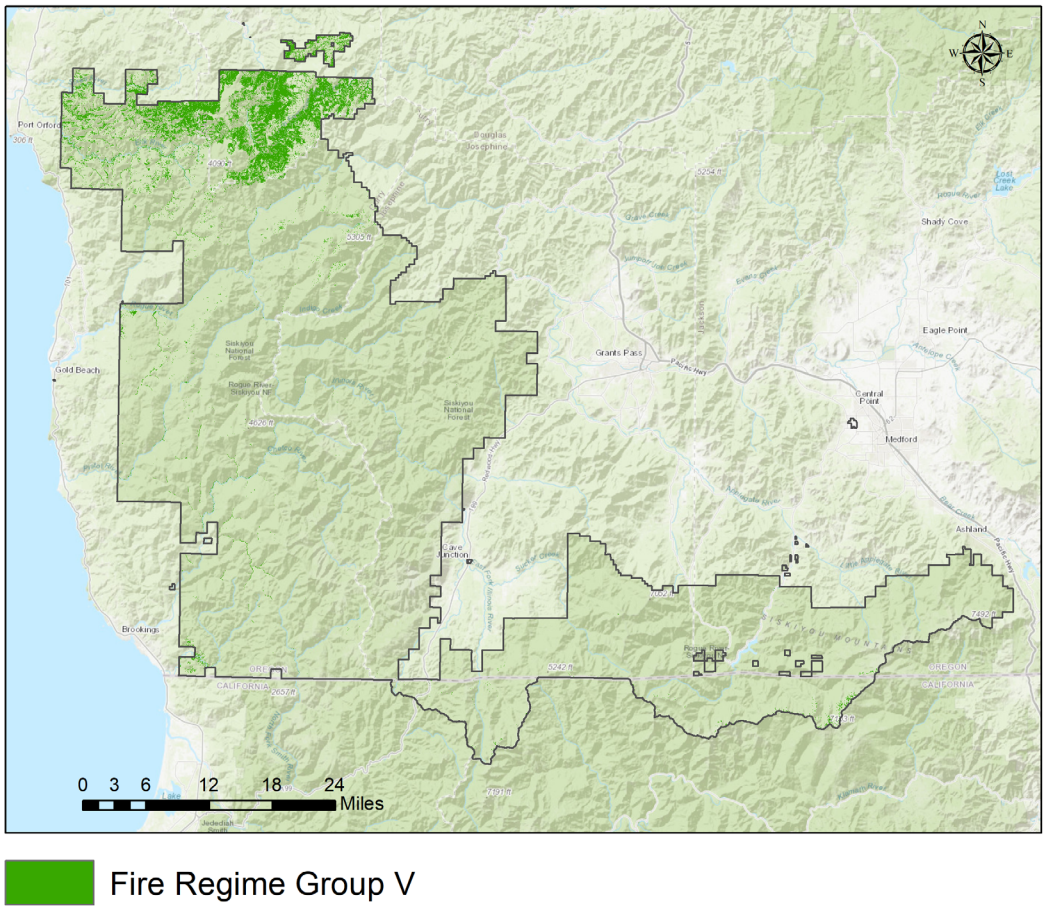

Figure 18—Extent of vegetation classified by LANDFIRE as fire regime group V (fire return interval <200 years) in the Rogue River-Siskiyou National Forest—Klamath Mountains unit.

Assessment of terrestrial ecosystems indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 4 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to the overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for 93 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects, sudden oak death and other diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are increasingly frequent and severe wildfires, effects of fire exclusion, and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with permanently flowing fish-bearing streams are likely altered and in moderate condition.

Permanently Flowing Nonfish-Bearing Streams

Distribution

There are 3,930 miles of permanently flowing nonfish-bearing streams within the administrative boundary of the RRSNF—Klamath Mountains unit (fig. 9). Of these, 3,680 miles are on NFS land. Riparian reserves associated with these streams cover 152,700 acres within the administrative boundary (142,600 acres on NFS land), or 11 percent of the unit (fig. 9). According to BioA data, permanently flowing nonfish-bearing streams and their RRs are distributed throughout this unit, but the uneven distribution (an obvious absence in the southwestern section) suggests that recent updates to the National Hydrography Dataset flowline data should be incorporated into subsequent mapping efforts (fig. 10). According to the WCF, dams and diversions have had limited impacts on hydrologic regimes (table 7). Drought has not been significant in this unit and small percentages of RRs have been converted by development and agriculture. Therefore, distribution of permanently flowing nonfish-bearing streams is likely to be intact in this unit.

Table 7—Percentage of the 98 watersheds with permanently flowing nonfish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Klamath Mountains unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	29	69	2
Exotic and/or aquatic invasive species attribute	74	24	1
Fire regime condition class attribute	15	20	64
Flow characteristics attribute	73	22	4
Habitat fragmentation attribute	78	22	0
Insects and disease attribute	77	9	14
Large woody debris attribute	24	55	20
Loss of forest cover attribute	44	15	41
Mass wasting attribute	94	4	2
Open road density attribute	58	39	3
Proximity to water attribute	12	78	10
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	16	82	2
Road and trail maintenance attribute	19	79	2
Roads and trails condition Indicator	54	43	3
Soil contamination attribute	85	15	0
Water quality indicator	43	34	23
Water quality problems attribute	55	15	30

[a] Rangeland vegetation condition rated in 70 watersheds.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 900 miles of permanently flowing nonfish-bearing stream habitat in the RRSNF—Klamath Mountains unit. Flow metrics modeled for 1977 through 2006 indicated 95 percent (858 miles) of permanently flowing nonfish-bearing streams in this unit had early, rainfall-dominated runoff (fig. 19). The remaining 5 percent (43 miles) of permanently flowing nonfish-bearing streams had intermediate runoff timing, with no late, snowfall-dominated systems present in this habitat. A shift in runoff timing is likely to occur, with a transition to earlier runoff in many historically intermediate reaches expected by the 2040s (fig. 19). A projected 45 percent reduction in the extent of reaches with intermediate runoff timing suggests that climate change is likely to contribute to altered hydrologic regimes by mid-century (table 8).

The magnitudes of high and low flows in permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit are expected to change by mid-century (table 8). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of average 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to change substantially between the historical period and mid-century, flow duration is likely to be impacted by shifts in the timing and amount of runoff (table 8). Because runoff timing is likely to occur earlier, the magnitude of 1.5-year return interval floods is expected to increase, and the magnitude of summer baseflows is likely to decrease, we expect that permanently flowing nonfish-bearing streams in this unit are likely to experience intermittency in some reaches.

Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 3). The TCA indicates drought and climate change have likely had limited impacts. There were 213 diversions located within permanently flowing nonfish-bearing streams in this unit. Of these diversions, 160 were on NFS land. According to the WCF, these structures have had limited impacts on hydrologic regimes (table 7). The WCF also suggests that hydrologic impacts of roads, livestock grazing, and timber harvest on permanently flowing nonfish-bearing streams are likely to be limited, but that altered wildfire regimes may have contributed to substantial changes in hydrology (table 7). Based on these results, we estimate hydrology of these habitats is likely to have been altered. Current trends in temperature and precipitation (see the section "Stressors"), projected changes in snowpack (see the section "Stressors"), and modeled flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be further impacted by projected changes in climate.

Water Quality

Water temperatures appear to be increasing in permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit (fig. 12a). According to the NorWeST model, the median August stream temperature between 1993 and 2011 was 57.0 °F. The median August stream temperature between 2002 and 2011 was 57.2 °F. Stream temperatures are expected to increase further by mid- and late century, with median August stream temperatures of 59.2 °F by the 2040s and 60.8 °F by the 2080s (fig. 12c). Of the 3,680 miles of permanently flowing nonfish-bearing streams in this unit, 48 miles are on the 303(d) list due to temperature.

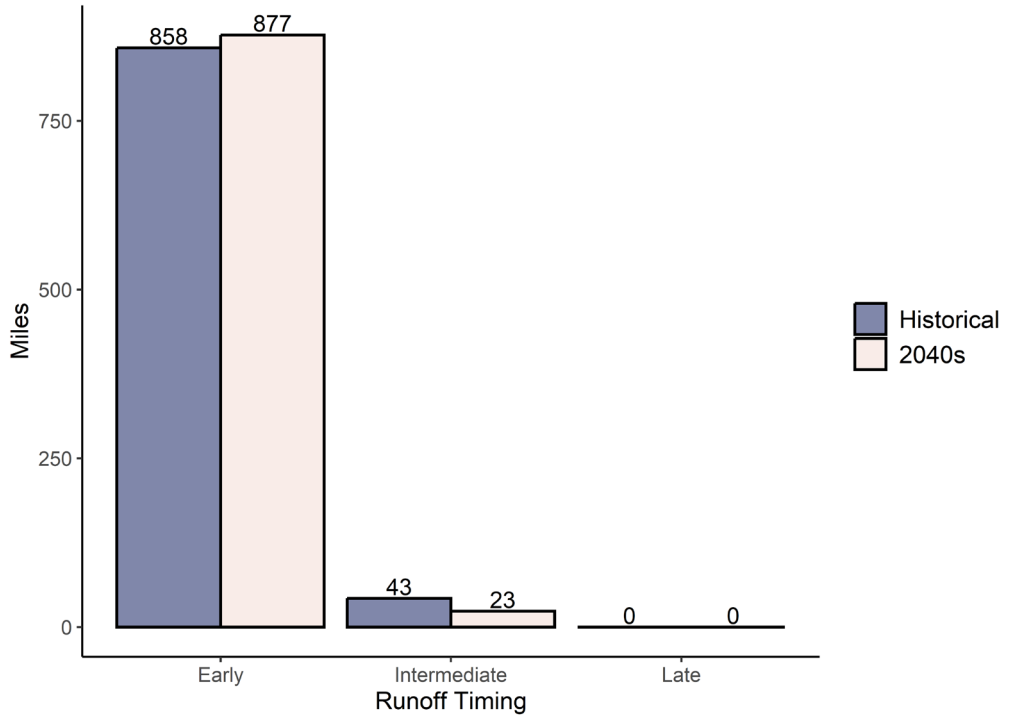

Figure 19—Total length (miles) of permanently flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 8—Flow metrics modeled for permanently flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	858 miles	877 miles	+2
	Extent of intermediate, transient runoff systems	43 miles	23 miles	-45
	Extent of late, snowmelt-dominated runoff systems	0 miles	0 miles	--
Magnitude	Average summer daily flow (June 1–September 30)	1.8 cfs[a]	1.5 cfs	-17
	Average August daily flow	1 cfs	0.9 cfs	-10
	Average baseflow index	0.1	0.1	-2
	Average 1.5-year return interval flood	153 cfs	159 cfs	+4
	Average maximum modeled flood	420 cfs	442 cfs	+5
Duration	Average daily flow	12 cfs	12 cfs	--

[a] cfs: cubic feet per second.
-- Indicates no change.

According to SPARROW model output, permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit receive suspended sediment loads primarily from forested and urban lands, including roads (fig. 13). The largest source of total nitrogen is atmospheric deposition. These streams also receive relatively large nitrogen loads from nitrogen fixation by red alder trees, as well as runoff from scrublands, grasslands, and urban lands, including roads (fig. 13). The largest source of phosphorus is weathering of upland geology. In addition to natural phosphorus loading from geologic sources, these streams receive relatively large inputs of phosphorus from urban lands, including roads (fig. 13). In general, sediment and nutrient loads in this stream type are low, with limited reaches exposed to large incremental and accumulated loads (table 9; figs. C4–C40). Of the 3,680 miles of permanently flowing nonfish-bearing streams in this unit, fewer than 1 mile appear on the 303(d) list due to fecal coliform and less than 1 mile is listed for pH.

Permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to stressors that can impact water quality, including altered fire regimes, loss of forest cover, land-use change, and pollution (see the section "Stressors" on page 3). The TCA indicates a departure from natural fire regimes in half of the unit, and most watersheds containing permanently flowing nonfish-bearing streams are classified as impaired by the WCF fire regime condition class attribute (table 7). Loss of forest cover, primarily driven by wildfire, is likely to have impacted these habitats, with nearly half of watersheds containing permanently flowing fish-bearing streams classified as impaired (table 7). These stressors are likely to interact with warming air temperatures and contribute to an overall increase in stream temperatures; however, only 1 percent of permanently flowing nonfish-bearing streams in this unit are on the 303(d) list due to temperature. Development, including roads, may impact water quality in localized areas, but the WCF suggests that roads are generally maintained, and that mass wasting is limited in watersheds with these habitats (table 7). Permanently flowing nonfish-bearing streams in this unit receive suspended sediment, nitrogen, and phosphorus from natural sources, but also are likely to receive inputs from largely human-generated atmospheric deposition and urban lands, including roads (fig. 13). Additionally, the TCA indicates that more than one-quarter of this unit is significantly impacted by pollution, including nitrogen deposition. Nevertheless, the WCF suggests no watersheds containing this habitat type are classified as impaired due to extensive soil contamination and less than one-third of watersheds have extensive water quality problems such as excessive sediment or nutrients (table 7). Riparian and wetland vegetation may improve resistance of permanently flowing fish-bearing streams to stressors; most watersheds containing this habitat are classified as functional-at-risk for riparian/wetland vegetation condition (table 7). Overall, impacts from stressors appear limited and very few permanently flowing nonfish-bearing reaches are listed as impaired. Based on these results, we estimate that water quality in these streams is likely to be high.

Connectivity

Stream connectivity can be disrupted by dams and diversions, but most watersheds containing permanently flowing nonfish-bearing streams have primarily free-flowing rivers with no or minor alterations from natural hydrographs (table 7). See the section "Hydrologic Regimes" on page 36 for more information on the number of diversions in this habitat and their impact

Table 9—Median (minimum; maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for permanently flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0; 196)	0 (0; 29)
	Forest land	197 (0; 5,719)	180 (0; 4,234)
	Agricultural land	0 (0; 489)	0 (0; 489)
	Urban land (including roads)	34 (0; 49,336)	28 (0; 14,721)
Total nitrogen	Scrublands and grasslands	0.1 (0; 4.58)	0.08 (0; 2.80)
	Atmospheric deposition	0.60 (0.01; 14.6)	0.51 (0; 9.50)
	Urban land (including roads)	0.13 (0; 3.89)	0.11 (0; 1.77)
	Spring discharge	0 (0; 0)	0 (0; 0)
	Red alder trees	0 (0; 27.9)	0 (0; 20.8)
	Fertilizer and manure applied to crop lands	0 (0; 0.75)	0 (0; 0.43)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
Total phosphorus	Urban land (including roads)	0.02 (0; 1.0)	0.02 (0; 0.49)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
	Fertilizer and manure applied to crop lands	0 (0; 0.16)	0 (0; 0.10)
	Manure from grazing cattle applied to rangeland	0 (0; 2.81)	0 (0; 1.55)
	Weathering of upland geology	0.07 (0; 8.06)	0.06 (0; 1.03)
	Channel	0.01 (0; 0.17)	0.01 (0; 0.12)
	Spring discharge	0 (0; 0)	0 (0; 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

as indicated by the WCF flow characteristics attribute. According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 7).

Fish passage data from AREMP show that there were 44 culverts in or bridges crossing permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit. Of these structures, 11 were full barriers, 2 structures were passable, and 31 structures had no data regarding passability. The AREMP functional stream network classified 1,210 miles of permanently flowing nonfish-bearing streams in this unit. According to the AREMP dataset, 3 percent of these streams were blocked by a barrier culvert somewhere downstream. One percent of stream miles were above a partial barrier. Eight percent were above a passable culvert. Twenty-one percent were above an open bridge or a structure with no data regarding passability. Finally, 68 percent of permanently flowing nonfish-bearing streams had no culvert or bridge downstream.

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the channel in most watersheds containing this habitat (table 7). According to the WCF road and trail maintenance attribute, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in most watersheds containing permanently flowing nonfish-bearing stream habitat (table 7).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the center of flow mass date for these streams was February 13. The center of flow mass is expected to shift earlier, with February 10 calculated as the mean date for the 2040s (fig. 14). Mean summer baseflows are likely to continue declining, with a 17 percent reduction in average summer daily flow from June 1 to September 30 expected by the 2040s (see the section "Hydrologic Regimes" on page 36). Earlier runoff and reduced summer baseflows may contribute to longitudinal fragmentation in this habitat. The magnitude of 1.5-year return interval floods is expected to increase by 4 percent, potentially increasing lateral connectivity by mid-century.

The median August stream temperature between 2002 and 2011 was 57.2 °F (fig. 12c), according to the NorWeST model. Stream temperatures are expected to increase by mid- and late century (see the preceding section, "Water Quality" on page 36). Based on AREMP stream temperature thresholds and modeled mean August stream temperatures from 2002 through 2011, 24 percent of total modeled stream miles exceeded 59 °F and 8 percent exceeded 60.8 °F (fig. 12c). Fragmentation of permanently flowing nonfish-bearing streams due to temperature is likely to increase in the future (fig. 20).

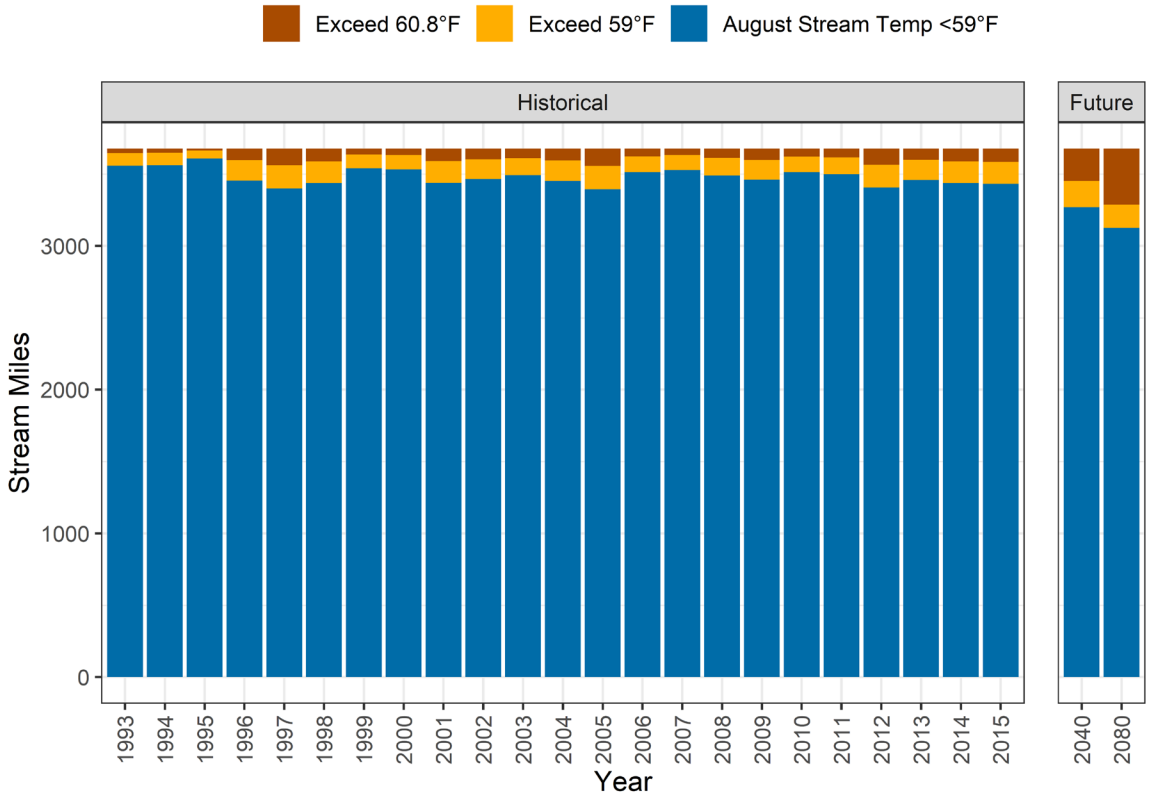

Figure 20—Total length (miles) of permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit that have mean August stream temperature less than 59 °F, exceeding 59 °F, and exceeding 60.8 °F from 1993 to 2015 and for future periods. Data from the NorWeST model.

According to the WCF, habitat fragmentation is not a serious concern in most watersheds with permanently flowing nonfish-bearing stream habitat (table 7). The WCF channel shape and function attribute indicates there is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain in most watersheds containing this habitat type (table 7).

Permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to limited stressors that impact connectivity (see the section "Stressors" on page 3). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. The AREMP functional stream network dataset estimates 96 percent of these habitats are unobstructed by downstream barriers. According to NorWeST stream temperature data, limited reaches experience temporary fragmentation due to warm stream temperatures during summer months. Additionally, both the WCF habitat fragmentation attribute and channel shape and function attribute indicate watersheds containing these habitats exhibit longitudinal and lateral connectivity in most stream reaches. Based on these results, we estimate connectivity of permanently flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit is likely to be high. Connectivity in these systems is likely to be vulnerable to projected climate impacts, including warming stream temperatures and reduced summer flows, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Riparian Reserves Condition

Only 1 percent of the area within RRs is classified by LANDFIRE as existing riparian vegetation. This vegetation is somewhat limited in these RRs. The area classified as potential riparian vegetation is greater (5 percent), suggesting that riparian extent has likely departed from historical conditions as a result of conifer encroachment, stream modifications, or other changes.

Of the vegetation in RRs classified by LANDFIRE as riparian, 87 percent is forest or woodland (appendix table 7). Woody riparian species include willows, bigleaf maple, red alder, white alder, Port Orford Cedar, Oregon ash (*Fraxinus latifolia*), and California laurel. Output from GNN classified 42 percent of RR area in 2017 as conifer forest, 31 percent as mixed conifer/hardwood forest, and 12 percent as hardwood forest. The most abundant forest types in RRs, such as *Pseudotsuga menziesii*, and *Pseudotsuga menziesii*/*Notholithocarpus densiflorus* are dominated by early- to mid-successional tree species (appendix table 12). Forest types with late successional (*Pseudotsuga menziesii*/*Tsuga heterophylla*, *Pseudotsuga menziesii*/*Abies grandis*) co-dominants are present as well.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is greater than 130 years, basal-area weighted mean diameter is greater than 19.7 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl and marbled murrelet. The presence of down wood and snags benefits Siskiyou Mountain salamander, harlequin duck, purple martin, fisher, Pacific marten, and other vertebrates (appendix table 1).

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 87 percent was upland vegetation with historically short (≤35 years) fire return intervals. Six percent of the vegetation, near streams in some RRs, is a combination of riparian and upland with longer (35–200 years) fire return intervals. Seven percent of the vegetation is classified as having a very long (>200 years) fire return interval. Most of this vegetation is within RRs in the northern portion of the unit. From 2013 through 2020, 36 percent of the RR area was within wildfire-burned area perimeters. According to GFC data, these fires caused forest loss in 10 percent of the RR area. Spatial data from the Forest Service indicate 9 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1939 and 2021 and 1 percent of the area was within projects completed since 1994.

Assessment of terrestrial ecosystems indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 4 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for 96 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings

are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects, sudden oak death and other diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are increasingly frequent and severe wildfires, fire exclusion, and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with permanently flowing nonfish-bearing streams are likely altered and in moderate condition.

Seasonally Flowing Fish-Bearing Streams

Distribution

There are 22 miles of seasonally flowing fish-bearing streams within the administrative boundary of the RRSNF—Klamath Mountains unit (fig. 9). Of these, 19 miles are on NFS lands. Riparian reserves associated with these streams cover 1,240 acres within the administrative boundary (1,070 acres on NFS land), or 0.1 percent of the unit (fig. 9). According to BioA data, seasonally flowing fish-bearing streams and their RRs have the smallest extent of the stream ecosystem types (fig. 6). Most of these stream segments and RRs occur at the confluence of intermittent streams and perennial streams. Others occur in the uppermost reaches of fish-bearing streams. These RRs are scattered throughout the study unit. There were no diversions or dams located within seasonally flowing fish-bearing streams, and the WCF indicates that few watersheds containing seasonally flowing fish-bearing streams were impaired for flow characteristics (table 10). Drought has not been significant in this unit, and small percentages of RRs have been converted by development and agriculture. Therefore, the distribution of seasonally flowing fish-bearing streams is likely to be intact in this unit.

Table 10—Percentage of the 44 watersheds with seasonally flowing fish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Klamath Mountains unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	18	80	2
Exotic and/or aquatic invasive species attribute	68	30	2
Fire regime condition class attribute	9	14	77
Flow characteristics attribute	55	36	9
Habitat fragmentation attribute	70	30	0
Insects and disease attribute	75	14	11
Large woody debris attribute	14	59	27
Loss of forest cover attribute	41	23	36
Mass wasting attribute	95	5	0
Open road density attribute	61	36	2
Proximity to water attribute	5	82	14
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	14	86	0
Road and trail maintenance attribute	11	86	2
Roads and Trails Condition Indicator	50	50	0
Soil contamination attribute	68	32	0
Water Quality Indicator	59	20	20
Water quality problems attribute	61	5	34

[a] Rangeland vegetation condition rated in 29 watersheds.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 8 miles of seasonally flowing fish-bearing stream habitat in the RRSNF—Klamath Mountains unit. Flow metrics modeled for 1977 through 2006 indicated that 98 percent (7.8 miles) of seasonally flowing fish-bearing streams had early, rainfall-dominated runoff (fig. 21). The remaining 2 percent (0.2 mile) had intermediate runoff timing, with no late, snowfall-dominated runoff systems present in this habitat. A shift in runoff timing is likely to occur; a transition to earlier runoff in many historically intermediate reaches is expected by the 2040s (fig. 21). A projected 72 percent reduction in the extent of reaches with intermediate runoff timing suggests that climate change is likely to contribute to altered hydrologic regimes by mid-century (table 11).

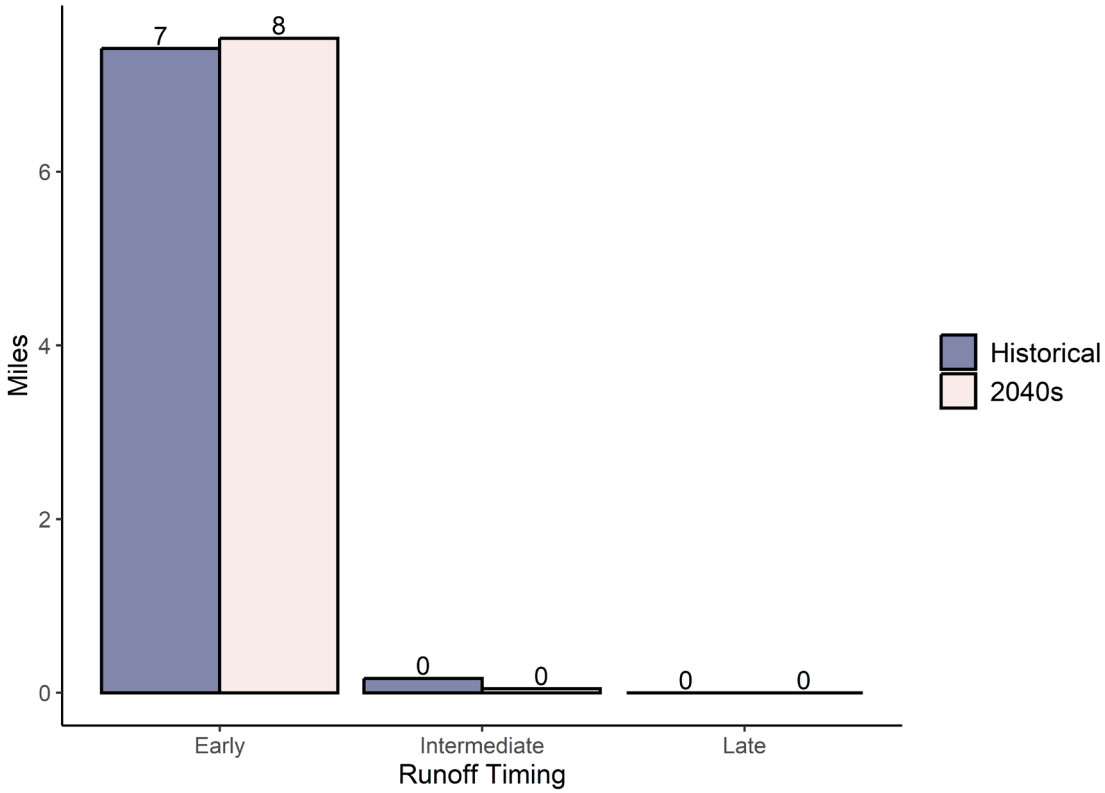

Figure 21—Total length (miles) of seasonally flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 11—Flow metrics modeled for seasonally flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	7 miles	8 miles	+2
	Extent of intermediate, transient runoff systems	0.2 mile	<0.1 mile	-72
	Extent of late, snowmelt-dominated runoff systems	0 miles	0 miles	--
Magnitude	Average summer daily flow (June 1–September 30)	1.2 cfs[a]	1.0 cfs	-17
	Average August daily flow	0.6 cfs	<0.6 cfs	-13
	Average baseflow index	0.1	0.09	-2
	Average 1.5-year return interval flood	72 cfs	77 cfs	+6
	Average maximum modeled flood	250 cfs	254 cfs	+2
Duration	Average daily flow	7 cfs	7 cfs	--

[a] cfs: cubic feet per second.
-- Indicates no change.

The magnitudes of high and low flows in seasonally flowing fish-bearing streams in the RRSNF—Klamath Mountains unit are expected to change by mid-century (table 11). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to substantially change between the historical period and mid-century, flow duration is likely to be impacted by shifts in the timing and amount of runoff (table 11). Because the magnitude of summer baseflows is likely to decrease, we expect that seasonally flowing fish-bearing streams in this unit are likely to experience increased intermittency in some reaches.

Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 3). Some of the land in the RRSNF—Klamath Mountains unit has been converted to agriculture and development. The amount of development may be large enough in some watersheds to have localized impacts on hydrology. The TCA indicates drought and climate change have not had significant impacts. There were no diversions or dams located within seasonally flowing fish-bearing streams and the WCF indicates that few watersheds containing seasonally flowing fish-bearing streams were impaired for flow characteristics (table 10). The WCF also suggests that hydrologic impacts of roads, livestock grazing, and timber harvest on seasonally flowing fish-bearing streams are likely to be limited (table 10), but that altered wildfire regimes and loss of forest cover may have contributed to substantial changes in hydrology in most watersheds (table 11). Based on these results, we estimate hydrology of these habitats is likely to have been altered. Current trends in temperature and precipitation (see the section "Stressors"), projected changes in snowpack (see the section "Stressors"), and modeled

flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be further impacted by projected changes in climate.

Water Quality

According to SPARROW model output, seasonally flowing fish-bearing streams receive low inputs of suspended sediment and nutrients compared to other stream types in the RRSNF—Klamath Mountains unit (fig. 13). In general, incremental sediment and nutrient loads in this stream type are low, with limited reaches exposed to large incremental or accumulated loads (table 12; figs. C.5–C.40). None of the seasonally flowing fish-bearing streams in this unit were listed by the State as impaired due to sedimentation, pH, or other nutrient-related issues.

Table 12—Median (minimum; maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for seasonally flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0; 39)	0 (0; 30)
	Forest land	122 (11; 1,434)	120 (6; 1,378)
	Agricultural land	0 (0; 2)	0 (0; 2)
	Urban land (including roads)	10 (0; 4,612)	8 (0; 4,612)
Total nitrogen	Scrublands and grasslands	0.04 (0; 1.34)	0.04 (0; 0.68)
	Atmospheric deposition	0.38 (0.03; 4.72)	0.35 (0.02; 4.17)
	Urban land (including roads)	0.06 (0; 2.40)	0.5 (0; 1.04)
	Spring discharge	0 (0; 0)	0 (0; 0)
	Red alder trees	0 (0; 4.29)	0 (0; 4.29)
	Fertilizer and manure applied to crop lands	0 (0; 0.09)	0 (0; 0.03)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
Total phosphorus	Urban land (including roads)	0.09 (0; 53.0)	0.01 (0; 0.50)
	Wastewater treatment discharge	0 (0; 152)	0 (0; 2.51)
	Fertilizer and manure applied to crop lands	0 (0; 6.42)	0 (0; 0.10)
	Manure from grazing cattle applied to rangeland	0 (0; 52.7)	0 (0; 0.94)
	Weathering of upland geology	0.23 (0; 146)	0.04 (0; 0.96)
	Channel	0.02 (0; 52.2)	4 (0; 0.12)
	Spring discharge	0 (0; 0)	0 (0; 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

Seasonally flowing fish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to stressors that can impact water quality, including altered fire regimes, loss of forest cover driven primarily by wildfire, land-use change, and pollution (see the section "Stressors"). The TCA indicates a departure from natural fire regimes in half of the unit, and more than three-quarters of watersheds containing seasonally flowing fish-bearing streams are classified as impaired by the WCF Fire Regime Condition Class attribute (table 10). Loss of forest cover, driven primarily by wildfire, is likely to impact these habitats; more than one-third of watersheds containing seasonally flowing fish-bearing stream habitat are classified as impaired (table 10). These stressors are likely to interact with warming air temperatures and contribute to an overall increase in stream temperatures. Development, including roads, may impact water quality in localized areas, but the WCF suggests that roads are generally maintained, and that mass wasting is limited (table 10). Seasonally flowing fish-bearing streams in this unit receive low inputs of sediment and nutrients (fig. 13). The TCA indicates more than one-quarter of this unit is significantly impacted by pollution, including nitrogen deposition. Nevertheless, the WCF suggests no watersheds containing this habitat type are classified as impaired due to extensive soil contamination. No seasonally flowing fish-bearing streams are classified on the 303(d) list as impaired, but about one-third of watersheds containing seasonally flowing fish-bearing streams are impaired for water quality problems according to the WCF (table 10). Based on these results, it appears water quality in seasonally flowing fish-bearing streams on the RRSNF—Klamath Mountains unit has likely been impacted by loss of forest cover and other water quality problems such as excessive sediment or nutrients. We estimate water quality in these streams is likely to have been altered.

Connectivity

There were no diversions or dams located within seasonally flowing fish-bearing streams in this unit. According to the WCF flow characteristics attribute, most watersheds containing this habitat have primarily free-flowing rivers and lakes with no or minor alterations from natural hydrographs (table 10). According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 10).

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the channel in most watersheds containing this habitat (table 10). According to the WCF road and trail maintenance attribute, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in most watersheds containing seasonally flowing fish-bearing stream habitat (table 10).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the average center of flow mass date for these streams was February 17. The center of flow mass is expected to shift earlier, with February 14 calculated as the mean date for the 2040s (fig. 14). Earlier runoff contributes to longitudinal fragmentation in this habitat. The magnitude of 1.5-year return interval floods is expected to increase by 6 percent, potentially

increasing lateral connectivity by mid-century (see the section "Hydrologic Regimes" on page 45).

According to the WCF, habitat fragmentation is not a serious concern in most watersheds containing seasonally flowing fish-bearing stream habitat (table 10). The WCF channel shape and function attribute indicates there is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain in most watersheds containing this habitat type (table 10).

Seasonally flowing fish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to limited stressors that impact connectivity (see the section "Stressors" on page 3). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. Both the WCF habitat fragmentation attribute and channel shape and function attribute indicate watersheds containing these habitats exhibit longitudinal and lateral connectivity in most stream reaches. Based on these results and because of the natural intermittency of seasonally flowing streams, we estimate connectivity of seasonally flowing fish-bearing streams in the RRSNF—Klamath Mountains unit is likely to be high. Connectivity in these systems is likely to be vulnerable to projected climate impacts, including potential changes in the timing and duration of dry periods, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Instream Habitat Quality

There are no seasonally flowing streams designated as critical habitat in this unit. There are 0 miles of seasonally flowing fish-bearing stream habitat with HIP for Chinook salmon, 0.4 mile for coho salmon, and 0.7 mile for steelhead.

There are no AREMP sampling sites for measuring instream wood at seasonally flowing fish-bearing streams in this unit. According to the WCF, large woody debris is present but recruited into the system at less-than-natural rates in most watersheds with seasonally flowing fish-bearing stream habitat (table 10).

Data from GNN models indicate that as of 2017, trees and snags in RRs have the potential to provide shade and down wood to streams. Mean tree canopy cover was estimated to be 48 percent for conifers and 43 percent for hardwoods in RRs. Mean tree density was estimated to be 55.9 stems per acre for live trees between 9.8 and 19.7 inches in diameter, 16.6 stems per acre for live trees 19.7 inches or greater in diameter, 5.7 stems per acre for snags between 9.8 and 19.7 inches in diameter, and 2.8 stems per acre for snags 19.7 inches or greater in diameter (appendix table 8). Spatial data from the Forest Service indicate 11 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1939 and 2021, and 4 percent of the area was within projects completed since 1994. From 2013 through 2020, 50 percent of RR area was within wildfire-burned area perimeters. These fires likely increased the short-term supply of instream wood. Additional sources of wood, including permanently flowing and seasonally flowing nonfish-bearing tributaries, should be considered as well (see the section “Riparian Reserves Condition” for each of these stream types). The preceding results suggest that instream wood is present in moderate to low amounts in multiple size classes and

that there is potential for recruitment of multiple size classes of wood from RRs. This potential has not been affected by recent timber harvest but was likely influenced by recent wildfires.

Fish passage data from AREMP are not available for seasonally flowing streams. No watersheds containing this habitat type are classified as impaired by the WCF habitat fragmentation attribute. See the preceding section, "Connectivity" on page 48, for more information.

According to the WCF, most watersheds have channels that maintain width-to-depth ratios within NRV and vertical stability except in places where riparian vegetation has been disturbed, between 5 and 25 percent of the channels have widened, channel degradation or aggradation (or both) has occurred in relatively small sections of the network, and downcutting has disconnected some channels from their floodplain (table 10).

Hydrologic regimes are likely to continue shifting; large declines in summer baseflow, earlier runoff, and small increases in the magnitude of high flows are expected by mid-century (see the section "Hydrologic Regimes" on page 45). According to the WCF flow characteristics attribute, most watersheds containing this habitat have primarily free-flowing rivers and streams, with no or minor alterations from natural hydrologic conditions (table 10). According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 10).

Seasonally flowing fish-bearing streams on the RRSNF—Klamath Mountains unit are exposed to stressors that may impact the quality of instream habitat, including roads, loss of forest cover, and departure from natural fire regimes (see the section "Stressors" on page 3). According to the TCA, roads are likely to have impacted terrestrial ecological integrity in more than half of the unit, but the WCF suggests roads have had less effect on watershed hydrology. Loss of forest cover, primarily driven by wildfire, has significantly impacted many watersheds containing this habitat. Finally, the TCA and WCF indicate the altered fire regimes are likely to have impacted terrestrial ecological integrity and watershed function in most of the unit. It appears that large woody debris is present but recruited at less-than-natural rates, and that stream channel degradation has occurred in small sections of these streams. Based on these results, it is likely that instream habitat quality in seasonally flowing fish-bearing streams has been impacted by departure from natural fire regimes. We estimate that instream habitat quality is likely to have been altered.

Riparian Reserves Condition

Only 1 percent of the area within RRs is classified by LANDFIRE as existing riparian vegetation, composed of willows, red alder, bigleaf maple, California laurel, and other species. The area classified as potential riparian vegetation is greater (6 percent), suggesting that riparian extent has likely departed from historical conditions as a result of conifer encroachment, stream modifications, or other changes.

Of the vegetation in RRs classified by LANDFIRE as riparian, 97 percent is forest or woodland (appendix table 7). Woody riparian species include willows, bigleaf maple, red alder, white alder, Port Orford Cedar, Oregon ash, and California laurel. Output from GNN models classified 30 percent of RR area in 2017 as conifer forest, 43 percent as mixed conifer/hardwood forest,

and 21 percent as hardwood forest. The most abundant forest types in RRs, such as *Pseudotsuga menziesii,* and *Pseudotsuga menziesii*/*Notholithocarpus densiflorus* are dominated by early- and mid-successional tree species (appendix table 13). Forest types with late successional (*Pseudotsuga menziesii*/*Abies grandis*) co-dominants are present as well.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is greater than 120 years, basal-area weighted mean diameter is greater than 19.7 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl and marbled murrelet. The presence of down wood and snags benefits Siskiyou Mountain salamander, harlequin duck, purple martin, fisher, Pacific marten, and other vertebrates (appendix table 1). If down wood, snags, or large trees are near streams, they contribute to habitat quality for Chinook salmon, coho salmon, steelhead, and other fishes.

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 91 percent was upland vegetation with historically short (≤35 years) fire return intervals. Seven percent of the vegetation, near streams in some RRs, is a combination of riparian and upland with longer (35–200 years) fire return intervals (fig. 17). Two percent of the vegetation is classified as having a very long (>200 years) fire return interval. Most of this vegetation is within RRs in the northern portion of the unit. From 2013 through 2020, 50 percent of RR area was within wildfire-burned area perimeters. According to GFC data, these fires caused forest loss in 25 percent of the RR area. Spatial data from the Forest Service indicate 11 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1939 and 2021, and 4 percent of the area was within projects completed since 1994.

Assessment of terrestrial ecosystems indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 3 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for 97 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects, sudden oak death and other diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are increasingly frequent and severe wildfires, effects of fire exclusion, and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with seasonally flowing fish-bearing streams are likely altered and in moderate condition.

