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OKANOGAN – WENATCHEE NATIONAL FOREST LATE-SUCCESSIONAL RESERVE ASSESSMENT

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Okanogan - Wenatchee National Forest

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Table of Contents

EXECUTIVE SUMMARY 1

1. INTRODUCTION 4

1.1. Assessment Framework 5

2. ECOLOGICAL PRINCIPLES, MANAGEMENT GUIDANCE AND POLICY BACKGROUND 8

2.1. Ecological Principles for Management of Late-Successional Forests 10

2.1.1. Northwest Forest Plan Standards and Guidelines – Washington Eastern Cascades 12

2.1.2. NWFP and Reference Conditions 14

2.1.3. Consultation on the Northwest Forest Plan 15

2.2. National Direction: US Forest Service 2012 Planning Rule and Policy for Ecological Resilience and Restoration 16

2.2.1. US Forest Service 2012 Planning Rule 16

2.2.2. Ecosystem Restoration Policy 17

2.3. Northern Spotted Owl Recovery Plan and Critical Habitat 17

2.4. Summary 22

3. CURRENT CONDITION OF LATE-SUCCESSIONAL AND OLD FOREST HABITATS AND ASSOCIATED SPECIES IN THE EASTERN WASHINGTON CASCADES 24

3.1. Ecology of Eastern Washington Cascades Forests 24

3.1.1. Dry Forest Group 24

3.1.2. Moist Forest Group 28

3.1.2.1. Stand/Patch Scale Reconstructions in Dry and Moist Forests 29

3.1.3. Cold Forest Group 29

3.2. Changes to Climate and Disturbances since 1994 30

3.3. Current Condition of Late-Successional and Old Forest Habitats 37

3.3.1. Old Growth Structure Index – 200 37

3.3.1.1. Current and Changed Conditions 39

3.3.2. Dry Forest Large-Tree Open-Canopy Habitats 40

3.3.3. Dry and Moist Forest Large-Tree Closed-Canopy Habitats 41

3.3.4. Cold Forest Medium-Large Tree Closed-Canopy Habitats 42

3.3.5. Northern Spotted Owl 43

3.3.5.1. Barred Owl and Spotted Owl Interactions 44

3.3.5.2. Habitat Loss from Disturbance 46

3.3.5.3. Northern Spotted Owl Population Monitoring 49

3.3.6. Habitat Connectivity 54

3.4. Current Condition Summary 59

4. RISK ASSESSMENT OF LATE-SUCCESSIONAL AND OLD FOREST HABITATS 60

4.1. Current Habitat Compared to Reference Conditions 60

4.1.1. Dry Forest Large-Tree Open-Canopy Habitats 61

4.1.2. Moist Forest Large-Tree Closed-Canopy Habitats 61

4.1.3. Dry and Moist Forest Large-Tree Closed-Canopy Habitats 61

4.1.4. Cold Forest Medium-Large-Tree Closed-Canopy Habitats 62

4.2. Large Tree Dense Forest Sustainability 62

4.3. Wildfire Hazard 66

4.4. Fire Refugia 67

4.5. Insects and Disease 69

4.6. Risk Assessment Matrix 71

4.7. Risk Assessment Summary 72

5. RESTORATION PRINCIPLES, TREATMENT EFFECTIVENESS, AND LANDSCAPE EVALUATIONS 74

5.1. Landscape-Scale Treatment Effectiveness 74

5.2. Stand-Scale Treatment Effectiveness 75

5.3. Restoration Principles 76

5.4. Okanogan-Wenatchee Forest Restoration Strategy 77

5.4.1. Landscape Evaluations 77

6. RESTORATION & RISK REDUCTION FRAMEWORK AND DESIGN CONSIDERATIONS 79

6.1. Desired Condition 80

6.2. Evaluating Treatment Needs at the Landscape-Scale in LSOF Forests 80

6.3. Stand-Scale Design Considerations 83

6.3.1. Design Considerations for **Large and old trees** ... 84
6.3.2. Design Considerations for **Tree Density** ... 84
6.3.3. Design Considerations for **Species composition** ... 86
6.3.4. Design Considerations for **Spatial arrangement** ... 86
6.3.5. Design Considerations for **Snags and down wood** ... 89
6.3.6. Design Considerations for **Prescribed Fire** ... 89
6.3.7. Design Considerations specific to **Northern Spotted Owl** ... 89
7. MONITORING AND ADAPTIVE MANAGEMENT ... 90
7.1. Desired Outcomes ... 90
7.2. Monitoring Items and Metrics ... 91
7.3. Adaptive Management Triggers ... 92
8. FIRE MANAGEMENT ... 94
8.1. Background ... 94
8.2. Fire prevention and risk reduction ... 97
8.3. Wildfire suppression ... 98
8.4. Prescribed fire and managed unplanned ignitions ... 99
9. PAST AND FUTURE VEGETATION MANAGEMENT ... 101
Literature Cited ... 105
Appendix A. Acronyms ... 129
Appendix B. Summary for Individual or Grouped LSRs/MLSAs ... 130
Chelan Group (Shady Pass, Lucerne and Slide Peak Late-Successional Reserves) ... 131
Chiwawa Late-Successional Reserve ... 136
Manastash Late-Successional Reserve ... 141
Methow/Twisp Group (Hunter Mtn, Nice, Sawtooth and Twisp River LSRs) ... 146
Naches Group (Bumping LSR, Crow MLSA, Haystack MLSA, Lost Lake MLSA, Milk Creek MLSA, Rattlesnake LSR, Russell Ridge MLSA and Upper Nile LSR) ... 151
Swauk Late-Successional Reserve ... 156
Teanaway Late-Successional Reserve ... 161
Tieton Late-Successional Reserve ... 166
Upper Methow Late-Successional Reserve ... 171

Wenatchee River Group (Boundary Butte LSR, Camas MLSA, Deadhorse LSR, Eagle MLSA, Icicle LSR, Little Wenatchee LSR, Natapoc MLSA, Sand Creek MLSA, Tumwater MLSA and Twin Lake MLSA) 176

Appendix C. Northern Spotted Owl Ecology in Eastern Washington Forests 181

Northern Spotted Owl 181

Northern Spotted Owl Population Monitoring 181

Northern Spotted Owls and Landscapes 182

Habitat Functions and Descriptions 183

Nesting-Roosting Function 183

Foraging Function and Habitat for Primary Prey Species 184

Dispersal Function 185

Forest Disturbances and Spotted Owls 186

Barred Owl and Spotted Owl Interactions 187

Spotted Owls and Climate Change 188

Appendix D. Mapping Northern Spotted Owl Habitat 189

Broad-Scale Assessments 189

Mid-Scale (2-4 subwatersheds) Assessments 189

Project-Scale Assessments 189

Foraging Habitat 189

Nesting-roosting Habitat 190

Developing a Desired Future Condition for northern spotted owl habitat 191

Appendix E. Assessing Focal Wildlife Habitat Treatment Needs Through the Landscape Evaluation Process 192

Appendix F. Snags and down wood 194

Appendix G. Example LSR Restorative Risk Reduction Prescriptions 196

Example: Dry Forest Risk Reduction Prescription 196

Example: Moist Forest Risk Reduction Prescription 198

Appendix H. Sensitive, Threatened, and Endangered Plants and Animals on the Okanogan-Wenatchee National Forest 201

Appendix I. Methods 212

Methods for mapping late-successional and old forest habitat 212

Methods to assess habitat connectivity 215

Methods to Determine Wildfire Burn Severity Classifications 217

Methods to Access Impacts of Insects and Diseases 219

Appendix J. LSRA Consistency Checklist 221

List of Figures

Figure 1.1-Conceptual diagram displaying the component spatial datasets for three of the major analysis pieces of this LSR assessment.. 7

Figure 2.1-The Late-Successional Reserve and Managed Late-Successional Area network on the Okanogan-Wenatchee National Forest, relative to the Eastern Cascades Physiographic Province delineated in the Northwest Forest Plan. 9

Figure 2.2-Late-Successional Reserves, Managed Late-Successional Reserve Areas, and designated spotted owl Critical Habitat within the Okanogan – Wenatchee National Forest. 18

Figure 3.1-Distribution of forested vegetation groups across the assessment area. 26

Figure 3.2-Area burned by wildfires on the Okanogan-Wenatchee National Forest and in the Late-Successional Reserve Network over time periods before (1985-1993) and after Northwest Forest Plan implementation (1994-2021). 32

Figure 3.3-Cumulative burn severity (acres by severity class) of wildfires in the Late-Successional Reserve Network since 1994. 32

Figure 3.4-Distribution of wildfire on the Okanogan-Wenatchee National Forest from 1984 to 2021 33

Figure 3.5-Acres of bark beetle-caused tree mortality across the (A) Okanogan-Wenatchee National Forest and (B) within the OWNF – LSR/MLSA Network. 35

Figure 3.6-Total acres of defoliator activity across the (A) Okanogan-Wenatchee National Forest, and within the (B) OWNF – LSR/MLSA Network. 36

Figure 3.7-Current mapped old growth structure index (OGSI-200) for the Okanogan-Wenatchee National Forest. Data are from Davis et al. 2022. 38

Figure 3.8-The OGSI200 monitoring results for all of the Northwest Forest Plan (NWFP) area and for the Okanogan-Wenatchee National Forest.. 39

Figure 3.9-Changes to OGSI200 between 1993 and 2021 within A) the Okanogan-Wenatchee National Forest and B) the Late-Successional Reserve network on the OWNF. 40

Figure 3.10-Results of the barred owl removal project on the Cle Elum Ranger District............ 45

Figure 3.11-Predicted relative habitat suitability for northern spotted owl on the Okanogan-Wenatchee National Forest based on current conditions 47

Figure 3.12-The changes to the amount of northern spotted owl habitat (by habitat function) from 1993 to 2022 on A) the Okanogan-Wenatchee National Forest and B) within the LSR/MLSA network on the Forest 48

Figure 3.13-A comparison of the relative proportions of northern spotted owl habitat within breeding territories (n=278) from 1993 to 2022. 49

Figure 3.14-Current and historical northern spotted owl activity centers, survey effort, and results on the Okanogan-Wenatchee National Forest, 2018-2022. 52

Figure 3.15-Northern spotted owl pairs detected on the Cle Elum, and Naches and Wenatchee River Ranger Districts, Okanogan-Wenatchee National Forest, from 1977 through 2022. 53

Figure 3.16-Comparison of resistance to moderate mobility wildlife movements across the Okanogan-Wenatchee National Forest, 1993-2021. 57

Figure 3.17-Distribution of spotted owl dispersal capable landscape across the OWNF in 1993 and 2022. 58

Figure 4.1-Map of existing dense large tree structure categorized into four categories of sustainability based on fire risk and drought vulnerability. 63

Figure 4.2-Wildfire hazard potential for the Okanogan-Wenatchee National Forest and within the Late-Successional Reserve network. 67

Figure 4.3-LSRs and MLSAs on the Okanogan-Wenatchee National Forest that contain area designated as Insect and Disease Epidemic Area designated by under Section 602(d) of the Healthy Forest Restoration Act 70

Figure 4.4-Risk factors for each LSR or LSR/MLSA group summarized by the proportion of area that is at risk or affected. 72

Figure 6.1-Flow diagram of steps for completing assessment of treatment need within an LSR that intersects within a priority landscape or proposed project area. 83

Figure 6.2- Basal area within 9 historical reference plots in the eastern Washington Cascades, by (A) species and by (B) diameter class 86

Figure 6.3-An example stem map of reconstructed conditions from the Nile reconstruction plot in the eastern Washington Cascades that demonstrates the fine-scale variability found in frequent fire forests 88

Figure 6.4-Number of large openings by size class for 9 historical reference plots in the eastern Washington Cascades 88

Figure 8.1-Annual simulated historical acres burned by severity class for each vegetation type in the Late-Successional Reserve network on the Okanogan-Wenatchee National Forest compared with contemporary acreages from 1993 – 2021 96

Figure 8.2-Comparisons between the proportion of fire by severity class in any given year based on simulations of historical structure and vegetation type compared with observed contemporary fire severity in each vegetation class within the Okanogan-Wenatchee Late-Successional Reserve network 96

Figure 9.1-Annual treatment acres across the Late-Successional Reserve network on the Okanogan-Wenatchee National Forest between 1994 – 2023 from the Forest Activity Tracking System (FACTS) database. 102

Figure 9.2-Annual treatment acres across the Late-Successional Reserve network on the Okanogan-Wenatchee National Forest by activity for the period between 1994 – 2023 from the Forest Activity Tracking System (FACTS) database 102

Figure B.1-Location of the Chelan Group on the Okanogan-Wenatchee National Forest 131

Figure B.2-Location of the Chiwawa LSR on the Okanogan-Wenatchee National Forest 136

Figure B.3-Location of the Manastash LSR on the Okanogan-Wenatchee National Forest 141

Figure B.4-Location of the Methow/Twisp Group on the Okanogan-Wenatchee National Forest.. 146

Figure B.5-Location of Naches Group on the Okanogan-Wenatchee National Forest 151

Figure B.6-Location of the Swauk LSR on the Okanogan-Wenatchee National Forest 156

Figure B.7-Location of the Teanaway LSR on the Okanogan-Wenatchee National Forest 161

Figure B.8-Location of the Tieton LSR on the Okanogan-Wenatchee National Forest 166

Figure B.9-Location of the Upper Methow LSR on the Okanogan-Wenatchee National Forest 171

Figure B.10-Location of the Wenatchee River Group on the Okanogan-Wenatchee National Forest 176

Figure D.1-Results of canopy height model and polygons drawn to refine spotted owl habitat mapping 190

Figure I.1-Distribution of data compiled to estimate late-successional and old forest habitats within the Okanogan-Wenatchee National Forest 214

List of Tables

Table 2.1-The Late-Successional Reserve (LSR) and Managed Late-Successional Area (MLSA) network on the Okanogan-Wenatchee National Forest 10

Table 2.2-The estimated number of owl pairs and amount of habitat consulted on in the Biological Opinion for the Washington Eastern Cascades Province under Alternative 9, the preferred alternative of the Northwest Forest Plan. 15

Table 3.1-Wildlife and plant species of conservation concern: Federally Threatened or Endangered plant species and Federally Threated Species, Region 6 Sensitive Species, or Washington State Species of Greatest Conservation Need (SGCN) vertebrate wildlife species that use Late-Successional and Old Forest habitats to meet some portion of their life history requirements on the Okanogan-Wenatchee National Forest. 27

Table 3.2-Climate data summarized from 1994-2022 for locations on the Okanogan-Wenatchee National Forest 31

Table 3.3-Acres mapped (and proportion of total area) that include at least one year with some amount of tree mortality due to bark beetles or severe defoliation caused by defoliating insects within Forest Groups on the Okanogan-Wenatchee NF and LSR Network. 34

Table 3.4-The current amounts of late-successional and old forest habitats for Forest Groups compared to estimates of their natural range of variability 41

Table 3.5-Barred owl detection rates as a result of Autonomous Recording Unit monitoring for northern spotted owls on select Ranger Districts on the Okanogan-Wenatchee National Forest. 45

Table 3.6-The area burned by wildfires on the Okanogan-Wenatchee National Forest, in the Late-Successional Reserve Network, and in the four largest Late-Successional Reserves and the corresponding changes to habitats for the northern spotted owl (1993-2021) 48

Table 3.7-Northern spotted owl activity centers in the Late-Successional Reserve Network that were identified in the original Late-Successional Reserve Assessments (USFS 1996, 1997, 1998). 51

Table 3.8-The 1993 and 2023 habitat-based carrying capacity estimated based on habitat amounts and no barred owl influence. 54

Table 3.9-Percent increase in resistance to wildlife movements for low and moderate mobility species across the Late-Successional Reserve network and within the four largest Late-Successional Reserves on the Okanogan-Wenatchee National Forest from 1993 to 2021. 56

Table 3.10-Comparison of dispersal capable landscape on the Okanogan-Wenatchee NF and within the LSR Network from 1993 to 2022 (Davis et al. 2016). 56

Table 4.1-Area of Large-Tree Dense-Forest in each sustainability category and for each Forest Group within the Okanogan-Wenatchee National Forest and the LSR network. 64

Table 4.2-The sustainability of the large-tree dense-forest habitat in Dry and Moist Forest Groups (61,543 acres) in the Upper Methow Late-Successional Reserve.................................. 64

Table 4.3-The sustainability of the large-tree dense-forest habitat in Dry and Moist Forest Groups (53,560 acres) in the Chiwawa Late-Successional Reserve. 65

Table 4.4-The sustainability of the large-tree dense-forest habitat in Dry and Moist Forest Groups (71,569 acres) in the Swauk Late-Successional Reserve. 65

Table 4.5-The sustainability of large-tree dense-forest habitat in Dry and Moist Forest Groups (35,171 acres) in the Manastash Late-Successional Reserve.. 66

Table 4.6-Area of fire refugia with >50% probability for each Forest Group under moderate (50th percentile) and extreme (90th percentile) fire weather scenarios (based on Krawchuk et al. 2023) within the Okanogan-Wenatchee National Forest and the LSR Network. 68

Table 4.7-Area of fire refugia under moderate (50th Percentile) and extreme (90th Percentile) fire weather conditions for the four largest Late-Successional Reserves on the Okanogan-Wenatchee National Forest. 69

Table 4.8-Acres of projected percentage loss of basal area from all pests. Predicted basal area loss > 25% is considered “at risk” 71

Table 6.1-Summary information for 9 historical reference plots in the eastern Washington Cascades. Forest structure was reconstructed to 1890.. 85

Table 6.2-Clump size distributions for historical reference plots in the eastern Washington Cascades summarized into low, medium, and high levels of spatial variability. 87

Table 7.1-Monitoring themes, indicators, scale, data sources, and frequency for adaptive management. 91

Table 9.1-Projects where NEPA has been initiated or that are planned to have signed decisions within the next 5 years (2024-2028) based on the Okanogan-Wenatchee National Forest 5-Year Plan. 104

Table B.1-Area of each Forest Group in the Chelan Group. 132

Table B.2-Acres of OGSI 200 by forest type and spatial configuration for the Chelan Group.. 132

Table B.3-Acres of northern spotted owl habitat by function and forest group for the Chelan Group 133

Table B.4-Acres identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Chelan Group. 133

Table B.5-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Chelan Group. 134

Table B.6-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Chelan Group. 134

Table B.7-Area of each Forest Group in the Chiwawa LSR. 137

Table B.8-Acres of OGSI 200 by forest type and spatial configuration for the Chiwawa LSR. 137

Table B.9-Acres of northern spotted owl habitat by function and forest group for the Chiwawa LSR 138

Table B.10-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Chiwawa LSR. 138

Table B.11-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Chiwawa LSR. 139

Table B.12-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Chiwawa LSR. 139

Table B.13-Area of each Forest Group in the Manastash LSR. 142

Table B.14-Acres of OGSI 200 by forest type and spatial configuration for the Manastash LSR 142

Table B.15-Acres of northern spotted owl habitat by function and forest group for the Manastash LSR 143

Table B.16-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Manastash LSR. 143

Table B.17-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Manastash LSR. 144

Table B.18-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Manastash LSR. 144

Table B.19-Area of each Forest Group in the Methow/Twisp LSR Group. 147

Table B.20-Acres of OGSI 200 by forest type and spatial configuration for the Methow/Twisp LSR Group 147

Table B.21-Acres of northern spotted owl habitat by function and forest group for the Methow/Twisp LSR Group.. 148

Table B.22-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Methow/Twisp LSR Group. 148

Table B.23-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Methow/Twisp LSR Group.................................... 149

Table B.24-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Methow/Twisp LSR Group. 149

Table B.25-Area of each Forest Group in the Naches LSR/MLSA Group. 152

Table B.26-Acres of OGSI 200 by forest type and spatial configuration for the Naches LSR/MLSA Group.. 152

Table B.27-Acres of northern spotted owl habitat by function and forest group for the Naches LSR/MLSA Group 153

Table B.28-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Naches LSR/MLSA Group. 153

Table B.29-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Naches LSR/MLSA Group. 154

Table B.30-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Naches LSR/MLSA Group. 154

Table B.31-Area of each Forest Group in the Swauk LSR.. 157

Table B.32-Acres of OGSI 200 by forest type and spatial configuration for the Swauk LSR ... 157

Table B.33-Acres of northern spotted owl habitat by function and forest group for the Swauk LSR 158

Table B.34-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Swauk LSR...................... 158

Table B.35-The acre amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Swauk LSR. 159

Table B.36-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Swauk LSR. 159

Table B.37-Area of each Forest Group in the Teanaway LSR. 162

Table B.38-Acres of OGSI 200 by forest type and spatial configuration for the Teanaway LSR 162

Table B.39-Acres of northern spotted owl habitat by function and forest group for the Teanaway LSR 163

Table B.40-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Teanaway LSR. 163

Table B.41-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Teanaway LSR. 164

Table B.42-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Teanaway LSR.. 164

Table B.43-Area of each Forest Group in the Tieton LSR. 167

Table B.44-Acres of OGSI 200 by forest type and spatial configuration for the Tieton LSR ... 167

Table B.45-Acres of northern spotted owl habitat by function and forest group for the Tieton LSR 168

Table B.46-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Tieton LSR. 168

Table B.47-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Tieton LSR.. 169

Table B.48-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Tieton LSR.. 169

Table B.49-Area of each Forest Group in the Upper Methow LSR. 172

Table B.50-Acres of OGSI 200 by forest type and spatial configuration for the Upper Methow LSR 172

Table B.51-Acres of northern spotted owl habitat by function and forest group for the Upper Methow LSR 173

Table B.52-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Upper Methow LSR. 173

Table B.53-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Upper Methow LSR. 174

Table B.54-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Upper Methow LSR. 174

Table B.55-Area of each Forest Group in the Wenatchee River LSR/MLSA Group. 177

Table B.56-Acres of OGSI 200 by forest type and spatial configuration for the Wenatchee River LSR/MLSA Group 177

Table B.57-Acres of northern spotted owl habitat by function and forest group for the Wenatchee River LSR/MLSA Group 178

Table B.58-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Wenatchee River LSR/MLSA Group. 178

Table B.59-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Wenatchee River LSR/MLSA Group. 179

Table B.60-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Wenatchee River LSR/MLSA Group. 179

Table F.1-Desired conditions for the percent of the Forest in snag density (number of snags/acre) classes by forest vegetation group and size classes. 194

Table F.2-Desired conditions for the amounts of down wood by forest vegetation Group........ 194

Table G.1-Clump size proportions from reconstructed historical sites in the Eastern Cascades of Washington. 197

Table G.2-Clump size proportions from reconstructed historical sites in the Eastern Cascades of Washington. 199

Table H.1-Known vertebrate and invertebrate species that are Federally Threatened (FT) or Endangered (FE), Region 6 Sensitive Species (SEN), or Washington State Sensitive Species (WA-SEN) and have the potential to be found within LSRs on the Okanogan-Wenatchee National Forest. 201

Table H.2-Known or suspected vascular plants (VA), bryophytes (BR), lichen (LI) and fungi (FU) that are Federally Threatened (FT) or Endangered (FE), Region 6 Sensitive Species (SEN), or Washington State Sensitive Species (WA-SEN) and have the potential to be found within LSRs on the Okanogan-Wenatchee National Forest. 203

Table I.1-Vegetation types placed into vegetation groups based on WADNR (2022)........ 212

Table I.2-Vegetation groups, vegetation types (both based on WADNR 2022) and Gradient Nearest Neighbor (GNNv2023.1) structure data (Bell et al. in review) used to map late-successional and old forest habitats, and HRV estimates. 213

Table I.3-Landscape characteristic resistance values and class names for development of landscape resistance surfaces for guilds of low mobility and moderate mobility species. 215

Table I.4-Burn severity classifications and thresholds based on Saberi & Harvey 2023. 218

Table I.5-Damage agents mapped by Aerial Detection Surveys from 1993 to 2021 on the Okanogan-Wenatchee National Forest and the forest types where damage agents are found. .. 219

List of Boxes

Box 1-A selection of recovery action and terminology definitions from the final Northern Spotted Owl Recovery Plan (USFWS 2011) 21

Box 2-Seven key restoration principles to consider in planning and implementing an integrated landscape restoration project (From: Hessburg et al. 2015): 76

Box 3-The Use of Reference Conditions in Assessing Northern Spotted Owl Habitat Sustainability and Landscape Resiliency: 78

EXECUTIVE SUMMARY

Since the Northwest Forest Plan was first implemented in 1994, the ecological condition of the Okanogan-Wenatchee National Forest and its LSR network (including LSRs, MLSAs and LSR4s) has dramatically changed. The management actions proposed in the original LSR Assessments for the Forest are no longer protecting and enhancing late successional and old forest conditions and the habitats for species that depend on these conditions. This document provides an update to the Okanogan-Wenatchee National Forest Late-Successional Reserve (LSR) Assessment, describing relevant policy and ecological principles, current conditions of the LSR network, future risks, an updated treatment framework (including a fire management guidelines) and a monitoring and adaptive management metrics and indicators. A summary of the key findings, including those necessary to make the determination for a changed condition that necessitated this update, are presented below.

The Okanogan-Wenatchee National Forest contains 946,465 acres (25% of the Forest) managed in 20 Late-Successional Reserves (LSRs) and 11 Managed Late-Successional Areas (MLSAs). Additionally, 4,994 acres occur in unmapped Late-Successional Reserves (LSR4s), which designate 100 acres of habitat around historical Northern Spotted Owl sites that occur outside of the LSR/MLSA network as a means of facilitating dispersal for species associated with late-successional and old forests.

Over 1.5 and 1.4 million acres, respectively, of the Forest has experienced insect-related mortality or wildfire, with approximately 26% of the burned area occurring within the Forest's LSR network. Over a third of the burned area in LSRs has burned severely. These and other disturbances, have considerably reduced the amount of late-successional and old forest habitats both across the Forest (-21%) and within the LSR network (-22%). In some LSRs the habitat loss from wildfire has been so extensive that these reserves can no longer provide for the diversity and conservation of late-successional and old forest habitats and associated species. Meanwhile, suitable habitat for northern spotted owl, a key indicator species for late-successional and old growth forests in the NWFP, has declined by 34% across the Forest and by 35% within the LSR network. Concurrently, competitive pressure from barred owls is having considerable negative impacts on northern spotted owl populations, with the number and distribution of northern spotted owls on the Forest and within the LSR network considerably reduced since the mid-1990s (from over 220 known pairs known to approximately 6 detected pairs in the past five years). Habitat connectivity for old forest associated species has also been considerably reduced due to habitat loss from wildfires, especially in the northern portion of the Forest and the LSR network. In some locations across the Forest, habitat loss in the past 10-15 years has exceeded the redundancy built into the original LSR network, challenging managers ability to meet the original conservation goals of the Northwest Forest Plan of "providing a functional and well-connected network of late-successional and old growth habitats".

Climate projections suggest that the likelihood of even larger and more severe disturbances and drought will increase in the coming decades, likely accelerating the decline of remaining late-successional and old growth forest conditions in undisturbed portions of the LSR network on the Okanogan-Wenatchee National Forest. Current scientific understanding, updated policy, and

changed ecosystem conditions compel the Forest to reevaluate and update the goals established in the original LSR Assessments and create a path forward that utilizes the flexibility of existing management direction and policies toward more resilient landscapes and sustainable habitats for late-successional and old forest associated species. The Northwest Forest Plan acknowledged the diversity of old forest ecosystems that occurred within the NWFP boundary and recognized the importance of maintaining and restoring ecological processes that are critical to the development and maintenance of late-successional and old forest habitats. Meanwhile, the 2012 Northern Spotted Owl Revised Recovery Plan recognizes that large and severe wildfires, exacerbated by climate change, pose a significant threat to the viability and recovery of the species, and suggest that treatments that enhance landscape and habitat resiliency may be necessary to support long-term species conservation goals.

This updated LSR Assessment for the Okanogan–Wenatchee National Forest provides the ecological framework supporting vegetation management activities to be undertaken within LSRs and MLSAs consistent with existing NWFP management direction that encourages the judicious reduction of risk of large stand-replacing disturbances in LSRs in the more fire-prone provinces (including the Washington East Cascades province encompassing the Okanogan-Wenatchee National Forest). This assessment establishes a framework that identifies priority locations for and types of treatment to meet and sustain desired conditions at the landscape scale in LSRs and MLSAs on the Okanogan-Wenatchee National Forest. This framework focuses on identifying and maintaining the most sustainable large tree structure and late-successional and old forest habitats at or above levels consistent with the natural range of variability. The treatment framework and design criteria will aid project planners and district specialists in determining (1) whether treatments are needed to enhance or maintain late-successional and old forest habitats within a LSR, (2) how much treatment is appropriate to meet management direction in the NWFP (e.g., reduce risk of uncharacteristic disturbances), and (3) the types of treatments that may be appropriate.

The intent is to identify the rationale for actions needed to restore, maintain, or promote the development of functional and connected late-successional and old-growth forest ecosystems while streamlining opportunities to meet landscape restoration needs, enhance habitat and landscape resiliency, and reduce the risk of large-scale habitat loss to disturbances. Project-level descriptions and analyses will clearly articulate specific amounts and locations of treatments, the end state of treatments, and why the treatments will benefit either the development of late-successional or old forest stand characteristics or reduce the risk of habitat loss to future fires or other large-scale disturbances. Proposed treatment would be evaluated and considered individually at the project level by district planning teams and the local line officer, in consultation with regulatory partners, and would weigh tradeoffs between reducing risk and maintaining current stand and habitat conditions.

Stand-level design considerations can inform prescriptions that are consistent with needs and goals identified in both the Northwest Forest Plan and the Okanogan-Wenatchee Forest Restoration Strategy and to move landscapes towards desired conditions for late-successional and old forest habitats in dry and moist forests within LSRs. In keeping with the intent of the

Northwest Forest Plan, treatments must focus on ensuring stands develop late-successional conditions consistent with underlying biophysical factors and be intentionally designed to reduce the risk of loss of late-successional and old forest stands to disturbance or drought-induced mortality. Stand-level conditions (e.g., departure in composition or structure) and other considerations, such as strategic risk reduction or topographic complexity, will factor into treatment locations and prescriptions, and will be informed by a landscape-level evaluation.

The guidance in this assessment is intended to help managers prioritize treatments to maintain old growth habitats and minimize risk, but we acknowledge that there are landscape-level tradeoffs associated with creating more fire-resilient stand structures and habitats, and these tradeoffs must be weighed against potential habitat loss associated with extensive high-severity fires or other disturbances. Science and monitoring support the role and effectiveness of strategic restoration treatments to alter stand and landscape fire behavior under most fire weather conditions and are vital for reducing risk of habitat loss to large-scale disturbances and creating more resilient forests. Managing these forests and habitats towards more resilient conditions can be informed by better understanding of their historical conditions while also considering ongoing and future climate impacts through thoughtful landscape-scale planning and monitoring.

The original Late Successional Reserve Assessments did not adequately address climate change, wildfire, and non-native species and included agency-imposed habitat goals for northern spotted owl which have limited the opportunity to implement needed risk reduction and resiliency projects. The Forest needs to be able to utilize the full flexibility afforded by the existing risk reduction emphasis in the Northwest Forest Plan and the ecosystem restoration and resilience emphasis in the northern spotted owl recovery plan and critical habitat rule. Time is of the essence as each fire season exposes forests to considerable risks of further loss of old-growth forest conditions.

1. INTRODUCTION

Assessments of the reserves that were associated with the conservation of old-forest associated species were a requirement as part of the implementation of the Northwest Forest Plan (NWFP, USDA and USDI 1994, p. C-11). The assessments for Late-Successional Reserves (LSRs) and Managed Late-Successional Areas (MLSAs) on the Wenatchee National Forest (USFS 1997) and the Okanogan National Forest (USFS 1998) were completed over 25 years ago. The assessments were completed prior to the administrative combination of the Okanogan and Wenatchee National Forests, which occurred in 2000.

Since the implementation of the NWFP (USDI and USDI 1994) began in 1994, habitat conditions for late-successional and old forest associated species on the Okanogan-Wenatchee National Forest (OWNF) have undergone considerable change. In addition, our scientific understanding of the disturbance and landscape ecology of the forest has advanced considerably, including the effects and effectiveness of restoration treatments. Finally, several new policies have been instituted that direct the planning and management of national forests and recovery of listed species, including the revised Northern Spotted Owl (NSO) Recovery Plan (Recovery Plan; USFWS 2011), revised designation of critical habitat for the northern spotted owl (USFWS 2012a), and the 2012 Forest Planning Rule (and amendments; USFS 2012a).

The condition of the forest has dramatically changed since the Northwest Forest Plan was first implemented in 1994. For example, over 1.4 million acres of the OWNF has experienced wildfire, with over 540,000 acres burning at high severity (~39% of burned area) and almost 370,000 acres of fire occurring within the LSR network (~26% of burned area, ~39% of LSR network) with approximately one third of that high severity fire. Projections suggest that the likelihood of even larger and more severe wildfires will increase in the coming decades (Wan et al. 2019). Both the northern spotted owl Recovery Plan and critical habitat rule recognized the growing threat of large wildfires and climate change and emphasized ecosystem restoration and resiliency in their management guidance (USFWS 2011, 2012). Similarly, the 2012 planning rule emphasizes a focus on ecological integrity and ecosystem resilience as primary management goals in amended or revised forest plans (USFS 2012a). Evolution of scientific understanding of eastern Cascades fire ecology, landscape ecology, and NSO habitat requirements as well as significant changes to conditions of the LSR network on the OWNF and continued declines of LSOF-dependent species, like NSO, compel the forest to update the original LSR assessments and reevaluate the habitat goals established in the Wenatchee LSR Assessment (USFS 1997, pg. 99 Section B). Extensive disturbance impacts over the past 30 years demonstrate that these original habitat goals are not attainable, and maintaining more habitat in a higher risk, closed canopy condition than the landscape would have supported historically could even contribute to the increased size and severity of recent and future wildfires. An updated assessment is needed to create a clear understanding of the current condition of the LSR network and create a path forward that utilizes the flexibility of existing management direction and policies toward more disturbance-resilient landscapes and sustainable habitat for late-successional and old forest associated species.

This updated LSR Assessment for the OWNF provides the ecological framework supporting activities to be undertaken within LSRs and MLSAs consistent with existing management direction. The intent is to identify the rationale for actions needed to restore, maintain, or promote the development of functioning and connected late-successional and old-growth forest ecosystems (hereafter referred to as late-successional and old forest [LSOF]), with an explicit focus on vegetation and habitat management and maintenance. Barred owl removal is currently being assessed in a parallel, but independent, process and remains outside the scope of this assessment. In addition, this update is intended to clearly articulate the goals and rationale for project-level analysis, and to streamline the process of LSR Workgroup review to expedite opportunities to meet landscape restoration needs, enhance habitat and landscape resiliency, and reduce the risk of large-scale habitat loss to disturbances.

An interdisciplinary and interagency team actively participated in the development of this LSR assessment update and developed the following goals to guide the process:

1. Update the current condition of vegetation structure and composition across the LSR/MLSA network on the forest. Evaluate the ability of the network to provide appropriate amounts and diversity of late-successional and old forest conditions across a range of open to closed canopy structure and functional habitats for old forest associated species, including, but not limited to, the northern spotted owl.

2. Update the science contained within the assessment to reflect a more nuanced and contemporary understanding of the natural range of variation of different forest types, northern spotted owl habitat requirements, disturbance risks, and climate change impacts.

3. Ensure consistency between the updated LSRA, the Northwest Forest Plan Standards and Guidelines (USDA and USDI 1994), and the Northern Spotted Owl Revised Recovery Plan (USFWS 2011). Clarify linkage between the goals of the Recovery Plan and the LSR Assessment and reevaluate the need for an additional set of species-specific habitat goals within the LSR Assessment.

4. Use a strength-of-evidence approach (Tallis et al. 2017, Salafsky et al. 2019) to assess tradeoffs of different management options for risk reduction in LSRs/MLSAs.

5. Outline a standardized process for assessing northern spotted owl habitat suitability, sustainability, and risk of disturbance to expedite project-level review and consultation.

6. Identify treatment exemptions (including design criteria) that are appropriate based on forest type and natural range of variability and ensure consistency of restoration projects with those exemptions to streamline consistency review with the LSR Workgroup, the Regional Ecosystem Office, and the Regional Interagency Executive Committee.

1.1. Assessment Framework

The Northwest Forest Plan Standards and Guidelines contain a description of what generally should be included in a late-successional reserve assessment:

> "(1) a history and inventory of overall vegetative conditions within the reserve,
> (2) a list of identified late-successional associated species known to exist within the Late-Successional Reserve and information on their locations,
> (3) a history and description of current land uses within the reserve,
> (4) a fire management plan,
> (5) criteria for developing appropriate treatments,
> (6) identification of specific areas that could be treated under those criteria,
> (7) a proposed implementation schedule tiered to high order (i.e. larger scale) plans, and
> (8) proposed monitoring and evaluation components to help evaluate if future activities are carried out as intended and achieve desired results (USDA and USDI 1994, p. C-11)."

These assessments are subject to review by the LSR Workgroup and the Regional Ecosystem Office, and approval by the Regional Interagency Executive Committee.

The framework for this assessment was based on the elements identified in the NWFP Standards and Guidelines and is comprised of seven sections. The assessment begins with an overview of ecological principles and policy direction relevant to eastern Washington forests (Section 2). Next is an overview of the ecology of different forest types that occur on the OWNF and the current conditions of late-successional and old forests and habitats and associated species that occur within the LSR network (Section 3; addressing criteria #1, 2, 3 above). Important in the context of NWFP implementation is an assessment of the risks that are known and anticipated to occur to late-successional and old forest habitats (Section 4), and the efficacy of actions that can be taken to address these risks (Section 5). The next sections of the assessment provide a framework to evaluate the condition and risk of LSOF within LSRs (or surrounding landscapes) and inform project designs to reduce risk of habitat loss and enhance the resiliency of old forest habitats, including adaptive management and specific design considerations (Section 5, Section 6; addressing criteria #5, 6 above). The fire management section details potential approaches to fire prevention, risk reduction and suppression relative to LSRs and provides the ecological context and grounding for observed changes in fire regimes across the forest (Section 8, addressing criteria #4 above). Information on past and future vegetation management on the OWNF is provided (Section 9, addressing criteria #3, #7 above). Finally, monitoring and adaptive management indicators and metrics are described (Section 7, addressing criteria # 8).

A conceptual diagram displaying the component datasets for three of the major analysis pieces of this LSR assessment is presented in Figure 1.1. A dozen different datasets were used or developed at different scales to demonstrate the current conditions, risk of LSRs, and a landscape evaluation framework for prioritizing treatment needs and locations (Figure 1.1). Details on these datasets can be found in the Sections 3, 4, and 6 of this document and in Appendix I. The Appendices also include supporting information and details specific to this process and individual LSRs and MLSAs.

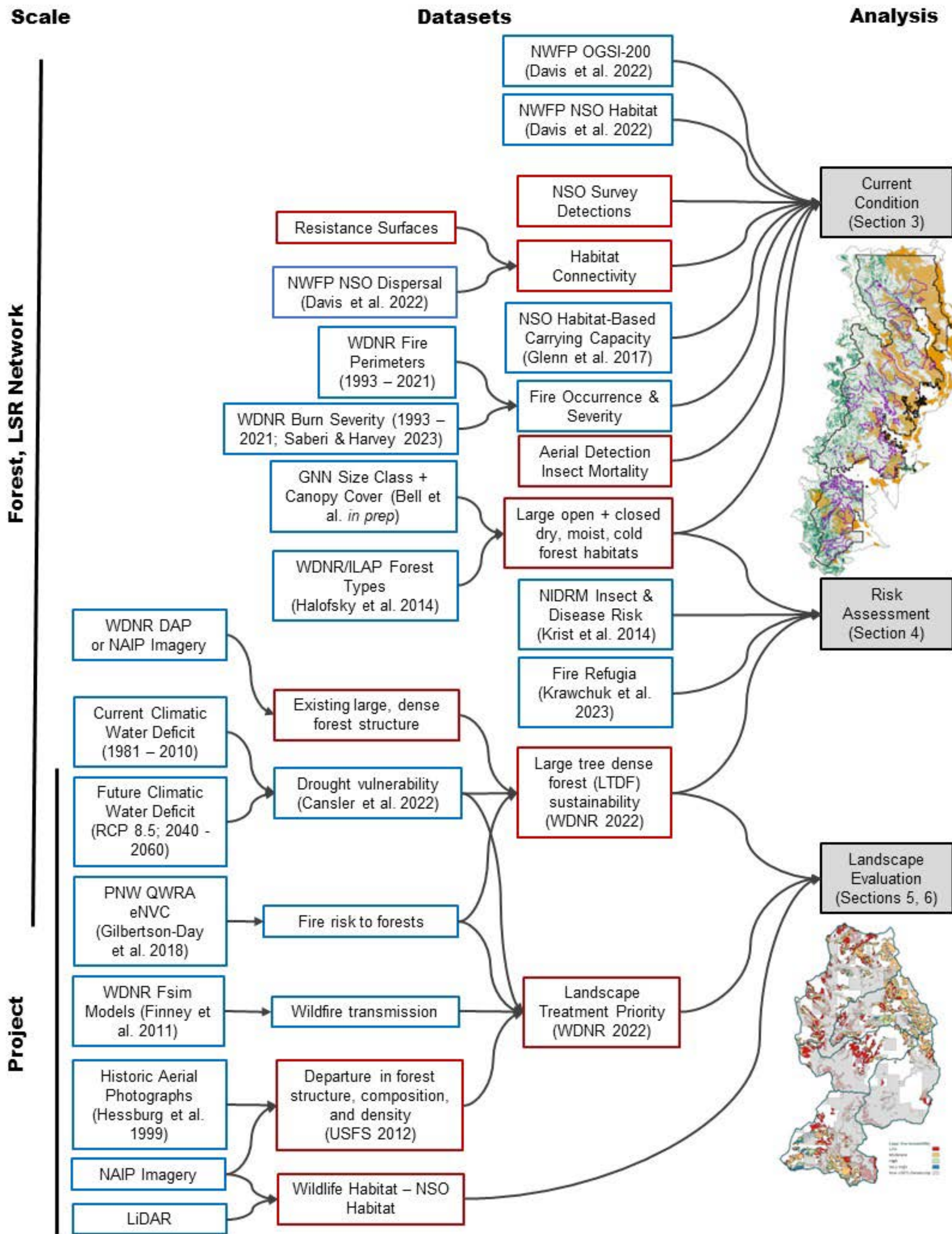

Figure 1.1-Conceptual diagram displaying the component spatial datasets for three of the major analysis pieces of this LSR assessment. Data sets were either derived and used at the Forestwide or project scale. All datasets denoted by blue boxes are spatial datasets that already existed while datasets denoted in the red boxes show datasets that were derived for this assessment or will be derived at the project-level when projects include LSRs.

2. ECOLOGICAL PRINCIPLES, MANAGEMENT GUIDANCE AND POLICY BACKGROUND

This section provides an overview of relevant management guidance and policy used to guide the development of this LSR Assessment. The overview draws from the ecological principles (Section B) and Standards and Guidelines (Section C) of the NWFP (USDA and USDI 1994). In addition, relevant national direction on ecological restoration and principles from the 2012 Planning Rule are summarized (USFS 2012a). Finally, management guidance from the Northern Spotted Owl Recovery Plan (USFWS 2011) and Northern Spotted Owl revised Critical Habitat Rule (USFWS 2012a) are reviewed. These guidance documents and policies are relevant to establishing the assessment methods and management context for late-successional and old forest habitats and associated species that are used in this Assessment update.

Late-Successional Reserves were established under the NWFP "to protect and enhance conditions of late-successional and old-growth forest ecosystems" (USDA and USDI 1994, p. S-8) where natural processes, such as fire, are allowed to function to the extent possible for a wide array of species that are associated with late-successional habitat. The LSRs were intended to serve a number of purposes: 1) provide a distribution, quantity, and quality of late-successional and old forest habitat sufficient to avoid foreclosure of future management options; 2) provide habitat for populations of species that are associated with late-successional and old forests, including, but not limited to, the northern spotted owl; and 3) help ensure that late-successional species diversity will be conserved.

Similarly, as described in the NWFP Record of Decision (USDA and USDI 1994: page A-4), Managed Late-Successional Areas (MLSAs) should be managed:

> "… similar to Late-Successional Reserves but are identified for certain owl locations in the drier provinces where regular and frequent fire is a natural part of the ecosystem. Certain silvicultural treatments and fire hazard reduction treatments are allowed to help prevent complete stand destruction from large catastrophic events such as high intensity, high severity fires; or disease or insect epidemics."

In total, there are 946,465 acres on the OWNF designated in 20 LSRs and 11 MLSAs (Figure 2.1, Table 2.1). Additionally, 4,994 acres occur in unmapped Late-Successional Reserves (referred to as LSR4s in the NWFP), which designated 100 acres of habitat around historical owl sites that occur outside of the LSR/MLSA network as a means of facilitating dispersal for species associated with late-successional and old forests. The LSR/MLSA land management designation represents approximately 25% of the land base managed by the OWNF. The MLSAs that occur on the OWNF represent 95% of the total MLSA acreage that was designated within the range of the northern spotted owl under the NWFP. Four of the LSRs were designated with enough area and habitat to provide for 20 or more pairs of northern spotted owls (Thomas et al. 1990). These are the Upper Methow, Chiwawa, Swauk, and Manastash LSRs.

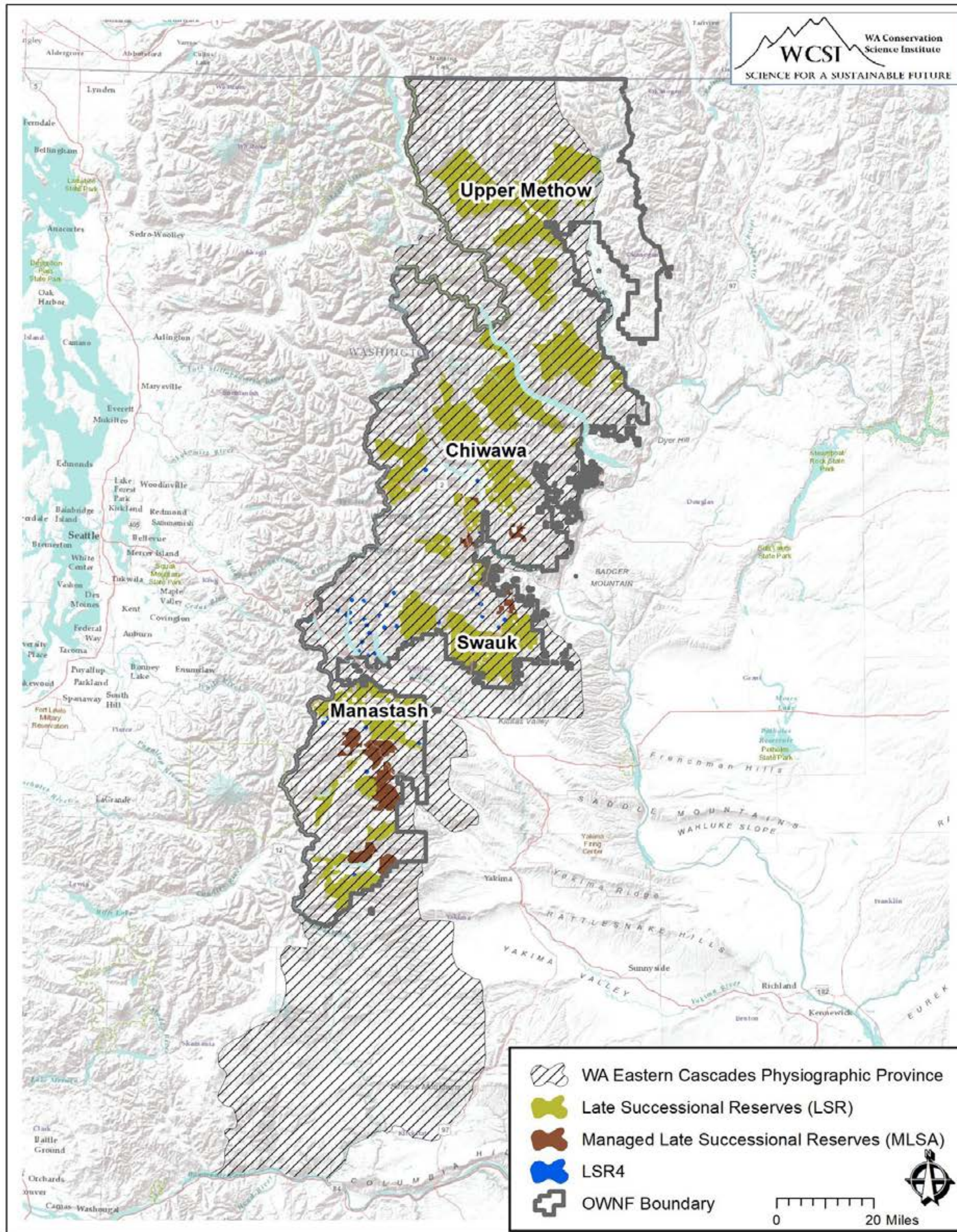

Figure 2.1-The Late-Successional Reserve and Managed Late-Successional Area network on the Okanogan-Wenatchee National Forest, relative to the Eastern Cascades Physiographic Province delineated in the Northwest Forest Plan.

Table 2.1-The Late-Successional Reserve (LSR) and Managed Late-Successional Area (MLSA) network on the Okanogan-Wenatchee National Forest. LSR4s are also mapped within the Forest and encompass 4,994 additional acres.

Late-Successional Reserve			Managed Late-Successional Area		
Name	**ID Number**	**Acres**	**Name**	**ID Number**	**Acres**
Boundary Butte	RW131	6,593	Camas	DM6	1,545
Bumping	RW126	13,498	Crow	DM14	9,727
Chiwawa	RW135	99,406	Eagle	DM5	4,378
Deadhorse	RW133	13,520	Haystack	DM10	23,559
Hunter Mountain	RW140	5,638	Lost Lake	DM12	6,948
Icicle	RW132	13,618	Milk Creek	DM9	15,489
Little Wenatchee	RW134	50,971	Natapoc	DM2	900
Lucerne	RW138	8,413	Russell Ridge	DM11	9,635
Manastash	RW125	78,936	Sand Creek[1]	DM7	4,195
Nice	RW143	3,120	Tumwater	DM3	3,196
Rattlesnake	RW128	10,513	Twin Lake	DM1	1,364
Sawtooth	RW139	66,992	**Total MLSA Acres**		**80,936**
Shady Pass	RW136	76,540			
Slide Peak	RW137	1,661			
Swauk	RW129	106,473			
Teanaway	RW130	34,001			
Tieton	RW153	39,673			
Twisp River	RW141	35,858			
Upper Methow	RW142	190,914			
Upper Nile	RW127	9,191			
Total LSR Acres		**865,529**			

2.1. Ecological Principles for Management of Late-Successional Forests

The following section provides a summary of the ecological principles described in Section B of the NWFP that are relevant to management of fire-prone forests and risk reduction (USDA and

[1] 2023 USFS data combined Sand Creek and Camas Creek MLSAs and reported as Sand Creek.

USDI 1994). In some cases, text is directly quoted to provide for consistency in how it is interpreted. In addition, the ecological basis for how risks to late-successional and old forest habitats were assessed in this LSRA update is presented.

In Late-Successional Reserves, management:

> "...standards and guidelines are designed to maintain late-successional forest ecosystems and protect them from loss due to large-scale fire, insect and disease epidemics, and major human impacts. The intent is to maintain natural ecosystem processes such as gap dynamics, natural regeneration, pathogenic fungal activity, insect herbivory, and low-intensity fire. The standards and guidelines encourage the use of silvicultural (including prescribed fire) practices to accelerate the development of [late-successional and old forest characteristics in younger natural stands or] overstocked young plantations…, and to reduce the risk to LSRs from severe impacts resulting from large-scale disturbances and unacceptable loss of habitat." (USDA and USDI 1994, S&G, p. B-1)

The structure and composition of late-successional and old forest ecosystems, as described in the NWFP, generally includes live old trees, standing dead trees, large fallen trees and logs on the forest floor and in streams, multiple canopy layers with smaller understory trees, canopy gaps, and patchy understories. However, these conditions are not always present across all forest types. The NWFP also recognized the diversity of old forest types that occur across the provinces, particularly in the dry forests:

> "In some forest types subject to frequent, low intensity fire, such as ponderosa pine, [the old forest stages] are typically characterized by relatively open understories and relatively few large fallen trees (in comparison to more moist Douglas-fir/western hemlock types). Standards and guidelines designed to promote the desired conditions vary among physiographic provinces [within the NWFP region] because characteristics of the natural structure and composition of late-successional and old growth forests also vary among the provinces." (USDA and USDI 1994, S&G, p. B-2)

In the warmer, drier physiographic provinces, such as considerable portions of the Washington Eastern Cascades, fire is more frequent and varies in intensity from high severity to low severity dependent upon forest type, topographic setting, and moisture regime (Hessburg and Agee 2003, Hessburg et al. 2005). Fire is an integral part of the internal dynamics of a typical stand and landscape. Additionally, it is noted in the NWFP that:

> "Natural disturbance is an important process within [LSOF] ecosystems, but [human activities] have altered disturbance regimes. …Fire suppression has resulted in significant increases in accumulated fuels within some forests, particularly in the Washington and Oregon Eastern Cascades Provinces, the California Cascades Province, and the Klamath Provinces. At the same time, these forests have become more vulnerable to insects and diseases." (USDA and USDI 1994, S&G, p. B-7)

Furthermore,

> "...fire control and timber harvest have decreased the abundance of some types of old forest, such as ponderosa pine, that are dependent on frequent, low-intensity fires. Other types of late-successional forest that are less fire resistant or are less desirable for harvest

> have become more widely distributed. In these areas, the potential for stand-replacing wildfires has increased, resulting in higher risk to the stability of current stands reserved for late-successional species.
>
> …Given the relatively low remaining proportion of late-successional ecosystems in the landscape at the present time, these older forests should be protected from uncharacteristically severe fire and other stand-resetting disturbances." (USDA and USDI 1994, S&G, p. B-4)

Silvicultural approaches are a viable option for LSR management where those approaches meet two principle objectives:

> "(1) development of late-successional and old growth [LSOF] characteristics including snags, logs on the forest floor, large trees, and canopy gaps that enable establishment of multiple tree layers and diverse species composition; and (2) prevention of large-scale disturbances by fire, wind, insects and diseases that would destroy or limit the ability of the reserves to sustain viable [LSOF] forest species populations. Small-scale disturbances by these agents are natural processes and will be allowed to continue." (USDA and USDI 1994, S&G, p. B-5)

Silvicultural approaches are also particularly relevant.

> "In [LSRs] in the Eastern Cascades [Provinces], silviculture aimed at reducing the risk of stand-replacing fires may be appropriate. Treatments may include thinning and underburning. Due to fire suppression, some forests have become quite dense and multistoried, primarily from the invasion of shade-tolerant species." (USDA and USDI 1994, S&G p. B-7)

Fire suppression and past management has led to increases in the amount of forest that provide successionally advanced habitat characteristics, but these forests are not sustainable where they are not consistent with the underlying moisture regimes, topographic, or edaphic factors of the sites where they developed (Hessburg and Agee 2003 Hessburg et al. 2005). As such, "density reduction in mid-level canopy layers by thinning may reduce the probability of crown fires" and "underburning can be used to reduce fuel loading and vertical fuel continuity." Because "these treatments may reduce the quality of habitat for LSOF associated species, … managers need to seek a balanced approach that reduces risk of fire while protecting large areas of fire-prone LSOF." (USDA and USDI 1994, S&G, p. B-7)

2.1.1. Northwest Forest Plan Standards and Guidelines – Washington Eastern Cascades

The following provides a summary of the Standards and Guidelines developed for LSR management from the NWFP (USDA and USDI 1994). The objectives of the LSRs, as described in the NWFP, are to protect and enhance conditions of late-successional and old forest ecosystems, which serve as habitat for late-successional and old forest related species, including the northern spotted owl. "These reserves are designed to maintain a functional, interacting, late-successional and old-growth forest ecosystem" (USDA and USDI 1994, S&G, p. C-11).

Given the increased risk of fire in the Washington Eastern Cascades province, due to lower moisture conditions and the rapid accumulation of fuels in the aftermath of insect outbreaks and

drought, additional management activities are allowed in LSRs. Several guidelines within the NWFP Record of Decision describe allowable activities to reduce risks of large-scale disturbance:

- "Large-scale disturbances are natural events, such as fire, that can eliminate spotted owl habitat on hundreds or thousands of acres. Certain risk management activities, if properly planned and implemented, may reduce the probability of these major stand-replacing events. There is considerable risk of such events in [LSRs] in the Washington and Oregon Eastern Cascades, and California Cascades Provinces … Elevated risk levels are attributed to changes in characteristics and distribution of mixed-conifer forests resulting from past fire [exclusion]. These forests occur in drier environments, have had repeated insect infestations, and are susceptible to major fires. Risk reduction efforts are encouraged where they are consistent with the overall recommendations in these guidelines." (USDA and USDI 1994, S&G, p. C-12).

- "Silvicultural activities aimed at reducing risk shall focus on younger stands in Late-Successional Reserves. The objective will be to accelerate development of late-successional conditions while making the future stand less susceptible to natural disturbances. Salvage activities should focus on the reduction of catastrophic insect, disease, and fire threats. Treatments should be designed to provide effective fuel breaks wherever possible. However, the scale of salvage and other treatments should not generally result in degeneration of currently suitable owl habitat or other late-successional conditions." (USDA and USDI 1994, S&G, p. C-12)

- "In some [LSRs] in these provinces, management that goes beyond these guidelines may be considered. Levels of risk in those [LSRs] are particularly high and may require additional measures. Consequently, management activities designed to reduce risk levels are encouraged in those [LSRs] even if a portion of the activities must take place in what is currently [LSOF] habitat. While risk-reduction efforts should generally be focused on young stands, activities in older stands may be appropriate if: (1) the proposed management activities will clearly result in greater assurance of long-term maintenance of habitat, (2) the activities are clearly needed to reduce risks, and (3) the activities will not prevent the [LSRs] from playing an effective role in the objectives for which they were established." (USDA and USDI 1994, S&G, p. C-13)

The implementation of this Standard and Guideline implies that where risks of large-scale or uncharacteristic disturbance are particularly high and cannot be sufficiently reduced through treatments outside of late-successional and old forest habitat, treatments may be applied to older stands provided there is clear justification. In order to show management activities would "clearly result in greater assurance of long-term maintenance of habitat" AND "are clearly needed to reduce risks," (USDA and USDI 1994, S&G, p. C-13) a process is necessary to assess risks and tradeoffs. The process used on the OWNF to assess disturbance risks and management tradeoffs, referred to as a Landscape Evaluation, is described in detail in Section 5.

This Standard and Guideline indicated that "activities" will not prevent the LSRs from playing an effective role toward achieving the objectives for which they were established. The purpose for which LSRs were established included to 1) provide a distribution, quantity, and quality of late-successional and old forest habitat sufficient to avoid foreclosure of future management options; 2) provide habitat for populations of species that are associated with late-successional and old forests; and 3) help ensure that late-successional species diversity will be conserved. In particularly high risk LSRs (e.g., the Swauk LSR), for example, appropriate "activities" could include the removal of trees in forests that have grown dense as a result of years of fire suppression to create open-canopied old forest conditions in order to accomplish dual objectives of: (1) reducing the risk of high severity fires and (2) ensuring the diversity of forest habitats and species are conserved.

2.1.2. NWFP and Reference Conditions

The Forest Ecosystem Management Assessment Team (FEMAT) report (FEMAT 1993) and the Final Environmental Impact Statement (FEIS) for the NWFP (USDA and USDI 1994) called for developing long-term average reference conditions and ranges of late-successional and old forest by province and plant community. However, at the time the NWFP was first implemented the long-term average regional abundance of late-successional and old forest communities could only be approximated from a few local studies of fire history. An expert panel was convened to develop the long-term average percentage of the regional landscape covered by late-successional forest. They estimated a long-term average of between approximately 40 and 65% the region in a late-successional forest condition (Hemstrom et al. 1998, Hemstrom 2003). They recognized that "this average percentage would certainly differ by physiographic province; moist, northerly provinces would have higher averages than drier provinces with higher fire frequencies". Because the long-term averages were not well documented at the time for much of the NWFP area (Hemstrom et al. 1998), this expert panel advised that the threshold reference conditions for the amount and spatial arrangement of LSOF "should be used with caution because late-successional and old forest development takes decades, long-term reference conditions by stratum are poorly understood, climatic conditions for the long-term average conditions may have been significantly different than they are now, and scientific understanding about forest development and succession is not well developed for many strata" (Hemstrom et al. 1998, p. 21). The FEMAT report and FEIS suggested developing better estimates for the reference conditions for late-successional and old forests through fire history studies, stratified by province and plant community (Hemstrom et al. 1998, Hemstrom 2003).

An additional reference regarding the use of the range of variability (reference conditions) can be found in the NWFP Standards and Guidelines section describing watershed analyses: "watershed analyses may include a description of resource needs, capabilities, opportunities, the range of natural variability, spatially explicit information that will facilitate environmental and cumulative effects analyses for NEPA" (USDI and USDA 1994, pp. B20-21). Much has been learned about the reference conditions for late-successional and old forests specific to the Washington East Cascades province and to specific forested plant communities. This information is summarized later in this report.

2.1.3. Consultation on the Northwest Forest Plan

The US Fish and Wildlife Service completed a Biological Opinion on the Preferred Alternative (Alternative 9) of the Environmental Impact Statement for the Northwest Forest Plan (Table 12, USFWS 1994). The Biological Opinion reiterates some key aspects of the NWFP that are relevant to this LSR Assessment. First, the Biological Opinion acknowledges that the Preferred Alternative was "intended to address a wide range of species associated with late-successional forests and were primarily developed from the current state of knowledge about the spotted owl, the marbled murrelet, anadromous fish, and late-successional forests". The approach is "intended to provide a strong contribution to the management and conservation of a wide range of species, including listed species". The species reviewed in the Biological Opinion represent "only a fraction of the total number of species considered in the development of the FEMAT report (which Alternative 9 was based on; over 1,000 species considered, including about one third of the 300 species within the range of the owl which are currently listed, proposed, petitioned, or candidates under the act)". In December of 1993, the NWFP SEIS team completed an additional analysis to look more closely at specific needs of some individual species or groups of species, which formed the basis for "several of the modifications to the original Alternative 9 described in the DEIS. These modifications were evaluated in the development of this opinion, where applicable to listed species". The Biological Opinion also recognized and reiterated the risk of habitat loss to fires in the Washington and Oregon East Cascades and in the Oregon and California Klamath provinces. The Biological Opinion recognized that "additional management activities are allowed in Late-Successional Reserves to reduce the risks of large-scale disturbances" (USFWS 1994, p. 1,2).

And finally, the Biological Opinion also described the estimated number of owl pairs and corresponding amount of spotted owl habitat that would be protected in the Washington Eastern Cascades province under implementation of the NWFP. These values are described in Table 2.2, and are further discussed relative to current conditions in Section 3.

Table 2.2-The estimated number of owl pairs and amount of habitat consulted on in the Biological Opinion for the Washington Eastern Cascades Province under Alternative 9, the preferred alternative of the Northwest Forest Plan. The Washington Eastern Cascades Province includes all of the Okanogan-Wenatchee National Forest and a portion of the Gifford Pinchot National Forest.

	Land Allocation					
	Congressionally Withdrawn	**Late-Successional Reserve**	**Adaptive Management Area**	**Administratively Withdrawn**	**Matrix**	**Total**
Spotted owl pairs	27	100	13	6	39	185
Spotted owl habitat (acres)	213,500	295,300	44,900	42,000	69,900	665,600

2.2. National Direction: US Forest Service 2012 Planning Rule and Policy for Ecological Resilience and Restoration

2.2.1. US Forest Service 2012 Planning Rule

A US Forest Service planning rule, finalized in 2012 (USFS 2012a), introduced a new planning approach and requirements (Nie 2018, Ryan et al. 2018). The NWFP was developed under a previous planning rule (1980) but subsequent amendments or revisions to the NWFP or a Forest Plan would need to follow the 2012 rule guidance. Thus, the OWNF considered some of the key elements of the 2012 rule when updating the LSR Assessment so that the assessment could use consistent definitions of key terms and could be used to inform Forest Plan amendments or revisions into the future.

A key purpose of the new planning rule was to "emphasize restoration of natural resources to make National Forest System (NFS) lands more resilient to climate change, protect water resources, and improve forest health" (USFS 2012a). Importantly, the 2012 plan rule focuses on *ecological integrity, ecosystem resilience, and ecological connectivity*.

Ecological integrity is defined in the rule as "the quality or condition of an ecosystem when its dominant ecological characteristics (composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence (USFS 2012a; 36 CFR 219.19)." The natural range of variation is used as an "ecological reference model" to assess whether an ecosystem has "integrity" (USFS 2015; FSH 1909.12).

Another important emphasis of the 2012 Planning Rule is the need to "make NFS lands more resilient to climate change" (Federal Register 2012, Bone et al. 2016). *Ecosystem resilience* is defined as "the ability of an ecosystem and its component parts to absorb, or recover from the effects of disturbances through preservation, restoration, or improvement of its essential structures and functions and redundancy of ecological patterns across the landscape (USFS 2015; FSH 1909.12)." Prior to intensive forest management and fire suppression, western North American forests exhibited a naturally occurring resistance and resilience to wildfires and other disturbances (Hessburg et al. 2019). However, forced removal of indigenous populations and their cultural burning practices, grazing, targeted removal of the large and old trees, and finally, fire suppression, have dramatically changed forest conditions and in turn led to increased frequency of large-scale high severity disturbances that are resulting in reorganization of plant and animal communities (Hessburg et al. 2019, Falk et al. 2022).

Finally, the 2012 Planning Rule includes the first requirements in US public land management history for National Forests to evaluate, protect and/or restore *ecological connectivity* as land management plans are revised (Williamson et al. 2020). Ecological connectivity refers to the degree to which a landscape facilitates or impedes movement among patches (Williamson et al. 2020).

2.2.2. Ecosystem Restoration Policy

Building upon the 2012 Planning Rule, in 2016, the US Forest Service issued "policy for reestablishing and retaining ecological resilience of National Forest System lands and resources to achieve sustainable multiple use management and provide a broad range of ecosystem services" (USFS 2016, p3). This directive "reaches across all program areas and activities applicable to management of National Forest System lands and resources" and was applied in this LSR Assessment update. The Directive promotes ecosystem resilience as a restoration goal for the Forest Service (USFS 2016).

In keeping with the intent of this policy and the 2012 Planning Rule, this LSR Assessment incorporates resilience concepts based on natural range of variability to assess (1) how and what kinds of late-successional and old forest habitats can be sustained and managed for, (2) the resilience of a landscape to endure and/or respond to disturbances and retain its structures and functions, and (3) as a filter to assess the current landscape condition and identify where and why management of LSOF might be appropriate.

2.3. Northern Spotted Owl Recovery Plan and Critical Habitat

The relationship between northern spotted owl conservation and LSR assessments is essential to effective and appropriate management within LSRs. The following discussion begins to describe that relationship with additional detail on current conditions in Section 3 and further consideration throughout the assessment.

In 2011, the northern spotted owl Recovery Plan (hereafter "Recovery Plan") was revised to recognize and incorporate significant threats to northern spotted owl (USFWS 2011) that were not clearly addressed in previous recovery plans: 1) loss of habitat as a result of uncharacteristically severe wildfires; 2) competitive interactions between the congeneric barred owl and the northern spotted owl; and 3) the influence of climate change on spotted owl habitat sustainability. While the NWFP emphasizes risk reduction in LSRs, both the Recovery Plan (USFWS 2011) and the revised northern spotted owl critical habitat rule (USFWS 2012a) emphasize landscape restoration of key ecological processes and functions in order to create landscapes that can support spotted owl populations and maintain owl habitat in a changing climate, and this emphasis is the focus of this assessment. The assessment discusses the impacts of barred owls on the OWNF at length in Section 3 as a substantial part of the changed condition. Even as one of the most significant threats to NSO populations on the OWNF, barred owl management is outside the scope of the current assessment. This action is currently being addressed through an interagency process but no decision on targeted management actions or commitment of agency funds has been made.

Forty-five percent of the known and historical northern spotted owl activity centers on the OWNF occurred outside of the LSR network. Over half of the known and historical spotted owl activity centers occur within dry and mesic mixed coniferous forests, making these forest types important to spotted owl recovery. Analysis completed for the revised critical habitat rule

(USFWS 2012a) showed that additional habitat and owl sites, beyond those in the NWFP reserve network were needed to achieve recovery (Dunk et al. 2019). As a result, considerable acres outside of existing reserves were designated as critical habitat for northern spotted owls throughout their range. On the OWNF, this resulted in an additional 418,275 acres outside of the existing LSR network designated as critical habitat for the northern spotted owl (Figure 2.1; USFWS 2012a, 2021).

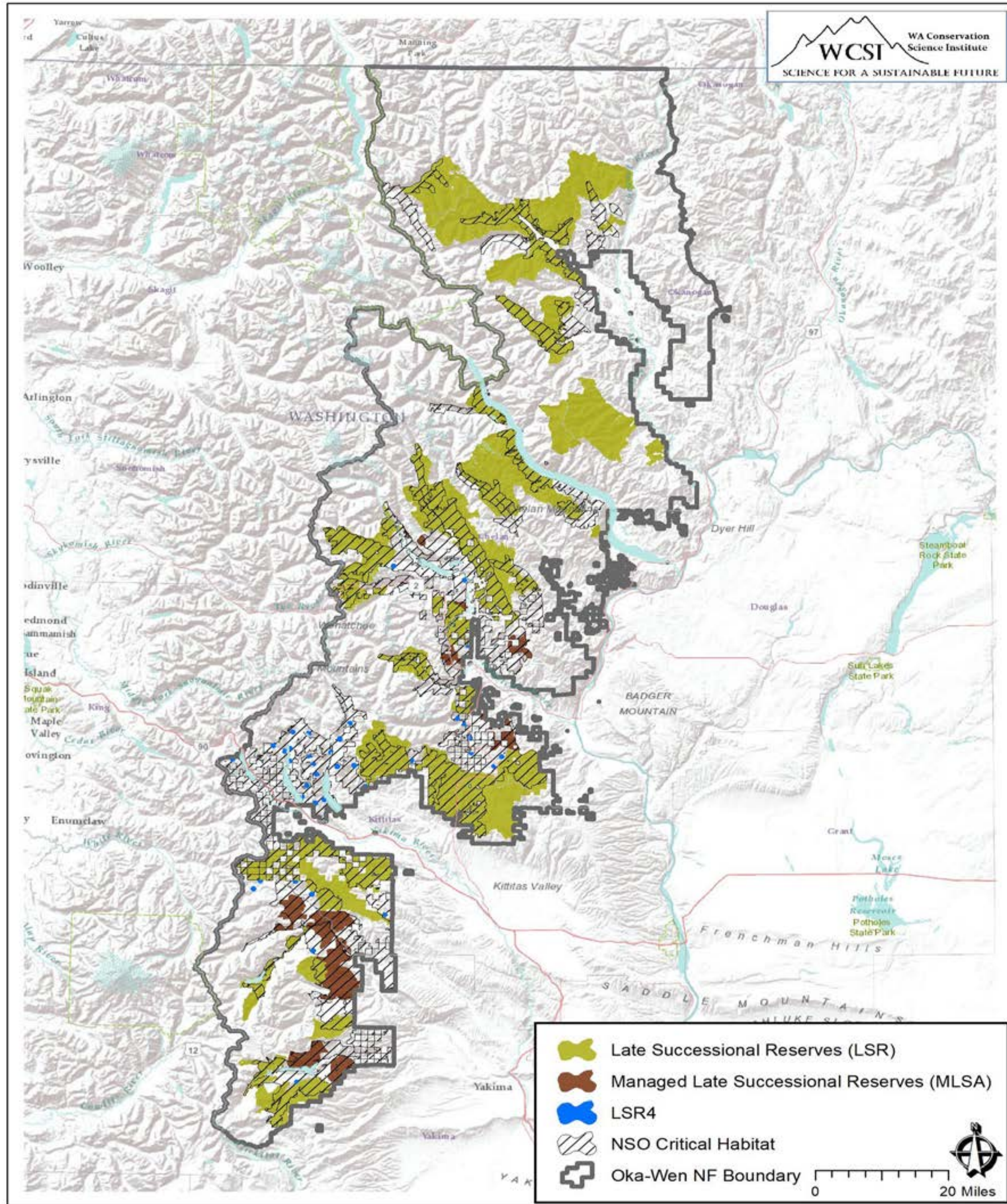

Figure 2.2-Late-Successional Reserves, Managed Late-Successional Reserve Areas, and designated spotted owl Critical Habitat within the Okanogan – Wenatchee National Forest.

In recognition of the risk of fire, and other forest disturbances (e.g., insects), to northern spotted owl habitat conservation, the Recovery Plan (USFWS 2011) and revised critical habitat rule (USFWS 2012a) emphasized the restoration of forest ecosystems, within which spotted owl habitat is embedded. In the Recovery Plan it was recognized that "restoring the large and old fire-tolerant trees and structure requires more than simply retaining them where they are found" and will require managing dry forest stands to promote the development of large tree structures that are currently lacking in many forests (USFWS 2011, p.III-35).

In particular, the Recovery Plan and revised critical habitat rule emphasized the need to actively manage forests to restore ecosystem health in many parts of the species' range. In addition, the revised critical habitat rule and Recovery Plan recognized that the effects of climate change, wildfire and past management practices are changing forest ecosystem processes and dynamics, including patterns of wildfires, insect outbreaks, and disease, to a degree greater than anticipated in the NWFP (USFWS 2012a). Wildfire is now attributed as the primary driver of northern spotted owl habitat loss on Federal lands, accounting for about 70% of all losses since 1993 (Davis et al. 2016, 2022). The loss of older forest on federal lands caused by timber harvest practices prior to the NWFP have now mainly been replaced by losses from wildfire (Davis et al. 2022, p. 40). Most climate models predict warmer and wetter winters, as well as hotter, drier summers for the Pacific Northwest which is predicted to result in more area burned and more frequent fires (Davis et al. 2017). This will further reduce the extent and connectivity of LSOF habitats and negatively impact northern spotted owl (Gaines et al. 2022, Wan et al. 2019).

Management actions that are designed to improve habitat will contribute to northern spotted owl conservation and recovery. As stated in the revised recovery plan for this species:

> "Vegetation management actions that may have short-term impacts but are potentially beneficial to occupied spotted owl sites in the long-term meet the goals of ecosystem conservation. Such actions may include silvicultural treatments that promote ecological restoration and are expected to reduce future losses of spotted owl habitat and improve overall forest ecosystem resilience to climate change, which should result in more habitat retained on the landscape for longer periods of time (USFWS 2011, p. I-9)."

The critical habitat rule included "Special Management Considerations" for the East Cascades provinces to address the effects of past activities associated with Euro-American colonization, such as timber harvest, livestock grazing, fire suppression, and fire exclusion, that have substantially altered the Inland Northwest, modifying patterns of vegetation and fuels, and subsequent disturbance regimes to the degree that contemporary landscapes no longer function as they did historically (Hessburg et al. 2000, 2005, 2007, 2015; Hessburg and Agee 2003). This affected not only the existing forest and disturbance regimes, but the quality, amount, and distribution of northern spotted owl habitat on the landscape (Buchanan 2009, Healey et al. 2008, Roloff et al. 2012, Ager et al. 2007, 2012; Franklin et al. 2008, Kennedy and Wimberly 2009). To address these issues, the USFWS (2012, p.71910) recommended the following management considerations:

1. Conserve older stands that contain the conditions to support northern spotted owl occupancy or high-value and high-quality northern spotted owl habitat as described in Recovery Actions 10 and 32.
2. Emphasize vegetation management treatments outside of northern spotted owl territories or highly suitable habitat.
3. Design and implement restoration treatments at the landscape scale.
4. Retain and restore key structural components, including large and old trees, large snags, and downed logs.
5. Retain and restore heterogeneity within stands.
6. Retain and restore heterogeneity among stands.
7. Manage roads to address fire risk.
8. Consider vegetation management objectives when managing wildfires, where appropriate.

The critical habitat rule goes on to state that:

> "The above principles will result in a variety of effects on northern spotted owl habitat in the short and long term. For example, some restoration treatments may have an immediate neutral or beneficial effect on existing spotted owl habitat (e.g., road management, some prescribed fire prescriptions). Other treatments, however, may involve reductions in stand densities, canopy cover, or ladder fuels (understory vegetation that has the potential to carry up into a crown fire) and thus affect the physical or biological features needed by the species. At the stand scale, this can result in a level of conflict between conserving existing northern spotted owl habitat and restoring dry-forest ecosystems. Resolution of these conflicts can be enhanced by considering a range of forest conditions that comprise suitable owl habitat and tailoring management accordingly.
>
> Land managers should change from implementing many small, uncoordinated and independent fuel-reduction and restoration treatments. Instead, coordinated and strategic efforts that link individual projects to large objectives of restoring landscapes while conserving and recovering northern spotted owl habitat are needed (Sisk et al. 2005, Prather et al. 2008, Gaines et al. 2010a). Some examples of this type of planning in the East Cascades that may be emulated or referenced include the Okanogan-Wenatchee Forest Restoration Strategy (USFS 2012b), The Nature Conservancy (Davis et al. 2012), and the Deschutes National Forest (Smith et al. 2011)" (USFWS 2012a, p. 71910).

Box 1-A selection of recovery action and terminology definitions from the final Northern Spotted Owl Recovery Plan (USFWS 2011)

Recovery Action 10: Conserve spotted owl sites and high value spotted owl habitat to provide additional demographic support to the spotted owl population. When planning management activities, Federal and non-federal land managers should work with the Service to prioritize known and historical spotted owl sites for conservation and/or maintenance of existing levels of habitat. The prioritization factors to consider are reproductive status and site condition. The conservation priorities are:

- Known sites with reproductive pairs;
- Known sites with pairs;
- Known sites with resident singles;
- Historical sites with reproductive pairs, pairs, and resident singles, respectively.

Active forest management may be necessary to maintain or improve ecological conditions. The USFWS supports projects whose intent is to provide long-term benefits to forest resiliency and restore natural forest dynamic process, when this management is implemented in a landscape context with carefully applied prescriptions to promote long-term forest health. It is recognized that these projects may have both short and/or long-term effects to spotted owls and that treatments will be designed to minimize impacts as much as possible in keeping with the project's intent.

Some definitions (from USFWS 2012a):

Activity Center: Spotted owls have been characterized as central-place foragers, where individuals forage over a wide area and subsequently return to a nest or roost location that is often centrally-located within the home range. Activity centers are a location or point representing "the best of detections" such as nest stands, stands used by roosting pairs or territorial singles, or concentrated nighttime detections. Activity centers are within core use areas and are represented by this central location.

Abandoned Activity Centers: Activity centers that have been determined through appropriate analyses with state or federal agencies, as no longer likely to be supporting territorial owls due to habitat changes and/or long-term surveys with negative responses. Synonymous with abandoned historical spotted owl site.

Known Spotted Owl Site: Includes both owl sites found during the current survey period and owl sites identified in previous years ('historical site"). Known spotted owl sites include both activity center and the area surrounding concentrations of "the best of" detections such as nest stands, stands used by roosting pairs or territorial singles, or areas of concentrated nighttime detections.

Historical Site: Spotted owl sites that contained territorial spotted owls in the past. These spotted owl sites are considered a subset of known spotted owl sites (see above definition).

Recovery Action 32: Because spotted owl recovery requires well distributed, older and more structurally complex multi-layered conifer forests on Federal and non-federal lands across its range, land managers should work with the Service as described below to maintain and restore such habitat while allowing for other threats, such as fire and insects, to be addressed by restoration management actions. These high-quality spotted owl habitat stands are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees.

In dry forest areas, actively manage habitat to meet the overlapping goals of spotted owl recovery, restoration of dry forest structure, composition and process including fire, insects and disease. Managers should refer to earlier discussions in the Plan for specific recommendations about landscape scale, science based adaptive restoration treatments to meet Recovery Action 32 goals. Land managers that utilize and document the application of these recommendations in their project planning are consistent with the intent of Recovery Action 32. An existing example of a site-specific plan that could be emulated is the Okanogan-Wenatchee National Forest Restoration Strategy (USFS 2010).

2.4. Summary

The ecological principles and standards and guidelines from the NWFP provided a foundation and focus used to guide this LSR Assessment. These guiding concepts included the following:

- Maintain and restore ecological processes that are important to the development and maintenance of late-successional and old forest habitats.
    - In the Dry Forests of the Washington East Cascades province this includes the restoration of old forest structure that is conducive to low and moderate severity fire.
- Recognize the diversity of old forest ecosystems that occur within the Washington East Cascades province, including "the abundance of some types of old forest, such as ponderosa pine".
    - The LSR Assessment addresses a variety of forest types and a diversity of old forest habitats, including both closed and open canopied forests.
- There is a need to focus on reducing the risk of large stand-replacing fires in LSRs in the Washington Eastern Cascades Province.
    - The risks associated with habitat loss from stand-replacing fires have increased considerably since the implementation of the NWFP.
    - Considerable loss of a variety of old forest habitats has already occurred, reducing the efficacy of some of the LSRs and fracturing the connectivity of the network across the province.
    - There is an urgent need to apply silviculture treatments, including prescribed fire, to reduce risk and minimize future habitat losses.

Key information from the *Revised Recovery Plan for the Northern Spotted Owl* and the *Final Revised Critical Habitat for Designation for Northern Spotted Owl* rule relevant to the LSR Assessment includes:

- Large and severe wildfires, exacerbated by climate change, pose a significant threat to the viability and recovery of the northern spotted owl.
    - This threat is addressed in the LSR assessment by assessing risks from fire and other disturbances, including the interactive impacts of climate change.
    - Promote treatments that enhance landscape and habitat resiliency.
        - Embed spotted owl habitat within a more resilient landscape.
- The recovery of the northern spotted owl is dependent upon management that reduces the impacts of competition from barred owls.
    - This risk factor is beyond the scope of the LSR assessment and is being addressed by the USFWS in an EIS in coordination with many partners including tribes, states, and federal agencies including Forest Service biologists.

- Focus on landscape scale forest restoration, using landscape evaluations to assess risks and tradeoffs.
    - Use and modify, as needed, the OWNF Restoration Strategy and the landscape evaluation process to assess risks, identify strategic treatment locations, and implement landscape scale restoration.

3. CURRENT CONDITION OF LATE-SUCCESSIONAL AND OLD FOREST HABITATS AND ASSOCIATED SPECIES IN THE EASTERN WASHINGTON CASCADES

This following section provides a synthesis of current understanding of the ecology of forests that occur within the LSR network in eastern Washington, including the recent "history and inventory of overall vegetative conditions within the reserve network" as recommended within the NWFP ROD. This section summarizes how forest conditions have changed for the primary habitats and species associated with different types of late-successional and old forests since the implementation of the NWFP and concludes with an overview of the changes to habitat and numbers of NSOs, a focal species of the NWFP, on the OWNF and across the LSR network.

3.1. Ecology of Eastern Washington Cascades Forests

There has been significant advancement in our understanding of the dynamics among forests, wildlife habitats, and disturbance regimes in the past 25 years in eastern Washington. Much of this research has occurred locally in partnerships between forest managers, agency researchers, and university scientists creating a rich base of knowledge to inform management. In particular, research on how contemporary eastern Washington Cascades forests have departed from historical conditions has greatly expanded our understanding of forest and landscape ecology and allowed management options to evolve. Monitoring data from the NWFP monitoring program has tracked changes in the amount and spatial arrangement of late-successional and old forests since the implementation of the NWFP in 1994.

We summarize the science on the dynamics of eastern Washington forests, interactions with disturbance regimes, and monitoring information for three broad forest groups categorized using updated ILAP Potential Vegetation Types (PVT; Halofsky et al. 2014; WDNR 2020) for the OWNF and Colville National Forests to establish an ecological context for forest restoration activities. A summary of how humans have interacted with these forests and altered forest composition, structure and disturbance regimes is included. This section is divided based on how late-successional and old forest habitats were mapped (e.g., Dry Forest, Moist Forest, and Cold Forest) as part of this LSR Assessment update.

3.1.1. Dry Forest Group

The Dry Forest Group (Figure 3.1) includes Oak Pine, Ponderosa Pine, Ponderosa Dry, and Dry Mixed Conifer potential vegetation types (WADNR 2020). There are several vertebrate wildlife species with conservation concerns and two federal listed plant species associated with Dry Forests in an open-canopy old forest condition (Table 3.1). The dominant fire regime in this group featured mean fire return intervals of 5-20 years (Agee 1993, 2003, Everett et al. 2000, Schellhaas et al. 2007) and primarily low severity with some mixed severity fire (Agee 1993, 2003, Peterson 2015). In some portions of the Dry Forests where grand fir occurs, low and mixed-severity fires with somewhat longer fire return intervals (11-24 years) occurred (Camp et al. 1997, Everett et al. 1997, Wright and Agee 2004).

Frequent, low-severity fires in dry forests contributed to the development and maintenance of open, park-like, early-seral forests dominated by large ponderosa pine and, occasionally, Douglas-fir trees (Agee 1993, 2003). Mixed-severity fires were also important in these forests and promoted a diversity of forest structures with some dense areas of closed-canopy forest (Agee 1993, 2003). Topography interacted with climate and hydrological processes to influence fire regimes and forest structure and composition. Fire “refuges” occurred where local topography reduced fire frequency or severity (Camp et al. 2017), allowing the development of old forest structure, persistence of populations of fire-intolerant species (generally grand fir), and post-fire seed dispersal (Peterson 2015). For example, Camp et al. (1997) found that fire refuges occurred in topographically protected areas like stream confluences, lower slopes, benches, and headwalls, occupying about 12% of a local landscape. Subsequently, Kolden et al. (2017) found that these historical refugial sites burned more severely under contemporary fire conditions than historical non-refugial sites and some sites transitioned to early development stages while others went from closed to open canopy structure.

Human activities have significantly altered disturbance regimes and forest structure and composition in Dry Forests. Indigenous peoples intentionally and regularly ignited fires to increase the availability of important plant resources (Hessburg and Agee 2003, Long et al. 2021, Knight et al. 2022). Euro-American settlers viewed fire as a threat to human life, property, and resources and began suppressing fires (Hessburg and Agee 2003). Livestock grazing further reduced fire frequencies by removing fuels and retarding fire spread (Hessburg and Agee 2003). Active fire suppression facilitated by better access during the 20th century further lengthened fire return intervals allowing fuels to build up and forest densification with more shade-tolerant tree species (Franklin and Johnson 2012, Hessburg et al. 2019, Hagmann et al. 2021). In addition, forest structure and composition were altered through timber harvest, which often removed the largest and most fire-tolerant tree species leaving behind smaller and more shade-tolerant trees (Hessburg and Agee 2003, Hessburg et al. 2005). Changes in forest structure, composition, and landscape patterns have, in turn, altered disturbance regimes, especially for insects, diseases, and fire (Hessburg et al. 2015, Peterson 2015, Hagmann et al. 2021, Gaines et al. 2022).

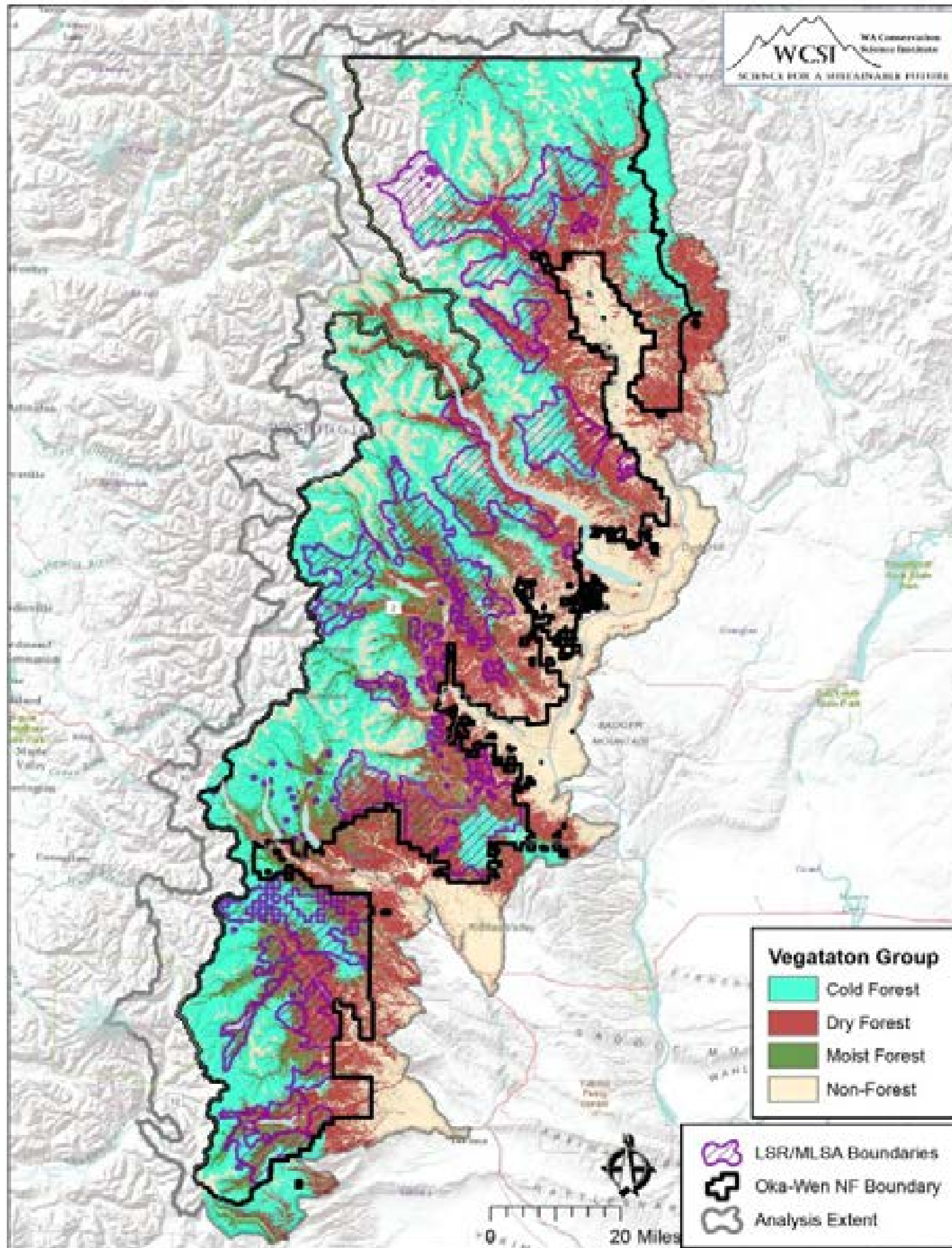

Figure 3.1-Distribution of forested vegetation groups across the assessment area.

Disturbances caused by native insects and pathogens are prevalent throughout forest ecosystems and represent natural components always active to some extent at varying temporal and spatial scales. However, the combination of selective harvests and fire exclusion have allowed more insect- and disease-susceptible tree species, particularly Douglas-fir and grand fir, to proliferate in forest types where they previously had less dominance (e.g. Arno et al. 2008, Hagle et al. 2000, Hessburg et al. 2000, Hessburg et al. 2019). Changes in species composition have been exceptionally pronounced in dry forests that have missed several fire cycles (Hessburg et al. 1994) and where many of the large, old ponderosa pine that are the critical backbone of these

forests were selectively harvested up to a century prior. According to Hessburg et al. (1994): "Excluding fire from grand fir and Douglas-fir forests has perhaps been the single greatest detriment to diversity of dry forests, and a primary factor in current susceptibility to major pathogens and insects." Major insect disturbance agents in the dry forest type are listed in Table 3.3. In addition to bark beetles and defoliating insects, the increase in susceptible tree species and fire exclusion has led to conditions for "nearly optimal spread of root diseases and dwarf mistletoes" across much of the dry forest types (Hessburg et al. 1994). In summary, altered disturbance regimes have created conditions that are more susceptible to extensive insect outbreaks and large, high severity wildfires (Peterson 2015, Hessburg et al. 2015, Gaines et al. 2022).

Table 3.1-Wildlife and plant species of conservation concern: Federally Threatened or Endangered plant species and Federally Threated Species, Region 6 Sensitive Species, or Washington State Species of Greatest Conservation Need (SGCN) vertebrate wildlife species that use Late-Successional and Old Forest habitats to meet some portion of their life history requirements on the Okanogan-Wenatchee National Forest. A list of vascular plants, bryophytes, lichen and fungi that are Federally Threatened or Endangered, Region 6 Sensitive Species, or Washington State Sensitive Species as well as a list of vertebrate and invertebrate wildlife Federally Threatened or Endangered, Region 6 Sensitive Species, or Washington State Sensitive Species that occur on the Forest or have the potential to be found within LSRs is listed in Appendix H. A list of known sensitive aquatic and terrestrial vertebrate species and mollusks for the Wenatchee National Forest at the inceptions of the NWFP can be found in the original Wenatchee LSRA (USFS 1997, Appendices 8 & 27).

Forest Type	Wildlife/Plant Species	Status	Species Viability Assessed in SAT
Dry Forest - Open	Flammulated Owl	SGCN	Yes
	White-headed Woodpecker	R6 Sensitive	Yes
	White-breasted Nuthatch	SGCN	No
	Pygmy Nuthatch	SGCN	Yes
	Red-breasted Nuthatch	SGCN	Yes
	Showy stickseed	Federal Endangered	NA
	Shiny tightcoil	R6 Sensitive	No
Dry-Moist Forest - Closed	Northern Spotted Owl	Federal Threatened	Yes
	Marbled Murrelet[1]	Federal Threatened	Yes
	Larch Mountain Salamander	R6 Sensitive	Yes
	Fisher	Proposed Federal Threatened	Yes
	Pileated Woodpecker	SGCN	Yes
	Northern Goshawk (nesting)	R6 Sensitive	Yes
	Bald Eagle (Riparian)	R6 Sensitive	Yes

Forest Type	Wildlife/Plant Species	Status	Species Viability Assessed in SAT
	Harlequin Duck (Riparian)	R6 Sensitive	Yes
	Tailed Frog (Riparian)	R6 Sensitive	Yes
	Puget Oregonian	R6 Sensitive	No
	Blue-gray taildropper	R6 Sensitive	No
	Ute ladies' tresses	Threatened	NA
	Wenatchee Mtns Checkermallow	Endangered	NA
Cold Forest - Closed	Canada Lynx	Federal Threatened	Yes
	Great Gray Owl	R6 Sensitive	Yes
	Pacific marten	SGCN	Yes
	Whitebark pine	Threatened	NA

[1] Suspected but not yet detected on the Okanogan-Wenatchee National Forest.

3.1.2. Moist Forest Group

The Moist Forest Group (Figure 3.1) includes the Moist Mixed Conifer, Northern Rocky Mountain Mixed Conifer, and Western Redcedar potential vegetation types updated from the ILAP PVT maps for Washington (Halofsky et al. 2014; WADNR 2020). There are a number of federal or state listed wildlife species, such as the northern spotted owl and northern goshawk, and one federal listed plant species that are associated with Moist Forests in a closed-canopy old forest condition (Table 3.1). The historical vegetation of the Moist Forest Group was influenced by frequent to moderately frequent fire return intervals (<20-50 years) that burned with mixed severity, containing both low- and high-severity patches (Stine et al. 2014, Hessburg et al. 2016). Consequently, the Moist Forest Group was historically a complex of different patches of fire severities and successional stages (Hessburg et al. 2016). Fires tended to burn in relatively small homogenous patches of different fire severities, largely shaped by prevailing topographic features and the imprint of prior fire effects across the landscape over time. (Hessburg et al. 2016). Fire severity patches commonly occurred in a continuum of sizes between 1-1,000 ha; with larger patches possible but historically rare (Moritz et al. 2011, Perry et al. 2011, Hessburg et al. 2016).

Past management and climatic warming have combined to greatly simplify the pyro-diversity of Moist Forests (Perry et al. 2011, Hessburg et al. 2016), resulting in increasingly larger and more severe wildfires (Hessburg et al. 2016). Past management influences include more than a century of fire suppression, forced removal of indigenous populations and their cultural burning practices, fire exclusion by livestock grazing and road building, selective removal of the largest and most fire-tolerant species, and clear-cut logging (Hessburg et al. 2016, Copes-Gerbitz et al.

2022). As a result, smaller diameter shade-tolerant Douglas-fir and grand fir are now more extensive while larger diameter fire-resistant Douglas-fir and western larch are lacking, structural heterogeneity has been reduced, and forests are more susceptible to large-scale disturbances from wildfire and insect and disease outbreaks (Lewis and Hrinkevich 2008, Gillette et al. 2014, Pettit et al. 2020).

Climate change is resulting in warmer temperatures and lower plant-available water (moisture deficits) and leading to declining resiliency of Moist Forests (Hessburg et al. 2016). In turn, these conditions have resulted in increased insect outbreaks, primarily by bark beetles (Stine et al. 2014, Allen et al. 2015, Hessburg et al. 2016), and greater risks of large, high severity wildfires (Meigs et al. 2015, Talucci et al. 2022). Insect-related tree mortality and defoliation, caused by agents listed in Table 3.3, are always present to some degree in moist forests.

Moist Forests with mixed severity fire regimes are uniquely challenging to manager because their successional pathways and disturbance patterns are so highly varied (Tepley et al. 2013, Larson et al. 2013, Hessburg et al. 2016). As climate becomes less limiting for fire ignition and spread in the future, extensive and severe wildfire effects may become more common in these forest types. An ongoing management challenge is balancing the competing goals of restoring more characteristic successional patterns and disturbance processes, while protecting late-successional forest habitats from uncharacteristic wildfires (Gaines et al. 2010a, Lehmkuhl et al. 2015).

3.1.2.1. Stand/Patch Scale Reconstructions in Dry and Moist Forests

Even though patches define the heterogeneity of landscapes, they also include fine-scale within-patch heterogeneity. Reconstructions from pre-settlement era forests show that patches in fire-prone dry and mesic mixed conifer forests were comprised of fine-scale mosaics of individual trees, tree clumps, and openings (gaps) of various sizes (Harrod et al. 1998, 1999; Larson and Churchill 2012, Churchill et al. 2013, Franklin et al. 2013, Churchill et al. 2016). These spatial patterns influence patch-level resilience to disturbances, rates of succession and stand dynamics (Sanchez Meador et al. 2009, Dodson et al. 2008, Stephens et al. 2009, Fettig et al. 2007), and wildlife habitat characteristics (Gaines et al. 2007, 2010b).

The results of these studies provide important information for the patch-level restoration treatment prescriptions. For example, contemporary forest patches are more uniform, and generally lack very large (>25 inches dbh) tree structures (live and dead) that dominated the overstories of open and closed canopy forest patches (Hessburg et al. 1999c, 2015). Restoration treatments can be designed to restore within-patch spatial and structural heterogeneity using historical stand reconstructions as reference conditions from which to develop silvicultural prescriptions (see Section 6; Harrod et al. 1999, Churchill et al. 2013b, Franklin et al. 2013, Hessburg et al. 2015).

3.1.3. Cold Forest Group

The Cold Forest Group (Figure 3.1) includes Silver Fir, Mountain Hemlock, Subalpine Parklands, Subalpine-Lodgepole pine, and Subalpine-Spruce vegetation types (WADNR 2020).

Several wildlife species with conservation concerns are associated with Cold Forests (Table 3.1). The primary fire regimes in this group include moderately frequent to infrequent mixed to high severity fire. Fire return intervals vary from as few as 30-40 years to as many as 150 years (Povak et al. 2023).

As with other forest groups and types, past management, in particular fire suppression, and environmental changes from climatic warming has altered the pyro-diversity of the Cold Forest Group (Hessburg et al. 2016, Povak et al. 2023). Historically, wildfire and regular re-burning in cold-forests played important roles in shaping and maintaining a shifting mosaic of successional stages (Agee 2000, Perera and Buse 2014, Hessburg et al. 2019, Prichard et al. 2021, Povak et al. 2023). Fires, at intervals of 30-150 years created a shifting patchwork of burned and recovering conditions, patches of non-forest, varied species composition with hardwood and mixed-wood forest, and varied open and closed canopy successional conditions (Povak et al. 2023, Prichard et al. 2023). This patchwork functioned to limit future fires sizes and their severities. An important role of small and mid-sized burn patches was to break up the landscape, thereby limiting the growth of future fires (Povak et al. 2023). While old forest habitats existed with the cold forest, recent research has shown that their patches sizes were relatively small and not a dominant part of these fire-maintained forests (Prichard et al. 2023, Povak et al. 2023).

Past fire suppression resulted in advanced forest succession, creating large areas of dense, vulnerable, cold-forest habitat (Hagmann et al. 2021, Povak et al. 2023, Prichard et al. 2023). During the past 20 years, a considerable portion of these successionally advanced cold forests have burned at high severity (Lyons et al. 2023) in the OWNF. The combination of regenerating forest, in particular lodgepole pine, vast quantities of dead fuels, and the increasing length of fire seasons and temperatures, create conditions ripe for large, high severity reburns (Prichard et al. 2023). A landscape approach is needed to restore the pyro- and vegetative diversity and provide wildlife habitats more resilient to the effects of climate change and wildfires (Hessburg et al. 2016, 2019, Lyons et al. 2023).

3.2. Changes to Climate and Disturbances since 1994

Climatic changes can directly influence the frequency and severity of forest disturbances. Considerable changes have occurred to the climate and environments on the OWNF since the NWFP amended the Land and Resource Management Plan in 1994 and since the original LSR Assessments were completed in 1997 and 1998. For example, mean summer temperatures have increased across the Forest, mean summer precipitation has decreased, and the snowpack (mean snow water equivalent) has decreased (Table 3.2). Rapid changes in climate are associated with, in part, longer fire seasons (Westerling et al. 2006, Westerling 2016) and influence forest insect outbreaks (Littel et al. 2010, Bennett et al. 2023).

Since 1994, more than 1.48 million acres have burned on the OWNF and 369,800 acres burned were within the LSR network, with 39% burned severely (Figure 3.2, Figure 3.3, Figure 3.4; Cova et al. 2022). Forests have also been impacted by bark beetles, defoliators, root diseases, and dwarf mistletoe (Table 3.3). Several native insects and diseases, particularly bark beetles, have resulted in over 1.51 million acres classified as experiencing severe (30 – 50% of polygon affected) or very severe tree mortality (> 50% of polygon affected; Table 3.3) in the past 30

years on the OWNF with 44,100 acres of that occurring within the LSR network. The large number of acres of bark beetle caused tree mortality and/or severely defoliated forest and acres burned in wildfires (Figure 3.5, Figure 3.6) substantiate the ongoing and growing risk associated with large-scale disturbances, which dramatically reduce habitats for late-successional and old associated species.

Table 3.2-Climate data (mean summer temperature, mean summer precipitation, mean April snow water equivalent) summarized from 1994-2022 for locations on the Okanogan-Wenatchee National Forest (Office of the Washington State Climatologist; https://climate.washington.edu/climate-data).

Summer Temperature		**Summer Precipitation**		**Snow Water Equivalent**	
Station	**Change ^{0}F**	**Station**	**% Change**	**Station**	**% Change**
Winthrop	+3.4	Winthrop	-11.4%	Rainy Pass	-9.5%
Wenatchee	+2.3	Wenatchee	-28.0%	Cloudy Pass	-10.1%
Ellensburg	+3.0	Ellensburg	-44.0%	Blewett Pass	-16.3%
				Green Lake	-35.2%

To date, this increasing risk to disturbance has been particularly evident on the northern end of the Forest where extensive wildfires have greatly reduced the amount of late-successional and old forest habitats within the LSR Network. For example, the Upper Methow LSR, located at the northern end of the network, is 191,000 acres in size. As of 2023, 82,400 acres have burned in wildfires since 1993, reducing old forest habitats (OGSI 200; Davis et al. 2022) by 36% and suitable spotted owl habitat by 66%.

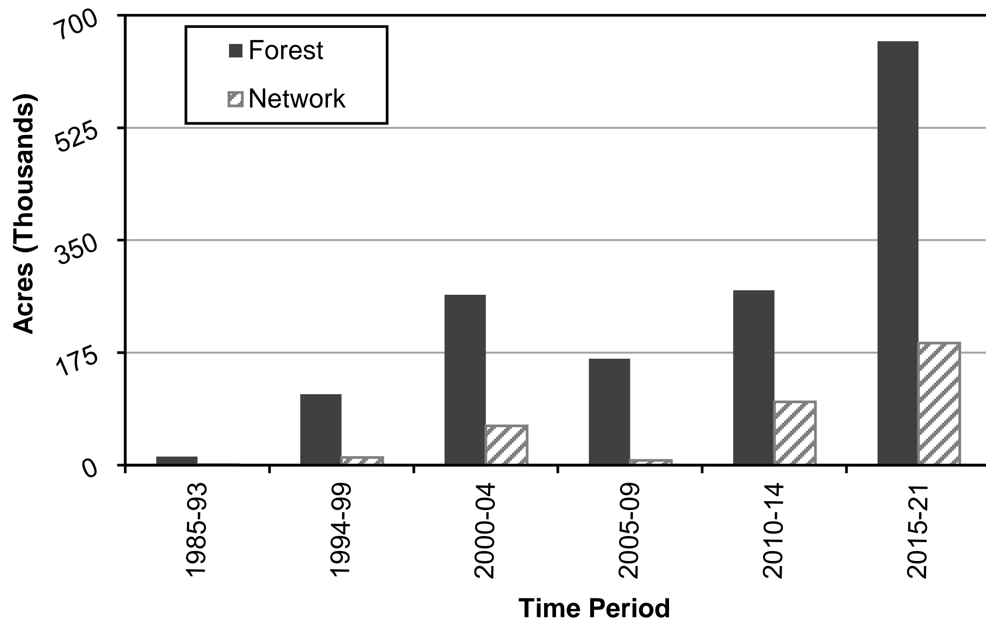

Figure 3.2-Area burned by wildfires on the Okanogan-Wenatchee National Forest and in the Late-Successional Reserve Network over time periods before (1985-1993) and after Northwest Forest Plan implementation (1994-2021).

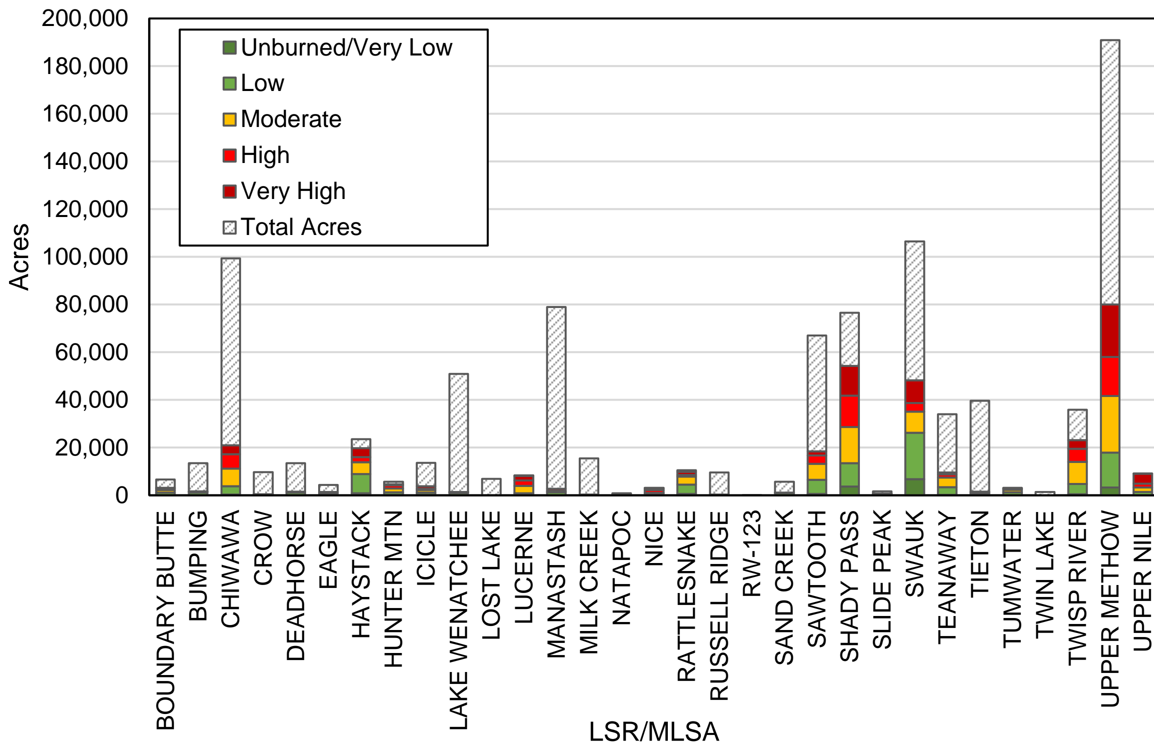

Figure 3.3-Cumulative burn severity (acres by severity class) of wildfires in the Late-Successional Reserve Network since 1994. Where multiple fires burned the same footprint, the highest severity was recorded for that pixel. Data come from the Washington DNR large wildfire database (WDNR 2022).

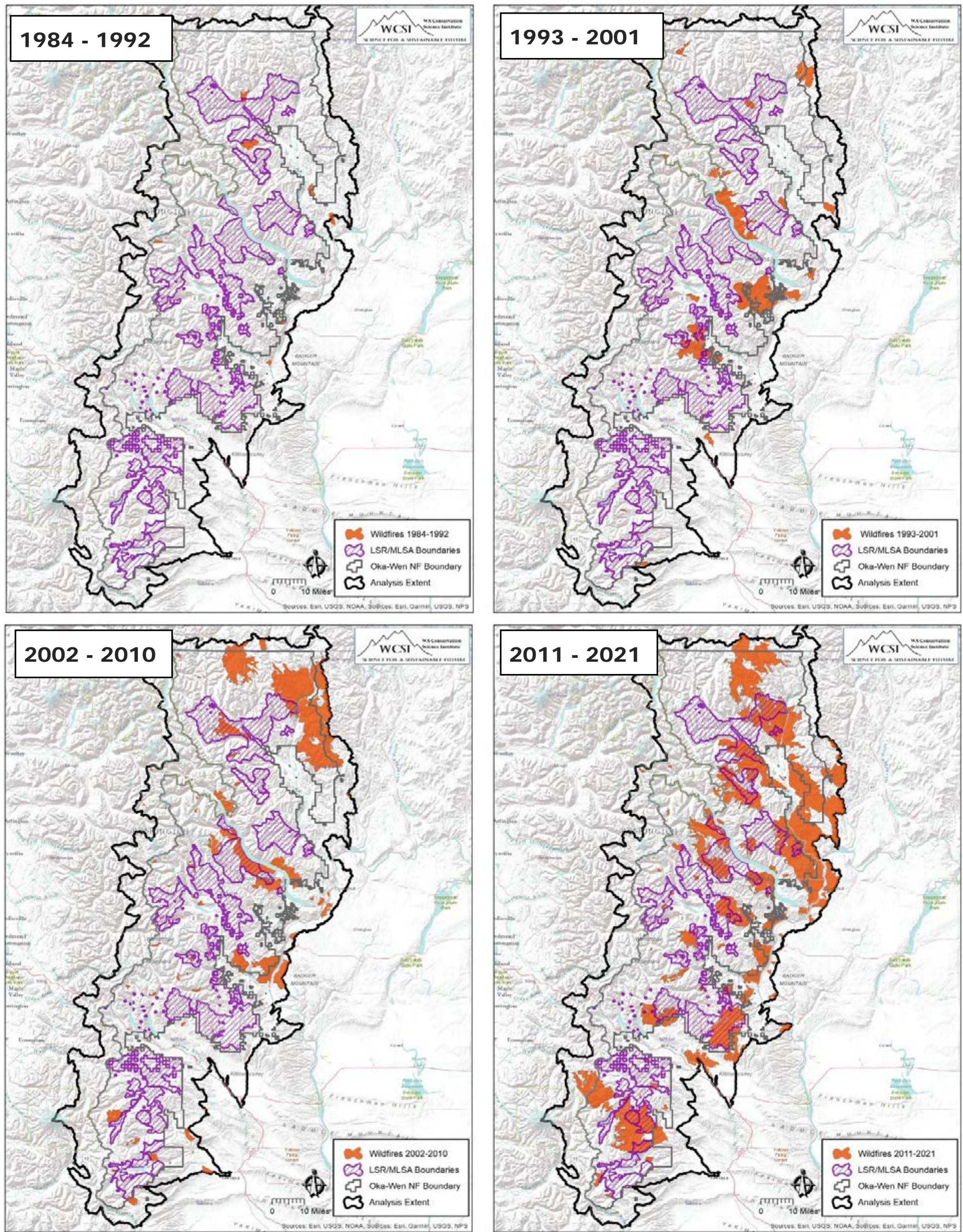

Figure 3.4-Distribution of wildfire on the Okanogan-Wenatchee National Forest from 1984 to 2021.