Seasonally Flowing Nonfish-Bearing Streams

Distribution

There are 1,410 miles of seasonally flowing nonfish-bearing streams within the administrative boundary of the RRSNF—Klamath Mountains unit (fig. 9). Of these, 1,240 miles are on NFS land. Riparian reserves associated with these streams cover 52,100 acres within the administrative boundary (45,300 acres on NFS lands), or 3.7 percent of the unit (fig. 9). According to BioA data, seasonally flowing nonfish-bearing streams and their RRs are largely limited to edges of this unit (fig. 10). This uneven distribution suggests that recent updates to the National Hydrography Dataset flowline data should be incorporated into subsequent maps. According to the WCF, dams and diversions have had limited impacts on hydrologic regimes; few watersheds containing seasonally flowing nonfish-bearing streams are classified as impaired for flow characteristics (table 13). Drought has not been significant in this unit, and small percentages of RRs have been converted by development and agriculture. Therefore, the distribution of seasonally flowing nonfish-bearing streams is likely to be intact in this unit.

Table 13—Percentage of the 72 watersheds with seasonally flowing nonfish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Klamath Mountains unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	21	76	3
Exotic and/or aquatic invasive species attribute	71	28	1
Fire regime condition class attributc	17	17	67
Flow characteristics attribute	65	29	6
Habitat fragmentation attribute	74	26	0
Insects and disease attribute	75	12	12
Large woody debris attribute	14	64	22
Loss of forest cover attribute	50	15	35
Mass wasting attribute	89	10	1
Open road density attribute	57	40	3
Proximity to water attribute	6	83	11
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	10	89	1
Road and trail maintenance attribute	12	83	4
Roads and Trails Condition Indicator	49	46	6
Soil contamination attribute	81	19	0
Water Quality Indicator	50	26	24
Water quality problems attribute	58	12	29

[a] Rangeland vegetation condition rated in 47 watersheds.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 98 miles of seasonally flowing nonfish-bearing stream habitat in the RRSNF—Klamath Mountains unit. Flow metrics modeled for 1977 through 2006 indicated 71 percent (70 miles) of seasonally flowing nonfish-bearing streams in the unit had early, rainfall-dominated runoff (fig. 22). The remaining 29 percent (28 miles) had intermediate runoff timing, with no late, snowfall-dominated runoff systems present in this habitat. A shift in runoff timing is likely to occur, with a transition to earlier runoff in many historically intermediate reaches expected by the 2040s (fig. 22). A projected 26 percent reduction in the extent of reaches with intermediate runoff timing suggests that climate change is likely to contribute to altered hydrologic regimes by mid-century (table 14).

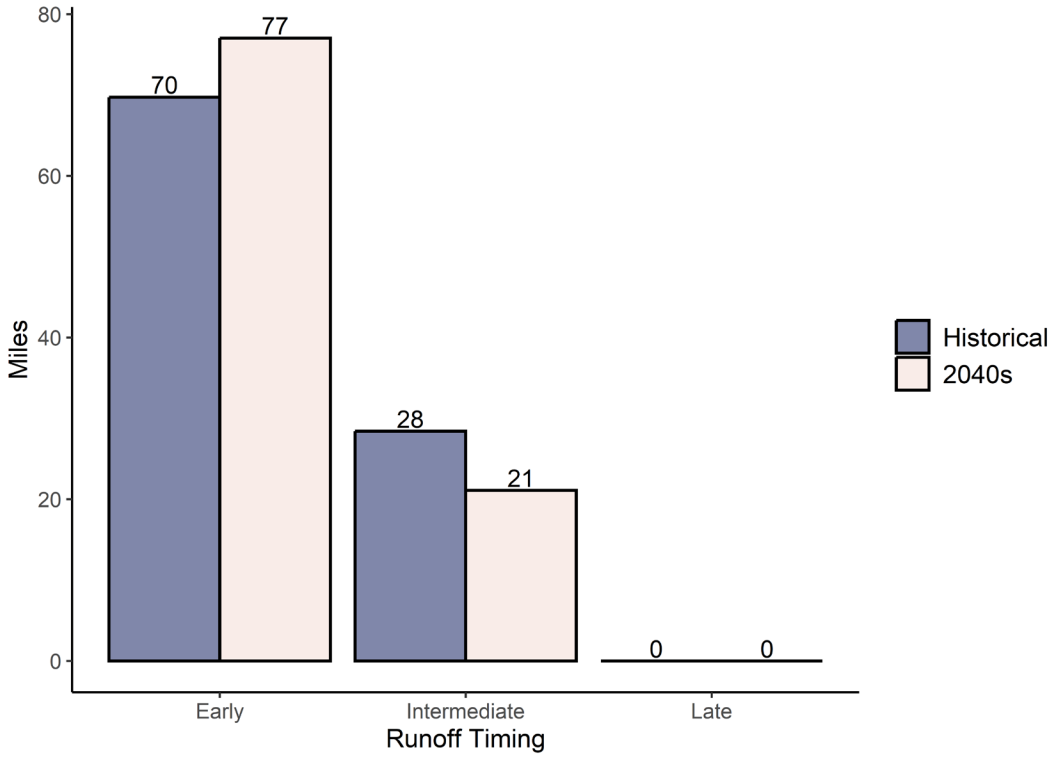

Figure 22—Total length (miles) of seasonally flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 14—Flow metrics modeled for seasonally flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	70 miles	77 miles	+10
	Extent of intermediate, transient runoff systems	28 miles	21 miles	-26
	Extent of late, snowmelt-dominated runoff systems	0 miles	0 miles	--
Magnitude	Average summer daily flow (June 1–September 30)	1 cfs[a]	0.9 cfs	-15
	Average August daily flow	0.6 cfs	<0.6 cfs	-10
	Average baseflow index	0.2	<0.2	-1
	Average 1.5-year return interval flood	62 cfs	66 cfs	+5
	Average maximum modeled flood	201 cfs	205 cfs	+2
Duration	Average daily flow	5 cfs	5 cfs	--

[a] cfs: cubic feet per second.
-- Indicates no change.

The magnitudes of high and low flows in seasonally flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit are expected to change by mid-century (table 14). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of average 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to substantially change between the historical period and mid-century, flow duration is likely to be impacted by shifts in the timing and amount of runoff (table 14). Because runoff is likely to occur earlier, the magnitude of seasonal floods is likely to increase, and the magnitude of summer baseflows is likely to decrease, we expect that seasonally flowing nonfish-bearing streams in this unit are likely to experience increased intermittency in some reaches.

Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 3). Some of the land in the RRSNF—Klamath Mountains unit has been converted by agriculture and development. The amount of development may be large enough in some watersheds to have localized impacts on hydrology. The TCA indicates drought and climate change have not had significant impacts in the unit. There were 51 diversions located within seasonally flowing nonfish-bearing streams in this unit. Of these, 30 were on NFS land. According to the WCF, these structures have had limited impacts on hydrologic regimes, with few watersheds containing seasonally flowing nonfish-bearing streams classified as impaired for flow characteristics (table 14). The WCF also suggests that hydrologic impacts of roads, livestock grazing, and timber harvest on seasonally flowing nonfish-bearing streams are likely to be limited (table 14), but that altered wildfire regimes and loss of forest cover may have

contributed to substantial changes in hydrology in most watersheds (table 13). Based on these results, we estimate hydrology of these habitats is likely to have been altered. Current trends in temperature and precipitation (see the section "Stressors"), projected changes in snowpack (see the section "Stressors"), and modeled flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be further impacted by projected changes in climate.

Water Quality

According to SPARROW model output, seasonally flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit receive suspended sediment from forested and urban lands, including roads. The largest source of nitrogen to these streams is atmospheric deposition (fig. 13). The largest source of phosphorus is weathering of upland geology (fig. 13). In general, incremental sediment and nutrient loads in this stream type are low (table 15), with limited reaches exposed to large incremental or accumulated loads (table 15; figs. C.5–C.40). Of the 1,240 miles of seasonally flowing nonfish-bearing stream habitat in this unit, none appear on the 303(d) list as impaired due to sedimentation or nutrient-related issues.

Seasonally flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit are exposed to stressors that can impact water quality, including altered fire regimes, loss of forest cover, land-use change, and pollution (see the section "Stressors" on page 3). The TCA indicates departure from natural fire regimes in half of the unit and most watersheds containing seasonally flowing nonfish-bearing streams are classified as impaired by the WCF forest regime condition class attribute (table 13). Loss of forest cover, driven primarily by wildfire, is likely to impact these habitats as more than one-third of watersheds containing seasonally flowing nonfish-bearing streams are classified as impaired (table 13). These stressors are likely to interact with warming air temperatures and contribute to an overall increase in stream temperatures; however, of the 1,240 miles of seasonally flowing nonfish-bearing streams in this unit, 1 mile was listed by the State as impaired for temperature. Development, including roads, may impact water quality in localized areas, but the WCF suggests that roads are generally maintained and that mass wasting is limited (table 13). Seasonally flowing nonfish-bearing streams in this unit receive suspended sediment, nitrogen, and phosphorus from natural sources, but also are likely to receive input from largely human-generated atmospheric deposition and urban land, including roads (fig. 13). Additionally, the TCA indicates more than one-quarter of this unit is significantly impacted by pollution, including nitrogen deposition. Nevertheless, the WCF suggests no watersheds containing this habitat type are classified as impaired due to extensive areas of soil contamination and less than one-third of watersheds have extensive water quality problems such as excessive sediment or nutrients (table 13). Riparian and wetland vegetation may increase resistance of seasonally flowing nonfish-bearing streams, with most watersheds containing this habitat classified as functional-at-risk for riparian/wetland vegetation condition (table 13). Overall, impacts from stressors appear limited and very few seasonally flowing fish-bearing streams are listed as impaired. Based on these results, we estimate that water quality in these streams is likely to be high.

Table 15—Median (minimum; maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for seasonally flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0; 46)	0 (0; 30)
	Forest land	121 (6; 4,292)	120 (0; 4,292)
	Agricultural land	0 (0; 119)	0 (0; 109)
	Urban land (including roads)	20 (0; 6,111)	20 (0; 6,111)
Total nitrogen	Scrublands and grasslands	0.07 (0; 1.77)	0.06 (0; 1.59)
	Atmospheric deposition	0.36 (0.02; 4.85)	0.34 (0; 4.85)
	Urban land (including roads)	0.1 (0; 1.91)	0.10 (0; 1.91)
	Spring discharge	0 (0; 0)	0 (0; 0)
	Red alder trees	0 (0; 8.29)	0 (0; 8.29)
	Fertilizer and manure applied to crop lands	0 (0; 0.39)	0 (0; 0.36)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
Total phosphorus	Urban land (including roads)	0.01 (0; 0.45)	0.01 (0; 0.45)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
	Fertilizer and manure applied to crop lands	0 (0; 0.05)	0 (0; 0.05)
	Manure from grazing cattle applied to rangeland	0 (0; 1.55)	0 (0; 1.55)
	Weathering of upland geology	0.03 (0; 0.94)	0.03 (0; 0.94)
	Channel	0.01 (0; 0.07)	0.01 (0; 0.03)
	Spring discharge	0 (0; 0)	0 (0; 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

Connectivity

Stream connectivity can be disrupted by dams and diversions, but according to the WCF most watersheds containing seasonally flowing nonfish-bearing streams have primarily free-flowing rivers with no or minor alterations from natural hydrographs (table 13). According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 13).

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the

channel in most watersheds containing this habitat (table 13). According to the WCF road and trail maintenance attributer, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in most watersheds containing seasonally flowing nonfish-bearing stream habitat (table 13).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the center of flow mass date for these streams was February 21. The center of flow mass is expected to shift earlier, with February 18 calculated as the mean date for the 2040s (fig. 14). Earlier runoff may contribute to longitudinal fragmentation in this habitat. The magnitude of 1.5-year return interval floods is expected to increase by 5 percent, potentially increasing lateral connectivity by mid-century (see the section "Hydrologic Regimes" on page 53).

According to the WCF, habitat fragmentation is not a serious concern in most watersheds containing seasonally flowing nonfish-bearing stream habitat (table 13). The WCF channel shape and function attribute indicates there is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain in most watersheds containing this habitat type (table 13).

Seasonally flowing nonfish-bearing streams on the RRSNF—Klamath Mountains unit are exposed to limited stressors that impact connectivity (see the section "Stressors" on page 3). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. Both the WCF habitat fragmentation attribute and channel shape and function attribute indicate watersheds containing these habitats exhibit longitudinal and lateral connectivity in most stream reaches. Based on these results, and because of the natural intermittency of seasonally flowing streams, we estimate connectivity of seasonally flowing nonfish-bearing streams in the RRSNF—Klamath Mountains unit is likely to be high. Connectivity in these systems is likely to be vulnerable to projected climate impacts, including potential changes in the timing and duration of dry periods, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Riparian Reserves Condition

Only 1 percent of the area within RRs associated with seasonally flowing nonfish-bearing streams is classified by LANDFIRE as existing riparian vegetation, composed of willows, red alder, bigleaf maple, California laurel, and other species. This vegetation is somewhat limited in these RRs (fig. 16). The area classified as potential riparian vegetation is also 1 percent, suggesting that these stream types are likely to support little riparian vegetation because of their physical settings and flow regimes.

Of the vegetation in RRs classified by LANDFIRE as riparian, 81 percent is forest or woodland (appendix table 7). Woody riparian species include willows, bigleaf maple, red alder, white alder, Port Orford Cedar, Oregon ash, and California laurel. Output from GNN models classified 44 percent of RRs in 2017 as conifer forest, 35 percent as mixed conifer/hardwood forest, and

12 percent as hardwood forest. The most abundant forest types, such as *Pseudotsuga menziesii* and *Pseudotsuga menziesii*/*Notholithocarpus densiflorus*, are dominated by early- and mid-successional tree species (appendix table 14). Forest types with late successional (*Pseudotsuga menziesii*/*Abies grandis*, *Pseudotsuga menziesii*/*Tsuga heterophylla*) co-dominants are present as well.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is greater than 120 years, basal-area weighted mean diameter is greater than 19.7 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl and marbled murrelet. The presence of down wood and snags benefits Siskiyou Mountain salamander, harlequin duck, purple martin, fisher, Pacific marten, and other vertebrates (appendix table 1).

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 91 percent was upland vegetation with historically short (≤35 years) fire return intervals. Four percent of the vegetation, near streams in some RRs, is a combination of riparian and upland with longer (35–200 years) fire return intervals (fig. 17). Five percent of the vegetation is classified as having a very long (>200 years) fire return interval. Most of this vegetation is within RRs in the northern portion of the unit. From 2013 through 2020, 30 percent of RR area was within wildfire-burned area perimeters. According to GFC data, these fires caused forest loss in 17 percent of the RR area. Spatial data from the Forest Service indicate 12 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1939 and 2021 and 2 percent of the area was within projects completed since 1994.

Assessment of terrestrial ecosystems indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 6 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for 93 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects, sudden oak death and other diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are increasingly frequent and severe wildfires, effects of fire exclusion, and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with seasonally flowing nonfish-bearing streams are likely altered and in moderate condition.

Lakes, Ponds, and Reservoirs

Distribution

According to National Hydrography Dataset for waterbodies, there are 271 waterbodies occupying 1,240 acres in the RRSNF—Klamath Mountains unit (fig. 23). This dataset incorrectly classifies at least some reservoirs within the study area as lakes (Steve Bachmann, USDA Forest Service, Yreka, CA, personal communication, July 7, 2021). Riparian reserves associated with lakes, ponds, and reservoirs cover approximately 4,939 acres, or 0.4 percent of the unit. Several reservoirs, including Applegate Lake, have been constructed in the southern portion of the unit. The construction of dams and reservoirs in this unit, as well as its history of beaver trapping (Luce et al. 2022), have likely altered the distribution of these waterbodies.

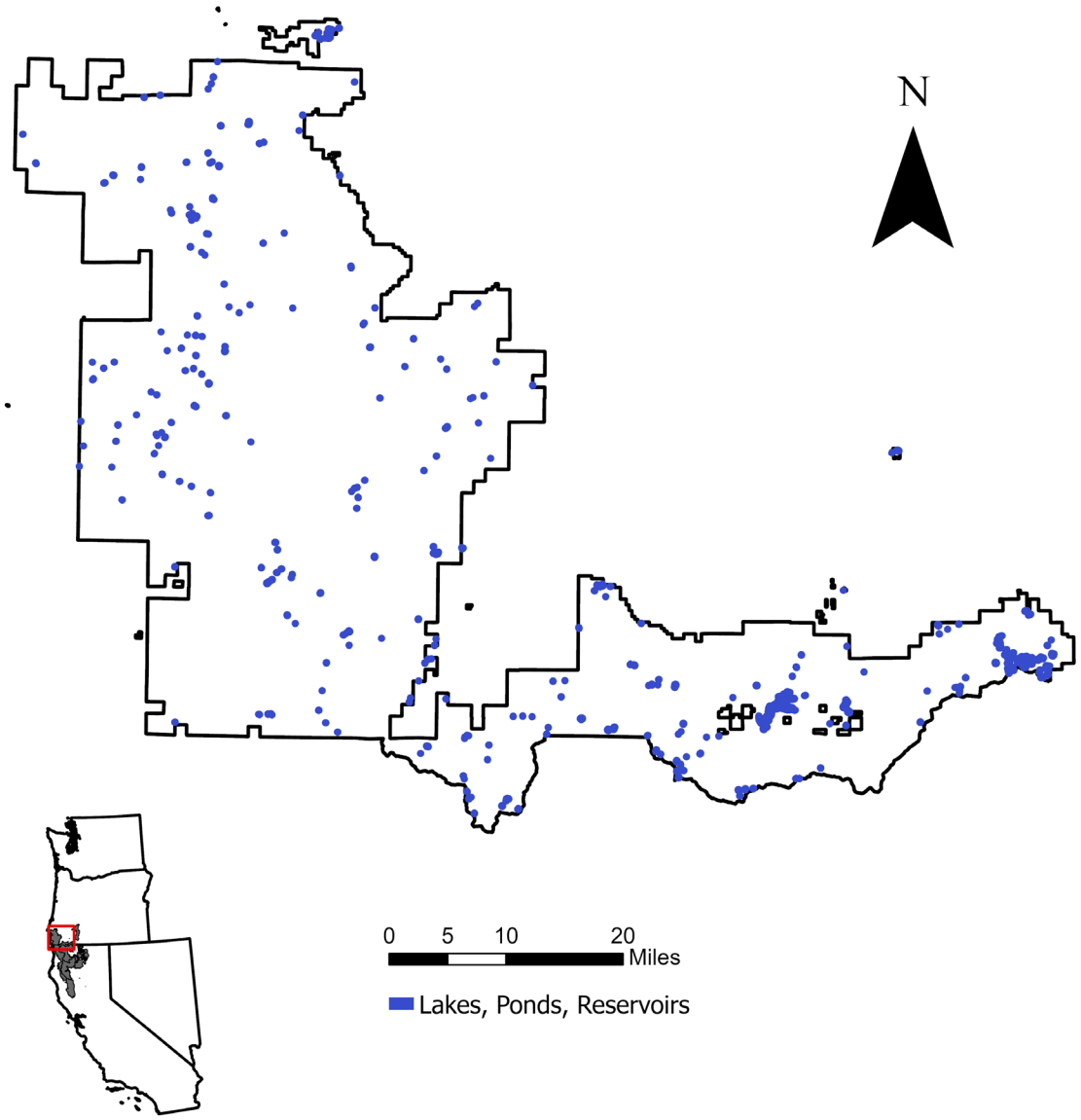

Figure 23— Lakes, ponds, and reservoirs mapped by the National Hydrography Dataset in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Lower map shows location of study area within Oregon and California.

Hydrologic Regimes

Lakes and reservoirs have moderate sensitivity to stressors that alter water levels (Sims et al. 2019a); ponds have moderate to high sensitivity (Sims et al. 2019a). Changes in precipitation, snowpack, and runoff timing have been linked to lower water levels in lakes and ponds (Sahoo et al. 2013; Sims et al. 2019a). Although annual precipitation has not changed significantly in this unit, substantial shifts in the timing of snow and rainfall have occurred (see the section "Stressors" on page 3). April 1 SWE has declined throughout the study area (Flint et al. 2013; Sims et al. 2019a) and large reductions in SWE and snow residence time are expected by the end of this century (see the section "Stressors"). Snowmelt and snowmelt-driven runoff in the western United States have shifted earlier (Hamlet et al. 2005; Sims et al. 2019a); however, most streams that feed lakes and ponds in this unit have been classified as historically rainfall-dominated with early runoff timing and this classification is not expected to change over the next 20 years (see the section “Hydrologic Regimes” for each stream type).

Severe drought can significantly reduce lake volume and cause ponds to dry entirely (Howard and Noble 2018; Lovich et al. 2017; Purcell et al. 2017; Sims et al. 2019a). According to the TCA, impacts on ecological integrity from drought are unlikely in this unit (see the section "Stressors"). Additionally, contemporary droughts are less severe and shorter in duration than historical drought (Gross et al. 2020; Malevich et al. 2013). Gross et al. (2020) suggest that hydrologic impacts from contemporary droughts, when not exacerbated by additional anthropogenic stressors, are likely to be within NRV.

Nonclimate stressors to lake and pond hydrology include altered fire regimes, timber harvest, and dams and diversions (Sims et al. 2019a). Impaired condition for fire regime may affect lake and pond hydrology in two ways: (1) Watersheds that are outside NRV due to lack of fire may not contribute as much runoff to lakes and ponds, resulting in drying of these habitats, or (2) watersheds that are impaired due to large, high-severity fires that removed significant amounts of vegetation may be contributing larger amounts of water to lakes and ponds as a result of reductions in evapotranspiration (Steve Bachmann, USDA Forest Service, personal communication, June 28, 2021). According to the WCF, water fluctuations in lakes and ponds throughout the RRSNF—Klamath Mountains unit are likely to have been impacted by loss of forest cover and altered fire regimes; 44 and 68 percent of watersheds containing these habitats are classified as impaired for loss of forest cover and Fire Regime Condition Class, respectively. Although a small percentage of the unit has been included in timber harvest projects, loss of forest cover in recent years has primarily been driven by wildfire (Steve Bachmann, USDA Forest Service, Yreka, CA, personal communication, June 2021). Dams and diversions are present in this unit (see the section "Stressors"), but these structures appear to have limited impacts on the hydrologic regimes of lakes and ponds, with 3 percent of watersheds containing these habitats classified by the WCF as impaired for flow characteristics. Due to the sensitivity of lakes and ponds to altered fire regimes and loss of forest cover, we expect hydrologic regimes in these habitats in the RRSNF—Klamath Mountains unit are likely to have been altered.

Water Quality

Of the 66 watersheds in this unit that contain lake and pond habitat, the WCF water quality problems attribute indicates 30 percent of watersheds were impaired. These watersheds have

extensive water quality problems such as excessive sediment or nutrients (Potyondy and Geier 2011). No watersheds with waterbodies are impaired for road and trail maintenance; BMPs that minimize impacts on water quality are applied to most roads. Additionally, no watersheds were classified as impaired for the WCF mass wasting attribute. Forty-four percent of watersheds containing lakes, ponds, and reservoirs were impaired due to loss of forest cover. Extensive loss of forest cover in these watersheds can affect erosion, sediment supply, and water temperatures (Potyondy and Geier 2011). The TCA indicates 27 percent of this unit is in poor or very poor condition due to pollution; however, the WCF soil contamination attribute indicates no watersheds containing lake, pond, or reservoir habitat are impaired due to extensive soil contamination.

Lakes, ponds, and reservoirs in the RRSNF—Klamath Mountains unit are exposed to several stressors that can impact water quality, including altered fire regimes, loss of forest cover, land-use change, and pollution (see the section "Stressors" on page 3). According to the WCF, there is a high likelihood of altered hydrologic and sediment regimes due to departure from historical ranges of variation in vegetation, fuel characteristics, fire frequency, fire severity, and fire pattern in most watersheds in this unit. Loss of forest cover in nearly half of watersheds is also likely to have altered hydrologic and sediment regimes. In addition to impacts on water quality from wildfire, land-use change is likely to alter chemical composition of systems that receive runoff from developed areas. Riparian and wetland vegetation may increase the resilience of some lakes, ponds, and reservoirs to water quality stressors, as 14 percent of watersheds containing these habitats are properly functioning for WCF riparian and wetland vegetation condition. In these watersheds, riparian and wetland vegetation is capable of dissipating stream energy, reducing erosion, and improving water quality (Potyondy and Geier 2011). Eighty-six percent of watersheds were classified as functional-at-risk, meaning riparian vegetation is functional, but susceptible to degradation. No lakes, ponds, or reservoirs are listed by the State as impaired, most stressors are limited, and the WCF water quality attributes indicate most watersheds containing these habitats are either properly functioning or functional-at-risk; therefore, we expect that water quality of most waterbodies in the RRSNF—Klamath Mountains unit is likely to be high. It is likely that these habitats are vulnerable to increases in pollution or high-severity wildfires.

Riparian Reserves Condition

We did not assess RRs associated with lakes, ponds, and reservoirs. These areas are likely to have been altered by increasingly frequent and severe wildfires, effects of fire exclusion, and interactions among climate change and other stressors, based on results from stream ecosystems.

Fens, Springs, and Vernal Pools

Distribution

Data related to the distribution of fens, springs, and vernal pools are limited within the study area. Serpentine fens are likely to be present in much of the western portion of this unit, where ultramafic bedrock and springs are abundant (fig. 24). Extensive alluvial and glacial deposits are rare in this unit (table A.7 in volume 1 of this series), thus potentially limiting the development of peatland fens. There are 342 mapped springs in the unit (0.2 per square mile). These springs

are clustered in several types of bedrock, with and without faults (fig. 24). The largest clusters are located in the southeastern portion of the unit in fractured intrusive and metamorphic rocks. Large springs may be associated with areas of carbonate karst in the southern portion of the unit. Volcanic plateaus are absent from this mountainous unit, so alluvial terraces are the landforms where vernal pools are most likely to occur. Alluvial deposits are rare in this unit (fig. 24), however, suggesting that abundance of vernal pools is low.

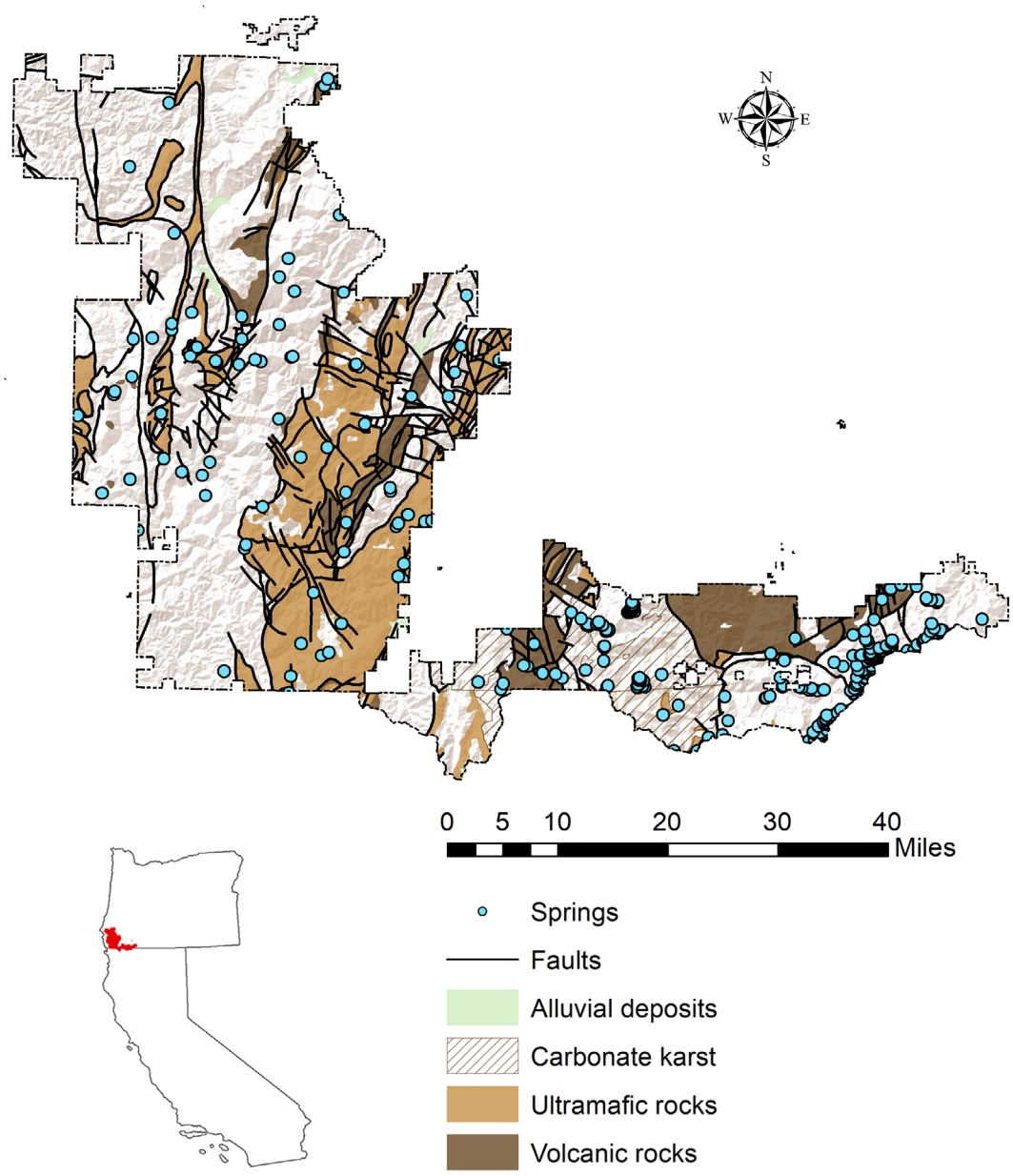

Figure 24—Distribution of rare and unique habitats and associated geologic features in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Peatland fens are likely to be found in alluvial deposits and glacial deposits, serpentine fens are associated with ultramafic rocks, and vernal pools are typically found on alluvial terraces and volcanic plateaus. Lower map shows location of study area within Oregon and California.

Hydrologic Regimes

Data related to the hydrologic conditions of fens, springs, and vernal pools are limited within the study area. Wetlands and fens have moderate to high sensitivity to climatic and anthropogenic stressors (Sims et al. 2019d), springs and seeps are moderately sensitive (Sims et al. 2019b), and vernal pools are highly sensitive (Sims et al. 2019c). We have summarized stressors to these habitats, but there is insufficient information to determine whether hydrologic regimes of fens, springs, and vernal pools are altered.

The hydrology of fens, springs, and vernal pools is strongly impacted by climate, including temperature and precipitation, drought, the amount and residence time of snowpack, runoff timing, and the magnitude of summer baseflows. Temperature has increased in all four seasons (see the section "Stressors" on page 3). Annual precipitation throughout the Five Forests planning area has remained consistent or slightly increased; however, the timing of precipitation has shifted, with increases in precipitation during winter and spring and loss of nearly half of summer precipitation observed in this unit (see the section "Stressors"). Changes in temperature and precipitation appear to have affected snowpack; significant declines in April 1 SWE have been observed throughout the Five Forests (Loose et al. 2019). Substantial reductions in SWE and snow residence time are expected by 2100 (see the section "Stressors"). Reduced summer precipitation and warmer temperatures are linked to shortened hydroperiods in wetlands, fens, and vernal pools (Montrone et al. 2019; Perry et al. 2012; Sims et al. 2019c,d). Changes in seasonal precipitation amounts can affect the magnitude and timing of recharge to groundwater systems that supply flow to springs and seeps (Sims et al. 2019b), and substantial shifts in seasonal precipitation alter the timing and length of vernal pool inundation (Bauder 2005; Montrone et al. 2019; Pyke 2004; Sims et al. 2019c). Reductions in snowpack are linked to increased drying of fens and vernal pools (Sims et al. 2019c,d). Finally, smaller snowpack affects the magnitude and timing of recharge to groundwater systems that support spring flows (Sims et al. 2019b).

Periods of drought are associated with channel incision that drains water from wetlands and fens, reduces water residence time, decreases recharge, and leads to further drying of these habitats (Null et al. 2010; Sims et al. 2019d; Viers et al. 2013). Additionally, springs associated with shallow aquifers can go dry during periods of drought (Sims et al. 2019b). Impacts of drought on fen, spring, and vernal pool hydrology are likely to be limited in this unit. According to the TCA, none of this unit was in poor or very poor condition for drought, and moisture deficits ranged from near normal to severe (see the section "Stressors"). Although drought years have occurred twice as often over the last two decades compared to the previous century (Diffenbaugh et al. 2015; Sims et al. 2019d), recent droughts are less severe and shorter in duration than historical drought (Gross et al. 2020; Malevich et al. 2013). Gross et al. (2020) suggest that hydrologic impacts of recent droughts, when not exacerbated by other stressors, are within NRV.

Changes in climate can alter stream hydrology, specifically the timing of runoff and the magnitude of summer baseflows, in ways that affect the hydrologic regimes of fens, springs, and vernal pools. Earlier runoff is linked to increased drying of wetlands and fens (Chambers and Miller 2011; Sims et al. 2019d). Additionally, earlier runoff affects the magnitude and timing

of recharge to groundwater systems that support spring flow. Most streams in this unit are characterized by early rainfall-dominated runoff and this pattern is not expected to change by mid-century (see the section “Hydrologic Regimes” for each stream type). Declines in summer baseflow can increase the drying of fens and wetlands (Chambers and Miller 2011; Sims et al. 2019d). The magnitude of summer baseflows in streams throughout this unit is expected to decline by mid-century (see the section “Hydrologic Regimes” for each stream type).

Alterations to fen, spring, and vernal pool hydrology imposed by changes in climate can be exacerbated by nonclimate stressors, including altered fire regimes, land-use change, dams and diversions, roads, and livestock grazing. According to the WCF fire regime condition class attribute, the hydrologic regimes of fens, springs, and vernal pools are likely to be affected by altered fire patterns; most watersheds in this unit are classified as impaired (see the section on page 3). Land-use change may have localized impacts, with small portions of the unit being converted to agriculture and development. Impacts from dams and diversions, roads, and livestock grazing are likely to be limited; the WCF indicates 4, 9, and 0 percent of watersheds are classified as impaired for flow characteristics, roads and trails condition, and rangeland vegetation condition, respectively. Of the 386 mapped springs in this unit, 86 percent were in watersheds classified as impaired for Fire Regime Condition Class and 27 percent were in watersheds classified as impaired for flow characteristics. Improved mapping of wetlands, fens, and vernal pools would allow analysis of whether these habitats are exposed to climate and nonclimate stressors.

Water Quality

Data related to the water quality of fens, springs, and vernal pools are limited within the study area. Wetlands and fens have moderate to high sensitivity to climatic and anthropogenic stressors (Sims et al. (2019d), springs and seeps are moderately sensitive (Sims et al. 2019b), and vernal pools are highly sensitive (Sims et al. 2019c). We have summarized stressors to these habitats, but there is insufficient information to determine whether water quality is altered.

Water quality at fen, spring, and vernal pool ecosystems can be impacted by climatic stressors that alter the amount of water in the system, including drought and changes in snowpack or precipitation amount (Sims et al. 2019d). Snowpack throughout the Five Forests planning area has declined by up to 40 percent over the last 40 to 70 years (Loose et al. 2019; Siegel 2009; Sims et al. 2019c) and significant reductions in April 1 SWE are expected to occur within this unit by the end of this century. Precipitation amounts have remained relatively consistent within the Five Forests and this pattern is expected to continue through the end of this century (Loose et al. 2019; Sims et al. 2019c). The TCA suggests none of this unit is in poor condition due to climate exposure and it is unlikely that changes in temperature and precipitation have compromised the water quality of springs. Drought conditions are unlikely to have impacted fen, spring, and vernal pool water quality within this unit. Moisture deficits have ranged from near normal to severe. Gross et al. (2020) and Malevich et al. (2013) suggest that droughts and their impact on aquatic ecosystems within the study area are within NRV; however, severe moisture deficits in limited areas within this unit may exacerbate impacts of nonclimate stressors on fen, spring, and vernal pool water quality. The TCA indicates none of this unit is in poor or very poor condition for drought and it is unlikely that drought has impacted the water quality of springs.

Nonclimate stressors that can degrade fen, spring, and vernal pool water quality include water withdrawal, development, and pollution (Sims et al. 2019c). According to the WCF, most watersheds in this unit were in good condition for flow characteristics, suggesting that no or limited groundwater withdrawals are impacting the water quality of fens, springs, and vernal pools. Pollution may impact water quality in some locations, as the TCA indicates about one-quarter of this unit is in poor or very poor condition and the WCF indicates soil contamination may impact some watersheds. Additionally, land-use change, specifically conversion to development and agriculture, can impact fen, spring, and vernal pool water quality (Scanlon et al. 2005; Sims et al. 2019c,d; Winter et al. 1998). Runoff from lands converted to agriculture or development can introduce contaminants to the groundwater systems that support fens and supply discharge to springs (Sims et al. 2019b,d; Winter et al. 1998). Water quality in these habitats can also be impacted by livestock operations that increase nutrient pollution (Brown et al. 2011; Sims et al. 2019c,d). Conversion of lands to development and agriculture has occurred within this unit and it is likely that these changes have had minor and localized impacts on the water quality of fens, springs, and vernal pools. The WCF indicates rangelands in nearly all watersheds are properly functioning.

The WCF Water Quality Condition Indicator addresses alteration of physical, biological, and chemical characteristics of water quality through consideration of State-listed waterbodies and problems within watersheds that include excessive sediment, excessive nutrients, or chemical pollution. Of the 386 mapped springs in the RRSNF—Klamath Mountains unit, 55 percent were in watersheds that were properly functioning according to the WCF Water Quality Condition Indicator. Of mapped springs, 36 percent were in watersheds rated as functional-at-risk for Water Quality Condition and only 9 percent were in watersheds classified as poor.

Habitat Condition

Data related to the condition of fens, springs, and vernal pools are limited within the study area. We have summarized stressors to these habitats, but there is insufficient information to determine whether conditions are altered. In the Five Forests planning area, anthropogenic disturbances to fens and surrounding meadows included recreation trails, trampling by livestock, and livestock grazing (Sikes et al. 2013). In addition to site-scale disturbances, fens are vulnerable to a variety of anthropogenic activities occurring at the watershed scale. Watershed-scale protections may have maintained or increased the ecological integrity of fens in the RRSNF, where much of the forest area is within KWs, LSRs, or congressional reserves (appendix table 2). Site visits are needed, however, to determine whether these landscape-scale patterns in stressors are reflected in conditions at fens in the RRSNF. The Spring Stewardship Institute has mapped 2,642 springs in the Five Forests planning area. Of the 1,922 springs in the Klamath Mountains units, 43 percent are within grazing allotments. Most springs in allotments are altered by diversions for stock water or directly impacted by livestock (or both) (Freed et al. 2019). Ecological integrity of springs may therefore be greater in forests where there are fewer active grazing allotments and low percentages of mapped springs within these allotments (table F.3). Site visits to these springs are needed, however, to confirm these conclusions. We found no information about vernal pool distribution and habitat condition specific to the RRSNF.

Interwatershed Connectivity

There were 147 twelve-digit hydrologic unit code (HUC12) watersheds with at least some area within the RRSNF—Klamath Mountains unit. Watersheds had between 2 and 10 neighboring watersheds within the administrative boundary for a total of 799 pairs of neighboring watersheds with potential for connection between RRs (fig. 25). Of these 799 pairs, 343 (43 percent) were classified as connected with 0 miles separating RRs in neighboring watersheds (fig. 26). An additional 225 (28 percent) pairs were classified as within 0.25 mile; that is, RRs in neighboring watersheds occurred within a quarter of a mile of each other (fig. 26). Finally, 231 (29 percent) neighboring watersheds were not connected, meaning RRs in these pairs were separated by a distance greater than 0.25 mile (fig. 26).

We identified four triads in the RRSNF—Klamath Mountains unit: the Applegate/Illinois/Lower Klamath, the Chetco/Illinois/Smith, the Coquille/Lower Rogue/Sixes, and the Coquille/Lower Rogue/South Umpqua.

In the Applegate/Illinois/Lower Klamath triad, there is RRSNF land within each of the three HUC8 watersheds. Most of the NFS land in the Lower Klamath watershed is part of the Klamath National Forest (fig. 27). Sixty-seven percent of the triad area was within the Five Forests' administrative boundaries. Key watersheds covered 29 percent and RRs covered 16 percent of the triad (appendix table 9). Road density was 1.8 miles per square mile across the full triad area and 1.9 miles per square mile within the administrative boundary. Mean canopy cover was 70 percent across the full triad area and 65 percent on lands within the administrative boundary (appendix table 9). Down wood cover was 3 percent both across the full triad area and within the administrative boundary. Large down wood cover was 1 percent across the full triad area and 1 percent within the administrative boundary. Tree density was 522 trees per acre across the full triad area and 473 trees per acre within the administrative boundary.