*Table 3.3-Acres mapped (and proportion of total area) that include at least one year with some amount of tree mortality due to bark beetles or severe defoliation caused by defoliating insects within Forest Groups on the Okanogan-Wenatchee NF and LSR Network. Damage agents mapped by Aerial Detection Surveys from 1993 to 2021. Aerial detection surveys do not attribute damage caused by root diseases or dwarf mistletoes, but these damage agents should be included in project analyses. *All insects listed are native with the exception of balsam woolly adelgid. Data source: USDA Forest Service, Forest Health Protection and its partners.*

		Okanogan-Wenatchee NF		**LSR Network**	
Vegetation Group	**Damage causing agents**	**Acres**	**%**	**Acres**	**%**
Dry Forest	Bark beetles • Western pine beetle • Douglas-fir beetle • Fir engraver • Mountain pine beetle	405,893	41%	163,533	50%
	Defoliators • Western spruce budworm • Douglas-fir tussock moth	403,197	41%	193,364	60%
Moist Forest	Bark beetles • Western pine beetle • Douglas-fir beetle • Fir engraver • Mountain pine beetle	199,657	47%	81,135	53%
	Defoliators • Western spruce budworm • Douglas-fir tussock moth • Balsam woolly adelgid*	233,234	55%	97,944	64%
Cold Forest	Bark beetles • Mountain pine beetle • Western Balsam Bark beetle • Spruce beetle • Balsam woolly adelgid • Silver fir beetle • Fir engraver	833,800	52%	195,426	57%
	Defoliators • Balsam woolly adelgid	16,101	10%	5,831	2%

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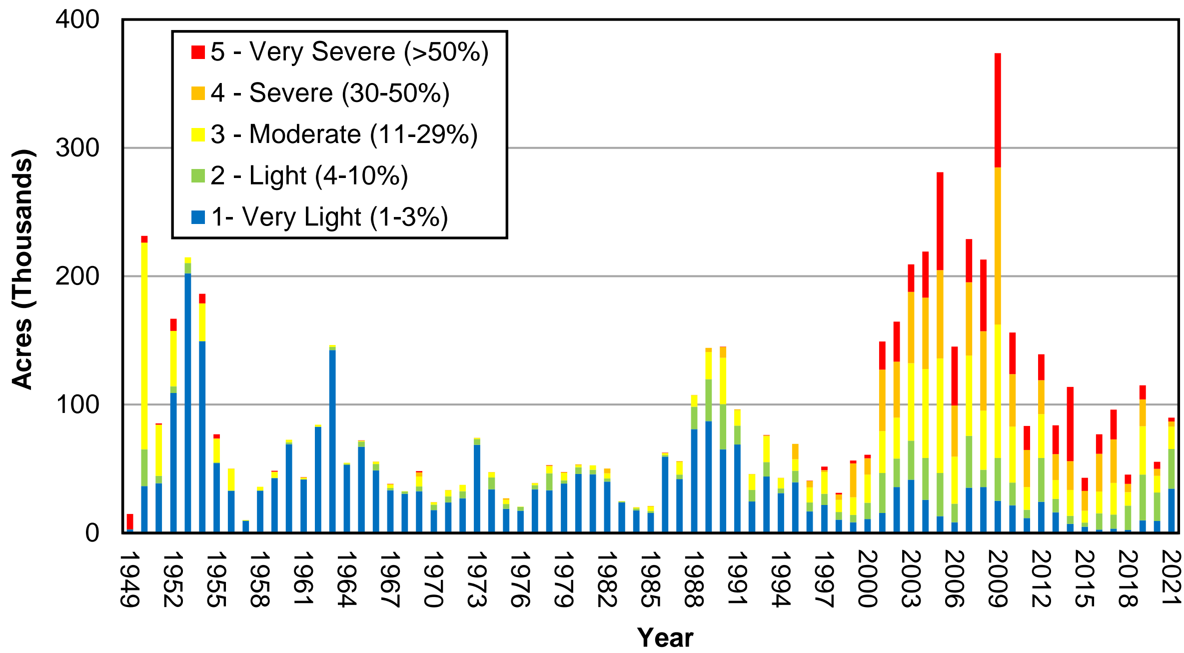

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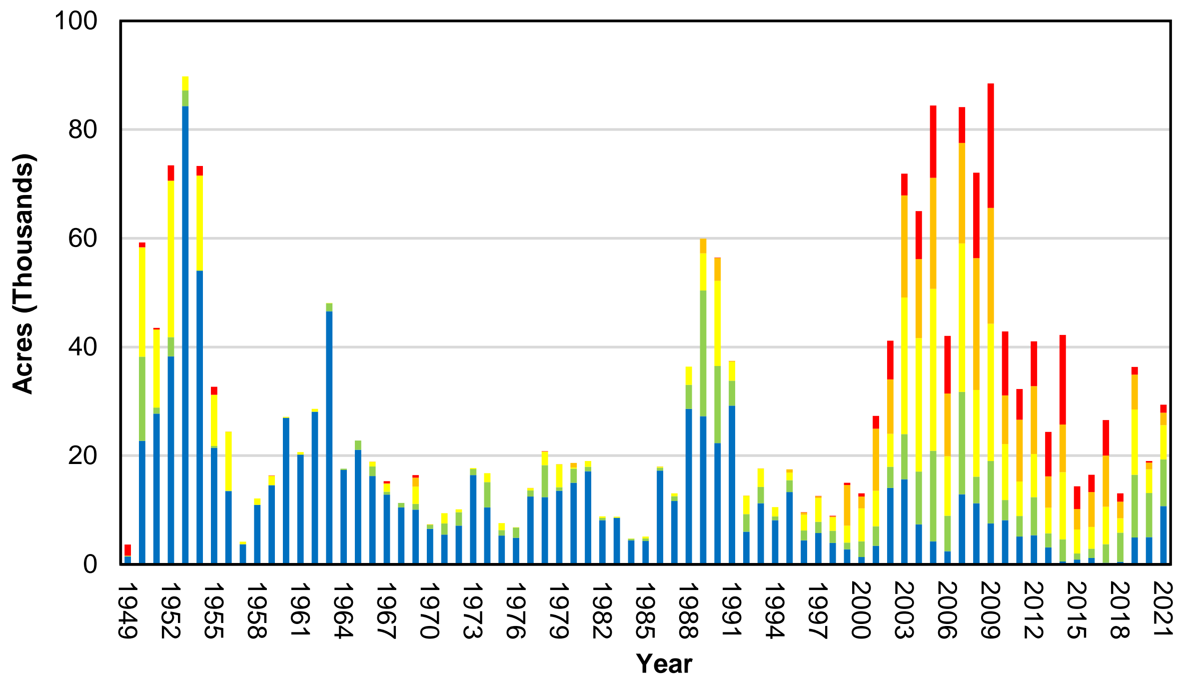
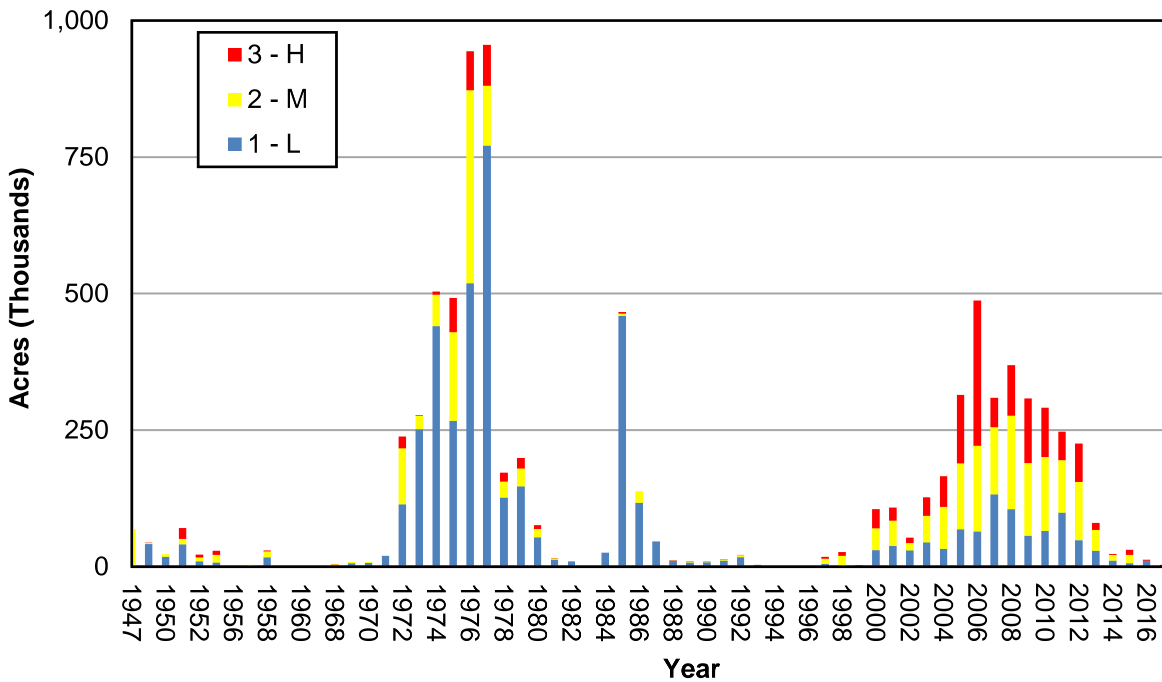


Figure 3.5-Acres of bark beetle-caused tree mortality across the (A) Okanogan-Wenatchee National Forest and (B) within the OWNF – LSR/MLSA Network. Severity, or intensity, levels are categorized as "the percent of damaged trees within the perimeter of the polygon or cell that are damaged/recently dead in relation to all trees in the cell or polygon" which does not only include host trees (Forest Health Detection Survey GIS Handbook and Data Conformity Standards Version 1.0. January 2022. Digital Mobile Sketch Mapping). Results have not been standardized to reflect survey effort.

A



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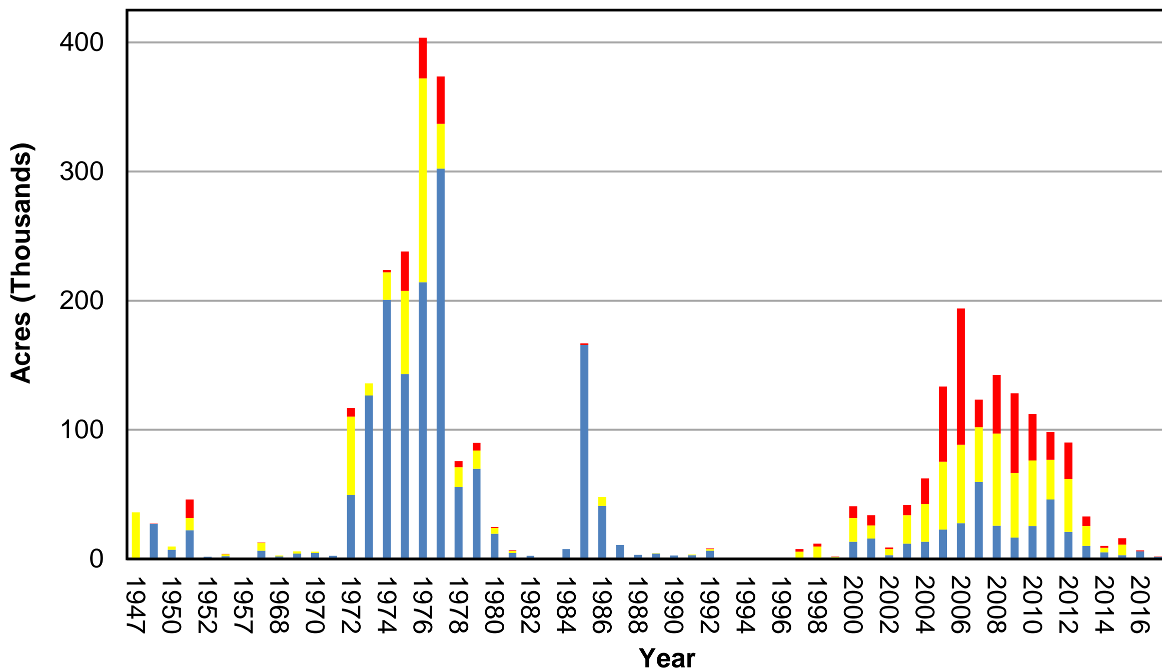

Figure 3.6-Total acres of defoliator activity across the (A) Okanogan-Wenatchee National Forest, and within the (B) OWNF – LSR/MLSA Network. Total represents "the percent of damaged trees within the perimeter of the polygon or cell that are damaged/recently defoliated in relation to all trees in the cell or polygon" which does not only include host trees (Forest Health Detection Survey GIS Handbook and Data Conformity Standards Version 1.0. January 2022. Digital Mobile Sketch Mapping). Results have not been standardized to reflect survey effort.

3.3. Current Condition of Late-Successional and Old Forest Habitats

The late-successional and old forest habitats that were mapped to assess the diversity of habitats and species for which the LSRs were designated under the NWFP are described in this section. This updated assessment includes information on the current amounts and spatial arrangement of LSOF and old forest habitats, including how conditions have changed since the NWFP was implemented in 1994. Conditions are presented for the following late-successional and old forest habitat categories: Old Growth Structure Index-200 (OGSI200, Davis et al. 2022), Dry Forest Large-Tree Open Canopy habitats, Dry and Moist Forest Large-Tree Closed-Canopy habitats, Cold Forest Medium-Large Tree Closed-Canopy habitats (GNNv2023.1-derived; Bell et al. in review) and northern spotted owl habitat (Davis et al. 2022). Appendix IMethods provides details on the methods and data sources used to map the diversity of old forest habitats). The conditions for each habitat category are described at the scale of the OWNF and for the LSR network. Information specific to each LSR/MLSA is in Appendix B.

3.3.1. Old Growth Structure Index – 200

The Northwest Forest Plan monitoring program uses the Old Growth Structure Index (OGSI; Davis et al. 2015, 2022) as one metric for tracking late-successional and old forest conditions (Figure 3.7). OGSI is calculated using one to four measurable old growth structure elements including (1) density of large live trees, (2) diversity of live-tree classes, (3) density of large snags, and (4) percentage cover of down woody material (Davis et al. 2015). A network of forest inventory plots was used to examine age-class distributions for different diameter classes in different forest types to determine which combination of structural elements to apply to the calculation of OGSI. Two age-related thresholds were then applied to estimate when structural conditions developed for mature forests. The first threshold is broadly referred to as OGSI80 and applied a threshold of 80 years for all forest vegetation zones and is used to describe the general point on the forest succession time scale at which young forests in the region generally begin to mature. An exception to this rule was applied to ponderosa pine forests, which are located in warmer, drier sites and are assumed to take 120 years to begin to mature. The second threshold is the OGSI200 based on a stand age of 200-years, which corresponds to the range of ages used to define an old growth forest condition. After reviewing the two OGSI spatial datasets with the Late-Successional Reserve Assessment interdisciplinary (LSRA IDT) team, the LSRA IDT selected the OGSI200 metric to track broad scale trends in the amounts and distribution of old forest over the past 30 years and developed GNN-based metrics (see Appendix I for details) to track changes to other late-successional and old forest habitats that was more synonymous with the description of habitat types used to bin old-forest dependent species in the eastern Cascades. For example, identification of open-canopied old forest habitats separate from closed-canopied old forest habitats was key to understanding how these habitats have changed over time for several species of conservation concern, such as the White-headed woodpecker and flammulated owl.

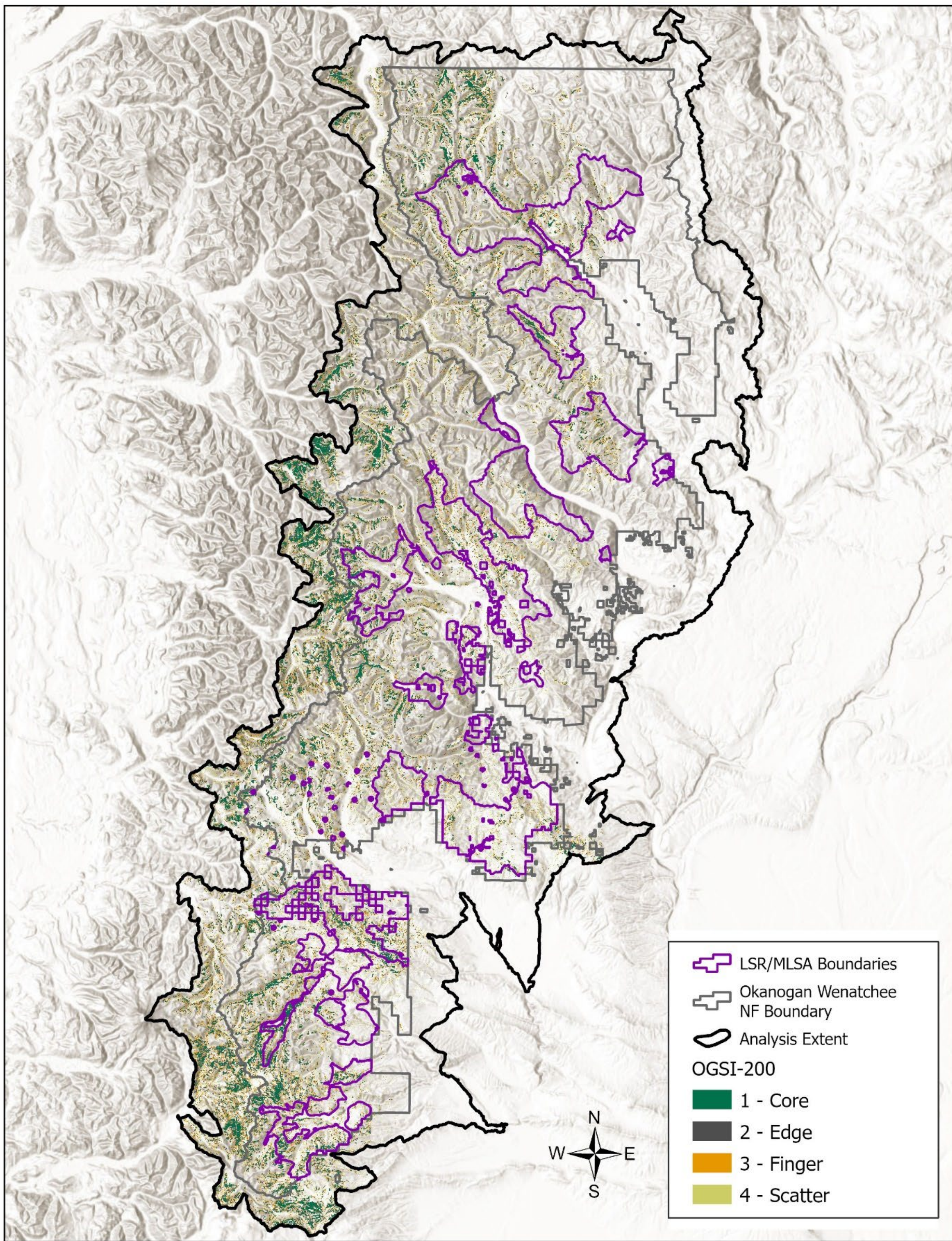

Figure 3.7-Current mapped old growth structure index (OGSI-200) for the Okanogan-Wenatchee National Forest. Data are from Davis et al. 2022.

3.3.1.1. Current and Changed Conditions

The amount of OGSI200 has declined substantially across the Forest and within the LSR Network since the implementation of the NWFP in 1994 (Figure 3.8, Figure 3.9). The total amount of OGSI200 on the OWNF was reduced by 21% from 1993 to 2021, with the majority of losses attributable to disturbance and almost entirely as a result of wildfires post-2017 (Figure 3.8; Davis et al. 2022). In addition to reductions in the amount of OGSI200, the spatial arrangement has also been altered. The OGSI200 that was identified as Core (larger patches-see Davis et al. 2015) has been reduced by 29% across the Forest (Figure 3.9). The amount of forest identified as OGSI200 within the LSR network has been reduced by 22% from 1993-2021. A similar but smaller reduction of OGSI200 Core habitat within the network has occurred (Figure 3.9).

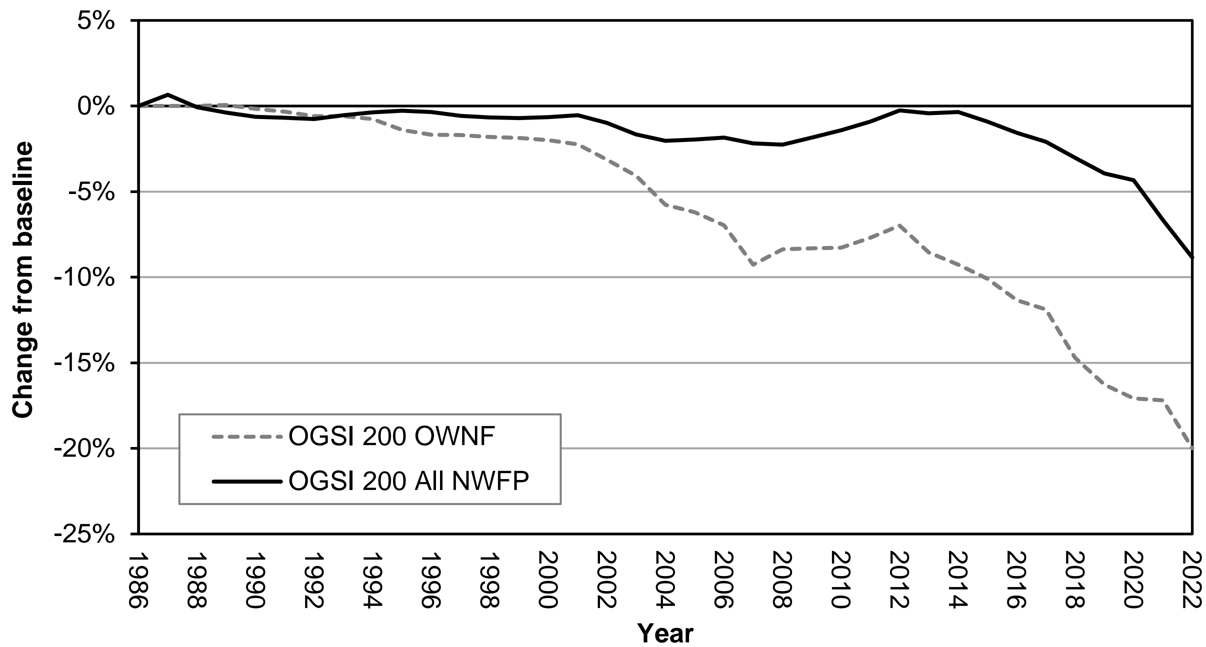

Figure 3.8-The OGSI200 monitoring results for all the Northwest Forest Plan (NWFP) area and for the Okanogan-Wenatchee National Forest (OWNF). Note that between 1986 – 2017, both gains and losses are accounted for in the data. Post-2017, only losses are attributed in the data, but given the slow rate of accumulation of additional forests meeting the OGSI-200 threshold, we assume that gains would have been minimal during this 5-year period.

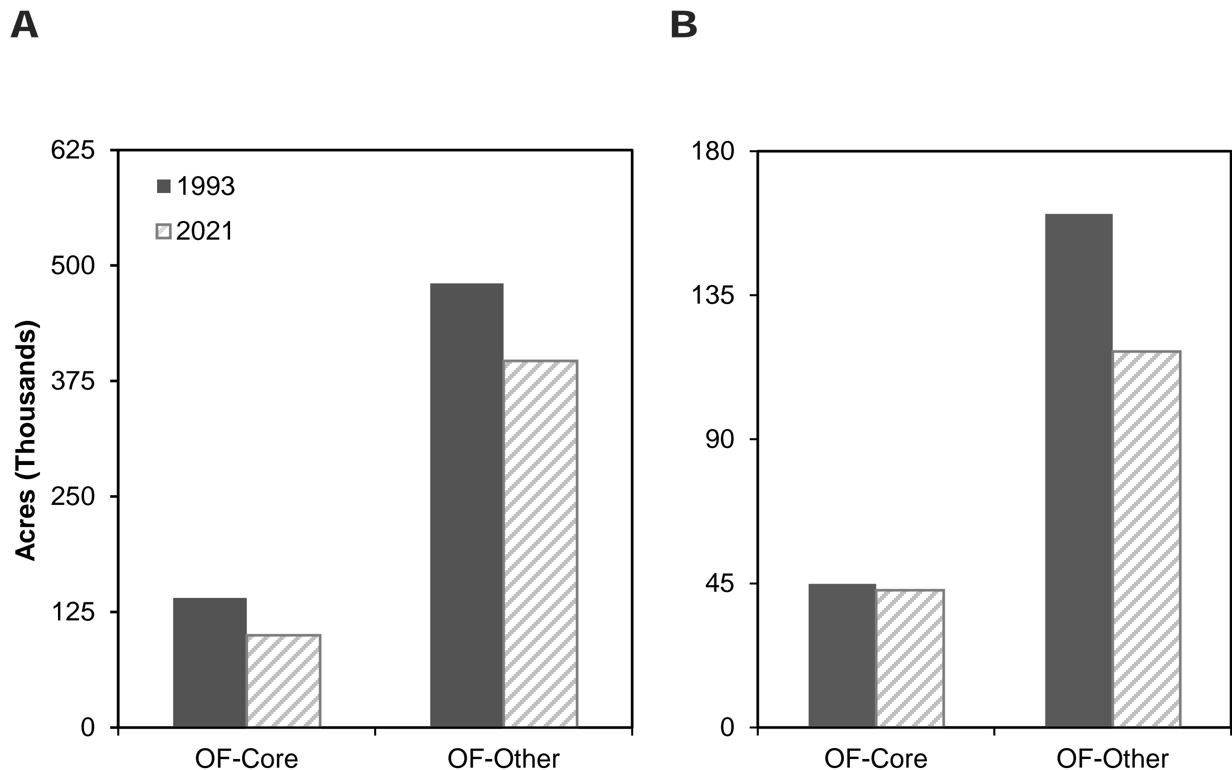

Figure 3.9-Changes to OGSI200 between 1993 and 2021 within A) the Okanogan-Wenatchee National Forest and B) the Late-Successional Reserve network on the OWNF. OF-Core refers to an interior portion of a group of older forest pixels that is large enough to contain at least one pixel 98 ft from the edge. OF-other is all other classes. Described in Davis et al. 2015.

3.3.2. Dry Forest Large-Tree Open-Canopy Habitats

Large-tree open-canopied habitats[2] once occupied 33-47% of the Dry Forest Group on the OWNF (Hessburg and Agee 2003, Hessburg et al. 2005). There are 985,530 acres (26% of the Forest) of the Dry Forest Group on the OWNF and 325,925 acres (34% of the network) within the LSR network.

Utilizing Gradient Nearest Neighbor (GNNv2023.1; Bell et al. in review) data up through 2021, approximately 42,500 acres (4% of the Dry Forest) of the OWNF were mapped as Dry Forest in a Large-Tree Open-Canopy habitat, with approximately 15,000 acres (5% of the Dry Forest in the LSR network) of that within the LSR network (see Appendix I for detailed methods). There has been an increase in the Dry Forest Large-Tree Open-Canopy habitats since 1993 by about 36% (15,300 acres) on the Forest and about by about 39% (5,850 acres) within the LSR network. While this shows that the amount of Large-Tree Open-Canopy habitats has increased, this habitat

[2] Dry Forest Large Tree Open Habitats were classified using GNN size class (large = QMD_DOM > 20" DBH) and canopy cover < 50% and include oak-pine woodlands, ponderosa pine woodlands, and dry mixed conifer forests dominated by Douglas-fir, ponderosa pine, and grand fir.

still remains well below historical levels (33-47%) at both the Forest and within the LSR network scales (see Section 4; Table 3.4).

Table 3.4-The current amounts of late-successional and old forest habitats for Forest Groups compared to estimates of their natural range of variability. Other habitat types, including early successional or small tree habitats are not presented here.

Forest Group	Old Forest Habitat Type	Percent of Forest	Percent of LSR Network	Natural Range of Variability
Dry Forest	Large-Tree Open-Canopy	4%	5%	33-47%
Moist Forest	Large-Tree Closed-Canopy	60%	65%	15-30%
Dry and Moist Forest	Large-Tree Closed-Canopy[1]	49%	59%	18-24%
Cold Forest	Medium-Large-Tree Closed-Canopy	23%	24%	20-60%

[1] This structural condition is most closely associated with known historic and current northern spotted owl activity centers in the East Cascades of Washington, and natural range of variability estimates for this habitat type are based on methods described in Halofsky et al. (in review).

There are several wildlife species that are federally or state listed that use Dry Forest large-tree open-canopy habitats (Table 3.1). Gaines et al. (2017) assessed the viability for species associated with these habitats, including the white-headed woodpecker, flammulated owl, white-breasted nuthatch and pygmy nuthatch. These species were also assessed by the Scientific Analysis Team (1993) and used to inform the management guidance in the Northwest Forest Plan. Gaines et al. (2017) found that habitats for these species were greatly departed and well below their historical availability resulting in low viability outcomes (Gaines et al 2017). As a result, they and other authors recommended that existing Dry Forest Large-Tree Open-Canopy habitats be conserved, including large and old trees, and that forest restoration treatments be implemented using thinning and prescribed fire to restore habitat amounts and stand structure (Gaines et al. 2007, 2010b) to better mimic historical amounts and conditions, and improve viability outcomes (Gaines et al. 2017, Altman et al. 2020).

3.3.3. Dry and Moist Forest Large-Tree Closed-Canopy Habitats

Large-Tree Closed-Canopy habitats[3] were combined for Dry and Moist Forest groups due to the way they are intermingled across the forest, and that several species have habitats that include the closed-canopy portion of each Forest group. Closed canopy habitats historically occupied roughly 18 – 24% of the Dry and Moist Forest Group (Halofsky et al. in review). Currently,

[3] Dry and Moist Forest Large Tree Closed-Canopy Habitats were classified using GNN size class (large = QMD_DOM > 20” DBH) and canopy cover > 50%. For Dry Forests, these forests include oak-pine woodlands, ponderosa pine woodlands, and dry mixed conifer forests dominated by Douglas-fir, ponderosa pine, and grand fir. Moist Forests include mixed conifer forests dominated by Douglas-fir, western larch, grand fir, western Redcedar, western white pine and western hemlock.

there are 1,412,020 acres (37% of Forest) of the Dry and Moist Forest Groups on the OWNF, and 479,861 acres (50% of LSR network) that occur in the LSR network (Table 3.4).

Utilizing GNN data from 2021 show that 688,320 acres (49% of the Dry and Moist on the Forest) of the Dry and Moist Forests are in a Large-Tree Closed-Canopy habitat condition across the Forest, and 280,740 acres (59% of the Dry and Moist in the LSR network) of that are within the LSR network (Bell et al. in review; Table 3.4). There has been a considerable decrease in the amount of Large-Tree Closed-Canopy habitats in the Dry and Moist Forests, primarily because of large high-severity wildfires. There has been a 29% decrease of these habitats (199,600 acres) across the Forest, and a 30% decrease across the Late-Successional Reserve network (84,200 acres). While the availability of these habitats has declined, they are still well above historical estimates (18-24%). Because of the considerable fuel loads associated with these complex-structured habitats, they are highly susceptible to high severity wildfires (see Section 4).

A number of species are associated with late-successional and old forest habitats in the Dry and Moist Forest-Large-Tree Closed-Canopy condition (Table 3.1). Viability assessments have been completed for species associated with these habitats, such as the larch mountain salamander, pileated woodpecker, fisher, and northern goshawk (Gaines et al. 2017). Assessments were also completed for bald eagle, Harlequin duck, and tailed frog, species associated with these habitats where they occur in riparian areas (Gaines et al. 2017). Although the marbled murrelet is included in this group, there is very limited habitat used by murrelets on the Forest. The northern spotted owl is associated with these habitats and is addressed below. All of these species were assessed by the Scientific Analysis Team (1993) and used to inform the development of management guidance in the NWFP.

Viability assessments showed that the availability of these habitats were within or above their historical abundances resulting in better viability outcomes (see northern goshawk, pileated woodpecker) compared to large-tree open-canopy associated species (Gaines et al. 2017). However, some key habitat elements, such are large trees and snags have declined and reduced habitat quality. Similarly, the viability outcomes for species associated with these forests in riparian habitats were generally better than for the dry forest large-tree open-canopy habitats, though some risk factors (e.g., roads in riparian areas) reduced habitat quality (Gaines et al. 2017).

3.3.4. Cold Forest Medium-Large Tree Closed-Canopy Habitats

Estimates for medium and large-tree closed-canopied habitats[4] vary more than other forests groups, but likely occupied 20-60% of the Dry Forest Group on the OWNF historically (but see Povak et al. 2023[5]). There are 1,600,597 acres (41% of Forest) of the Cold Forest Group on the

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[4] Medium and Large tree closed canopy cold forests were characterized by ≥ 50% canopy cover and a QMD_DOM of ≥ 15" DBH (see Appendix I for details). Cold forests include Pacific silver fir, mountain hemlock, and subalpine fir-Englemann spruce or lodgepole pine dominated vegetation types as well as subalpine parklands with whitebark pine.

[5] Povak et al. 2023 suggests that old forest single story and old forest multistory structural stages made up less than 5% of historical cold forests under a functioning fire regime in the North Cascades.

OWNF, and 345,358 acres (36% of LSR network) that occur within the LSR network (Table 3.4).

Utilizing GNN data from 1993 to 2021 (GNNv2023.1; Bell et al. in review), approximately 696,490 acres of Cold Forest are in a Medium-Large-Tree Closed-Canopy habitat condition across the Forest, and 162,841 of those acres (25%) are within the LSR network (Table 3.4). Disturbances have resulted in a 10% decrease of these habitats across the Forest and 3% decrease within the LSR network over the past 30 years. The effects of fires on the Cold Forest have been most intense in the northern portion of the Forest.

Federal or state listed wildlife species that use Cold Forests in an old forest condition for a portion of their life history include the Canada lynx, Pacific marten, and great gray owl (Table 3.1). These species were assessed by the Scientific Analysis Team (1993) and used to develop management guidance in the Northwest Forest Plan.

Lynx historically occupied the high-elevation boreal forests of northern Washington (Koehler et al. 2008). Historical trapping and habitat loss substantially reduced lynx numbers in Washington, and today lynx occur only in the northern portions of the OWNF (Lewis 2016). Most recently, Lyons et al. (2023) assessed the impacts of wildfire, climate change, and past forest management on Canada lynx carrying capacity on the northern portion of the OWNF and adjacent lands. They found that 32% of lynx habitat burned since 2000, altering habitat distribution and the capacity of the landscape to support Canada lynx. There was a 66-73% reduction in lynx carrying capacity and considerable decreases in the probability of lynx persistence (Lyons et al. 2023). Maintenance of the existing lynx habitat in LSRs on the northern portion of the OWNF will be important for this species going forward.

Pacific marten primarily occur in upper elevation cold-forests on the OWNF (Munzing and Gaines 2008). The viability of Pacific marten has departed somewhat from historical conditions, primarily as a result of risk factors such as roads reducing habitat quality (Gaines et al. 2017). A considerable portion of these habitats (267,027 acres) have burned in wildfires since the last viability assessment was completed for marten.

Great gray owls are relatively rare on the OWNF, with most known locations on the northern portion of the Forest. They use mature forests and are linked to northern boreal coniferous forest habitat in the Cascade Mountains (Anderson and Woodruff 2005).

3.3.5. Northern Spotted Owl

Since the OWNF LSR Assessments were completed in 1997-98, additional research has been conducted and policy implemented concerning the ecology and conservation of the northern spotted owl (*Strix occidentalis caurina*). The policy documents include a revised recovery plan (USFWS 2011) and revised designated critical habitat (USFWS 2012a, 2021). In these recovery planning documents, two risk factors were identified that are critical to address in spotted owl recovery: (1) the increasing risk of large-scale habitat loss from wildfires and interactions with climate change, and (2) the competition from the con-generic barred owl. In this section, an overview of the current and changed conditions from local research and monitoring is presented for these two risk factors, along with corresponding population implications based on local

monitoring information. This section synthesizes the main issues around spotted owl habitat management and restoration. See Appendix C for additional background information and analyses pertaining to northern spotted owl to support this assessment.

3.3.5.1. Barred Owl and Spotted Owl Interactions

The barred owl is now found at significant densities throughout the entire range of the northern spotted owl (Livezey 2009, Franklin et al. 2021). The continued range expansion of the barred owl constitutes a considerable threat to northern spotted owl persistence, which was not evaluated as such when the spotted owl was first Federally listed under the Endangered Species Act (Franklin et al. 2021), despite evidence that barred owls were present in the Pacific Northwest (Taylor and Forsman 1976). Effects of the barred owl invasion are most notable in the northern range of the spotted owl, such as on the OWNF, where the invasion of barred owls has been ongoing for over four decades (Taylor et al. 1976, Singleton et al. 2010; Singleton 2013; USFWS 2011, 2012, Kroll et al. 2010, Sovern et al. 2014, Franklin et al. 2021).

Local research was done on the OWNF as a means of better understanding barred owl habitat use and to determine the degree of overlap in barred owl habitat and space use compared to northern spotted owls (Singleton 2015). The results of this research showed that barred owls and spotted owls in eastern Washington use forests with similar structural characteristics, especially during the breeding season (Singleton 2015). However, barred owls appear more closely associated with moist forests on gentle slopes or in valley bottoms (Singleton et al. 2010). The areas that are least suitable for barred owls, and the most likely areas where spotted owls can evade barred owls, are the drier forest types (Singleton et al. 2010, Gaines et al. 2010a). There is an approximate 75% overlap between habitats preferred by both species, meaning that less than 25% of the "good" (used greater than expected) spotted owl habitat on the Forest was also identified as "poor" (used less than expected) habitat for barred owls (Singleton 2013). Multiple studies have assessed the effects of barred owls on northern spotted owl occupancy and consistently shown declines in occupancy rates by northern spotted owls in the presence of barred owls (Kroll et al. 2010, Sovern et al. 2014, Mangan et al. 2019, Wiens et al. 2020, 2021). In addition, Singleton (2013) assessed the implications of habitat-based resource selection overlap between barred and spotted owls on northern spotted owl occupancy, showing similar rates of decline.

In the most recent northern spotted owl demography assessment, the influence of barred owls on northern spotted owls appears to have substantially increased from 2013 through 2018 (Franklin et al. 2021). This has led researchers to suggest that near-term extirpation of the northern spotted owl, especially in the northern portions of the range, is imminent unless barred owl management is widely implemented to reduce competition (Franklin et al. 2021). Experimental removal of barred owls has occurred in portions of the northern spotted owl's range, including in the Cle Elum demography study area.

Local monitoring data from autonomous-recording units (ARU; using protocols from USFWS 2021) on several Ranger Districts (Table 3.5) and data from the Cle Elum demography barred owl removal study (Wiens et al. 2020, 2021*)* were summarized to assess the influence of barred owls on spotted owls on the OWNF and in the LSR network for this assessment (Figure 3.10). The results of the autonomous recording unit monitoring shows widespread distribution of barred

owls across the monitoring areas and high detection rates. Similar detection rates of barred owls were recorded in the barred owl removal study (Wiens et al. 2020, 2021) on the Cle Elum Ranger District prior to initiation of barred owl removals. In total, over 400 barred owls were removed over a five-year period. Barred owl removal reduced the detections of barred owls to a low of 43% of the hexes (n=75) during the final year of removal (Figure 3.10). However, the years following cessation of barred owl removal showed that barred owl detections quickly recovered to pre-removal levels, suggesting that the effectiveness of barred owl removal may have a limited duration (Figure 3.10). This indicates that for barred owl removal to be successful at reducing competition with spotted owls, it would need to be extensively and consistently applied.

Table 3.5-Barred owl detection rates as a result of Autonomous Recording Unit monitoring for northern spotted owls on select Ranger Districts on the Okanogan-Wenatchee National Forest.

Ranger District	Year	Number of Hexes Surveyed	Proportion of Hexes with Barred Owl Detection
Methow Ranger District	2020	16	38%
	2021	34	79%
Wenatchee River Ranger District	2020	51	71%
	2021	63	86%
	2022	73	86%
Cle Elum Ranger District	2020	69	70%
	2021	75	67%

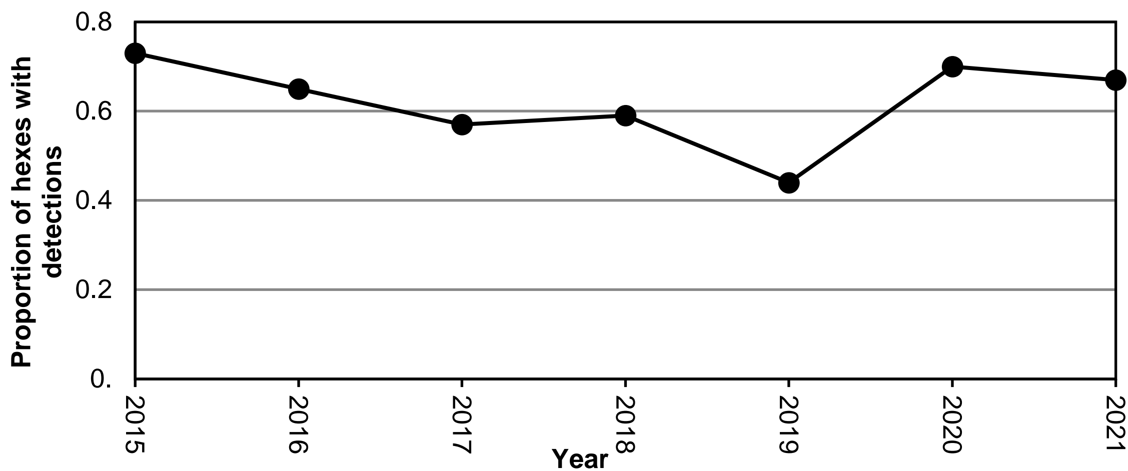


Figure 3.10-Results of the barred owl removal project on the Cle Elum Ranger District (OWNF) showing the proportion of 75 hexes in which barred owls were detected during the removal experiment (2015-2019; Wiens et al. 2020 and two years after barred owl removal ceased(2020-2021; data from OWNF).

3.3.5.2. Habitat Loss from Disturbance

Large-scale disturbances can have considerable impacts on spotted owl habitat by removing much of the live forest structure (e.g., canopy closure, canopy layers, large trees, mistletoe brooms, etc.) associated with spotted owl habitat (Buchanan 2023). The degree of impact is dependent on the disturbance size and severity. Since the implementation of the NWFP in 1994, several large wildfires and extensive insect-related mortality have affected habitat for spotted owls in the LSRs, in Critical Habitat, and across the Forest. The available monitoring information was summarized in several ways to assess the impacts of disturbances on spotted owl habitat. The impacts of disturbances in the Washington East Cascades province on the amount of nesting and roosting habitat between 1993 and 2017 was summarized from the NWFP 25-Year Monitoring Report (Figure 3.12; Davis et al. 2022). Further, area burned and changes in nesting, roosting, foraging and dispersal habitats from 1993 to 2022 was summarized at the Forest scale, for the LSR network, and for the four largest LSRs. Additional information for each individual LSR and MLSA can be found in Appendix B. Finally, changes to the amount of habitat within the breeding ranges (0.7-mile radius of a spotted owl activity center) of the historical activity centers was summarized.

Since 1993 on the Okanogan-Wenatchee National Forest, northern spotted owl nesting-roosting habitat has decreased by 20%, suitable habitat (includes nesting, roosting and foraging) by 34%, and dispersal habitat by 25% as a result of disturbances, primarily high severity fire. Between 1993 and 2017, 23, 55, 17, and 5% of the loss of nesting-roosting habitat on forested lands in the Washington East Cascades province was attributed to timber harvest, wildfires, insect mortality, or other causes, respectively (Davis et al. 2022). Post-2017, additional losses can mostly be attributed to wildfire. Within the LSR network the amount of nesting-roosting habitat has decreased by 20%, suitable habitat by 35%, and dispersal habitat by 45% (Table 3.6, Figure 3.12). Between 1993 and 2017, 14, 60, 19, and 7% of the loss of nesting-roosting habitat on federally reserved lands in the Washington East Cascades province was attributed to timber harvest, wildfires, insect mortality, or other causes, respectively (see Davis 2022 and Appendix C for description of owl habitat mapping). Post-2017, additional losses can mostly be attributed to wildfire. Wildfire continues to be the primary cause of spotted owl habitat loss on Federal lands across the NWFP area, accounting for about 70% of all losses since 1993 (Davis et al. 2016, 2022).

Of particular interest is the role that wildfire has played in altering the amount of spotted owl habitat within the largest LSRs on the OWNF (Table 3.6). The largest LSRs on the Forest include: Upper Methow, Chiwawa, Swauk, and Manastash (Table 2.1, Figure 2.1). Fires have occurred within all these LSRs, with the largest burned area in the Upper Methow (43%) and the lowest burned area in the Manastash (4%; Table 3.6). Wildfires have resulted in considerable declines in the amount of spotted owl habitat, especially in three of the four largest LSRs (Table 3.6, Figure 3.12).

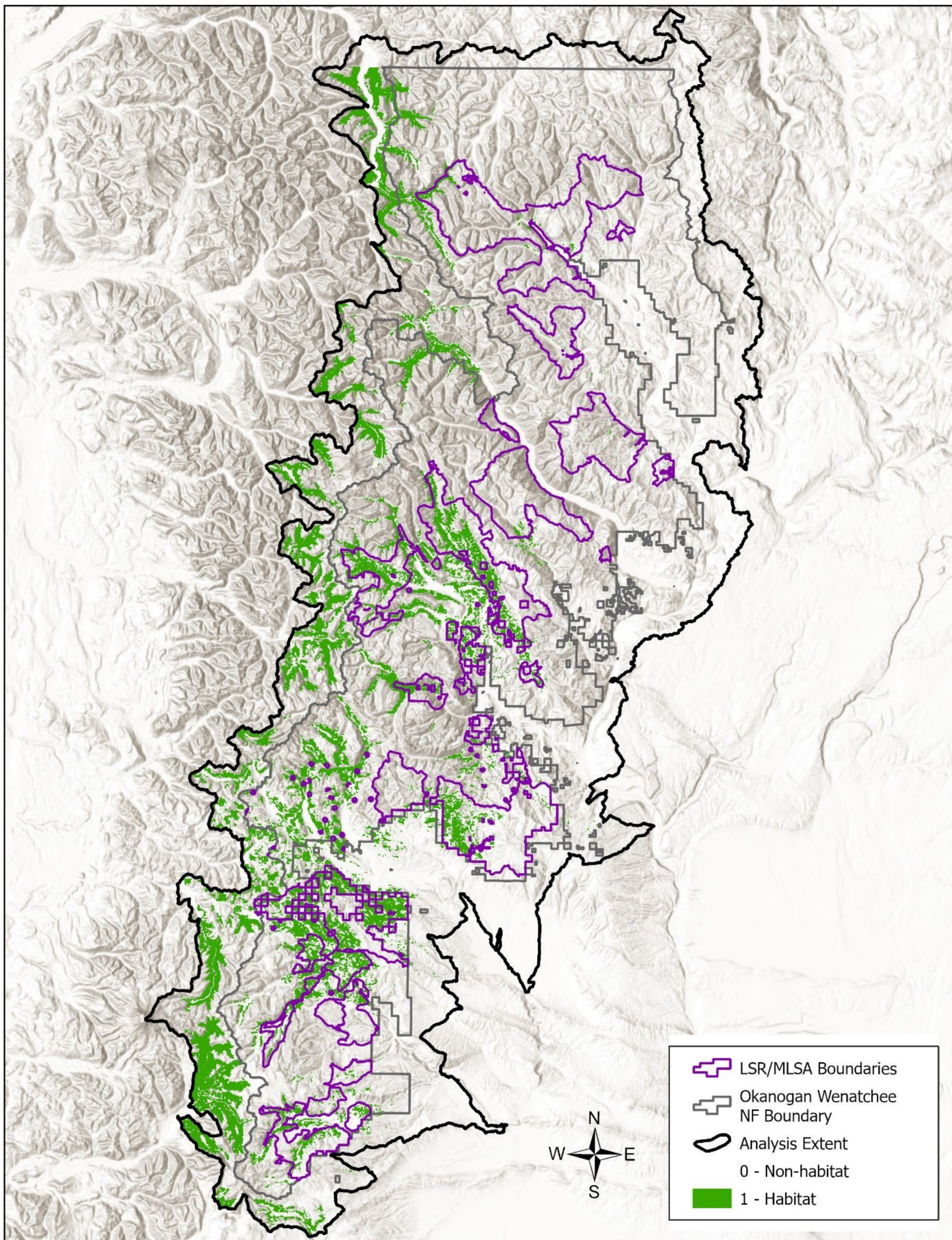


Figure 3.11-Predicted relative habitat suitability for northern spotted owl on the Okanogan-Wenatchee National Forest based on current conditions. Data are from Davis et al. 2022.

Table 3.6-The area burned by wildfires on the Okanogan-Wenatchee National Forest, in the Late-Successional Reserve Network, and in the four largest Late-Successional Reserves and the corresponding changes to habitats for the northern spotted owl (1993-2021).

	Size (acres)	Area Burned (acres/%)	Habitat Class	Change in Northern Spotted Owl Habitat
Okanogan-Wenatchee National Forest	3.8 million	1.48 million (39%)	Suitable Dispersal	-34% -25%
Late-Successional Reserve Network	948,011	369,800 (39%)	Suitable Dispersal	-35% -45%
Upper Methow LSR	190,914	82,400 (43%)	Suitable Dispersal	-66% -55%
Chiwawa LSR	99,405	21,400 (22%)	Suitable Dispersal	-19% -23%
Swauk LSR	106,473	49,900 (47%)	Suitable Dispersal	-38% -45%
Manastash LSR	78,936	2,800 (4%)	Suitable Dispersal	-7% -10%

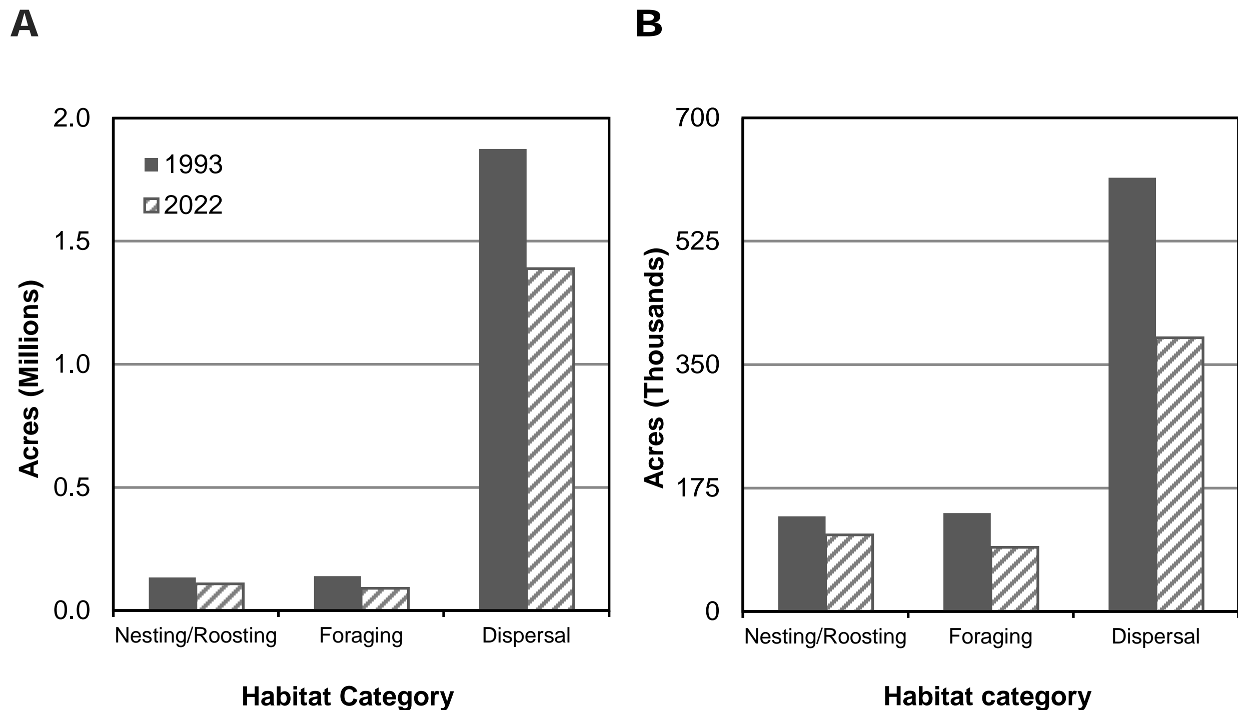


Figure 3.12-The changes to the amount of northern spotted owl habitat (by habitat function) from 1993 to 2022 on A) the Okanogan-Wenatchee National Forest and B) within the LSR/MLSA network on the Forest.

The effects of fire on current and historical northern spotted owl activity centers was assessed by calculating the area within a breeding territory (the area within a 0.7-mile radius of an activity center) that was impacted by fire. The 0.7-mile radius is also used to assess spotted owl habitat "take" by the USFWS. Take is assumed to occur when there is less than 500 acres (<50%) of the area in suitable habitat. Fire severity within 278 breeding territories (from 1989 thru 2022) from the OWNF was used in the assessment (see Appendix I). Habitat within 126 (45%) of the breeding territories has been impacted by wildfire and 106 of those sites experienced varying levels of high to very high fire severity. In 1993, 47% of the breeding territories had ≥50% of the area in suitable (nesting, roosting, foraging) habitat. In 2022, only 30% of the breeding territories had ≥50% of the area in suitable habitat (Figure 3.13). Wildfires resulted in a substantial reduction in suitable habitat within breeding territories and pushed a considerable number of spotted owls activity centers below a 50% threshold.

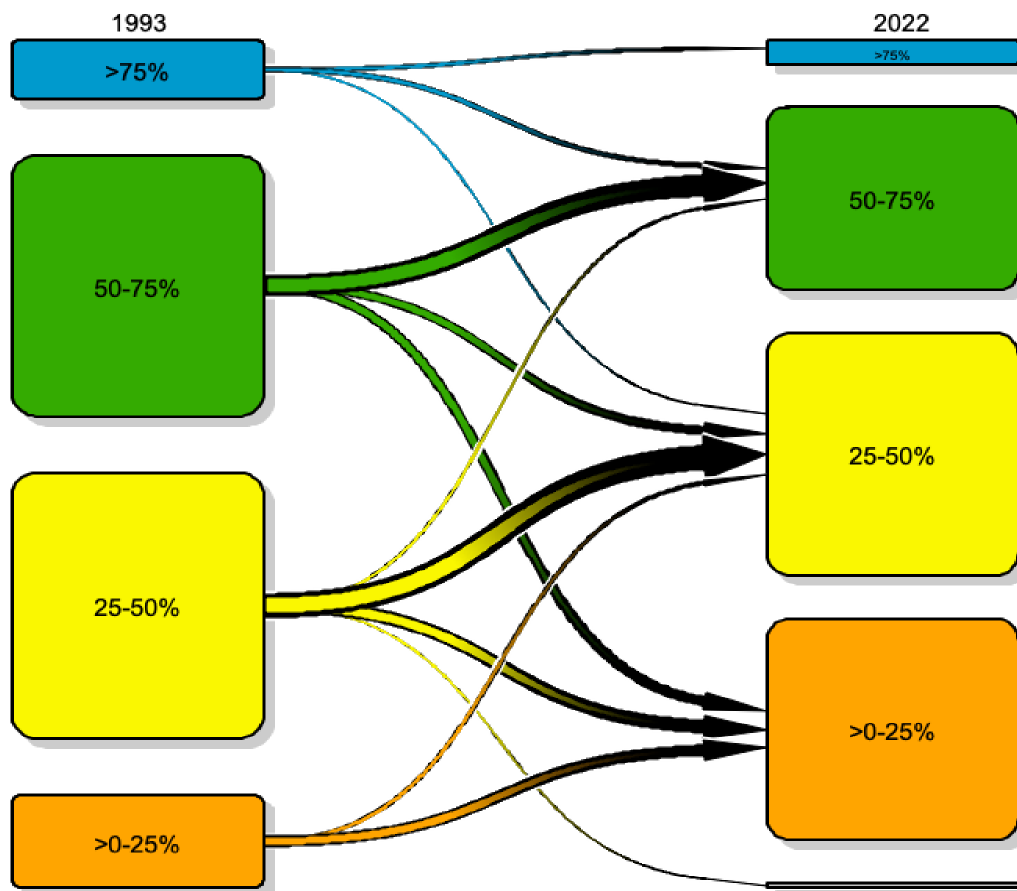


Figure 3.13-A comparison of the relative proportions of northern spotted owl habitat within breeding territories (n=278) from 1993 to 2022. Habitat amount categories are: >0-25% of the breeding territory in habitat (orange boxes), >25-50% (yellow boxes), >50-75% (green boxes), and >75-100% of the breeding territory in habitat (blue boxes).

3.3.5.3. Northern Spotted Owl Population Monitoring

Several sources of information were used to summarize changes to northern spotted owl numbers on the Forest and within the LSR network. These information sources included the Cle Elum

Demography Study, surveys on the Forest, surveys within the largest LSRs, and the application of a habitat-based (no barred owl influence) occupancy model (Glenn et al. 2017, Davis et al. 2022). With the exception of the Cle Elum Demographic Study Area, it is important to note that comprehensive surveys for northern spotted owls on the OWNF ended in the early 2000s and, as a result, the precise number of owls remaining is not known. A new range-wide population survey was initiated in 2023 and will provide population estimates in 2024 (Lesmeister and Jenkins 2022).

In the Cle Elum Study Area, monitoring shows that fecundity, survival, and population trends are all declining (Forsman et al. 2011, Dugger and Davis 2012, Dugger et al. 2016, Franklin et al. 2021). The estimated abundance of spotted owls on the Cle Elum study area declined by >90% from 1995 to 2020 (Franklin et al. 2021, Lesmeister et al. 2022).

There were 159 known spotted owl activity centers within the LSR network at the time the original LSR Assessment was completed (Table 3.7). More current information on northern spotted owl numbers on the OWNF comes from two primary sources: 1) locations where broadcast surveys were conducted, and 2) locations where ARUs have been used. These survey efforts are summarized to show locations where spotted owls have been detected by either survey method within the past five years on the Forest (Figure 3.14). In addition, where possible the information was summarized to show changes in spotted owl numbers over time.

Northern spotted owl monitoring within the four largest LSRs provides good examples of changes to the detections and activity centers of spotted owls over time. The most recent survey data from 2018 through 2022 is summarized here. Note that not all breeding ranges were surveyed each year, and dispersing spotted owls, referred to as "floaters" may have been detected within multiple breeding ranges. The Upper Methow LSR had eight occupied spotted owl activity centers when the LSR Assessment was completed in 1998 (Table 3.7). There were no occupied activity centers or spotted owl detections from 2018-2022.

The number of northern spotted owl activity centers in the Chiwawa LSR has declined from 17 known activity centers in 1996 (Table 3.7) to no currently occupied activity centers. There have been only two breeding ranges with detections of single owls from 2018 - 2022. A considerable portion of the spotted owl habitat resides in low gradient valley bottom settings within moist forests occupied by barred owls at high densities (Singleton et al. 2010, Singleton 2013).

The Swauk LSR had 24 pairs of spotted owls in 1996 (Table 3.7), but currently there is only one known pair (A. Woodrow, pers. comm.). There have been 11 breeding ranges with detections of spotted owls in the Swauk LSR from 2018 - 2022.

The Manastash Ridge LSR had 33 known pairs of spotted owls in 1996 (Table 3.7). From 2018 to 2022 there have been 16 breeding ranges with spotted owl detections and only five occupied activity centers.

Table 3.7-Northern spotted owl activity centers in the Late-Successional Reserve Network that were identified in the original Late-Successional Reserve Assessments (USFS 1996, 1997, 1998).

Name	Number of Activity Centers	Name	Number of Activity Centers
Boundary Butte LSR	2	Nice LSR	0
Bumping LSR	4	Rattlesnake LSR	3
Chiwawa LSR	19	Russell Ridge MLSA	2
Crow MLSA	5	Sand Creek LSR*	3
Deadhorse LSR	9	Sawtooth LSR	1
Eagle MLSA	1	Shady Pass LSR	4
Haystack MLSA	8	Slide Peak LSR	0
Hunter Mountain LSR	0	Swauk LSR	24
Icicle LSR	2	Teanaway LSR	5
Little Wenatchee LSR	9	Tieton LSR	13
Lost Lake MLSA	1	Tumwater MLSA	1
Lucerne LSR	1	Twin Lakes MLSA	1
Manastash Ridge LSR	33	Twisp River LSR	1
Milk Creek LSR	3	Upper Methow LSR	8
Natapoc MLSA	0	Upper Nile LSR	3

*Camas Creek MLSA has been combined with Sand Creek LSR for this assessment. Camas Creek MLSA did not have an occupied activity center in the previous assessment.

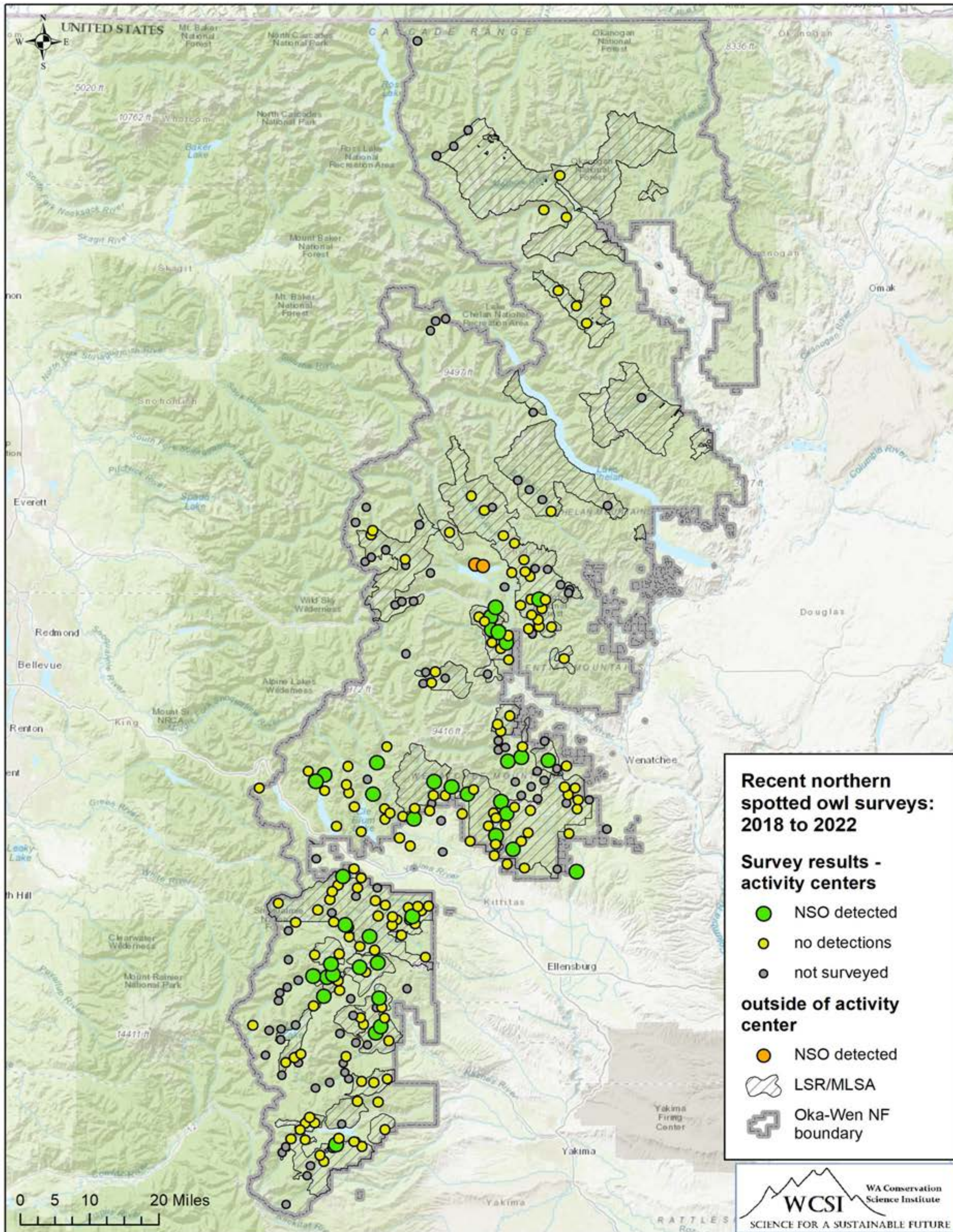


Figure 3.14-Current and historical northern spotted owl activity centers, survey effort, and results on the Okanogan-Wenatchee National Forest, 2018-2022.

The Naches, Cle Elum, and Wenatchee River Ranger Districts, where surveys have been the most extensive and continuous, provide good examples of the changes in the spotted owl detections since surveys were initiated in the late 1980s (Figure 3.15). The survey information shows that the number of spotted owls detected on those districts peaked in the early-mid 1990s at around 50 per ranger district and has been on a steady decline since. These patterns are similar to those reported in other areas in the northern portion of the spotted owl range where long-term monitoring has occurred (Franklin et al. 2021).

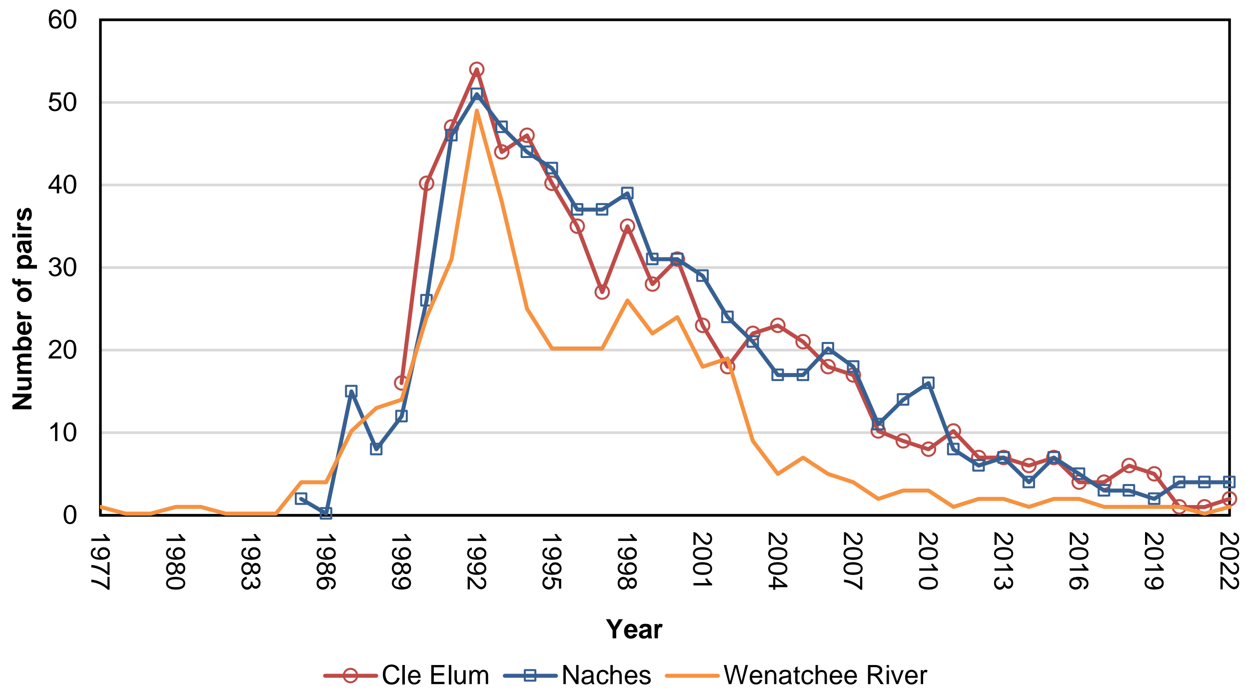


Figure 3.15-Northern spotted owl pairs detected on the Cle Elum, and Naches and Wenatchee River Ranger Districts, Okanogan-Wenatchee National Forest, from 1977 through 2022.

During the peak of spotted owl surveys on the OWNF in the mid-1990s, 278 activity centers were identified on the Forest, of which all or a portion of 159 activity center circles (0.7 mile) occurred within the LSR network. From 2018 to 2022 (5 survey seasons), spotted owls were detected at 34 (12%) activity centers, 135 (49%) activity centers were surveyed but had no response, and 109 (39%) were not surveyed or data were not available (Figure 3.14).

The OWNF has experienced a steady decline in northern spotted owl numbers attributed to barred owl competition and habitat loss, largely from wildfires. Recent habitat-based carrying capacity modeling (Glenn et al. 2017, Davis et al. 2022) suggests that in 1993 the Eastern Washington Physiographic Province may have had enough habitat to support 392 spotted owl pairs, and the LSR network may have supported 152 pairs (Table 3.8). In 2023, the habitat-based capacity estimate for the Eastern Washington province was 341 pairs, a decline of 13%, and the 2023 estimate for the LSR network was 122 pairs, a decline of 20% (Table 3.8). It is important to note that these carrying capacity estimates reflect only habitat changes and not the additional and substantial impacts of barred owls. In reality, as of 2023 there were fewer than six documented pairs of northern spotted owls on the OWNF, and even fewer in the LSR network.

Table 3.8-The 1993 and 2023 habitat-based carrying capacity estimated based on habitat amounts and no barred owl influence.

	Land Allocation				
	Congressionally Withdrawn	**Late-Successional Reserve**	**Adaptive Management Area**	**Administratively Withdrawn**	**Matrix**
1993 Habitat Carry Capacity Estimates*	116 (113–118)	152 (149–54)	24 (23-25)	22 (21-24)	78 (76-80)
1993 Habitat Acres	109,692	197,125	28,943	22,178	85,599
2023 Habitat Carrying Capacity Estimates*	97 (95-99)	122 (120-125)	23 (22-24)	22 (20-23)	77 (75-79)
2022 Habitat Acres	91,006	190,735	33,861	20,420	105,588

* Based on Glenn et al. (2017) and Davis et al. (2022), showing 95% confidence intervals.

3.3.6. Habitat Connectivity

The NWFP addressed habitat connectivity by intentionally locating the LSRs throughout the plan area, with the spacing between LSRs based largely on natal dispersal distances for northern spotted owls (ISC 1993). Additional management direction in the NWFP provided for habitat between the LSRs to facilitate species movements. This included Riparian Reserves, retention of 100 acres of the best habitat around spotted owl activity centers outside of reserves, and retention of 15% of forest within harvest units. Collectively, management direction was intended to provide a connected network of habitats for species associated with late-successional and old forest.

In this LSR Assessment, habitat connectivity was assessed by developing maps of resistance surfaces based on movement capability of groups of species (see Appendix I for more detail on methods). Resistance is a commonly used approach to identify combinations of factors that influence species movement and habitat connectivity and has been used in other similar types of assessments (Singleton et al. 2002; WHCWG 2010, 2013). The primary assumption of this approach was that as resistance to movement increased, habitat connectivity decreased.

The approach allowed for an assessment of changes to habitat connectivity over time and space, and used spatial data for human development, major highways and freeways, major waterways, non-forest, and forest composition and structure. The forest composition and structure data were derived from the NWFP monitoring data for the years 1993 and 2021 to assess temporal changes in resistance to movement across the Forest and within each LSR. Resistance values were assigned based on a literature review for low (e.g., mountain snails, plants, etc.) and moderate mobility species (e.g., Pacific marten, fisher, northern flying squirrels, etc.). In addition, northern spotted owl habitat connectivity was assessed using the "dispersal-capable landscape" assessment tool described in Davis et al. (2022).

In this section, resistance to wildlife movement for the LSR network is summarized by showing how resistance has changed in the areas between the LSRs across the Forest for moderate mobility species and for the northern spotted owl. In addition, changes to resistance values within the four largest LSRs are summarized to show how habitat connectivity has changed for moderate and low mobility species. Changes to resistance values within each individual LSR for low and moderate mobility species are presented in Appendix B.

There have been substantial increases in resistance to species movement across the LSR network and a corresponding decrease in habitat connectivity for low mobility (Table 3.9), moderate mobility (Table 3.9, Figure 3.16) and high mobility species (see northern spotted owl dispersal capable landscape, Figure 3.17). The reduction in habitat connectivity (increase in resistance) is primarily a result of large patches of high severity wildfire and is most evident in the northern and central portions of the LSR network (Figure 3.16) where the greatest changes have occurred since 1993. When the initial LSR assessments were completed, the LSR network was relatively well connected for moderate mobility species with the exceptions of the areas around Lake Chelan and along the Interstate 90 corridor. However, wildfires have further fragmented habitats in these areas but also fragmented habitats in the central portion of the network, considerably reducing habitat connectivity between the Swauk, Icicle, and Chiwawa LSRs. Similarly, a reduction in the "dispersal-capable landscape" for the northern spotted owl is most severe in the northern portion of the LSR network (Table 3.9, Figure 3.17). Wildfires have considerably reduced habitat connectivity for many wildlife species on the northern portion of the network, resulting in considerable gaps in late-successional and old forest habitats that have fragmented the LSR network compared to conditions in 1993. In some cases, habitat connectivity within LSRs has been significantly reduced as well. In the Upper Methow, Swauk, Chiwawa, and Manastash LSRs, resistance to animal movements has greatly increased for both low and moderate mobility species since 1993 (Table 3.9).

Another element of monitoring tracked by the NWFP monitoring team focuses on the dispersal-capable habitat landscape (Davis et al. 2016). A dispersal-capable landscape was defined as areas within a 15.5 mi radius moving window with ≥ 40 percent dispersal habitat. The amount of dispersal capable landscape for spotted owls has decreased across the OWNF and within the LSR network, particularly within the Upper Methow and Swauk LSRs (Table 3.10, Figure 3.17). The Manastash LSR has experienced a smaller decrease in dispersal capable landscape.

Table 3.9-Percent increase in resistance to wildlife movements for low and moderate mobility species across the Late-Successional Reserve network and within the four largest Late-Successional Reserves on the Okanogan-Wenatchee National Forest from 1993 to 2021. Resistance was calculated as the total cost weighted distance within an individual LSR, or the total of cost-weighted distance for all LSRs/MLSAs within the LSR Network.

Late-Successional Reserve	Low Mobility Species	Moderate Mobility Species
Chiwawa	31%	29%
Manastash	23%	22%
Swauk	58%	52%
Upper Methow	26%	27%
Network	33%	31%

Table 3.10-Comparison of dispersal capable landscape on the Okanogan-Wenatchee NF and within the LSR Network from 1993 to 2022 (Davis et al. 2016).

	Year	Acres	% change
Forest	1993	2,600,833	-52%
	2022	1,260,261	
Network	1993	741,330	-63%
	2022	271,821	

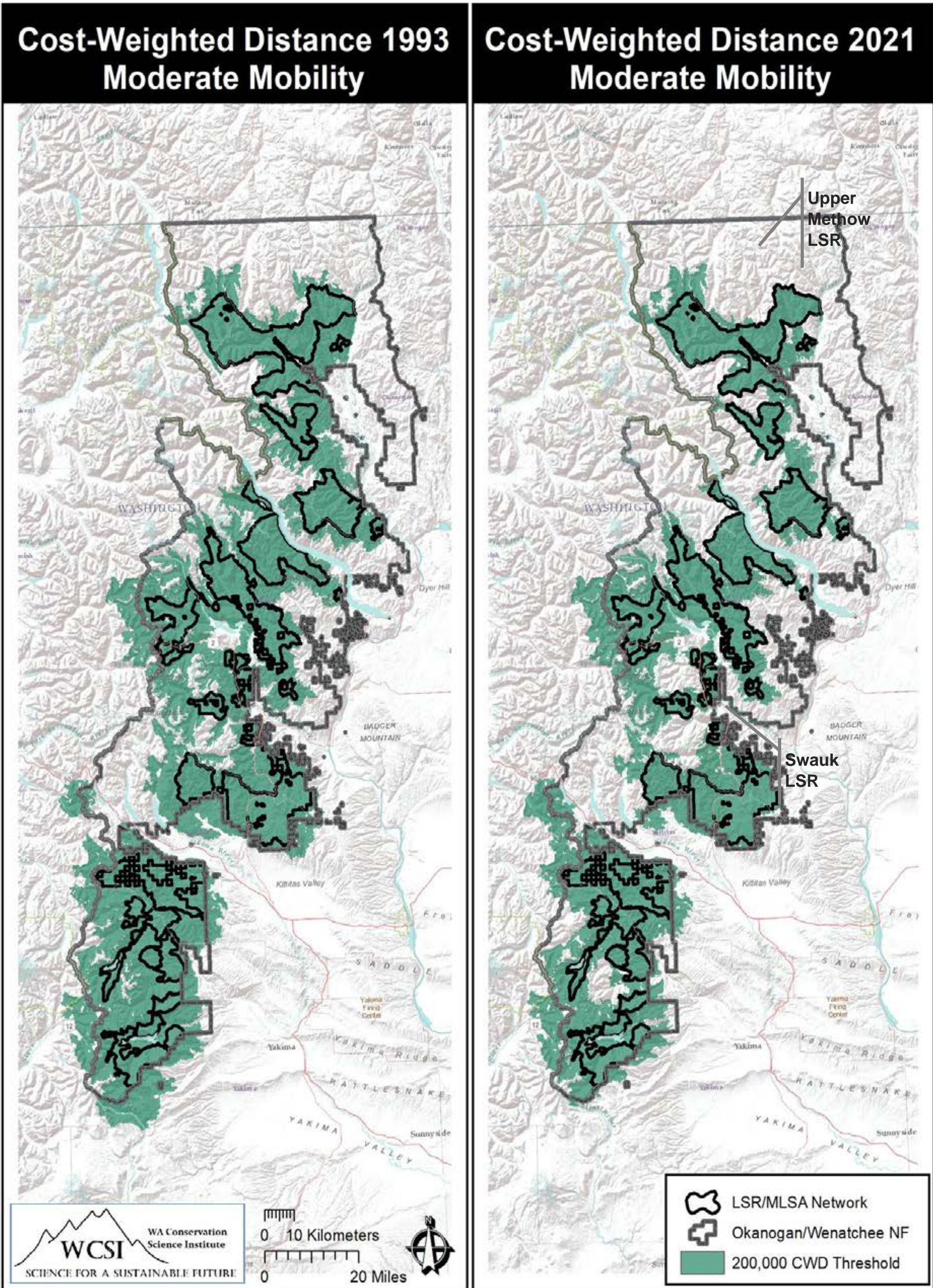


Figure 3.16-Comparison of resistance to moderate mobility wildlife movements across the Okanogan-Wenatchee National Forest, 1993-2021.

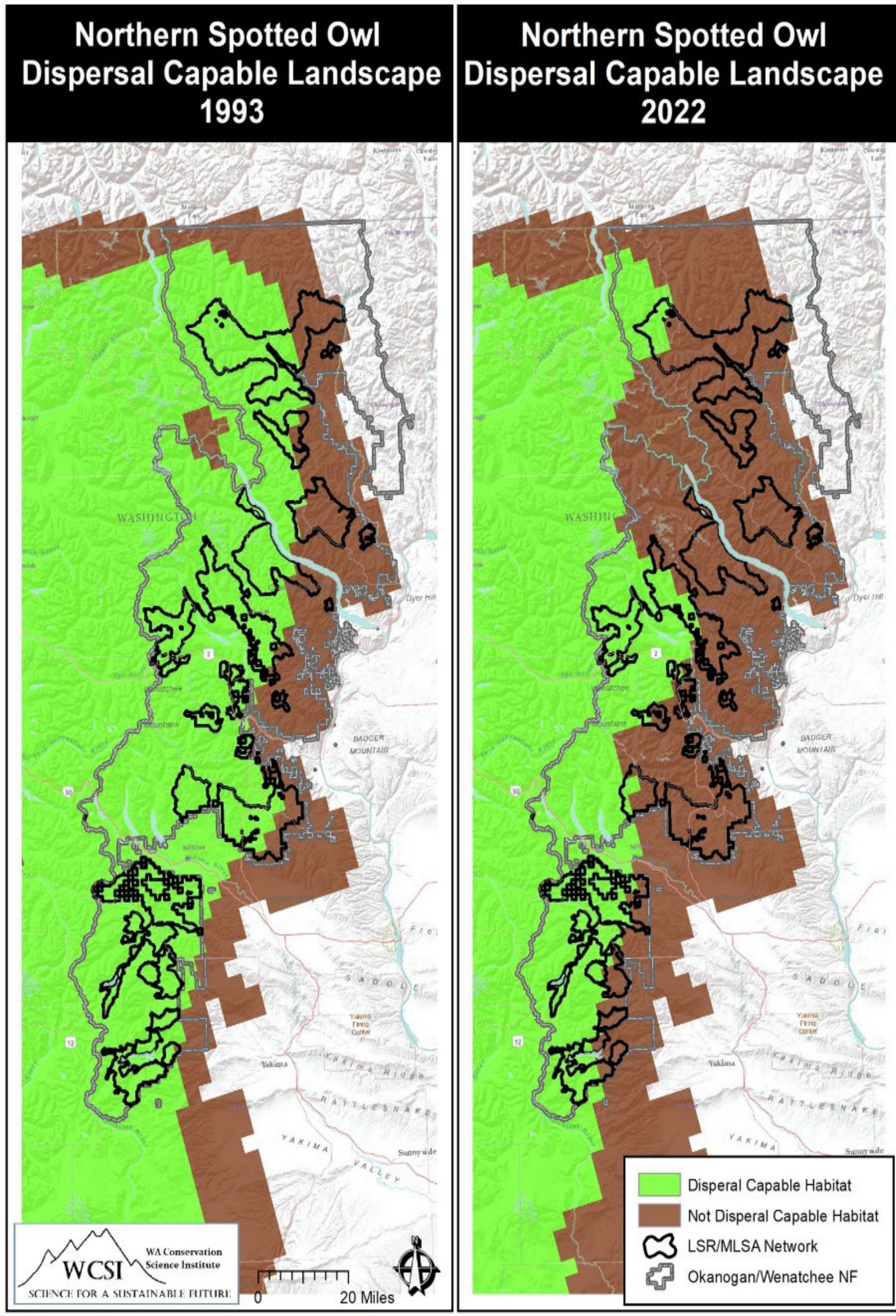


Figure 3.17-Distribution of spotted owl dispersal capable landscape across the OWNF in 1993 and 2022.

3.4. Current Condition Summary

In summary, key information relative to changes to conditions within the LSR network include:

- Large disturbances, and especially wildfires, have considerably reduced the amount of late-successional and old forest habitats both across the Forest and within the LSR network. These habitat losses have exceeded the redundancy built into the NWFP reserve network. In some LSRs (e.g., Upper Methow, Lucerne, Twisp River, Hunter Mountain, Nice, Slide Peak, Shady Pass, Teanaway, Upper Nile have >50% loss) the habitat loss from wildfire has been so extensive that these LSRs are no longer effectively providing functional and connected LSOF habitats for late successional and old growth dependent species.
    - For northern spotted owls the rate of habitat loss from disturbance has been considerable. Insect mortality and wildfires have been the primary contributors to a decline in suitable habitat by 34% across the Forest and by 35% within the LSR network.
- Barred owls are widespread across the Forest, including within the LSR network, and are having considerable negative impacts on northern spotted owls. Although outside of the scope of this LSRA, barred owl management to reduce the negative impacts to spotted owls is currently being proposed by USFWS but a decision has not been reached. Any actions would need to be extensive and continual to achieve spotted owl recovery objectives.
- The number and distribution of northern spotted owls on the Forest and within the Late-Successional Reserve network has been considerably reduced since the mid-1990s. Currently, the few spotted owl detections that have occurred in the past five years are primarily located on the southern portion of the Forest and the LSR network. Reducing the risk of continued large-scale habitat loss to wildfires and other disturbances is of critical importance.
- Habitat connectivity for old forest associated species has been considerably reduced for low and moderate mobility species and for the northern spotted owl as a result of habitat loss from disturbances, and especially wildfire. The reduction in habitat connectivity is most pronounced in the northern portion of the Forest and the LSR network.

4. RISK ASSESSMENT OF LATE-SUCCESSIONAL AND OLD FOREST HABITATS

The previous section (Section 3) presented an assessment of the current condition of various late-successional and old forest habitats and how those conditions have changed since 1994. A major emphasis of the Standards and Guidelines in the NWFP (as described in Section 2) addresses reducing the risk of habitat loss from large-scale disturbances. In this section (Section 4), a risk assessment of the remaining late-successional and old forest habitats is presented. Risk was assessed using multiple sources of information and evidence. First, the current amounts of different late-successional and old forest habitats were compared to estimates of the natural range of variability. Next, the risks to large-tree dense-forest habitats were assessed using information on current and projected moisture deficit and fire risk. The amount of area that is likely to be retained as "fire refugia" was identified using projections for moderate and extreme fire weather scenarios. Finally, the potential future impacts of forest insects and diseases were used to project the number of acres that are susceptible to high levels of tree mortality. These assessments were completed for late-successional and old forest habitats across the OWNF, within the LSR network, and for each individual LSR and MLSA (presented in Appendix B). A risk matrix was then used to assess which LSRs are at the greatest risk of habitat loss and which are more sustainable and resilient to future disturbances.

4.1. Current Habitat Compared to Reference Conditions

The utility behind natural range of variability (NRV) is that the broad historical envelope of possible ecosystem conditions, such as burned area, vegetation cover type area, or patch size distributions, provides a representative time series of reference conditions to guide land management (Morgan et al. 1994, Aplet and Keeton 1999, Keane et al. 2009, Lehmkuhl et al. 2015). This theory assumes the following (based on Keane et al. 2009): (1) ecosystems are dynamic and their responses to changing processes are represented by past variability; (2) ecosystems are complex and have a range of conditions within which they are self-sustaining, and beyond this range they transition to disequilibrium; (3) historical conditions can serve as a proxy for ecosystem health; (4) time and space domains of NRV are sufficient to quantify variation; and (5) the ecological characteristics being assessed for ecosystems or landscapes match the management objective. The natural range of variability can provide useful insights on how ecosystems have changed (or remained stable) over time and what ecosystem characteristics (e.g., structural, compositional) provide for resistance and resilience to disturbances.

Natural range of variability is used in this risk assessment to understand the degree to which LSOF conditions[6] are departed from historic conditions and to evaluate restoration need. Estimating landscape departure from the NRV is a coarse filter approach to assessing biodiversity and assumes that functioning landscapes will provide for the viability of the species found within them. Rare habitats and their associated species may require additional measures to ensure viability, but NRV is, nevertheless, a useful benchmark of how well landscapes are

[6] Defined for the purposes of this assessment using large tree structure and open (<50%) or dense (>50%) canopy cover derived from recent (2021) GNN data. See Appendix I for additional details.

functioning overall. A key assumption of this approach is that when a landscape is determined to be outside of reference conditions (NRV) there is an increased risk of habitat loss from uncharacteristic disturbances and a corresponding decline in landscape resilience. Despite ongoing climate change and the possibility of novel future conditions, moving systems towards NRV is likely to be an improvement over current conditions in terms of adaptation to climate change impacts (Keene et al. 2009).

Estimates of the NRV used in this assessment were derived from three main sources: historical photos used to reconstruct landscapes (Hessburg et al. 1999a), historical forest inventories (Halofsky et al. in review.), and state-transition models (ILAP, Halofsky et al. in review.). Where possible, multiple lines of evidence were used to estimate variability ranges. Current estimates of each habitat type were summarized using GNNv2023.1 data up through 2021 (see Appendix I for additional details; Bell et al. in review).

4.1.1. Dry Forest Large-Tree Open-Canopy Habitats

Historical estimates (Table 3.4) of the different types of old forest in this group suggest that about 33-47% of the Dry Forest Group were in large-tree-open canopied (<50% canopy cover) condition while only a small proportion (2-15%) was comprised of large tree-closed canopy (>50% canopy cover) condition. Currently, about 4% of the Dry Forest Group on the Forest, and 5% of the Dry Forest Group within the LSR network is comprised of large-tree open-canopy habitats, considerably below the historical estimates.

4.1.2. Moist Forest Large-Tree Closed-Canopy Habitats

Estimates of the NRV for Large-Tree Closed-Canopy habitats in the Moist Forest Group are 15-30% (Table 3.4). Currently there are 256,800 acres (60%) of the Moist Forest Group on the OWNF in a Large-Tree Closed-Canopy condition. At the scale of the LSR network, there are 100,120 acres (65%) in a Large-Tree Closed-Canopy condition. These estimates suggest that the amount of Large-Tree Closed-Canopy habitats within the Moist Forest Group are considerably above the NRV at both the Forest and LSR network scales.

4.1.3. Dry and Moist Forest Large-Tree Closed-Canopy Habitats

Halofsky et al. (in prep) used multiple lines of evidence (historical photos, historical forest inventory, state-transition model) to estimate the NRV for large-tree closed-canopy forest structure in the Dry and Moist Mixed Conifer Forests of the eastern Cascades. They found that historically about 18-24% of the forested landscape was in large-tree closed-canopy structure and that these estimates were remarkable consistent across multiple lines of evidence. The structural characteristics used by Halofsky et al. (in prep.) to map large-tree closed-canopy forest were based on an assessment of conditions used by northern spotted owls (Halofsky et al. in review) and thus represent an estimate of potential northern spotted owl habitat based on Digital Aerial Photogrammetry (DAP). Presently, there are 688,322 acres (49%) of the Dry and Moist Forest Groups on the OWNF are in a large-tree closed-canopy condition (Table 3.4). Similarly, 280,740 acres (59%) of the Dry and Moist Forest Groups in the LSR network are in a large-tree closed

canopy condition. The amounts of these habitats are presently well above the NRV for this forest structure, especially within the LSR network.

4.1.4. Cold Forest Medium-Large-Tree Closed-Canopy Habitats

Historical estimates suggest that 20-60% of these forests may have been dominated by medium to large trees with a closed-canopy condition (Table 3.4). Currently, 366,842 acres (23%) of the Cold Forest Group on the OWNF is in a medium-large tree closed-canopy condition. There are 81,374 acres (24%) of the Cold Forest Group within the LSR network in a medium-large tree closed canopy condition, which is near the low end of the historical estimates.

The comparison of current conditions to the natural range of variability component of the risk assessment shows considerable departures in the amount of Large-Tree Open-Canopy habitats in the Dry Forests and Large-Tree Closed-Canopy habitats in the Dry and Moist Forests. The amount of habitat for Large-Tree Open-Canopied species is well below historical levels and is a key factor that reduces their viability outcomes (Gaines et al. 2017). The Large-Tree Closed-Canopy habitats in the Dry and Moist Forests are considerably above their historical amounts suggesting they may be at risk of habitat loss from large-scale disturbances. The amount of Cold Forest in a late-successional and old forest condition is currently at the low end of the historical estimates, and significant habitat losses associated with large-scale high severity wildfires, especially on the northern portion of the Forest, has decreased the probability of persistence of some species associated with these forests (e.g., King et al. 2020a, b; Lyons et al. 2023).

4.2. Large Tree Dense Forest Sustainability

To understand where existing large tree structure might be able to be sustained on the landscape, information on large trees (from Digital Aerial Photogrammetry, WADNR 2022), fire's expected net value change (eNVC) to forests from the Quantitative Wildfire Risk Assessment (Gilbertson-Day et al. 2018), and drought vulnerability using current (1981-2010) and future (RCP 8.5 2040 – 2070) climatic water deficit derived using an ensemble global circulation model (Cansler et al. 2022, WADNR 2020) were combined into a "Large-Tree Dense-Forest Sustainability" layer (Figure 1.1, Figure 4.1; see Appendix I for additional details). These data sources were used to develop a probability surface assigned to each pixel of forest based on potential risk of drought and wildfire (Table 4.1).

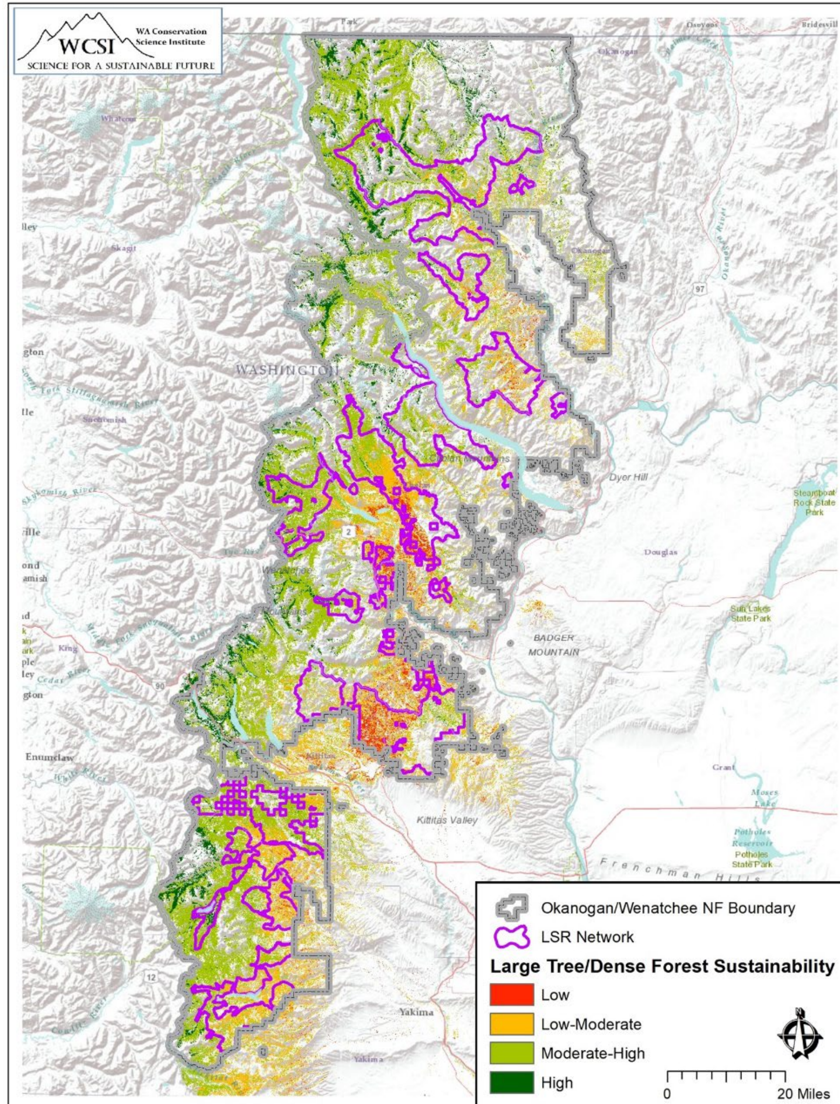


Figure 4.1-Map of existing dense large tree structure categorized into four categories of sustainability based on fire risk and drought vulnerability. Dense large tree structure is mapped using Digital Aerial Photogrammetry (DAP) data from 2022 and uses tree height and canopy cover.

This component of the risk assessment showed that Large-Tree Dense-Forests are most at risk where they occur in the Dry Forest (60-64% are in very low-low sustainability categories) and are more sustainable in the Moist and Cold Forest Groups (>66% are in the moderate to high sustainability categories; Table 4.1). It is important to note that one reason there are not more acres and a higher proportion of Large-Tree Dense-Forest in the Very Low sustainability category in the Dry and Moist Forest Groups is because extensive large fires on the north end of the Forest removed large areas of large tree cover (i.e., areas with higher fire risk and drought vulnerability have few remaining large trees; See Table 4.2 for Upper Methow LSR, Churchill et al. 2022). A considerable proportion of the least sustainable (most at-risk) Dry and Moist Large-Tree Dense-Forest habitat has already burned in wildfires in the Upper Methow LSR (Table 4.2), and rapid successive reburns could inhibit seed sources and post-fire regeneration (Coop et al.

2020, Hoecker et al. 2023). The Chiwawa and Manastash LSRs exhibited a similar trend with substantial area of low sustainability, however they appeared to have lower level of risk compared to the Upper Methow and Swauk LSRs(Table 4.2, Table 4.3, Table 4.4, Table 4.5). The Swauk LSR remains at considerable risk due to the high proportion of Large-Tree Dense-Forest Habitat in the Very Low and Low sustainability categories (51%, Table 4.4).

Table 4.1-Area of Large-Tree Dense-Forest in each sustainability category and for each Forest Group within the Okanogan-Wenatchee National Forest and the LSR network.

		Forest Sustainability Category			
Forest Group		**Very low acres (%)**	**Low acres (%)**	**Moderate acres (%)**	**High acres (%)**
Dry Forest Group	Forest	50,749 (12)	208,144 (48)	154,619 (36)	18,009 (4)
	Network	29,111 (16)	87,160 (48)	60,463 (33)	3,992 (2)
Moist Forest Group	Forest	6,681 (3)	57,677 (22)	164,194 (64)	28,250 (11)
	Network	4,574 (5)	29,255 (29)	60,420 (60)	5,767 (6)
Cold Forest Group	Forest	2,386 (<1)	77,089 (11)	504,277 (72)	112,740 (16)
	Network	1,547 (1)	33,278 (20)	116,889 (72)	11,127 (7)

Table 4.2-The sustainability of the large-tree dense-forest habitat in Dry and Moist Forest Groups (61,543 acres) in the Upper Methow Late-Successional Reserve.

Sustainability Category	**Dry Forest Large-Tree Dense-Forest (acres)**	**Moist Forest Large-Tree-Dense Forest (acres)**	**Total: Dry and Moist Forest (acres)**	**% Large-Tree Dense- Forest in Dry and Moist Forest**	**% of LSR in Large-Tree Dense-Forest**
Very Low	160	0	160	<1%	<1%
Low	4,511	125	4,636	8%	2%
Moderate	15,233	8,860	24,093	39%	13%
High	2,230	1,612	3,842	6%	2%
Total	22,134	10,597	32,731	53%	17%

Table 4.3-The sustainability of the large-tree dense-forest habitat in Dry and Moist Forest Groups (53,560 acres) in the Chiwawa Late-Successional Reserve.

Sustainability Category	Dry Forest Large-Tree Dense-Forest (acres)	Moist Forest Large-Tree-Dense Forest (acres)	Total: Dry and Moist Forest (acres)	% Large-Tree Dense- Forest in Dry and Moist Forest	% of LSR in Large-Tree Dense-Forest
Very Low	6,680	1,769	8,449	16%	8%
Low	8,979	8,062	17,041	28%	17%
Moderate	3,837	7,864	11,701	22%	12%
High	88	372	460	<1%	<1%
Total	19,584	18,068	37,651	70%	38%

Table 4.4-The sustainability of the large-tree dense-forest habitat in Dry and Moist Forest Groups (71,569 acres) in the Swauk Late-Successional Reserve.

Sustainability Category	Dry Forest Large-Tree Dense-Forest (acres)	Moist Forest Large-Tree-Dense Forest (acres)	Total: Dry and Moist Forest (acres)	% Large-Tree Dense- Forest in Dry and Moist Forest	% of LSR in Large-Tree Dense-Forest
Very Low	14,027	2,079	16,106	23%	15%
Low	15,549	4,265	19,814	28%	19%
Moderate	6,442	2,573	9,015	13%	8%
High	169	110	279	<1%	<1%
Total	36,187	9,027	45,213	63%	42%

Table 4.5-The sustainability of large-tree dense-forest habitat in Dry and Moist Forest Groups (35,171 acres) in the Manastash Late-Successional Reserve.

Sustainability Category	Dry Forest Large-Tree Dense-Forest (acres)	Moist Forest Large-Tree-Dense Forest (acres)	Total: Dry and Moist Forest (acres)	% Large-Tree Dense- Forest in Dry and Moist Forest	% of LSR in Large-Tree Dense-Forest
Very Low	59	0	59	<1%	<1%
Low	5,950	2,303	8,253	23%	10%
Moderate	6,757	12,058	18,815	53%	24%
High	65	513	578	2%	1%
Total	12,831	14,874	27,705	79%	35%

4.3. Wildfire Hazard

Wildfires have had significant effects to the amount and distribution of late-successional and old forest on the OWNF since the implementation of the NWFP began in 1994 (see Section 3). We assessed fire hazard using the Wildfire Hazard Potential map (Dillon 2023) generated for the continental US. This map uses spatial datasets of wildfire likelihood and intensity generated with the Large Fire Simulator (FSim), as well as spatial fuels and vegetation data from LANDFIRE and point locations of past fire occurrence to generate a wildfire hazard rating (Dillon et al. 2015). This dataset does not explicitly quantify risk to any given values, but rather summarizes the probability or likelihood that current fuel conditions will produce torching, crowning, or other extreme fire behavior under conducive weather conditions. For example, 53% of the forested area on the OWNF and 62% of the forested area within the LSR network have high to very high wildfire hazard potential (Figure 4.2). The risk of additional wildfires remains high and is projected to increase considerably in the coming decades. Even under relatively modest greenhouse gas emissions scenarios, burned area is likely to triple by the 2050s (Littell et al. 2010) with increasing likelihood of large fires (Davis et al. 2017). As a result, sustaining late-successional and old forest habitats is likely to be even more challenging in the near future.

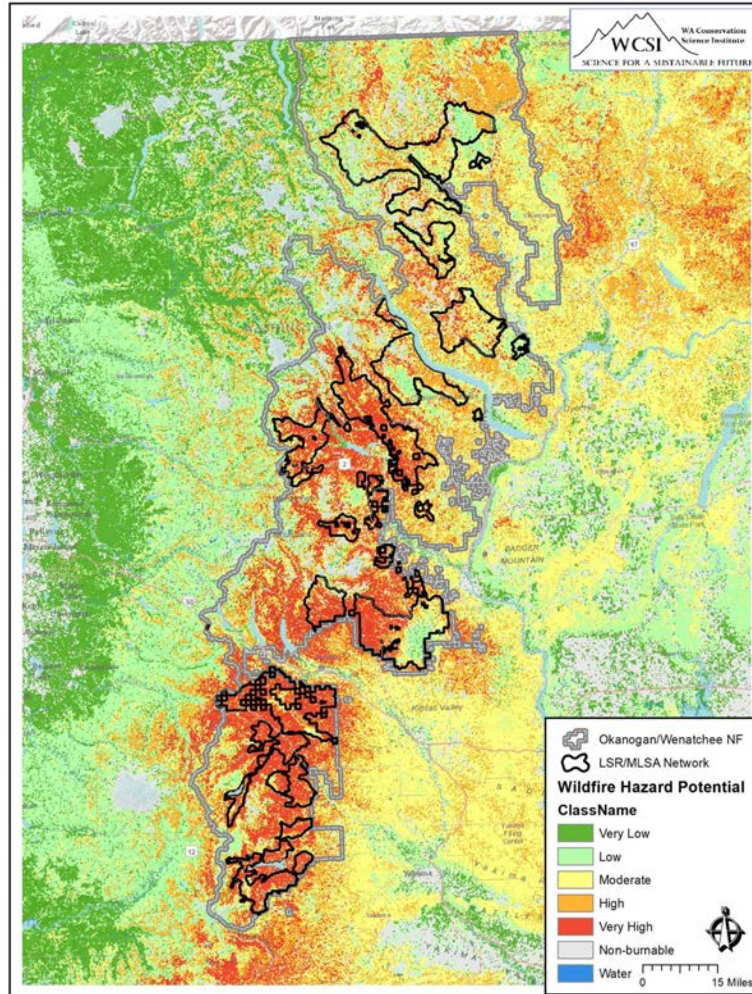


Figure 4.2-Wildfire hazard potential for the Okanogan-Wenatchee National Forest and within the Late-Successional Reserve network.

4.4. Fire Refugia

Fire refugia are areas within a burn mosaic that experience comparatively low-severity fire or remain unburned. These locations can contribute important habitats for species sensitive to fire and support populations that contribute to the reassembly of biotic communities following fire (Camp et al. 1997, Krawchuk et al. 2016, Van Biachi et al. 2017, Lesmeister et al. 2021, Krawchuk et al. 2023). Multiple studies have shown that fire refugia areas are often associated with topographical settings, fire-resistant forest structures, and interior forest microclimates that influence fire behavior and severity (Camp et al. 1997, Krawchuk et al. 2016, Downing et al. 2021, Lesmeister et al. 2021). Identification of potential fire refugia may help managers to determine the best landscape locations where mature and old trees have the greatest probability of survival (Camp et al. 1997, Krawchuk et al. 2016, Lesmeister et al. 2019, 2021) and protection efforts could be focused in future wildfire events. Information from the Oregon State University cooperative fire refugia project was accessed to identify potential fire refugia areas (e.g., Krawchuk et al. 2023). This "holistic" fire refugia model examines the conditional probability of

contemporary fire refugia across the NWFP areas using explanatory variables for topography, fire weather, and fuels or vegetation (e.g., Meigs et al. 2020, Naficy et al. 2021). Models were parameterized using "normal" fire spread conditions (as opposed to "blow-up" fire spread conditions) and 50th (moderate levels of temperature and relative humidity in a fire season) and 90th percentile (high temperatures and low relative humidity in a fire season) fire weather conditions were used in this assessment, as even a smaller proportion of the landscape was quantified as fire refugia under the fire spread (i.e., "blow-up") models.

This portion of the risk assessment showed that very little of the forested areas across the Forest or within the LSR network are likely to function as fire refugia (Table 4.6, Table 4.7). This result varied little across forest groups and under different fire weather conditions. This assessment demonstrates how difficult it is to sustain late-successional and old forest habitats under both moderate (e.g., 50th percentile weather) and extreme (90th percentile weather) fire weather conditions. Fire weather models are not dynamic as they rely on historical weather data to establish percentiles and do not use future climate projections; however, it can be assumed that more fires will occur under 90th percentile (severe) fire weather conditions in the future (see Krawchuk et al. 2023 for interpretations). Sustaining late-successional and old forest habitats may be particularly difficult within the Swauk LSR, where very little area was potential fire refugia under either fire weather condition.

Table 4.6-Area of fire refugia with >50% probability for each Forest Group under moderate (50th percentile) and extreme (90th percentile) fire weather scenarios (based on Krawchuk et al. 2023) within the Okanogan-Wenatchee National Forest and the LSR Network.

		Fire Refugia: >50% Probability	
Forest Group		**Moderate Fire Weather acres (%)**	**Extreme Fire Weather acres (%)**
Dry Forest Group	Forest	22,122 (2)	6,536 (1)
	Network	5,715 (2)	2,230 (1)
Moist Forest Group	Forest	15,384 (4)	5,971 (1)
	Network	5,145 (3)	2,342 (2)
Cold Forest Group	Forest	35,055 (2)	12,277 (1)
	Network	5,543 (2)	2,421 (1)
Total Forest		94,590 (3)	32,940 (1)
Total Network		20,281 (2)	8,585 (1)

Table 4.7-Area of fire refugia under moderate (50th Percentile) and extreme (90th Percentile) fire weather conditions for the four largest Late-Successional Reserves on the Okanogan-Wenatchee National Forest. Percent of LSR that is mapped within fire refugia is also presented.

	Fire Refugia: >50% Probability	
Late-Successional Reserve	**Moderate Fire Weather acres (%)**	**Extreme Fire Weather acres (%)**
Upper Methow	2,233 (1%)	1,256 (1%)
Chiwawa	3,432 (3%)	2,158 (2%)
Swauk	810 (1%)	143 (<1%)
Manastash	3,815 (5%)	1,200 (2%)

4.5. Insects and Disease

Forest insects and diseases have had considerable effects on late-successional and old forests both across the Forest and within the LSR network (see Section 3). For example, bark beetles affected 50% of the Dry Forest, 53% of the Moist Forest, and 57% of the Cold Forest in LSRs. In 2014, 108,491 acres of LSRs were designated as Insect and Disease Epidemic Areas under Section 602(d) of the Healthy Forest Restoration Act (as added by section 8204 of the Agricultural Act of 2014; Figure 4.3), including large portions of the Swauk, Milk Creek, and Tieton LSRs.

Anticipated longer and drier summer seasons along with warmer winters with climate change will also influence the impact that forest insects and disease will have on late-successional habitats (Littel et al. 2010, Bennett et al. 2023). In order to assess these risks, information from the National Insect and Disease Risk Map (NIDRM, Krist et al. 2014) were used to project the number of acres across the Forest and within the LSR network that could be impacted by forest insects and diseases (Table 4.8). NIDRM is a nationwide spatial assessment of the hazard of tree mortality due to insects and diseases. Insect and disease risk, or hazard, is defined as: the expectation that, without remediation, at least 25% of standing live basal area greater than one inch in diameter will die over a 15-year time frame (2013 to 2027) due to insects and diseases (Krist et al. 2014).

These results show that substantial portions of the forested areas on the Forest (1.1 million acres) and within the LSR network (165,650 acres) are projected to experience >25% basal area loss from forest insects and diseases.

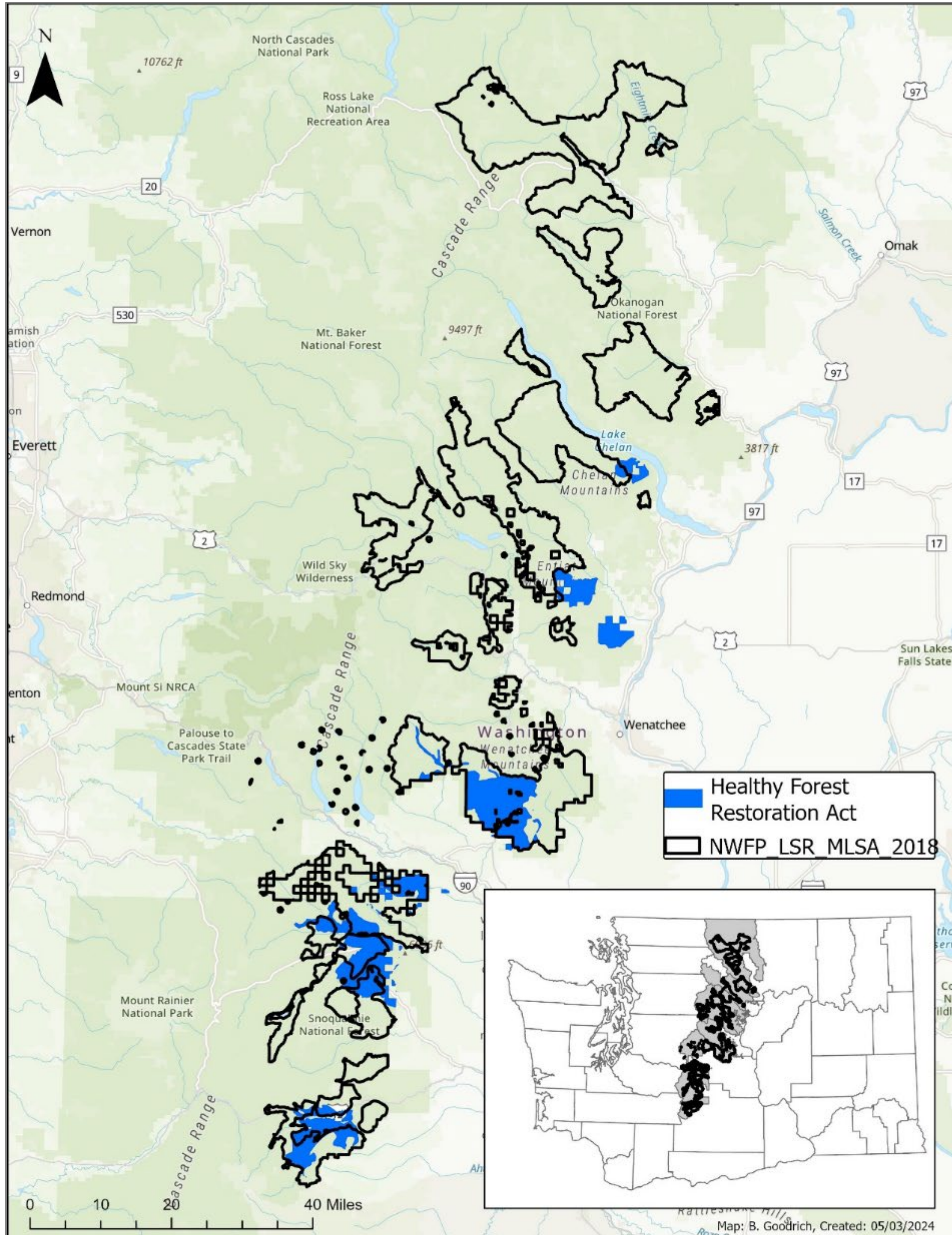


Figure 4.3-LSRs and MLSAs on the Okanogan-Wenatchee National Forest that contain area designated as Insect and Disease Epidemic Area designated by under Section 602(d) of the Healthy Forest Restoration Act. The 2014 Farm Bill amended the Healthy Forests Restoration Act (HFRA) by adding sections 602 and 603 for Insect and Disease Designations. Section 602 provides for 1) a definition of declining forest health; 2) designation of landscape-scale treatment areas; and 3) authorizes the Secretary to carry out priority projects within designated areas to reduce the risk or extent of, or increase the resilience to, insect or disease infestation; and to reduce hazardous fuels. Sections 602(d)(3) authorizes use of the expedited NEPA procedures set out in section 104 of the HFRA for qualified treatments.