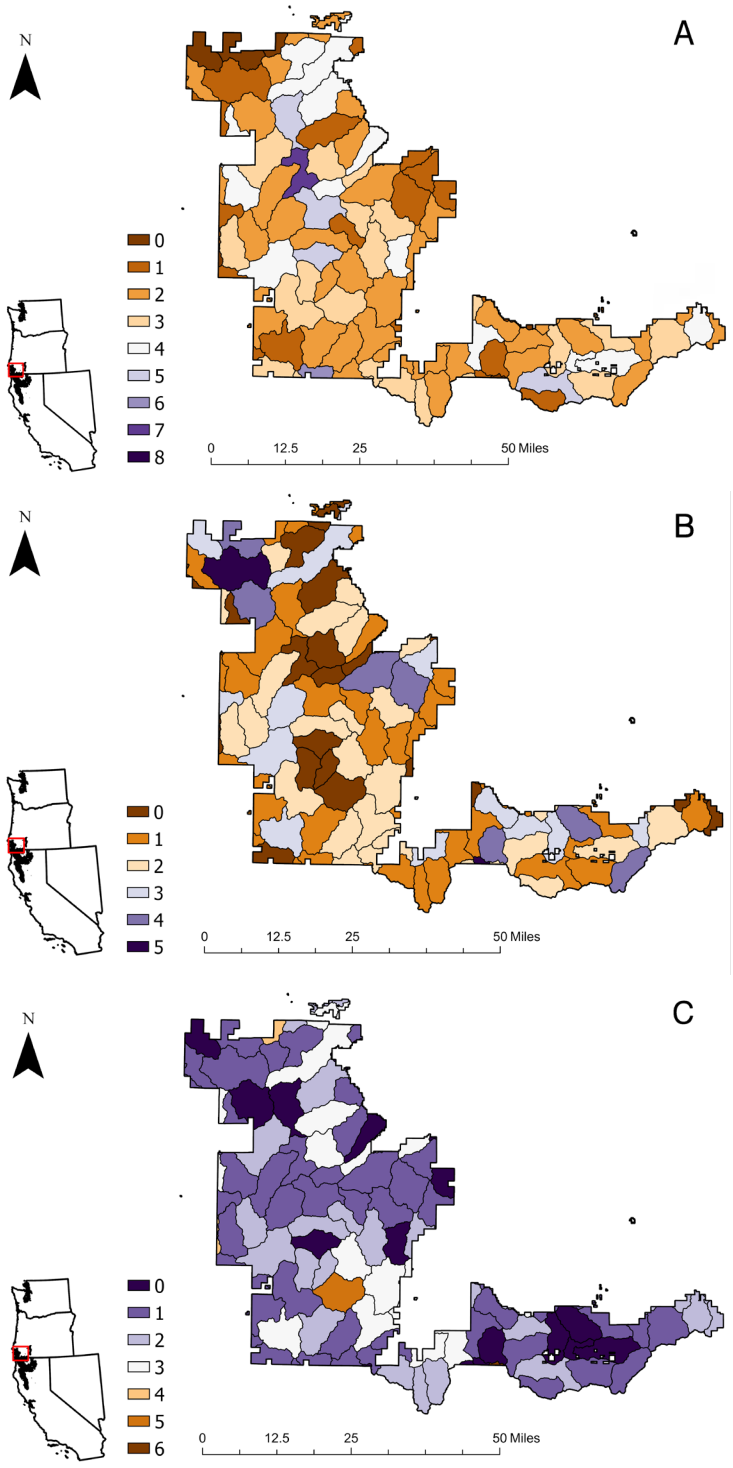

Figure 25—Riparian reserve (RR) connectivity between 12th-level hydrologic unit (HUC12) watersheds in the Rogue River-Siskiyou National Forest—Klamath Mountains unit: the number of neighboring watersheds: (a) with a distance of 0 miles between RRs, (b) with RRs within 0.25 mile of each other, and (c) with no connection between RRs. Purple watersheds have greater connectivity or potential connectivity with neighbors and brown watersheds have less connectivity with neighbors. Insets show location of study area within Oregon and California.

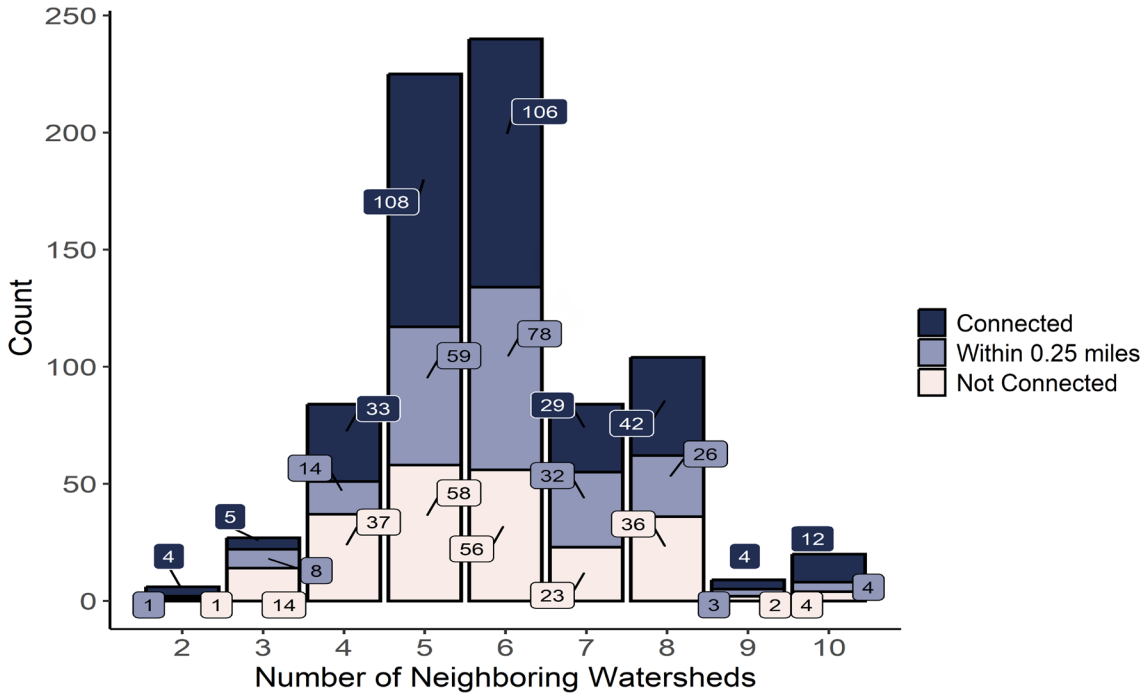

Figure 26—Count of neighboring watershed pairs classified as having connected riparian reserves (RRs), RRs within 0.25 mile, or no connection between RRs by the number of neighboring watersheds in the Rogue River-Siskiyou National Forest—Klamath Mountains unit.

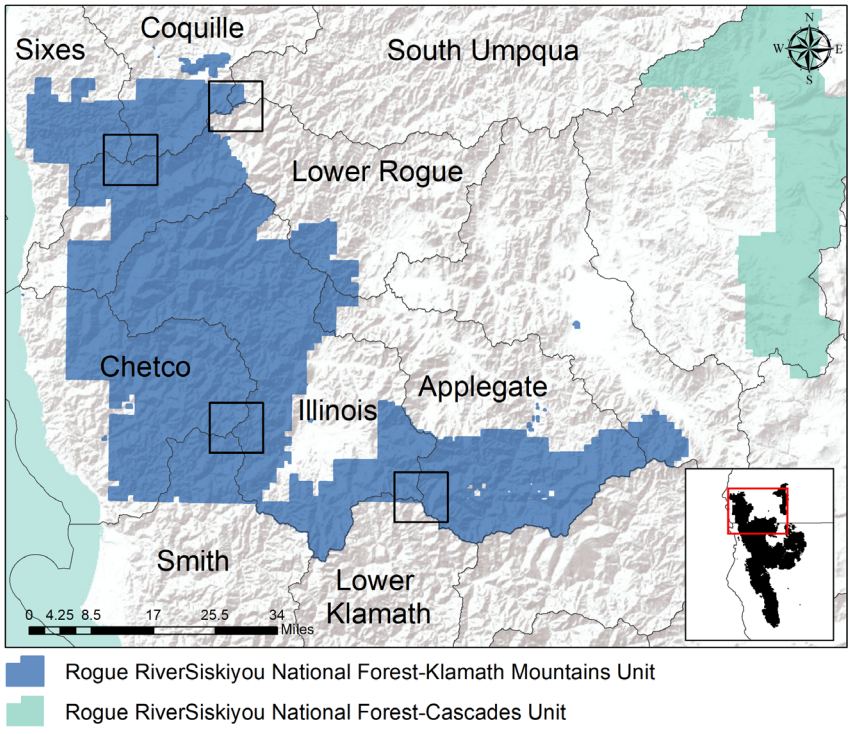

Figure 27—Triads (black squares) within the Rogue River-Siskiyou National Forest—Klamath Mountains unit (blue area), with labels indicating 8th-level hydrologic unit (HUC8) watersheds that are joined by triads. Inset shows location of study area within Oregon and California.

In the Chetco/Illinois/Smith triad, there is RRSNF land within each of the three watersheds. Most of the NFS land in the Smith watershed is part of the Six Rivers National Forest. Sixty-four percent of the triad area was within the Five Forests' administrative boundaries. Key watersheds covered 37 percent and RRs covered 17 percent of the triad (appendix table 9). Road density was 1.6 miles per square mile across the full triad area and 1.3 miles per square mile within the administrative boundary. Mean canopy cover was 64 percent both across the full triad area and on lands within the administrative boundary (appendix table 9). Down wood cover was 3 percent across the full triad area and 2 percent within the administrative boundary. Large down wood cover was 1 percent across the full triad area and 1 percent within the administrative boundary. Tree density was 497 trees per acre across the full triad area and 519 trees per acre within the administrative boundary.

In the Coquille/Lower Rogue/Sixes triad, there is RRSNF land within each of the three watersheds. Twenty-one percent of the triad area was within the Five Forests' administrative boundaries. Key watersheds covered 14 percent and RRs covered 5 percent of the triad (appendix table 9). Road density was 2.2 miles per square mile across the full triad area and 2.1 miles per square mile within the administrative boundary. Mean canopy cover was 68 percent across the full triad area and 79 percent on lands within the administrative boundary (appendix table 10). Down wood cover was 3 percent both across the full triad area and within the administrative boundary. Large down wood cover was 1 percent across the full triad area and 1 percent within the administrative boundary. Tree density was 428 trees per acre across the full triad area and 587 trees per acre within the administrative boundary.

In the Coquille/Lower Rogue/South Umpqua triad, there is RRSNF land within each of the three watersheds, but a small amount is within the South Umpqua watershed. Most of the land in the South Umpqua watershed is outside of the Five Forests planning area. Twelve percent of the triad area was within the Five Forests' administrative boundaries. Key watersheds covered 29 percent and RRs covered 3 percent of the triad (appendix table 9). Road density was 3.2 miles per square mile across the full triad area and 6.1 miles per square mile within the administrative boundary. Mean canopy cover was 65 percent across the full triad area and 73 percent on lands within the administrative boundary (appendix table 10). Down wood cover was 3 percent across the full triad area and 4 percent within the administrative boundary. Large down wood cover was 1 percent both across the full triad area and within the administrative boundary. Tree density was 417 trees per acre across the full triad area and 575 trees per acre within the administrative boundary.

Two areas where three watersheds meet (Chetco/Illinois/Lower Rogue and Applegate/Illinois/Lower Rogue) were not selected as triads for this analysis because at least two of the watersheds in these groups are hydrologically connected.

ASSESSMENT FOR THE ROGUE RIVER-SISKIYOU NATIONAL FOREST—CASCADES UNIT

The 460,000-acre Cascades unit of the Rogue River-Siskiyou National Forest is located in southwestern Oregon. Seven level IV ecoregions are present within this unit (table A.1). Of this unit, 66 percent is classified as Low Southern Cascades Mixed Conifer Forest (Southern Cascades). These moderately dissected mountains are between 1,400 and 5,300 feet in elevation (Thorson et al. 2003). Lower elevations are characterized by Douglas-fir, ponderosa pine, white fir, cedar (*Calocedrus* spp.), and some sugar pine (*Pinus lambertiana*). Vegetation communities at higher elevations include red fir, mountain hemlock (*Tsuga mertensiana*), and whitebark pine (*Pinus albicaulis*). Mean annual precipitation ranges from 45 to 80 inches and temperatures range from January minimums of 30 °F to July maximums of 85 °F. Streams are generally medium to high gradient. Reservoirs and a few large lakes of glacial origin are present within this ecoregion. Soils are generally Ultisols, Inceptisols, Alfisols and Mollisols and geologic formations include colluvium, pyroclasic rocks, basalt, basaltic andesite, breccia, tuff, sandstone, and siltstone (Thorson et al. 2003).

Of the RRSNF—Cascades unit, 19 percent is classified as High Southern Cascades Montane Forest. These areas are characterized by fir-hemlock. At higher elevations, whitebark pine and open meadows are common (Thorson et al. 2003). Elevations range from 4,000 to 8,200 feet. Mean annual precipitation ranges from 45 to 70 inches and temperatures range from January minimums of 23 °F to July maximums of 74 °F. Streams in these areas tend to be medium to high gradient. Soils are generally Andisols and Spodosols and geologic formations include glacial depositions, volcanic ash, pumice, and colluvium (Thorson et al. 2003).

Ten percent of this unit is classified as the Western Cascades Montane Highlands ecoregion. These partially glaciated, highly dissected mountains with buttes and ridges range from 3,000 to 6,500 feet in elevation (Thorson et al. 2003). Mean annual precipitation ranges from 70 to 120 inches and temperatures range from January minimums of 26 °F to July maximums of 75 °F. Streams in these areas are medium to high gradient. Soils are generally Inceptisols, Andosols, Haplocryands, and Ultisols and geologic depositions include colluvium, volcanic ash, basaltic lava flows, and breccia (Thorson et al. 2003).

The four additional ecoregions present in the RRSNF—Cascades unit are Cascades Subalpine/Alpine, Southern Cascades Slope, Oak Savanna Foothills, and Inland Siskiyous. Each occupies 2 percent or less of the unit.

Stressors

Climate Change

According to the TCA, 10 percent of the RRSNF—Cascades unit was in poor or very poor condition for climate exposure. This finding means the changes in climate are unlikely to have impacted terrestrial ecological integrity within the unit (Cleland et al. 2017). Air temperatures in this unit have increased in all four seasons (table 16). Since 1900, annual precipitation has remained consistent or slightly increased throughout the Five Forests planning area (Loose et al. 2019), and these trends are expected to continue within this unit through 2100 (table 17). The timing of precipitation in this unit has changed over the last century, with significant decreases in summer precipitation and increases in winter and spring snow and rainfall (table 16).

Snowpack throughout the Five Forests has declined by up to 40 percent over the last 40 to 70 years (Loose et al. 2019; Siegel 2009; Sims et al. 2016c), and significant reductions in April 1 SWE and snow residence time are expected to occur within this unit by the end of this century (table 17). Snowmelt has shifted earlier by 15 to 40 days throughout the western United States since 1915 (Hamlet et al. 2005; Loose et al. 2019), and snowmelt-driven runoff in the same area has shifted 10 to 30 days earlier since the 1940s (Loose et al. 2019; Stewart et al. 2005).

Table 16—Mean (minimum, maximum) deviation in temperature and percentage change in precipitation for each season in the Rogue River-Siskiyou National Forest—Cascades unit. Values were determined by the 2019 USDA Forest Service Terrestrial Condition Assessment (TCA; Cleland et al. 2017) using PRISM data as the mean departure of a recent 5 years from the historical record. The TCA uses an increase of 2 °F and a decrease of 10 percent as thresholds to identify land type associations that have experienced recent severe temperature or precipitation stress.

Season	Deviation in mean (minimum, maximum) temperature, °F	Percentage change in mean (minimum, maximum) precipitation
Winter	1.5 (1.1, 1.9)	7.6 (-2.6, 16.5)
Spring	2.0 (1.4, 2.1)	4.3 (-3.6, 23.8)
Summer	3.4 (2.5, 3.4)	-48.2 (-49.2, -40.7)
Fall	0.5 (0.3, 0.7)	-8.8 (-16.7, 3.1)

Table 17—Historical and projected annual precipitation, snow water equivalent, and snow residence time for the Rogue River-Siskiyou National Forest—Cascades unit. Data from the National Forest Climate Change Maps (USDA FS 2022).

Variable	Historical (1975–2005) mean (minimum, maximum)	Projected (2071–2090) mean (minimum, maximum)
Annual precipitation (inches)	49.9 (33.6, 65.1)	51.4 (34.3, 67.8)
April 1 snow water equivalent (inches)	13.9 (0, 38.7)	1.2 (0, 19.8)
Snow residence time	56.4 (13.6, 109.6)	11.2 (0, 65.1)

Dams and Diversions

There were 0.5 diversions per square mile and 8 dams in this unit. Of the 376 diversions within the unit boundary, 290 occurred on NFS land. According to the WCF, 55 percent of watersheds were properly functioning for flow characteristics. These watersheds had primarily free-flowing rivers and streams, unmodified lakes, and no or limited groundwater withdrawals (Potyondy and Geier 2011). Thirty-six percent of watersheds were classified as functional-at-risk for flow characteristics. Peak and base flows are maintained in these watersheds, but changes in the timing, rate of change, or duration (or combination thereof) of mid-range discharges have occurred (Potyondy and Geier 2011). Nine percent of watersheds were classified as impaired for flow characteristics, meaning hydrographs significantly departed from natural flow regimes (Potyondy and Geier 2011).

Departure from Natural Disturbance Regimes

According to the TCA, 76 percent of the unit is in poor or very poor condition for fire deficit. These areas have not burned as frequently as projected by LANDFIRE's mean fire return interval. Data from the TCA were available through 2018. Since then, none of this unit has

burned at low, moderate, or high severity (table 18). According to the WCF fire regime condition class attribute, 3 percent of watersheds in this unit were properly functioning. In these areas, vegetation characteristics, fuel composition, fire frequency, and fire severity were within NRV across a predominant percentage of the land within each watershed. Vegetation in these watersheds offers good protection to soil and water resources (Potyondy and Geier 2011). Sixty-one percent of watersheds were classified as functional-at-risk. These areas have moderate departure from reference fire regimes across the majority of each watershed. Vegetation in these watersheds was somewhat affected by abnormal fire patterns, resulting in less protection of soil and water resources (Potyondy and Geier 2011). Thirty-seven percent of watersheds were impaired for Fire Regime Condition Class. These areas tend to experience periods of fuel accumulation followed by infrequent, intense, high-severity fires that lead to vegetation mortality and poor protection of soil and water resources (Potyondy and Geier 2011). In addition to departures in fire regime, the magnitude of maximum flows may decrease by up to 5 percent or increase by up to 6 percent and the magnitude of 1.5-year return interval floods is expected to increase by 16 to 21 percent throughout the unit by the 2040s (see the section "Hydrologic Regimes" for each stream type). Miller et al. (2017) suggest that streams experiencing an increase in peak flow of greater than 36 percent are very likely to be impaired. Increases in peak flow of less than 5 percent are likely to have minimum impacts (Miller et al. 2017).

Table 18—Percentage of the Rogue River-Siskiyou National Forest—Cascades unit burned at low, moderate, and high severity from 2012 through 2021. Data from the Rapid Assessment of Vegetation Condition after Wildfire composite burn index.

Year	Percentage burned at low severity	Percentage burned at moderate severity	Percentage burned at high severity
2012	--	--	--
2013	--	--	--
2014	0.2	0.2	0.1
2015	0.4	0.2	0.1
2016	--	--	--
2017	2.0	1.1	1.1
2018	2.0	0.4	0.2
2019	--	--	--
2020	--	--	--
2021	--	--	--

-- Indicates no burn.

Drought

According to the TCA, 10 percent of this unit was in poor or very poor condition for drought. The Z-scores (values that represent a long-term deviation in annual moisture) were calculated by the TCA using moisture indices from 1900 to 2017 (Cleland et al. 2017; Koch et al. 2015) (fig. C.2). This index indicated that condition in this unit ranged from mild to moderate drought (fig. 28).

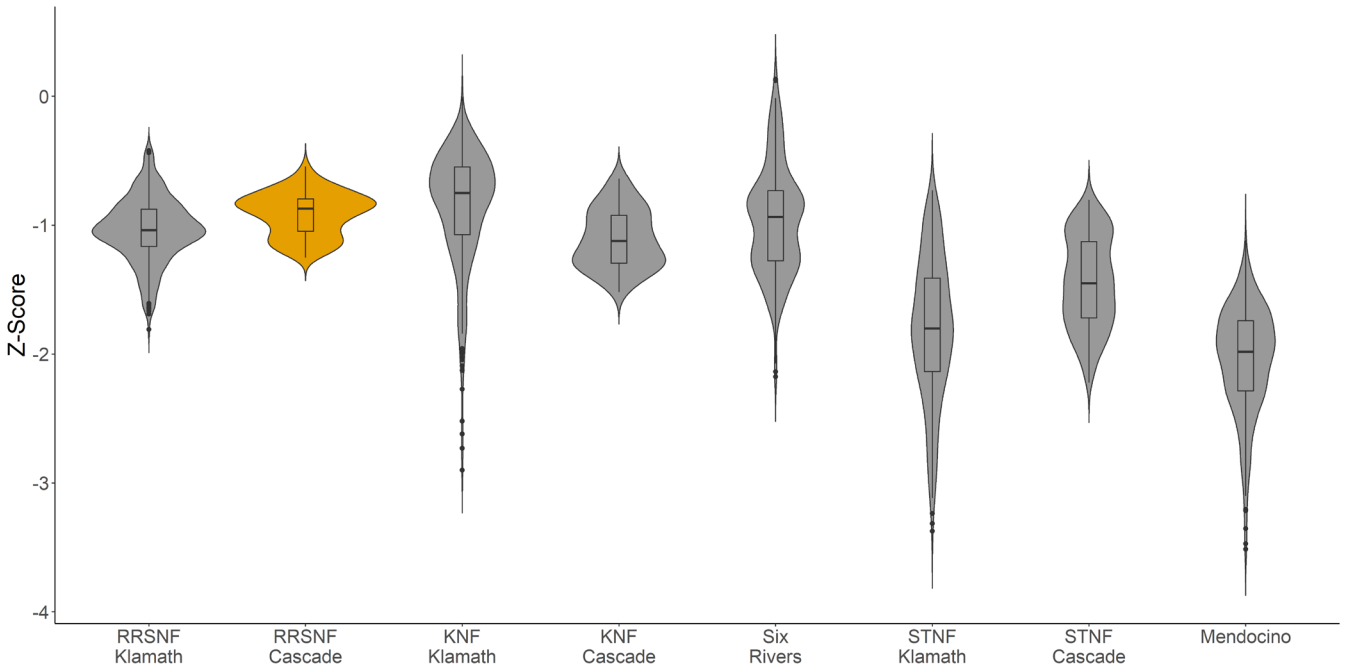

Figure 28—Violin and box plot displaying distribution, median, and quartile values of pixel Z-scores for every 4 km pixel present within each study unit of the Five Forests cohort. Z-scores ranging from 0.5 to –0.5 indicate near-normal conditions; -0.5 to -1 indicate mild drought, -1 to -1.5 indicate moderate drought, -1.5 to -2 indicate severe drought, and -2 or less indicate extreme drought. KNF: Klamath National Forest; RRSNF: Rogue River-Siskiyou National Forest; STNF: Shasta-Trinity National Forest.

Invasive Species

There were no invasive plant species at AREMP sampling sites in this unit. According to the WCF exotic and/or aquatic invasive species attribute, 30 percent of watersheds in this unit were properly functioning, 67 percent were classified as functional-at-risk, and 1 watershed was impaired. These findings mean that invasive species are generally present and have lowered the health and sustainability of native species in most watersheds in this unit (Potyondy and Geier 2011).

Land-use Change

According to LANDFIRE data from 2016, 22 acres (0.01 percent) in the unit were classified as agriculture (fig. 29). We determined that less than 1 acre of agriculture occurred on NFS land, while the remaining 22 acres occurred on non-NFS lands within the unit. An additional 1,464 acres (0.3 percent) have been converted to development (fig. 29). Of these acres, 1,250 occurred on NFS land and the remaining 214 occurred on non-Forest Service land within the unit. Conversion to agriculture and development has occurred within 1.1 percent of permanently flowing fish-bearing stream RRs within the administrative boundary, which includes some non-Forest Service lands. Conversion to agriculture and development also occurred within 0.1 percent of permanently flowing nonfish-bearing streams RRs, 2.9 percent of seasonally flowing fish-bearing stream RRs, and 0.3 percent of seasonally flowing nonfish-bearing stream RRs. Agricultural types are Western Cool Temperate Close Grown Crop and Western Cool Temperate

Fallow/Idle Cropland. Sixty-five percent of developed land is classified as landscaped vegetation types, such as Western Cool Temperate Urban Deciduous Forest, 30 percent is roads, and 5 percent is other nonvegetated cover. Based on Miller et al. (2017), watersheds with less than 0.05 percent agriculture and less than 2.0 percent development rank among least-disturbed reference conditions.

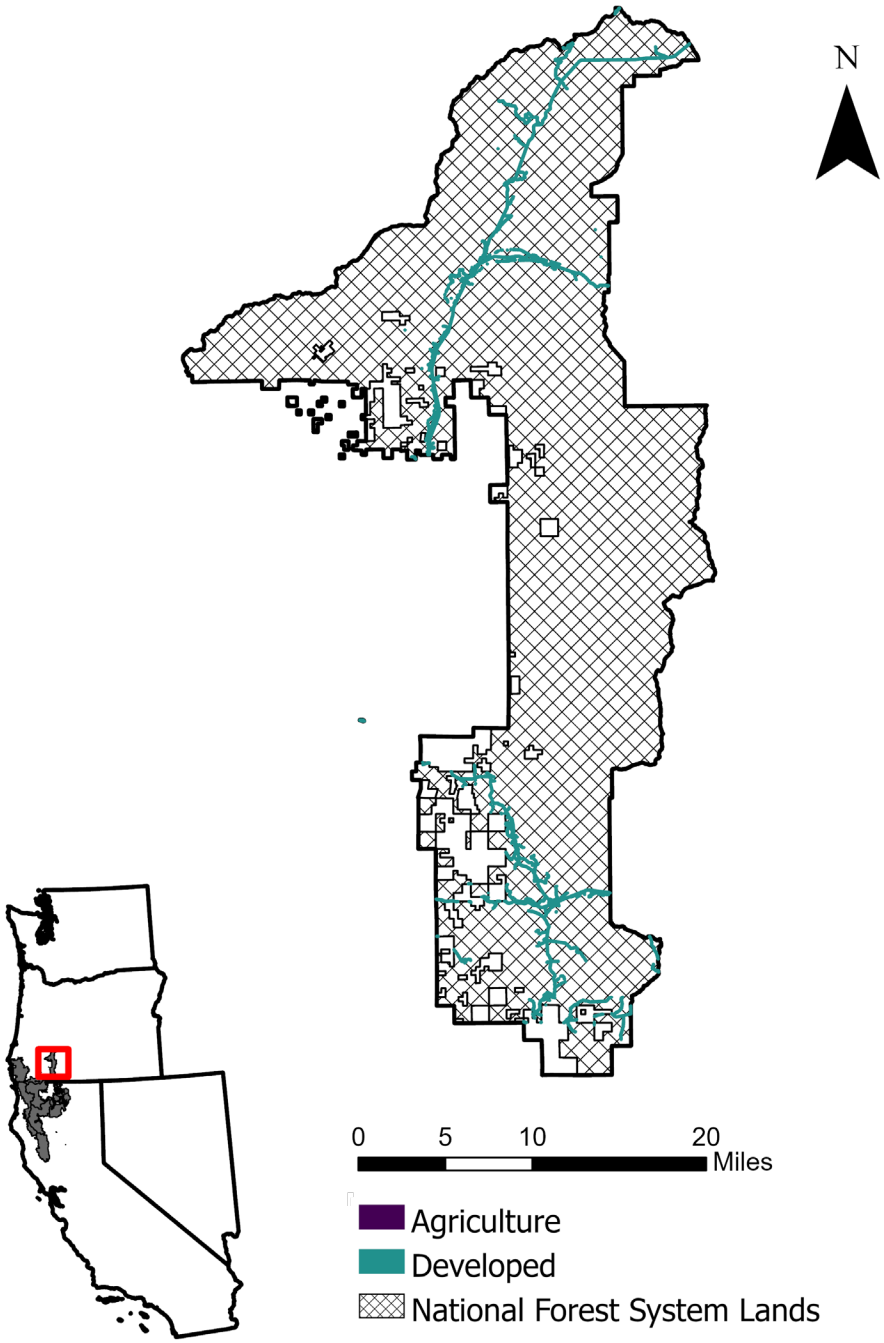

Figure 29—Agriculture and developed lands mapped by LANDFIRE within the Rogue River-Siskiyou National Forest—Cascades unit. Lower map shows location of study area within Oregon.

Livestock Grazing

Of this unit, 73 percent was within a grazing allotment. The WCF classified rangeland vegetation condition in 19 of the 38 watersheds present in this unit. Of the rated watersheds, the WCF rangeland vegetation condition attribute indicates all were properly functioning. In these watersheds, rangelands have the capacity to capture, store, and safely release water from rainfall, runoff, and snowmelt (Potyondy and Geier 2011). These rangelands also limit the redistribution and loss of soil resources, including nutrients and organic matter (Potyondy and Geier 2011).

Loss of Forest Cover

According to the WCF loss of forest cover attribute, 91 percent of watersheds were properly functioning. Less than 5 percent of NFS land in these watersheds contained cut-over, denuded, or deforested land that could contribute to increased erosion and sediment supply or alter stream temperature (Potyondy and Geier 2011). Nine percent of watersheds were classified as functional-at-risk, meaning between 5 and 15 percent of NFS land was cut over, denuded, or deforested. Twenty-seven percent of the unit was located within the boundary of a timber harvest project that occurred between 1934 and 2017. Approximately 2 percent of the RR area was within a timber harvest or stand treatment project since 1994. Most of the timber projects that have occurred within the Five Forests planning area under the Northwest Forest Plan have been thinning or selection cuts. The most extensive treatment type in the RRSNF—Cascades unit was single-tree selection cutting, which affected 1 percent of the RR area. Commercial thinning affected 0.7 percent. Seed-tree seed cuts, group selection cuts, stand clearcuts, and shelterwood removal cuts each affected 0.1 percent. In recent decades, timber harvest has become less of a driver for change in the loss of forest cover attribute as large, uncharacteristic wildfire has become increasingly common (Steve Bachmann, USDA Forest Service, Yreka, CA, personal communication, June 28, 2021). Since 2013, 12 percent of this unit was within wildfire-burned area perimeters and 2 and 2 percent of the unit was burned at moderate and high severity, respectively. Eighteen percent of the RR area was within burned-area perimeters of fires that occurred between 2013 and 2020.

Mining

There were 78 mines located in this unit and 87 acres impacted. Nearly all mines are historical and not active (Steve Bachmann, USDA Forest Service, Yreka, CA, personal communication, July 13, 2021). Most mines were classified as quarries, gravel pits, and borrow pits (fig. 30). Gravel pits impacted more acres than other mining activities.

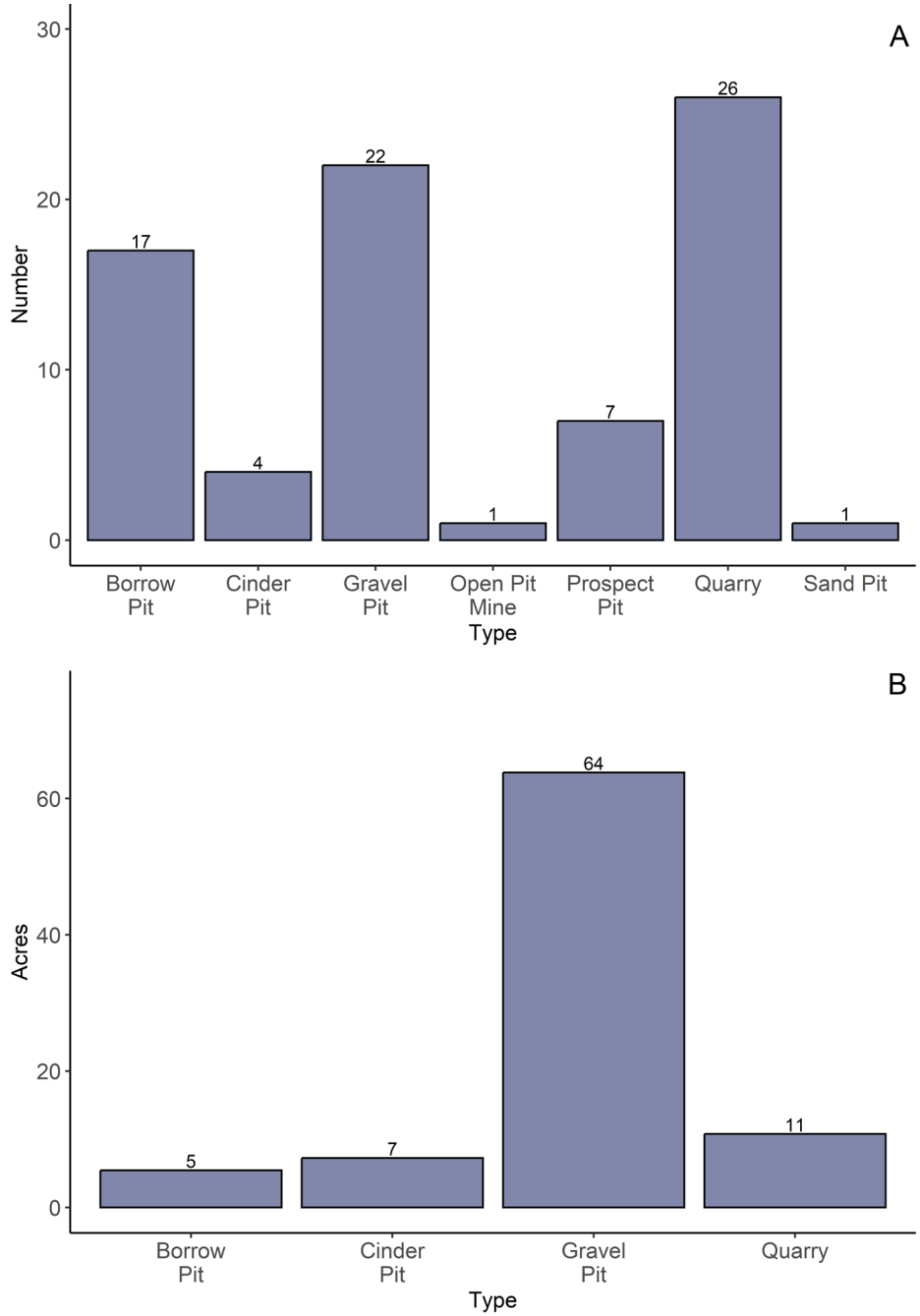

Figure 30—(a) Number of different types of mines and (b) acreage impacted by mining activities in the Rogue River-Siskiyou National Forest—Cascades unit.

Pollution

According to the TCA Pollution Indicator, none of this unit was in poor or very poor condition. This indicator considers acid and nitrogen deposition (figs. C.3, C.4) and ozone exposure. Based on the WCF soil contamination attribute, 55 percent of watersheds were properly functioning. Atmospheric deposition of sulfur or nitrogen (or both) in these watersheds is

more than 10 percent below the terrestrial critical load and there are no substantial areas of soil contamination. Forty-five percent of watersheds were rated functional-at-risk, meaning atmospheric deposition of sulfur and nitrogen is 0 to 10 percent below the terrestrial critical load and there are only limited areas of soil contamination. No watersheds were rated as impaired.

Recreation

This unit had 0.6 trail mile per square mile. See the section "Roads" below for information on the application of BMPs for trails. There were 80 recreation sites (0.1 site per square mile) in this unit. Most of these recreation sites were trailheads and campgrounds (fig. 31).

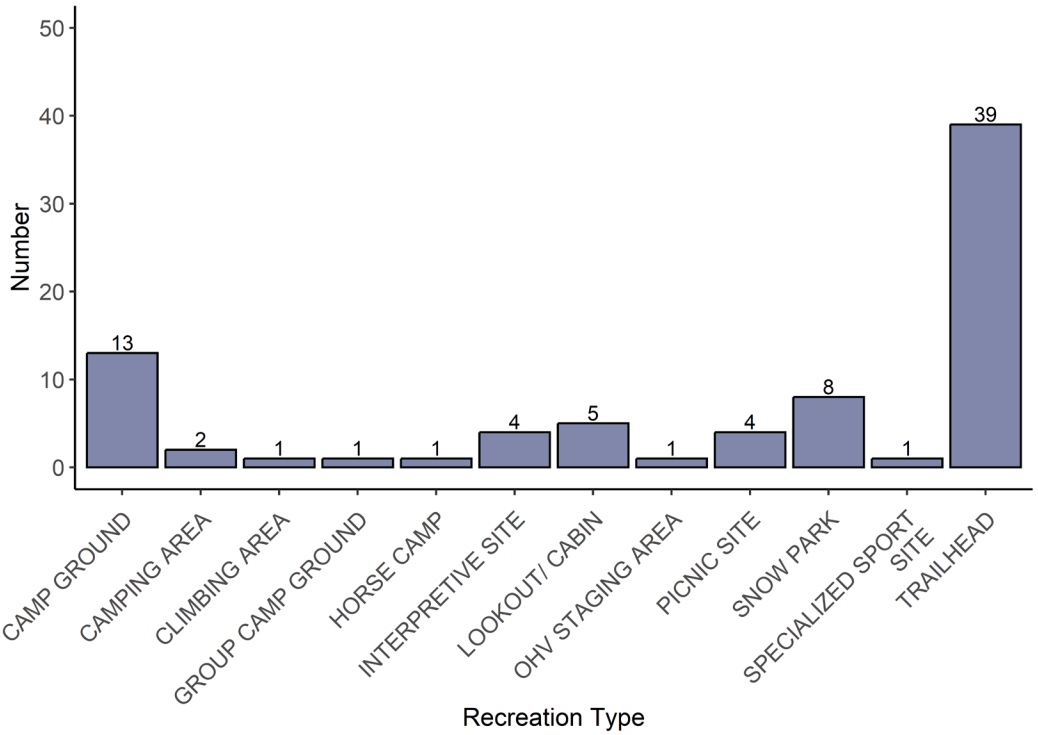

Figure 31—Number of different recreation site types within the Rogue River-Siskiyou National Forest—Cascades unit.

Roads

There were 3.2 road miles per square mile in this unit, but only 0.9 road mile per square mile within RRs. According to the TCA, 84 percent of the unit was in poor or very poor condition for road density, suggesting roads have impacted terrestrial ecological integrity in most of the unit. According to the WCF Roads and Trails Condition Indicator, 24 percent of watersheds were properly functioning. Hydrologic regimes within these watersheds were largely unimpacted by the density and distribution of roads and trails (Potyondy and Geier 2011). Forty-two percent of watersheds were rated as functional-at-risk, meaning there was moderate probability that the hydrologic regime was substantially altered by road density or distribution (Potyondy and Geier 2011). The remaining 33 percent of watersheds were impaired; there was high probability that density and distribution of roads had contributed to substantial hydrologic alterations (Potyondy and Geier 2011). According to the WCF, 100 percent of watersheds were classified as

functional-at-risk for road and trail maintenance; that is, BMPs for maintenance of drainage features are applied to between 50 and 75 percent of roads, trails, and water crossings in the watershed (Potyondy and Geier 2011). According to the WCF, all watersheds were properly functioning for mass wasting, meaning few roads were on unstable landforms, and there was no danger of large quantities of debris being delivered to the stream channel (Potyondy and Geier 2011).

Vegetation Mortality

Of this unit, 3 and 4 percent was impacted by tree mortality between 2009 and 2013 and between 2014 and 2018, respectively (fig. 32). The WCF insects and disease (Potyondy and Geier 2011) attribute indicates that 61 percent of watersheds were properly functioning, meaning less than 20 percent of forested land was at imminent risk of abnormally high levels of tree mortality due to insects and disease. Twenty-four percent of watersheds were rated as functional-at-risk; that is, between 20 and 40 percent of forested land had an imminent risk of abnormally high tree mortality due to insects and disease. Fifteen percent of watersheds were impaired, meaning more than 40 percent of forested land had imminent risk of abnormally high tree mortality due to insects and disease.

Ecosystems

Streams

The National Hydrography Dataset mapped 2,480 total miles of streams within the administrative boundary of the RRSNF—Cascades unit. Of the miles mapped, 2,290 occurred on NFS land. Of streams on NFS land, 19 percent were classified as permanently flowing fish-bearing streams, 23 percent were permanently flowing nonfish-bearing streams, 1 percent were seasonally flowing fish-bearing streams, and 57 percent were seasonally flowing nonfish-bearing streams (fig. 33). According to Loose et al. (2019), streams within the Five Forests planning area have moderate to high sensitivity to climatic and anthropogenic stressors and to changes in disturbance regimes.

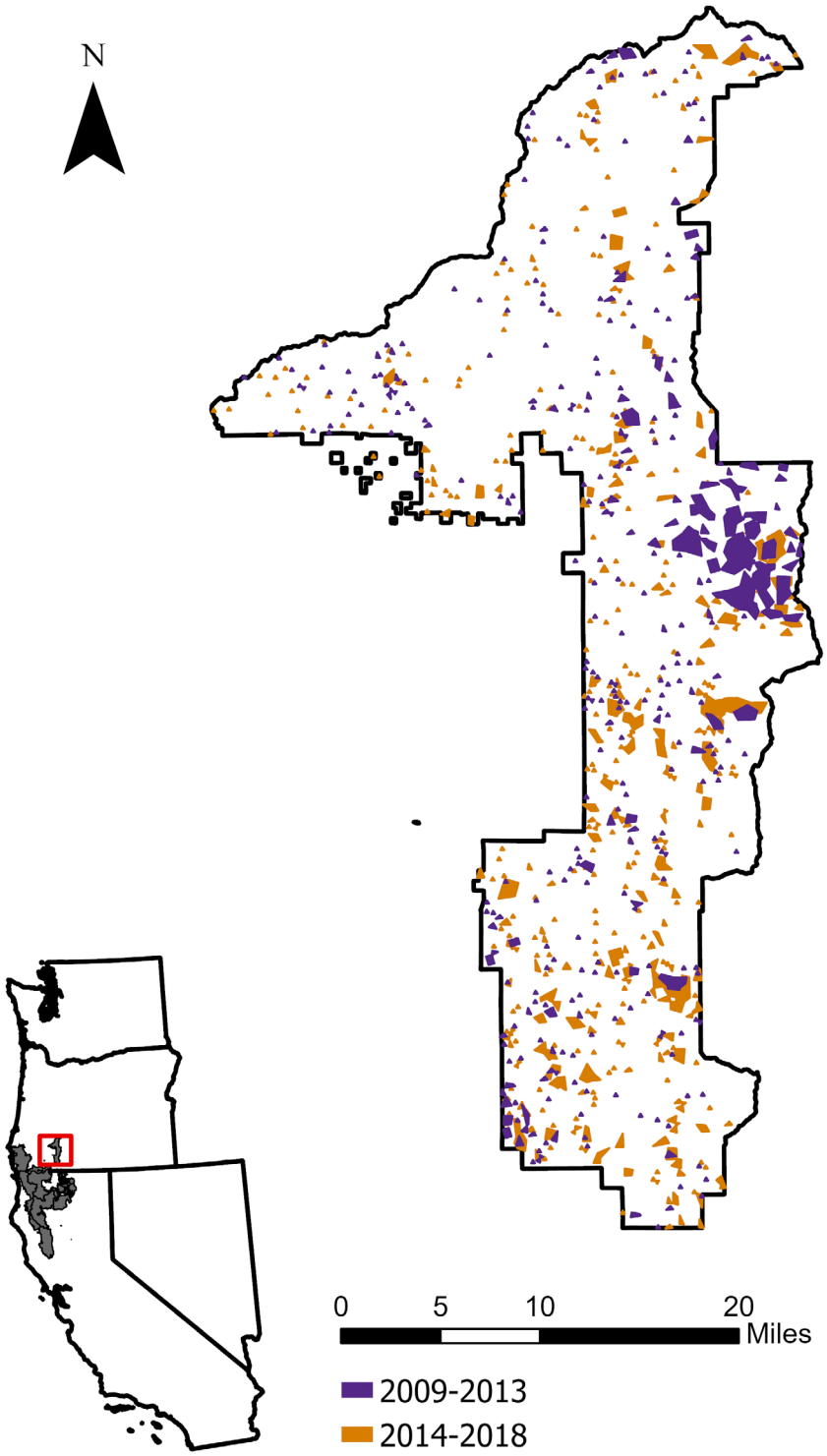

Figure 32—Tree mortality on the Rogue River-Siskiyou National Forest—Cascades unit mapped by the USDA Forest Service Forest Health Assessment and Applied Sciences Team for two time periods. Lower map shows location of study area within Oregon. Data from the Terrestrial Condition Assessment.

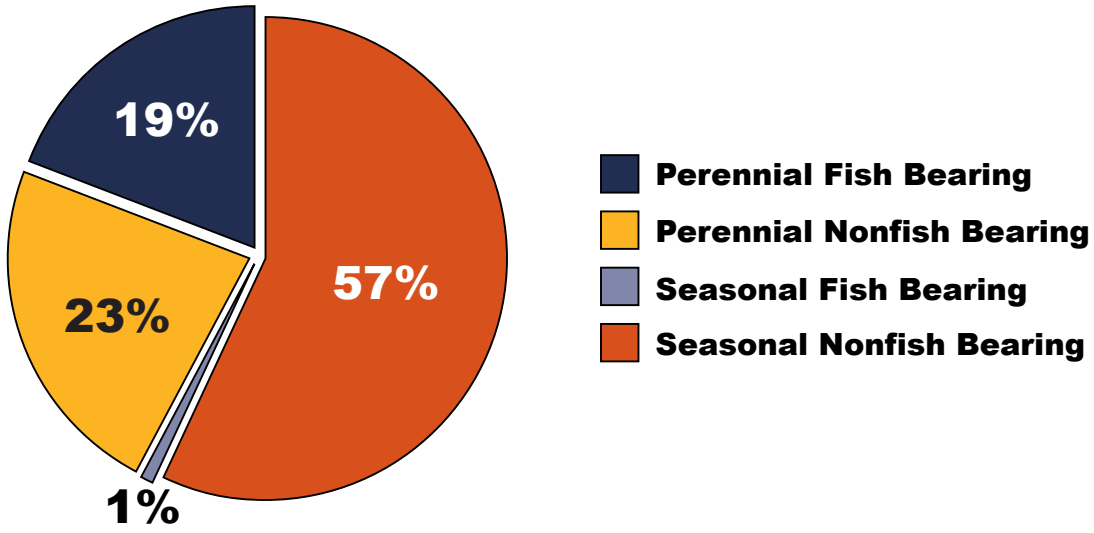

Figure 33—Relative proportions of stream types present in the Rogue River-Siskiyou National Forest—Cascades unit.

Management Status

This unit contains potential spawning and rearing habitat for the Federally threatened Southern Oregon and Northern California Coasts evolutionarily significant unit of coho salmon, the Klamath Mountains Province distinct population segment of steelhead, and the Southern Oregon/Northern California evolutionarily significant unit of Chinook salmon. Most of this habitat is located within the upper Rogue River watershed.

Watersheds in this unit either are protected or receive special management considerations under several land-use designations. Late successional reserves compose 37 percent of the unit, KWs 21 percent, and congressional reserves 17 percent. An additional 4 percent is within administratively withdrawn areas. Streams are also buffered by RRs, which make up 25 percent of the unit.

Intrinsic Potential

This unit contains streams with HIP for Chinook salmon, coho salmon, and steelhead. There are 23 stream miles classified as HIP for coho salmon, 21 miles for steelhead, and 9 miles for Chinook salmon (fig. 34). Of the four HUC8 watersheds overlapping this unit, only the upper Rogue River watershed has streams with HIP overlapping within the unit (appendix table 3). This habitat is largely accessible and unobstructed by dams, including William L. Jess Dam, outside of the study unit or by culverts, bridges, and other barriers within the unit (fig. 8). Some steelhead HIP habitat is upstream from barriers on several streams, including North Fork Little Butte Creek. Of HIP stream miles, less than 5 percent are within KWs or LSRs for Chinook salmon and coho salmon. Greater than 60 percent of HIP stream miles for steelhead are within KWs and nearly 50 percent are within LSRs (appendix table 2).

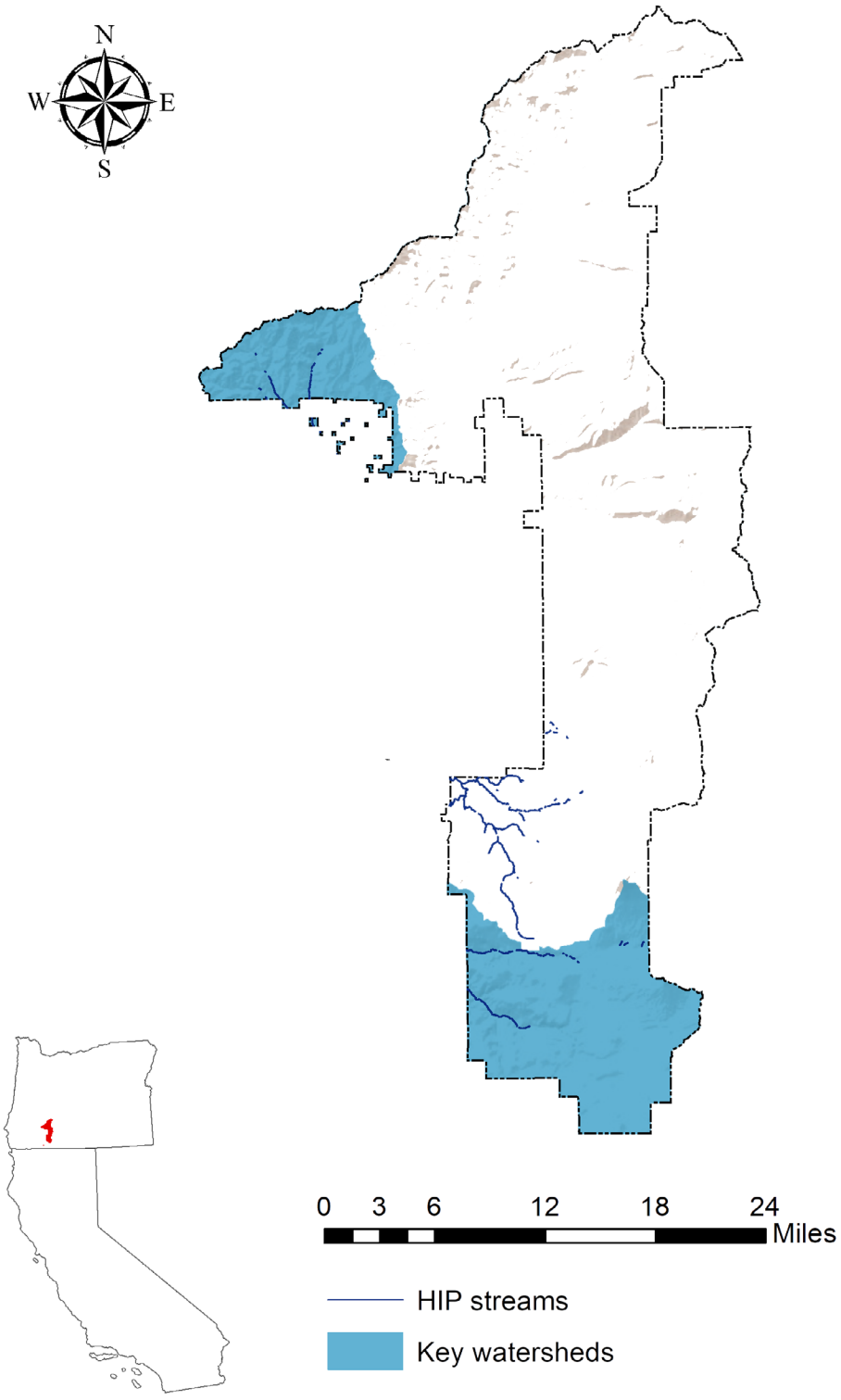

Figure 34—Distribution of key watersheds and streams with high intrinsic potential (HIP) for salmon and steelhead in the Rogue River-Siskiyou National Forest—Cascades unit. Lower map shows location of study area within Oregon.

Permanently Flowing Fish-Bearing Streams

Distribution

There are 491 miles of permanently flowing fish-bearing streams within the administrative boundary of the RRSNF—Cascades unit (fig. 35). Of these, 436 miles are on NFS land. Riparian reserves associated with these streams cover 30,600 acres within the administrative boundary (27,400 acres on NFS lands), or 6.7 percent of the unit (fig. 35). According to BioA data, permanently flowing fish-bearing streams and their RRs are evenly distributed throughout the RRSNF—Cascades unit (fig. 36). According to the WCF, dams and diversions have had limited impacts on hydrologic regimes, with few watersheds containing permanently flowing fish-bearing streams classified as impaired for flow characteristics (table 19). Drought effects have been limited in this unit, and small percentages of RRs have been converted by development and agriculture. Therefore, the distribution of permanently flowing fish-bearing streams is likely to be intact in this unit.

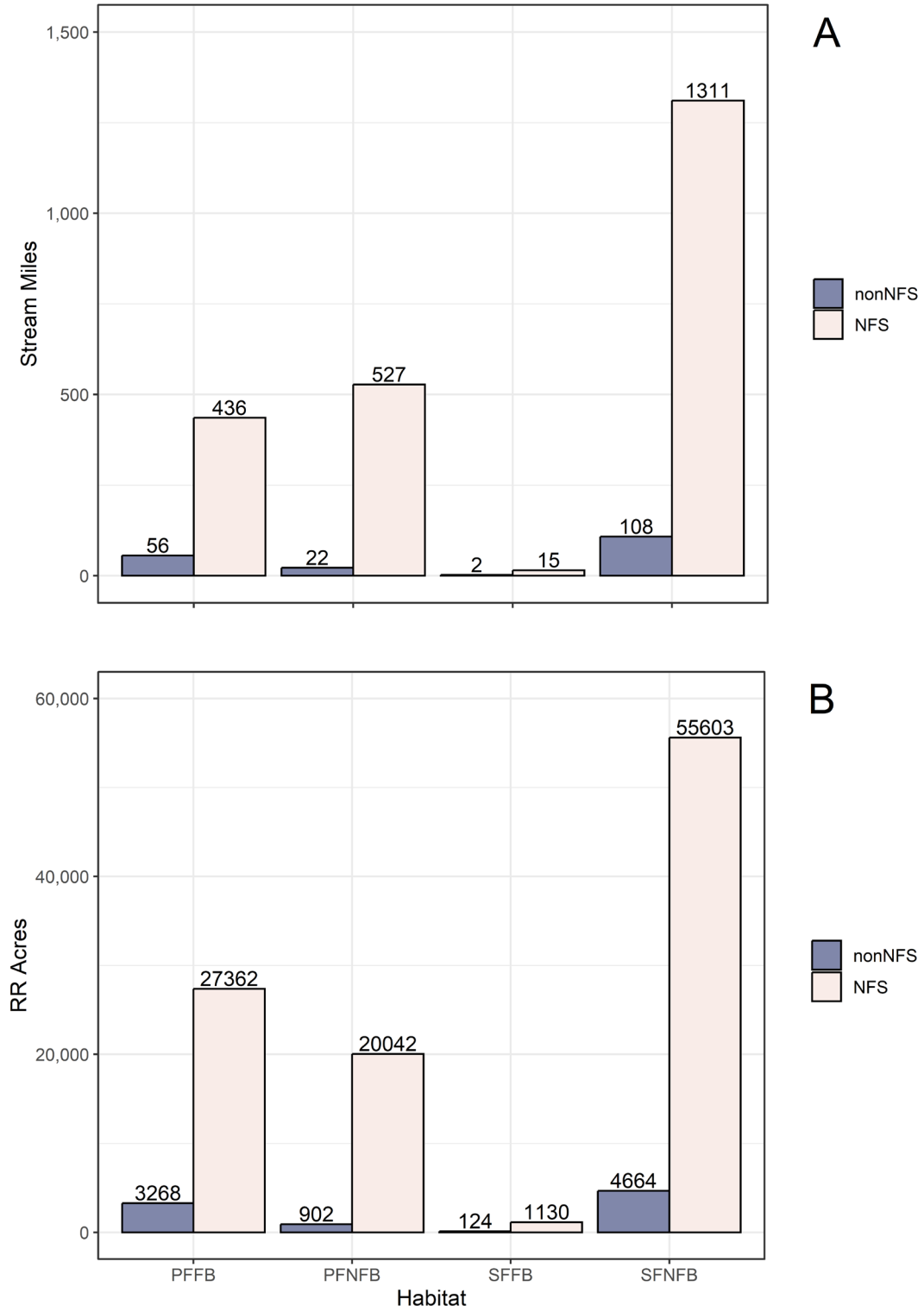

Figure 35—Total stream miles and riparian reserve acres associated with the four stream habitat types in the Rogue River-Siskiyou National Forest—Cascades unit. NFS: National Forest System; RR: riparian reserve; PFFB: permanently flowing fish-bearing; PFNFB: permanently flowing nonfish-bearing; SFFB: seasonally flowing fish-bearing; SFNFB: seasonally flowing nonfish-bearing.

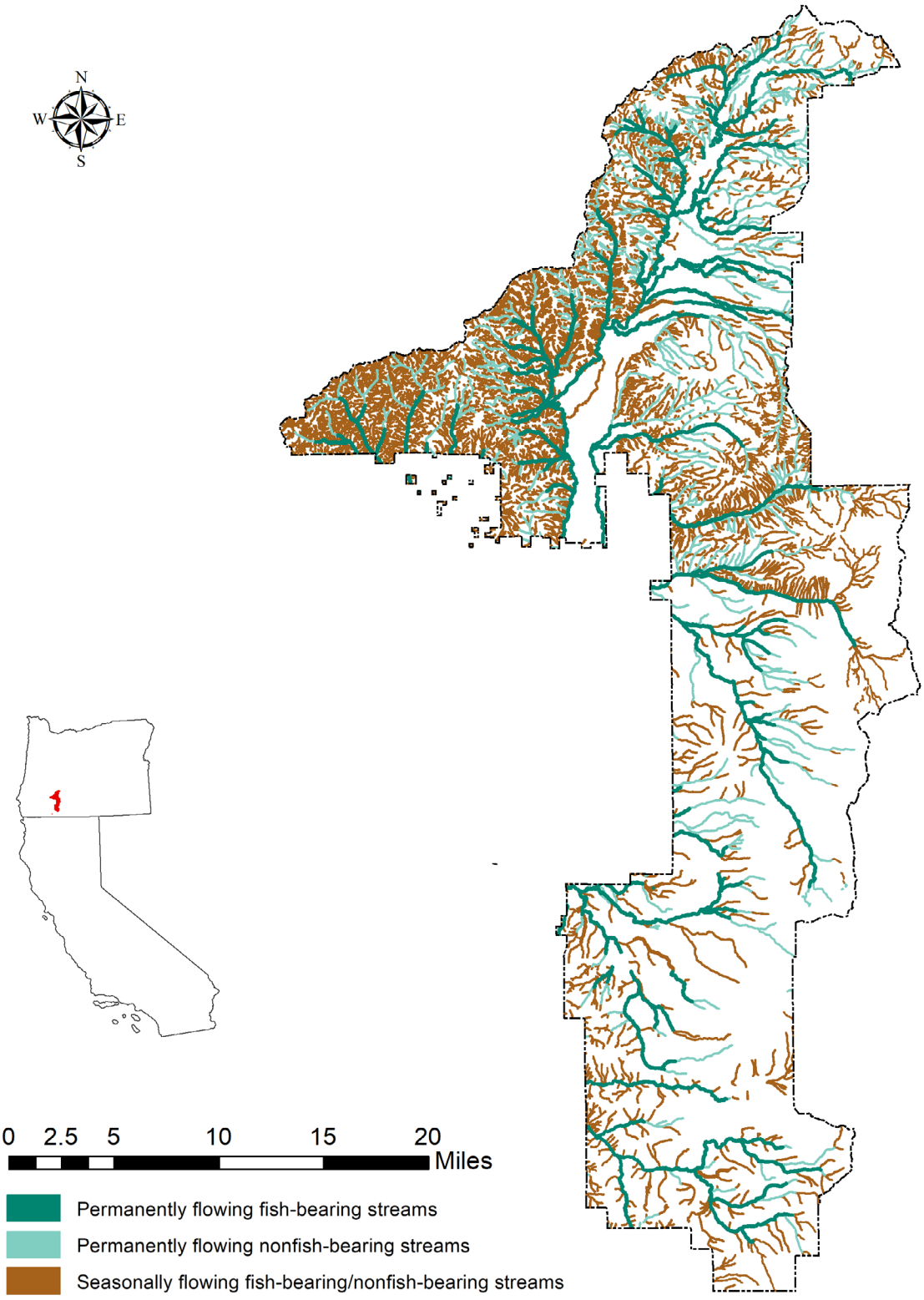

Figure 36—Distribution of riparian reserves associated with streams in the Rogue River-Siskiyou National Forest—Cascades unit. Lower map shows location of study area within Oregon.

Table 19—Percentage of the 31 watersheds with permanently flowing fish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Cascades unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	10	81	10
Exotic and/or aquatic invasive species attribute	29	68	3
Fire regime condition class attribute	0	65	35
Flow characteristics attribute	58	32	10
Habitat fragmentation attribute	39	48	13
Insects and disease attribute	61	26	13
Large woody debris attribute	3	77	19
Loss of forest cover attribute	90	10	0
Mass wasting attribute	100	0	0
Open road density attribute	26	61	13
Proximity to water attribute	0	97	3
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	19	81	0
Road and trail maintenance attribute	0	100	0
Roads and Trails Condition Indicator	26	42	32
Soil contamination attribute	55	45	0
Water Quality Indicator	58	32	10
Water quality problems attribute	74	13	13

[a] Rangeland vegetation condition rated in 16 watersheds.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 344 miles of permanently flowing fish-bearing stream habitat in the RRSNF—Cascades unit. Flow metrics modeled for 1977 through 2006 indicated 17 percent of permanently flowing fish-bearing streams had early, rainfall-dominated runoff (fig. 37). The remaining 83 percent had intermediate runoff timing, with no late, snowfall-dominated runoff systems present in this habitat. A shift in runoff timing is likely to occur, with a transition to earlier runoff in many historically intermediate reaches expected by the 2040s (fig. 37). A projected 51 percent reduction in the extent of reaches with intermediate runoff timing suggests that climate change is likely to contribute to altered hydrologic regimes by mid-century (table 20).

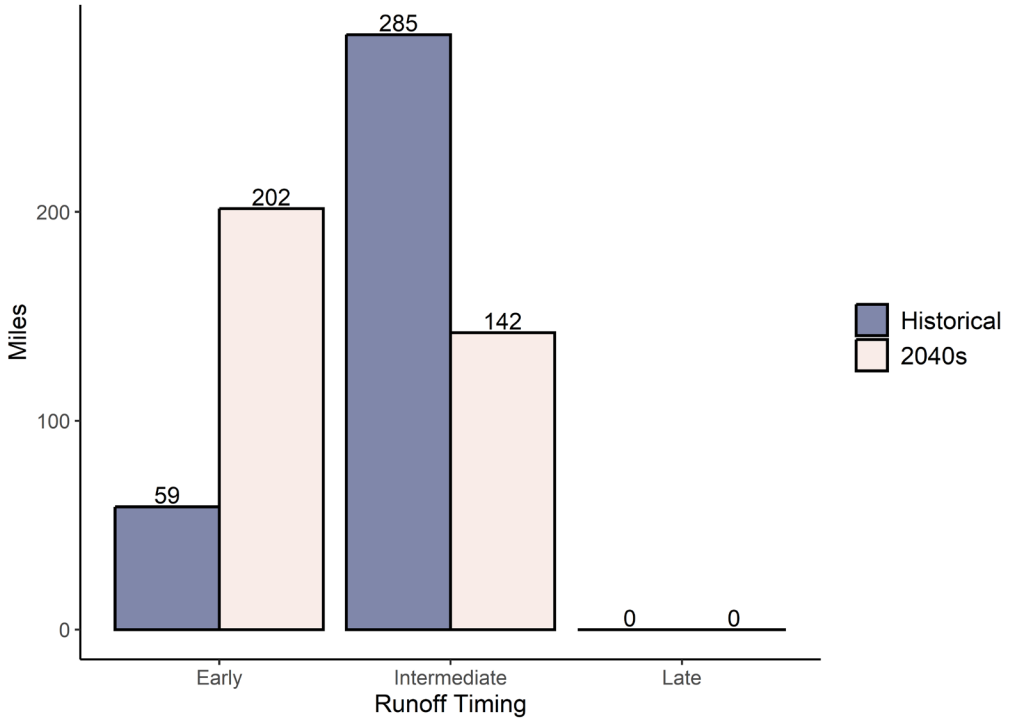

Figure 37—Total length (miles) of permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 20—Flow metrics modeled for permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	59 miles	202 miles	+243
	Extent of intermediate, transient runoff systems	285 miles	142 miles	-51
	Extent of late, snowmelt-dominated runoff systems	0 miles	0 miles	--
Magnitude	Average summer daily flow (June 1–September 30)	36 cfs[a]	16 cfs	-55
	Average August daily flow	10 cfs	9 cfs	-12
	Average baseflow index	0.13	<0.13	-2
	Average 1.5-year return interval flood	479 cfs	579 cfs	+21
	Average maximum modeled flood	3,102 cfs	2,952 cfs	-5
Duration	Average daily flow	80 cfs	79 cfs	-1

[a] cfs: cubic feet per second.
-- Indicates no change.

The magnitudes of high and low flows in permanently flowing fish-bearing streams in the RRSNF—Cascades unit are expected to change by mid-century (table 20). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of average 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to substantially change between the historical period and mid-century, flow duration is likely to be impacted by shifts in the timing and amount of runoff (table 20). Because runoff timing is likely to occur earlier, the magnitude of 1.5-year return interval floods is expected to increase, and the magnitude of summer baseflows is likely to decrease, we expect that permanently flowing fish-bearing streams in this unit are likely to experience intermittency in some reaches.

Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 70). The TCA indicates drought and climate change have affected 10 percent of this unit. There were 276 diversions located within permanently flowing fish-bearing streams. Of these diversions, 246 were on NFS lands. In addition to these diversions, three dams (South Fork Diversion Dam on the South Fork Rogue River, North Fork Dam and North Fork Regulating Dam on the North Fork Rogue River) were located within permanently flowing fish-bearing streams in this unit. According to the WCF, these structures have had limited impacts on hydrologic regimes, with few watersheds containing permanently flowing fish-bearing streams classified as impaired for flow characteristics (table 19). The WCF also suggests that hydrologic impacts of livestock grazing and timber harvest on permanently flowing fish-bearing streams are likely to be limited, but that roads and altered wildfire regimes may have contributed to substantial

changes in hydrology in many watersheds (table 19). Based on these results, we estimate hydrology of these habitats is likely to be intact; however, current trends in temperature and precipitation (see the section "Stressors"), projected changes in snowpack (see the section "Stressors"), and modeled flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be impacted by projected changes in climate.

Water Quality

Water temperatures appear to be increasing in permanently flowing fish-bearing streams of the RRSNF—Cascades unit (fig. 38a). The median August stream temperature between 1993 and 2011 was 52.2 °F according to the NorWeST model. The median August stream temperature between 2002 and 2011 was 52.3 °F. Stream temperatures are expected to increase further by mid- and late century, with modeled median August stream temperatures of 54.5 °F by the 2040s and 56.3 °F by the 2080s (fig. 38b). Of the 435 miles of permanently flowing fish-bearing stream habitat in this unit, 39 miles appear on the 303(d) list as impaired due to temperature.

According to SPARROW model output, permanently flowing fish-bearing streams in the RRSNF—Cascades unit receive suspended sediment loads primarily from forested lands (fig. 39). The largest source of total nitrogen is atmospheric deposition; however, these streams also receive relatively large inputs of nitrogen from runoff from scrublands and grasslands (fig. 39). The largest sources of phosphorus to permanently flowing fish-bearing streams are stream channels and weathering of upland geology (fig. 39). In general, incremental sediment and nutrient loads in this stream type are low throughout the unit, with limited reaches exposed to large incremental or accumulated loads (table 21; figs. C.5–C.40). Of the 435 miles of permanently flowing fish-bearing streams in this unit, 8 miles were listed by the State as impaired for pH.

Permanently flowing fish-bearing streams on the RRSNF—Cascades unit are exposed to limited stressors that can impact water quality (see the section "Stressors" on page 70). The TCA indicates departure from natural fire regimes in more than three-quarters of the unit and more than one-third of watersheds containing permanently flowing fish-bearing streams are classified as impaired by the WCF fire regime condition class attribute (table 19). None of these watersheds are impaired for loss of forest cover. Air temperatures have warmed in this unit and are likely to be contributing to an increase in stream temperature; 9 percent of permanently flowing fish-bearing streams in this unit appear on the 303(d) list due to temperature. Permanently flowing fish-bearing streams in this unit receive suspended sediment, nitrogen, and phosphorus from natural sources, but also are likely to receive inputs from largely human-generated atmospheric deposition (fig. 39). The WCF suggests that roads are generally maintained and that mass wasting is limited (table 19). The TCA indicates none of this unit is significantly impacted by pollution and the WCF suggests no watersheds containing this habitat type are impaired due to extensive soil contamination. Only a few watersheds are in poor condition due to water quality problems according to the WCF (table 19). Overall, impacts from stressors appear limited and most permanently flowing fish-bearing streams are not listed as impaired. Based on these results, we estimate that water quality in these streams is likely to be high.

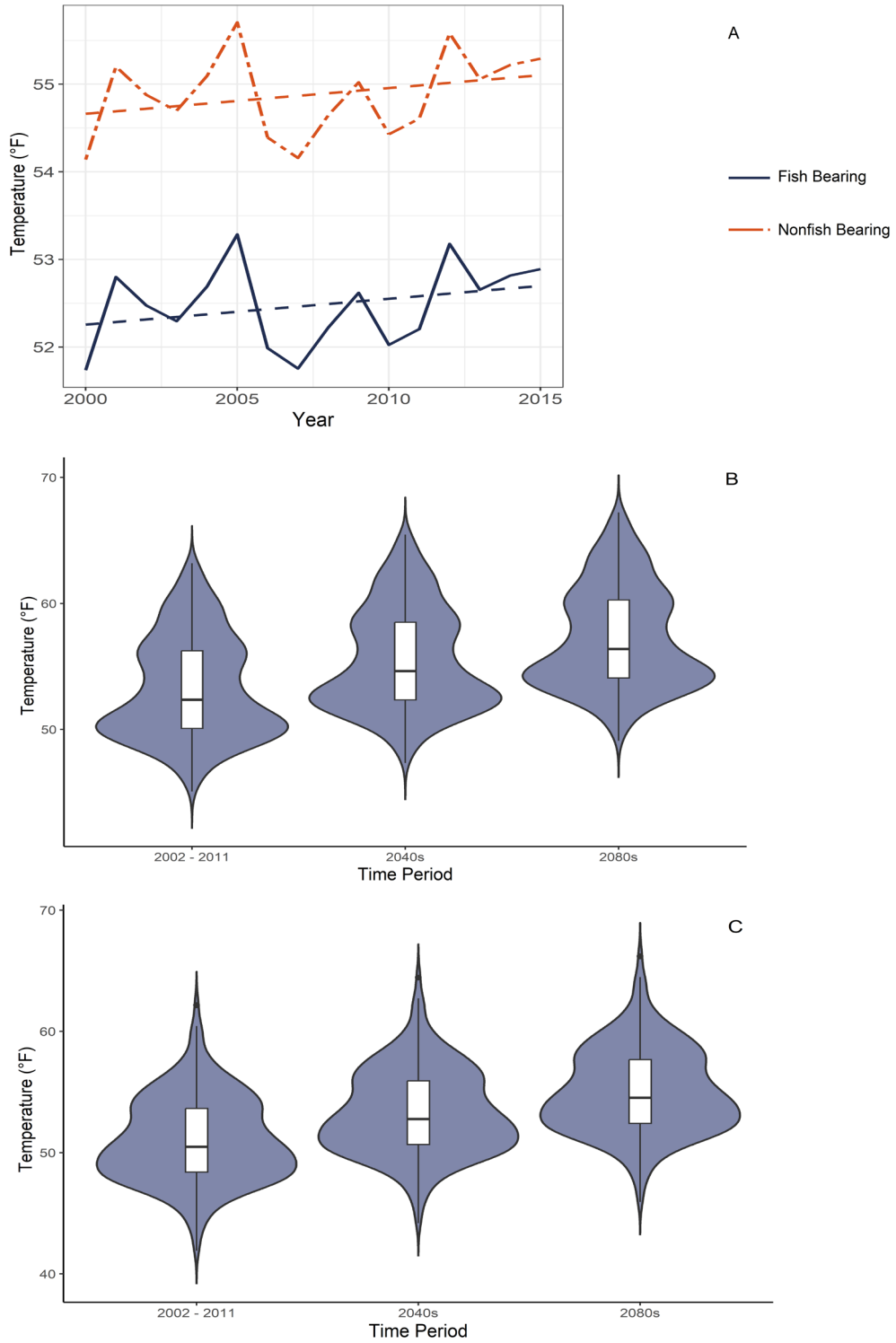

Figure 38—For the Rogue River-Siskiyou National Forest—Cascades unit: (a) modeled median August stream temperature and trend line from 1993 to 2015 for permanently flowing streams; (b) distribution of modeled mean August stream temperature values in reaches of permanently flowing fish-bearing streams for historical and future periods; (c) distribution of modeled mean August stream temperature values in reaches of permanently flowing nonfish-bearing streams for historical and future periods. Data from the NorWeST model.

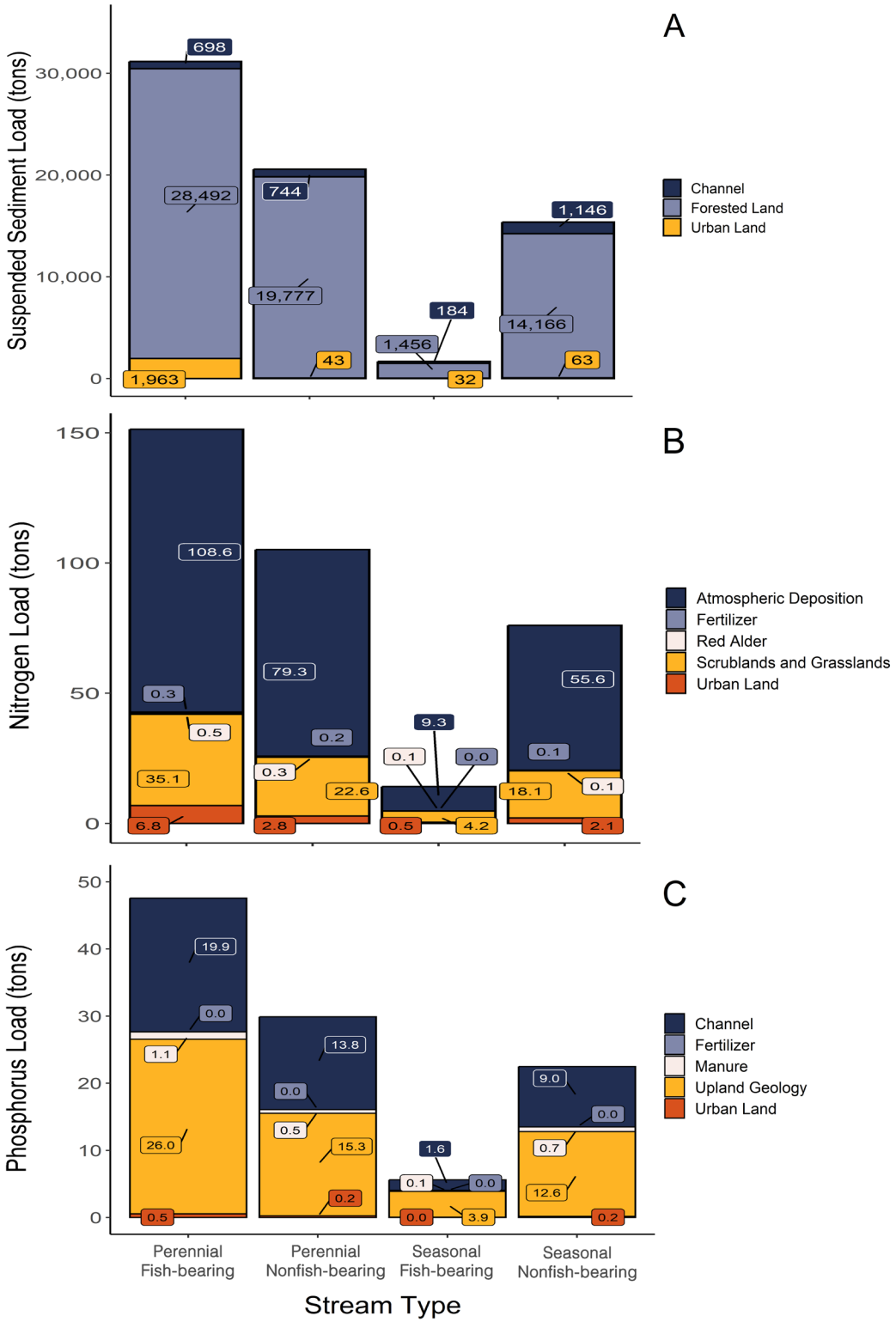

Figure 39—Incremental suspended sediment (a), total nitrogen (b), and total phosphorus loads (tons) (c) estimated for streams in the Rogue River-Siskiyou National Forest—Cascades unit. Data from the U.S. Geological Survey's SPARROW model.

Table 21—Median (minimum; maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0; 417)	0 (0; 49)
	Forest land	168 (0; 9,589)	36 (0; 1,022)
	Agricultural land	0 (0; 0)	0 (0; 0)
	Urban land (including roads)	0 (0; 1,816)	0 (0; 1,724)
Total nitrogen	Scrublands and grasslands	222 (0; 10,869)	35 (0; 1,755)
	Atmospheric deposition	877 (28; 48,587)	189 (0; 3,063)
	Urban land (including roads)	0 (0; 4,450)	0 (0; 850)
	Spring discharge	0 (0; 0)	0 (0; 0)
	Red alder trees	0 (0; 351)	0 (0; 160)
	Fertilizer and manure applied to crop lands	0 (0; 159)	0 (0; 345
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
Total phosphorus	Urban land (including roads)	0 (0; 0.4)	0 (0; 0.09)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
	Fertilizer and manure applied to crop lands	0 (0; 0.01)	0 (0; 0)
	Manure from grazing cattle applied to rangeland	0 (0; 1.14)	0 (0; 0.15)
	Weathering of upland geology	0.15 (0; 0.11)	0.03 (0; 2.28)
	Channel	0.14 (0.01; 9.67)	0.04 (0; 0.4)
	Spring discharge	0 (0; 0)	0 (0; 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

Connectivity

Stream connectivity can be disrupted by dams and diversions, but most watersheds in this unit containing permanently flowing fish-bearing streams have primarily free-flowing rivers with no or minor alterations from natural hydrographs (table 19). See the section "Hydrologic Regimes" on page 86 for more information on the number of diversions in this habitat and their impact as indicated by the WCF flow characteristics attribute. According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 19).

Fish passage data from AREMP show that there were 104 culverts in or bridges crossing permanently flowing fish-bearing streams in the RRSNF—Cascades unit. Of these structures, 50 were full barriers, 17 structures were passable, 17 were partial barriers, and 20 structures had no data regarding passability. The AREMP functional stream network classified 339 miles of permanently flowing fish-bearing streams in this unit. According to this dataset, 18 percent of these streams were blocked by a barrier culvert somewhere downstream. Five percent of stream miles were above a partial barrier. Two percent were above a passable culvert. Thirty-eight percent were above an open bridge or a structure with no data regarding passability. Finally, 37 percent of permanently flowing fish-bearing streams in this unit had no culvert or bridge downstream.

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the channel in most watersheds containing this habitat (table 19). According to the WCF road and trail maintenance attribute, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in all watersheds containing permanently flowing fish-bearing stream habitat (table 19).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the average center of flow mass date for these streams was March 14. The center of flow mass is expected to shift earlier, with February 26 calculated as the mean date for the 2040s (fig. 40). Mean summer baseflows are likely to continue declining, with a 55 percent reduction in average summer daily flow from June 1 to September 30 expected by the 2040s (see the section "Hydrologic Regimes" on page 86). Earlier runoff and reduced summer baseflows may contribute to longitudinal fragmentation in this habitat. Additionally, the magnitude of 1.5-year return interval floods is expected to increase by 21 percent (see the section "Hydrologic Regimes"), potentially increasing lateral connectivity by mid-century.

The median August stream temperature between 2002 and 2011 was 52.3 °F (fig. 38b), according to the NorWeST model. Stream temperatures are expected to increase by mid- and late century (see the preceding section, "Water Quality"). Stream temperatures were reported by AREMP at 40 sites within permanently flowing fish-bearing streams in the RRSNF—Cascades unit between 2010 and 2016. The average 7-day maximum temperature at these sites was 62.1 °F. Based on AREMP stream temperature thresholds and modeled mean August stream temperatures from 2002 through 2011, 12 percent of modeled stream miles exceeded 59 °F and 4 percent exceeded 60.8 °F (fig. 38b). Fragmentation of permanently flowing fish-bearing streams due to temperature is likely to increase by the end of this century (fig. 41).

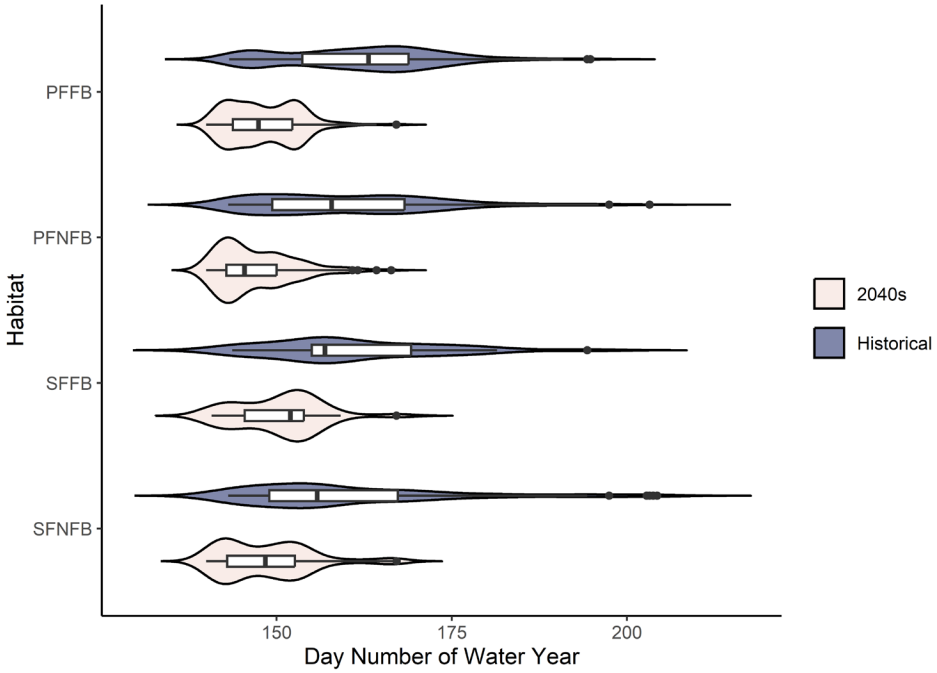

Figure 40—Distribution of modeled center of flow mass dates for stream habitats in the Rogue River-Siskiyou National Forest—Cascades unit. Data from the Western U.S. Stream Flow Metrics dataset. Day 150 = February 28; day 200 = April 19. PFFB: permanently flowing fish-bearing; PFNFB: permanently flowing nonfish-bearing; SFFB: seasonally flowing fish-bearing; SFNFB: seasonally flowing nonfish-bearing.