Table 4.8-Acres of projected percentage loss of basal area from all pests. Predicted basal area loss > 25% is considered "at risk". Risk is summarized at the 240-m pixel scale. In more productive sites or stands dominated by mature or old forests, lower basal area (< 25%) mortality may still represent a considerable loss, especially if that mortality is concentrated in a single species or larger size class.

Location	1-5%	6-5%	16-25%	26-35%	>35%
Okanogan-Wenatchee National Forest	259,022	545,216	944,794	758,448	343,654
Late-Successional Reserve Network	122,124	207,852	226,370	135,261	30,389
Four Largest LSRs					
Chiwawa	10,020	20,582	28,581	20,368	5,024
Manastash	13,123	23,784	20,596	9,480	726
Swauk	11,899	22,916	32,694	17,180	2,847
Upper Methow	37,206	32,751	26,503	10,220	2,405

4.6. Risk Assessment Matrix

The information presented above was used to create a matrix of risk factors in order to assess which of the LSRs are at the greatest risk. The information that was summarized for each LSR included: (1) the degree of departure from reference conditions, (2) the proportion of forest in very low and low sustainability large-tree dense-forest categories, (3) the proportion of fire refugia under moderate fire weather conditions, and (4) the proportion of forest with projected basal area loss >25% from forest pests (Figure 4.4).

The results of the risk matrix (Figure 4.4) showed that the most at-risk LSRs/MLSAs included the Tieton, Swauk, and the Naches Group. Risk reduction activities in these LSRs is particularly warranted. Risks in other LSRs are still high but not as extreme as those listed above. These included the Wenatchee River Group, Manastash, and Chiwawa. The LSRs that are a relatively lower risk included Upper Methow, Teanaway, Methow/Twisp Group, and Chelan Group where considerable amounts of wildfire has removed some of the most susceptible habitats (e.g., large-tree dense-forest). Additional information on risks within individual LSRs/MLSAs is provided in Appendix B.

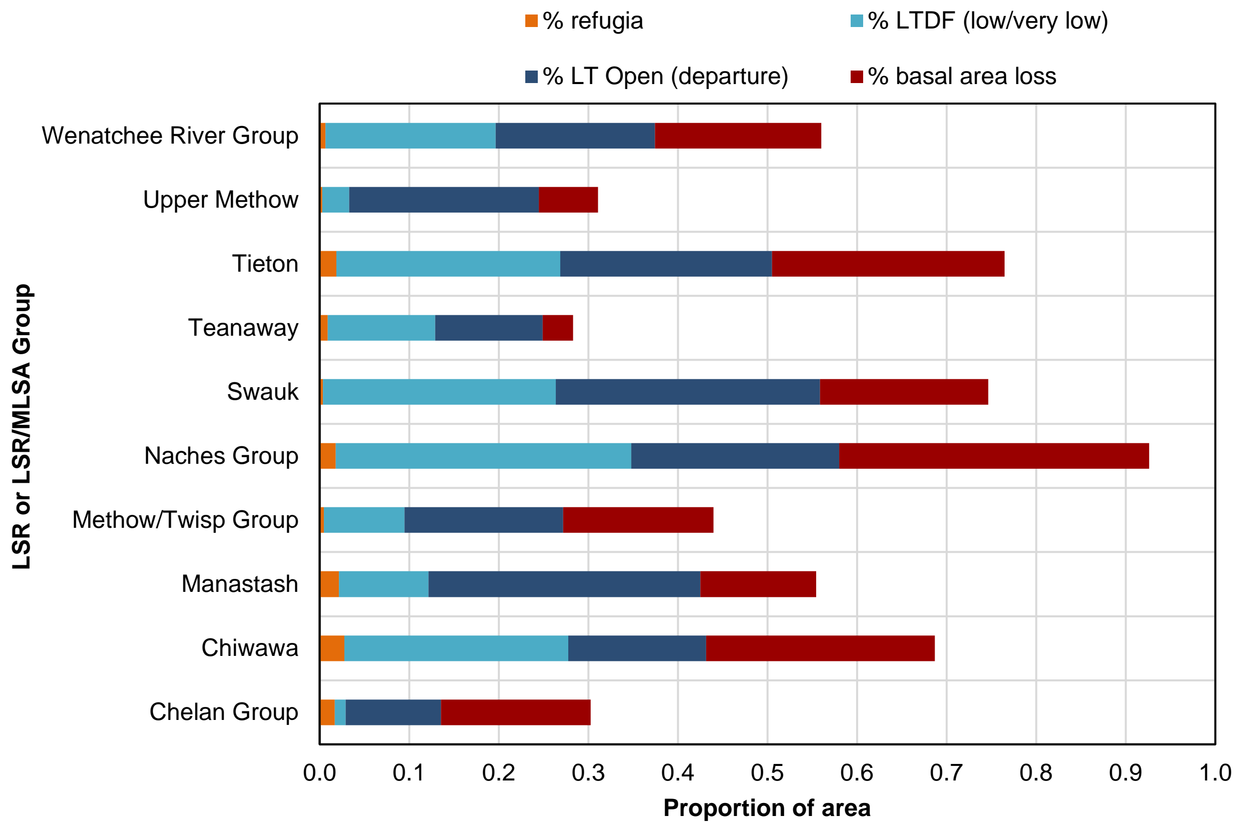


Figure 4.4-Risk factors for each LSR or LSR/MLSA group summarized by the proportion of area that is at risk or affected. LSRs or LSR groups with high degrees of departure in large tree open canopy (LT Open; dark blue) habitats, low sustainability of existing large dense forest (LTDF; light blue) structure, and high predicted basal area loss from insect mortality (red) are considered the most at-risk LSRs.

4.7. Risk Assessment Summary

- Large-scale disturbances, in particular wildfires, are creating considerable risk of continued degradation and possibly permanent loss from wildfires, challenging the ability of forest managers to meet the conservation goals of the NWFP for late-successional forest species in the Dry and Moist Forests on the OWNF (Gaines et al. 2015, Hessburg et al. 2015, Halofsky et al. in review.). The present forest conditions in combination with ongoing and predicted effects of climate change (e.g., longer fire seasons, increased drought) present tremendous challenges for managers attempting to accomplish both short-term single-species goals and longer-term ecosystem resiliency goals (Jones et al. 2016, Stephens et al. 2020, Hessburg et al. 2021, Gaines et al. 2022). The risk assessment for the LSR Assessment, using multiple lines of evidence, supports the conclusions of these and many other studies.

- The wildfire threat to late-successional habitats is primarily associated with high surface fuel loads and ladder fuels from understory trees (Franklin et al. 2000, Keane 2014, Hessburg et al. 2016). Forest densification, homogenization, increased canopy cover and

layering, and compositional shifts toward shade–tolerant, fire-sensitive tree species have benefited a number of wildlife species, but assessment of the NRV suggests that the resulting habitats is largely novel and likely ephemeral. There are landscape-level tradeoffs associated with creating more fire-resilient stand structures and habitats (Gomez et al. 2005, Manning et al. 2012, Moriarty et al. 2016), and these tradeoffs must be weighed against potential habitat loss associated with extensive high-severity fires. Some of these risks can be reduced by leaving larger patches of untreated forest that are surrounded by thinned open-canopy patches that can isolate the risk of crown fire (Ager et al. 2007, Hessburg et al. 2016). Managing these forests and habitats toward more resilient conditions can be informed by better understanding their historical conditions while also considering ongoing and future climate impacts through thoughtful landscape-scale planning (Gaines et al. 2010a, Hessburg et al. 2016, Halofsky et al. in review.).

- A substantial amount of the Cold Forest has been affected by wildfire since 1994. In addition, over half (57%) of the Cold Forest has been impacted by bark beetles. This has considerably reduced the amount of old forest habitats for species associated with Cold Forest. This trend is likely to continue as a result of past management practices, including timber harvest and fire suppression, combined with increasing risks of wildfires and the ongoing and projected climate change effects (Lyons et al. 2023). Past fire suppression resulted in large areas of dense forests with extensive fuels. A substantial portion of these forests have now experienced high severity wildfires and now have large expanses of standing dead trees, downed wood, and a developing understory of lodgepole pine and subalpine fir. Considerable concerns have been raised about the sustainability of these forests and the potential for reburn (Stevens-Rumann and Morgan 2019, Povak et al. 2023, Prichard et al. 2023). Management strategies need to be implemented to reduce climate and wildfire vulnerability and increase habitat sustainability by recreating a more structurally diverse forest landscape more typical of Cold Forest ecosystems where fire played its historical role (Hagmann et al. 2021).

- Restoration and risk reduction efforts are imperative to reduce the risk of further large-scale habitat losses from disturbances, in particular wildfires. This will require using the full flexibility afforded by the Risk Reduction management direction in the NWFP (C-12-13) and the emphasis on ecosystem restoration for the East Cascades provinces described in national direction on ecosystem resiliency and in the northern spotted owl Recovery Plan (USFWS 2011) and critical habitat rule (USFWS 2012a).

5. RESTORATION PRINCIPLES, TREATMENT EFFECTIVENESS, AND LANDSCAPE EVALUATIONS

This section presents a review of primarily local research on the effects and effectiveness of forest restoration and risk reduction treatments at the landscape and stand scales. This section also provides an overview of an analysis process, called the Landscape Evaluation, that can be used to understand how landscapes will be evaluated to inform the application of the assessment framework and design criteria (Section 6). In particular, the section provides a description of how late successional and old forest habitats would be evaluated within a landscape to assess risks to these habitats, determine the most sustainable locations for these habitats, and identify opportunities to maintain or enhance habitat conditions, reduce risk of habitat loss to large-scale disturbances and increase landscape resiliency.

5.1. Landscape-Scale Treatment Effectiveness

Wildfires and insect mortality have modified the structure, composition, and patterns of forested landscapes at rates that have far exceeded mechanical thinning and prescribed fire treatments on the OWNF over the past 30 years. Some studies have shown that these disturbances, especially fire, restore landscape resiliency to future climate and wildfires while others show that they contribute to further departures from the natural range of variability and leave landscapes prone to large-scale and severe reburn (Haugo et al. 2019, North et al. 2021, Churchill et al. 2022, Prichard et al. 2023). Churchill et al. (2022) studied landscape-level effects of four wildfires that occurred in eastern Washington between 2014-2017, two of which were located on the OWNF. They found that large patches of high-severity fire in the dry and moist mixed-conifer forests homogenized landscape pattern beyond the Future Range of Variability (FRV, a warmer-drier climate change analog) toward simplified conditions dominated by non-forest vegetation types. Fires realigned and reconnected landscape patterns with the topo-edaphic template in some cases, but pre-existing fragmentation and spatial mismatches were compounded in many other cases. Patches of large-tree closed-canopy forest were reduced by high severity fire, killing even the largest trees, and reducing the potential for this structure within these fire footprints for decades to centuries. The potential to restore more climate-adapted large-tree, open-canopy forest was also lost in these patches.

Re-establishing landscape patterns following large disturbances with desired patch sizes of forest, in particular patches with large trees, will take many decades to centuries and may not naturally occur in drier locations or where seed trees are no longer present. Furthermore, local reforestation efforts suggest that it may become increasingly difficult to reestablish trees in fires that burn in dry locations at edge of forest and shrubland ecotones (Meigs et al. 2023). Intentionally planned mechanical and prescribed fire treatments that are integrated with strategic wildfire response will better prepare and adapt landscapes for future wildfires and climate (Prichard et al. 2021, Churchill et al. 2022, Prichard et al. 2023).

Recent and ongoing research and monitoring have focused on determining the conditions under which restoration treatments are likely to reduce drought and insect-related mortality, and fire spread and the risk of habitat loss, particularly under extreme fire weather conditions. Research

on wildfires that occurred on the OWNF showed that fire behavior and burn pattern were moderated by treatments and that areas treated with thinning and underburning or with underburning-only had greater percentages of unburned and low severity wildfire areas compared to untreated or thinning-only treatments (Prichard et al. 2010, 2020). The fires in these studies burned under some severe fire weather, in particular high winds. These results provided evidence that strategic placement of fuel reduction treatments can effectively reduce fire spread and severity even under severe fire weather (Prichard et al. 2010, 2020). Additional research from dry-mixed conifer forests across the west demonstrates that restoration treatments designed to reduce fire risk that include thinning, or a combination of thinning and prescribed fire, can also reduce drought and insect-related mortality during widespread insect outbreaks (Hood et al. 2016, Kalies and Kent 2016, Restaino et al. 2019, Prichard et al. 2012). In forest stands that were thinned and underburned, remaining trees were able to maintain growth rates and had lower mortality rates during drought than trees in untreated stands (Tepley et al. 2020, Young et al. 2023).

Thinning can also be an important tool for improving forest health and accelerating the development of large tree structure. Management that restores historically appropriate stand densities with thinning treatments can improve individual tree growth and vigor (Sala et al. 2005, Looney et al. 2024), as well as overall forest resilience to drought-related stress by reducing competition and tree water stress in dry, snowpack dominated precipitation environments (Tague et al. 2018, Gleason et al. 2017, Gleason et al. 2021). Mortality rates in pine-dominated mixed-conifer forests in California were highest in dry forest sites with high basal area during an extreme 4-year drought (Young et al. 2017). In contract, low density stands (~40 ft^2/ac BA) in relatively dry sites experienced relatively low mortality during the same drought (Young et al. 2017). Thinning may also decrease the susceptibility to insect-related mortality, as tree inherent insect and disease defenses are increasingly compromised by competition-related stressors (Fettig et al. 2007, Hood et al. 2016). Because thinning reduces competition for resources in water-limited forested systems and can impact individual tree growth, it can be an effective climate adaptation strategy to address future climate-related sensitivities (Halofsky and Peterson 2016).

5.2. Stand-Scale Treatment Effectiveness

Numerous local research projects have been carried out on the Forest to better understand the effect and effectiveness of forest restoration treatments, mostly in the Dry Forests (see McIver et al. 2012 for a synthesis). The results of these monitoring and research studies showed that restoration treatments that incorporated thinning and prescribed fire were effective at restoring more natural (historical) stand-level structure and species composition, and the spatial distribution of key habitat features (e.g., large trees; Harrod et al. 2009, Hessburg et al. 2010). Restoration treatments created more characteristic fuel patterns and fire behavior by reducing fire severity and restoring predominately low-severity fire (Agee and Lolley 2006, Prichard et al. 2010). Additionally, restoration treatments restored more characteristic understory plant species composition and abundance, with little or no increase in invasive vegetation (Povak et al. 2008).

Restoration treatments were also effective at restoring habitat conditions for a variety of bird species, including those with conservation concerns. For example, white-headed woodpeckers, white-breasted nuthatches, and pygmy nuthatches showed positive responses to thinning and burning treatments that retained the large trees and mimicked historical tree spatial patterning (Gaines et al. 2007, Saab et al. 2007, Gaines et al. 2010b). Survival rates were little influenced by treatment effects apart from spring burning which occurred during nesting (Gaines et al. 2010b). In addition, restoration treatments enhanced foraging habitat conditions for nuthatches and woodpeckers, and these species foraged on the largest available trees in the treated stands (Lyons et al. 2008).

5.3. Restoration Principles

A culmination of the above-described research, along with practical experience of forest restoration implementation, resulted in a collaborative synthesis of knowledge specific to restoring landscapes in the Pacific Northwest (Hessburg et al. 2015). This synthesis was used to guide the development of the OWNF Restoration Strategy (see below) which is used on the Forest for restoration project planning and treatment prioritization (Box 2; Hessburg et al. 2015). These principles allow project planners and implementers to move landscapes toward more sustainable habitat conditions, reduce the risk of large-scale habitat loss from uncharacteristically large and severe wildfires or insect outbreaks, and enhance ecosystem resiliency.

Box 2-Seven key restoration principles to consider in planning and implementing an integrated landscape restoration project (From: Hessburg et al. 2015):

- ✓ **Principle 1**: Important ecological processes operate across spatial scales – from tree neighborhoods to regional landscapes. *Implication: Planning and management must incorporate and link the tree neighborhood, patch, drainage/hillslope, local landscapes, and regional landscapes.*
- ✓ **Principle 2:** Topography provides a natural template for vegetation and disturbance patterns across the landscape hierarchy scales. *Implication: Use topography to guide restoration treatments*
- ✓ **Principle 3:** Disturbance and succession drive ecosystem dynamics. *Implication: Focus on restoring the ecosystems' inherent fire/disturbance regimes and vegetation successional patterns; other ecological processes will follow.*
- ✓ **Principle 4:** Predictable distributions of forest-patch sizes naturally emerge from linked climate-disturbance-topography-vegetation interactions. *Implication: Focus on restoring the natural distribution of forest patch sizes across landscapes.*
- ✓ **Principle 5**: Patches are "landscapes within landscapes." *Implication: Focus on restoring characteristic tree clump and gap patterns within stands/patches*.
- ✓ **Principle 6:** Widely distributed large, old trees provide a critical ecological backbone for forested landscapes. *Implication: Focus on retaining and promoting large/old trees and post-disturbance large snags and down logs*.
- ✓ **Principle 7:** Traditional patterns of land ownership and management disrupt inherent landscape and ecosystem patterns. *Implication: Develop restoration projects that effectively work across forest ownership and management allocations*

5.4. Okanogan-Wenatchee Forest Restoration Strategy

The original LSR Assessment (USFS 1997, 1998) established an objective "to develop an understandable, consistent and streamlined process for assessing projects planned in LSRs/MLSAs". The process that was established in the original LSR Assessment used a series of assessment modules that have since been replaced by more modern and scientifically rigorous tools for assessing landscape conditions, and this process (known as Landscape Evaluations) was codified with the development of the OWNF Forest Restoration Strategy (FRS; USFS 2012b). The emphasis on restoration of the forest ecosystems upon which spotted owls depend in the northern spotted owl revised Recovery Plan (USFWS 2011) and the implementation of the Ecosystem Restoration directive (initiated in 2008 as an interim directive) further lent support to the development of the FRS and Landscape Evaluation process.

5.4.1. Landscape Evaluations

The FRS (USFS 2012b) was a collaborative effort between the OWNF, USFWS Wenatchee Field Office, and the US Forest Service Research Station Wenatchee Forestry Sciences Lab to develop assessment tools to allow managers to better evaluate and standardize the assessment risks and tradeoffs between restoration of fire regimes, reduction of risks of habitat loss from uncharacteristically severe disturbances, and creation of more sustainable habitat conditions for late-successional and old forest associated species, including the northern spotted owl. In addition, the FRS allowed the forest a tool to better understand the amount and spatial arrangement of different types of late-successional and old forest (e.g., dense multilayered LSOF, open LSOF). Finally, national direction focused on Forest Restoration and Resiliency to better address climate change was also considered (FSM 202, 78FR56202) along with the application of the natural range of variation used in the 2012 planning rule as an "ecological reference model" to assess whether an ecosystem has "integrity" (FSH 1909.12).

Landscape evaluations are a primary component of the Forest Restoration Strategy and are useful for assessing the interactions among late-successional and old forests, northern spotted owl or other focal wildlife species habitat, forest disturbances, and vegetation departure. Landscape evaluations were identified as an important tool in the implementation of the northern spotted owl Recovery Plan and critical habitat rule (USFWS 2011, 2012). The landscape evaluation uses reference conditions assessed at the subwatershed scale based on two estimates of the natural range of variability: historical (HRV) and future (FRV) along with other information sources (e.g., moisture deficit, fire severity and burn probability) to assess landscape conditions (USFS 2012b; Hessburg et al. 2013, Cannon et al. 2018). Landscape evaluations improve the ability to estimate effects of management actions on the functions (e.g., dispersal, foraging, nesting-roosting) of northern spotted owl habitat and to better identify and prioritize treatment areas and actions to restore landscapes and reduce the risk of habitat loss from disturbances, while conserving spotted owl habitat (Box 3; USFWS 2012a, Gaines et al. 2015). Relevant objectives of Landscape Evaluations to the NWFP Standards and Guidelines are: 1) determine the location and amount of LSOF and focal wildlife habitats, including northern spotted owl habitat; 2) compare the current amount and spatial pattern of LSOF and focal habitats to reference conditions within a subwatershed (natural range of variability); 3) assess risks to LSOF and focal

wildlife habitats, and 4) identify restoration opportunities and priorities to enhance LSOF and focal habitat conditions and sustainability, and landscape resiliency.

An important outcome of the landscape evaluations is that it provides managers with a "landscape prescription" that describes the amount and spatial arrangement for different kinds of late-successional and old forest that a landscape is likely to support and helps to identify priority locations for strategic and active landscape restoration to restore disturbance regimes, create more sustainable habitat conditions, and reduce the risk of uncharacteristically severe wildfires at the project and/or subwatershed scale. The integrated landscape prescription can be used to inform a Purpose and Need for project planning.

Box 3-The Use of Reference Conditions in Assessing Northern Spotted Owl Habitat Sustainability and Landscape Resiliency:

The theory behind historical range of variability (HRV) is that the broad historical envelope of possible ecosystem conditions, such as burned area, vegetation cover type area, or patch size distributions, provides a representative time series of reference conditions to guide land management (Aplet and Keeton 1999, Keane et al. 2009, Lehmkuhl et al. 2015b). This theory assumes the following (based on Keane et al. 2009): (1) ecosystems are dynamic and their responses to changing processes are represented by past variability; (2) ecosystems are complex and have a range of conditions within which they are self-sustaining, and beyond this range they transition to disequilibrium; (3) historical conditions can serve as a proxy for ecosystem health; (4) time and space domains of HRV are sufficient to quantify variation; and (5) the ecological characteristics being assessed for ecosystems or landscapes match the management objective.

Forest Service Manual (FSM 2020) promotes resilience as a restoration goal for the Forest Service (78 FR 56202) and defines resilience as the capacity of an ecosystem to endure disturbances and retain its structures and functions. The policy further states that in order to identify an ecosystem in need of restoration, current conditions should be evaluated against: the natural range of variation as a reference to understand ecosystem function; the dynamic nature of ecosystems, associated natural and current disturbance regimes; and likely future environments resulting from climate change and increasing human uses. The directive applies to all National Forest System resource management programs. For example, the directive applies when there is an objective to restore watershed condition and function, control invasive species, re-create natural stream channel complexity, improve or reestablish habitat for threatened and endangered species, and restore natural fire regimes. Key to the implementation of this policy is defining the natural range of variation (NRV): spatial and temporal variation in ecosystem characteristics under historical disturbance regimes during a reference period. Natural range of variation is a term used synonymously with historical range of variation or range of natural variation.

As a result of this policy and the supporting science, the OWNF Restoration Strategy uses HRV in the landscape evaluation as a means of assessing how much spotted owl and LSOF habitat a landscape can sustain, and as a means of assessing the resilience of a landscape to endure disturbances and retain its structures and functions. **A key assumption of this approach is that when a landscape is determined to be outside of reference conditions (HRV) there is an increased risk of habitat loss from uncharacteristic disturbances and a corresponding decline in landscape resilience**.

6. RESTORATION & RISK REDUCTION FRAMEWORK AND DESIGN CONSIDERATIONS

This section demonstrates how the landscape ecology principles and landscape evaluation framework described in the previous section can be applied to inform restoration and risk reduction treatments within LSRs, and design considerations to facilitate urgent and necessary restoration and risk reduction actions.

The restoration and risk reduction framework and design considerations detailed below will aid project planners in determining (1) whether treatments are needed to enhance or maintain late-successional and old forest conditions and habitats within an LSR, (2) how much treatment is appropriate to meet management direction in the NWFP (e.g., reduce risk of uncharacteristic disturbances), and (3) the types of treatments that may be appropriate.

Following this framework and adhering to the design considerations should allow for a streamlined review process and consistency with this LSRA and, by default, the NWFP Standards and Guidelines (see Appendix J). A landscape evaluation (see Section 5) would be required to ensure that this framework and design considerations are informed by a structured and scientifically rigorous approach (OWNF FRS 2012, as amended). Project-level proposed actions and effects analyses will need to clearly articulate the end state of the treatments and describe why the treatments will benefit either the development of late-successional or old forest stand characteristics (following the silviculture pathway in the NWFP C-12) or reduce the risk of habitat loss to future fires or other large-scale disturbances (following the risk reduction pathway in the NWFP C-13). Project-level proposed actions utilizing the risk reduction pathway should include insect and/or fire risk modeling to demonstrate benefits of risk reduction treatments. Treatment prescriptions in dry to moist mixed conifer forests should be guided by the design considerations listed below. This framework and the design considerations are intended to address commonly applied ecological forestry treatments in dry and moist mixed-conifer forests based on years of landscape restoration and risk reduction project experience and science. As such, unique situations that are not covered by this framework and design considerations will require additional coordination with the LSR Workgroup.

When treatments are needed, they will be outcome based and utilize the best tools or methods available to move vegetation and habitat toward the desired condition while minimizing resource impacts at the stand level. Treatments may include, but are not limited to, commercial thinning, precommercial thinning, and prescribed fire (inclusive of pile burning, jackpot burning, broadcast burning, and management of unplanned ignitions) for the purposes of restoration or risk reduction. Treatments may also include planting or salvage in post-fire landscapes, following NWFP Standards and Guidelines (NWFP ROD, p. C-13 to C-16). It is important to note that "treatment" does not necessarily mean habitat downgrade, degrade, or removal. It is possible to treat stands to reduce risk without changing the overall stand classification. Proposed treatments should be evaluated based on current conditions, informed by monitoring of habitat and LSOF conditions, and considered individually at the project level by district planning teams and the local line officer, in consultation with regulatory partners. Local line officers should weigh tradeoffs between reducing risk and maintaining current stand and habitat conditions.

6.1. Desired Condition

The desired condition for the LSR network on the OWNF is a landscape that contains amounts and spatial arrangements of dry, moist, and cold closed and open canopy old-forest conditions that contribute to old forest dependent species viability and recovery and are resilient to climate change and increasing disturbance severity and frequency.

It is recognized that LSRs only play a role in providing old-forest conditions and habitat in a portion of the landscape and that these conditions and structural stages will shift through time and across space. This section outlines a restoration framework and design considerations for reducing risk that can be applied to late-successional and old-forests across management allocations more broadly, including within designated critical habitat for the northern spotted owl (USFWS 2012a).

6.2. Evaluating Treatment Needs at the Landscape-Scale in LSOF Forests

At the landscape scale, the following framework can help guide interdisciplinary teams in identifying whether treatments are needed to enhance or maintain late-successional and old forests within a LSR and where stand-level treatments are most appropriate. This framework contains an assessment of how current conditions compare with the NRV at the subwatershed(s) or LSR-scale (for large LSRs > 75,000 acres). Natural range of variability is intended to be used as a guide to help provide context and rationale around the need for treatment, but not as a treatment target, nor would NRV be a feasible or desirable target in many cases. Specifically, project teams will use the landscape evaluation process (from the OWNF Forest Restoration Strategy, see Section 5) to identify existing large tree structure that may represent LSOF conditions or LSOF habitats (as described in Section 3) and assess risks from disturbance, tradeoffs between risk reduction and habitat maintenance, priority areas for treatments, and appropriate treatment types and amounts.

Use the following steps to identify treatment needs within LSR/MLSAs consistent with the Standards and Guidelines of the NWFP (e.g., NWFP ROD, C-12 to C-13):

1. Complete Landscape Evaluation – Within project planning area map existing vegetation condition, focal wildlife habitats (see Appendix E) and existing remnant large and old trees, current or potential large and old tree structure or LSOF patches using vegetation information derived from the photo-interpretation, LiDAR, DAP, or/and a combination of similar tools. Follow the landscape evaluation quality control process to evaluate and make necessary adjustments to meet quality control standards each of the mapped attributes (USFS 2012b).
2. Departure Assessment - Once the existing vegetation, large tree and old forest structure (e.g., Remnant Large and Old Trees, Old Forest Single Story or Old Forest Multistory structure or Large-Tree Open-Canopy and Large-Tree Closed-Canopy) and focal wildlife habitat patches are mapped at sufficient quality, compare the current amount (percent land) and spatial configuration to the historical and future reference conditions (USFS 2012; see also Appendix E). Compare the current amount (percent land) of each mapped

attribute with the natural ranges of variability (historical and future) as a means to evaluate sustainability and inform need for restoration.

3. Risk Assessment – Assess vegetation, focal wildlife habitats, and large and old tree and LSOF sustainability and risk of loss to disturbances. Use information from the landscape evaluation on insect risk, fire risk (probability and severity) and drought vulnerability (derived from current and future moisture deficit[7] projections) to inform the degree of risk of large tree or LSOF loss from disturbances and to identify the locations on the landscape where existing large tree structure is most sustainable.
4. Generate Treatment Priority Layer – Use the landscape evaluation process to generate a layer that overlays information from the departure and risk assessments to identify areas on the landscape with the highest priority for restoration or risk reduction treatments (see approach in DNR 2022).
5. Assess Departure within LSR: Evaluate departure from natural range of variability using mapped existing remnant large trees and/or LSOF structure (Appendix I) at the scale of the entire LSR (for large LSRs > 75,000 acres) or at the scale of the subwatershed(s) containing or intersecting the LSR (for smaller LSRs). Map the sustainability of the existing large tree structure (see Section 4.2).

   For **dry forest types** that are identified in the Treatment Priority layer within the LSR:

   1. Focus treatments largely outside of existing Large-Tree Dense-Forest (and existing "high quality" nesting-roosting habitat for Northern Spotted Owls) to reduce risk.

   2. Consider treatments to shift existing Large-Tree Dense-Forest to Large-Tree Open-Canopy forest when:

      a. The amount of Large-Tree Dense-Forest is above NRV (18-24% historically)[8]

      b. AND the Large-Tree Open-Canopy Forest is below NRV (33-47% historically)[8]

      c. AND the identified Large-Tree Dense Forest exists in a low to very low sustainability category[9].

[7] Moisture deficit incorporates topographic position as a variable in its calculation. Generally, north slopes and valley bottoms have lower moisture deficit than south slopes or the upper portions of ridges.
[8] HRV calculations should be done at the appropriate scale for the analysis, which may either be at the scale of the LSR (for large LSRs > 75,000 acres) or at the scale of the subwatershed(s) that intersect with or encompass smaller LSRs. Grouping close by LSRs (as in Appendix B) to reach the size threshold above can also an appropriate scale for this analysis.
[9] This layer will be generated using DAP-derived large dense forest sustainability data from WADNR (which is updated annually).

3. Prioritize areas of very low or low sustainability for treatment. In cases where "2a" and "2b" are met and the Large-Tree Dense Forest exists in a moderate to high sustainability category, evaluate the need for a low intensity treatment (e.g., small tree thinning or ladder fuel reductions) or maintenance (e.g., prescribed fire) to promote and enhance those conditions into the future or protect adjacent habitats at risk.

For **moist forest types** that are identified in the Treatment Priority layer within the LSR:

1. Focus treatments largely outside of existing Large-Tree Dense-Forest (existing "high quality" nesting-roosting habitat for Northern Spotted Owls) to reduce risk.

2. Consider treatments within existing Large-Tree Dense-Forest when:

    a. Current moist forest stands are classified as low or very low sustainability[9].

    b. AND stands present a risk to nearby high priority old-forest habitat (e.g., NSO Recovery Action 32 habitat).

    c. AND the amount of Large-Tree Dense Forest is above NRV (15-30%).[8]

In situations where the existing forest structure is within the natural range of variability for the LSR or the landscape encompassing the LSR, and the existing large tree structure is classified as moderately or highly sustainable, treatment may not be ecologically necessary.

Due to the nature of historically infrequent, large disturbance events, it is not appropriate to evaluate departure from natural range of variability in cold forest types at the scale of an individual LSRs or subwatershed(s) (Haugo et al. 2015). However, this does not preclude planning teams from proposing treatments in cold LSOF stands based on site-specific risk factors or species-specific habitat needs. These treatments should be evaluated and reviewed in consultation with the LSR Working Group to ensure consistency with the NWFP Standards and Guidelines.

6. Conduct risk modeling – For treatments proposed under the risk reduction criteria of the NWFP (NWFP ROD C-12 to C-13), evaluate the effectiveness of proposed treatments in LSRs by demonstrating how insect & disease risk or fire risk (e.g., crown fire risk, flame length) is reduced post-treatment.

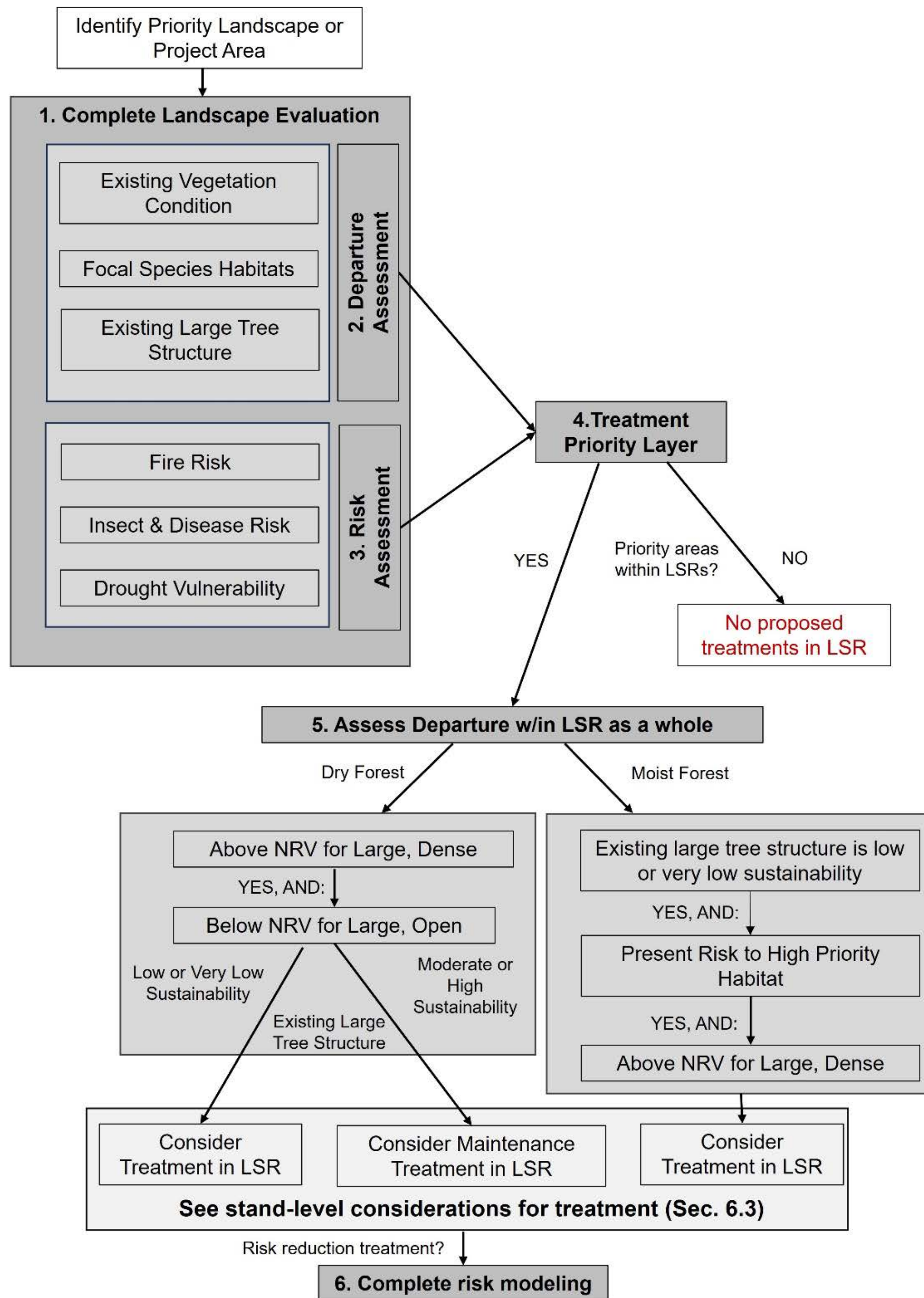


Figure 6.1-Flow diagram of steps for completing assessment of treatment need within an LSR that intersects within a priority landscape or proposed project area. Numbers correspond to steps described in Section 6.2, above.

6.3. Stand-Scale Design Considerations

Forested landscapes are made up of patches of even-aged and uneven-aged stands and small to large openings. Complexity and heterogeneity at the stand-level moderates disturbance scale such that landscapes are resilient to uncharacteristic disturbances over time and space. Processes such as wildfire behavior and transmission across a landscape are constrained by patch (stand) -

level heterogeneity, especially in dry and moist mixed-conifer forests historically dominated by low to mixed-severity fire regimes (Hessburg et al. 2015, Povak et al. 2023). Stand-level treatments can thus play an important role in reducing landscape-level risk to disturbance.

Stand-level design considerations will be used to inform prescriptions that are consistent with needs and goals identified in the Forest Restoration Strategy landscape evaluation and to move landscapes toward desired conditions for LSOF and LSOF habitats in LSRs. In keeping with the intent of the NWFP (p. C-12-13), treatments should focus on ensuring stands are aligned to develop late-successional conditions consistent with underlying biophysical factors of a site. Furthermore, treatments should be intentionally designed to accelerate the development of LSOF or reduce the risk of LSOF stands to disturbance or drought-induced mortality and follow the risk-reduction management direction outlined in the Northwest Forest Plan (p. C-12-13) and subsequent Late-Successional Working Group guidance (REO 2009). Stand-level conditions (e.g., departure in composition or structure) and other considerations, such as topographic complexity or risk reduction to homes, will factor into treatment locations and prescriptions, and will be informed by the landscape evaluation.

The following are design considerations for dry and moist mixed conifer areas identified through a landscape evaluation as priority for treatment to enhance LSOF characteristics and/or to reduce risk of habitat loss to large-scale disturbances.

6.3.1. Design Considerations for **Large and old trees**

1. Large (>20” DBH), very large (≥ 25” DBH) and old trees (≥ 150 years old) are an important structural component of wildlife habitat and contribute to ecosystem processes and function (Hessburg et al. 2020). Old trees are considered one of the most critical structural attributes in dry forest ecosystems (Franklin et al. 2008). Old trees have distinctive attributes related to crown structure, bark thickness and color, heartwood content, and decadence (wounds, rots, brooms, etc.) and these characteristics are usually developed between 150 to 250 years (Van Pelt 2008, Franklin et al. 2008). Retain all old trees (≥150 years old) through treatments. Provide rationale for removal of large or very large trees and promote the growth and retention of large early-seral tree species.

2. Apply historical stand reconstruction data from eastern Washington to develop desired condition ranges for large and old trees for different forest types in the eastern Cascades (see Harrod et al. 1999, Churchill 2013, Churchill 2016; Table 6.1).

3. Retain or aim to restore an appropriate abundance and spatial arrangement of large, old early-seral trees as informed by historical stand reconstruction information (see details below; Franklin and Johnson 2012, Franklin et al. 2013, Hessburg et al. 2015, Spies et al. 2018, Johnston et al. 2021).

6.3.2. Design Considerations for **Tree Density**

1. Use stand density index to define a sustainable condition that maximizes tree growth and restores conditions, and associated functions, consistent with a historical disturbance

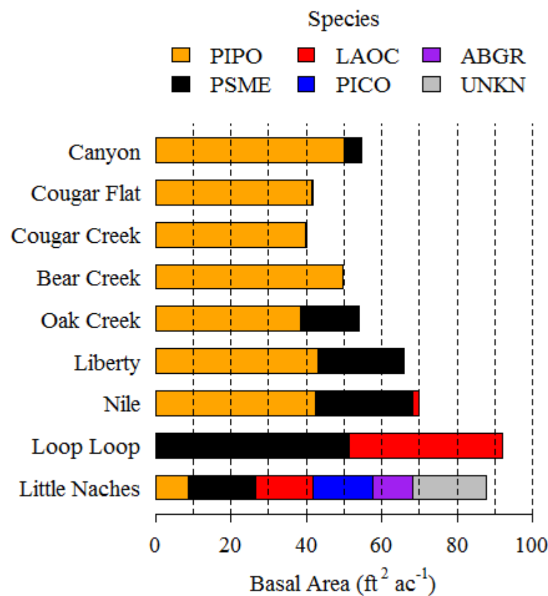
regime. These associated functions may include sufficient light for understory plant species, low overstory density to reduce drought vulnerability, insect susceptibility, and crown fire risk, or promoting individual tree or small clump vigor (See Table 6.1 for example target SDI for reference stands across the Washington East Cascades).

2. Vary target stand density depending on habitat objectives (see examples in Appendix G).

Table 6.1-Summary information for 9 historical reference plots in the eastern Washington Cascades. Forest structure was reconstructed to 1890. Data is for trees > 5.9" diameter at breast height.

Plot	Plant Association Group	Acres	Basal Area $Ft^2 Ac^{-1}$	Trees Ac^{-1}	Avg. DBH (inch)	QMD[1] (inch)	SDI[2]	Openings[3] (%)
Little Naches	Cool Mesic PSME	9.2	88	52	16.3	17.6	140	35
Loop Loop	Cold-Mesic PSME	5.3	92	60	15.8	16.8	148	14
Nile	Cool-Dry PSME	17.8	70	38	17.3	18.3	110	54
Liberty	Cool-Dry PSME	13.9	66	41	16.1	17.1	106	47
Oak Creek	Cool-Dry PSME	15.2	54	33	16.3	17.5	86	61
Bear Creek	Hot Dry PIPO	6.9	50	27	17.4	18.5	78	69
Cougar Creek	Hot Dry PSME	6.3	40	18	18.7	20.3	62	81
Cougar Flat	Hot Dry PIPO	6.1	42	14	22.1	23.8	61	86
Canyon	Hot Dry PSME	5	55	19	21.7	23.2	80	77

[1] Quadratic mean diameter
[2] Stand density index in English units. An exponent of 1.7 was used to calculate SDI
[3] Percent of plot in large openings.



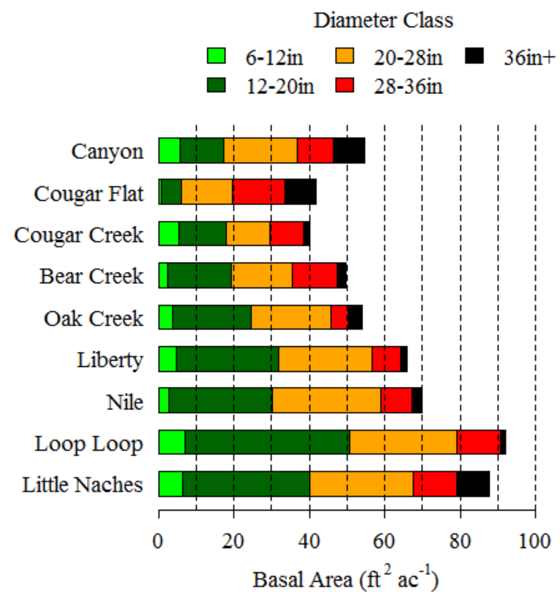


Figure 6.2- Basal area within 9 historical reference plots in the eastern Washington Cascades, by (A) species and by (B) diameter class.

6.3.3. Design Considerations for **Species composition**

1. Large, early-seral species such as ponderosa pine, western larch, and Douglas-fir trees have the highest resistance to wildfire due to the unique attributes they develop as they age (Stevens et al. 2020, Greenler et al. 2023) and play important roles in post-fire recovery processes (e.g., resilience; Covington et al. 1997, Allen et al. 2002, Hessburg et al. 2020). Increasing dominance of early-seral fire-resistant tree species may also help increase forest resistance and resilience to climate change and increasing disturbance severity and frequency (Hessburg et al. 2019, 2020). Prioritize retention of early-seral tree species where possible.

2. Tree species diversity can be an important hedge against processes such as drought-induced mortality or insects and pathogens that target specific host species (Young et al. 2020). Provide for tree species diversity by targeting an appropriate mix of species based on historical stand reconstruction data (see Figure 6.1; Churchill 2013, Churchill 2016) and retain and promote broadleaf species where they are present.

6.3.4. Design Considerations for **Spatial arrangement**

1. Spatial patterns influence important ecological processes, such as fire spread and insect outbreaks, and tree diseases. Historically, trees within dry forest stands were clumped at fine scales (<1/2 acre) and natural openings limited the potential for crown fire and created diversity of habitat for a diverse understory (Harrod et al. 1999, North et al. 2009,

Churchill et al. 2013). The number and size of openings in historical forests is directly related to density (TPA = trees/acre) and the degree of clumping (Churchill et al. 2013, 2016). On high-density sites (>~30 TPA) historical plot reconstructions show that almost all openings with no or very few trees were <1 acre in size. On plots with low tree densities (<~30 TPA) openings often fused together with low density areas (~5-15 TPA) and reached 2-5 acres in size (Churchill et al. 2013, 2016). Openings were sinuous and amorphous in shape and rarely circular (Churchill et al. 2013, 2016). To ensure that tree clumping and openings occur in sizes, amounts, and distributions represented by historical (reference) conditions (see Table 6.2, Figure 6.2 & Figure 6.3), we suggest the following guidelines for prescriptions:

a. Openings with no or very few trees (1-5 TPA) should generally be small (1/10 – ¼ ac in size), with some larger openings up to 1 acre.

b. Prescriptions may also include low density areas (5-15 TPA) that should generally be small to medium in size (1/4 – 2 acres), with some large areas up to 5 acres. Openings should be sinuous and amorphous in shape and rarely circular.

2. Both vertical and horizontal heterogeneity were important components of old forest stands, where stands were made up of individual large trees, clumps of multiple tree ages and sizes, and patches of regenerating seedlings or saplings (North et al. 2009, Churchill et al. 2013). Retain trees in different canopy strata at the patch-scale to provide important wildlife habitat, including mistletoe platforms, to contribute to ecosystem processes and function. Limit ladder fuels beneath desirable large or old early-seral trees.

Table 6.2-Clump size distributions for historical reference plots in the eastern Washington Cascades summarized into low, medium, and high levels of spatial variability. The clump size distribution is the proportion of trees by clump size. Clump size is the number of trees in a clump. Clumps are defined as trees within at least 20' of another tree in the clump. See Churchill et al. (2016) for instructions on how to incorporate clump size distributions into prescriptions to achieve variability in treatments.

	Clump (Bin) Size (# of trees)					
Clumping Level	**1**	**2-4**	**5-9**	**10-15**	**16-20+**	**TPA**
High	0.22	0.38	0.24	0.10	0.06	40-60+
Moderate	0.30	0.42	0.11	0.17		25-40
Low	0.45	0.43	0.12			15-25

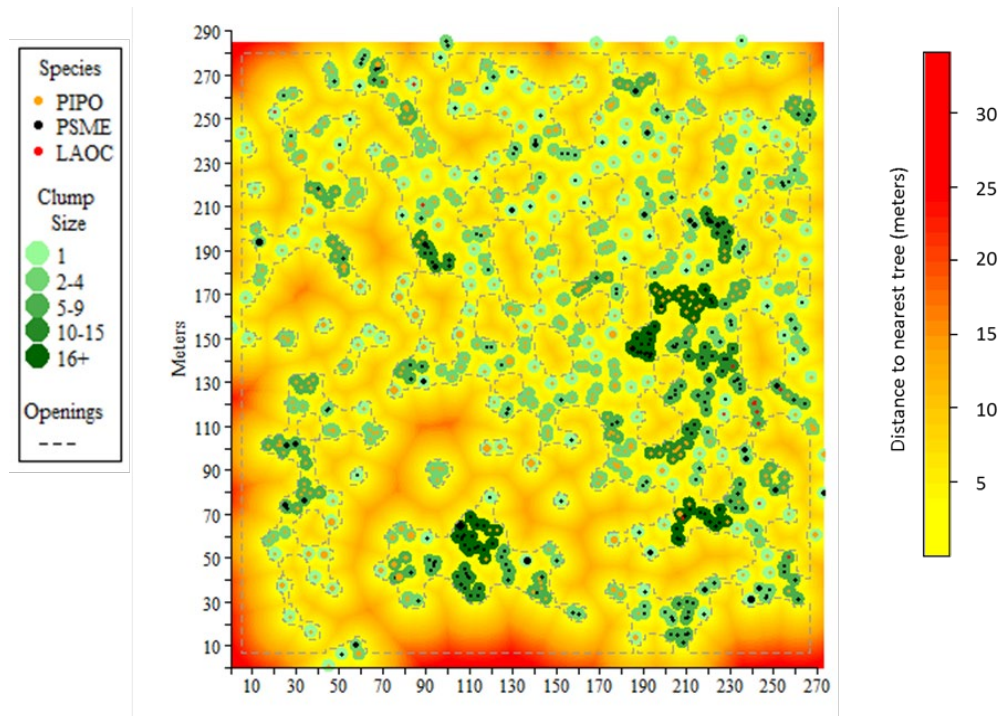


Figure 6.3-An example stem map of reconstructed conditions from the Nile reconstruction plot in the eastern Washington Cascades that demonstrates the fine-scale variability found in frequent fire forests. The background colors display the degree of open space as measured by the distance to the nearest tree. Yellow indicates areas close to a tree canopy, while red areas are the middle of larger openings.

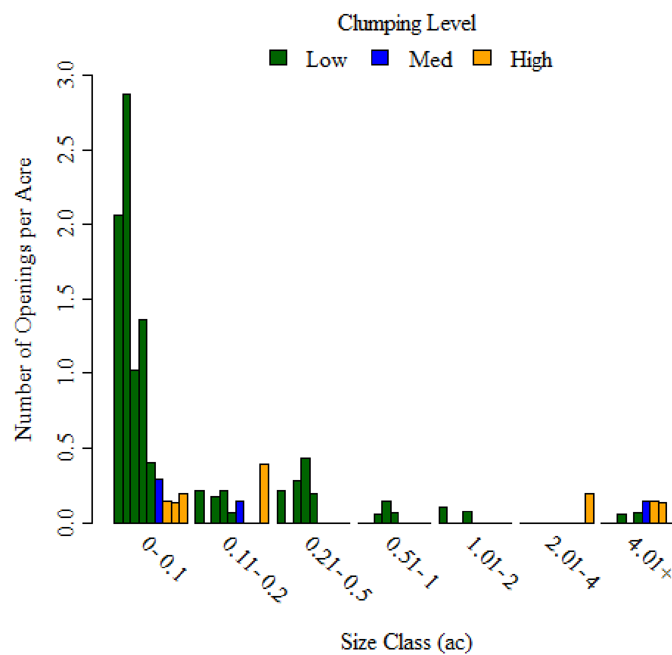


Figure 6.4-Number of large openings by size class for 9 historical reference plots in the eastern Washington Cascades. Plots are colored by clumping level from Table 6.2.

6.3.5. Design Considerations for **Snags and down wood**

1. Retain snags and down wood in sizes, amounts, and distributions represented by historical (reference) conditions to provide important wildlife habitat and contribute to ecosystem processes and function. Retain some decadent or dying large diameter trees to serve as future snags or downed logs (Larson & Churchill 2023). Reference conditions for density and spatial arrangement of large snags and downed wood are based on the most recent updates to DecAID (2023, and Appendix F) and are summarized by watershed. Conditions for snags and down wood levels should be evaluated at the watershed scale for an individual project.

6.3.6. Design Considerations for **Prescribed Fire**

1. Use fire, including planned and unplanned ignitions, to reduce hazardous fuels and restore fundamental ecosystem processes where appropriate (See Section 8 for details).

6.3.7. Design Considerations specific to **Northern Spotted Owl**

1. Focus retention and future development of nesting-roosting and/or foraging habitats where they are most sustainable into the future based on site-specific landscape evaluations (see Landscape-Scale Framework sections, above).

2. Carefully consider appropriate treatments within “high quality” (Recovery Action 32, Box 1; USFWS 2011; Appendix E) habitat, as determined through project-level landscape evaluations and field verification. Treatments should generally not result in a downgrade in function of “high quality” habitat.

3. Retain nesting-roosting and/or foraging habitat within the breeding range (0.7-mi radius) and home range (1.8-mi radius) around recently known occupied (within last 5 years) activity centers (Recovery Action 10; USFWS 2011).

4. Use surveys to identify recent (within last 5 years) resident occupied northern spotted owl breeding and home ranges. Breeding and home ranges would be considered abandoned (see definition in USFWS 2012b, p. 31) if resident owl(s) were not detected during 5 annual surveys since resident owls were last detected, with at least 2 of those surveys occurring in the past 5 years. Ranges would also be considered abandoned if less than 10% nesting-roosting and/or foraging habitat remained in the breeding range and the home range after a disturbance event, followed by resident owl(s) not detected during a single annual survey. Consider applying results of forthcoming occupancy probability mapping (Lesmeister and Jenkins 2022) to inform survey effort in nesting-roosting and/or foraging habitat in abandoned ranges prior to implementation.

7. MONITORING AND ADAPTIVE MANAGEMENT

7.1. Desired Outcomes

Adaptive management is a system of management practices that (1) clearly identifies desired outcomes, (2) ensures active monitoring to evaluate if management actions are leading to desired outcomes, and (3) anticipates and requires management changes to ensure that outcomes can be met or reevaluated (Walters 1986, Gaines and Lehmkuhl 2015). Adaptive management stems from the recognition that the behavior of natural systems is often difficult to predict (36 CFR 219.16: FSM 1905). Because of the uncertainty and complexity surrounding the interactions between forest restoration, landscape risk-reduction, and providing habitat for late-successional associated species, an adaptive management approach has been suggested as an appropriate approach to managing late-successional and old forest conditions in the range of the northern spotted owl in the Eastern Cascades (USFWS 2012a, Gaines and Lehmkuhl 2015).

There is a considerable amount of guidance and policy concerning the use of adaptive management within the federal agencies that oversee or carry out forest restoration within the NWFP area. For example, at the national level, adaptive management is described in the Land Management Planning Handbook (FSH 1909.12 Chapter 20), is a critical component of the Forest Service Strategic Framework for Responding to Climate Change (USFS 2008), and the Forest Service manual FSM 2000, Chapter 2020 Ecological Restoration and Resilience states that "adaptive management, monitoring, and evaluation are essential to ecological restoration". At the regional level, adaptive management is described in the Record of Decision for the Northwest Forest Plan (USDA and USDI 1994, E12-15). In addition, adaptive management figures prominently in the final Northern Spotted Owl Recovery Plan and revised critical habitat rules, especially as it relates to fire-prone provinces (USFWS 2011, 2012). Finally, the update of the LSR Assessments for the Okanogan-Wenatchee National Forest (this document) demonstrates adaptive management in action. After 25 years of implementation, a failure to achieve the desired outcomes of the original LSRAs has necessitated revisiting our assessment framework and management guidance.

The Northwest Forest Plan provides management objectives relevant to the Dry Forest Provinces such as the Eastern Cascades physiographic province that can be used to develop Desired Outcomes. These objectives include: (1) a functional and well-connected network of diverse late-successional and old forest habitats, and (2) risk reduction to reduce the loss of late-successional and old forest habitats to large-scale disturbances. Monitoring (using the metrics described below) will be used to assess progress in meeting these two Desired Outcomes:

- Desired Outcome 1: Provide a functional and well-connected network of diverse late-successional and old forest habitats.
    - Increase the amount of Dry Forest Large-Tree Open-Canopy conditions and habitat across the LSR network using the natural range of variability (historic and future from the Landscape Evaluation) as a guide.

- Retain and promote the Dry and Moist Forest Large-Tree Closed-Canopy habitats in the most sustainable locations using the natural range of variability (historic and future from the Landscape Evaluation) as a guide.
- Manage the amount of Cold Forest Medium-Large-Tree Open and Closed-Canopy habitats using the natural range of variability (historic and future from the Landscape Evaluation) as a guide.