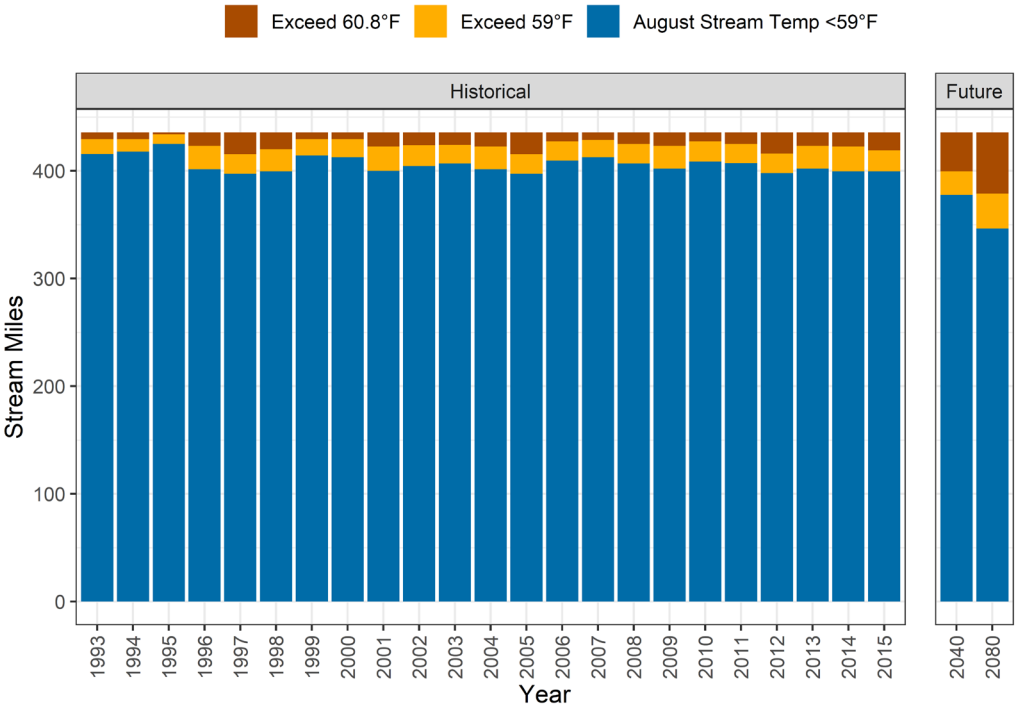

Figure 41—Total length (miles) of permanently flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit that have mean August stream temperature less than 59 °F, exceeding 59 °F, and exceeding 60.8 °F from 1993 to 2015 and for future periods. Data from the NorWeST model.

According to the WCF habitat fragmentation attribute, fragmentation due to temperature, blockages to aquatic organism passage, or dewatering has occurred in half of watersheds containing permanently flowing fish-bearing streams (table 19), with 25 to 95 percent of historical aquatic habitats still connected in these watersheds (Potyondy and Geier 2011). The WCF channel shape and function attribute indicates there is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain in most floodplains containing permanently flowing fish-bearing stream habitat (table 19).

Permanently flowing fish-bearing streams on the RRSNF—Cascades unit are exposed to limited stressors that impact connectivity (see the section "Stressors" on page 70). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. The AREMP functional stream network dataset estimates 83 percent of these habitats are unobstructed by downstream barriers. According to NorWeST stream temperature data, some reaches of permanently flowing fish-bearing streams are likely to experience temporary fragmentation due to warm stream temperatures during summer months. Although the WCF channel shape and function attribute suggests watersheds containing these habitats exhibit lateral connectivity in most stream reaches, the WCF habitat fragmentation attribute indicates the majority of watersheds containing permanently flowing fish-bearing streams in this unit have experienced some fragmentation because of temperature, aquatic organism passage blockages, or dewatering. Based on these results, we estimate connectivity of permanently flowing fish-bearing streams in the RRSNF—Cascades unit is likely to have been altered. Additionally, connectivity in these systems is likely to be vulnerable to projected climate impacts, including warming stream temperatures and reduced summer flows, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Instream Habitat Quality

Critical habitat for the Southern Oregon and Northern California evolutionarily significant unit of coho salmon has been designated in the Upper Rogue watershed, but data showing the extent of this habitat are unavailable. There are 9 miles of permanently flowing fish-bearing stream habitat with high HIP for Chinook salmon, 23 miles for coho salmon, and 21 miles for steelhead (appendix table 2).

The presence of instream wood was measured at 37 AREMP sampling sites along permanently flowing fish-bearing streams. Sampling sites contained instream wood in four size classes, with wood jams present at 35 percent of sites (appendix table 6). According to the WCF, large woody debris is present but recruited into the system at less-than-natural rates in more than three-quarters of watersheds containing permanently flowing fish-bearing stream habitat (table 19).

Data from GNN models indicate that as of 2017, large conifer trees and snags in riparian reserves have the potential to provide shade and down wood to streams. Mean tree canopy cover was estimated to be 67 percent for conifers and 4 percent for hardwoods in RRs. Mean tree density was estimated to be 44.1 stems per acre for live trees between 9.8 and 19.7 inches in diameter, 21.9 stems per acre for live trees 19.7 inches or greater in diameter, 6.9 stems per acre for snags between 9.8 and 19.7 inches in diameter, and 4.5 stems per acre for snags 19.7

inches or greater in diameter (appendix table 8). Spatial data from the Forest Service indicate 18 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1939 and 2021 and 2 percent of the area was within projects completed since 1994. From 2013 through 2020, wildfire perimeters overlapped 7 percent of the area of RRs associated with these streams. These fires likely increased the short-term supply of instream wood, but to a small extent. Additional sources of wood, including permanently flowing and seasonally flowing nonfish-bearing tributaries, should be considered as well (see the section “Riparian Reserves Condition” for each of these stream types). The preceding results suggest that instream wood is present in moderate amounts and multiple size classes, and there is potential for recruitment of multiple size classes of wood from RRs. This potential has been minimally affected by recent timber harvest but could be influenced by future wildfires.

Fish passage data from AREMP indicate that 83 percent of permanently flowing fish-bearing streams in this unit are unobstructed by downstream full or partial barriers. Additionally, only 11 percent of watersheds containing this habitat type are classified as impaired by the WCF habitat fragmentation attribute. See the preceding section, "Connectivity" on page 91, for more information.

According to the WCF, channels in most watersheds containing permanently flowing fish-bearing streams maintain width-to-depth ratios within NRV and vertical stability except in places where riparian vegetation has been disturbed, between 5 and 25 percent of the channels have widened, channel degradation or aggradation (or both) has occurred in relatively small sections of the network, and downcutting has disconnected some channels from their floodplain (table 19).

Hydrologic regimes are likely to continue shifting within permanently flowing fish-bearing streams in this unit; large declines in summer baseflow, earlier runoff, and large increases in bankfull flows are expected by mid-century (see the section "Hydrologic Regimes" on page 86). According to the WCF flow characteristics attribute, most watersheds containing this habitat have primarily free-flowing rivers and streams, with no or minor alterations from natural hydrologic conditions (table 19). According to NorWeST stream temperature data, most stream reaches maintain mean August stream temperatures that support cold-water fish (see the section "Connectivity" on page 91). Stream temperatures are expected to increase by mid-century (see the preceding section, "Water Quality" on page 88). According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 19).

Permanently flowing fish-bearing streams in the RRSNF—Cascades are exposed to stressors that may impact the quality of instream habitat, including roads and departure from natural fire regimes (see the section "Stressors" on page 70). According to the TCA, roads have impacted terrestrial ecological integrity in most of the unit and the WCF suggests roads have significantly impacted hydrologic processes in one-third of watersheds. The TCA and WCF indicate altered fire regimes are likely to have impacted terrestrial ecological integrity and watershed function in much of the unit. It appears that large woody debris is present but recruited at less-than-natural rates, and that stream channel degradation has occurred in small sections of these

streams. Based on these results, it is likely that instream habitat in permanently flowing fish-bearing streams has been impacted by roads and departure from natural fire regimes. We estimate instream habitat quality is likely to have been altered.

Riparian Reserves Condition

Nineteen percent of the area within RRs is classified by LANDFIRE as existing riparian vegetation. This vegetation covers extensive areas within some RRs (fig. 42). The area classified as potential riparian vegetation is greater (27 percent), suggesting that riparian extent has likely departed from historical conditions as a result of conifer encroachment, stream modifications, or other changes.

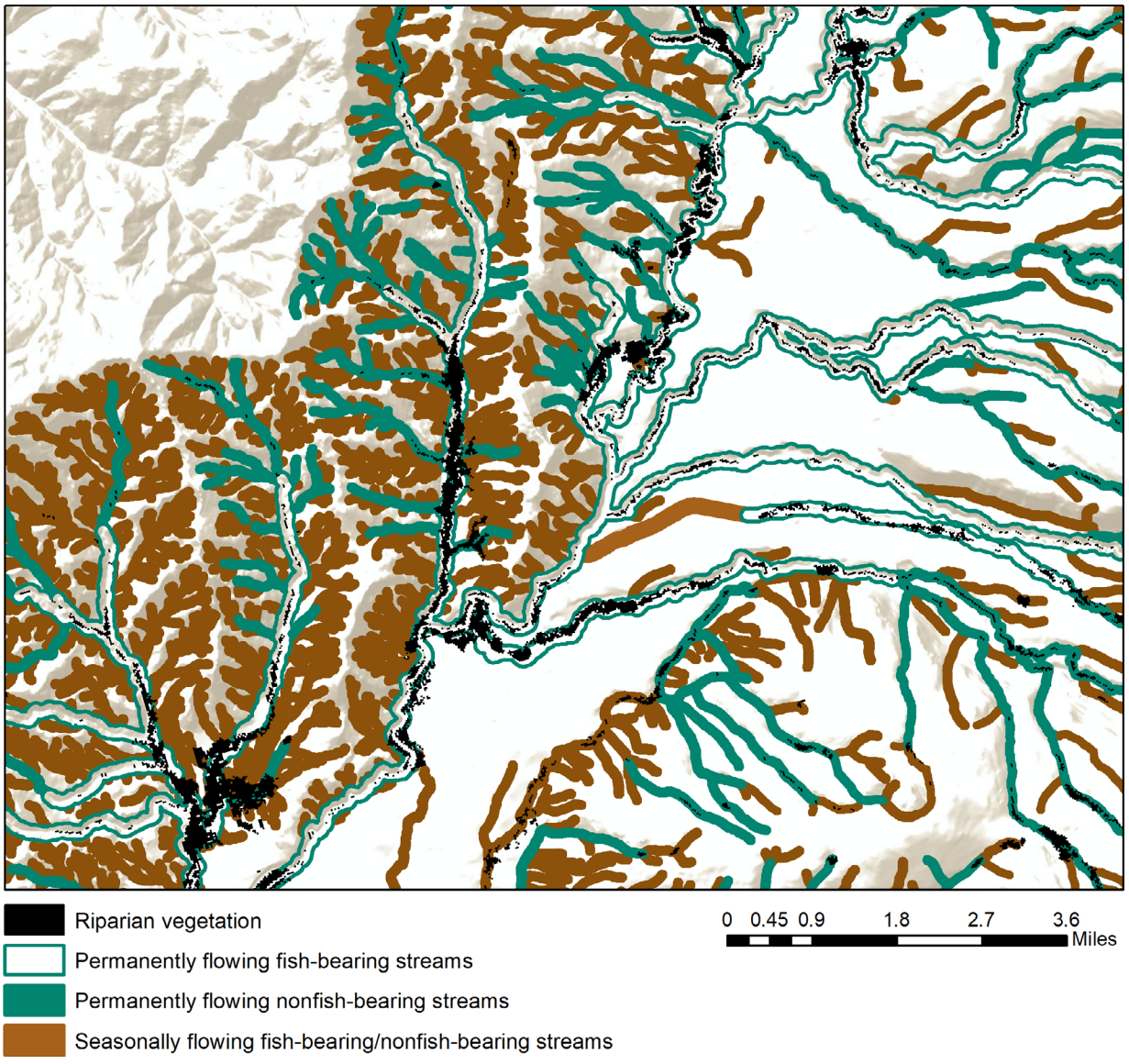

Figure 42—Example of LANDFIRE existing vegetation classification, showing extent of riparian vegetation within riparian reserves in the Rogue River-Siskiyou National Forest—Cascades unit.

Of the vegetation in RRs classified by LANDFIRE as riparian, 93 percent is forest or woodland (appendix table 7). Woody riparian species include willows, bigleaf maple, red alder, black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), and chokecherry (*Prunus virginiana*). Output from GNN models classified 87 percent of RR area in 2017 as conifer forest, 3 percent as mixed conifer/hardwood forest, and less than 1 percent as hardwood forest. The most abundant forest types in RRs, such as *Pseudotsuga menziesii*/*Abies grandis*, *Pseudotsuga menziesii*/*Tsuga heterophylla*, and *Abies grandis*/*Pseudotsuga menziesii*, are dominated by mid- and late successional species, indicating effects of wildfire suppression (appendix table 13). Forest types representing fire-dependent vegetation (*Pseudotsuga menziesii*/*Pinus ponderosa*, *Pinus ponderosa*/*Pseudotsuga menziesii*, *Quercus garryana*/*Quercus kelloggii*) are also present, but at lower frequencies. The forest types indicative of hydric riparian sites (*Acer macrophyllum*/*Populus balsamifera* ssp. *trichocarpa*/*Populus balsamifera* ssp. *trichocarpa*/*Alnus rubra*) are present at low frequencies as well.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is greater than 150 years, basal-area weighted mean diameter is greater than 23.6 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl. If down wood, snags, or large trees are near streams, they contribute to habitat quality for steelhead and other fishes (appendix table 1).

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 46 percent was upland vegetation with historically short (≤35 years) fire return intervals (fig. 43). Fifty-three percent of the vegetation, extensive in some RRs, is a combination of riparian and upland with longer (35–200 years) fire return intervals. One percent of the vegetation is classified as having a very long (>200 years) fire return interval. Most of this vegetation is within RRs at the upper elevations of the unit (fig. 44). From 2013 through 2020, 7 percent of RR area was within wildfire-burned area perimeters. According to GFC data, these fires caused forest loss in 3 percent of the RR area. Spatial data from the Forest Service indicate 18 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1949 and 2021 and 2 percent of the area was within projects completed since 1994.

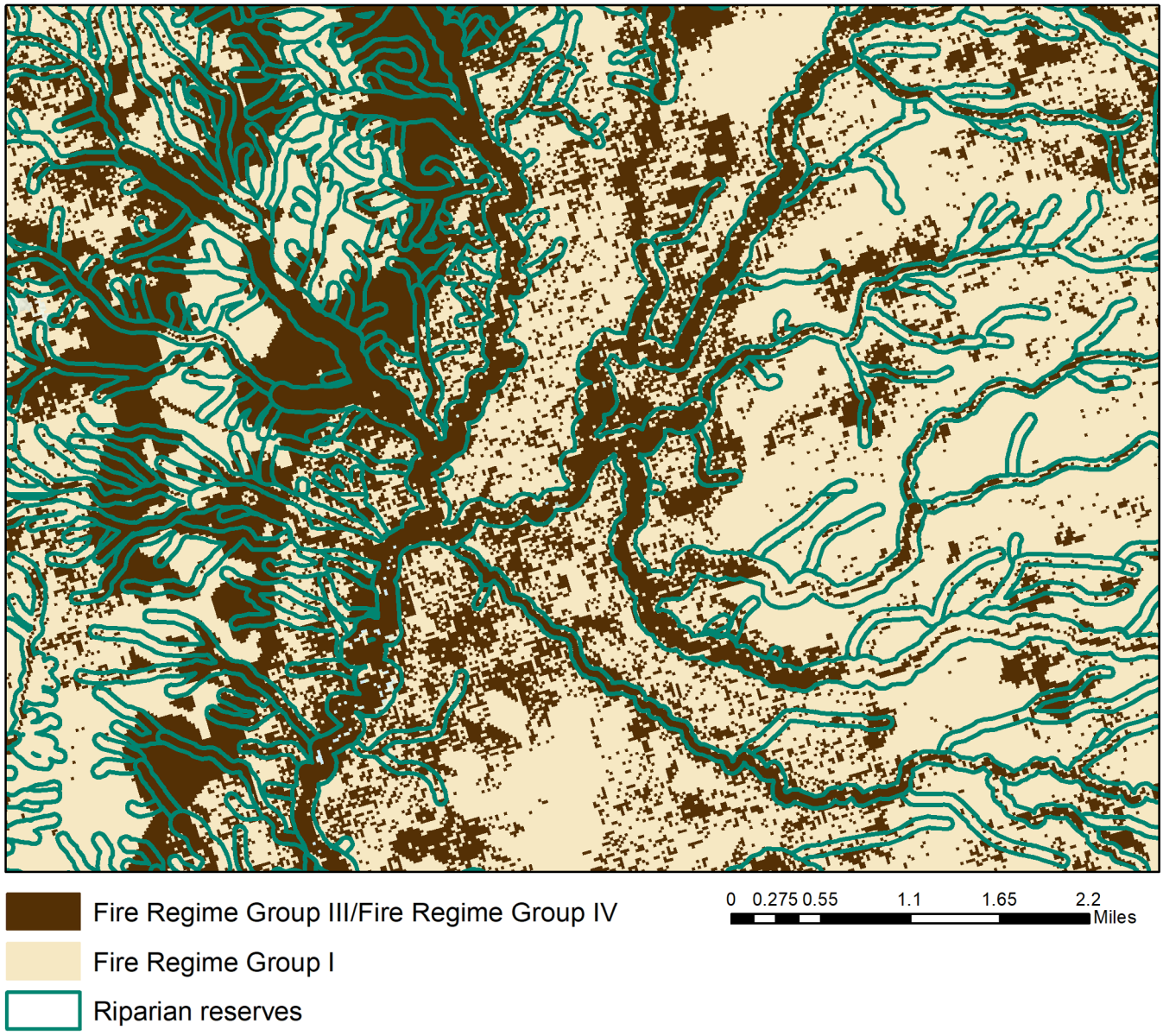

Figure 43—Example of LANDFIRE fire regime group classification, showing extent of vegetation classified as fire regime group I (fire return interval ≤35 years) and fire regime group III or IV (fire return interval 35–200 years). This map depicts vegetation within and outside of riparian reserves in the Rogue River-Siskiyou National Forest—Cascades unit.

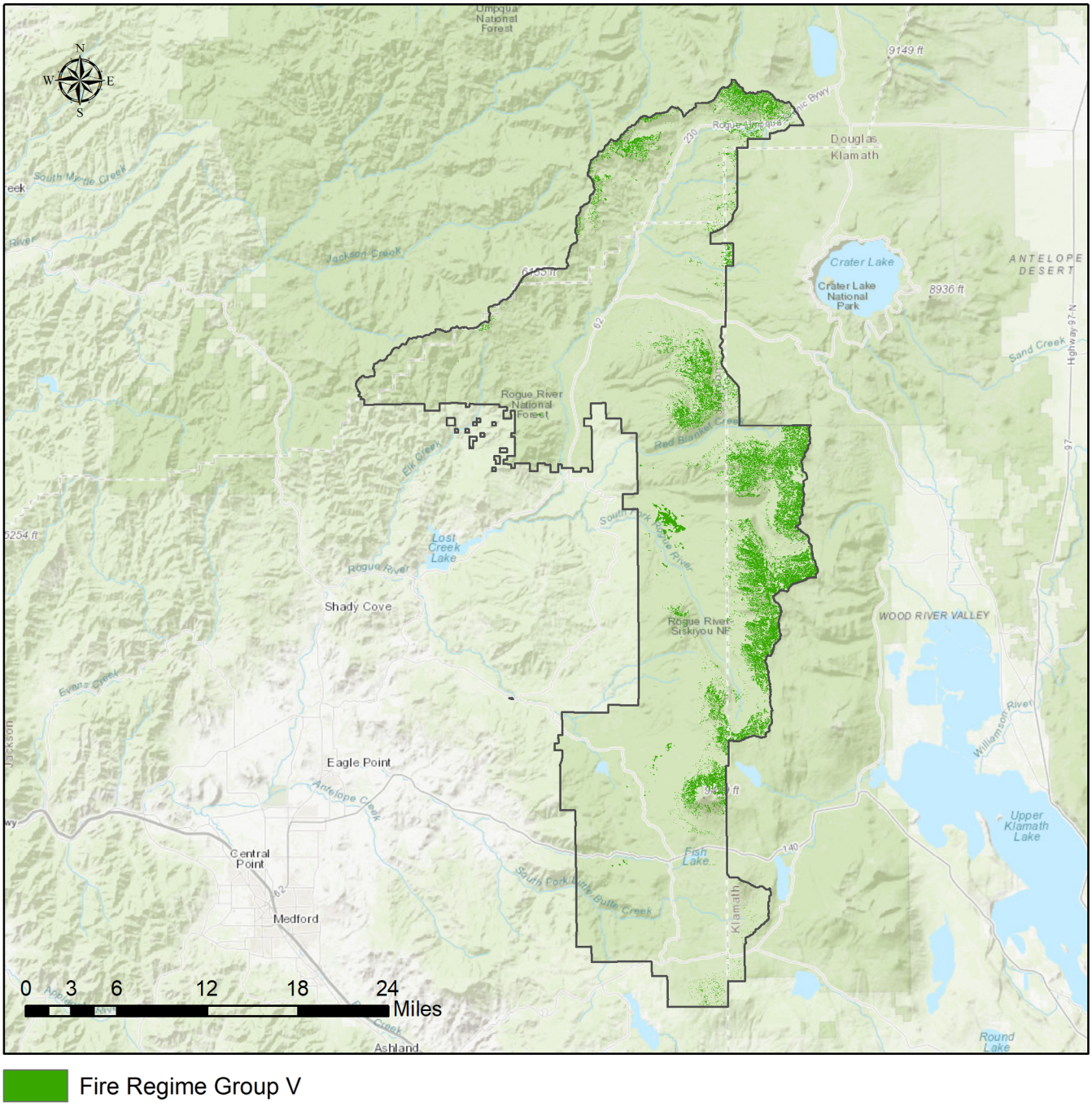

Figure 44—Extent of vegetation classified by LANDFIRE as fire regime group V (fire return interval <200 years) in the Rogue River-Siskiyou National Forest—Cascades unit.

Assessment of terrestrial ecosystems indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 3 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to the overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past

logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for 96 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects and diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are effects of fire exclusion and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with permanently flowing fish-bearing streams are likely altered and in moderate condition.

Permanently Flowing Nonfish-Bearing Streams

Distribution

There are 549 miles of permanently flowing nonfish-bearing streams within the administrative boundary of the RRSNF—Cascades unit (fig. 35). Of these miles, 527 are on NFS land. Riparian reserves associated with these streams cover 20,900 acres within the administrative boundary (20,000 acres on NFS lands), or 4.6 percent of the unit (fig. 35). According to BioA data, permanently flowing nonfish-bearing streams and their RRs are distributed throughout the unit, but with a higher density in the northern portion (fig. 36). According to the WCF, dams and diversions have had limited impacts on hydrologic regimes, with few watersheds containing permanently flowing nonfish-bearing streams classified as impaired for flow characteristics (table 22). Drought effects have been limited in this unit and small percentages of RRs have been converted by development and agriculture. Therefore, the distribution of permanently flowing nonfish-bearing streams is likely to be intact in this unit.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 241 miles of permanently flowing nonfish-bearing stream habitat in the RRSNF—Cascades unit. Flow metrics modeled for 1977 through 2006 indicated 26 percent of permanently flowing nonfish-bearing streams in this unit had early, rainfall-dominated runoff (fig. 45). The remaining 74 percent of permanently flowing nonfish-bearing streams had intermediate runoff timing, with less than 1 mile of late, snowfall-dominated systems present in this habitat. A shift in runoff timing is likely to occur; a transition to earlier runoff in many historically intermediate reaches is expected by the 2040s (fig. 45). A projected 72 percent reduction in the extent of reaches with intermediate runoff timing suggests that climate change is likely to contribute to altered hydrologic regimes in some permanently flowing nonfish-bearing streams by mid-century (table 23).

Table 22—Percentage of the 32 watersheds with permanently flowing nonfish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Cascades unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	9	81	9
Exotic and/or aquatic invasive species attribute	28	69	3
Fire regime condition class attribute	0	66	34
Flow characteristics attribute	56	34	9
Habitat fragmentation attribute	38	50	12
Insects and disease attribute	62	25	12
Large woody debris attribute	3	78	19
Loss of forest cover attribute	91	9	0
Mass wasting attribute	100	0	0
Open road density attribute	28	59	12
Proximity to water attribute	0	97	3
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	19	81	0
Road and trail maintenance attribute	0	100	0
Roads and Trails Condition Indicator	25	41	34
Soil contamination attribute	56	44	0
Water Quality Indicator	59	31	9
Water quality problems attribute	75	12	12

[a] Rangeland vegetation condition rated in 16 watersheds.

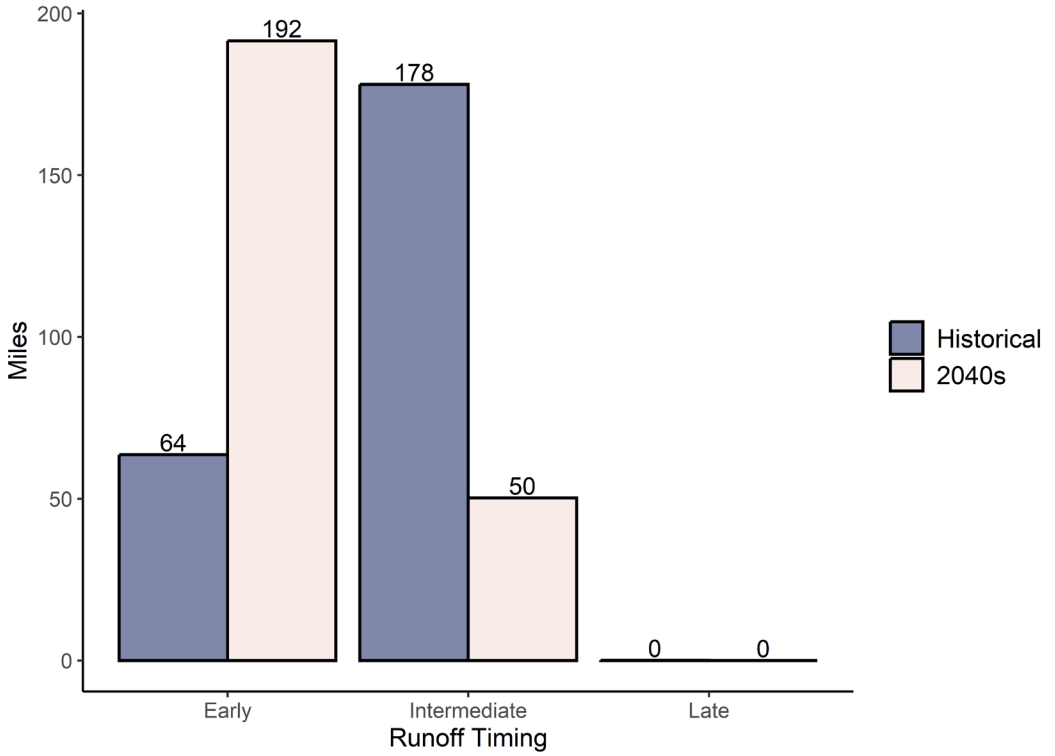

Figure 45—Total length (miles) of permanently flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 23—Flow metrics modeled for permanently flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	64 miles	192 miles	+201
	Extent of intermediate, transient runoff systems	178 miles	50 miles	-72
	Extent of late, snowmelt-dominated runoff systems	0.04 mile	0 miles	-100
Magnitude	Average summer daily flow (June 1–September 30)	4 cfs[a]	2 cfs	-53
	Average August daily flow	1.1 cfs	1.0 cfs	-11
	Average baseflow index	0.13	0.13	-2
	Average 1.5-year return interval flood	61 cfs	67 cfs	+10
	Average maximum modeled flood	347 cfs	326 cfs	-6
Duration	Average daily flow	9 cfs	9 cfs	--

[a] cfs: cubic feet per second.
-- Indicates no change.

The magnitudes of high and low flows in permanently flowing nonfish-bearing streams in the RRSNF—Cascades unit are expected to change by mid-century (table 23). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of average 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to change substantially between the historical period and mid-century, flow duration is likely to be impacted by shifts in the timing and amount of runoff (table 23). Because the magnitude of 1.5-year return interval floods is expected to increase and the magnitude of summer baseflows is likely to decrease, we expect that permanently flowing nonfish-bearing streams in this unit are likely to experience intermittency in some reaches.

Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 70). The TCA indicates drought and climate change have had limited impacts. There were 40 diversions located within permanently flowing nonfish-bearing streams in this unit. Of these diversions, 27 were on NFS land. According to the WCF, these structures have had limited impacts on hydrologic regimes, with few watersheds containing permanently flowing nonfish-bearing streams classified as impaired for flow characteristics (table 22). The WCF also suggests that hydrologic impacts of livestock grazing and timber harvest on permanently flowing nonfish-bearing streams are likely limited, but that roads and altered wildfire regimes may have contributed to substantial changes in hydrology in many watersheds (table 22). Based on these results, we estimate hydrology of these habitats is likely to be intact; however, current trends in temperature and precipitation (see the section "Stressors"), projected changes in snowpack (see the section "Stressors"), and modeled flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be further impacted by projected changes in climate.

Water Quality

Water temperatures appear to be increasing in permanently flowing nonfish-bearing streams of the RRSNF—Cascades unit (fig. 38a). According to the NorWeST model, the median August stream temperature between 1993 and 2011 for permanently flowing fish-bearing streams in this unit was 50.4 °F. The median August stream temperature between 2002 and 2011 was 50.5 °F. Stream temperatures are expected to increase further by mid- and late century, with median August stream temperatures of 52.7 °F by the 2040s and 54.5 °F by the 2080s (fig. 38c). Of the 527 miles of permanently flowing nonfish-bearing stream habitat in this unit, 5 miles were on the 303(d) list due to temperature.

According to SPARROW model output, permanently flowing nonfish-bearing streams in the RRSNF—Cascades unit receive suspended sediment loads primarily from forested lands (fig. 39). The largest source of total nitrogen is atmospheric deposition. Permanently flowing fish-bearing streams in this unit also receive relatively large nitrogen inputs from runoff from scrublands and grasslands (fig. 39). The largest sources of phosphorus are channels and weathering of upland geology (fig. 39). In general, incremental sediment and nutrient loads in this stream type are low, with limited reaches exposed to large incremental or accumulated loads (table 24; figs. C.5–C.40). Of the 527 miles of permanently flowing nonfish-bearing stream habitat in this unit, fewer than 1 mile appear on the 303(d) list due to pH.

Table 24—Median (minimum; maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for permanently flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0; 129)	0 (0; 58)
	Forest land	97 (0; 1,499)	66 (0; 946)
	Agricultural land	0 (0; 0)	0 (0; 0)
	Urban land (including roads)	0 (0; 21)	0 (0; 21)
Total nitrogen	Scrublands and grasslands	0.07 (0; 1.27)	0.06 (0; 1.27)
	Atmospheric deposition	0.37 (0.04; 6.0)	0.29 (0; 2.72)
	Urban land (including roads)	0 (0; 1.86)	0 (0; 0.95)
	Spring discharge	0 (0; 0)	0 (0; 0)
	Red alder trees	0 (0; 0.18)	0 (0; 0.18)
	Fertilizer and manure applied to crop lands	0 (0; 0.04)	0 (0; 0.04)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
Total phosphorus	Urban land (including roads)	0 (0; 0.16)	0 (0; 0.09)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
	Fertilizer and manure applied to crop lands	0 (0; 0)	0 (0; 0)
	Manure from grazing cattle applied to rangeland	0 (0; 0.16)	0 (0; 0.14)
	Weathering of upland geology	0.05 (0; 1.75)	0.04 (0; 0.9)
	Channel	0.06 (0; 1.08)	0.05 (0; 0.39)
	Spring discharge	0 (0; 0)	0 (0; 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

Permanently flowing fish-bearing streams in the RRSNF—Cascades unit are exposed to limited stressors that can impact water quality (see the section "Stressors" on page 70). The TCA indicates departure from natural fire regimes in more than three-quarters of the unit and more than one-third of watersheds containing permanently flowing fish-bearing stream habitat are classified as impaired by the WCF fire regime condition class (table 22). None of the unit is impaired for loss of forest cover. Air temperatures have warmed in this unit and are likely to be contributing to an increase in stream temperature. Nevertheless, only 1 percent of these streams in this unit appear on the 303(d) list due to temperature. Permanently flowing nonfish-bearing streams in this unit receive suspended sediment, nitrogen, and phosphorus from

natural sources, but also are likely to receive nitrogen inputs from largely human-generated atmospheric deposition (fig. 39). The WCF suggests that roads are generally maintained and that mass wasting is limited (table 22). The TCA indicates none of this unit is significantly impacted by pollution. The WCF suggests no watersheds containing this habitat type are classified as impaired due to extensive soil contamination and less than one-fifth of watersheds have extensive water quality problems such as excessive sediment or nutrients (table 22). Riparian and wetland vegetation may increase resistance of permanently flowing fish-bearing streams to stressors; most watersheds containing this habitat are classified as functional-at-risk for riparian/wetland vegetation condition (table 22). Overall, impacts from stressors appear limited and very few permanently flowing nonfish-bearing reaches are listed as impaired. Based on these results, we estimate that water quality in these streams is likely to be high.

Connectivity

Stream connectivity can be disrupted by dams and diversions, but according to the WCF most watersheds containing permanently flowing fish-bearing streams in the RRSNF—Cascades unit have primarily free-flowing rivers with no or minor alterations from natural hydrographs. See the section "Hydrologic Regimes" on page 100 for more information on the number of diversions in this habitat and their impact according to the WCF flow characteristics attribute. According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 22).

Fish passage data from AREMP show that there were 20 culverts in and bridges crossing permanently flowing nonfish-bearing streams in the RRSNF—Cascades unit. Of these structures, 11 were full barriers, 1 structure was passable, 3 were partial barriers, and 5 structures had no data regarding passability. The AREMP functional stream network classified 379 miles of permanently flowing nonfish-bearing streams in this unit. According to this dataset, 20 percent of these streams were blocked by a barrier culvert somewhere downstream. Six percent of stream miles were above a partial barrier. Two percent were above a passable culvert. Twenty-six percent were above an open bridge or a structure with no data regarding passability. Finally, 45 percent of permanently flowing nonfish-bearing streams in this unit had no culvert or bridge downstream.

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the channel in nearly all watersheds containing this habitat (table 22). According to the WCF road and trail maintenance attribute, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in all watersheds containing permanently flowing nonfish-bearing stream habitat in this unit (table 22).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the average center of flow mass date for these streams was March 14. The center of flow mass is expected to shift earlier, with March 9 calculated as the mean date for the 2040s (fig. 40). Mean summer baseflows are likely to continue declining, with a 53 percent

reduction in average summer daily flow from June 1 to September 30 expected by the 2040s (see the section "Hydrologic Regimes"). Earlier runoff and reduced summer baseflows may contribute to longitudinal fragmentation in this habitat. Additionally, the magnitude of 1.5-year return interval floods is expected to increase by 10 percent, potentially increasing lateral connectivity by mid-century.

The median August stream temperature between 2002 and 2011 was 50.5 °F (fig. 38c), according to the NorWeST model. Stream temperatures are expected to increase by mid- and late century (see the preceding section, "Water Quality" on page 103). Stream temperatures were reported by AREMP at nine sites within permanently flowing nonfish-bearing streams in the RRSNF—Cascades unit between 2011 and 2016. The average 7-day maximum temperature at these sites was 61.2 °F. Based on AREMP stream temperature thresholds and modeled mean August stream temperatures from 2002 through 2011, 1 percent of total modeled stream miles exceeded 57.2 °F and no streams experienced August temperatures that exceeded 60.8 °F (fig. 38c). Fragmentation of permanently flowing nonfish-bearing streams due to temperature is likely to increase by the end of this century (fig. 46).

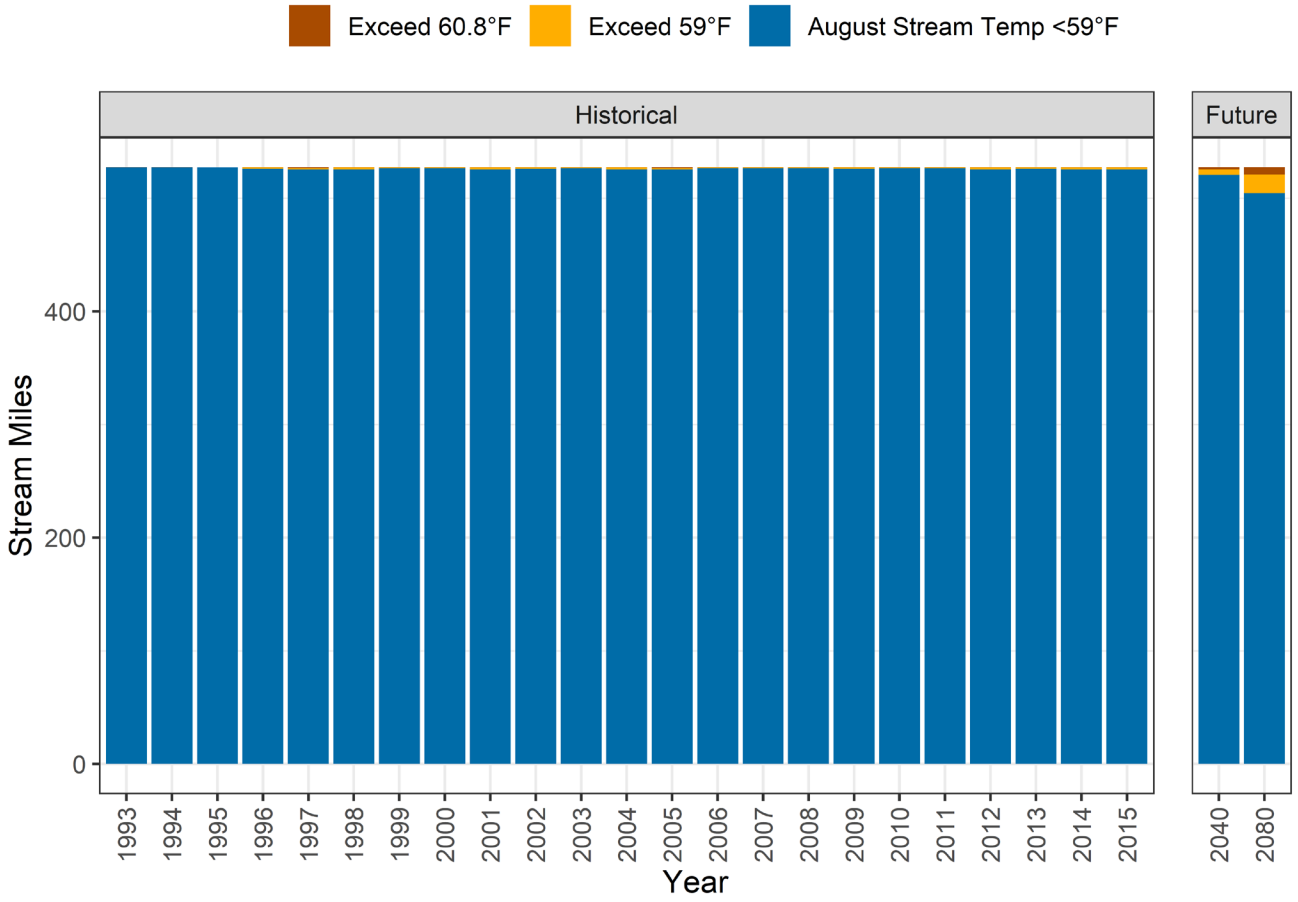

Figure 46—Total length (miles) of permanently flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit that have mean August stream temperature less than 59 °F, exceeding 59 °F, and exceeding 60.8 °F from 1993 to 2015 and for future periods. Data from the NorWeST model.

According to the WCF, fragmentation due to temperature, blockages to aquatic organism passage, or dewatering has occurred in more than half of watersheds containing permanently flowing nonfish-bearing streams; 25 to 95 percent of historical aquatic habitats are still connected in these watersheds (table 22). The WCF channel shape and function attribute indicates there is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain in more than three-quarters of watersheds containing permanently flowing nonfish-bearing streams (table 22).

Permanently flowing nonfish-bearing streams on the RRSNF—Cascades unit are exposed to limited stressors that impact connectivity (see the section "Stressors" on page 70). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. The AREMP functional stream network dataset estimates 74 percent of these habitats are unobstructed by downstream barriers. According to NorWeST stream temperature data, few reaches of permanently flowing nonfish-bearing streams experience temporary fragmentation due to warm stream temperatures during summer months. Although the WCF channel shape and function attribute suggests watersheds containing these habitats exhibit lateral connectivity in most stream reaches, the WCF habitat fragmentation attribute indicates the majority of watersheds containing permanently flowing nonfish-bearing streams in this unit have experienced fragmentation because of temperature, blockages to aquatic organism passage, or dewatering (table 22). Based on these results, we estimate connectivity of permanently flowing nonfish-bearing streams in the RRSNF—Cascades unit is likely to have been altered. Additionally, connectivity in these systems is likely to be vulnerable to projected climate impacts, including warming stream temperatures and reduced summer flows, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Riparian Reserves Condition

Eight percent of the area within RRs associated with permanently flowing nonfish-bearing streams is classified by LANDFIRE as existing riparian vegetation composed of willows, red alder, black cottonwood, and other species. This vegetation is patchily distributed in some of the RRs (fig. 42). The area classified as potential riparian vegetation is greater (16 percent), suggesting that riparian extent has likely departed from historical conditions as a result of conifer encroachment, stream modifications, or other changes.

Of the vegetation in RRs classified by LANDFIRE as riparian, 95 percent is forest or woodland (appendix table 7). Woody riparian species include willows, bigleaf maple, red alder, black cottonwood, and chokecherry (*Prunus virginiana*). Output from GNN models classified 92 percent of RR area in 2017 as conifer forest, 3 percent as mixed conifer/hardwood forest, and less than 1 percent as hardwood forest. The most abundant forest types in RRs, such as *Pseudotsuga menziesii* and *Pseudotsuga menziesii*/*Abies grandis*, are dominated by mid- and late successional species (appendix table 14). Forest types representing fire-dependent vegetation (*Pseudotsuga menziesii*/*Pinus ponderosa*, *Quercus garryana*) are present but at lower frequencies. Forest types indicative of hydric riparian sites (*Acer macrophyllum*/*Populus balsamifera* ssp. *trichocarpa*, *Populus balsamifera* ssp. *trichocarpa*/*Alnus rubra*) are present at low frequencies as well.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is nearly 180 years, basal-area weighted mean diameter is greater than 23.6 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl. The presence of down wood and snags benefits a variety of vertebrates as well (appendix table 1).

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 57 percent was upland vegetation with historically short (≤35 years) fire return intervals. Forty percent of the vegetation is a combination of riparian and upland with longer (35–200 years) fire return intervals (fig. 43). Three percent of the vegetation is classified as having a very long (>200 years) fire return interval. Most of this vegetation is within RRs at the upper elevations of the unit (fig. 44). From 2013 through 2020, 13 percent of RR area was within wildfire-burned area perimeters. According to GFC data, these fires caused forest loss in 5 percent of the RR area. Spatial data from the Forest Service indicate 24 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1949 and 2021 and 2 percent of the area was within projects completed since 1994.

Assessment of terrestrial ecosystems indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 5 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for 94 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects and diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are effects of fire exclusion and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with permanently flowing nonfish-bearing streams are likely altered and in moderate condition.

Seasonally Flowing Fish-Bearing Streams

Distribution

There are 17 miles of seasonally flowing fish-bearing streams within the administrative boundary of the RRSNF—Cascades unit (fig. 35). Of these, 15 miles are on NFS land. Riparian reserves associated with these streams cover 1,250 acres within the administrative boundary (1,130 acres on NFS land), or 0.3 percent of the unit (fig. 35). According to BioA data, seasonally flowing fish-bearing streams and their RRs have the smallest extent of the stream habitats in this unit. Most of these stream segments and RRs occur at the confluence of intermittent

streams and perennial streams. Others occur in upper reaches of fish-bearing streams. These RRs are scattered throughout the study unit (fig. 36). According to the WCF, dams and diversions have had limited impacts on hydrologic regimes; few watersheds containing seasonally flowing fish-bearing streams are classified as impaired for flow characteristics (table 25). Drought effects have been limited in this unit, and small percentages of RRs have been converted by development and agriculture. Therefore, the distribution of seasonally flowing fish-bearing streams is likely to be intact in this unit.

Table 25—Percentage of the 30 watersheds with seasonally flowing fish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Cascades unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	10	80	10
Exotic and/or aquatic invasive species attribute	30	67	3
Fire regime condition class attribute	0	67	33
Flow characteristics attribute	57	33	10
Habitat fragmentation attribute	40	47	13
Insects and disease attribute	60	27	13
Large woody debris attribute	3	77	20
Loss of forest cover attribute	90	10	0
Mass wasting attribute	100	0	0
Open road density attribute	23	63	13
Proximity to water attribute	0	97	3
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	20	80	0
Road and trail maintenance attribute	0	100	0
Roads and Trails Condition Indicator	23	43	33
Soil contamination attribute	57	43	0
Water Quality Indicator	60	33	7
Water quality problems attribute	77	13	10

[a] Rangeland vegetation condition rated in 16 watersheds.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 8 miles of seasonally flowing fish-bearing stream habitat in the RRSNF—Cascades unit. Flow metrics modeled for 1977 through 2006 indicated 1 percent of seasonally flowing fish-bearing streams had early, rainfall-dominated runoff (fig. 47). The remaining 99 percent had intermediate runoff timing, with no late, snowfall-dominated runoff systems present in

this habitat. A shift in runoff timing is likely to occur; a transition to earlier runoff in many historically intermediate reaches is expected by the 2040s (fig. 47). A projected 14 percent reduction in the extent of reaches with intermediate runoff timing suggests that climate change is likely to contribute to altered hydrologic regimes by mid-century (table 26).

The magnitudes of high and low flows in seasonally flowing fish-bearing streams in the RRSNF—Cascades unit are expected to change by mid-century (table 26). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of average 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to substantially change between the historical period and mid-century (table 26), flow duration is likely to be impacted by shifts in the timing and amount of runoff. Because runoff is expected to occur earlier and the magnitude of summer baseflows is likely to decrease, we expect that seasonally flowing fish-bearing streams in this unit are likely to experience increased intermittency in some reaches.

Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 70). The TCA indicates drought and climate change are likely to have had limited impacts in the unit. There were three diversions located within seasonally flowing fish-bearing streams and all are on NFS land. According to the WCF, these structures have had limited impacts on hydrologic regimes, with few watersheds containing seasonally flowing fish-bearing streams classified as impaired for flow characteristics (table 25). The WCF also suggests that hydrologic impacts of livestock grazing and timber harvest on seasonally flowing fish-bearing streams are likely to be limited, but that roads and altered wildfire regimes may have contributed to substantial changes in hydrology in many watersheds (table 25). Based on these data, we estimate that hydrologic regimes in seasonally flowing fish-bearing stream habitat are likely to be intact; however, current trends in temperature and precipitation (see the section "Stressors"), projected changes in snowpack (see the section "Stressors"), and modeled flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be impacted by projected changes in climate.

Water Quality

According to SPARROW model output, seasonally flowing fish-bearing streams receive low inputs of suspended sediment and nutrients compared to other stream types in the RRSNF—Cascades unit (fig. 39). In general, incremental sediment and nutrient loads in this stream type are low, with limited reaches exposed to large incremental or accumulated loads (table 27; figs. C.5–C.40). Of the 15 miles of seasonally flowing fish-bearing streams in this unit, none were listed by the State as impaired due to sedimentation or nutrient-related issues.

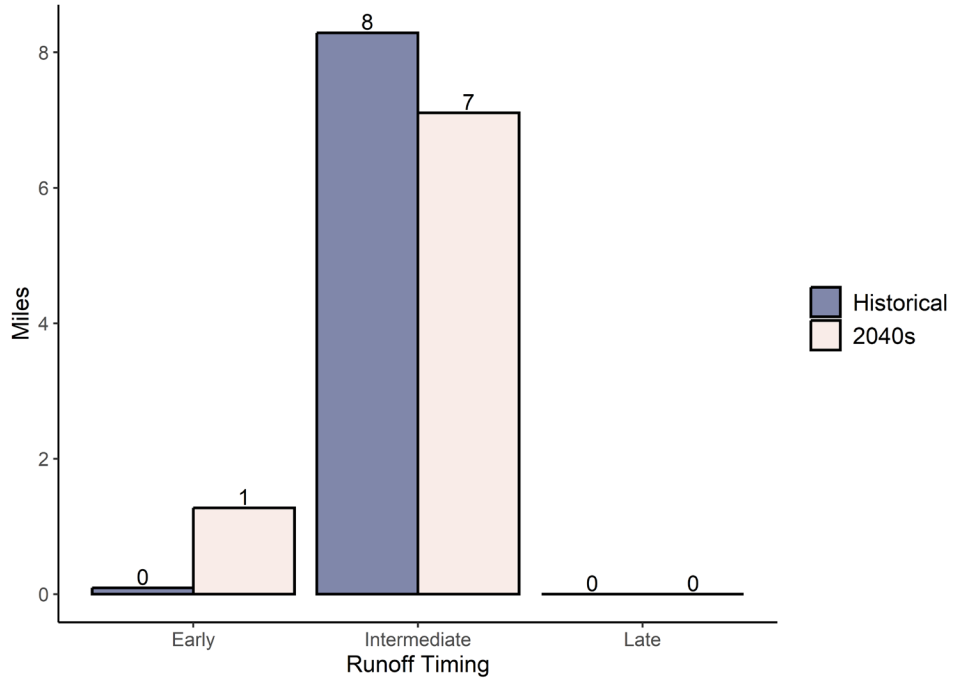

Figure 47—Total length (miles) of seasonally flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 26—Flow metrics modeled for seasonally flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	0.1 mile	1.3 miles	+1,278
	Extent of intermediate, transient runoff systems	8 miles	7 miles	-14
	Extent of late, snowmelt-dominated runoff systems	0 miles	0 miles	--
Magnitude	Average summer daily flow (June 1–September 30)	4 cfs[a]	2 cfs	-41
	Average August daily flow	1.6 cfs	1.5 cfs	-6
	Average baseflow index	0.2	0.2	--
	Average 1.5-year return interval flood	55 cfs	64 cfs	+16
	Average maximum modeled flood	317 cfs	335 cfs	+6
Duration	Average daily flow	8 cfs	8 cfs	--

[a] cfs: cubic feet per second.
-- Indicates no change.

Table 27—Median (minimum, maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for seasonally flowing fish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0, 80.5)	0 (0, 39.7)
	Forest land	33 (0, 710)	18 (0, 305)
	Agricultural land	0 (0, 0)	0 (0, 0)
	Urban land (including roads)	0 (0, 20.9)	0 (0, 20.9)
Total nitrogen	Scrublands and grasslands	0.1 (0, 1.27)	0.05 (0, 1.27)
	Atmospheric deposition	0.28 (0.10, 3.56)	0.16 (0.03, 1.46)
	Urban land (including roads)	0 (0, 0.28)	0 (0, 0.19)
	Spring discharge	0 (0, 0)	0 (0, 0)
	Red alder trees	0 (0, 0.11)	0 (0, 0.03)
	Fertilizer and manure applied to crop lands	0 (0, 0.01)	0 (0, 0.01)
	Wastewater treatment discharge	0 (0, 0)	0 (0, 0)
Total phosphorus	Urban land (including roads)	0 (0, 0.03)	0 (0, 0.02)
	Wastewater treatment discharge	0 (0, 0)	0 (0, 0)
	Fertilizer and manure applied to crop lands	0 (0, 0)	0 (0, 0)
	Manure from grazing cattle applied to rangeland	0 (0, 0.16)	0 (0, 0.08)
	Weathering of upland geology	0.05 (0.01, 2.17)	0.03 (0, 1.84)
	Channel	0.07 (0.01, 0.45)	0.03 (0.01, 0.12)
	Spring discharge	0 (0, 0)	0 (0, 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

Seasonally flowing fish-bearing streams in the RRSNF—Cascades unit are exposed to limited stressors that can impact water quality (see the section "Stressors" on page 70). The TCA indicates departure from natural fire regimes in more than three-quarters of the unit. According to the WCF, fire regimes are altered in many of the watersheds that contain seasonally flowing fish-bearing streams in this unit, but none of these watersheds are impaired for loss of forest cover (table 25). Air temperatures have warmed in this unit and are likely to be contributing to an increase in stream temperature. Despite warming temperatures, no seasonally flowing fish-bearing streams appear on the 303(d) list due to temperature. Seasonally flowing fish-bearing streams in this unit receive suspended sediment, nitrogen, and

phosphorus from natural sources, but also are likely to receive nitrogen inputs from largely human-generated atmospheric deposition (fig. 39). The WCF suggests that roads are generally maintained and that mass wasting is limited (table 25). The TCA indicates none of this unit is significantly impacted by pollution and the WCF suggests no watersheds containing this habitat type are impaired due to extensive soil contamination (table 25). No seasonally flowing fish-bearing streams are listed as impaired, and few watersheds are in poor condition due to water quality problems according to the WCF (table 25). Riparian and wetland vegetation may increase resistance of seasonally flowing fish-bearing streams; all watersheds containing this habitat type are classified as properly functioning or functional-at-risk for riparian/wetland vegetation condition (table 25). Overall, impacts from stressors appear limited. Based on these results, we estimate that water quality in seasonally flowing fish-bearing streams is likely to be high.

Connectivity

Stream connectivity can be disrupted by dams and diversions, but most watersheds containing seasonally flowing fish-bearing streams have free-flowing rivers with no or minor alterations from natural hydrographs (table 25). See the section "Hydrologic Regimes" on page 109 for more information on the number of diversions in this habitat and their impact according to the WCF flow characteristics attribute. According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (table 25).

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the channel in most watersheds containing this habitat (table 25). According to the WCF road and trail maintenance attribute, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in all watersheds with seasonally flowing fish-bearing stream habitat (table 25).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the average center of flow mass date for these streams was March 12. The center of flow mass is expected to shift earlier, with March 3 calculated as the mean date for the 2040s (fig. 40). Earlier runoff may contribute to longitudinal fragmentation in this habitat. Additionally, the magnitude of 1.5-year return interval floods is expected to increase by 16 percent, potentially increasing lateral connectivity by mid-century (see the section "Hydrologic Regimes").

According to the WCF habitat fragmentation attribute, fragmentation due to temperature, blockages to aquatic organism passage, or dewatering has occurred in nearly half of watersheds containing seasonally flowing fish-bearing streams (table 25); 25 to 95 percent of historical aquatic habitat is still connected in these watersheds. Habitat fragmentation is not a serious concern in many other watersheds containing this habitat type, however (table 25). The WCF channel shape and function attribute indicates there is evidence of downcutting to the extent

that some stream channels are no longer connected to their floodplain in most watersheds with seasonally flowing fish-bearing streams (table 25).

Seasonally flowing fish-bearing streams in the RRSNF—Cascades unit are exposed to limited stressors that impact connectivity (see the section "Stressors" on page 70). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. Although the WCF channel shape and function attribute suggests watersheds containing these habitats exhibit lateral connectivity in most stream reaches, the WCF habitat fragmentation attribute indicates about half of watersheds containing seasonally flowing fish-bearing streams in this unit have experienced some longitudinal fragmentation. Based on these results, we estimate connectivity of seasonally flowing fish-bearing streams in the RRSNF—Cascades unit is likely to have been altered. Additionally, connectivity in these systems is likely to be vulnerable to projected climate impacts, including potential changes in the timing and duration of dry periods, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Instream Habitat Quality

There are no seasonally flowing streams designated as critical habitat in this unit. There are 0.2 mile of seasonally flowing fish-bearing stream habitat with HIP for Chinook salmon, 2 miles for coho salmon, and 0.5 mile for steelhead.

There are no AREMP sampling sites for measuring instream wood at seasonally flowing fish-bearing streams in this unit. According to the WCF, large woody debris is present but recruited into the system at less-than-natural rates in more than three-quarters of watersheds containing this habitat type (table 25).

Data from GNN models indicate that as of 2017, large conifer trees and snags in riparian reserves have the potential to provide shade and down wood to streams. Mean tree canopy cover was estimated to be 65 percent for conifers and 8 percent for hardwoods in RRs. Mean tree density was estimated to be 50.9 stems per acre for live trees between 9.8 and 19.7 inches in diameter, 21.1 stems per acre for live trees 19.7 inches or greater in diameter, 5.7 stems per acre for snags between 9.8 and 19.7 inches in diameter, and 2.8 stems per acre for snags 19.7 inches or greater in diameter (appendix table 8). Spatial data from the Forest Service indicate 20 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1949 and 2021 and 8 percent of the area was within projects completed since 1994. From 2013 through 2020, 4 percent of RR area was within wildfire-burned area perimeters. These fires likely increased the short-term supply of instream wood, but to a small extent. Additional sources of wood, including permanently flowing and seasonally flowing nonfish-bearing tributaries, should be considered as well (see the section “Riparian Reserves Condition” for each of these stream types). The preceding results suggest that instream wood is present in moderate to high amounts and multiple size classes, but survey sites are needed for confirmation. There is also potential for recruitment of multiple size classes of wood from RRs. This potential has likely been minimally affected by recent timber harvest but could be influenced by future wildfires.

Fish passage data from AREMP are not available for seasonally flowing streams. Only 11 percent of watersheds containing this habitat type are classified as impaired by the WCF habitat fragmentation attribute. See the preceding section, "Connectivity", for more information.

According to the WCF, channels in most watersheds containing seasonally flowing fish-bearing streams in this unit maintain width-to-depth ratios within NRV and vertical stability except in places where riparian vegetation has been disturbed, between 5 and 25 percent of the channels have widened, channel degradation or aggradation (or both) has occurred in relatively small sections of the network, and downcutting has disconnected some channels from their floodplain (table 25).

Hydrologic regimes are likely to continue shifting; large declines in summer baseflow and increases in bankfull flows are expected by mid-century (see the section "Hydrologic Regimes" on page 109). According to the WCF flow characteristics attribute and Water Quality Indicator, most watersheds containing this habitat have primarily free-flowing rivers and streams, with no or minor alterations from natural hydrologic conditions and minor to no impairment of beneficial uses (table 25).

Seasonally flowing fish-bearing streams in the RRSNF—Cascades unit are exposed to stressors that may impact the quality of instream habitat, including roads and departure from natural fire regimes (see the section "Stressors" on page 70). According to the TCA, roads are likely to have impacted ecological integrity in most of the unit, and the WCF suggests roads are likely to have significantly impacted hydrologic processes in one-third of watersheds. The TCA and WCF indicate the altered fire regimes are likely to have impacted terrestrial ecological integrity and watershed function across much of the unit. It appears that large woody debris is present but recruited at less-than-natural rates and that stream channel degradation has occurred in small sections of these streams. Based on these results, it is likely that instream habitat in seasonally flowing fish-bearing streams has been impacted by roads and departure from natural fire regimes. We estimate instream habitat quality is likely to have been altered.

Riparian Reserves Condition

Nine percent of the area within RRs is classified by LANDFIRE as existing riparian vegetation, composed of willows, red alder, black cottonwood, and other species. This vegetation is patchily distributed in some of the RRs (fig. 42). The area classified as potential riparian vegetation is greater (14 percent), suggesting that riparian extent has likely departed from historical conditions as a result of conifer encroachment, stream modifications, or other changes.

Of the vegetation in RRs classified by LANDFIRE as riparian, 90 percent is forest or woodland (appendix table 7). Woody riparian species include willows, bigleaf maple, red alder, black cottonwood, and chokecherry. Output from GNN models classified 81 percent of RR area in 2017 as conifer forest, 6 percent as mixed conifer/hardwood forest, and less than 1 percent as hardwood forest. The most abundant forest types in RRs, such as *Pseudotsuga menziesii*/*Abies grandis*, *Abies grandis*/*Pseudotsuga menziesii*, *Pseudotsuga menziesii*/*Tsuga heterophylla*, and *Pseudotsuga menziesii*, are dominated by mid- and late successional species, indicating effects of fire suppression (appendix table 13). Forest types representing fire-dependent vegetation

(*Pseudotsuga menziesii*/*Pinus ponderosa*, *Pseudotsuga menziesii*/*Quercus kelloggii*) are present but at lower frequencies.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is nearly 140 years, basal-area weighted mean diameter is greater than 19.7 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl. If down wood, snags, or large trees are near streams, they contribute to habitat quality for steelhead and other fishes (appendix table 1).

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 77 percent was upland vegetation with historically short (≤35 years) fire return intervals (fig. 43). Twenty-three percent of the vegetation is a combination of riparian and upland with longer (35–200 years) fire return intervals. From 2013 through 2020, 4 percent of RR area was within wildfire-burned area perimeters. According to GFC data, these fires caused forest loss in 2 percent of the RR area. Spatial data from the Forest Service indicate 20 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1949 and 2021 and 8 percent of the area was within projects completed since 1994.

Assessment of terrestrial ecosystems indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 5 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for greater than 95 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects and diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are effects of fire exclusion and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with seasonally flowing fish-bearing streams are likely altered and in moderate condition.

Seasonally Flowing Nonfish-Bearing Streams

Distribution

There are 1,420 miles of seasonally flowing nonfish-bearing streams within the administrative boundary of the RRSNF—Cascades unit (fig. 35). Of these, 1,310 miles are on NFS land. Riparian reserves associated with these streams cover 60,300 acres within the administrative boundary (55,600 acres on NFS land), or 13.1 percent of the unit (fig. 35). According to BioA data, seasonally flowing nonfish-bearing streams and their RRs are distributed throughout the unit, but with higher densities in the northern and western portions. According to the WCF, dams and diversions have had limited impacts on hydrologic regimes; few watersheds containing

seasonally flowing nonfish-bearing streams are classified as impaired for flow characteristics (table 28). Drought effects have been limited in this unit, and small percentages of RRs have been converted by development and agriculture. Therefore, the distribution of seasonally flowing nonfish-bearing streams is likely to be intact in this unit.

Table 28—Percentage of the 33 watersheds with seasonally flowing nonfish-bearing stream habitat in the Rogue River-Siskiyou National Forest—Cascades unit rated by the Watershed Condition Framework (WCF) as properly functioning, functional-at-risk, and impaired for 16 attributes and 2 indicators. For more information on the WCF, see Potyondy and Geier (2011) and Appendix D in volume 1 of this series.

Attribute or indicator	Properly functioning	Functional-at-risk	Impaired
Channel shape and function attribute	9	82	9
Exotic and/or aquatic invasive species attribute	30	67	3
Fire regime condition class attribute	0	64	36
Flow characteristics attribute	55	36	9
Habitat fragmentation attribute	39	48	12
Insects and disease attribute	61	24	15
Large woody debris attribute	3	79	18
Loss of forest cover attribute	91	9	0
Mass wasting attribute	100	0	0
Open road density attribute	30	58	12
Proximity to water attribute	0	97	3
Rangeland vegetation condition attribute[a]	100	0	0
Riparian/Wetland vegetation condition attribute	18	82	0
Road and trail maintenance attribute	0	100	0
Roads and Trails Condition Indicator	24	42	33
Soil contamination attribute	55	45	0
Water Quality Indicator	61	30	9
Water quality problems attribute	76	12	12

[a] Rangeland vegetation condition rated in 16 watersheds.

Hydrologic Regimes

The Western U.S. Stream Flow Metrics dataset modeled historical and future hydrologic conditions for 95 miles of seasonally flowing nonfish-bearing stream habitat in the RRSNF—Cascades unit. Flow metrics modeled for 1977 through 2006 indicated 14 percent (13 miles) of seasonally flowing nonfish-bearing streams in the RRSNF—Cascades unit had early, rainfall-dominated runoff (fig. 48). Eighty-five percent (81 miles) had intermediate runoff timing, and the remaining 1 percent had late, snowfall-dominated runoff. A shift in runoff timing is likely to occur, with a transition to earlier runoff in many historically intermediate reaches expected by

the 2040s (fig. 48). A projected 39 percent reduction in the extent of reaches with intermediate runoff timing and loss of all late runoff suggest that climate change is likely to contribute to altered hydrologic regimes by mid-century (table 29).

The magnitudes of high and low flows in seasonally flowing nonfish-bearing streams in the RRSNF—Cascades unit are expected to change by mid-century (table 29). Average summer baseflows (weighted by reach length) are projected to decline from the historical period to the 2040s. The magnitude of average 1.5-year return interval floods is expected to increase. Although average daily flows are not projected to substantially change between the historical period and mid-century, flow duration is likely to be impacted by shifts in the timing and amount of runoff (table 30). Because runoff is likely to occur earlier, the magnitude of seasonal floods is likely to increase, and the magnitude of summer baseflows is likely to decrease, we expect that seasonally flowing nonfish-bearing streams in this unit are likely to experience increased intermittency in some reaches.

Stressors to hydrologic regimes are present in this unit (see the section "Stressors" on page 70). The TCA indicates drought and climate change have had limited impacts. There were 23 diversions located within seasonally flowing nonfish-bearing streams in this unit. Of these diversions, five were on NFS lands. We identified a single dam (Shipler Reservoir on Big Creek) within seasonally flowing nonfish-bearing stream habitat. According to the WCF, these structures have had limited impacts on hydrologic regimes, with few watersheds containing seasonally flowing nonfish-bearing streams classified as impaired for flow characteristics (table 28). The WCF also suggests that hydrologic impacts of livestock grazing and forest cover loss on seasonally flowing nonfish-bearing streams are likely to be limited, but that roads and altered wildfire regimes may have contributed to substantial changes in hydrology in many watersheds (table 28). Based on these data, we estimate that hydrologic regimes in seasonally flowing nonfish-bearing stream habitat are likely to be intact; however, current trends in temperature and precipitation (see the section "Stressors"), projected changes in snowpack (see the section "Stressors"), and modeled flow metrics for the 2040s indicate hydrologic regimes in this unit are likely to be impacted by projected changes in climate.

Water Quality

According to SPARROW model output, seasonally flowing nonfish-bearing streams in the RRSNF—Cascades unit receive suspended sediment loads primarily from forested lands (fig. 39). The largest source of nitrogen to seasonally flowing nonfish-bearing streams in this unit is atmospheric deposition. These streams also receive relatively large inputs of nitrogen from runoff from scrublands and grasslands (fig. 39). The largest sources of phosphorus to seasonally flowing nonfish-bearing streams are channels and weathering of upland geology (fig. 39). In general, incremental sediment and nutrient loads in this stream type are low, with limited reaches exposed to large incremental or accumulated loads (table 30; figs. C.5–C.40). None of the miles of seasonally flowing nonfish-bearing streams in this unit appear on the 303(d) list for sedimentation or nutrient-related issues.

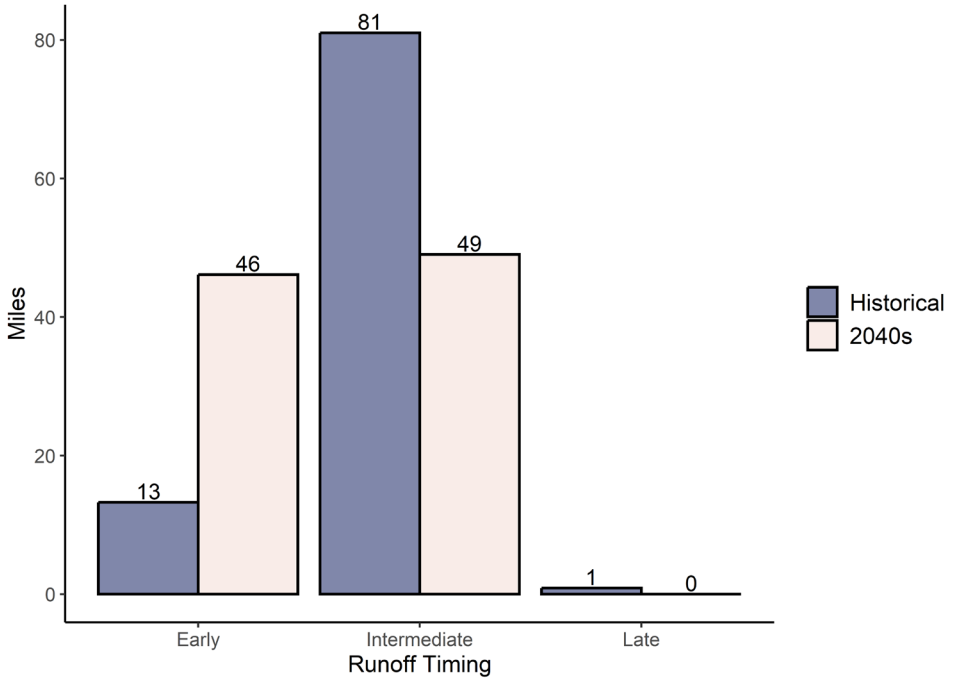

Figure 48—Total length (miles) of seasonally flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit experiencing early rainfall-dominated runoff, intermediate transition runoff, and late snowmelt-dominated runoff for historical and future time periods.

Table 29—Flow metrics modeled for seasonally flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit for historical and projected future climates.

Variable	Flow metric	Historical period (1977–2006)	Mid-century projection (2030–2059)	Percentage change
Timing	Extent of early, rainfall-dominated systems	13 miles	46 miles	+248
	Extent of intermediate, transient runoff systems	81 miles	49 miles	-39
	Extent of late, snowmelt-dominated runoff systems	0.9 mile	0 miles	-100
Magnitude	Average summer daily flow (June 1–September 30)	3 cfs[a]	1 cfs	-48
	Average August daily flow	0.9 cfs	0.8 cfs	-11
	Average baseflow index	0.17	0.17	-2
	Average 1.5-year return interval flood	39 cfs	44 cfs	13
	Average maximum modeled flood	217 cfs	216 cfs	-0.3
Duration	Average daily flow	6 cfs	6 cfs	--

[a] cfs: cubic feet per second.
-- Indicates no change.

Table 30—Median (minimum; maximum) accumulated and incremental loads of suspended sediment (tons), total nitrogen (tons), and total phosphorus (tons) for seasonally flowing nonfish-bearing streams in the Rogue River-Siskiyou National Forest—Cascades unit. Data from the U.S. Geological Survey's SPARROW model.

Variable	Source	Median (minimum; maximum) accumulated load (tons)[a]	Median (minimum; maximum) incremental load (tons)[a]
Suspended sediment	Channel	0 (0; 104)	0 (0; 55)
	Forest land	62 (0; 1,027)	54 (0; 1,027)
	Agricultural land	0 (0; 0)	0 (0; 0)
	Urban land (including roads)	0 (0; 22)	0 (0; 22)
Total nitrogen	Scrublands and grasslands	0.07 (0; 2.29)	0.05 (0; 1.93)
	Atmospheric deposition	0.32 (0.04; 3.33)	0.26 (0; 1.96)
	Urban land (including roads)	0 (0; 0.91)	0 (0; 0.56)
	Spring discharge	0 (0; 0)	0 (0; 0)
	Red alder trees	0 (0; 0.06)	0 (0; 0.03)
	Fertilizer and manure applied to crop lands	0 (0; 0.02)	0 (0; 0.02)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
Total phosphorus	Urban land (including roads)	0 (0; 0.08)	0 (0; 0.05)
	Wastewater treatment discharge	0 (0; 0)	0 (0; 0)
	Fertilizer and manure applied to crop lands	0 (0; 0)	0 (0; 0)
	Manure from gazing cattle applied to rangeland	0 (0; 0.18)	0 (0; 0.18)
	Weathering of upland geology	0.05 (0; 2.7)	0.04 (0; 2.28)
	Channel	0.05 (0; 0.45)	0.04 (0; 0.2)
	Spring discharge	0 (0; 0)	0 (0; 0)

[a] Accumulated loads reflect the accumulated mass of the constituent contributed by a source in the total drainage area upstream of the reach outlet. The accumulated value includes the effects of instream attenuation processes in all upstream reaches. The incremental load reflects only those sources contributed from within the incremental drainage area of that reach. The incremental value includes the effects of instream attenuation processes associated with one-half of the incremental reach length (Wise 2019).

Seasonally flowing nonfish-bearing streams in the RRSNF—Cascades unit are exposed to limited stressors that can impact water quality (see the section "Stressors" on page 70). The TCA indicates departure from natural fire regimes in three-quarters of the unit. The WCF suggests fire regimes are altered in many watersheds containing seasonally flowing nonfish-bearing streams in this unit, but none of these watersheds are impaired for loss of forest cover (table 28). Air temperatures have warmed in this unit and are likely to be contributing to an increase in stream temperature. Of the 1,310 miles of seasonally flowing nonfish-bearing streams in this unit, 2 miles appear on the 303(d) list due to temperature. The WCF suggests that roads are generally maintained, and that mass wasting is limited in watersheds containing these

habitats (table 28). Seasonally flowing nonfish-bearing streams in this unit receive suspended sediment, nitrogen, and phosphorus from natural sources, but also are likely to receive input from largely human-generated atmospheric deposition (fig. 39). The TCA indicates none of this unit is significantly impacted by pollution and the WCF suggests no watersheds containing this habitat type are impaired due to extensive soil contamination (table 28). Less than 1 percent of seasonally flowing nonfish-bearing streams are listed as impaired, and few watersheds are in poor condition due to water quality problems according to the WCF (table 28). Riparian and wetland vegetation may increase resistance of seasonally flowing nonfish-bearing streams to stressors; most watersheds containing this habitat are classified as functional-at-risk for riparian/wetland vegetation condition (table 28). Based on these results, we estimate that water quality in these streams is likely to be high.

Connectivity

Stream connectivity can be disrupted by dams and diversions, but most seasonally flowing nonfish-bearing streams in this unit have primarily free-flowing rivers with no or minor alterations from natural hydrographs (table 28). See the section "Hydrologic Regimes" on page 117 for more information on the number of diversions in this habitat and their impact according to the WCF flow characteristics attribute. According to the WCF Water Quality Indicator, most watersheds containing this habitat have minor to no impairment to beneficial uses of waterbodies (Potyondy and Geier 2011).

The WCF proximity to water attribute indicates that between 10 and 25 percent of road or trail length is located within 300 feet of streams or otherwise hydrologically connected to the channel in most watersheds containing this habitat (table 28). According to the WCF road and trail maintenance attribute, BMPs for maintenance of designed drainage features have been applied to 50 to 75 percent of the roads, trails, and water crossings in all watersheds containing seasonally flowing nonfish-bearing streams (table 28).

Using the Western U.S. Stream Flow Metrics dataset, we calculated the average center of flow mass—the day number of the water year (October 1–September 30) by which half of the year's flow occurs—weighted by reach length for two time periods: historical and 2040s. For the historical period, the average center of flow mass date for these streams was March 11. The center of flow mass is expected to shift earlier, with February 28 calculated as the mean date for the 2040s (fig. 40). Earlier runoff may contribute to longitudinal fragmentation in this habitat. Additionally, the magnitude of 1.5-year return interval floods is expected to increase by 13 percent, potentially increasing lateral connectivity by mid-century (see the section "Hydrologic Regimes").

According to the WCF, habitat fragmentation due to temperature, blockages to aquatic organism passage, or dewatering has occurred in half of watersheds containing seasonally flowing nonfish-bearing streams (table 28). Habitat fragmentation is not a serious concern in many other watersheds containing this habitat, however (table 28). The WCF channel shape and function attribute indicates there is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain in more than three-quarters of watersheds containing seasonally flowing nonfish-bearing stream habitat (table 28).

Seasonally flowing nonfish-bearing streams on the RRSNF—Cascades unit are exposed to limited stressors that impact connectivity (see the section "Stressors"). It appears unlikely that connectivity in these systems has been significantly impacted by dams, diversions, roads, land-use change, climate change, or drought. Although the WCF channel shape and function attribute suggests watersheds containing these habitats exhibit lateral connectivity in most stream reaches, the WCF habitat fragmentation attribute indicates many watersheds containing seasonally flowing nonfish-bearing streams in this unit have experienced some fragmentation because of temperature, blockages to aquatic organism passage, or dewatering (table 28). Based on these results, we estimate connectivity of seasonally flowing nonfish-bearing streams in the RRSNF—Cascades unit is likely to have been altered. Additionally, connectivity in these systems is likely to be vulnerable to projected climate impacts, including potential changes in the timing and duration of dry periods, as well as any increases in the proximity of roads to streams or reduced maintenance of road infrastructure.

Riparian Reserves Condition

Only 2 percent of the area within RRs associated with seasonally flowing nonfish-bearing streams is classified by LANDFIRE as existing riparian vegetation, composed of willows, red alder, black cottonwood, and other species. This vegetation is somewhat limited in these RRs (fig. 42). The area classified as potential riparian vegetation is only 3 percent, suggesting that these stream types support little riparian vegetation because of their physical settings and flow regimes.

Of the vegetation in RRs classified by LANDFIRE as riparian, 87 percent is forest or woodland (appendix table 7). Woody riparian species include willows, bigleaf maple, red alder, black cottonwood, and chokecherry. Output from GNN models classified 88 percent of RR area in 2017 as conifer forest, 3 percent as mixed conifer/hardwood forest, and less than 1 percent as hardwood forest. The most abundant forest types in RRs, such as *Pseudotsuga menziesii*, *Pseudotsuga menziesii*/*Abies grandis*, *Abies grandis*/*Pseudotsuga menziesii*, and *Pseudotsuga menziesii*/*Tsuga heterophylla*, are dominated by mid- and late successional species (appendix table 14). Forest types representing fire-dependent vegetation (*Pseudotsuga menziesii*/*Pinus ponderosa*, *Pinus ponderosa*/*Pseudotsuga menziesii*, *Quercus garryana*) are present but at lower frequencies. Forest types indicative of hydric riparian sites (*Acer macrophyllum*/*Populus balsamifera* ssp. *trichocarpa*) are present at low frequencies as well.

Results from GNN models indicate that as of 2017, live trees, snags, and down wood exist in a range of sizes and densities suitable for providing desired aquatic and wildlife habitat. Mean stand age is greater than 160 years, basal-area weighted mean diameter is greater than 19.7 inches, and there is a large range in the density of trees across size classes (appendix table 8). The large trees and snags and dense forest patches indicated by these data are components of nesting habitat for northern spotted owl. The presence of down wood and snags benefits a variety of vertebrates as well (appendix table 1).

Of the vegetation within RRs classified into fire regime groups by LANDFIRE, 74 percent was upland vegetation with historically short (≤35 years) fire return intervals. Twenty-two percent of the vegetation is a combination of riparian and upland with longer (35–200 years)

fire return intervals (fig. 43). Four percent of the vegetation is classified as having a very long (>200 years) fire return interval. Most of this vegetation is within RRs at the upper elevations of the unit (fig. 44). From 2013 through 2020, 25 percent of RR area was within wildfire-burned area perimeters. According to GFC data, these fires caused forest loss in 11 percent of the RR area. Spatial data from the Forest Service indicate 29 percent of the RR area was within timber harvest or stand treatment projects that were completed between 1949 and 2021 and 2 percent of the area was within projects completed since 1994.

Assessment of terrestrial ecosystems of the KNF indicated that dry mixed conifer ecosystems and yellow pine ecosystems, which together make up 6 percent of the potential natural vegetation in RRs, have low ecological integrity (EMPSi 2022). This low rating is attributed to the overabundance of shade-tolerant, fire-intolerant trees; loss of large, fire-tolerant trees; closed canopy conditions; and lack of structural heterogeneity. These conditions are the result of fire exclusion and past logging practices. Other stressors include climate change, changing fire regimes, and increases in insects and disease. Other conifer-dominated ecosystems, which account for greater than 94 percent of potential natural vegetation, have moderate to high ecological integrity. Moderate ratings are attributed to susceptibility to warming temperatures, decreased snowpack, aridification, insects and diseases, and wildfire risk. In addition, fire exclusion and past logging have altered stand structure, increased density, and decreased structural diversity.

These results indicate that, in this ecosystem, the greatest likely threats to ecological integrity are increasingly frequent and severe wildfires, effects of fire exclusion, and interactions among climate change and other stressors. Based on the preceding indicators of composition and structure of forest vegetation, RRs associated with seasonally flowing nonfish-bearing streams are likely altered and in moderate condition.

Lakes, Ponds, and Reservoirs

Distribution

According to the National Hydrography Dataset for waterbodies, there are 340 waterbodies occupying 1,200 acres of the RRSNF—Cascades unit (fig. 49). This dataset incorrectly classifies at least some reservoirs within the study area as lakes (Steve Bachmann, USDA Forest Service, Yreka, CA, personal communication, July 7, 2021). Riparian reserves associated with lakes, ponds, and reservoirs cover approximately 5,500 acres, or 1.2 percent of the unit. Small and medium-sized reservoirs, such as Willow Lake and Fish Lake, have been constructed throughout the unit. Natural mountain lakes are abundant in the eastern portion. The construction of dams and reservoirs in this unit, as well as its history of beaver trapping (Luce et al. 2022), has likely altered the distribution of these waterbodies.