- Desired Outcome 2: Reduce the risk of habitat loss from uncharacteristic large-scale disturbances across the Forest, to the LSR network, and within individual LSRs.
  - Increase the amount of Dry Forest Large- and Medium-Tree Open-Canopy habitats through restorative treatments within and adjacent to the highest risk LSRs.
  - Reduce the risk of loss of Dry and Moist Large-Tree Dense-Forest habitats to large-scale disturbances by strategically locating treatments and retaining high quality habitats in the most sustainable locations.

7.2. Monitoring Items and Metrics

The following indicators (Table 7.1) will be monitored by the Forest and updated at the described frequency, unless a large disturbance event occurs primarily within one or more LSRs, necessitating a reevaluation in the interim.

Table 7.1-Monitoring themes, indicators, scale, data sources, and frequency for adaptive management.

Theme	**Indicators**	**Scale**	**Method or Data Source**	**Frequency**
Late and old structure[a]	Amount and spatial arrangement of Old Growth Structure Index 200	Forest, LSR Network	NWFP Old Growth Monitoring Data (Davis et al. 2022)	Every 2 years
	Amount of Dry Forest Large-Tree Open-Canopy	LSR Network, Forest	GNN	Every 3-5 years, or after large disturbance
	Amount of Dry and Moist Forest Large-Tree Closed-Canopy	LSR Network, Forest	DNR DAP data – Large, dense forest sustainability data layer	Every 2 years

Theme	Indicators	Scale	Method or Data Source	Frequency
	Amount of Cold Forest Medium-Large-Tree Closed-Canopy	LSR Network, Forest	GNN	Every 3-5 years, or after large disturbance
Habitat[b]	Amount and spatial arrangement of northern spotted owl habitat by habitat function (nesting-roosting, foraging, dispersal)	LSR, Forest	NWFP NSO Monitoring Data (Davis et al. 2022)	Every 2 years
	Northern spotted owl habitat-based carrying capacity estimates for the Late-Successional Reserve network within the Washington East Cascades province	Washington East Cascades province	ArcGIS toolbox based on Glenn et al. 2017 models; HexSim	Every 2 years
	Habitat connectivity for late-successional and old forest habitats	LSR – Low and moderate mobility species Forest – High mobility species	Resistance surfaces NWFP Connectivity Monitoring Data	Every 5 years
Risk reduction[c]	Treatments are moving vegetation conditions toward the natural range of variability	LSR	DNR DAP for closed canopy GNN habitat model for open canopy	Before and after project implementation
	Treatment implementation in high risk locations	LSR	Dry and Moist Forest Large-Tree Dense-Forest sustainability FACTS database	Before and after project implementation

[a] Late and old structure indicators and data sources are described in the risk assessment section (Section 4) of this document.
[b] Habitat indicators and data sources are described in the current conditions section (Section 3) of this document.
[c] Risk reduction indicators and data sources, including the DNR DAP data used to derive the large tree dense forest sustainability data layer and the GNN habitat models are described in Section 4 and 3, respectively. Data from the Forest Service Activity Tracker (FACTS) database can be overlaid on these data layers to understand the intersection between forest treatments and project priority areas.

7.3. Adaptive Management Triggers

Many of the monitoring indicators described above rely on data sources that would be updated while planning new landscape restoration projects or at regular recurring intervals. For example,

prior to the initiation of a new landscape restoration project involving a part or all a LSR or MLSA, landscape departure analysis would be run using the most current aerial imagery for all subwatersheds intersecting or within the project boundary and northern spotted owl habitat would be mapped and assessed. As models are rerun at the intervals suggested above, habitat amounts should be updated in the Appendix B of this document. Results should be used to adaptively manage as new projects are developed.

In the course of refreshing indicators at the intervals suggested in Table 7.1, if any of the following triggers were met, this would prompt a review of the LSR Assessment to determine if an update to the assessment and/or modification of treatment framework and design criteria is needed. This determination would occur in coordination with the LSR Working Group.

- Changes to the habitat-based spotted owl carrying capacity estimates:
  - A reduction of >15% in the habitat-based potential activity centers across the Washington East Cascades province; OR
  - A reduction of >10% of the habitat-based potential activity centers within the LSR network on the OWNF.
- A large fire event occurs over >10% of the LSR network substantially reducing late successional and old forest habitats.
- The amount of Dry and Moist Large-Tree Dense-Forest is below the upper end of the estimated natural range of variability (>24%) at any of the following:
  - Forest scale
  - LSR network scale
  - Within Upper Methow, Chiwawa, Swauk, or the Manastash LSRs
- A substantial change in policy or plan
  - E.g., An amendment to the Northwest Forest Plan
  - E.g., Change in the regulatory status of the northern spotted owl

8. FIRE MANAGEMENT

8.1. Background

Fire regimes across the LSR network on the OWNF vary based on forest type. Historically, dry forests (34% of LSR network) dominated by a mix of Douglas-fir and ponderosa pine experienced relatively frequent (5-20-year mean fire return interval (MFRI)) surface fires with low and moderate severity effects (Agee 1993, Everett et al. 2000, Schellhaas et al. 2007, Kernan and Hessl 2010, Povak et al. 2023, Walsh et al. 2023), with low severity effects dominating in dry forests with open canopy structures and medium to large trees (Hessburg et al. 2007). Moist mixed-conifer forests (16% of LSR network) dominated by Douglas-fir, grand-fir, and western hemlock also experienced a mix of frequent and infrequent (17 - 80 year MFRI, Rushton and Walsh 2021, Povak et al. 2023) low, moderate, and high severity fires (Haugo et al. 2019, Rushton and Walsh 2021, Donato et al. 2023) which varied in their effects over space and time, leading to a heterogeneous landscape of uneven-aged, even-aged, and multi-cohort stands (Hessburg et al. 2000, Stine et al. 2014). Cold forests dominated by lodgepole pine and/or Englemann spruce and subalpine fir experience more stand-replacing fires with greater variability in the mean fire return intervals (modeled FRI range: 15–88 years, Povak et al. 2023, Agee 1993). Cold forest parklands on the OWNF that contain whitebark pine were historically dependent on mixed-severity fire for maintaining characteristic old growth stand conditions and habitat for species like Clark's nutcracker and grizzly bear. This patchwork of different stand structures, as well as persistent openings and openings created by fire, were important in regulating fire behavior and fire flow across the OWNF and played a key role in regulating historical fire size (Hessburg et al. 2019). Fire simulation models across the vegetation and environmental gradients of the OWNF suggest that, historically, wildfires would have rarely exceeded 10,000 hectares in size and patch sizes of high severity fire rarely (< 1% of the time) exceeded 100 acres in size (Povak et al. 2023).

Wildfire was also an important element in creating and maintaining old growth conditions across the OWNF and the LSR network, especially in low elevation dry forests. In dry forests, repeated frequent low severity fire reduced fuels and favored the survival of scatted fire-resistant ponderosa pine and Douglas-fir which persisted through subsequent disturbance events, creating the characteristic open-canopy large-tree structure that dominated these forest types historically (Agee 1993). Recent simulation models trained on historical fire and vegetation data for this forest (Prichard et al. 2023) suggest that low and moderate severity fire was a stabilizing force maintaining roughly 10% of the landscape in old forest conditions in dry and moist forests, with roughly 30% of the landscape maintained in dry forest open canopy conditions (either stem-exclusion open canopy or old forest single story, Povak et al. 2023). The less frequent, but more severe nature of fire in cold forests created old forest conditions that would increase across the landscape over roughly 300 years before being reset to stand initiation by a subsequent high severity fire, but simulations suggest that <5% of cold forest landscapes were maintained in old forest conditions at any given time (Povak et al. 2023).

Over the past 30 years, wildfires have impacted 369,800 acres of LSRs on the OWNF with roughly a third of the acres burning at high severity (see Section 3). Across the inland Pacific

Northwest, the amount of low and moderate severity fire continues to be less than expected based on simulations of historical fire regime conditions (Haugo et al. 2015, Donato et al. 2023). This fire deficit demonstrates the importance of continuing to return fire to landscapes on the OWNF to restore forest conditions. However, relative proportions of high severity fire, especially in dry forests historically dominated by frequent, low severity fire regimes, are much higher than would have been expected historically (Haugo et al. 2019, Donato et al. 2023). This general trend is reflected in recent fires that have burned within LSRs as well. Specifically, there continues to be a deficit of low and moderate severity fire while high severity fire is within range of simulated historical annual averages (Figure 8.1) though the proportion of high severity fire in dry forest systems in recent fires in LSRs is nearly triple the proportion of high severity fire that would have been expected under a historical disturbance regime (32 vs. 11%, Figure 8.2). This evidence suggests that opportunities to increase the amount of area burned within LSRs under favorable weather or controlled conditions to address the deficit of low and moderate severity fire, especially in dry and moist forests, should be considered when feasible.

Despite there being a deficit of fire across the LSR network and the eastern Cascades physiographic province compared with expected historical averages, there has been significantly more fire than was anticipated when the Okanogan and Wenatchee National Forests completed their original LSR assessments in 1997 and 1998. However, these initial estimates were artificially low and based on a relatively uncharacteristic low fire period between 1977-1987. Fire that has occurred since 1993 has been unevenly distributed across the LSR network (see Cova et al. 2022). Late Successional Reserves in the north half of the network (especially on the Okanogan portion of the Forest) have experienced much greater amounts and impacts of fire than other LSRs, with some LSRs burning in their entirety (e.g., Nice LSR) since 1994 and others experiencing significant amounts of fire (e.g., Upper Methow LSR).

The NWFP recognizes the important role of natural disturbances, such as fire, in LSRs and acknowledges that disturbances should be allowed to play a natural role in maintaining late seral and old forest conditions:

> "In Late-Successional Reserves, standards and guidelines are designed to maintain late-successional forest ecosystems and protect them from loss due to large-scale fire, insect and disease epidemics, and major human impacts. The intent is to maintain natural ecosystem processes such as gap dynamics, natural regeneration, pathogenic fungal activity, insect herbivory, and low-intensity fire." (USDA and USDI 1994, ROD B-1)

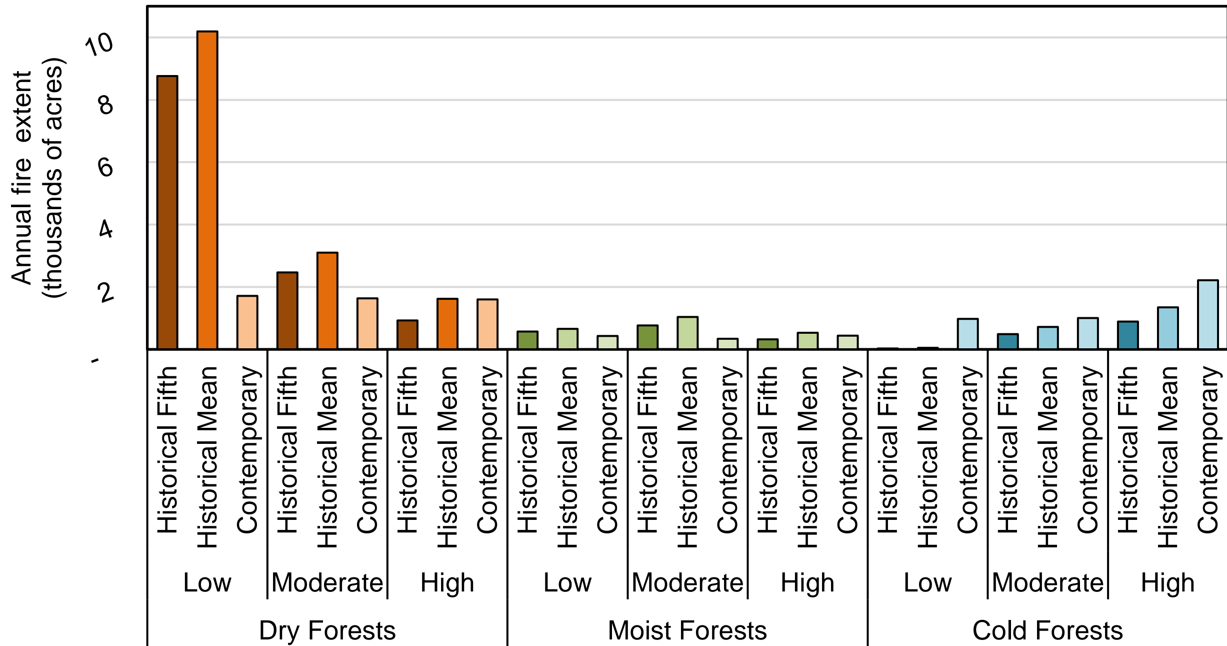


Figure 8.1-Annual simulated historical acres burned by severity class for each vegetation type in the Late-Successional Reserve network on the Okanogan-Wenatchee National Forest compared with contemporary acreages from 1993 – 2021 (annualized for comparison; data from Donato et al. 2023).

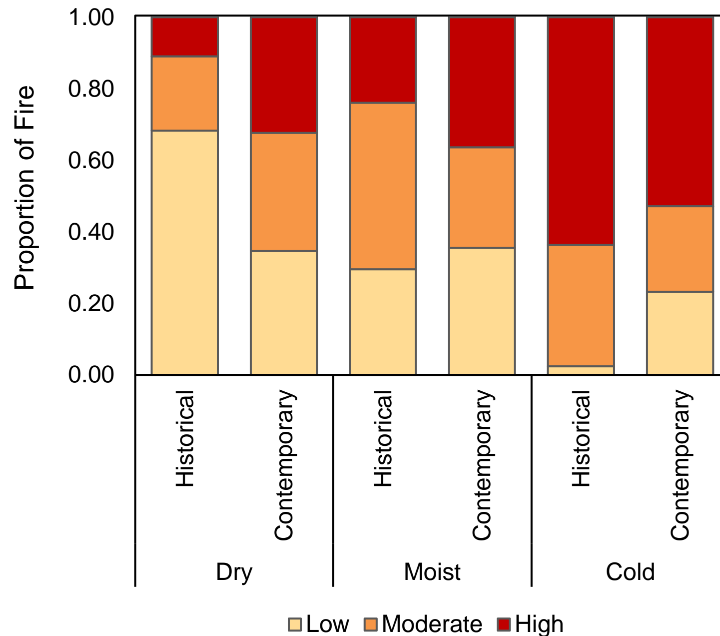


Figure 8.2-Comparisons between the proportion of fire by severity class in any given year based on simulations of historical structure and vegetation type compared with observed contemporary fire severity in each vegetation class within the Okanogan-Wenatchee Late-Successional Reserve network (data summarized from Donato et al. 2023).

This guidance recognizes the important role of low-severity fire while also acknowledging the impacts of large-scale uncharacteristic wildfire in compromising late-successional and old forest amounts and habitat, allowing flexibility for forests east of the Cascades Crest to "…reduce the risk to LSRs from severe impacts resulting from large-scale disturbances and unacceptable loss of habitat" (USDA and USDI 1994, ROD B-1) through both silvicultural activities and prescribed fire.

Fire management standards and guidelines are established in the existing Land and Resource Management Plans (Forest Plans) for the Okanogan and Wenatchee National Forests and within the NWFP. Fire management activities must also follow regulatory requirements laid out by the Environmental Protection Agency under the Clean Air Act and the Washington Smoke Management Plan (administered by Washington Department of Natural Resources on behalf of the Washington Department of Ecology). Guidance in the original LSR assessments emphasized maintaining late-successional habitat and old growth through suppression activities, where the goal was to limit the size of wildfires within LSRs. Furthermore, this guidance suggested that fire management activities should "rapidly extinguish smoldering coarse woody debris and duff should be considered to preserve these ecosystem elements." Current science and evidence-based practice suggests that the role of fire in LSRs needs to be revised considering the challenges associated with fire suppression in an era where climate change is creating considerably longer fire seasons and more intense and dangerous fire conditions to suppress. The goal of this LSR assessment update is to provide a broader range and more flexible options to address wildfires within LSRs. The following sections detail the application of new science on treatment options and effectiveness used to develop guidance.

8.2.Fire prevention and risk reduction

The goal and intent of risk reduction activities in Late-Successional Reserves should focus on reducing the risk of large, uncharacteristic wildfires that threaten to eliminate late-successional and old forest. Old trees are one of the most critical and limiting elements of dry and moist forest ecosystems in the eastern Cascades (Hessburg et al. 2015), take 200 – 300 years to recover after loss, and are often lost in high severity fires (Churchill et al. 2022), and may not regenerate if drought conditions persist following high severity fire (Kemp et al. 2019, Meigs et al. 2022, Davis et al. 2023).

Risk reduction activities may include mechanical treatments to reduce fuels both in the overstory and understory as well as prescribed fire activities such as broadcast burning, jackpot burning, and pile burning. Specific locations where these treatments are likely to be appropriate will be evaluated using the criteria in Section 6, which utilizes the landscape evaluation of wildfire risk and departure from historical conditions from the Forest Restoration Strategy (USFS 2012b). Specific treatment types and locations at the project level should be evaluated using fire modeling tools to assess how the proposed treatments will change modeled fire behavior and impacts to LSOF habitat.

Treatments that include a combination of thinning and prescribed fire, and especially broadcast burning, have been shown to have the highest likelihood of moderating fire behavior and reducing fire severity during large, uncharacteristic wildfire events (Martinson and Omi 2013,

Kalies and Yokum Kent 2016, Prichard et al. 2021). Evidence from recent local extreme fire events has suggested that the strategic placement of fuel reduction treatments that included thinning and prescribed fire or prescribed fire only effectively reduced localized fire spread and severity even under severe fire weather (Prichard et al. 2010, 2014, 2020). Effective risk reduction treatments must create gaps in surface and canopy fuel structures to reduce the potential for crown fire initiation and spread, and not simply rearrange fuels from the canopy or midstory to the surface (Prichard et al. 2021).

8.3.Wildfire suppression

Wildfire suppression responses in Late-Successional Reserves will vary depending on a variety of factors at the time of an incident, but should generally account for three key objectives:

1. Protecting prioritized values at risk within and adjacent to Late-Successional Reserves. These values include late-successional and old forest structure, habitat for northern spotted owl, or habitats for other old-growth dependent species;

2. Maintaining intact late-successional and old forest structure;

3. Minimizing resource damage from incident suppression activities.

Fire suppression strategies in LSR should utilize the full range of suppression responses to effectively meet land management objectives. This may include utilizing unplanned ignitions under moderate fire weather conditions to strategically reintroduce variability through low and moderate intensity fire. In some cases, aggressive full suppression may be necessary or desirable, but the short- and long-term tradeoffs of this approach should be carefully weighed by agency administrators. For example, while full suppression actions may decrease risk to values within and adjacent to the LSR and reduce the amount of area effected in the short-term, this approach is likely to increase risk to the late-successional and old forest structure and habitat and surrounding communities or infrastructure over the long-term. Meanwhile, indirect suppression actions could reduce some risks to identified values both in the near- and long-term by utilizing natural features and control lines to create safe and effective fire response but increases the operational complexity of an incident. Both suppression activities have the potential to result in increased resource damage. Conversely, modified suppression activities that utilize monitoring and point protection of identified values will likely have lower resource damage due to more limited suppression activities, but incident management teams may have less ability to maintain desirable landscape and stand-level structural attributes or minimize adverse effects to values within and adjacent to LSRs.

Incident management teams should prioritize the use of identified, high probability of success control locations and existing potential operational delineations to protect both the prioritized values at risk and LSOF stand structure during fire suppression activities. These potential control lines can be identified as part of the landscape evaluation during project planning. Proposed creation or maintenance of potential control lines may be appropriate within LSRs, but resource specialists should carefully weigh their potential to modify fire behavior or increase fire

management options during suppression activities with their impacts to other resource values within LSRs.

Managing wildfires has the potential to create numerous beneficial impacts while reducing future risk of large, uncharacteristic wildfires (Parks et al. 2015, 2016, Buma et al. 2020) when it can be safely and effectively carried out under the right suite of conditions. Long-duration events that create some smoldering of downed wood or duff have the potential to kill some desirable trees, but if effects can be moderated, this fire activity may be desirable in that it will create future snags and downed wood that make up important habitat components of late-successional systems. Ultimately, the Forest should utilize suppression strategies that maximize the amount of low and moderate severity fire effects within a fire perimeter during a fire event in LSRs. This approach acknowledges the important role of low to moderate severity fire in creating and maintaining old forest structural conditions over the long-term, while allowing for maximum flexibility for suppression tactics to meet and maintain desired long-term resource objectives in LSRs. The integration of landscape-level restoration treatments with strategic wildfire response will be an important tool for adapting dry, moist, and cold forest to develop more resilient conditions within LSRs into the future (Churchill et al. 2022).

8.4.Prescribed fire and managed unplanned ignitions

Prescribed fire is an important tool that should be utilized to manage stands for late-successional and old forest characteristics and reduce future fire risk. Prescribed fire can include a suite of different approaches, including broadcast burning that occurs over much of a stand or treatment unit, jackpot burning, or pile burning following guidance contained within PMS-484 (NWCG 2022).

Broadcast burning most closely approximates the ecological conditions that would have been created by low severity fire, which was historically present in different proportions in dry, moist, and cold forests (Figure 8.2). However, broadcast burning is not always feasible, especially in moist or cold forest types where fuels must dry and cure before being receptible to carry fire or as a first entry due to excessive fuels in an untreated stand. Operational burn windows are often short and smoke regulations limit the number of burns that can be carried out during these windows. Predictions suggest that climate change will increasingly shorten burn windows over the next several decades (Swain et al. 2023), with burn windows already shortening by approximately one day per year over the past several decades (Baijnath-Rodino et al. 2022), leaving fuels managers with fewer options for applying fire in treated and untreated areas.

In some locations, objectives may only be able to be met during fire season and with unplanned ignitions. Where unplanned ignitions result in fires that burn under favorable weather conditions or create low and moderate severity effects, resource management objectives for LSRs may be met (see WADNR 2023). Even large wildfires have shown to move some dry forest patches in eastern Washington toward more desirable conditions reflective of the natural range of variability where moderate and low severity fire shifted closed canopy structural conditions to open canopy or from drought and fire-intolerant species to a more fire-tolerant species composition (Churchill et al. 2022). However, wildfires burning under extreme weather conditions can have the potential to shift forests away from a resilient condition and can remove

patches of dense large tree forest conditions that are optimal habitat for old-growth dependent species (Churchill et al. 2022) or preclude natural tree regeneration for the next cohort of old forests where high severity patches are large (Littlefield 2019, Povak et al. 2020). Prescribed fire restoration treatments, in combination with mechanical treatments that intentionally prepare landscapes for wildfires, may help to limit the extent of large, high severity patches and result in more positive outcomes during future wildfires (Churchill et al. 2022).

9. PAST AND FUTURE VEGETATION MANAGEMENT

Vegetation management planned for implementation within LSRs will follow the OWNF 5-year plan, which is updated annually to reflect proposed outyear restoration projects. Amounts and specific treatment types are not yet determined, but will include some combination of commercial thinning, non-commercial thinning, hazardous fuels reduction, and prescribed burning. Future projects proposing work in LSRs will continue to be consulted on with regulatory partners and would be required to go through the NEPA process. Specific treatments will be consistent with the framework and design criteria laid out in Section 6 of this document or reviewed by the LSR Workgroup to ensure consistency with the NWFP.

Past treatments in LSRs have included commercial thinning[10], pre-commercial thinning, hazardous fuels reduction[11], and prescribed fire[12]. Footprint acres of the following treatments totaled 65,300 acres between 1994 – 2023. Pre-commercial thinning, piling, and pile burning have been the most common activities completed in LSRs on the OWNF. Over the past 30 years, acres treated in LSRs varied by activity (Figure 9.1, Figure 9.2). Commercial harvest in LSRs has never exceeded more than 2,500 acres/year, with a median of 430 acres/year. Precommercial thinning has averaged around 490 acres/year, with a median of 318 acres/year. Fuels reduction treatments and prescribed fire have averaged around 1,300 acres/year and 420 acres/year, with a median of 784 and 292 acres/year respectively.

As much as over 16,500 acres per year would need to be treated in LSRs over the next ten years to move the landscape from its current condition to a historically representative amount of large, dense tree structure in dry and moist forests (18 – 24% of the total landscape, Halofsky et al. in review). This far exceeds the amount of treatment that has ever been accomplished annually in LSRs on the OWNF, and for some types of treatment, exceeds the total acres of treatments completed over the past 30 years in LSRs. It is unrealistic that the magnitude and scale of future treatment would approach this amount. Treatments in LSRs will continue to be constrained by factors such as access, terrain, smoke management, land management designations (e.g., riparian reserves or roadless areas), and other factors. However, treatments that move the landscape toward a representative range of open and closed forests habitats in strategic or high priority areas will create more resilient stands that, in combination with endemic insect and disease activity or low or moderate intensity wildfires, may eventually create more resilient and sustainable landscapes that have a diverse, functional, and connected network of LSOF habitats. Thus, the goal of treatment is not to treat every acre possible to reach the natural range of variability for different forest types, but rather to use treatments to move landscapes toward conditions in which disturbances can play a more natural and characteristic role that, eventually (over decades), may create functioning landscapes that are resilient to climate change and increasing disturbance severity.

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[10] In addition to traditional commercial thinning activities, this category has included salvage cuts, sanitation harvests, seed tree and shelterwood establishment cuts and minor other types of commercial harvest activities.

[11] Hazardous fuel treatments include non-commercial thinning activities, pruning, piling of fuels, fuels rearrangement (such as mastication), and yarding of fuels.

[12] Prescribed fire includes activities such as broadcast or under burning, pile burning, or jackpot burning.

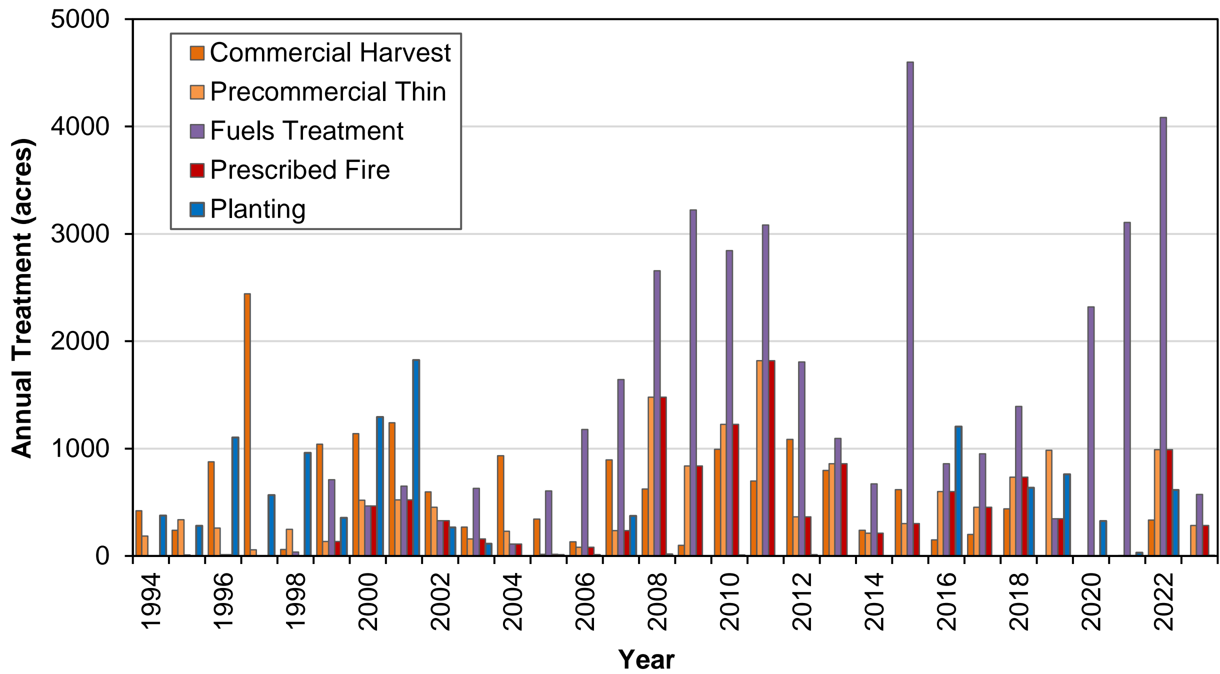

Figure 9.1-Annual treatment acres across the Late-Successional Reserve network on the Okanogan-Wenatchee National Forest between 1994 – 2023 from the Forest Activity Tracking System (FACTS) database. Multiple treatments can occur with a single treatment unit. These treatment totals therefore do not represent footprint acres.

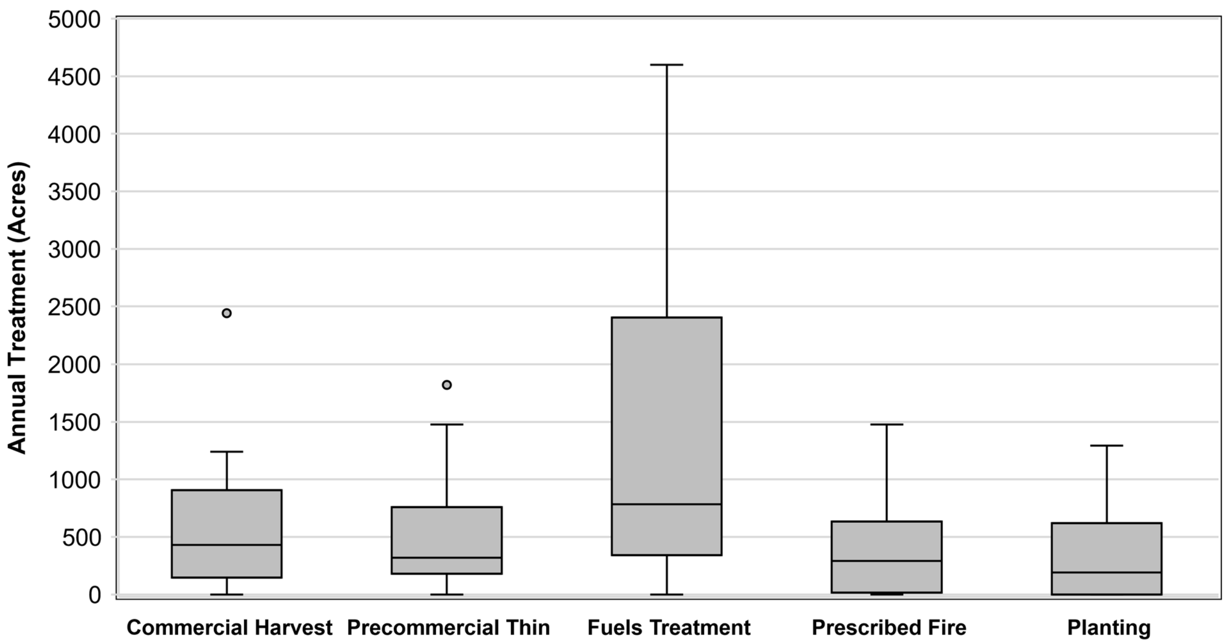

Figure 9.2-Annual treatment acres across the Late-Successional Reserve network on the Okanogan-Wenatchee National Forest by activity for the period between 1994 – 2023 from the Forest Activity Tracking System (FACTS) database. Boxes represent the 25th and 75th percentiles of the data, while the bars represent the 5th and 95th percentiles of the data. Median acres are represented by the vertical black line within the boxes. One outlier for fuels treatment (10,725 acres in 2022) was excluded in order to better represent the range of other treatment types.

with decisions expected in the next 5 years, with two additional projects on deck for outyear planning in this timeframe (2024 – 2028; Table 9.1). These projects are largely intended to be landscape scale restoration projects, but also include some more narrowly focused fuel breaks or hazardous fuel reduction projects as well. Specific treatment areas within LSRs either have not yet been defined or are in development, but because of many of the constraints listed previously, only some fraction of the amount of area in LSR that intersects the project area is likely to be proposed for treatment. An example of this is the recent Taneum Restoration Project, which has approximately 19,500 acres in LSR but only approximately 5,000 acres of treatments proposed within the LSR, with 150 acres of that treatment occurring within northern spotted owl nesting-roosting and/or foraging habitat.

Table 9.1-Projects where NEPA has been initiated or that are planned to have signed decisions within the next 5 years (2024-2028) based on the Okanogan-Wenatchee National Forest 5-Year Plan. LSRs that have the potential to be treated and the acres and proportions of these LSRs within the existing project area boundary are listed. Acres within LSRs within project area boundaries are not guaranteed for treatment. Additional projects will be identified in the future as part of the Forest's 5-Year Plan.

Project Planning Area	**District**	**LSRs**	**Project Size (acres)**	**Acres within LSR/MLSAs**	**Proportion of project in LSR/MLSA**
NEPA Initiated					
Chumstick to LP	Wenatchee River Ranger District	RW-131, 133, 135	115,316	23,257	0.20
Lower North Shore	Entiat Ranger District	RW-137, 139	98,012	23	0.00
Midnight Restoration	Methow Valley Ranger District	RW-141, 142	53,009	36,233	0.68
Muddy Fox	Entiat Ranger District	RW-135, 136	95,328	9,581	0.10
Nason	Wenatchee River Ranger District	RW-133, 134	48,853	14,054	0.29
South Fork Tieton	Naches Ranger District	RW-128, 153	102,345	56,314	0.55
Upper Methow Restoration	Methow Valley Ranger District	RW-142, 143	57,520	38,665	0.67
Upper Swauk	Cle Elum Ranger District	RW-129	35,762	34,613	0.97
Total:			**634,893**	**232,333**	**0.37**
Out Year Planning					
Cle Elum Small Tree Thinning	Cle Elum Ranger District	RW-123, 125, 129	19,229	1,794	0.09
Gold Springs Restoration	Naches Ranger District	RW-139	57,921	49,286	0.85
Total:			**77,150**	**51,080**	**0.66**

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Appendix A. Acronyms

ARU	Autonomous-recording Units
DAP	Digital Aerial Photogrammetry
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
FEMAT	Forest Ecosystem Management Assessment Team
FRV	Future Range of Variability
GIS	Geographic Information System
GNN	Gradient Nearest Neighbor
HRV	Historical Range of Variability
ICO	Individuals, Clumps, and Openings
LIDAR	Light Detection and Ranging
LSOF	Late-Successional and Old Forest
LSR	Late-Successional Reserve
LSRA	Late-Successional Reserve Assessment
MLSA	Manage Late-Successional Area
NEPA	National Environmental Policy Act
NFS	National Forest System
NSO	Northern Spotted Owl
NWFP	Northwest Forest Plan
OGSI	Old Growth Structure Index
OWNF	Okanogan-Wenatchee National Forest
S & G	Standards and Guidelines from Northwest Forest Plan
TPA	Trees Per Acre
TPI	Topographic Position Index
USDA	U.S. Department of Agriculture Forest Service
USDI	U.S. Department of the Interior
USFS	U.S. Forest Service
USFWS	United States Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WADNR	Washington State Department of Natural Resources

Appendix B. Summary for Individual or Grouped LSRs/MLSAs

This section provides information for individual Late-Successional Reserves and Managed Late-Successional Areas. Some of the smaller reserves were grouped based on their proximity to each other. As previously discussed, wildfire has had an impact on the entire LSR network on the Okanogan-Wenatchee National Forest (Figure B.1). Considerable loss of a variety of old forest habitats has already occurred, reducing the efficacy of some of the Late-Successional Reserves, and fracturing the connectivity of the network across the province. The results of the risk assessment showed that the most at-risk Late-Successional Reserves/Managed Late-Successional Areas included the Tieton, Swauk, and the Naches Group. Risks in other Late-Successional Reserves are still high but not as extreme as those listed above. These included the Wenatchee River Group, Manastash, and Chiwawa. The Late-Successional Reserves that are a lower risk included Upper Methow, Teanaway, Methow/Twisp Group, and Chelan Group where considerable amounts of wildfire has removed some of the most susceptible habitats (e.g., large-tree dense-forest). The resulting condition of the LSRs or Groups are described below.

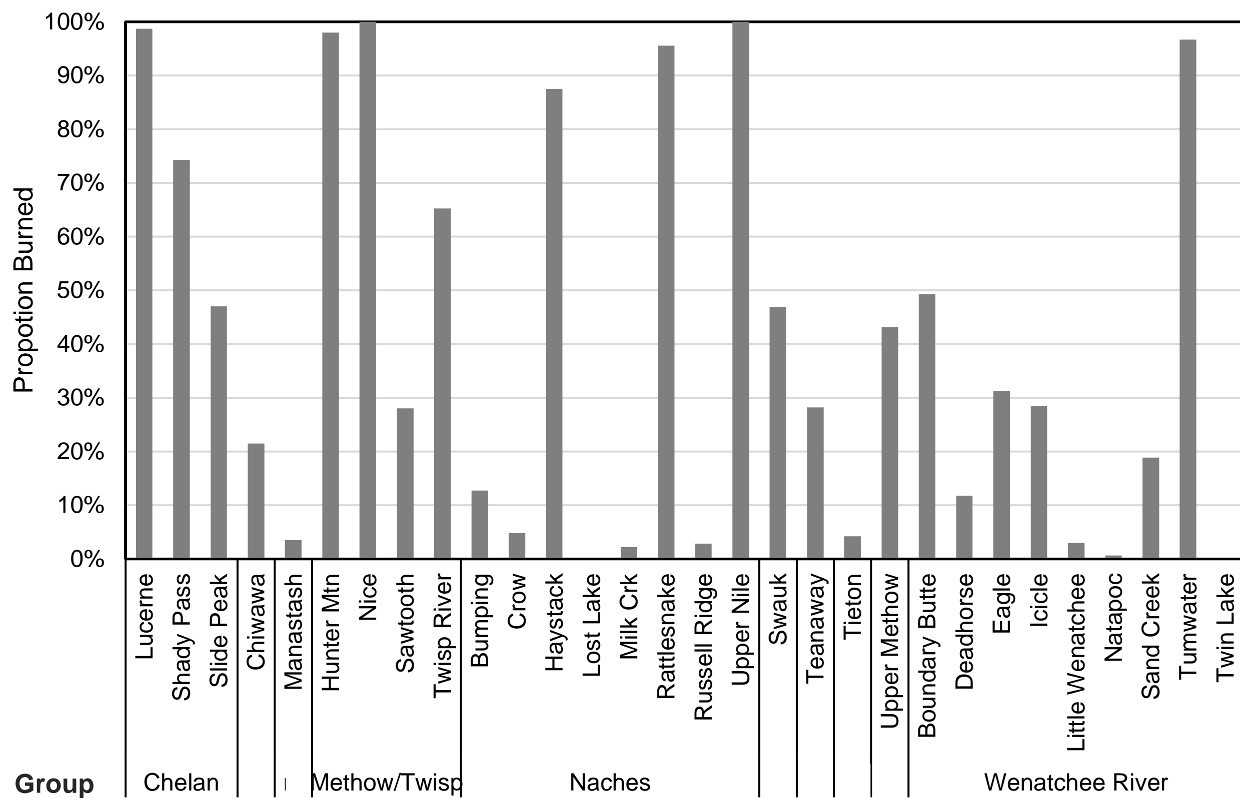

Figure B.1-Proportion of each LSR/MLSA that has burned from 1993-2021.

Chelan Group (Shady Pass, Lucerne and Slide Peak Late-Successional Reserves)

Current Condition

The Chelan Group consists of the Shady Pass, Lucerne and Slide Peak Late-Successional Reserves, all located near Lake Chelan (Figure B.2). This group of LSRs is about 86,615 acres in size. This group is comprised primarily of the Dry Forest Vegetation Group (35%) and the Cold Forest group (38%), with smaller amounts of Moist Forest (9%) and non-forest (18%) (Table B.1).

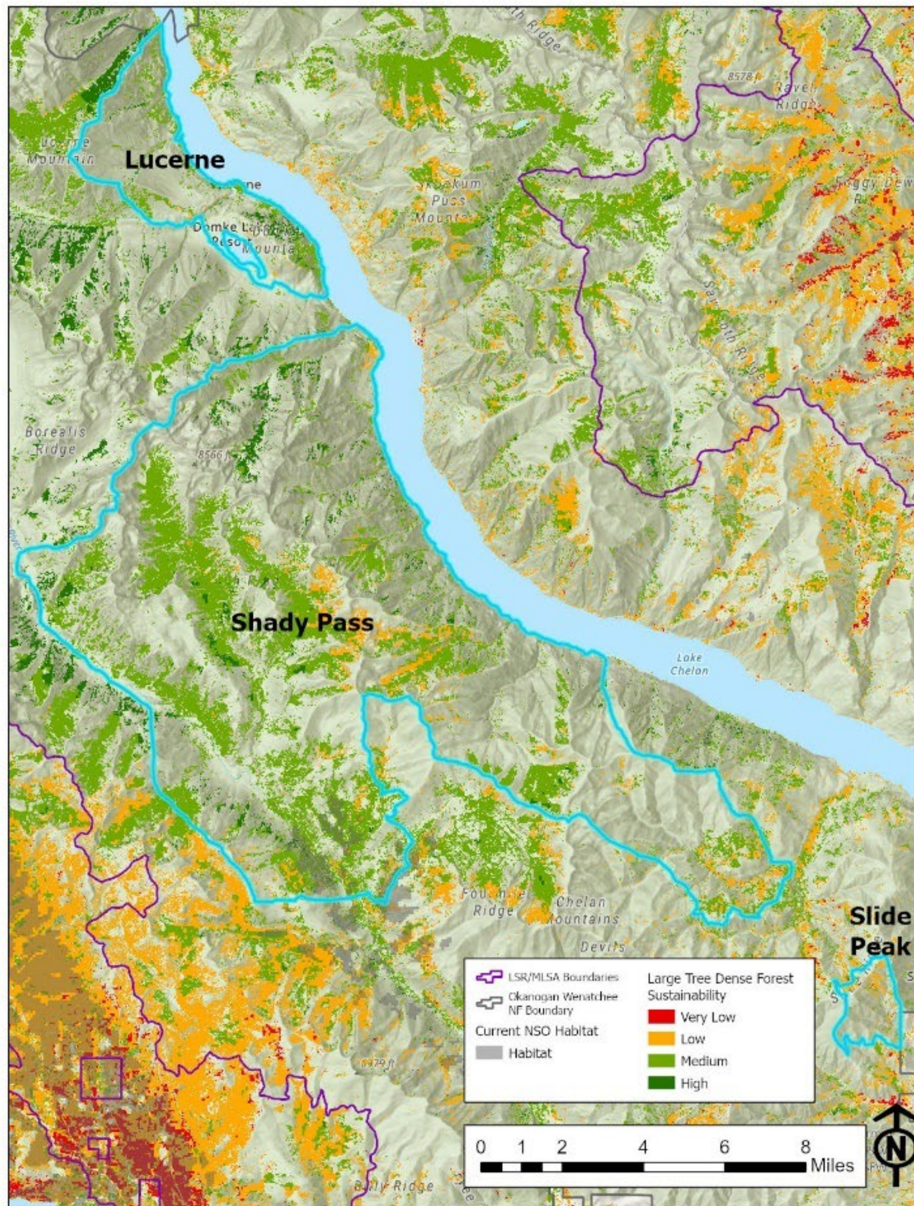

Figure B.2-Location of the Chelan Group on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.1-Area of each Forest Group in the Chelan Group.

Forest Group	Acres	Percent of LSR
Non-Forest	15,502	18%
Dry Forest	30,772	35%
Moist Forest	7,571	9%
Cold Forest	32,770	38%

Currently there are about 5,725 acres in the Chelan Group identified as OGSI 200, including 1,930 acres in the Dry Forest, 659 acres in the Moist Forest and 3,135 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (7% of the OGSI 200 is "core").

Table B.2-Acres of OGSI 200 by forest type and spatial configuration for the Chelan Group (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total acres
Core	117	24	284	425
Edge	282	77	589	948
Finger	514	193	993	1,700
Scatter	1,017	365	1,270	2,651
Total	1,930	659	3,135	5,725

Currently there are only about 1,450 acres in the Chelan Group identified as northern spotted owl nesting-roosting habitat and 1,800 acres of northern spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Dry Forest (64%). At the time the NWFP was implemented in 1994, there were only 5 known pairs of northern spotted owls in the Chelan Group. There have been no detections of northern spotted owls since 2003.

Table B.3-Acres of northern spotted owl habitat by function and forest group for the Chelan Group (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2016, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	3,402	1,589	7,025	12,016	14%
Foraging-only	1,151	478	179	1,808	2%
Nesting-roosting	829	478	149	1,456	2%

The amount of forest within the Chelan Group identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 1,474 acres and under more extreme fire weather conditions (90th percentile) is only 410 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.4-Acres identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Chelan Group.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	28,461	6,939	35,400 (96%)
50th – ≥50%	998	476	1,474 (4%)
90th – <50%	29,086	7,282	36,368 (99%)
90th – ≥50%	280	129	410 (<1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 10,264 acres of the Dry and Moist Forest in the Chelan Group that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of these acres (75%) are located in the Dry Forest and a smaller amount is in the Moist Forest (25%). Considering the impacts of drought and fire, a large proportion (90%) of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category, primarily in the moderate category. The remaining large-tree dense-forest (10%) is in the low to very low sustainability categories. This suggests that although there is not

[13] Refers to ≥50% probability that under different fire weather scenarios conditions forest would function as fire refugia (Krawchuk et al. 2023).

a substantially large amount of Large-Tree Dense-Forest in this group, it may be in more sustainable locations relative to other Late-Successional Reserves.

Table B.5-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Chelan Group.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	3	0	3	0.0%
Low	888	128	1,016	1.2%
Moderate	6,337	2,193	8,530	9.8%
High	423	292	715	0.8%
Total	7,651	2,613	10,264	11.9%

Medium-Tree Dense-Forest

The status of medium-tree dense-forest is quite similar to large-tree dense-forest. There are 3,759 acres of the Dry and Moist Forest in the Chelan Group that are comprised of medium-tree dense-forest (MTDF). Most of these acres (78%) are located in the Dry Forest and a smaller amount is in the Moist Forest (22%). Considering the impacts of drought and fire, a large proportion (88%) of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category, primarily in the moderate category. The remaining medium-tree dense-forest (12%) is in the low to very low sustainability categories.

Table B.6-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Chelan Group.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	1	0	1	0.0%
Low	397	36	433	0.5%
Moderate	2,342	665	3,007	3.5%
High	206	112	318	0.4%
Total	2,946	813	3,759	4.3%

Dry Forest

Currently, an estimated 6,779 acres (8%) of Dry Forest within the Chelan Group provides Large-Tree Open-Canopied habitats. Historical estimates suggest that 33% to 47% of the dry forest

would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the Northwest Forest Plan (SAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 14,490 acres (17%) of the Chelan Group is projected to experience more than 25% loss of tree basal area from forest pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Chelan Group experienced a 57% increase in resistance.

Summary

The Chelan Group is considered to be at high risk, although at a lower risk relative to the Late-Successional Reserve network on the Okanogan-Wenatchee National Forest, because considerable amounts of wildfire have already removed some of the most susceptible habitats (Figure B.2). This risk assessment is therefore based on three primary factors: (1) wildfire has already removed some of the most susceptible habitats (e.g., large-tree closed-canopy habitat), (2) there is a lower proportion of Moist Forest (9%), and (3) few acres (4%) are identified as "fire refugia" even under moderate fire weather conditions.

Chiwawa Late-Successional Reserve

Current Condition

The Chiwawa Late-Successional Reserve is about 99,410 acres in size and is one of the larger "source" reserves located centrally within the network on the OWNF (Figure B.3). It is comprised primarily of the Cold Forest Vegetation Group (38%), and also includes Dry Forest (29%), and Moist Forest (25%). The remainder of the area is in non-forest (8%) (Table B.7).

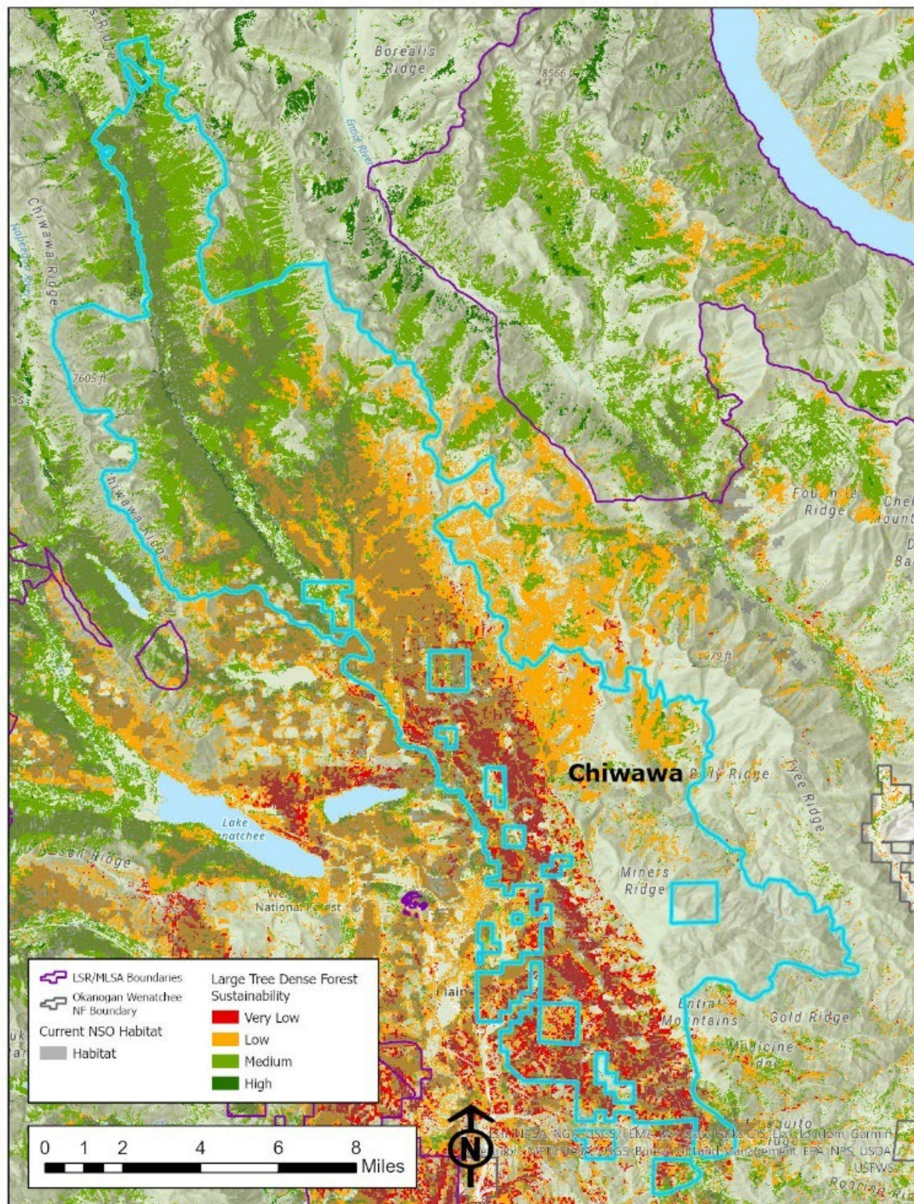

Figure B.3-Location of the Chiwawa LSR on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.7-Area of each Forest Group in the Chiwawa LSR.

Forest Group	Acres	Percent of LSR
Non-Forest	7,840	8%
Dry Forest	28,738	29%
Moist Forest	24,822	25%
Cold Forest	38,009	38%

Currently there are about 19,033 acres in the Chiwawa LSR identified as OGSI 200, including 4,941 acres in the Dry Forest, 5,379 acres in the Moist Forest and 8,713 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (15% of the OGSI 200 is "core").

Table B.8-Acres of OGSI 200 by forest type and spatial configuration for the Chiwawa LSR (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	705	811	1,291	2,807
Edge	1,172	1,423	2,061	4,657
Finger	1,545	1,882	3,058	6,485
Scatter	1,518	1,264	2,303	5,085
Total	4,941	5,379	8,713	19,033

Currently there are 22,493 acres in the Chiwawa LSR identified as northern spotted owl nesting-roosting habitat and 15,170 acres of northern spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Moist Forest (41%), with a similar proportion (36%) in the Dry Forest. At the time the Northwest Forest Plan was implemented in 1994, there were 17 known pairs of northern spotted owls in the Chiwawa Late-Successional Reserve. There have been only two detections of single owls over the past five years and no occupied activity centers.

Table B.9-Acres of northern spotted owl habitat by function and forest group for the Chiwawa LSR (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	17,967	18,078	21,260	57,304	58%
Foraging-only	6,795	5,800	2,575	15,170	15%
Nesting-roosting	6,843	9,629	6,020	22,493	23%

The amount of forest within the Chiwawa LSR identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 2,745 acres and under more extreme fire weather conditions (90th percentile) is only 1,952 acres (≥50% probability). This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.10-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Chiwawa LSR.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	26,581	22,921	49,502 (95%)
50th - ≥50%	1,268	1,477	2,745 (5%)
90th – <50%	26,909	23,293	50,202 (96%)
90th - ≥50%	901	1,051	1,952 (4%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 37,650 acres of the Dry and Moist Forest in the Chiwawa LSR that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). About half of these acres (52%) are located in the Dry Forest and the other half in Moist Forest (48%). Considering the impacts of drought and fire, about 32% of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest is in the low (45%) to very low (22%) sustainability categories.

Table B.11-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Chiwawa LSR.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	6,680	1,769	8,449	8%
Low	8,979	8,062	17,042	17%
Moderate	3,837	7,864	11,701	12%
High	88	372	460	0%
Total	19,584	18,068	37,651	38%

Medium-Tree Dense-Forest

The status of medium tree dense forest is quite similar to large tree dense forest. There are 9,560 acres of the Dry and Moist Forest in the Chiwawa LSR that are comprised of medium-tree dense-forest (MTDF). Slightly more than half of these acres (57%) are located in the Dry Forest and a smaller amount is in the Moist Forest (43%). Considering the impacts of drought and fire, only 33% of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (67%) is in the low (44%) to very low (23%) sustainability categories.

Table B.12-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Chiwawa LSR.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	1,826	416	2,243	2%
Low	2,463	1,722	4,185	4%
Moderate	1,110	1,945	3,055	3%
High	15	62	77	0%
Total	5,414	4,146	9,560	10%

Dry Forest

Currently, an estimated 4,421 acres (4%) of Dry Forest within the Chiwawa LSR provides Large-Tree Open-Canopied habitats. Historical estimates suggest that 33% to 47% of the dry

forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 25,393 acres (26%) of the Chiwawa LSR is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Chiwawa Late-Successional Reserve experienced a 31% increase in resistance.

Summary

Risk of habitat loss from large-scale disturbances in the Chiwawa Late-Successional Reserve is still considered to be high relative to other parts of the Late-Successional Reserve network in the region. However, larger portions of the Chiwawa Late-Successional Reserve have large-tree dense-forest in more sustainable locations that other Late-Successional Reserves (e.g., Tieton, Swauk and the Naches Group). This risk assessment is based on four primary factors: (1) there is a higher proportion of Moist Forest (29%), (2) a considerable proportion of the large-tree closed canopy habitat is in landscape locations that are difficult to sustain, (3) few acres (2,745 acres) are identified as “fire refugia” even under moderate fire weather conditions, and (4) the amount of large-tree open-canopy habitat is presently well below the natural range of variability and desired conditions. A considerable amount of active management is needed to create more sustainable and resilient habitat conditions for species associated with old forests.

Manastash Late-Successional Reserve

Current Condition

The Manastash Late-Successional Reserve (LSR) is 78,910 acres in size and is one of the larger reserves located in the southern end of the network on the OWNF (Figure B.4). It is comprised primarily of the Cold Forest Vegetation Group (53%), and also includes Moist Forest (24%) and Dry Forest (20%). The small remainder of the area is in non-forest (3%) (Table B.13).