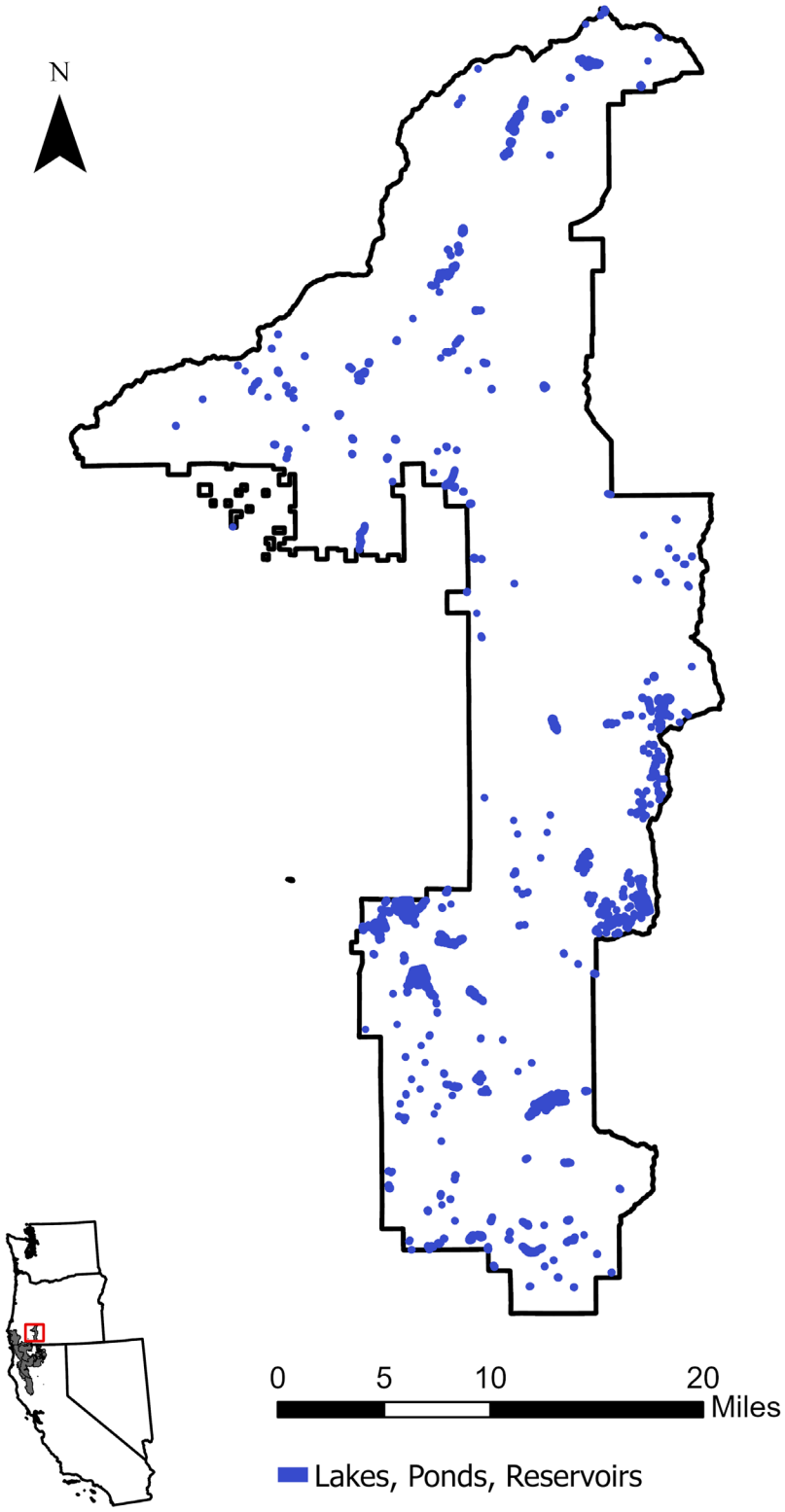

Figure 49—Lakes, ponds, and reservoirs mapped by the National Hydrography Dataset in the Rogue River-Siskiyou National Forest—Cascades unit. Lower map shows location of study area within Oregon.

Hydrologic Regimes

Lakes and reservoirs have moderate sensitivity to climate and nonclimate stressors that alter water levels; ponds have moderate to high sensitivity (Sims et al. 2019a). Changes in precipitation, snowpack, and runoff timing have been linked to lower water levels in lakes and ponds (Sahoo et al. 2013; Sims et al. 2019a). Although annual precipitation has not changed significantly in this unit, substantial shifts in the timing of snow and rainfall have occurred (see the section "Stressors" on page 70). April 1 SWE has declined throughout the study area (Flint et al. 2013; Sims et al. 2019a) and large reductions in SWE and snow residence time are expected to occur by the end of this century (see the section "Stressors"). Snowmelt and snowmelt-driven runoff in the western United States have shifted earlier (Hamlet et al. 2005; Sims et al. 2019a). Most streams that feed lakes and ponds in this unit were historically influenced by snowmelt, with intermediate runoff timing (see the section “Hydrologic Regimes” for each stream type). Many of these stream systems are expected to shift to earlier rainfall-dominated runoff by mid-century.

Severe drought can significantly reduce lake volume and cause ponds to dry entirely (Howard and Noble 2018; Lovich et al. 2017; Purcell et al. 2017; Sims et al. 2019a). According to the TCA, impacts on ecological integrity from drought are limited in this unit. Additionally, contemporary droughts are less severe and shorter in duration than historical drought (Gross et al. 2020; Malevich et al. 2013). Gross et al. (2020) suggest that hydrologic impacts from contemporary droughts, when not exacerbated by additional anthropogenic stressors, are likely to be within NRV.

Nonclimate stressors to lake and pond hydrology include dams and diversions, timber harvest, and altered wildfire disturbance (Sims et al. 2019a). Impaired condition for fire regime may affect lake and pond hydrology in two ways: (1) watersheds that are outside NRV due to lack of fire may not contribute as much runoff to lakes and ponds, resulting in drying of these habitats, or (2) watersheds that are impaired due to large, high-severity fires that removed significant amounts of vegetation may be contributing larger amounts of water to lakes and ponds as a result of reductions in evapotranspiration (Steve Bachmann, USDA Forest Service, personal communication, June 28, 2021). According to the WCF, water fluctuations in lakes and ponds throughout the RRSNF—Cascades unit are likely to have been impacted by altered fire regimes, with 38 percent of watersheds containing these habitats classified as impaired for Fire Regime Condition Class. It appears that loss of forest cover has had limited impacts on lake and pond hydrology; no watersheds containing these habitats are classified by the WCF as impaired for loss of forest cover. Although dams and diversions are present in this unit (see the section "Stressors"), these structures are likely to have had limited impacts on the hydrologic regimes of lakes and ponds, with 13 percent of watersheds containing these habitats classified by the WCF as impaired for flow characteristics. Based on these data, we estimate that lake and pond hydrology is likely to be intact throughout most of this unit; however, we expect that hydrologic regimes in these habitats are likely to be vulnerable to projected changes in snowpack and runoff timing and to larger and more severe wildfires.

Water Quality

Of the 24 watersheds that contain lakes, ponds, and reservoirs in this unit, the WCF water quality problems attribute indicates 8 percent were classified as impaired. These watersheds have extensive water quality problems such as excessive sediment or nutrients (Potyondy and Geier 2011). No watersheds with waterbodies are impaired for road and trail maintenance; BMPs that minimize impacts on water quality are applied to most roads. Additionally, no watersheds were impaired for the WCF mass wasting attribute. No watersheds containing lake, pond, and reservoir habitat were impaired due to loss of forest cover. The TCA indicates none of this unit is in poor or very poor condition due to pollution and the WCF soil contamination attribute suggests no watersheds containing waterbodies are impaired due to extensive soil contamination.

Lakes, ponds, and reservoirs in the RRSNF—Cascades unit are exposed to limited stressors that can impact water quality (see the section "Stressors"). According to the WCF, there is a high likelihood of altered hydrologic and sediment regimes because of departure from historical ranges of variation in vegetation, fuel characteristics, fire frequency, fire severity, and fire pattern in many watersheds in this unit. Riparian and wetland vegetation may increase resilience of some lakes, ponds, and reservoirs to water quality stressors, as 17 percent of watersheds containing these habitats are properly functioning for the WCF riparian and wetland vegetation condition. In these watersheds, riparian and wetland vegetation is capable of dissipating stream energy, reducing erosion, and improving water quality (Potyondy and Geier 2011). Eighty-three percent of watersheds containing waterbodies were classified as functional-at-risk, meaning riparian vegetation is functional, but susceptible to degradation. One 442-acre lake (Fish Lake) was listed by the State as impaired due to pH. Because very few lakes, ponds, and reservoirs in this unit are on the 303(d) list, stressors are limited, and the WCF water quality attributes indicate most watersheds containing these habitats are either properly functioning or functional-at-risk, we expect that water quality of most lakes and ponds in the RRSNF—Cascades unit is likely to be high.

Riparian Reserves Condition

We did not assess RRs associated with lakes, ponds, and reservoirs. These areas are likely to have been altered by increasingly frequent and severe wildfires, effects of fire exclusion, and interactions among climate change and other stressors, based on results from stream ecosystems.

Fens, Springs, and Vernal Pools

Distribution

Data related to the distribution of fens, springs, and vernal pools are limited within the study area. With abundant glacial deposits and springs, the eastern portion of this unit is likely to contain numerous peatland fens (fig. 50). Bedrock in this unit is almost entirely volcanic, so serpentine fens are absent. There are 223 springs mapped in the unit (0.3 per square mile). There are few faults in this unit, but volcanic karst is abundant. The karst topography produces springs with high discharge, including Boundary Spring, which is the source of the Rogue River. Volcanic bedrock is present throughout the unit. Where plateaus with impermeable surfaces

occur, vernal pools may have formed. Alluvial deposits cover a small percentage of the unit (fig. 50), suggesting that few vernal pools occur in this setting.

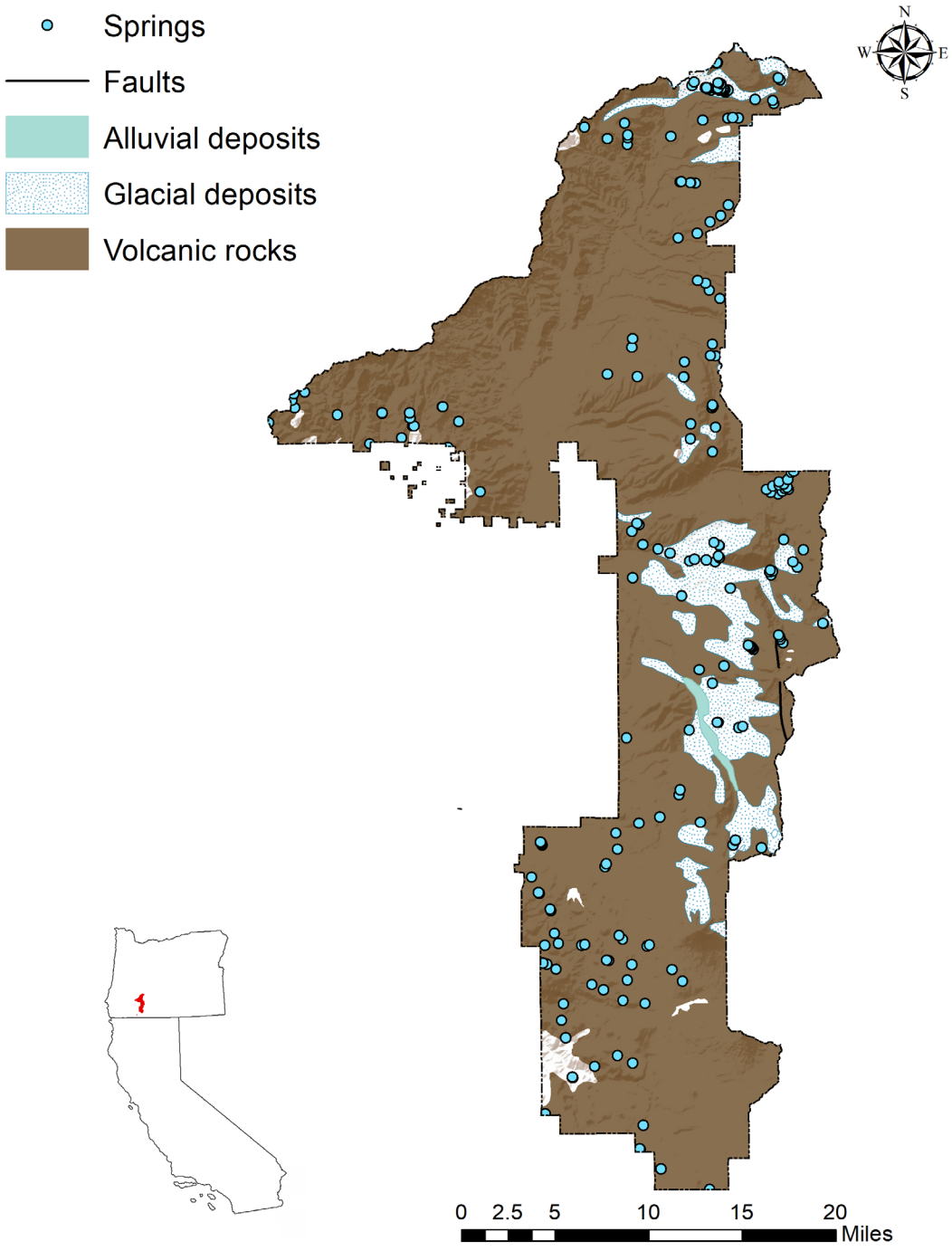

Figure 50— Distribution of rare and unique habitats and associated geologic features in the Rogue River-Siskiyou National Forest—Cascades unit. Peatland fens are likely to be found in alluvial deposits and glacial deposits, serpentine fens are associated with ultramafic rocks, and vernal pools are typically found on alluvial terraces and volcanic plateaus. Lower map shows location of study area within Oregon.

Hydrologic Regimes

Data related to the hydrologic conditions of fens, springs, and vernal pools are limited within the study area. Wetlands and fens have moderate to high sensitivity to climatic and anthropogenic stressors Sims et al. (2019d), springs and seeps are moderately sensitive (Sims et al. 2019b), and vernal pools are highly sensitive (Sims et al. 2019c). We have summarized stressors to these habitats, but there is insufficient information to determine whether hydrologic regimes of fens, springs, and vernal pools are altered.

The hydrology of fens, springs, and vernal pools is strongly impacted by climate, including temperature and precipitation, drought, the amount and residence time of snowpack, runoff timing, and the magnitude of summer baseflows. Temperatures have increased in all four seasons. Annual precipitation throughout the Five Forests planning area has remained consistent or slightly increased; however, the timing of precipitation has shifted. Increases in precipitation during winter and spring and loss of nearly half of summer precipitation have been observed in this unit (see the section "Stressors" on page 70). Changes in temperature and precipitation appear to have affected snowpack, with significant declines in April 1 SWE observed throughout the Five Forests (Loose et al. 2019; Siegel 2009). Substantial reductions in SWE and snow residence time are expected by 2100 (see the section "Stressors"). Reduced summer precipitation and warmer temperatures are linked to shortened hydroperiods in wetlands, fens, and vernal pools (Montrone et al. 2019; Perry et al. 2012; Sims et al. 2019c,d). Changes in seasonal precipitation amounts can affect the magnitude and timing of recharge to groundwater systems that supply flow to springs and seeps (Sims et al. 2019b), and substantial shifts in precipitation timing alter the timing and length of vernal pool inundation (Bauder 2005; Montrone et al. 2019; Pyke 2004; Sims et al. 2019c). Reductions in snowpack are linked to increased drying of fens and vernal pools (Sims et al. 2019c,d). Finally, smaller snowpack affects the magnitude and timing of recharge to groundwater systems that support spring flows (Sims et al. 2019b).

Periods of drought are associated with channel incision that drains water from wetlands and fens, reduces water residence time, decreases recharge, and leads to further drying of these habitats (Null et al. 2010; Sims et al. 2019d; Viers et al. 2013). Additionally, springs associated with shallow aquifers can go dry during drought (Sims et al. 2019b). It appears impacts of drought to fen, spring, and vernal pool hydrology are likely to be limited in this unit. According to the TCA, 10 percent of this unit was in poor or very poor condition for drought, and moisture deficits ranged from mild to moderate (see the section "Stressors" on page 70). Although drought years have occurred twice as often over the last two decades compared to the previous century (Diffenbaugh et al. 2015; Sims et al. 2019d), recent droughts are less severe and shorter in duration than historical drought (Gross et al. 2020; Malevich et al. 2013). Gross et al. (2020) suggest that hydrologic impacts from these droughts, when not exacerbated by other stressors, are within NRV.

Changes in climate can alter stream hydrology, specifically the timing of runoff and the magnitude of summer baseflows, in ways that affect the hydrologic regimes of fens, springs, and vernal pools. Earlier runoff is linked to increased drying of wetlands and fens (Chambers and Miller 2011; Sims et al. 2019d). Additionally, earlier runoff affects the magnitude and timing

of recharge to groundwater systems that support spring flow. Most streams in this unit are characterized by snowmelt-dominated runoff with intermediate runoff timing. Many of the streams that feed lakes and ponds are expected to shift to earlier runoff timing (see the section “Hydrologic Regimes” for each stream type). Declines in summer baseflow can increase the drying of fens and wetlands (Chambers and Miller 2011; Sims et al. 2019d). The magnitude of summer baseflows in streams throughout this unit are expected to decline by mid-century (see the section “Hydrologic Regimes” for each stream type).

Alterations to wetland, fen, spring, and vernal pool hydrology imposed by changes in climate can be exacerbated by nonclimate stressors, including altered fire regimes, land-use change, dams and diversions, roads, and livestock grazing. According to the WCF fire regime condition class attribute, the hydrologic regimes of at least some of these habitats are likely to be affected by altered fire patterns; many watersheds in this unit are classified as impaired (see the section "Stressors" on page 70). Land-use change may have localized impacts, with small portions of the unit being converted to agriculture and development. Impacts from dams and diversions, roads, and livestock grazing are likely to be limited; the WCF indicates 8, 29, and 0 percent of watersheds are classified as impaired for flow characteristics, road condition, and rangeland vegetation condition, respectively. Of the 254 mapped springs in this unit, 86 percent were in watersheds classified as impaired for Fire Regime Condition Class and 13 percent were in watersheds classified as impaired for flow characteristics. Improved mapping of wetlands, fens, and vernal pools would allow analysis of whether these habitats are exposed to climate and nonclimate stressors.

Water Quality

Data related to the water quality of fens, springs, and vernal pools are limited within the study area. Wetlands and fens have moderate to high sensitivity to climatic and anthropogenic stressors (Sims et al. 2019d), springs and seeps are moderately sensitive (Sims et al. 2019b), and vernal pools are highly sensitive (Sims et al. 2019c). We have summarized stressors to these habitats, but there is insufficient information to determine whether water quality of springs and seeps is altered.

Water quality at fens, springs, and vernal pool ecosystems can be impacted by climatic stressors that alter the amount of water in the system, including drought and changes in snowpack or precipitation amount (Sims et al. 2019d). Snowpack throughout the Five Forests planning area has declined by up to 40 percent over the last 40 to 70 years (Loose et al. 2019; Siegel 2009; Sims et al. 2019c) and significant reductions in the April 1 SWE are expected to occur within this unit by the end of this century (see the section "Stressors" on page 70). Precipitation amounts have remained relatively consistent within the Five Forests planning area and this pattern is expected to continue through the end of this century (Loose et al. 2019; Sims et al. 2019c). The TCA suggests 10 percent of this unit is in poor condition due to climate exposure; it is unlikely that changes in temperature and precipitation have compromised the water quality of springs. Moisture deficits have ranged from near normal to severe. Gross et al. (2020) and Malevich et al. (2013) suggest that droughts and their impacts on aquatic ecosystems within the study area are within NRV; however, severe moisture deficits in limited areas within this unit may exacerbate impacts of nonclimate stressors on spring water quality. The TCA indicates 10 percent of this

unit is in poor or very poor condition for drought and it is unlikely that drought has impacted the water quality of springs.

Nonclimate stressors including water withdrawal, development, and pollution can degrade fen, spring, and vernal pool water quality (Sims et al. 2019b,c). According to the WCF, most watersheds in this unit were in good or fair condition for flow characteristics, suggesting impacts of groundwater withdrawals are likely to be limited. The TCA indicates none of the unit is in poor or very poor condition due to pollution and the WCF indicates all watersheds are either properly functioning or functional-at-risk for soil contamination, suggesting impacts of pollution to spring water quality are unlikely. Land-use change, specifically conversion to development and agriculture, impacts spring water quality (Scanlon et al. 2005; Sims et al. 2019b; Winter et al. 1998). Runoff from lands converted to agriculture or development can introduce contaminants to the groundwater systems that support fens and supply discharge to springs (Sims et al. 2019b,d; Winter et al. 1998). Fen, spring, and vernal pool water quality can also be impacted by livestock operations that increase nutrient pollution (Brown et al. 2011; Sims et al. 2019c,d). Conversion of lands to development and agriculture has occurred within this unit and it is likely these changes have had minor, localized impacts on the water quality. The WCF indicates rangelands in all watersheds are properly functioning.

The WCF Water Quality Condition Indicator addresses alteration of physical, biological, and chemical impacts on water quality through consideration of State-listed waterbodies and problems within watersheds that include excessive sediment, excessive nutrients, or chemical pollution. Of the 254 mapped springs in the RRSNF—Cascades unit, 81 percent were in watersheds that were in good condition according to the WCF Water Quality Condition Indicator. Thirteen percent of mapped springs were in watersheds rated as functional-at-risk for Water Quality Condition and only 5 percent were in watersheds classified as poor.

Habitat Condition

Data related to the condition of fens, springs, and vernal pools are limited within the study area. We have summarized stressors to these habitats, but there is insufficient information to determine whether conditions are altered. In the Five Forests planning area, anthropogenic disturbances to fens and surrounding meadows included recreation trails, trampling by livestock, and livestock grazing (Sikes et al. 2013). In addition to site-scale disturbances, fens are vulnerable to a variety of anthropogenic activities occurring at the watershed scale. Watershed-scale protections may have maintained or increased the ecological integrity of fens in the RRSNF, where much of the forest area is within KWs, LSRs, or congressional reserves (appendix table 2). Site visits are needed, however, to determine whether these landscape-scale patterns in stressors are reflected in conditions at fens in the Five Forests. The Spring Stewardship Institute has mapped 2,642 springs in the Five Forests planning area (fig. 50). Of the 720 springs in the Cascades units, 45 percent are within grazing allotments. Most springs in allotments are altered by diversions for stock water or directly impacted by livestock (or both) (Freed et al. 2019). Ecological integrity of springs may therefore be greater in forests where there are fewer active grazing allotments and low percentages of mapped springs within these allotments (table A.3 in Appendix A). Site visits to these springs are needed, however, to confirm these conclusions.

We found no information about vernal pool distribution and habitat condition specific to the RRSNF.

Interwatershed Connectivity

There were 57 HUC12 watersheds with at least some area within the RRSNF—Cascades unit. Watersheds had between two and nine neighboring watersheds within the administrative boundary for a total of 266 pairs of neighboring watersheds within the unit (fig. 51). Of these 266 pairs, 136 (51 percent) were classified as connected with 0 miles separating RRs in neighboring watersheds (fig. 52). An additional 30 pairs (11 percent) were classified as within 0.25 mile; in other words, RRs in neighboring watersheds occurred within a quarter mile of each other (fig. 52). Finally, 100 (38 percent) neighboring watersheds were not connected, meaning RRs in these pairs were separated by a distance greater than 0.25 mile (fig. 52).

The Cascades unit is almost entirely within the Upper Rogue watershed. There are several locations where watersheds containing other national forests (Umpqua and Fremont-Winema) border this unit, but these other watersheds are hydrologically connected. We therefore did not select triads for analysis in this unit.

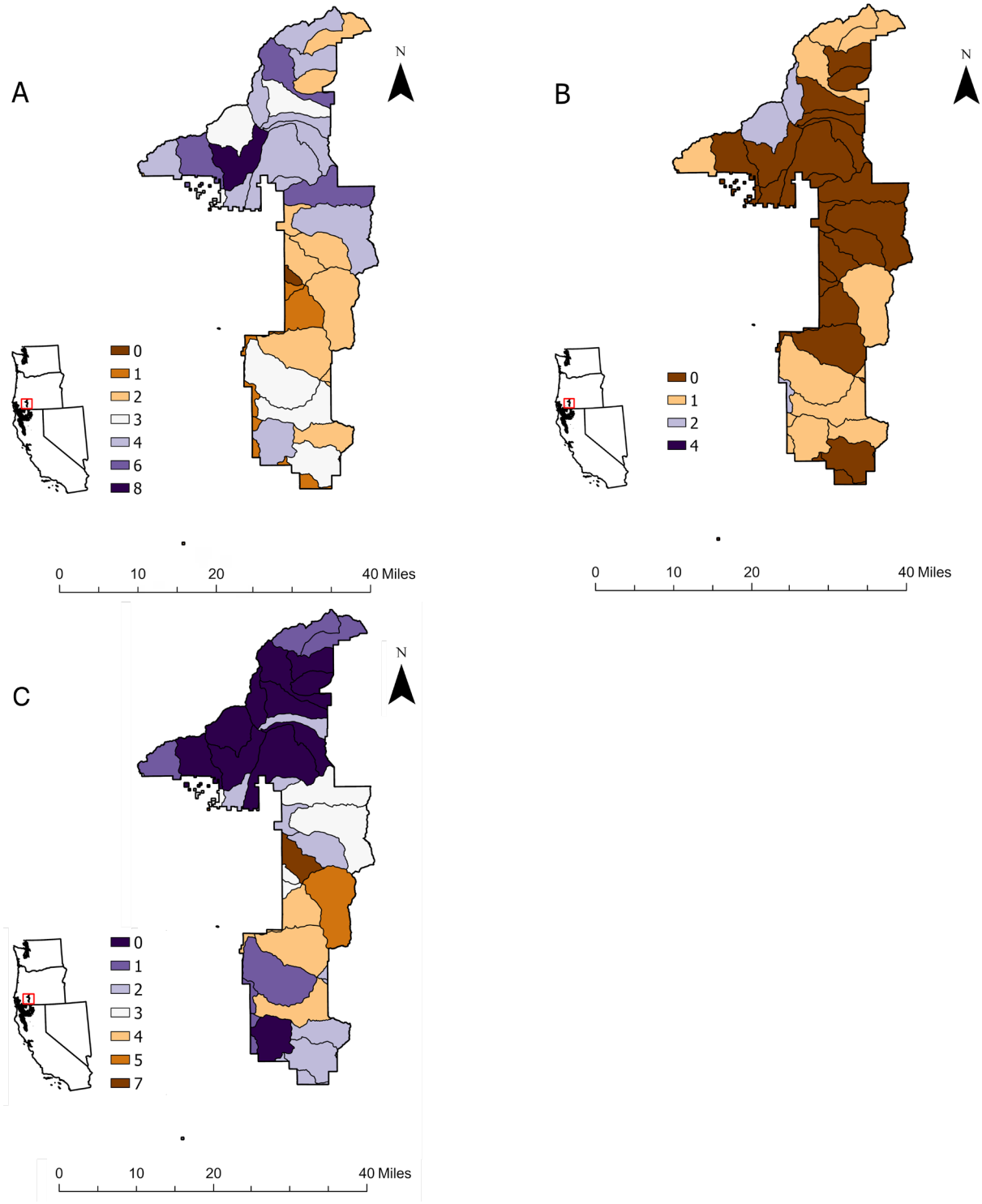

Figure 51— Riparian reserve (RR) connectivity between 12th-level hydrologic unit (HUC12) watersheds in the Rogue River-Siskiyou National Forest—Cascades unit: the number of neighboring watersheds (a) with a distance of 0 miles between RRs, (b) with RRs within 0.25 mile of each other, and (c) with no connection between RRs. Purple watersheds have greater connectivity or potential connectivity with neighbors and brown watersheds have less connectivity with neighbors. Insets show location of study area within Oregon.

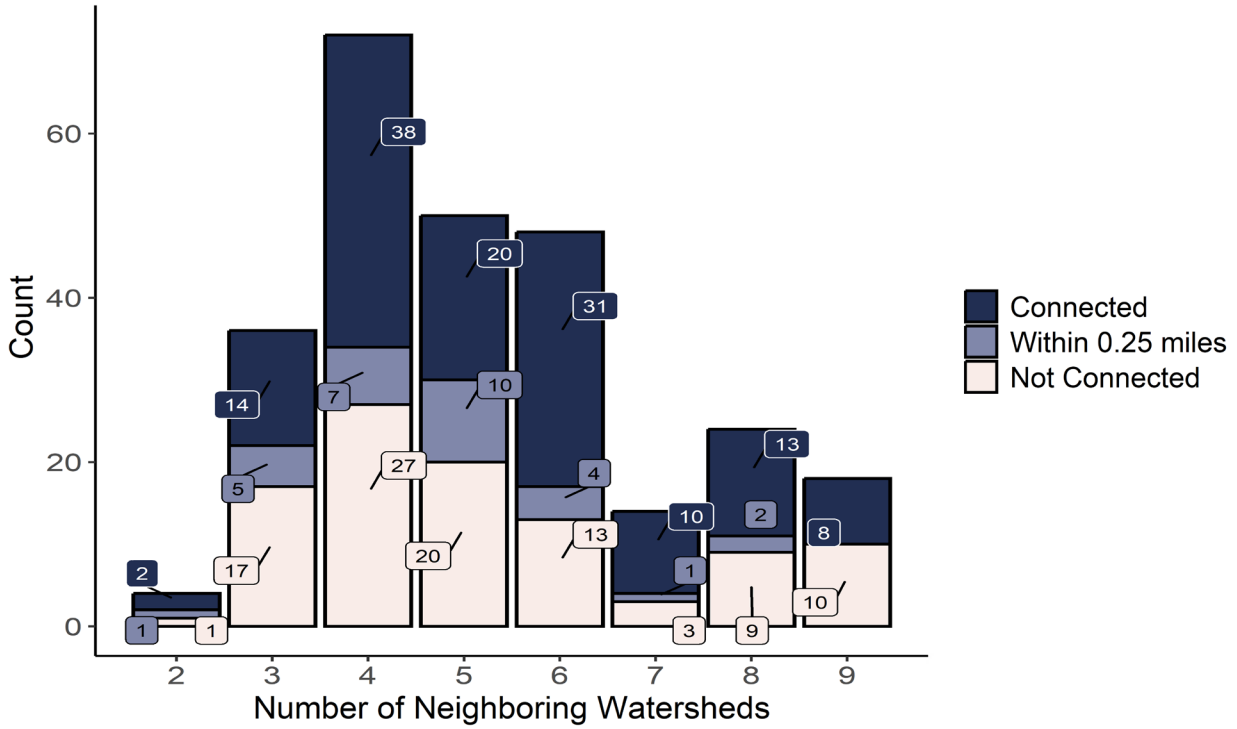

Figure 52—Count of neighboring watershed pairs classified as having connected riparian reserves (RRs), RRs within 0.25 mile, or no connection between RRs by the number of neighboring watersheds in the Rogue River-Siskiyou National Forest—Cascades unit.

SUMMARY

The ecological integrity of stream ecosystems on the Rogue River-Siskiyou National Forest is likely to be moderately to substantially altered (see chapter 4, "Conclusions," in volume 1), as several KECs indicate departure from the natural range of variation. The stream distribution KEC appears resistant to stressors, with distribution of all stream habitats in both the Klamath Mountains and Cascades units estimated to be intact. The hydrologic regimes of streams in the Klamath Mountains unit appear to have been impacted by multiple interacting stressors. In contrast, the hydrologic regimes of streams in the Cascades unit are generally intact; however, systems across the RRSNF are likely to be vulnerable to expected impacts of climate change. With the exception of permanently and seasonally flowing fish-bearing streams in the Klamath Mountains unit, water quality across the RRSNF appears to be high and contributing to ecological integrity. Stream connectivity has generally been maintained within the Klamath Mountains unit but impacted throughout the Cascades unit. Instream habitat of fish-bearing streams across the RRSNF has been impacted, and riparian reserves condition throughout the forest is altered.

It appears that the ecological integrity of lakes, ponds, and reservoirs in the Klamath Mountains unit has been altered, but that these habitats may have high ecological integrity in the Cascades unit. The distribution of lakes, ponds, and reservoirs is altered across the RRSNF. The hydrologic regimes of these habitats are likely to have been impacted in the Klamath Mountains unit, but remain intact in the Cascades unit. Finally, water quality of lakes, ponds, and reservoirs is likely to be high across this national forest.

We found evidence that stream ecosystems on the RRSNF have been altered by fire exclusion, roads, and increases in stream temperature. In the Klamath Mountains unit, we also identified impacts associated with high-severity fire and forest loss, and low water quality ratings. Dams, diversions, and roads have reduced connectivity on the RRNSF, but their impacts are somewhat limited. Interwatershed connectivity is greater in the Klamath Mountains unit than in the Cascades unit. Protected areas such as LSRs, RRs, and KWs contribute to ecological integrity in both units, as do features such as instream wood, high percentage of canopy cover, and density of large trees. Potential connectivity is moderate on the RRSNF because of the intermediate number of watersheds connected by RRs and the intermediate number of triads. Ecosystems associated with streams, lakes, ponds, and reservoirs are vulnerable to impacts of climate change such as earlier runoff timing, decreases in streamflow volume, increases in flood severity, and increases in water temperature. Additional data are needed to evaluate distribution, condition, and vulnerability of fens, springs, and vernal pools in this national forest.

REFERENCES

Bauder, E.T. 2005. The effects of an unpredictable precipitation regime on vernal pool hydrology. Freshwater Biology. 50(12): 2129–2135. https://doi.org/10.1111/j.1365-2427.2005.01471.x

Brown, J.; Bach, L.; Aldous, A.; Wyers, A.; DeGagné, J. 2011. Groundwater-dependent ecosystems in Oregon: An assessment of their distribution and associated threats. Frontiers in Ecology and the Environment. 9(2): 97–102. https://doi.org/10.1890/090108

Burnett, K.M.; Reeves, G.H.; Miller, D.J.; Clarke, S.; Vance-Borland, K.; Christiansen, K. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications. 17(1): 66–80. https://doi.org/10.1890/1051-0761(2007)017[0066:dosprt]2.0.co;2

Chambers, J.C.; Miller, J.R. 2011. Geomorphology, hydrology, and ecology of Great Basin meadow complexes—Implications for management and restoration. RMRS-GTR-258. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 125 p. https://doi.org/10.2737/RMRS-GTR-258

Cleland, D.; Reynolds, K.; Vaughan, R.; Schrader, B.; Li, H.; Laing, L. 2017. Terrestrial condition assessment for national forests of the USDA Forest Service in the continental US. Sustainability. 9(11): 2144. https://doi.org/10.3390/su9112144

Diffenbaugh, N.S.; Swain, D.L.; Touma, D. 2015. Anthropogenic warming has increased drought risk in California. Proceedings of the National Academy of Sciences. 112(13): 3931–3936.

EMPSi. 2022. Draft terrestrial ecosystem assessment for the Rogue River-Siskiyou National Forest. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Klamath National Forest, Yreka, CA. 559 p.

Flint, L.E.; Flint, A.L.; Thorne, J.H.; Boynton, R. 2013. Fine-scale hydrologic modeling for regional landscape applications: The California Basin Characterization Model development and performance. Ecological Processes. 2(1): 25. https://doi.org/10.1186/2192-1709-2-25

Freed, Z.; Aldous, A.; Gannett, M.W. 2019. Landscape controls on the distribution and ecohydrology of central Oregon springs. Ecohydrology. 12(2): e2065. https://doi.org/10.1002/eco.2065

Griffith, G.E.; Omernik, J.M.; Smith, D.W.; Cook, T.D.; Tallyn, E.; Moseley, K.; Johnson, C.B. 2016. Ecoregions of California. [Poster]. [Accessed September 27, 2022]. https://www.epa.gov/eco-research/ecoregion-download-files-state-region-9#pane-04

Gross, S.; Wijayratne, U.; Bohlman, G.; Butz, R. 2020. Natural range of variation of non-meadow riparian zones in northwestern California and southwestern Oregon, USA. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Vallejo, CA. 58 p.

Hamlet, A.F.; Mote, P.W.; Clark, M.P.; Clark, M.P.; Lettenmaier, D.P. 2005. Effects of temperature and precipitation variability on snowpack trends in the Western United States. Journal of Climate. 18(21): 4545–4561. https://www.jstor.org/stable/26253740

Howard, K.; Noble, P. 2018. Hydrological perturbations drive rapid shifts in phytoplankton biodiversity and population dynamics in Butte Lake (Lassen Volcanic National Park, California). Lake and Reservoir Management. 34(1): 21–41. https://doi.org/10.1080/10402381.2017.1360418

Koch, F.H.; Smith, W.D.; Coulston, J.W. 2015. Chapter 4: Drought patterns in the conterminous United States. In: Potter, K.M.; Conkling, B.L., eds. Forest health monitoring: National status, trends, and analysis 2013. Gen. Tech. Rep. GTR-SRS-207. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 55–69. [Accessed September 3, 2022]. https://www.fs.usda.gov/research/treesearch/58657

Loose, E.L.; Hilberg, L.E.; Reynier, W.A.; Kershner, J.M. 2019. Rivers, streams, and floodplains: Northern California climate change vulnerability assessment synthesis, ver. 1.0. Bainbridge Island, WA: EcoAdapt. 46 p. https://www.cakex.org/documents/rivers-streams-floodplains-climate-change-vulnerability-assessment-northern-california [Accessed September 3, 2022].

Lovich, J.E.; Quillman, M.; Zitt, B.; Schroeder, A.; Green, D.E.; Yackulic, C.; Gibbons, P.; Goode, E. 2017. The effects of drought and fire in the extirpation of an abundant semi-aquatic turtle from a lacustrine environment in the southwestern USA. Knowledge & Management of Aquatic Ecosystems. (418): 18. https://doi.org/10.1051/kmae/2017008

Luce, C.H.; Newcomb, K.D.; Hoyer, R.W.; Blanchard, J.H.; Halofsky, J.E. 2022. Chapter 3: Climate change effects on water resources and infrastructure in southwest Oregon. In: Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., eds. Climate Change Vulnerability and Adaptation in southwest Oregon. General Technical Report PNW-GTR-995. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 47–98. https://doi.org/10.2737/PNW-GTR-1013

Malevich, S.B.; Woodhouse, C.A.; Meko, D.M. 2013. Tree-ring reconstructed hydroclimate of the Upper Klamath basin. Journal of Hydrology. 495: 13–22.

Miller, S.A.; Gordon, S.N.; Eldred, P.; Beloin, R.M.; Wilcox, S.; Raggon, M.; Andersen, H.; Muldoon, A. 2017. Northwest Forest Plan—the first 20 years (1994–2013): Watershed condition status and trends. PNW-GTR-932. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 74 p.

Montrone, A.; Saito, L.; Weisberg, P.J.; Gosejohan, M.; Merriam, K.; Meija, J.F. Climate change impacts on vernal pool hydrology and vegetation in northern California. Journal of Hydrology. 574: 1003–1013.

Null, S.E.; Viers, J.H.; Mount, J.F. 2010. Hydrologic response and watershed sensitivity to climate warming in California's Sierra Nevada. PLoS ONE. 5(4): e9932. https://doi.org/10.1371/journal.pone.0009932

Perry, L.G.; Andersen, D.C.; Reynolds, L.V.; Nelson, S.M.; Shafroth, P.B. 2012. Vulnerability of riparian ecosystems to elevated CO2 and climate change in arid and semiarid western North America. Global Change Biology. 18(3): 821–842. https://doi.org/10.1111/j.1365-2486.2011.02588.x

Potyondy, J.P.; Geier, T.W. 2011. Watershed condition classification technical guide. FS-978. Washington, DC: U.S. Department of Agriculture, Forest Service. 49 p. https://www.fs.usda.gov/biology/resources/pubs/watershed/maps/watershed_classification_guide2011FS978.pdf [Accessed September 3, 2022].

Purcell, K.L.; McGregor, E.L.; Calderala, K. 2017. Effects of drought on western pond turtle survival and movement patterns. Journal of Fish and Wildlife Management. 8(1): 15–27. https://doi.org/10.3996/012016-JFWM-005

Pyke, C.R. 2004. Habitat loss confounds climate change impacts. Frontiers in Ecology and the Environment. 2(4): 178–182. https://doi.org/10.1890/1540-9295(2004)002[0178:HLCCCI]2.0.CO;2

Sahoo, G.B.; Schladow, S.G.; Reuter, J.E.; Coats, R.; Dettinger, M.; Riverson, J.; Wolfe, B.; Costa-Cabral, M. 2013. The response of Lake Tahoe to climate change. Climatic Change. 116(1): 71–95. https://doi.org/10.1007/s10584-012-0600-8

Scanlon, B.R.; Reedy, R.C.; Stonestrom, D.A.; Stonestrom, D.A.; Prudic, D.E.; Dennehy, K.F. 2005. Impact of land use and land cover change on groundwater recharge and quality in the southwestern US. Global Change Biology. 11(10): 1577–1593. https://doi.org/10.1111/j.1365-2486.2005.01026.x

Siegel, J. 2009. Examining monthly relationships between temperature, precipitation, snowpack, and streamflow in the Upper Klamath Basin over a 26 year SNOTEL record. Poughkeepsie, NY: Vassar College. Undergraduate thesis. [Accessed October 13, 2022]. facultysites.vassar.edu/macunningham/past_theses/Jared_Siegel_2009_Thesis.pdf

Sikes, K.; Cooper, D.; Weis, S.; Keeler-Wolf, T.; Barbour, M.; Ikeda, D.; Stout, D.; Evens, J. 2013. Fen conservation and vegetation assessment in the national forests of the Sierra Nevada and adjacent mountains, California. Sacramento, CA: California Native Plant Society. 314 p. https://cnps.org/wp-content/uploads/2019/01/veg-fen-sierra-nev-2013.pdf [Accessed September 3, 2022].

Sims, S.A.; Hilberg, L.E.; Reynier, W.A.; Kershner, J.M. 2019a. Lakes and ponds: Northern California climate change vulnerability assessment synthesis. Ver. 1.0. Bainbridge Island, WA: EcoAdapt. 23 p. https://www.cakex.org/documents/lakes-ponds-climate-change-vulnerability-assessment-northern-california [Accessed September 3, 2022].

Sims, S.A.; Hilberg, L.E.; Reynier, W.A.; Kershner, J.M. 2019b. Seeps and springs: Northern California climate change vulnerability assessment synthesis. Ver. 1.0. Bainbridge Island, WA: EcoAdapt. 20 p. https://www.cakex.org/documents/seeps-springs-climate-change-vulnerability-assessment-northern-california [Accessed September 3, 2022].

Sims, S.A.; Hilberg, L.E.; Reynier, W.A.; Kershner, J.M. 2019c. Vernal pools: Northern California climate change vulnerability assessment summary. Ver. 1.0. Bainbridge Island, WA: EcoAdapt. 5 p. https://www.cakex.org/documents/vernal-pools-climate-change-vulnerability-assessment-northern-california [Accessed September 3, 2022].

Sims, S.A.; Hilberg, L.E.; Reynier, W.A.; Kershner, J.M. 2019d. Wet meadows and fens: Northern California climate change vulnerability assessment synthesis. Ver. 1.0. Bainbridge Island, WA: EcoAdapt. 37 p. https://www.cakex.org/documents/wet-meadows-fens-climate-change-vulnerability-assessment-northern-california [Accessed September 3, 2022].

Stewart, I.T.; Cayan, D.R.; Dettinger, M.D. 2005. Changes toward earlier streamflow timing across Western North America. Journal of Climate. 18(8): 1136–1155. https://doi.org/10.1175/JCLI3321.1

Thorson, T.D.; Bryce, S.A.; Lammers, D.A.; Woods, A.J.; Omernik, J.M.; Kagan, J.; Pater, D.E.; Comstock, J.A. 2003. Ecoregions of Oregon. [Color poster with map, descriptive text, summary tables, and photographs]. [Accessed September 27, 2022]. https://www.epa.gov/eco-research/ecoregion-download-files-state-region-10#pane-35

USDA Forest Service [USDA FS]. 2022. National Forest Climate Change Maps: Your guide to the future. Page last modified: April 4, 2022. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. [Accessed September 26, 2022]. https://www.fs.usda.gov/rm/boise/AWAE/projects/national-forest-climate-change-maps.html

USDA Forest Service [USDA FS]. [N.d.]. Planning Rule overview. [Accessed September 3, 2022]. https://www.fs.usda.gov/planning rule

Viers, J.H.; Purdy, S.E.; Peek, R.A.; Fryjoff-Hung, A.; Santos, N.R.; Katz, J.V.E.; Emmons, J.D.; Dolan, D.V.; Yarnell, S.M. 2013. Montane meadows in the Sierra Nevada: Changing hydroclimatic conditions and concepts for vulnerability assessment. Center for Watershed Sciences Technical Report. Davis, CA: University of California, Davis. 67 p. http://calcommons.org/sites/default/files/CWSMeadowsVulnerabilityWhitePaper_2013-1-1_FinalReport_0.pdf [Accessed September 3, 2022].

Winter, T.C.; Harvey, J.W.; Franke, O.L.; Alley, W.M. 1998. Ground water and surface water: A single resource. Circular 1139. Denver, CO: U.S. Department of the Interior, U.S. Geological Survey. 79 p. https://doi.org/10.3133/cir1139

Wise, D.R. 2019. Spatially referenced models of streamflow and nitrogen, phosphorus, and suspended-sediment loads in streams of the Pacific region of the United States. Scientific Investigations Report 2019–5112. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey. 64 p. https://doi.org/10.3133/sir20195112

Appendix. Data for the Rogue River-Siskiyou National Forest

This appendix contains the following tables, with brief descriptions, for the Rogue River-Siskiyou National Forest (RRSNF).

Table 1—Endangered, threatened, and sensitive wildlife that may rely on streams or riparian reserves for seasonal or year-round habitat.

Table 2—Total miles of streams with high intrinsic potential for Chinook salmon, coho salmon, and steelhead within eight-digit hydrologic unit code (HUC8) watersheds in each of the two RRSNF units and the Five Forests cohort, along with percentages of these miles within key watersheds and late successional reserves.

Table 3—Total miles of streams with high intrinsic potential for Chinook salmon within HUC8 watersheds in each of the two RRSNF units, along with the percentage of these miles overlapping the Five Forests cohort.

Table 4—Total miles of streams with high intrinsic potential for coho salmon within HUC8 watersheds in each of the two RRSNF units, along with the percentage of these miles overlapping the Five Forests cohort.

Table 5—Total miles of streams with high intrinsic potential for steelhead within HUC8 watersheds in each of the two RRSNF units, along with the percentage of these miles overlapping the Five Forests cohort.

Table 6—Measured and estimated wood-related variables such as mean and maximum wood count by size class and percent canopy cover for fish-bearing streams in each RRSNF unit.

Table 7—Estimates of vegetation composition in riparian reserves for each of the four stream types within each RRSNF unit.

Table 8—Estimates of vegetation structure in riparian reserves for each of the four stream types within each RRSNF unit. Among the estimated variables are tree and snag density for different size classes and basal area.

Table 9—Characteristics of groups of watersheds joined by triads. Data include percentage of watershed area overlapping a key watershed or in riparian reserves and road density.

Table 10—Estimates of vegetation structure in watersheds that are joined by triads. Data include percent down wood for two size classes and percent canopy cover.

Table 11—Area and percentage of riparian reserve area for abundant forest types in three vegetation classes in riparian reserves associated with permanently flowing fish-bearing streams for each of the RRSNF units.

Table 12—Area and percentage of riparian reserve area for abundant forest types in three vegetation classes in riparian reserves associated with permanently flowing nonfish-bearing streams for each of the RRSNF units.

Table 13—Area and percentage of riparian reserve area for abundant forest types in three vegetation classes in riparian reserves associated with seasonally flowing fish-bearing streams for each of the RRSNF units.

Table 14—Area and percentage of riparian reserve area for abundant forest types in three vegetation classes in riparian reserves associated with seasonally flowing nonfish-bearing streams for each of the RRSNF units.

Table 1—Endangered, threatened, and sensitive fish and wildlife species that may rely on streams or riparian reserves for seasonal or year-round habitat on the Rogue River-Siskiyou National Forest. Species were compiled from lists of sensitive species and special status species produced by USDA Forest Service Regions 5 and 6. Habitat requirements were obtained from the NatureServe (2021) Explorer database.

Group	Species and scientific name	Federal status	State status	Habitat requirements
Amphibians	Foothill yellow-legged frog (*Rana boylii*)	No status	Sensitive–Critical	Partially shaded, undammed, rocky streams at low to moderate elevations; pools surrounded by gravel or rocks
	Siskiyou Mountain salamander (*Plethodon stormi*)	No status	Sensitive–Critical	Rocky talus slopes in areas of dense mature and late-seral forest; logs, leaf litter, and other cover if talus is nearby
	Speckled black salamander (*Aneides flavipunctatus*)	No status	No status	Grassy areas and moist woodlands along streams and at springs
Birds	Harlequin duck (*Histrionicus histrionicus*)	No status	Sensitive	Fast-moving rivers and mountain streams; rocky islands or banks; log jams; overhanging vegetation
	Lewis's woodpecker (*Melanerpes lewis*)	No status	Sensitive–Critical	Riparian woodland with open canopy and perches
	Marbled murrelet (*Brachyramphus marmoratus*)	Threatened	Endangered	Mature conifer forests with large trees providing mossy nest platforms
	Northern spotted owl (*Strix occidentalis caurina*)	Threatened	Threatened	Mature to old-growth forest with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; numerous large snags; heavy accumulations of logs and other woody debris on the forest floor; considerable open space within and beneath the canopy
	Northern waterthrush (*Parkesia noveboracensis*)	No status	No status	Cool, wooded wetlands and slow-moving rivers; rivers bordered with willow and alder
	Purple martin (*Progne subis*)	No status	Sensitive–Critical	Cavities and abandoned woodpecker holes in trees and snags near water

Table 1 continued.

Group	Species and scientific name	Federal status	State status	Habitat requirements
Fishes	Chinook salmon (*Oncorhynchus tshawytscha*) Oregon Coast ESU[a]	No status	Sensitive	Cold upper reaches of streams; spawning gravel; instream wood
	Chinook salmon Southern Oregon Coast/Northern California Coast ESU	No status	Sensitive	Cold upper reaches of streams; spawning gravel; instream wood
	Coho salmon (*Oncorhynchus kisutch*) Oregon Coast ESU	Threatened	Sensitive	Loose coarse gravel at heads of riffles, shallow stream margins, instream wood, shaded pools, backwaters, beaver ponds
	Coho salmon Southern Oregon and Northern California Coasts ESU	Threatened	Sensitive	Loose coarse gravel at heads of riffles; shallow stream margins; instream wood; shaded pools; backwaters; beaver ponds
	Steelhead (*Oncorhynchus mykiss*) Klamath Mountains Province DPS[b]	No status	Sensitive	Deep holding pools with cover; spawning gravels in clear, oxygenated, perennial or intermittent streams; well-vegetated banks and abundant instream cover such as boulders, wood, and undercut banks
	Steelhead Oregon Coast DPS	No status	Sensitive	Deep holding pools with cover; spawning gravels in clear, oxygenated, perennial or intermittent streams; well-vegetated banks and abundant instream cover such as boulders, wood, and undercut banks
	Green sturgeon (*Acipenser medirostris*) Southern DPS	Threatened	Sensitive–Critical	Coastal marine waters; estuaries; lower reaches of large rivers
	Pacific eulachon (*Thaleichthys pacificus*) Southern DPS	Threatened	No status	Lower sections of coastal rivers draining large snowpacks or glaciers; silt, sand, gravel, cobble or detritus in spawning beds; bar and riffle habitat containing sand or pea-gravel
	Pacific lamprey (*Entosphenus tridentatus*)	No status	Sensitive	Streambeds with fine sediment for larval burrowing

[a] ESU: evolutionarily significant unit.
[b] DPS: distinct population segment.

Table 1 continued.

Group	Species and scientific name	Federal status	State status	Habitat requirements
Mammals	Fisher (*Pekania pennanti*)	Proposed: threatened	Sensitive–Critical	Coniferous, mixed, and deciduous forests with hollow trees or rocky areas for dens; riparian areas with important rest site elements such as broken tops, snags, and coarse down wood
	Pacific marten (*Martes caurina*)	Proposed: threatened	Sensitive	Dense deciduous, mixed, or conifer forest with abundant snags, down wood, or stumps
Reptiles	Western pond turtle (*Actinemys marmorata*)	No status	Sensitive–Critical	Connected aquatic and terrestrial habitats: deep, slow-moving water with underwater cover; sunny banks or fields for estivation sites; areas with loose soil or duff for winter burrows; dispersal corridors without barriers

Table 2—Total length (miles) of streams with high intrinsic potential for Chinook salmon, coho salmon, and steelhead and percentages of these miles located within key watersheds and late successional reserves in the Five Forests cohort and Rogue River-Siskiyou National Forest (RRSNF) study units.

Species	Variable[a]	Five Forests cohort	RRSNF— Klamath Mountains unit	RRSNF— Cascades unit
Chinook salmon	Total HIP stream miles	297.0	58.5	9.4
	HIP stream miles in KWs (%)	21	38	3
	HIP stream miles in LSRs (%)	15	49	1
Coho salmon	Total HIP stream miles	550.2	46.2	23.1
	HIP stream miles in KWs (%)	28	46	3
	HIP stream miles in LSRs (%)	12	38	2
Steelhead	Total HIP stream miles	1,841.6	545.9	21.1
	HIP stream miles in KWs (%)	52	46	67
	HIP stream miles in LSRs (%)	31	55	48

[a] HIP: high intrinsic potential. KWs: key watersheds. LSRs: late successional reserves.

Table 3—Total miles of streams with high intrinsic potential (HIP) for Chinook salmon within eight-digit hydrologic unit code (HUC8) watersheds and within portions of these watersheds that overlap the Five Forests cohort and the Rogue River-Siskiyou National Forest (RRSNF) study units.

Watershed	Total HIP miles	Percentage of HIP miles on Five Forests cohort	HIP miles in RRSNF—Klamath Mountains unit	HIP miles in RRSNF—Cascades unit
Illinois	95.7	25	23.5	0
Chetco	44.4	23	10.4	0
Sixes	77.2	15	11.7	0
Upper Rogue	74.5	13	0	9.4
Applegate	69.6	8	5.6	0
Lower Rogue	66.2	8	5.1	0
Coquille	204.0	1	2.2	0

Table 4—Total miles of streams with high intrinsic potential (HIP) for coho salmon within eight-digit hydrologic unit code (HUC8) watersheds and within portions of these watersheds that overlap the Five Forests cohort and the Rogue River-Siskiyou National Forest (RRSNF) study units.

Watershed	Total HIP miles	Percentage of HIP miles on Five Forests cohort	HIP miles in RRSNF—Klamath Mountains unit	HIP miles in RRSNF—Cascades unit
Smith	98.7	39	7.4	0
Chetco	29.2	17	4.9	0
Upper Rogue	167.9	14	0	23.1
Illinois	196.4	11	21.0	0
Applegate	107.3	5	5.2	0
Lower Rogue	111.5	4	3.9	0
Sixes	153.0	1	2.0	0
Coquille	362.8	0.1	0.2	0

Table 5—Total miles of streams with high intrinsic potential (HIP) for steelhead within eight-digit hydrologic unit code (HUC8) watersheds and within portions of these watersheds that overlap the Five Forests cohort and the Rogue River-Siskiyou National Forest (RRSNF) study units.

Watershed	Total HIP miles	Percentage of HIP miles on Five Forests cohort	HIP miles in RRSNF—Klamath Mountains unit	HIP miles in RRSNF—Cascades unit
Smith	175.0	94	23.5	0
Illinois	238.9	84	200.4	0
Chetco	217.4	72	156.7	0
Sixes	167.2	42	70.7	0
Lower Rogue	137.0	40	54.3	0
Applegate	64.6	24	15.6	0
Upper Rogue	101.6	21	0	21.1
Coquille	253.9	9	23.0	0
Middle Rogue	51.7	2	0.9	0

Table 6A—Wood-related variables measured at Aquatic and Riparian Ecosystem Monitoring Program (AREMP) stream sampling sites within the Rogue River-Siskiyou National Forest (RRSNF).

Variable	RRSNF—Klamath Mountains unit		RRSNF—Cascades unit	
	Permanently flowing fish-bearing streams	Seasonally flowing fish-bearing streams	Permanently flowing fish-bearing streams	Seasonally flowing fish-bearing streams
Number of AREMP sampling sites	55	0	37	0
Mean wood count, size class 1	9.6	NA[a]	14.5	NA
Maximum wood count, size class 1	38	NA	51	NA
Mean wood count, size class 2	5.4	NA	9.6	NA
Maximum wood count, size class 2	21	NA	36	NA
Mean wood count, size class 3	2.6	NA	3.9	NA

[a] NA: not applicable.

Table 6A continued.

Variable	RRSNF—Klamath Mountains unit		RRSNF—Cascades unit	
	Permanently flowing fish-bearing streams	Seasonally flowing fish-bearing streams	Permanently flowing fish-bearing streams	Seasonally flowing fish-bearing streams
Maximum wood count, size class 3	17	NA	22	NA
Mean wood count, size class 4	1.7	NA	2.4	NA
Maximum wood count, size class 4	10	NA	13	NA
Percentage of sites with wood jams	21.8	NA	35.1	NA

Table 6B—Wood-related variables estimated in riparian reserves with gradient nearest neighbor (GNN) imputation mapping within the Rogue River-Siskiyou National Forest (RRSNF).

Variable	RRSNF—Klamath Mountains unit		RRSNF—Cascades unit	
	Permanently flowing fish-bearing streams	Seasonally flowing fish-bearing streams	Permanently flowing fish-bearing streams	Seasonally flowing fish-bearing streams
Riparian reserves area (acres)	87,494.7	1,242.6	30,629.8	1,254.0
Mean canopy cover conifers	44.95	48.4	67.0	64.7
Maximum canopy cover conifers	99.1	90.0	95.1	93.6
Mean canopy cover hardwoods	36.4	43.18	4.0	8.46
Maximum canopy cover hardwoods	96.58	93.5	69.3	56.95

Table 7A—Estimates of riparian vegetation composition in riparian reserves on the Rogue River-Siskiyou National Forest (RRSNF). Values were derived from gradient nearest neighbor imputation mapping (existing and potential upland vegetation and LANDFIRE remote sensing (existing and potential upland vegetation; LANDFIRE 2016a,b).

Variable	RRSNF—Klamath Mountains unit				RRSNF—Cascades unit			
	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing
Riparian reserves area (acres)	87,494.7	152,732.9	1,242.6	52,051.7	30,629.8	20,943.5	1,254.0	60,266.8
Percent existing riparian vegetation	4.7	0.8	1.1	0.7	19.2	7.9	8.6	2.2
Percent potential riparian vegetation	14.0	4.9	5.6	1.3	27.4	16.0	14.4	3.0
Percent existing riparian forest or woodland	82.8	87	96.8	80.5	93.3	94.5	90.3	86.5
Percent existing riparian shrubland	8.3	2.8	0	2.5	0.5	0.6	4.1	1.0
Percent existing riparian herbaceous	8.9	10.1	3.1	17	6.2	5.0	5.6	12.6

Table 7B—Estimates of upland vegetation composition in riparian reserves on the Rogue River-Siskiyou National Forest (RRSNF). Values were derived from gradient nearest neighbor imputation mapping (existing and potential upland vegetation) and LANDFIRE remote sensing (existing and potential upland vegetation; LANDFIRE 2016a,b).

Variable	RRSNF—Klamath Mountains unit				RRSNF—Cascades unit			
	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing
Riparian reserves area (acres)	87,494.7	152,732.9	1,242.6	52,051.7	30,629.8	20,943.5	1,254.0	60,266.8
Percent existing conifer forest	34.0	41.5	30.3	43.5	87.2	91.7	81.1	88.4
Percent existing mixed conifer/ hardwood forest	32.7	30.5	42.6	35.3	2.6	2.7	6.0	3.2
Percent existing hardwood forest	17.1	12.0	20.8	12.1	0.2	0.1	0.2	0.3
Percent potential moist mixed conifer forest	93.3	95.8	97.2	93.4	95.7	94.2	94.7	93.8
Percent potential dry mixed conifer forest	1.6	1.8	1.9	3.4	1.8	5.0	1.9	5.3
Percent potential yellow pine forest	2.7	2.3	0.6	2.4	0.8	0.4	2.9	0.6

Table 8—Estimates of vegetation structure in riparian reserves on the Rogue River-Siskiyou National Forest (RRSNF). Values were derived from gradient nearest neighbor imputation mapping of the Northwest Forest Plan area.

Variable	RRSNF—Klamath Mountains unit				RRSNF—Cascades unit			
	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing
Riparian reserves area (acres)	87,494.7	152,732.9	1,242.6	52,051.7	30,629.8	20,943.5	1,254.0	60,266.8
Mean live tree density (trees/acre) ≥1 inch diameter	460.1	478.9	493.0	487.7	362.3	380.2	356.6	380.8
Maximum live tree density (trees/acre) ≥1 inch diameter	3,881.0	3,998.0	2,406.1	3986.2	2,013.4	2,115.0	1,676.9	2,085.8
Mean live tree density (trees/acre) 1–9.8 inches diameter	394.9	420.6	412.1	412.1	296.1	284.7	308.6	309.3
Maximum live tree density (trees/acre) 1–9.8 inches diameter	3,874.1	2,363.2	3,993.1	3,983.4	1,988.3	1,599.2	2,088.3	2,070.4
Mean live tree density (trees/acre) 9.8–19.7 inches diameter	49.4	50.0	55.9	59.4	44.1	47.6	50.9	48.8
Maximum live tree density (trees/acre) 9.8–19.7 inches diameter	230.4	230.4	180.2	229.1	167.2	226.7	151.8	230.8

Table 8 continued.

Variable	RRSNF—Klamath Mountains unit				RRSNF—Cascades unit			
	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing
Mean live tree density (trees/acre) >19.7 inches diameter	15.4	16.8	16.6	16.0	21.9	24.0	21.1	22.7
Maximum live tree density (trees/acre) >19.7 inches diameter	101.2	105.3	66.0	100.8	89.5	104.9	90.3	106.1
Mean snag density (trees/acre) ≥9.8 inches diameter and ≥ 6.6 ft tall	10.6	11.4	8.3	8.5	11.1	13.0	8.5	11.9
Maximum snag density (trees/acre) ≥9.8 inches diameter and ≥6.6 ft tall	100.4	101.2	81.0	98.9	153.6	155.3	108.0	154.2
Mean snag density (trees/ha) 9.8–19.7 inches diameter and ≥6.6 ft tall	7.7	7.8	5.7	5.7	6.9	8.6	5.7	8.1
Maximum snag density (trees/acre) 9.8–19.7 inches diameter and ≥6.6 ft tall	95.7	97.8	63.7	96.0	134.9	135.1	91.4	134.7

Table 8 continued.

Variable	RRSNF—Klamath Mountains unit				RRSNF—Cascades unit			
	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing
Mean snag density (trees/acre) ≥19.7 inches diameter and ≥ 6.6 ft tall	3.2	3.6	2.8	2.8	4.5	4.5	2.8	3.8
Maximum snag density (trees/acre) ≥19.7 inches diameter and ≥6.6 ft tall	43.0	47.9	30.6	41.4	57.1	57.3	35.7	57.3
Mean % down wood cover ≥5 inches	2.7	2.8	2.6	2.8	4.2	4.3	3.5	3.8
Maximum % down wood cover ≥5 inches	17.6	20.6	13.9	18.7	21.7	20.1	15.9	21.5
Mean % down wood cover ≥19.7 inches	0.6	0.7	0.7	0.8	1.3	1.1	1.1	1.0
Maximum % down wood cover ≥19.7 inches	10.7	11.0	7.6	11.9	16.1	12.9	9.0	16.1
Mean live tree basal area (feet2/acre)	171.6	182.5	185.5	185.5	192.5	205.2	179.5	197.3
Maximum live tree basal area (feet2/acre)	993.1	986.6	496.1	973.0	489.6	530.1	432.1	541.0

Table 8 continued.

Variable	RRSNF—Klamath Mountains unit				RRSNF—Cascades unit			
	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing	Permanently flowing fish-bearing	Permanently flowing nonfish-bearing	Seasonally flowing fish-bearing	Seasonally flowing nonfish-bearing
Mean basal-area weighted stand age (years)	129.7	139.0	129.2	126.9	173.2	179.8	138.4	161.9
Maximum basal-area weighted stand age (years)	710.8	717.0	349.4	711.2	552.8	550.4	418.6	543.8
Mean basal-area weighted mean diameter (inches)	20.2	21.3	20.9	20.0	23.7	23.7	21.0	22.3
Maximum basal-area weighted mean diameter (inches)	112.5	109.8	54.3	107.7	58.1	58.3	41.8	57.9

Table 9—Characteristics of groups of watersheds joined by triads in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Data were summarized across the three 8-digit hydrologic unit code (HUC8) watersheds of each triad, and across the lands within the administrative boundaries of the Five Forests cohort.

Triad	Total area of watersheds (acres)	Percentage of watersheds area within administrative boundary	Percentage of watershed area overlapping key watershed	Percentage of watershed area in riparian reserves	Road density in watersheds (miles per square miles)	Road density on land within admin. boundary in watersheds (miles per square mile)
Applegate/ Illinois/Lower Klamath	2,105,176	67.3	28.8	15.7	1.8	1.9
Chetco/Smith/ Illinois	1,755,976	63.8	37.1	17.3	1.6	1.3
Coquille/ Lower Rogue/ Sixes	1,737,757	20.5	13.9	5.1	2.2	2.1
Coquille/ Lower Rogue/ South Umpqua	2,408,104	11.5	28.9	2.7	3.2	6.1

Table 10—Estimates of vegetation structure in watersheds that are joined by triads in the Rogue River-Siskiyou National Forest—Klamath Mountains unit. Values were derived from gradient nearest neighbor imputation mapping of the Northwest Forest Plan area. Data were summarized across the three 8-digit hydrologic unit code (HUC8) watersheds of each triad, and across the lands within the administrative boundaries of the Five Forests cohort.

Triad	Mean % canopy cover in watershed		Mean % down wood cover in watershed		Mean % large down wood cover in watershed		Mean tree density (live trees per acre) in watershed	
	Full area	Admin. boundary	Full area	Admin. boundary	Full area	Admin. boundary	Full area	Admin. boundary
Applegate/ Illinois/Lower Klamath	69.8	64.6	2.7	2.6	0.7	0.7	521.5	472.5
Chetco/Smith/ Illinois	63.6	63.9	2.5	2.3	0.6	0.5	497.3	519
Coquille/ Lower Rogue/ Sixes	67.5	78.6	3.2	2.7	0.8	0.7	427.5	587

Table 10 continued.

Triad	Mean % canopy cover in watershed		Mean % down wood cover in watershed		Mean % large down wood cover in watershed		Mean tree density (live trees per acre) in watershed	
	Full area	Admin. boundary	Full area	Admin. boundary	Full area	Admin. boundary	Full area	Admin. boundary
Coquille/ Lower Rogue/ South Umpqua	65.0	73.3	3.4	3.5	0.8	0.9	416.6	575.3

Table 11—Area of abundant conifer-dominated, mixed conifer/hardwood, and hardwood-dominated forest types in riparian reserves associated with permanently flowing fish-bearing streams on the Rogue River-Siskiyou National Forest (RRSNF). Forest types were mapped using gradient nearest neighbor imputation for the Northwest Forest Plan area.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Conifer-dominated forest	*Pseudotsuga menziesii*	15,929.0 (18.2)	Conifer-dominated forest	*Pseudotsuga menziesii/ Abies grandis*	5,871.7 (19.2)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Notholithocarpus densiflorus*	11,283.6 (12.9)	Conifer-dominated forest	*Pseudotsuga menziesii*	4,568.9 (14.9)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Arbutus menziesii*	4,429.7 (5.1)	Conifer-dominated forest	*Pseudotsuga menziesii/ Tsuga heterophylla*	3,614.4 (11.8)
Conifer-dominated forest	*Pseudotsuga menziesii/ Calocedrus decurrens*	2,124.8 (2.8)	Conifer-dominated forest	*Abies grandis/Pseudotsuga menziesii*	3,236.5 (10.6)
Hardwood-dominated forest	*Notholithocarpus densiflorus*	2,373.2 (2.7)	Conifer-dominated forest	*Pseudotsuga menziesii/ Pinus ponderosa*	1,655.3 (5.4)
Conifer-dominated forest	*Pseudotsuga menziesii/Abies grandis*	1,852.8 (2.1)	Conifer-dominated forest	*Pseudotsuga menziesii/ Pinus lambertiana*	604.2 (2.0)
Conifer-dominated forest	*Pseudotsuga menziesii/ Chamaecyparis lawsoniana*	1,824.5 (2.1)	Conifer-dominated forest	*Pseudotsuga menziesii/ Calocedrus decurrens*	587.8 (1.9)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Arbutus menziesii*	1,816.7 (2.1)	Conifer-dominated forest	*Tsuga heterophylla/ Pseudotsuga menziesii*	580.4 (1.9)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Quercus chrysolepis*	1,750.0 (2.0)	Conifer-dominated forest	*Pinus ponderosa/ Pseudotsuga menziesii*	537.5 (1.8)

Table 11 continued.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Hardwood-dominated forest	*Notholithocarpus densiflorus/ Umbellularia californica*	1,693.5 (1.9)	Conifer-dominated forest	*Pseudotsuga menziesii/ Abies procera*	517.1 (1.7)
Hardwood-dominated forest	*Umbellularia californica/ Acer macrophyllum*	1,308.3 (1.5)	Hardwood-dominated forest	*Quercus garryana*	172.4 (0.6)
Mixed conifer/ hardwood forest	*Notholithocarpus densiflorus/Pseudotsuga menziesii*	1,265.0 (1.4)	Mixed conifer/ hardwood forest	*Quercus garryana/ Pseudotsuga menziesii*	74.5 (0.2)
Hardwood-dominated forest	*Arbutus menziesii*	1,261.9 (1.4)	Hardwood-dominated forest	*Quercus garryana/Quercus kelloggii*	17.8 (0.06)
Hardwood-dominated forest	*Umbellularia californica/ Alnus rubra*	1,121.3 (1.3)	Mixed conifer/ hardwood forest	*Quercus garryana/Pinus ponderosa*	11.6 (0.04)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/Alnus rubra*	1,061.9 (1.2)	Hardwood-dominated forest	*Acer macrophyllum/ Populus balsamifera ssp. trichocarpa*	11.3 (0.04)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Quercus kelloggii*	1,053.9 (1.2)	Hardwood-dominated forest	*Populus balsamifera ssp. trichocarpa/ Alnus rubra*	5.3 (0.02)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/Acer macrophyllum*	947.0 (1.1)	Mixed conifer/ hardwood forest	*Acer macrophyllum/ Pseudotsuga menziesii*	7.6 (0.02)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Quercus chrysolepis*	994.5 (1.1)	Hardwood-dominated forest	*Arbutus menziesii*	1.8 (0.01)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Acer macrophyllum*	582.5 (0.7)	Mixed conifer/ hardwood forest	*Prunus virginiana/ Pseudotsuga menziesii*	1.1 (0.004)
Mixed conifer/ hardwood forest	*Alnus rubra/Pseudotsuga menziesii*	476.1 (0.5)	Hardwood-dominated forest	*Alnus rubra*	0.9 (0.003)

Table 12—Area of abundant conifer-dominated, mixed conifer/hardwood, and hardwood-dominated forest types in riparian reserves associated with permanently flowing nonfish-bearing streams on the Rogue River-Siskiyou National Forest (RRSNF). Forest types were mapped using gradient nearest neighbor imputation for the Northwest Forest Plan area.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Conifer-dominated forest	*Pseudotsuga menziesii*	31,826.4 (20.8)	Conifer-dominated forest	*Pseudotsuga menziesii*	3,417.8 (16.3)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Notholithocarpus densiflorus*	19,270.7 (12.6)	Conifer-dominated forest	*Pseudotsuga menziesii/ Abies grandis*	3,375.1 (16.1)
Conifer-dominated forest	*Pseudotsuga menziesii/ Tsuga heterophylla*	5,669.3 (3.7)	Conifer-dominated forest	*Abies grandis/Pseudotsuga menziesii*	2,028.7 (9.7)
Conifer-dominated forest	*Pseudotsuga menziesii/ Chamaecyparis lawsoniana*	5,321.0 (3.5)	Conifer-dominated forest	*Pseudotsuga menziesii/ Tsuga heterophylla*	1,609.9 (7.7)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Arbutus menziesii*	5,103.1 (3.3)	Conifer-dominated forest	*Abies procera/Abies grandis*	528.0 (2.5)
Hardwood-dominated forest	*Notholithocarpus densiflorus*	4,417.6 (2.9)	Conifer-dominated forest	*Abies grandis/Calocedrus decurrens*	496.6 (2.4)
Conifer-dominated forest	*Pseudotsuga menziesii/Abies grandis*	4,068.9 (2.7)	Conifer-dominated forest	*Pseudotsuga menziesii/ Pinus ponderosa*	490.2 (2.3)
Conifer-dominated forest	*Pseudotsuga menziesii/ Calocedrus decurrens*	3,382.6 (2.2)	Conifer-dominated forest	*Pseudotsuga menziesii/ Abies amabilis*	460.8 (2.2)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Quercus chrysolepis*	2,548.0 (1.7)	Conifer-dominated forest	*Pseudotsuga menziesii/ Abies procera*	459.2 (2.2)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Arbutus menziesii*	2,477.5 (1.6)	Conifer-dominated forest	*Pseudotsuga menziesii/ Pinus lambertiana*	328.5 (1.6)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Alnus rubra*	2,448.6 (1.6)	Hardwood-dominated forest	*Quercus garryana*	31.8 (0.2)
Mixed types	*Notholithocarpus densiflorus/Pseudotsuga menziesii*	2,029.6 (1.3)	Mixed conifer/ hardwood forest	*Quercus garryana/ Pseudotsuga menziesii*	15.1 (0.1)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Chrysolepis chrysophylla*	1,817.4 (1.2)	Mixed conifer/ hardwood forest	*Quercus garryana/Pinus ponderosa*	4.4 (0.02)

Table 12 continued.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Mixed conifer/ hardwood forest	*Arbutus menziesii*	1,808.1 (1.2)	Hardwood-dominated forest	*Quercus garryana/Quercus kelloggii*	2.0 (0.01)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Quercus chrysolepis*	1,549.6 (1.0)	Hardwood-dominated forest	*Acer macrophyllum/ Populus balsamifera ssp. trichocarpa*	1.8 (0.01)
Hardwood-dominated forest	*Umbellularia californica/ Alnus rubra*	1,134.4 (0.7)	Mixed conifer/ hardwood forest	*Alnus rubra/Abies procera*	1.6 (0.01)
Mixed conifer/ hardwood forest	*Alnus rubra/Pseudotsuga menziesii*	901.4 (0.6)	Mixed conifer/ hardwood forest	*Chrysolepis chrysophylla/ Pseudotsuga menziesii*	0.9 (0.004)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Acer macrophyllum*	877.3 (0.6)	Hardwood-dominated forest	*Populus balsamifera ssp. trichocarpa/Alnus rubra*	0.9 (0.004)
Hardwood-dominated forest	*Alnus rubra*	869.8 (0.6)	Hardwood-dominated forest	*Arbutus menziesii*	0.7 (0.003)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Umbellularia californica*	850.4 (0.6)	Mixed conifer/ hardwood forest	*Alnus rubra/Pseudotsuga menziesii*	0.4 (0.002)

Table 13—Area of abundant conifer-dominated, mixed conifer/hardwood, and hardwood-dominated forest types in riparian reserves associated with seasonally flowing fish-bearing streams on the Rogue River-Siskiyou National Forest (RRSNF). Forest types were mapped using gradient nearest neighbor imputation for the Northwest Forest Plan area.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	**Forest type**	**Acres (percentage of riparian reserves)**	**Vegetation class**	**Forest type**	**Acres (percentage of riparian reserves)**
Conifer-dominated forest	*Pseudotsuga menziesii*	183.9 (14.8)	Conifer-dominated forest	*Pseudotsuga menziesii/ Abies grandis*	257.3 (20.5)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Notholithocarpus densiflorus*	212.8 (17.1)	Conifer-dominated forest	*Pseudotsuga menziesii*	156.3 (12.5)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Arbutus menziesii*	109.0 (8.8)	Conifer-dominated forest	*Abies grandis/Pseudotsuga menziesii*	154.1 (12.3)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Umbellularia californica*	75.4 (6.1)	Conifer-dominated forest	*Pseudotsuga menziesii/ Pinus ponderosa*	129.0 (10.3)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Umbellularia californica*	38.3 (3.1)	Conifer-dominated forest	*Pseudotsuga menziesii/ Tsuga heterophylla*	58.9 (4.7)
Hardwood-dominated forest	*Umbellularia californica/ Acer macrophyllum*	33.4 (2.7)	Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Quercus kelloggii*	50.3 (4.0)
Conifer-dominated forest	*Pseudotsuga menziesii/Abies grandis*	32.9 (2.6)	Conifer-dominated forest	*Abies grandis*	35.4 (2.8)
Hardwood-dominated forest	*Umbellularia californica/ Alnus rubra*	30.2 (2.4)	Conifer-dominated forest	*Pinus ponderosa/ Pseudotsuga menziesii*	32.0 (2.6)
Conifer-dominated forest	*Abies grandis*	24.9 (2.0)	Conifer-dominated forest	*Pinus ponderosa*	24.5 (2.0)
Mixed conifer/ hardwood forest	*Notholithocarpus densiflorus/Pseudotsuga menziesii*	24.7 (2.0)	Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Calocedrus decurrens*	19.1 (1.5)
Hardwood-dominated forest	*Acer macrophyllum/Alnus rhombifolia*	24.5 (2.0)	Hardwood-dominated forest	*Quercus garryana*	9.3 (0.7)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Quercus chrysolepis*	20.7 (1.7)	Mixed conifer/ hardwood forest	*Quercus garryana/ Pseudotsuga menziesii*	1.8 (0.1)
Conifer-dominated forest	*Abies grandis/Pseudotsuga menziesii*	18.5 (1.5)	Hardwood-dominated forest	*Quercus garryana/Quercus kelloggii*	0.4 (0.04)

Table 13 continued.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Conifer-dominated forest	*Pseudotsuga menziesii/ Calocedrus decurrens*	17.8 (1.4)			
Conifer-dominated forest	*Pseudotsuga menziesii/Pinus ponderosa*	16.9 (1.4)			
Mixed conifer/ hardwood forest	*Arbutus menziesii/ Pseudotsuga menziesii*	11.3 (0.9)			
Hardwood-dominated forest	*Notholithocarpus densiflorus*	11.1 (0.9)			
Hardwood-dominated forest	*Notholithocarpus densiflorus/Arbutus menziesii*	11.1 (0.9)			
Hardwood-dominated forest	*Quercus chrysolepis*	11.1 (0.9)			
Mixed conifer/ hardwood forest	*Umbellularia californica/ Pseudotsuga menziesii*	10.0 (0.8)			

Table 14—Area of abundant conifer-dominated, mixed conifer/hardwood, and hardwood-dominated forest types in riparian reserves associated with seasonally flowing nonfish-bearing streams on the Rogue River-Siskiyou National Forest (RRSNF). Forest types were mapped using gradient nearest neighbor imputation for the Northwest Forest Plan area.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Conifer-dominated forest	*Pseudotsuga menziesii*	10,040.4 (19.2)	Conifer-dominated forest	*Pseudotsuga menziesii*	11,590.1 (19.2)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Notholithocarpus densiflorus*	5,169.1 (9.9)	Conifer-dominated forest	*Pseudotsuga menziesii/ Abies grandis*	8,804.8 (14.6)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Arbutus menziesii*	3.770.7 (7.2)	Conifer-dominated forest	*Abies grandis/Pseudotsuga menziesii*	5,232.5 (8.7)

Table 14 continued.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Conifer-dominated forest	*Pseudotsuga menziesii/Abies grandis*	2,208.2 (4.2)	Conifer-dominated forest	*Pseudotsuga menziesii/ Tsuga heterophylla*	3,579.9 (5.9)
Hardwood-dominated forest	*Notholithocarpus densiflorus*	1,603.5 (3.1)	Conifer-dominated forest	*Pseudotsuga menziesii/ Calocedrus decurrens*	2,494.8 (4.1)
Conifer-dominated forest	*Pseudotsuga menziesii/ Tsuga heterophylla*	1,261.0 (2.4)	Conifer-dominated forest	*Pseudotsuga menziesii/ Pinus ponderosa*	1,926.6 (3.2)
Conifer-dominated forest	*Abies grandis*	1,087.3 (2.1)	Conifer-dominated forest	*Abies procera/Abies grandis*	1,681.3 (2.8)
Conifer-dominated forest	*Abies grandis/Pseudotsuga menziesii*	1,023.9 (2.0)	Conifer-dominated forest	*Pinus ponderosa/ Pseudotsuga menziesii*	1,591.2 (2.6)
Conifer-dominated forest	*Pseudotsuga menziesii/ Calocedrus decurrens*	1,023.0 (2.0)	Conifer-dominated forest	*Pseudotsuga menziesii/ Pinus lambertiana*	1,094.0 (1.8)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Quercus kelloggii*	998.1 (1.9)	Conifer-dominated forest	*Abies grandis*	860.4 (1.4)
Mixed conifer/ hardwood forest	*Pseudotsuga menziesii/ Alnus rubra*	993.4 (1.9)	Hardwood-dominated forest	*Quercus garryana*	274.9 (0.5)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Umbellularia californica*	772.2 (1.5)	Mixed conifer/ hardwood forest	*Quercus garryana/ Pseudotsuga menziesii*	45.8 (0.1)
Mixed conifer/ hardwood forest	*Notholithocarpus densiflorus/Pseudotsuga menziesii*	651.8 (1.3)	Hardwood-dominated forest	*Quercus garryana/Quercus kelloggii*	32.0 (0.1)
Hardwood-dominated forest	*Quercus garryana*	490.8 (0.9)	Hardwood-dominated forest	*Arbutus menziesii*	27.1 (0.04)
Mixed conifer/ hardwood forest	*Arbutus menziesii/ Pseudotsuga menziesii*	453.2 (0.9)	Mixed conifer/ hardwood forest	*Quercus garryana/Pinus ponderosa*	26.7 (0.04)
Hardwood-dominated forest	*Notholithocarpus densiflorus/Arbutus menziesii*	441.5 (0.8)	Hardwood-dominated types	*Quercus kelloggii/Arbutus menziesii*	6.0 (0.01)
Hardwood-dominated forest	*Umbellularia californica/ Alnus rubra*	391.0 (0.8)	Mixed conifer/ hardwood forest	*Quercus kelloggii/Pinus ponderosa*	4.7 (0.01)

Table 14 continued.

RRSNF—Klamath Mountains unit			RRSNF—Cascades unit		
Vegetation class	Forest type	Acres (percentage of riparian reserves)	Vegetation class	Forest type	Acres (percentage of riparian reserves)
Mixed conifer/ hardwood forest	*Alnus rubra/Pseudotsuga menziesii*	376.1 (0.7)	Hardwood-dominated forest	*Acer macrophyllum/ Populus balsamifera ssp. trichocarpa*	3.8 (0.01)
Hardwood-dominated forest	*Quercus chrysolepis*	357.6 (0.7)	Mixed conifer/ hardwood forest	*Quercus kelloggii/ Pseudotsuga menziesii*	3.3 (0.01)
Hardwood-dominated forest	*Umbellularia californica/ Acer macrophyllum*	293.1 (0.6)	Hardwood-dominated forest	*Arbutus menziesii/Quercus garryana*	2.2 (0.004)

REFERENCES

LANDFIRE. 2016a. Biophysical Setting Layer, LANDFIRE 2.0.0. U.S. Department of the Interior, U.S. Geological Survey; U.S. Department of Agriculture, Forest Service. [Accessed September 26, 2022]. http://www.landfire/viewer

LANDFIRE. 2016b. Existing Vegetation Type Layer, LANDFIRE 2.0.0. U.S. Department of the Interior, U.S. Geological Survey; U.S. Department of Agriculture, Forest Service. [Accessed September 26, 2022]. http://www.landfire/viewer

NatureServe. 2021. NatureServe Explorer. https://explorer.natureserve.org [Accessed October 25, 2021].

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

To learn more about RMRS publications or search our online titles:

www.fs.usda.gov/research/rmrs/products/publications

www.fs.usda.gov/research/treesearch