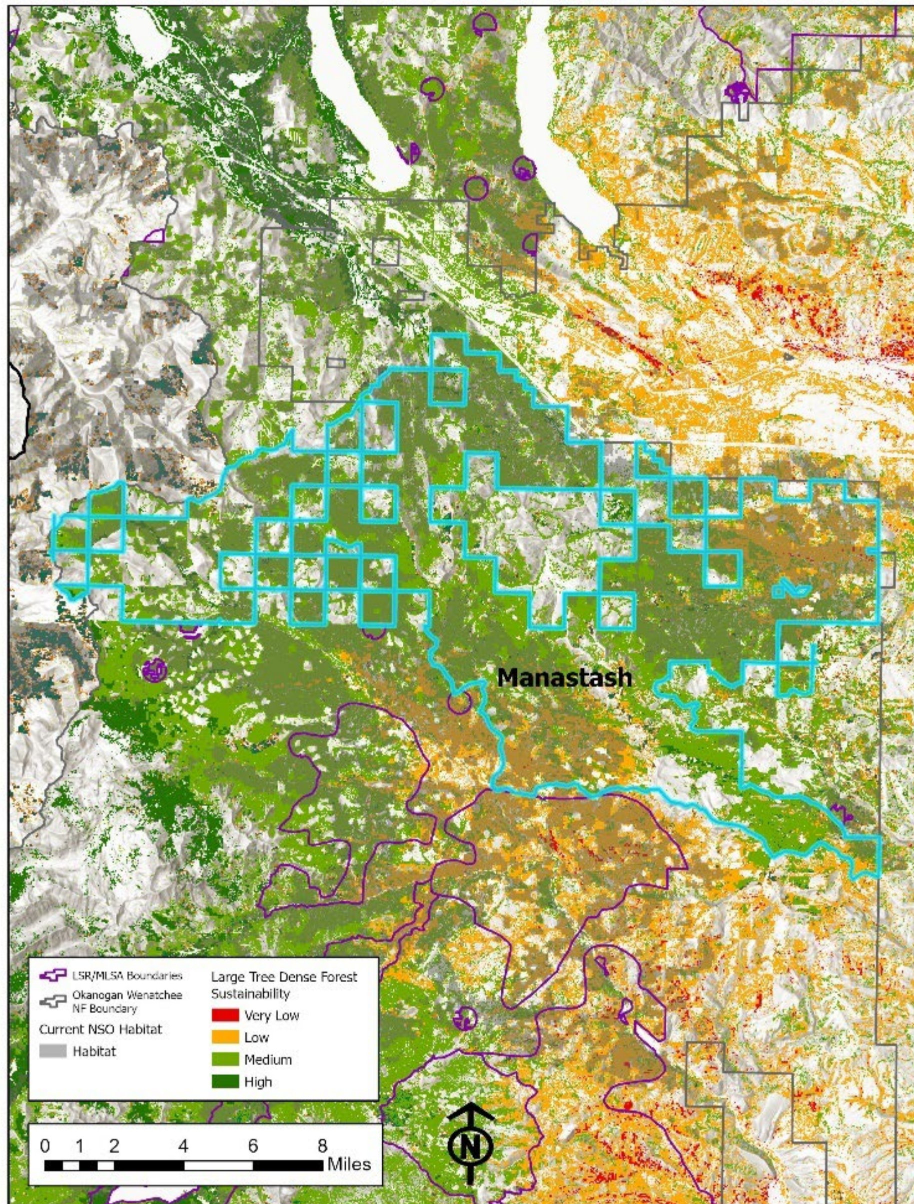

Figure B.4-Location of the Manastash LSR on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.13-Area of each Forest Group in the Manastash LSR.

Forest Group	Acres	Percent of LSR
Non-Forest	2,269	3%
Dry Forest	16,001	20%
Moist Forest	19,169	24%
Cold Forest	41,470	53%

Currently there are about 22,552 acres in the Manastash LSR identified as OGSI 200, including 2,860 acres in the Dry Forest, 4,541 acres in the Moist Forest and 15,150 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (25% of the OGSI 200 is "core"; 75% are "edge, finger, or scattered"), although this LSR has much more core OGSI than other LSRs.

Table B.14-Acres of OGSI 200 by forest type and spatial configuration for the Manastash LSR (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015, 2022).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	393	800	4,373	5,566
Edge	707	1,176	4,743	6,626
Finger	913	1,522	4,537	6,971
Scatter	848	1,044	1,497	3,388
Total	2,860	4,541	15,150	22,552

Currently there are 28,798 acres in the Manastash LSR identified as northern spotted owl nesting-roosting habitat and 10,689 acres of northern spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Cold Forest (41%). At the time the NWFP was implemented in 1994, there were 33 known pairs of northern spotted owls in the Manastash LSR. Spotted owls have been detected within 16 breeding ranges and occupied five activity centers from 2018 to 2022.

Table B.15-Acres of northern spotted owl habitat by function and forest group for the Manastash LSR (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	1,741	2,449	14,608	18,798	24%
Foraging-only	3,102	3,102	4,485	10,689	14%
Nesting-roosting	7,857	9,371	11,571	28,798	37%

The amount of forest within the Manastash LSR identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 1,689 acres and under more extreme fire weather conditions (90th percentile) is only 492 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.16-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Manastash LSR.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	15,352	18,054	33,406 (95%)
50th - ≥50%	629	1,059	1,689 (5%)
90th – <50%	15,837	18,753	34,590 (99%)
90th - ≥50%	163	330	492 (1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 27,704 acres of Dry and Moist Forest in the Manastash LSR that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). This forest type is split almost evenly between Moist Forest (54%) and Dry Forest (46%). In contrast to the other large LSRs, when considering the impacts of drought and fire, a substantial proportion (70%) of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (30%) is in the low to very low sustainability categories.

Table B.17-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Manastash LSR.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	59	0	59	0%
Low	5,950	2,303	8,252	10%
Moderate	6,757	12,058	18,815	24%
High	65	513	577	1%
Total	12,830	14,874	27,704	35%

Medium-Tree Dense-Forest

The situation regarding medium tree dense forest is quite similar to large tree dense forest. There are 11,017 acres of the Dry and Moist Forest in the Manastash LSR that are comprised of medium-tree dense-forest (MTDF). This forest type is split almost evenly between Moist Forest (54%) and Dry Forest (46%). In contrast to the other large LSRs, when considering the impacts of drought and fire, a substantial proportion (74%) of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (26%) is in the low to very low sustainability categories.

Table B.18-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Manastash LSR.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	9	0	9	<1%
Low	2,049	813	2,861	4%
Moderate	2,927	4,988	7,915	10%
High	33	199	232	<1%
Total	5,018	5,999	11,017	14%

Dry Forest

Currently, there is only an estimated 422 acres (<1%) of Dry Forest within the Manastash LSR that provides Large-Tree Open-Canopied habitats. Historical estimates suggest that 33% to 47% of the dry forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 10,205 acres (13%) of the Manastash LSR is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Manastash Late-Successional Reserve experienced a 23% increase in resistance.

Summary

Risk to the Manastash Late-Successional Reserve is still considered to be high relative to the Late-Successional Reserve network in the region. This is based on four primary factors: (1) there is a lower proportion of Dry Forest (20%), (2) a considerable proportion of the large-tree closed canopy habitat is in landscape locations that are less difficult to sustain, however, (3) few acres (5%) are identified as “fire refugia” even under moderate fire weather conditions, and (4) the amount of large-tree open-canopy habitat is presently well below the natural range of variability and desired conditions. A considerable amount of active management is needed to create more sustainable and resilient habitat conditions for species associated with old forests.

Methow/Twisp Group (Hunter Mtn, Nice, Sawtooth and Twisp River LSRs)

Current Condition

The Methow/Twisp Late-Successional Reserve Group is 111,598 acres located at the northern end of the OWNF network. This grouping includes: Hunter Mtn, Nice, Sawtooth and Twisp River Late-Successional Reserves (Figure B.5). It is comprised primarily of the Dry Forest Vegetation Group (42%), and also includes Cold Forest (34%) and some Moist Forest (3%). A large portion of the reserve group is in non-forest (22%) (Table B.19).

Figure B.5-Location of the Methow/Twisp Group on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.19-Area of each Forest Group in the Methow/Twisp LSR Group.

Forest Group	Acres	Percent of LSR
Non-Forest	24,204	22%
Dry Forest	46,299	41%
Moist Forest	2,992	3%
Cold Forest	38,104	34%

Currently there are about 14,760 acres in the Methow/Twisp Late-Successional Reserve Group identified as OGSI 200, including 6,297 acres in the Dry Forest, 607 acres in the Moist Forest and 7,855 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (20% of the OGSI 200 is "core"), although this LSR group has much more core OGSI 200 than other LSRs.

Table B.20-Acres of OGSI 200 by forest type and spatial configuration for the Methow/Twisp LSR Group (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	1,466	91	1,402	2,959
Edge	1,531	144	2,019	3,695
Finger	1,670	211	2,596	4,478
Scatter	1,630	161	1,839	3,629
Total	6,297	607	7,855	14,760

Currently there are 1,054 acres (1%) in the Methow/Twisp Late-Successional Reserve Group identified as spotted owl nesting-roosting habitat and 4,081 acres (4%) of spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Dry Forest (80%). At the time the NWFP was implemented in 1994, there were 2 known pairs of northern spotted owls in the Methow/Twisp LSR Group. There have been no detections of spotted owls since 2013.

Table B.21-Acres of northern spotted owl habitat by function and forest group for the Methow/Twisp LSR Group (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	13,422	711	10,974	25,108	23%
Foraging-only	3,150	107	824	4,081	4%
Nesting-roosting	958	36	60	1,054	<1%

The amount of forest within the Methow/Twisp LSR Group identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 538 acres and under more extreme fire weather conditions (90th percentile) is only 106 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.22-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Methow/Twisp LSR Group.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	43,350	2,932	46,282 (99%)
50th - ≥50%	518	20	538 (1%)
90th – <50%	43,695	2,945	46,641 (99%)
90th - ≥50%	102	4	106 (<1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 19,358 acres of Dry and Moist Forest in the Methow/Twisp LSR Group that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of this occurs in the Dry Forest (95%) and less so in Moist Forest (5%). When considering the impacts of drought and fire, a moderate proportion (47%) of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (53%) is in the low (48%) to very low (5%) sustainability categories. However, there is not very much LTDF within the LSR (17%).

Table B.23-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Methow/Twisp LSR Group.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	1,004	43	1,048	1%
Low	8,846	374	9,221	8%
Moderate	7,676	519	8,195	7%
High	792	103	895	1%
Total	18,319	1,039	19,358	17%

Medium-Tree Dense-Forest

The situation regarding medium tree dense forest is quite similar to large tree dense forest. There are 13,312 acres of the Dry and Moist Forest in the Methow/Twisp LSR Group that are comprised of medium-tree dense-forest (MTDF). Most of this occurs in the Dry Forest (95%) and less so in Moist Forest (5%). When considering the impacts of drought and fire, a moderate proportion (46%) of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (54%) is in the low (49%) to very low (5%) sustainability categories. However, there is not very much LTDF within the LSR (12%).

Table B.24-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Methow/Twisp LSR Group.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	691	27	718	1%
Low	6,221	282	6,503	6%
Moderate	5,202	359	5,561	5%
High	466	63	529	0%
Total	12,580	732	13,312	12%

Dry Forest

Currently, there are only an estimated 7,077 acres (6%) of the Dry Forest within the Methow/Twisp LSR Group that provide Large-Tree Open-Canopied habitats. Historical

estimates suggest that 33% to 47% of the dry forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 18,731 acres (17%) of the Methow/Twisp Group is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Methow/Twisp Group experienced a 25% increase in resistance.

Summary

The Methow/Twisp Group is considered to be high risk, although at a lower risk relative to the Late-Successional Reserve network on the Forest because considerable amounts of wildfire have already removed some of the most susceptible habitats (Figure B.1). This risk assessment is therefore based on three primary factors: (1) there is a low proportion of Moist Forest (3%), (2) wildfire has already removed some of the most susceptible habitats (e.g., large-tree closed-canopy habitat), and (3) few acres (1%) are identified as "fire refugia" even under moderate fire weather conditions.

Naches Group (Bumping LSR, Crow MLSA, Haystack MLSA, Lost Lake MLSA, Milk Creek MLSA, Rattlesnake LSR, Russell Ridge MLSA and Upper Nile LSR)

Current Condition

The Naches LSR/MLSA Group is 98,548 acres located at the southern end of the OWNF network. This group includes: Bumping LSR, Crow MLSA, Haystack MLSA, Lost Lake MLSA, Milk Creek MLSA, Rattlesnake LSR, Russell Ridge MLSA and Upper Nile LSR (Figure B.6). It is comprised primarily of the Dry Forest Vegetation Group (50%), and also includes Moist Forest (27%) and Cold Forest (16%). There is also some non-forest (7%) (Table B.25).

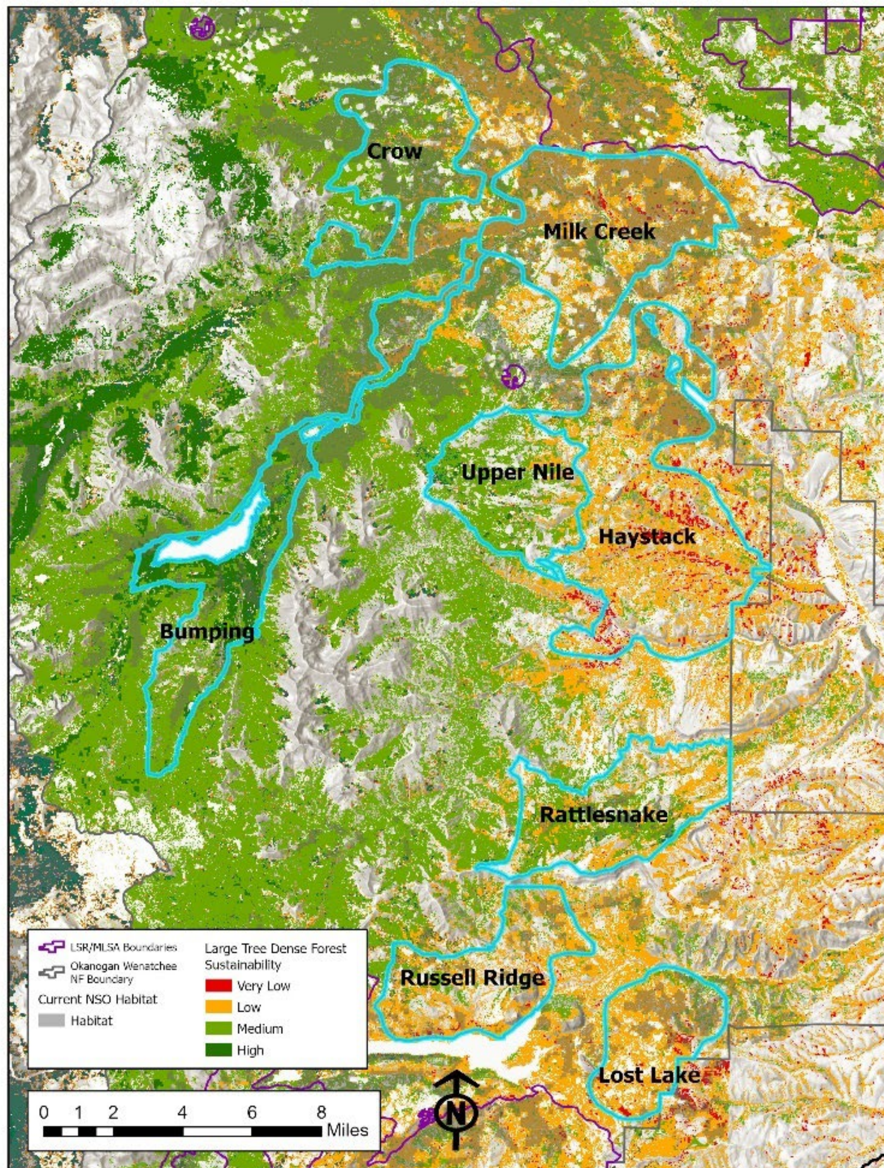

Figure B.6-Location of Naches Group on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.25-Area of each Forest Group in the Naches LSR/MLSA Group.

Forest Group	Acres	Percent of LSR
Non-Forest	6,710	7%
Dry Forest	49,757	50%
Moist Forest	26,317	27%
Cold Forest	15,765	16%

Currently there are about 20,526 acres in the Naches LSR/MLSA Group identified as OGSI 200, including 6,635 acres in the Dry Forest, 7,441 acres in the Moist Forest and 6,181 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (25% of the OGSI 200 is "core"), although this LSR group has much more core OGSI than other LSRs.

Table B.26-Acres of OGSI 200 by forest type and spatial configuration for the Naches LSR/MLSA Group (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	733	2,274	2,150	5,158
Edge	1,155	1,961	1,860	4,976
Finger	1,761	1,917	1,620	5,298
Scatter	2,985	1,288	551	4,825
Total	6,635	7,441	6,181	20,256

Currently there are 15,783 acres in the Naches LSR/MLSA Group identified as spotted owl nesting-roosting habitat and 13,198 acres of spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Dry Forest (54%). At the time the NWFP was implemented in 1994, there were 27 known pairs of northern spotted owls in the Naches LSR/MLSA Group. Spotted owls have been detected in 9 breeding ranges from 2018 through 2022.

Table B.27-Acres of northern spotted owl habitat by function and forest group for the Naches LSR/MLSA Group (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	**Dry Forest (acres)**	**Moist Forest (acres)**	**Cold Forest (acres)**	**Total (acres)**	**% of LSR**
Dispersal-only	24,306	15,639	8,474	48,419	49%
Foraging-only	8,729	3,309	1,160	13,198	13%
Nesting-roosting	6,904	6,662	2,218	15,783	16%

The amount of forest within the Naches LSR/MLSA Group identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 1,765 acres and under more extreme fire weather conditions (90th percentile) is only 793 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.28-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Naches LSR/MLSA Group.

Fire Weather Conditions	**Dry Forest (acres)**	**Moist Forest (acres)**	**Total Acres (%)**
50th – <50%	48,590	25,130	73,721 (98%)
50th - ≥50%	836	929	1,765 (1%)
90th – <50%	49,097	25,532	74,629 (99%)
90th - ≥50%	369	423	793 (1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 51,842 acres of Dry and Moist Forest in the Naches LSR/MLSA Group that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of this occurs in the Dry Forest (64%) and less so in Moist Forest (36%). When considering the impacts of drought and fire, a low proportion (38%) of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (62%) is in the low (59%) to very low (3%) sustainability categories.

Table B.29-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Naches LSR/MLSA Group.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	1,638	36	1,674	2%
Low	25,426	5,113	30,539	31%
Moderate	6,236	11,485	17,721	18%
High	119	1,789	1,908	2%
Total	33,419	18,423	51,842	53%

Medium-Tree Dense-Forest

The situation regarding medium tree dense forest is quite similar to large tree dense forest. There are 23,353 acres of the Dry and Moist Forest in the Naches LSR/MLSA Group that are comprised of medium-tree dense-forest (MTDF). Most of this occurs in the Dry Forest (65%) and less so in Moist Forest (35%). When considering the impacts of drought and fire, a low proportion (37%) of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (63%) is in the low (60%) to very low (3%) sustainability categories.

Table B.30-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Naches LSR/MLSA Group.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	709	16	726	1%
Low	11,571	2,364	13,934	14%
Moderate	2,764	5,140	7,904	8%
High	65	724	789	1%
Total	15,109	8,244	23,353	24%

Dry Forest

Currently, there are only an estimated 4,865 acres (5%) of Dry Forest within the Naches LSR/MLSA Group that provide Large-Tree Open-Canopied habitats. Historical estimates suggest that 33% to 47% of the dry forest would have had large trees and an open canopy,

providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 34,104 acres (35%) of the Naches Group is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Naches Group experienced a 59% increase in resistance.

Summary

The Naches Group is considered to be one of the most at-risk of all of the Late-Successional Reserves or Groups on the Forest and is a candidate for the application of the risk reduction standard where risks of large-scale habitat loss are "particularly high" (NWFP C-13). This is based on four primary factors: (1) there is a high proportion of Dry Forest (50%), (2) a considerable proportion of the large-tree closed canopy habitat is in landscape locations that are difficult to sustain, (3) few acres (1%) are identified as "fire refugia" even under moderate fire weather conditions, and (4) the amount of large-tree open-canopy habitat is presently well below the natural range of variability and desired conditions. A considerable amount of active management is needed to create more sustainable and resilient habitat conditions for species associated with old forests.

Swauk Late-Successional Reserve

Current Condition

The Swauk Late-Successional Reserve (LSR) is 106,460 acres in size and is one of the larger "source" reserves located centrally within the network on the OWNF (Figure B.7). It is comprised primarily of the Dry Forest Vegetation Group (53%), and also includes Moist Forest (14%) and Cold Forest (22%). The remainder of the area is in non-forest (11%) (Table B.31).

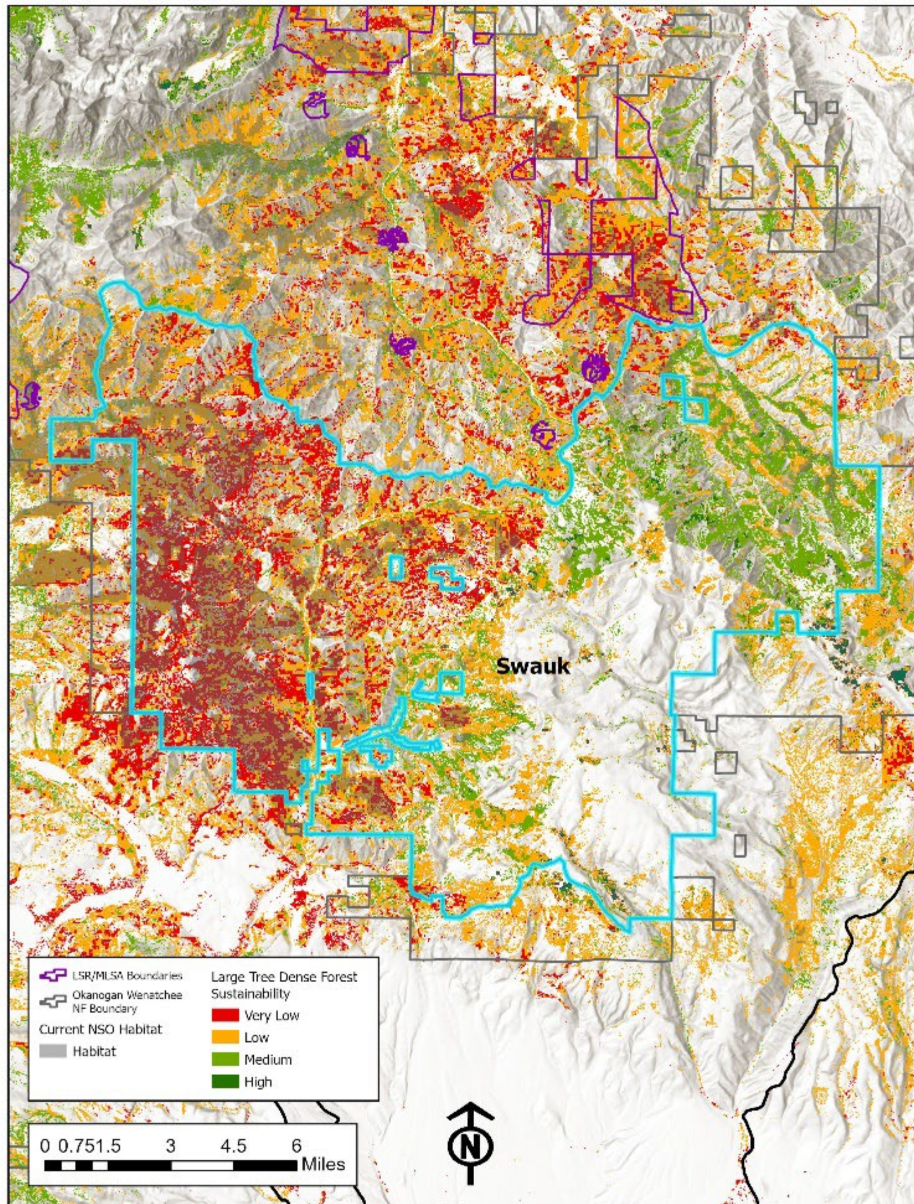

Figure B.7-Location of the Swauk LSR on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.31-Area of each Forest Group in the Swauk LSR.

Forest Group	Acres	Percent of LSR
Non-Forest	11,205	11%
Dry Forest	56,435	53%
Moist Forest	15,130	14%
Cold Forest	23,690	22%

Currently there are about 12,630 acres in the Swauk LSR identified as OGSI 200, including 7,605 acres in the Dry Forest, 1,950 acres in the Moist Forest and 3,074 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (9% of the OGSI 200 is "core").

Table B.32-Acres of OGSI 200 by forest type and spatial configuration for the Swauk LSR (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	510	176	497	1,183
Edge	1,114	264	775	2,153
Finger	1,996	457	959	3,412
Scatter	3,985	1,053	844	5,882
Total	7,605	1,950	3,075	12,630

Currently there are 8,563 acres in the Swauk LSR identified as spotted owl nesting-roosting habitat and 11,576 acres of spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Dry Forest (77%). At the time the NWFP was implemented in 1994, there were 24 known pairs of northern spotted owls in the Swauk LSR. Spotted owls have been detected in five breeding ranges from 2018 through 2022 and one activity center is currently occupied.

Nearly 50,000 acres of the Swauk LSR burned in the 2012 Table Mountain fire, reducing the amount of OGSI 200 habitat by 42% and the amount of spotted owl suitable habitat (nesting, roosting and/or foraging) by 38%.

Table B.33-Acres of northern spotted owl habitat by function and forest group for the Swauk LSR (based on NWFP Monitoring data from 2021. Methodology described in – Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	14,869	4,325	852	20,046	19%
Foraging-only	9,193	2,205	178	11,576	11%
Nesting-roosting	6,371	1,978	214	8,563	8%

The amount of forest within the Swauk LSR identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 403 acres and under more extreme fire weather conditions (90th percentile) is only 73 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.34-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Swauk LSR.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	55,412	14,813	70,225 (99%)
50th - ≥50%	308	95	403 (1%)
90th – <50%	55,723	14,809	70,532 (99%)
90th - ≥50%	46	27	73 (1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 23,410 acres of the Dry and Moist Forest in the Swauk LSR that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of these acres (81%) are located in the Dry Forest and with a smaller amount in the Moist Forest (19%). Considering the impacts of drought and fire, only 19% of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (81%) is in the low (43%) to very low (38%) sustainability categories.

Table B.35-The acre amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Swauk LSR.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	7,802	1,058	8,860	12%
Low	7,891	2,092	9,983	14%
Moderate	3,202	1,258	4,460	6%
High	66	40	106	<1%
Total	18,961	4,448	23,409	33%

Medium-Tree Dense-Forest

The status of medium tree dense forest is quite similar to large tree dense forest. There are 27,691 acres of the Dry and Moist Forest in the Swauk LSR that are comprised of medium-tree dense-forest (MTDF). Many of these acres (78%) are located in the Dry Forest and a smaller amount is in the Moist Forest (22%). Considering the impacts of drought and fire, only 20% of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (80%) is in the low (41%) to very low (39%) sustainability categories.

Table B.36-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Swauk LSR.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	9,048	1,763	10,811	15%
Low	8,822	2,607	11,429	16%
Moderate	3,677	1,562	5,239	7%
High	132	81	213	<1%
Total	21,679	6,012	27,691	39%

Dry Forest

Currently, an estimated 1,992 acres (4%) of the Dry Forest within the Swauk LSR provides Large-Tree Open-Canopied habitats. Historical estimates suggest that 33% to 47% of the dry

forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 20,027 acres (19%) of the Swauk LSR is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Swauk Late-Successional Reserve experienced a 57% increase in resistance.

Summary

The Swauk Late-Successional Reserve is considered to be one of the most at-risk of all of the Late-Successional Reserves on the Forest and is a candidate for the application of the risk reduction standard where risks of large-scale habitat loss are “particularly high” (NWFP C-13). This is based on four primary factors: (1) there is a high proportion of Dry Forest (53%), (2) a considerable proportion of the large-tree closed-canopy habitat is in landscape locations that are difficult to sustain, (3) few acres (1%) are identified as “fire refugia” even under moderate fire weather conditions, and (4) the amount of large-tree open-canopy habitat is presently well below the natural range of variability and desired conditions. A considerable amount of active management is needed to create more sustainable and resilient habitat conditions for species associated with old forests.

Teanaway Late-Successional Reserve

Current Condition

The Teanaway Late-Successional Reserve (LSR) is 33,998 acres in size and is one of the smaller reserves located centrally within the network on the OWNF (Figure B.8). It is comprised primarily of the Dry Forest Vegetation Group (43%), and also includes Moist Forest (16%) and Cold Forest (20%). A substantial portion of the LSR is in non-forest (21%) (Table B.37).

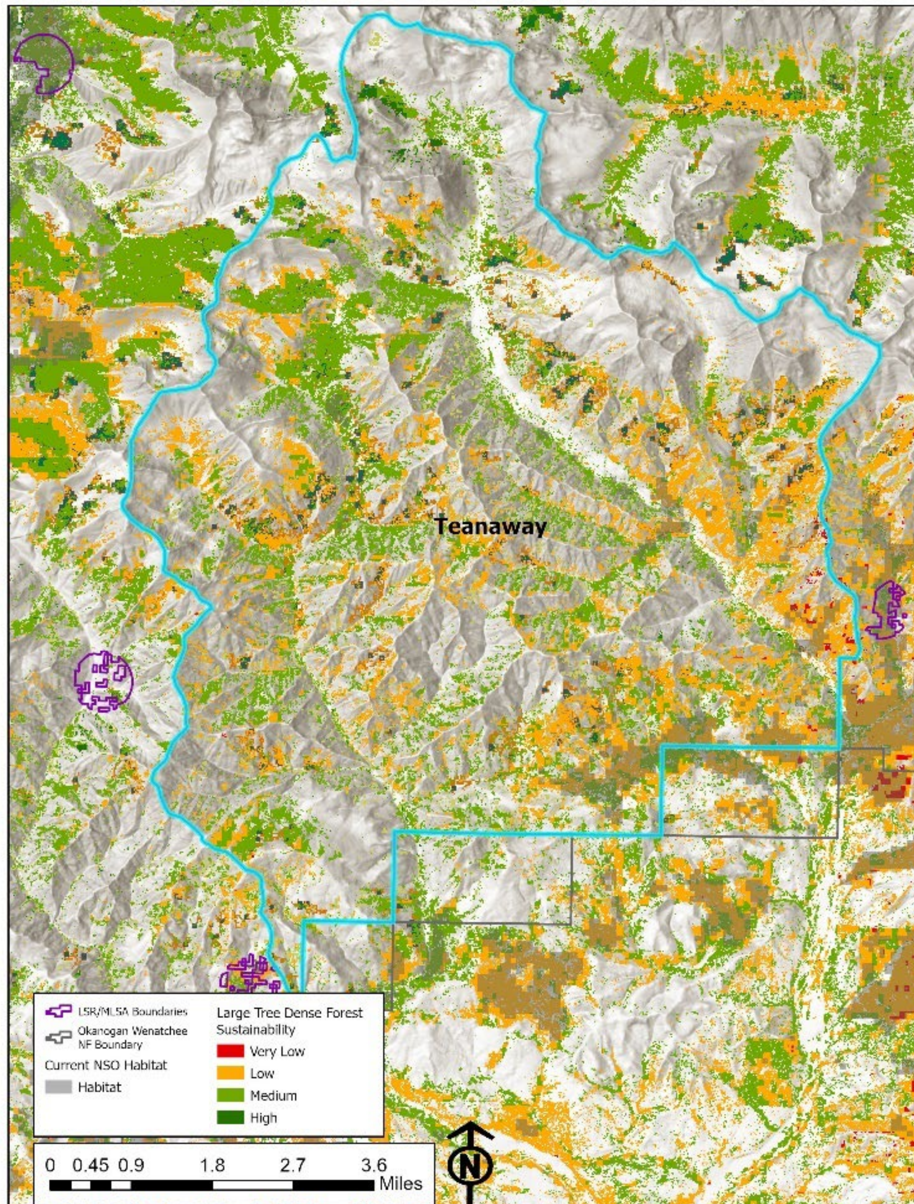

Figure B.8-Location of the Teanaway LSR on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.37-Area of each Forest Group in the Teanaway LSR.

Forest Group	Acres	Percent of LSR
Non-Forest	7,082	21%
Dry Forest	14,470	43%
Moist Forest	5,583	16%
Cold Forest	6,862	20%

Currently there are about 4,377 acres in the Teanaway LSR identified as OGSI 200, including 2,384 acres in the Dry Forest, 979 acres in the Moist Forest and 1,014 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (6% of the OGSI 200 is “core”).

Table B.38-Acres of OGSI 200 by forest type and spatial configuration for the Teanaway LSR (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	121	38	106	265
Edge	330	123	226	680
Finger	717	290	289	1,295
Scatter	1,217	527	393	2,137
Total	2,384	979	1,014	4,377

Currently there are 1,601 acres in the Teanaway LSR identified as spotted owl nesting-roosting habitat and 1,185 acres of spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Dry Forest (58%). At the time the NWFP was implemented in 1994, there were 5 known pairs of northern spotted owls in the Teanaway LSR. From 2018 through 2022 spotted owls were detected in one breeding range and once activity center was occupied.

Table B.39-Acres of northern spotted owl habitat by function and forest group for the Teanaway LSR (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	2,495	1,560	2,268	6,323	19%
Foraging-only	731	328	127	1,185	4%
Nesting-roosting	881	594	127	1,601	5%

The amount of forest within the Teanaway LSR identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 310 acres and under more extreme fire weather conditions (90th percentile) is only 76 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.40-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Teanaway LSR.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	14,097	5,405	19,502 (98%)
50th - ≥50%	207	103	310 (2%)
90th – <50%	14,248	5,458	19,705 (99%)
90th - ≥50%	34	41	76 (<1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 7,037 acres of the Dry and Moist Forest in the Teanaway LSR that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of these acres (70%) are located in the Dry Forest and with a smaller amount in the Moist Forest (30%). Considering the impacts of drought and fire, 52% of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (48%) is in the low to very low sustainability categories. It is worth noting that there is not very much large-tree dense-forest within this LSR (21%) due primarily to the 2017 Jolly Mountain Fire and 2001-2015 western spruce budworm outbreak.

Table B.41-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Teanaway LSR.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	40	3	42	<1%
Low	2,963	699	3,662	11%
Moderate	1,946	1,374	3,320	10%
High	5	7	12	<1%
Total	4,954	2,082	7,037	21%

Medium-Tree Dense-Forest

The status of medium tree dense forest is quite similar to large tree dense forest. There are 3,662 acres of the Dry and Moist Forest in the Teanaway LSR that are comprised of medium-tree dense-forest (MTDF). Most of these acres (70%) are located in the Dry Forest and a smaller amount is in the Moist Forest (30%). Considering the impacts of drought and fire, 52% of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (48%) is in the low to very low sustainability categories. Again, it is worth noting that there is not very much medium-tree dense-forest within this LSR (11%) due primarily to the 2017 Jolly Mountain Fire and 2001-2015 western spruce budworm outbreak.

Table B.42-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Teanaway LSR.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	21	1	22	<1%
Low	1,424	326	1,750	5%
Moderate	1,112	770	1,883	6%
High	3	4	7	<1%
Total	2,561	1,101	3,662	11%

Dry Forest

Currently, an estimated 3,043 acres (9%) of the Dry Forest within the Teanaway LSR provides Large-Tree Open-Canopied habitats. This LSR has proportionally more of this habitat than most of the network. Historical estimates suggest that 33% to 47% of the dry forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 1,153 acres (3%) of the Teanaway LSR is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Teanaway Late-Successional Reserve experienced a 34% increase in resistance.

Summary

The Teanaway Late-Successional Reserve is considered to be high risk, although at a lower risk relative to the Late-Successional Reserve network on the Forest because considerable amounts of wildfire have already removed some of the most susceptible habitats (Figure B.1). This is based on three primary factors: (1) there is a high proportion of Dry Forest (43%), (2) wildfire has already removed some of the most susceptible habitats (e.g., large-tree closed-canopy habitat), and (3) few acres (2%) are identified as "fire refugia" even under moderate fire weather conditions.

Tieton Late-Successional Reserve

Current Condition

The Tieton Late-Successional Reserve (LSR) is about 39,673 acres in size and is one of the smaller reserves located on the southern end of the OWNF network (Figure B.9). It is comprised primarily of the Moist Forest Vegetation Group (41%), and also includes Dry Forest (20%), and Cold Forest (31%). The remainder of the area is in non-forest (8%) (Table B.43).

Figure B.9-Location of the Tieton LSR on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.43-Area of each Forest Group in the Tieton LSR.

Forest Group	Acres	Percent of LSR
Non-Forest	3,212	8%
Dry Forest	8,036	20%
Moist Forest	16,192	41%
Cold Forest	12,233	31%

Currently there are about 12,745 acres in the Tieton LSR identified as OGSI 200, including 2,358 acres in the Dry Forest, 4,545 acres in the Moist Forest and 5,843 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (24% of the OGSI 200 is “core”).

Table B.44-Acres of OGSI 200 by forest type and spatial configuration for the Tieton LSR (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	287	634	2,171	3,092
Edge	604	1,142	1,900	3,646
Finger	957	1,748	1,389	4,094
Scatter	509	1,021	384	1,914
Total	2,358	4,545	5,843	12,745

Currently there are 6,587 acres in the Tieton LSR identified as spotted owl nesting-roosting habitat and 5,737 acres of spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Moist Forest (58%), with a smaller proportion (32%) in the Dry Forest. At the time the NWFP was implemented in 1994, there were 11 known pairs of northern spotted owls in the Tieton LSR. There have been no spotted owls detected over the past five years.

Table B.45-Acres of northern spotted owl habitat by function and forest group for the Tieton LSR (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	5,461	10,969	7,742	24,173	61%
Foraging-only	1,944	3,028	765	5,737	15%
Nesting-roosting	1,972	4,132	482	6,587	17%

The amount of forest within the Tieton LSR identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 745 acres and under more extreme fire weather conditions (90th percentile) is only 203 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.46-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Tieton LSR.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	7,704	15,448	23,152 (97%)
50th - ≥50%	258	487	745 (3%)
90th – <50%	7,897	15,783	23,680 (99%)
90th - ≥50%	71	133	203 (1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 16,857 acres of the Dry and Moist Forest in the Tieton LSR that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of this occurs within Moist Forest (66%) with the remaining located in Dry Forest (34%). Considering the impacts of drought and fire, about 43% of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (57%) is in the low to very low sustainability categories.

Table B.47-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Tieton LSR.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	83	9	93	<1%
Low	4,053	5,433	9,486	24%
Moderate	1,615	5,637	7,252	18%
High	3	23	26	<1%
Total	5,754	11,103	16,857	42%

Medium-Tree Dense-Forest

The situation regarding medium tree dense forest is similar to large tree dense forest. There are 7,046 acres of the Dry and Moist Forest in the Tieton LSR that are comprised of medium-tree dense-forest (MTDF). Most of these acres (67%) are located in the Moist Forest and a smaller amount is in the Dry Forest (33%). Considering the impacts of drought and fire, 45% of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (5%) is in the low to very low sustainability categories.

Table B.48-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Tieton LSR.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	36	4	40	<1%
Low	1,587	2,232	3,819	10%
Moderate	707	2,467	3,174	8%
High	2	11	13	<1%
Total	2,332	4,714	7,046	18%

Dry Forest

Currently, only an estimated 754 acres (2%) of Dry Forest within the Tieton LSR provides Large-Tree Open-Canopied habitats. Historical estimates suggest that 33% to 47% of the dry

forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 10,305 acres (26%) of the Tieton LSR is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Tieton Late-Successional Reserve experienced a 17% increase in resistance.

Summary

The Tieton Late-Successional Reserve is considered to be one of the most at risk relative to the Late-Successional Reserve network on the Forest and is a candidate for the application of the risk reduction standard where risks of large-scale habitat loss are "particularly high" (NWFP C-13). This is based on four primary factors: (1) there is a higher proportion of Moist Forest (41%), (2) a larger proportion of the large-tree closed canopy habitat is in landscape locations that are difficult to sustain, (3) few acres (3%) are identified as "fire refugia" even under moderate fire weather conditions, and (4) the amount of large-tree open-canopy habitat is presently well below the natural range of variability and desired conditions. A considerable amount of active management is needed to create more sustainable and resilient habitat conditions for species associated with old forests.

Upper Methow Late-Successional Reserve

Current Condition

The Upper Methow Late-Successional Reserve (LSR), located at the northern end of the OWNF, is the largest LSR within the OWNF network at 190,837 acres (Figure B.10). It is comprised primarily of the Cold Forest Vegetation Group (47%), and also includes Dry Forest (24%) and some Moist Forest (9%). The large portion of the LSR is in non-forest (21%) (Table B.49).

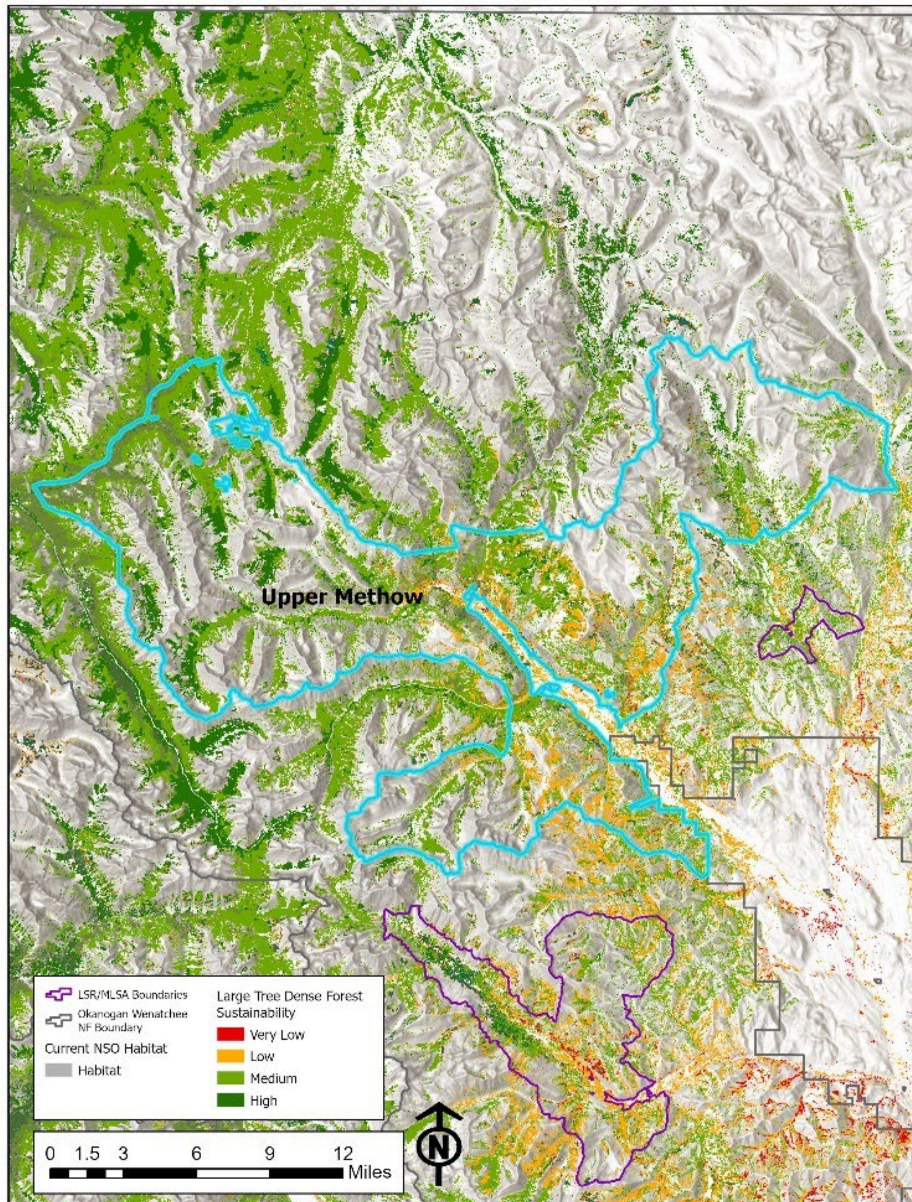

Figure B.10-Location of the Upper Methow LSR on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.49-Area of each Forest Group in the Upper Methow LSR.

Forest Group	Acres	Percent of LSR
Non-Forest	39,610	21%
Dry Forest	44,944	24%
Moist Forest	16,589	9%
Cold Forest	89,693	47%

Currently there are about 25,515 acres in the Upper Methow LSR identified as OGSI 200, including 9,187 acres in the Dry Forest, 4,243 acres in the Moist Forest and 12,085 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (18% of the OGSI 200 is "core"), although this LSR has much more core OGSI than other LSRs.

Table B.50-Acres of OGSI 200 by forest type and spatial configuration for the Upper Methow LSR (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015, 2022).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	1,892	1,149	1,575	4,616
Edge	2,482	1,357	2,828	6,668
Finger	2,630	1,136	3,838	7,603
Scatter	2,183	600	3,844	6,627
Total	9,187	4,243	12,085	25,515

Currently there are 4,325 acres in the Upper Methow LSR identified as spotted owl nesting-roosting habitat and 8,180 acres of spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are in the Dry Forest (52%). At the time the NWFP was implemented in 1994, there were 8 known pairs of northern spotted owls in the Upper Methow LSR. There have been no detections of spotted owls in the past 5 years.

Table B.51-Acres of northern spotted owl habitat by function and forest group for the Upper Methow LSR (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	11,930	10,253	22,246	44,430	23%
Foraging-only	4,748	1,932	1,500	8,180	4%
Nesting-roosting	1,721	2,418	185	4,325	2%

The amount of forest within the Upper Methow LSR identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 533 acres and under more extreme fire weather conditions (90th percentile) is only 212 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.52-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Upper Methow LSR.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	41,969	15,136	57,105 (99%)
50th - ≥50%	357	176	533 (1%)
90th – <50%	42,154	15,204	57,357 (99%)
90th - ≥50%	140	72	212 (<1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 32,731 acres of Dry and Moist Forest in the Upper Methow LSR that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of this occurs in the Dry Forest (68%) and less so in Moist Forest (32%). In contrast to the other large LSRs, when considering the impacts of drought and fire, a substantial proportion (85%) of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (14%) is in the low to very low sustainability categories. However, there is not very much LTDF within the LSR (17%).

Table B.53-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Upper Methow LSR.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	160	0	160	<1%
Low	4,511	125	4,636	2%
Moderate	15,233	8,860	24,093	13%
High	2,230	1,612	3,842	2%
Total	22,135	10,596	32,731	17%

Medium-Tree Dense-Forest

The situation regarding medium tree dense forest is quite similar to large tree dense forest. There are 19,109 acres of the Dry and Moist Forest in the Upper Methow LSR that are comprised of medium-tree dense-forest (MTDF). Most of this occurs in the Dry Forest (73%) and less so in Moist Forest (27%). In contrast to the other large LSRs, when considering the impacts of drought and fire, a substantial proportion (85%) of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (15%) is in the low to very low sustainability categories.

Table B.54-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Upper Methow LSR.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	90	0	90	0%
Low	2,665	72	2,737	1%
Moderate	9,727	4,083	13,811	7%
High	1,530	942	2,472	1%
Total	14,012	5,097	19,109	10%

Dry Forest

Currently, there are only an estimated 5,306 acres (3%) of Dry Forest within the Upper Methow LSR that provide Large-Tree Open-Canopied habitats. Historical estimates suggest that 33% to 47% of the dry forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 12,625 acres (7%) of the Upper Methow LSR is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Upper Methow Late-Successional Reserve experienced a 26% increase in resistance.

Summary

The Upper Methow Late-Successional Reserve is considered to be high risk, although at a lower risk relative to the Late-Successional Reserve network on the Forest because considerable amounts of wildfire have already removed some of the most susceptible habitats (Figure B.1). This is based on three primary factors: (1) there is a lower proportion of Dry and Moist Forest (33%), (2) wildfire has already removed some of the most susceptible habitats (e.g., large-tree closed-canopy habitat) and the amount of large-tree closed canopy habitat is not well represented across the landscape (17%), and (3) few acres (1%) are identified as “fire refugia” even under moderate fire weather conditions.

Wenatchee River Group (Boundary Butte LSR, Camas MLSA, Deadhorse LSR, Eagle MLSA, Icicle LSR, Little Wenatchee LSR, Natapoc MLSA, Sand Creek MLSA, Tumwater MLSA and Twin Lake MLSA)

Current Condition

The Wenatchee River LSR/MLSA Group, centrally located within the OWNF network, is comprised of Boundary Butte LSR, Camas MLSA, Deadhorse LSR, Eagle MLSA, Icicle LSR, Little Wenatchee LSR, Natapoc MLSA, Sand Creek MLSA, Tumwater MLSA and Twin Lake MLSA (Figure B.11). This Group covers a total of 100,263 acres. It is comprised primarily of the Cold Forest Vegetation Group (44%), and also includes Dry Forest (29%) and Moist Forest (18%). The remaining area is in non-forest (8%) (Table B.55).

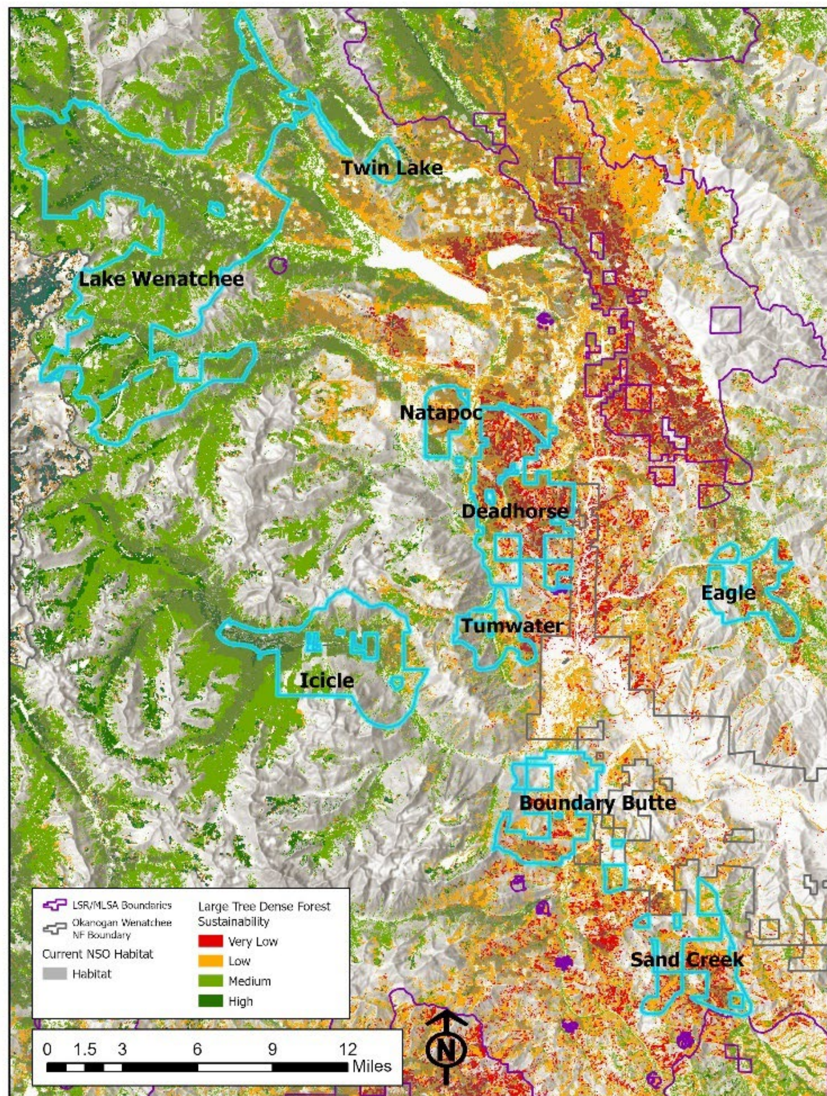

Figure B.11-Location of the Wenatchee River Group on the Okanogan-Wenatchee National Forest. Large tree dense forests are classified by their sustainability to drought and wildfire in red, orange, and green colors. Predicted relative habitat suitability for northern spotted owl is shown in grey (from Davis et al. 2022).

Table B.55-Area of each Forest Group in the Wenatchee River LSR/MLSA Group.

Forest Group	Acres	Percent of LSR
Non-Forest	8,375	8%
Dry Forest	29,448	29%
Moist Forest	17,844	18%
Cold Forest	44,596	44%

Currently there are about 17,568 acres in the Wenatchee River LSR/MLSA Group identified as OGSI 200, including 3,696 acres in the Dry Forest, 2,855 acres in the Moist Forest and 11,017 acres in the Cold Forest. Most of these acres are highly fragmented and scattered across the landscape (20% of the OGSI 200 is "core"), although this LSR has much more core OGSI 200 than many of the other LSRs.

Table B.56-Acres of OGSI 200 by forest type and spatial configuration for the Wenatchee River LSR/MLSA Group (based on NWFP monitoring data from 2021. OGSI methodology described in Davis et al. 2015).

OGSI 200 Class	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total Acres
Core	416	380	2,766	3,562
Edge	742	594	3,159	4,494
Finger	1,006	831	3,042	4,879
Scatter	1,532	1,050	2,050	4,633
Total	3,696	2,855	11,017	17,568

Currently there are 14,682 acres in the Wenatchee River LSR/MLSA Group identified as spotted owl nesting-roosting habitat and 16,987 acres of spotted owl foraging habitat. The greatest proportion of nesting-roosting and foraging habitats are somewhat evenly distributed across the Forest Groups, with the majority of nesting-roosting located in the Cold Forest Group (39%). At the time the NWFP was implemented in 1994, there were 27 known pairs of northern spotted owls in the Wenatchee River LSR/MLSA Group. Spotted owls have been detected repeatedly since 2017 within the Deadhorse LSR and Sand Creek and Natapoc MLSAs.

Table B.57-Acres of northern spotted owl habitat by function and forest group for the Wenatchee River LSR/MLSA Group (based on NWFP Monitoring data from 2021. Methodology described in Davis et al. 2015, 2022).

Habitat Function	Dry Forest (acres)	Moist Forest (acres)	Cold Forest (acres)	Total (acres)	% of LSR
Dispersal-only	17,345	12,060	32,771	62,176	62%
Foraging-only	7,705	3,539	5,743	16,987	17%
Nesting-roosting	2,996	5,115	6,571	14,682	15%

The amount of forest within the Wenatchee River LSR/MLSA Group identified as probable[13] "fire refugia" under very modest fire weather conditions (50th percentile) is only 659 acres and under more extreme fire weather conditions (90th percentile) is only 257 acres. This provides an indication of the difficulties in sustaining large tree habitats in a dense forest condition in frequent fire landscapes (Spies et al. 2019).

Table B.58-The amount of area identified as probable (≥50% probability) fire refugia under different fire weather conditions (50th and 90th percentile) for the Wenatchee River LSR/MLSA Group.

Fire Weather Conditions	Dry Forest (acres)	Moist Forest (acres)	Total Acres (%)
50th – <50%	28,137	16,151	44,289 (99%)
50th - ≥50%	334	325	659 (1%)
90th – <50%	28,329	16,264	44,592 (99%)
90th - ≥50%	126	131	257 (<1%)

Dry and Moist Forests

Large-Tree Dense-Forest

There are 32,086 acres of Dry and Moist Forest in the Wenatchee River LSR/MLSA Group that are comprised of large-tree dense-forest (also associated with northern spotted owl habitat, Singleton et al. in prep.). Most of this occurs in the Dry Forest (62%) and less so in Moist Forest (38%). When considering the impacts of drought and fire, a moderate proportion (41%) of the large-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining large-tree dense-forest (59%) is in the low (40%) to very low (19%) sustainability categories.

Table B.59-The amount and percent of large-tree dense-forest (LTDF) in dry and moist forest groups by sustainability categories for the Wenatchee River LSR/MLSA Group.

Sustainability Category	LTDF Dry Forest (acres)	LTDF Moist Forest (acres)	Total Acres of LTDF for Dry and Moist Forest	% of Dry and Moist Forest that is LTDF within LSR
Very Low	5,418	635	6,053	6%
Low	9,994	2,753	12,747	13%
Moderate	4,384	7,858	12,242	12%
High	97	947	1,044	1%
Total	19,893	12,192	32,086	32%

Medium-Tree Dense-Forest

The status of medium tree dense forest is quite similar to large tree dense forest. There are 9,495 acres of the Dry and Moist Forest in the Wenatchee River LSR/MLSA Group that are comprised of medium-tree dense-forest (MTDF). Most of this occurs in the Dry Forest (63%) and less so in Moist Forest (37%). A moderate proportion (44%) of the medium-tree dense-forest is in a landscape location that is classified in the moderate to high sustainability category. The remaining medium-tree dense-forest (56%) is in the low (39%) to very low (17%) sustainability categories.

Table B.60-The amount and percent of medium-tree dense-forest (MTDF) in dry and moist forest groups by sustainability categories for the Wenatchee River LSR/MLSA Group.

Sustainability Category	MTDF Dry Forest (acres)	MTDF Moist Forest (acres)	Total Acres of MTDF for Dry and Moist Forest	% of Dry and Moist Forest that is MTDF within LSR
Very Low	1,450	135	1,584	2%
Low	3,018	710	3,728	4%
Moderate	1,496	2,324	3,820	4%
High	38	325	363	0%
Total	6,001	3,494	9,495	9%

Dry Forest

Currently, there are only an estimated 4,479 acres (5%) of Dry Forest within the Wenatchee River LSR/MLSA Group that provide Large-Tree Open-Canopied habitats. Historical estimates

suggest that 33% to 47% of the dry forest would have had large trees and an open canopy, providing important habitats for a variety of old forest species that were assessed in the NWFP (SAT 1992, FEMAT 1993).

Insect and Disease Risk

Risk associated with insects and disease was derived from the National Insect and Disease Risk Map (NIDRM) produced by USFS Forest Health Protection (FHP). Approximately 18,617 acres (19%) of the Wenatchee River Group is projected to experience more than 25% loss of basal area from all pests.

Connectivity

Habitat connectivity within the Late-Successional Reserve Network was estimated by calculating the percent difference in the total resistance between 1993 and 2021. The Wenatchee River Group experienced a 10% increase in resistance.

Summary

Risk to the Wenatchee River Group is considered to be high relative to the Late-Successional Reserve network on the Forest. This is based on four primary factors: (1) there is a lower proportion of Dry Forest (29%), (2) a moderate proportion of the large-tree closed canopy habitat is in landscape locations that are difficult to sustain, (3) few acres (1%) are identified as "fire refugia" even under moderate fire weather conditions, and (4) the amount of large-tree open-canopy habitat is presently well below the natural range of variability and desired conditions. A considerable amount of active management is needed to create more sustainable and resilient habitat conditions for species associated with old forests.

Appendix C. Northern Spotted Owl Ecology in Eastern Washington Forests

Northern Spotted Owl

This Appendix provides a detailed overview of current understanding of northern spotted owl ecology and conservation in the eastern Washington Cascades and is summarized below in the following topic areas: Spotted Owl Population Monitoring, Spotted Owls and Landscapes, Spotted Owls and Habitat, Forest Disturbances and Spotted Owl Habitat, Barred Owl and Spotted Owl Interactions, Spotted Owls and Climate Change, and Spotted Owl Recovery Plan and Critical Habitat.

Northern Spotted Owl Population Monitoring

Population monitoring for the northern spotted owl is ongoing as part of the NWFP monitoring program (Lint 2003, Lesmeister and Jenkins 2022). Eleven Demographic Study Areas are distributed throughout the range of the northern spotted owl and one of these, the Cle Elum Study Area, occurs on the OWNF. The rate of population decline throughout the range of the northern spotted owl has increased substantially (Franklin et al. 2021) compared to previous population assessments (Anthony et al. 2006, Forsman et al. 2011, Dugger et al. 2016) in response to ongoing negative consequences from competition with barred owls and habitat loss, primarily from wildfires (Franklin et al. 2021). Franklin et al. (2021) found rates of significant declines of 6-9% annually in six study areas (including the Cle Elum) and 2-5% annually on five other study areas. As of 2018, these annual declines have led to ≤35% of the northern spotted owl population remaining in seven study areas since 1995 (Franklin et al. 2021).

The most recent analysis of northern spotted owl demography shows two primary and considerable threats to the northern spotted owl across their range (Franklin et al. 2021). These threats are greatest in the northern portions of the northern spotted owl's range (e.g., OWNF). First, current trends suggest that northern spotted owls will face extirpation if competition from barred owls is not ameliorated (Franklin et al. 2021). Second, when populations or subpopulations become small, they are increasingly susceptible to catastrophic events. Increasing wildfire activity in the Pacific Northwest due to climate change coupled with past fire suppression (Gaines et al. 2015, Davis et al. 2017, Reilly et al. 2017) is impacting the amount and distribution of northern spotted owl habitat (Davis et al. 2022). For example, Lesmeister et al. (2019) found that >93% of pre-fire nesting-roosting habitat that burned at high severity was no longer suitable forest for nesting and roosting in southwest Oregon in 2013. Under certain fire behavior, northern spotted owl nesting habitat may serve as "fire refugia" (e.g., burn at low severity and retain some of its nesting-roosting structure; Lesmeister et al. 2021), but the increasing frequency and intensity of mega-fires poses a considerable threat to small populations or clusters of northern spotted owls and other old forest species associated with mature and old forests (Jones et al. 2016, Jones et al. 2021).

Northern Spotted Owls and Landscapes

Northern spotted owls have large home ranges. In the Washington Cascades the median annual home range is about 6,200 acres (USFWS 2011). On the Cle Elum study area in eastern Washington, male spotted owl home ranges average 7,062 acres and female home ranges averaged 4,652 acres (Forsman et al. 2015). Spotted owl seasonal home ranges vary in size and shape. Forsman et al. (2015) found non-breeding season home ranges were 3.5 times larger than breeding season home ranges. Spotted owls use parts of their home range more intensively than others, but that use also varies among seasons or years.

Given the size of home ranges and amount of habitat associated with territorial owl sites, the distribution of habitat on the landscape is important (Forsman et al. 2015, Sovern et al. 2015). In the Cle Elum demography study area, for example, Forsman et al. (2015) found that the amount of habitat (includes mid-successional forest) within northern spotted owl home ranges varied from 20-63%. Sovern et al. (2014) assessed the influence of barred owls and landscape attributes on northern spotted owl site occupancy on the Cle Elum study area and found that barred owl presence had a substantial negative influence on the probability of northern spotted owl occupancy (see more under Spotted owl and Barred Owl Interactions). They also found a negative association (less spotted owl use) with the amount of "non-habitat" within a 600 ha (0.86 mi. radius) area and a positive association (increased spotted owl use) with the amount of late-successional forest edge (presumably for foraging) within a 600-ha area of the site center. Singleton (2013) also assessed northern spotted owl habitat at various spatial scales around activity centers on the Cle Elum study area and reported the average proportion of "good" northern spotted owl habitat (i.e. areas used by spotted owls > than available) was 59% at the 100 ha (0.35 mi. radius), 48% at 500 ha (0.78 mi. radius), and 39% at the 2000 ha (1.57 mi/ radius). Non-breeding spotted owls, commonly referred to as floaters, are also present in many landscapes, and may occupy peripheral areas or even areas embedded within territories occupied by reproductive owls (Reid et al. 2021).

Young of the year and adults that elect to change territories between years engage in dispersal. The two types of dispersal are referred to as natal (juveniles) dispersal and breeding (adult) dispersal (Forsman et al. 2002, Jenkins et al. 2021). Dispersing owls move across landscapes in search of territories where they can become resident. Natal dispersal distances tend to be greater for females (15 miles) than males (8.5 miles; Forsman et al. 2002, Hollenbeck et al. 2018). Natal dispersers are naïve and lack knowledge of landscape conditions along the directionally random pathways they follow. Landscapes with conditions that facilitate safe passage and allow opportunities to forage will therefore be more conducive to successful dispersal.

Dry and mesic forest landscapes with a mosaic of nesting and roosting habitat provide suitable conditions for foraging and survival but may also result in conditions vulnerable to large-scale stand-replacement fires (Buchanan et al. 1995, Everett et al. 1997, Gaines et al. 2010a, Lesmeister et al. 2019). Providing adequate amounts of nesting-roosting habitat within spotted owl breeding and home ranges will require careful consideration of the risk of habitat loss associated with wildfire and habitat amounts that can support spotted owl activity centers and

reproduction (Buchanan et al. 1995, Everett et al. 1997, Gaines et al. 2010a, Lesmeister et al. 2019).

Habitat Functions and Descriptions

The northern spotted owl Recovery Plan (USFWS 2011) and critical habitat rule (USFWS 2012a) identified three essential functions served by spotted owl habitat: (1) nesting and roosting, (2) foraging, and (3) dispersal. These functions can be useful for describing spotted owl habitat but the structural conditions associated with these functions can vary and overlap (Buchanan and Irwin 1998, Buchanan pers. comm.). For spotted owls to be sustained on a landscape, sufficient nesting, roosting, foraging, and dispersal habitat must be available to meet their life history needs.

Nesting-Roosting Function

Nesting habitat provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks (USFWS 2011). Roosting habitat provides for thermal regulation, shelter, and cover to reduce predation risk during resting or foraging (USFWS 2011). Habitat requirements for nesting and roosting are assumed to be nearly identical, and often they are combined and referred to as nesting-roosting habitat.

Forest conditions that provide for nesting-roosting functions for northern spotted owls in the eastern Cascades are generally characterized as having a high canopy cover (e.g., >70%), with a component of large (>20 inches dbh) trees, and multiple canopy layers (Forsman et al. 2015). These mid- to late-successional forests typically are composed of grand fir (*Abies grandis*) and Douglas-fir (*Pseudotsuga menziesii*) forested plant associations in the dry forest areas or western hemlock (*Tsuga heterophylla*) forested plant associations in moist forest areas (Buchanan et al. 1995, Lillybridge et al. 1995, Herter et al. 2002, Irwin et al. 2000, Loehle et al. 2011). The presence of large snags and coarse downed wood is quite variable, but mistletoe is regularly associated with nesting habitat (Buchanan et al. 1993, 1995, Loehle et al. 2011, Marshall et al. 2003).

Nest structures that are most commonly used by spotted owls in the East Cascades include nests originally made by northern goshawks (*Accipiter gentilis*) in mistletoe brooms in Douglas-fir trees (Buchanan et al. 1993, Wilk et al. 2018). Occasionally spotted owls may nest in broken top trees or cavities (Buchanan et al. 1993, Wilk et al. 2018). Buchanan et al. (1993) suggested that the presence of mistletoe brooms may facilitate occupancy of younger stands that otherwise lack nesting structures.

Key Habitat Components of Spotted Owl nesting-roosting (High Quality as per Recovery Action 32) Habitat (based on the above cited literature):

- Presence of large trees (≥20 inches dbh), preferably Douglas-fir when appropriate to the forest type.

- High overall canopy cover (≥70 percent) across the stand (see within stand variability below) and two or more canopy layers. Canopy cover of habitat patches should vary from >70-100%.
- Presence of mistletoe brooms used for nesting. About 80% of nests on OWNF are in mistletoe brooms or abandoned goshawk nest platforms, <10% are in broken top trees or cavities.
- Snags and downed wood in variable densities and a diversity of size classes, including large sizes and advanced decay classes.
- Within stand spatial variability may occur: as an example, ≤10 percent open, ≤20 percent single story, ≥70 percent multistory.
- Minimum patch size of 2 acres.

Foraging Function and Habitat for Primary Prey Species

Foraging habitat provides a food supply for survival and reproduction and appears to include a broader range of forest conditions than nesting-roosting habitat (USFWS 2011, Forsman et al. 2015). Foraging habitat is thought to be quite variable and may be tied to forest conditions associated with primary prey species (Irwin et al. 2007, USFWS 2011). Diet (Forsman et al. 2001, 2004) and telemetry (Irwin et al. 2007, 2012) studies indicate that spotted owls in some areas use a variety of open and closed-canopy stand types, including stands that have recently burned (Clark et al. 2011, Irwin et al. 2013). While foraging habitat may include nesting-roosting habitat, it may also include forest conditions that do not support successful nesting pairs (Irwin et al. 2007, 2012, USFWS 2011, Forsman et al. 2015).

The primary prey species of spotted owls in the eastern Cascades is the northern flying squirrel (*Glaucomys sabrinus*) followed by bushy-tailed woodrat (*Neotoma cinerea) (*Bevis et al. 1997, Forsman et al. 2001, 2004). Lehmkuhl et al. (2004) studied northern flying squirrel diet and found that truffles were their primary food source in dry forests of eastern Washington. They found that truffle abundance was lowest in the open pine forests, moderate in the young mixed-conifer forest, and highest in the mature mixed-conifer forests. Management of dry and moist forests to maintain or restore more typical or natural fire regimes might reduce truffle diversity at stand scales by simplifying stand composition and structure, but such management might increase long-term truffle diversity and persistence by reducing the frequency of large high-intensity fires and stabilizing fire regimes (Lehmkuhl et al. 2004).

Lehmkuhl et al. (2006a) also studied the demography of northern flying squirrels in dry and moist forests of the eastern Cascades. Squirrel densities were lower and home ranges larger in ponderosa pine forests compared to mixed conifer forests. A key predictor of squirrel density was canopy closure, with an apparent threshold of >55% separating lower- from higher-density populations. Lehmkuhl et al. (2006a) inferred that impacts to northern flying squirrel populations from restoration treatments could be ameliorated or reduced by the retention of large trees, woody debris, and mistletoe brooms at the stand scale. While restoration treatments such as

forest thinning may reduce flying squirrel densities within treated stands, at the landscape scale these effects could be ameliorated to some degree by retaining patches of forest with high canopy-closure, multiple canopy layers, and large trees (Sollmann et al. 2016), as would be maintained/restored by mimicking historical landscape conditions. A landscape perspective is necessary to address the trade-off between increased resistance and resilience of dry-forest landscapes with low to moderate density prey populations versus higher density prey populations with low resistance to large-scale stand replacement fires (Lehmkuhl et al. 2006a, Sollmann et al. 2016).

Another important prey species of spotted owls in the eastern Cascades of Washington is the bushy-tailed woodrat (Forsman et al. 2001, 2004). The density of bushy-tailed woodrat in dry and moist forests did not differ by forest type (mature mixed conifer vs young mixed conifer vs open ponderosa pine), but was best predicted by the cover of large snags, mistletoe brooms, and soft downed logs (Lehmkuhl et al. 2006b). Variable-density thinning and prescribed fires that emulate mixed-severity fires with patchy coverage and retention of fire "skips" may retain the complex structures needed to sustain woodrat abundance in dry forests (Lehmkuhl et al. 2006b).

Key Habitat Components of Spotted Owl Foraging Habitat (based on the above cited literature):

- Presence of medium (≥15 inches dbh)-large trees (≥20 inches dbh), preferably Douglas-fir when appropriate to the forest type.
- Moderately-high overall canopy cover (>60 percent) across the stand (see within stand spatial variability below) and one or more canopy layers, but with limited number of trees 5 to 8 inches dbh that allows owl movements under the canopy. Canopy cover of habitat patches varies from >60-100 percent.
- Presence of mistletoe brooms.
- Snags and downed wood in variable abundance and a diversity of size classes, including large sizes and advanced decay classes.
- Within stand spatial variability: ≤25 percent open, ≤25 percent single story, ≥50 percent multistory.
- Minimum patch size of 2 acres.

Dispersal Function

Little is known about the features that affect spotted owl selection of habitat during dispersal (Buchanan 2004, Davis et al. 2022). Sovern et al. (2015) found that dispersing juvenile spotted owls used stands with some large trees (>20 inches dbh) and high canopy cover (>70 percent) as roosting habitat. Davis et al. (2011) defined the structural components of dispersal habitat based on the "50-11-40 rule" described in Thomas et al. (1990). This "rule", based on expert input, hypothesized that to facilitate spotted owl dispersal that at least 50% of a landscape be forested with conifer stands that average >11 inches and >40% canopy cover (Thomas et al. 1990, Davis et al. 2011, Lesmeister et al. 2018).

Key Habitat Components of Spotted Owl Dispersal Habitat (based on Davis et al. 2011)

- Conifer trees average ≥11 inches dbh.
- Conifer cover ≥40%
- Some stands with large trees (>20 inches dbh) and high canopy cover (>70 percent) used as roosting habitat during dispersal.
- Minimum patch size of 2 acres.

Forest Disturbances and Spotted Owls

Discussions about the sustainability of spotted owl habitat in dry forests have been ongoing for at least three decades (Agee and Edmunds 1992, Buchanan et al. 1995), Everett et al. 1997, Gaines et al. 2010a, USFWS 2011, Lehmkuhl et al. 2015) and were known at the time the OWNF LSR Assessments were completed in 1997-98. However, our understanding of the interactions between spotted owls and fire has evolved considerably.

Wildfires that create large patches of high-severity burned area have a negative impact on spotted owl habitat, particularly nesting-roosting habitat (Elliot 1985, Gaines et al. 1997, MacCracken et al. 1996, Clark et al. 2013, Lesmeister et al. 2019). Large high-severity patches alter the structure of coniferous forests associated with spotted owl nest and roost sites (i.e., high canopy closure, large-live tree basal area, and total live-tree basal area; Gaines et al. 1997, Lesmeister et al. 2019). Additionally, the survival rate of northern spotted owls that are exposed to wildfires or are displaced by wildfires is reduced, at least in the short-term (3-5 years post-burn), and can be exacerbated by post-fire salvage harvest (Clark et al. 2013).

There is limited information available on northern spotted owl use of the post-fire landscape for foraging and dispersal. More information is available for the conspecific California spotted owl. Although nesting in areas burned during high-severity fire is generally precluded, selective use of areas near high-severity burn patches for foraging by California spotted owls (*Strix occidentalis occidentalis*) has been observed where burn patch size was small and relatively high amounts (>30 percent) of unburned area remained on the landscape, and after shrubs and associated prey species had recovered (Bond et al. 2009, Lee et al. 2012). Low-severity wildfires may have little or slightly positive impacts on California spotted owl habitat (Bond et al. 2002, 2009; Lee et al. 2012; Roberts et al. 2011; Seamans and Gutierrez 2007), particularly foraging habitat. However, Jones et al. (2016) showed that when severe fire occurs over ≥50% of a California spotted owl territory, there was an increased risk of mortality and territory abandonment. While it is unknown how well the impacts of fires on California spotted owls translate to northern spotted owls, the fire ecology in eastern Washington forests, under which northern spotted owls evolved, is more similar to that experienced by the California spotted owl (primarily low- and mixed-severity), than it is to the disturbance regimes on the west side of the Cascades (Gaines et al. 2010a, Jones et al. 2020).

Increasing wildfire activity in the Pacific Northwest due to climate change coupled with past fire suppression (Gaines et al. 2015, Davis et al. 2017, Reilly et al. 2017, Parisien et al. 2023) is impacting the amount and distribution of northern spotted owl habitat (Davis et al. 2022). For example, Lesmeister et al. (2019) found that >93% of pre-fire nesting-roosting habitat that burned at high severity in fires in southwest Oregon in 2013 was no longer suitable for nesting and roosting. While under certain fire behavior, northern spotted owl nesting habitat may occur in areas that serve as "fire refugia" (e.g., burned at low severity and retain some nesting-roosting habitat structure; Gaines et al. 1997, Lesmeister et al. 2021), the increasing frequency and intensity of mega-fires poses a considerable threat to small populations of northern spotted owls, other old forest species (Jones et al. 2016, Jones et al. 2021, Franklin et al. 2021) and future forest cover (Meigs et al. 2022).

Several studies have modeled scenarios that integrated spotted owl habitat, fire behavior and movement models to provide managers with insights and tools that can be used to determine amount and location of optimal treatments (Ager et al. 2007, Kennedy et al. 2008, Lehmkuhl et al. 2007, Jones et al. 2022). Generally, these studies suggest that if 20 to 30 percent of the landscape can be treated in optimal locations there is a corresponding decrease in the risk of landscape-level fire. These studies also suggest that when treatment locations cannot be optimized, such as when there are constraints related to land allocation, the amount of area that needs to be treated to achieve the same level of risk reduction increases substantially (Finney et al. 2007). In addition, while these levels of treatments may influence landscape fire behavior, they do not account for other disturbances such as insect outbreaks (Bennett et al. 2023). Fortunately, tools for modeling fire movement and behavior are now being more commonly used in landscape evaluations (Hessburg et al. 2013) and for project-level planning. This type of evaluation is important for understanding the dynamic nature of forest landscapes, and for building strong rationale for impacting spotted owl habitat functionality to achieve broader landscape restoration goals (USFWS 2012a, Gaines et al. 2015). Providing adequate amounts of habitat within spotted owl breeding and home ranges will require careful consideration of the risk of habitat loss associated with wildfire and habitat amounts that can support spotted owl activity centers and reproduction.

Barred Owl and Spotted Owl Interactions

The barred owl is now found at significant densities throughout the entire range of the northern spotted owl (Livezey 2009, Franklin et al. 2021). The continued range expansion of the barred owl constitutes a significant threat to northern spotted owl persistence, which was not evaluated as such a significant threat when the spotted owl was first Federally listed under the Endangered Species Act (Franklin et al. 2021). Effects of the barred owl invasion are most notable in the northern range of the spotted owl where the invasion of barred owls has been ongoing for over four decades (Taylor et al. 1976, Singleton et al. 2010; Singleton 2013; USFWS 2011, 2012, Kroll et al. 2010, Sovern et al. 2014, Franklin et al. 2021).

Spotted Owls and Climate Change

Climate change is a reality affecting spotted owl abundance, habitat distribution and availability, and the functionality of reserved lands across the owl's range (Carroll 2010, Carroll et al. 2010, Glenn et al. 2010, Spies et al. 2010). Most climate change models predict warmer, wetter winters and hotter, drier summers for the Pacific Northwest in the first half of the 21st century (Elsner et al. 2009, Mote 2003, Mote et al. 2005, Raymond et al. 2014). Results from Glenn et al. (2010) suggest that these conditions have the potential to negatively affect annual survival, recruitment, and population growth rates for northern spotted owls.

Climate change is expected to alter the distribution of forests, with a trend that is generally upward in elevation and northerly in latitude. Littell et al. (2010) and Kralicek et al. (2023) predicted that by the mid-21st century, some areas of the eastern Cascade Range are likely to experience substantial declines in climatically suitable areas for Douglas-fir growth. Spotted owls in the eastern Cascades show a strong preference for Douglas-fir as a nest tree (Buchanan et al. 1993) and as a dominant tree in spotted owl "neighborhoods" (Everett et al. 1997).

Since the mid-1980s, the size and intensity of large wildfires in the western United States have increased markedly (Westerling et al. 2006, Keane et al. 2013, Westerling 2016, Parks et al. 2023). The frequency of large fires increased fourfold during the period 1987 to 2003 (compared to 1970 to 1986, Westerling et al. 2006) and has continued to increase in recent decades (Westerling 2016). Comparing the 1973-1982 and 2003-2012 decades, Westerling (2016) found that the average fire season length had increased by 84 days. Westerling et al. (2006) attributed increased burned area to adequate fuel abundance and lower than normal fuel moistures driven by higher spring and summer temperatures and reduced snowpack. The increases in fuel loads can be attributed, at least in part, to fire suppression and past timber harvest practices (McKenzie et al. 2004).

The predicted increases in spring and summer temperature will exacerbate the frequency and intensity of disturbances such as fire (McKenzie et al. 2004, Wotton and Flannigan 1993, Keane et al. 2013, Davis et al. 2017, Wan et al. 2019) and forest insects (Littell et al. 2010). In the interior Columbia Basin, Littell et al. (2010) predicted that the area burned is likely to triple by 2050. Climate-driven changes in fire regimes will likely be the dominant driver of changes to forests in the Western US over the next century (McKenzie et al. 2004, Hoecker et al. 2023) and will likely exacerbate concerns about the sustainability and resiliency of habitat for spotted owls and other species associated with mature and older forests (Gaines et al. 2015, Lehmkuhl et al. 2015, Jones et al. 2016, Wan et al. 2019, Jones et al. 2021).

Appendix D. Mapping Northern Spotted Owl Habitat

Broad-Scale Assessments

For spotted owl habitat assessments that summarize habitat amounts at the LSR/MLSA scale or larger or a 5th field watershed scale or larger, data from Davis et al. (2022) can generally be used (Ackers et al. 2015). The advantage of this dataset is that it can show changes over time (1986 to present) and it is updated annually and supported by the Regional Northwest Forest Plan Monitoring program. However, the precision of this dataset for key spotted owl habitat attributes (live trees, canopy cover, tree quadratic mean diameter, stand height) in diverse eastern Washington forests is lower compared to other areas (e.g., western Oregon; Pierce et al. 2009, Bell et al. 2015, Merschel et al. 2019). This limitation prevents assessments at the precise location of a patch of forest (e.g., Glenn et al. 2017), rather it allows for a summary of the amount of habitat and changes over time.

Mid-Scale (2-4 subwatersheds) Assessments

The spotted owl habitat that is identified from the Forest Restoration Strategy Landscape Evaluation uses a broad definition of habitat to identify nesting-roosting and/or foraging. It also uses a rather coarse-scale of mapping resolution (1:8,000 and ≥10 ac) to identify habitat at the mid-scale. The advantage of this dataset is that it can be compared to both historical and future reference conditions as a means of assessing habitat sustainability and it reflects actual conditions on the ground from recent aerial imagery, rather than imputed stand data modeled to a pixel. However, for project-scale assessments and to identify "high quality" habitat (per RA 32), further refinement of this data layer is needed.

Project-Scale Assessments

Additional refinement of the classification of spotted owl habitat derived from the Forest Restoration Strategy Landscape Evaluation is needed to produce maps that (1) identify "high quality" habitat (per Recovery Action 32), (2) can be used in project level risk assessment and treatment design, and (3) can be used to assess effects and quantify the effects to habitat. Refinements can be made to stratify foraging habitat (based on Forsman et al. 2015) and nesting-roosting habitat (based on Sovern et al. 2019). "Higher quality" nesting and roosting habitat, as described in RA 32, includes large live trees, high canopy cover, multiple layers, decadence in large snags and downed wood, and the presence of mistletoe for nesting structures.

Foraging Habitat

The base map for stratifying foraging habitat is the derived spotted owl habitat data layer from the Forest Restoration Strategy Landscape Evaluation. Forsman et al. (2015) showed that foraging habitat selection by spotted owls declined with increasing topographic position (higher on the slope) and developed a Topographic Position Index (TPI) that can be used to categorize foraging habitat into "high quality" (i.e., lower slope position and higher selection ratios) and "low quality" (i.e., high slope position and lower selection ratios). This information may be useful when assessing habitat sustainability and risk of habitat loss to disturbance.

Nesting-roosting Habitat

The base map to be used to refine spotted owl habitat mapping and to identify nesting-roosting and high-quality habitat is the FRS LE spotted owl habitat data layer. In all cases, recent activity centers (≤5 years) would be protected and the best habitat within 0.7-mile radius identified using a combination of photo-interpretation data, LiDAR data, and field evaluation. The Forest Restoration Strategy Landscape Evaluation layer can be refined using LiDAR tree information to identify large live trees and multiple canopy layers. Field evaluation is needed to identify large snags, downed wood, and mistletoe platforms. Shown below are examples of how the photo-interpreted data and LiDAR can be used on combination to identify "high quality" habitat.

- Option 1: Intersect a LiDAR canopy height model showing trees >40 feet tall with the derived FRS LE habitat data layer. Use this information to identify polygons of habitat that include areas with high concentrations of large trees and multiple canopy layers (Figure D.1). This provides a refined habitat map that can then be used by project biologists to field verify and revise for project level use.

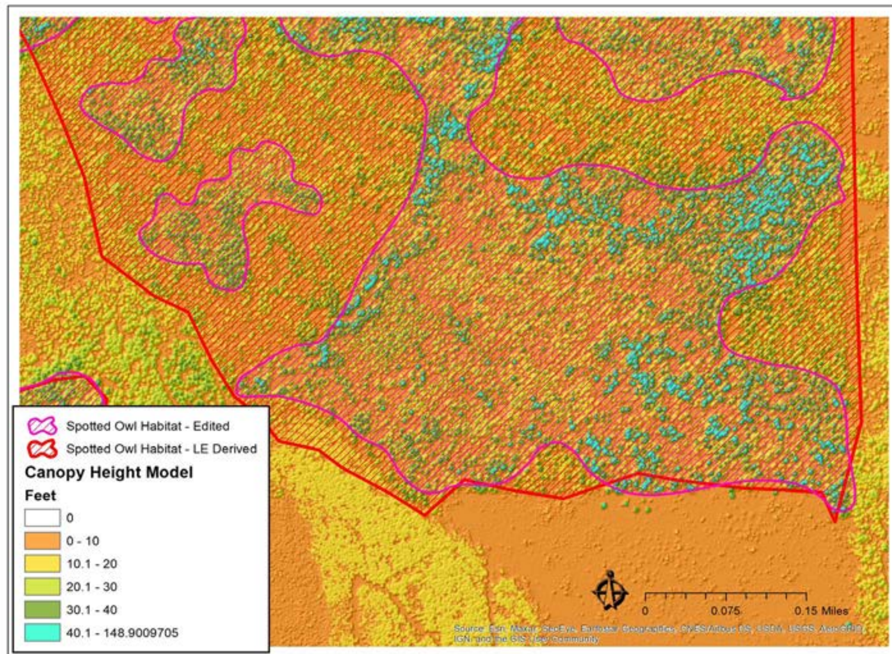

Figure D.1-Results of canopy height model and polygons drawn to refine spotted owl habitat mapping.

- Option 2: Using a LiDAR-based model from Sovern et al. (2019) would allow for "tuning the dial" to local conditions and produce a relative index based on canopy cover standard deviation and percent canopy cover to identify the high-quality nesting-roosting structure. An index value of 0.05 was used to identify nesting-roosting habitat in the Upper Manastash project area.

Developing a Desired Future Condition for northern spotted owl habitat

Identify current known resident northern spotted owl activity centers (active within the past 5 years; see Section 6.3.7). Known northern spotted owl activity centers include any site that was occupied by a reproductive pair, pair, or resident single. If multiple spotted owl locations occur in close proximity to one other (<1/4 mile) identify the highest quality habitat within the cluster.

Identify the most sustainable locations, following the spotted owl design criteria, on the landscape using moisture deficit maps, large-tree dense-forest sustainability layer, and local knowledge, while considering how to restore landscape and habitat pattern. Note that in some cases areas that are not currently habitat but have potential to become habitat may be identified.

Identify future spotted owl habitat based on information on current stand conditions, the reference conditions for these stand types, and the spatial arrangement using spatial metrics. Future spotted owl habitat can then be mapped by:

- Identifying areas that are in the most sustainable landscape positions that have medium (≥15” DBH) and/or large (≤20” DBH) trees as habitat-capable in the short-term (could become habitat in <50 years).
- Identifying areas that are in the most sustainable landscape positions, but do not have medium and/or large trees as habitat-capable long-term (will take >50 years to become habitat).

Appendix E. Assessing Focal Wildlife Habitat Treatment Needs Through the Landscape Evaluation Process

A key component of the focal habitat assessment portion of the landscape evaluation is a comparison of current habitat conditions with the historical and future range of variability. This provides managers a means of estimating sustainable amounts and proportions of different types of LSOF habitats (e.g., Large-Tree Closed-Canopy vs Large-Tree Open-Canopy; see Section 3). As described above, this assessment also compares existing habitats to current and future moisture deficits (Cansler et al. 2022, DNR 2022) as a means to identify areas that are most likely to support forested habitats into the future. It also assesses the risk of disturbance (including fire probability and intensity) to habitats.

Focal wildlife habitat types can be selected based on association with a federally listed species, the northern spotted owl, or identified as a Region 6 Sensitive Species (Table 3.1, Appendix H). A focal/multi-species approach helps to ensure the full-suite of late-successional associated habitats are included (Van Lanen et al. 2023).

For treatments within LSR/MLSAs the following process and key components can be used to map LSOF habitat:

1. Map Habitat - Derive a map of current and potential late-successional habitats, including habitat for the northern spotted owl, using vegetation information from the photo-interpretation completed for the landscape evaluation, as well as LiDAR information or other data sources to identify "high quality" habitat (see spotted owl habitat mapping Appendix D). Follow the Landscape Evaluation quality control process to evaluate habitat maps and make necessary adjustments to meet quality control standards (USFS 2017).
2. Habitat Departure - Once the focal wildlife habitats are mapped at sufficient quality, compare the current amount (percent land) and spatial configuration of habitat to the historical and future reference conditions.
3. Habitat Desired Conditions - Assess habitat sustainability and risk of habitat loss to disturbances.
    a. Compare the current amount (percent land) of habitat with the historical and future ranges of variability as a means to evaluate habitat sustainability and inform Desired Conditions for the amount of each type of late-successional and old forest habitat (e.g., Large-Tree Open-Canopy vs Large-Tree Closed-Canopy).
    b. Use information from the landscape evaluation on disturbance risk and moisture deficit[7] (current and future) to inform the degree of risk of habitat loss from disturbances and to identify the locations on the landscape where habitat is most sustainable.
    c. Provide a short, written description of the amount of habitat that is the Desired Condition for the landscape, including within the LSR/MLSA/CHU that balances the amount of habitat with the risk of loss from disturbances (see Box 3).

4. Habitat Pattern and Connectivity - Assess the spatial arrangement of focal wildlife habitats for the landscape by comparing the current spatial metrics to the historical and future range of variability. From this, develop a general written description of the Desired Condition for habitat pattern and connectivity across the landscape (e.g., make fewer and larger habitat patches).
5. Landscape Prescription - Develop a landscape prescription for focal wildlife habitats that addresses:
    a. The amount of habitat (percent of area),
    b. The spatial arrangement and habitat pattern (landscape metrics), future habitat, and a map showing habitat around current spotted owl activity centers, current habitat, and future habitat areas.

Appendix F. Snags and down wood

Snags and down wood are a key habitat element for many wildlife species, including late-successional old forest associated species. The numbers of snags are highly variable across the landscape and are determined and maintained by disturbance processes such as fire, insects and diseases, management activities, and ecosystem services such as firewood gathering and safety (e.g., hazard trees in recreation sites). Snags occur across the landscape in size classes, numbers, and distribution to provide habitat to support viable populations of snag-associated species. The Okanogan-Wenatchee National forest experienced high levels of selective timber harvest in the 1930's and 1940's and substantial wildfire and insect and disease impacts since 1993, which has altered snag and down wood distribution.

One objective of the LSRA is to maintain snag and down wood density within the historical range and to increase the density of large snags, and subsequently large down wood, over the long-term. The desired condition for snags across the Forest is the historical range of variability and is estimated for each Forested Vegetation Group by snag size and density classes in Table F.1. Very high levels of snags will generally only occur in areas experiencing stand-replacing disturbances. Correspondingly, the desired condition for amounts of down wood across the Forest is also based on the historical range of variability and is presented by Forest Group (Table F.2).

Table F.1-Desired conditions for the percent of the Forest in snag density (number of snags/acre) classes by forest vegetation group and size classes.

				Snags Per Acre >20 Inches DBH	
Forest Type	**0 – 2**	**2-4**	**4-6**	**6-10**	**>10**
Moist Forest	79%	6%	1%	10%	2%
Dry Forest	83%	6%	2%	6%	3%
Cold Forest	49%	9%	4%	19%	9%

*Vegetation types may not be capable of developing snags >20 inches dbh, in which case snags >15 inches dbh are substituted.

Table F.2-Desired conditions for the amounts of down wood by forest vegetation Group.

Forest Group	Down Wood (tons per acre)
Moist Forest	5-40
Dry Forest	3-7
Cold Forest	5-40

A DecAID (Mellen-McLean et al. 2017, Version 3.06 April 2023) distributional analysis for snags and down wood within the Okanogan-Wenatchee National Forest was performed to inform Desired Conditions within the Late-Successional Reserves. The DecAID wildlife habitat types on the Okanogan-Wenatchee National Forest include Eastside Mixed Conifer, Montane Mixed Conifer and Ponderosa pine/Douglas-fir. This information is presented here as an example of data available to assess snag and down wood abundance relative to reference conditions. The wildlife habitat types used in DecAID were arranged to correspond to the vegetation groupings used in the Late-Successional Reserve Assessment.

Large snag (≥20 inches) density is generally lower than reference conditions in all forest types. Substantially more of the landscape has a low density of large snags, indicating there are far fewer large snags compared to desired conditions. In general, the DecAID distribution analysis indicated that amounts of large down wood (≥ 20") is above reference conditions in all three forest types in the lowest density class (0-2 percent cover), suggesting the Forest is deficient in large logs. This tracks the snag distribution with fewer large snags available to become large down wood.

Appendix G. Example LSR Restorative Risk Reduction Prescriptions

Although there exist a variety of different stand conditions in LSRs that the Forest may choose to treat under the risk reduction or silviculture pathways in the NWFP, the following prescriptions provide some generalizable examples of prescriptions that may be used to address restoration of characteristic structure and function through a risk-reduction framework. The following prescriptions are not meant to be applied uniformly across dry or moist forest settings in LSRs, but rather to serve as a guide for how a prescription might be developed to address risk-reduction following the design criteria in Section 6. Other treatments prescriptions may be appropriate when the goal is to maintain focal species habitat.

Example: Dry Forest Risk Reduction Prescription

The objective of this treatment is to remove shade tolerant species to promote large, fire and drought resistant trees across the residual stands. The resulting structure will be an open canopy forest dominated by medium and large trees (Stem Exclusion Open Canopy and Old Forest Single Story structural stages in the OWNF FRS (OWNF 2012)). Large and old trees will have increased resilience to disturbance agents, primarily fire, but also insects. The resulting stand will have variable stocking including patches of large diameter trees, areas containing well-spaced individuals, tree clumps or groups of different sizes/age classes and openings. The stand would be on a trajectory to develop into Old Forest Single Story, or may achieve this stage immediately post-treatment in stands that have a sizable number of large trees, and should be maintained through time with planned or unplanned fire.

- **Do not cut old trees**; (thick bark/deep furrows, generally >150 years). Use Van Pelt guide for trees characteristics. Ponderosa pine scores ≥ 6 and western larch≥7 and Douglas-fir ≥ 7 are highly valued for retention.
- **Max cut diameter is 24.9" DBH**, trees < 20" DBH are targeted for removal. Only cut trees 20"-24.9" when needed to meet stand objectives (e.g., where late seral trees [20"-24.9" DBH] have established near early seral fire resistant very large and/or old trees or overstocked areas that are mostly even aged trees > 20" DBH).
- **Thin from below leaving dominants and co-dominants, a target of 15-35% of max SDI should be used to set densities for tree retention.** Retain some "wolf" trees that contain large limbs and or broom configurations, broken tops, or old and overmature trees with well-developed heart, trunk, or ring rot; these trees are conducive to wildlife habitat for old-growth dependent species. Residual stocking would be determined based on stand conditions and the maximum SDI that corresponds to the plant association. After mechanical and/or burning treatments, residual densities would generally average approximately 15-40 trees per acre greater than 6" DBH. Concentrations of very large and/or old trees may exceed the target density.
- **Promote the survival and growth of old and very-large early-seral trees** by thinning and removing ladder fuels within 1-2 driplines of these individual trees or clumps.

- **Retain important wildlife habitat components in 'complex 'patches.** These may include small patches of seedling/saplings with desired species, patches of shrubs and/or broadleaf trees, concentrations of snags and downed wood, clumps of overstory trees that provide shade, and overmature and old trees with dwarf mistletoe brooms or well-developed heart, truck, or ring rot. The number and size of these complex patches will depend on the size and configuration of the unit as well as what is present in the unit.
- **Species preference** for retention, in order, is ponderosa pine, western larch, Douglas-fir, white pine, western hemlock, grand fir. The presence of forest pests (pathogens and insects) may modify residual species preferences.
- **Create stand-level heterogeneity using ICO guidelines** for fine scale stem distribution from representative stand reconstruction data sets (Churchill et al. 2016). Use the natural landscape template and existing stand conditions (e.g., encroached openings) to set targets for clumps and openings and determine their locations. See Table G.1 (from Churchill et al. 2016) for guidelines.
    - **Openings** with low tree densities (5-15 TPA) up to 2 acres in size may occur to address forest insect and disease issues or to expand natural openings (e.g. small pockets of root disease might be appropriate locations to expand by removing additional host species).
    - **Clumps** should focus on retention of >20" DBH early-seral trees and ecologically valuable areas with evidence of wildlife use, snags and down wood. Leave isolated clumps of dwarf mistle-toe infested trees to provide habitat for wildlife and prey species.

Table G.1-Clump size proportions from reconstructed historical sites in the Eastern Cascades of Washington. Values are the percent of the total number of trees in the unit in each clump size. From Churchill et al. 2016.

	Clump (Bin) Size (# of trees)					
Clumping Level	**1**	**2-4**	**5-9**	**10-15**	**16-20+**	**TPA**
High	0.22	0.38	0.24	0.10	0.06	40-60+
Moderate	0.30	0.42	0.11	0.17		25-40
Low	0.45	0.43	0.12			15-25

- **Use prescribed fire** (underburns) to reduce natural and activity fuels and restore fundamental ecosystem processes.
    - Residual fuel loading after burning is targeted to be between 3-10 tons/ac.
    - Target number of snags/acre in a given size class should be informed by the most recent DecAID models for that subwatershed and the Forest Group that most closely resembles the stand characteristics.

- When burning in stands with old (>150 y.o.) trees, utilize lighting techniques and targeted mop-up to reduce burn intensity and smoldering time around old tree boles.

Example: Moist Forest Risk Reduction Prescription

The objective of this treatment is to restore fire and drought resistant structure as guided by the Landscape Evaluation. Stands identified and prioritized for treatments would be based on landscape-level risk reduction and desired conditions derived through reference conditions. Generally, treatments in these stands would focus on retaining higher density, with more tree clumping and larger, complex wildlife habitats than the dry forest restorative risk reduction treatment. Actions would include the removal of shade tolerant species to promote large trees in fire and drought resilient stands. Large and old trees will have increased resilience to disturbance agents, primarily fire, but also insects. The stand will have horizontal and vertical heterogeneity including patches of large diameter trees, areas containing well-spaced trees and clumps of seedling/saplings, complex patches would be incorporated into the treatment areas. These stands will initially be managed to **Stem Exclusion Open Canopy** by removing most of the understory < 7" with the exception of complex patches. As natural regeneration occurs over time, fire risk will increase and the stands will develop into **Understory Re-initiation.** See structural stage definitions in the OWNF FRS (OWNF 2012).

- **Do not cut old trees**; (thick bark/deep furrows, generally >150 years). Use Van Pelt guide for trees characteristics. Ponderosa pine scores ≥ 6 and western larch ≥7 and Douglas-fir ≥ 7 are highly valued for retention.
- **Max cut diameter is 24.9" DBH**, trees < 20" DBH are targeted for removal. Only cut trees 20"-24.9" when needed to meet stand objectives (e.g., where late seral trees [20"-24.9" DBH] have established near early seral fire resistant very large and/or old trees or overstocked areas that are mostly even aged trees > 20" DBH).
- **Thin from below leaving dominants and co-dominants, a target of 25-40% of max SDI should be used to set densities for tree retention.** Retain "wolf" trees that contain large limbs and or broom configurations, broken tops or old and overmature trees with well-developed heart, trunk, or ring rot; these trees are conducive to wildlife habitat for old-growth dependent species. Residual densities would generally average approximately 40-70 TPA for trees > 7" DBH. Concentrations of very large and/or old trees may exceed the target density.
- **Promote the survival and growth of old and very-large trees** by removing ladder fuels within 1-2 driplines of these trees.
- **Retain important wildlife habitat components in 'complex 'patches.** These may include small patches of seedling/saplings with desired species, patches of shrubs and/or broadleaf trees, concentrations of snags and downed wood, clumps of overstory trees that provide shade, and trees with dwarf mistletoe brooms or overmature and old trees with

well-developed heart, truck, or ring rot. The number and size of these complex patches will depend on the size and configuration of the unit as well as what is present in the unit but would generally average slightly larger than in dry forest types.

- **Species preference** for retention, in order, is western larch, Douglas-fir, western redcedar, western white pine, western hemlock, grand fir, lodgepole pine. The presence of forest pests (pathogens and insects) may modify residual species preferences.
    - Favor fire-resistant species such as western larch and Douglas-fir. Where ponderosa pine is present, it should be retained and prioritized in the species preference order.
- **Create stand-level heterogeneity using ICO guidelines** for fine scale stem distribution from representative stand reconstruction data sets (Churchill et al. 2018). Use the natural landscape template and existing stand conditions (e.g., encroached openings) to set targets for clumps and openings and determine their locations. In general, higher pre-treatment stand densities should have higher levels of clumping and smaller openings may be appropriate. See Table G.1 (from Churchill et al. 2018) for guidelines.
    - **Openings** with low tree densities (5-15 TPA) up to 2 acres in size may occur to address forest insect and disease issues or to expand natural openings (e.g. - small pockets of root disease might be appropriate locations to expand by removing additional host species).
    - **Clumps** should focus on retention of >20” DBH and ecologically valuable areas with evidence of wildlife use, snags and down wood. Leave isolated clumps of dwarf mistle-toe infested trees to provide habitat for wildlife and prey species.

Table G.2-Clump size proportions from reconstructed historical sites in the Eastern Cascades of Washington. Values are the percent of the total number of trees in the unit in each clump size.

	Clump (Bin) Size (# of trees)					
Clumping Level	**1**	**2-4**	**5-9**	**10-15**	**16-20+**	**TPA**
High	0.21	0.39	0.3	0.07	0.04	40-60+

- Use prescribed fire to reduce natural and activity fuels and restore fundamental ecosystem processes, where appropriate.
    - o Residual fuel loading should be between 5-40 tons/ac, primarily in the 1,000 or 10,000 hour fuel class.
    - o Target number of snags/ac in a given size class should be informed by the most recent DecAID models for that subwatershed and the Forest Group (Wildlife Habitat Type) that most closely resembles the stand characteristics.

- When burning in stands with old (>150 y.o.) trees, utilize appropriate lighting techniques and targeted mop-up to reduce burn intensity and smoldering time around old tree boles.

Appendix H. Sensitive, Threatened, and Endangered Plants and Animals on the Okanogan-Wenatchee National Forest

Table H.1-Known vertebrate and invertebrate species that are Federally Threatened (FT) or Endangered (FE), Region 6 Sensitive Species (SEN), or Washington State Sensitive Species (WA-SEN) and have the potential to be found within LSRs on the Okanogan-Wenatchee National Forest. Most of the listed species are not associated specifically with LSOF conditions.

Scientific Name	Common Name	Status	LSOF Types
Accipiter gentilis	Northern goshawk	WA-SEN	Y - Dry/Moist Closed
Aeshna sitchensis	Zigzag darner	SEN	N
Aeshna subarctica	Subarctic darner	SEN	N
Boloria astarte	Astarte fritillary	WA-SEN	N
Boloria bellona	Meadow fritillary	WA-SEN	N
Boloria freija	Freija fritillary	WA-SEN	N
Bombus frigidus	Frigid bumble bee	WA-SEN	N
Bombus kirbiellus	High country bumble bee	WA-SEN	N
Bombus occidentalis	Western bumble bee	SEN	N
Bombus vagans	Half-black bumble bee	WA-SEN	N
Canis lupus	Gray wolf	SEN	N
Colias nastes	Labrador sulphur	WA-SEN	N
Cryptomastix devia	Puget oregonian	SEN	Y - Moist Closed
Driloleirus americanus	Giant palouse earthworm	WA-SEN	N
Empidonax wrightii	Gray flycatcher	WA-SEN	N
Entosphenus tridentatus	Pacific lamprey	SEN	N
Gavia immer	Common loon	WA-SEN	N
Grus canadensis	Sandhill crane	WA-SEN	N
Gulo gulo	Wolverine	SEN	N
Haliaeetus leucocephalus	Bald eagle	SEN	Y - Dry/Moist Closed, Riparian
Histrionicus histrionicus	Harlequin duck	SEN	Y - Dry/Moist Closed, Riparian
Lycaena cupreus	Lustrous copper	WA-SEN	N
Melanerpes lewis	Lewis's woodpecker	SEN	N

Myotis lucifugus	Little Brown myotis	WA-SEN	N
Numenius americanus	Long-billed curlew	WA-SEN	N
Oeneis melissa	Melissa arctic	WA-SEN	N
Oncorhynchus clarkii lewisi	Westslope cutthroat trout	SEN	N
Oncorhynchus mykiss gairdneri	Inland Columbia Basin redband trout	SEN	N
Oreamnos americanus	Mountain goat	WA-SEN	N
Oreohelix junii	Grand coulee mountainsnail	WA-SEN	N
Ovis canadensis	Bighorn sheep	SEN	N
Pekania pennanti	Fisher	SEN	Y - Dry/Moist Closed
Picoides albolarvatus	White-headed woodpecker	SEN	Y - Dry Open
Plethodon larselli	Larch mountain salamander	SEN	Y
Polites mardon	Mardon skipper	SEN	N
Polites peckius	Peck's skipper	WA-SEN	N
Polites themistocles	Tawny-edged skipper	WA-SEN	N
Pristiloma wascoense	Shiny tightcoil	SEN	Y - Dry Open
Prosopium coulterii	Pygmy whitefish	WA-SEN	N
Sciurus griseus	Western gray squirrel	WA-SEN	N
Strix nebulosa	Great gray owl	WA-SEN	Y - Cold Forest Closed
Vulpes vulpes cascadensis	Cascade red fox	WA-SEN	N
Lagopus leucura rainierensis	Mount Rainier white-tailed ptarmigan	FPT	N
Lynx canadensis	Canada lynx	FT	Y - Cold Forest Closed
Oncorhynchus mykiss	Steelhead	FT	N
Oncorhynchus mykiss	Steelhead	FT	N
Oncorhynchus tshawytscha	Chinook salmon	FE	N
Salvelinus confluentus	Bull trout	FT	N
Strix occidentalis caurina	Northern spotted owl	FT	Y IN TABLE
Ursus arctos horribilis	Grizzly bear	FT	N
Actinemys marmorata	Western pond turtle	SEN	N
Bombus suckleyi	Suckley cuckoo bumble bee	SEN	N

Branchinecta campestris	Pocked Pouch Fairy Shrimp	WA-SEN	N
Coenagrion interrogatum	Subarctic bluet	WA-SEN	N
Cupido comyntas	Eastern tailed blue	WA-SEN	N
Fluminicola fuscus	Columbia pebblesnail	SEN	N
Prophysaon coeruleum	Blue-gray tail-dropper	WA-SEN	Y - Moist Closed
Speyeria egleis	Great basin fritillary	WA-SEN	N

N=Not associated with LSOF, Y=LSOF associated

Table H.2-Known or suspected vascular plants (VA), bryophytes (BR), lichen (LI) and fungi (FU) that are Federally Threatened (FT) or Endangered (FE), Region 6 Sensitive Species (SEN), or Washington State Sensitive Species (WA-SEN) and have the potential to be found within LSRs on the Okanogan-Wenatchee National Forest.

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
VA	*Achnatherum richardsonii*	Richardson's ricegrass	SEN	Dry open	
VA	*Agoseris aurantiaca var. carnea*	Pink agoseris	WA-SEN	Dry/Moist Closed , Cold Forest	wet meadows in upper montane/subalpine zone
VA	*Agrostis mertensii*	Northern bentgrass	WA-SEN	Cold Forest	dry alpine meadows and talus slopes
VA	*Allium campanulatum*	Sierra onion	WA-SEN	Dry open	dry meadows, open slopes
VA	*Anemone patens var. multifida*	Pasqueflower	WA-SEN	Dry open, Dry/Moist Closed, Cold Forest	dry and moist meadows in PIPO/PSME, dry alpine slopes and ridges
VA	*Antennaria corymbosa*	Flat-top pussy-toes	WA-SEN	Cold Forest-closed	riparian and wet meadows in subalpine and alpine
LI	*Arctoparmelia incurva*	Lichen	WA-SEN	Dry/Moist Closed	On lava rock within a lava flow
VA	*Astragalus arrectus*	Palouse milk-vetch	WA-SEN	Dry open	grassy and shrub dominated openings
VA	*Astragalus microcystis*	Least bladdery milk-vetch	WA-SEN	Dry open, Dry/Moist Closed	PIPO forests
VA	*Botrychium ascendens*	Upward-lobed moonwort	SEN	Dry open, Dry/Moist Closed	wet and dry meadows, streamsides
VA	*Botrychium hesperium*	Western moonwort	SEN	Dry open	moist and dry meadows, within sagebrush shrub steppe
VA	*Botrychium lineare*	Slender moonwort	SEN	Dry/Moist Closed, Cold Forest	meadows, under conifers, on cliffs at higher elevations
VA	*Botrychium paradoxum*	Twin-spiked moonwart	SEN	Dry/Moist Closed	riparian, PICO regen, meadows
VA	*Botrychium pedunculosum*	Stalked moonwort	SEN	Dry open, Dry/Moist Closed, Cold Forest	moist and dry meadows, streamsides, conifer forests

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
VA	*Carex capillaris*	Hairlike sedge	SEN	Dry open, Dry/Moist Closed	streambanks, wet meadows, marshy lakeshores
VA	*Carex chordorrhiza*	Cordroot sedge	WA-SEN	Dry open, Dry/Moist Closed	wetlands, fens, sphagnum bogs, lake shores
VA	*Carex cordillerana*	Cordilleran sedge	SEN	Dry/Moist Closed	mesic PSME forest and flood channels
VA	*Carex gynocrates*	Yellow bog sedge	SEN	Dry/Moist Closed, Cold Forest	sphagnum bogs, forested wetlands
VA	*Carex heteroneura var. epapillosa*	Different nerve sedge	WA-SEN	Dry/Moist Closed, Cold Forest	streams and lake margins, seeps, moist meadows, steep rocky or gravelly slopes
VA	*Carex media*	Intermediate sedge	SEN	Dry/Moist Closed, Cold Forest	moist meadows, perennial streams and ponds
VA	*Carex pauciflora*	Few-flowered sedge	WA-SEN	Dry/Moist Closed, Cold Forest	sphagnum bogs, peat, partial conifer shade
VA	*Carex proposita*	Smokey Mtn. sedge	WA-SEN	Cold Forest	open rocky slopes and ridges near treeline
VA	*Carex rostrata*	Beaked sedge	WA-SEN	Dry/Moist Closed, Cold Forest	floating peat, lake shoreline
VA	*Carex scirpoidea ssp. scirpoidea*	Canadian single-spike sedge	WA-SEN	Dry/Moist Closed, Cold Forest	moist meadows, streambanks, open rocky slopes often above treeline
VA	*Carex sychnocephala*	Many-headed sedge	WA-SEN	Dry/Moist closed, Cold Forest	moist ground often marshes, lakeshores
VA	*Carex tenuiflora*	Sparseflower sedge	WA-SEN	Dry/Moist Closed, Cold Forest	bogs, fens, swamps, seeps in forests
VA	*Carex vallicola*	Valley sedge	WA-SEN	Dry open, Dry/Moist Closed	moist to dry slopes, from foothills to mid elevations, often with sagebrush or aspen
VA	*Castilleja cryptantha*	Obscure indian-paintbrush	WA-SEN	Cold Forest	subalpine meadows
VA	*Chaenactis thompsonii*	Thompson's chaenactis	WA-SEN	Dry open, Cold Forest	dry rocky slopes and ridges 4,000-8,000 elevation on serpentine soils.
VA	*Chrysosplenium tetrandrum*	Northern golden-carpet	WA-SEN	Dry open, Dry/Moist Closed forest	seeps, rock crevices, wet banks, open wet places low to mid elevations
VA	*Cicuta bulbifera*	Bulb-bearing water-hemlock	WA-SEN	Dry/Moist Closed, Cold Forest	bogs, marshes, wet meadows, shallow standing water
VA	*Comastoma tenellum*	Slender gentian	SEN	Cold Forest	subalpine to alpine meadows
VA	*Coptis aspleniifolia*	Spleenwort-leaved goldthread	WA-SEN	Dry/Moist Closed	moist cool sites in old growth forests with well-developed litter layer
VA	*Cryptogramma stelleri*	Steller's rockbrake	SEN	Dry/Moist Closed, Cold Forest	moist shaded cliffs and ledges 3000-6000 ft
VA	*Cypripedium parviflorum*	Yellow lady's-slipper	WA-SEN	Dry/Moist Forest, Cold Forest	bogs, swamps, pond edges, wet forests

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
LI	*Dactylina arctica*	Lichen	WA-SEN	Cold Forest	alpine heaths
VA	*Dactylorhiza viridis*	Long-bract frog orchid	WA-SEN	Dry/Moist Closed	moist to wet meadows, mid elevations
VA	*Delphinium viridescens*	Wenatchee larkspur	WA-SEN	Dry Open, Dry/Moist Closed	moist meadows, seeps, springs, and riparian areas
LI	*Dermatocarpon meiophyllizum*	Lichen	WA-SEN	Dry/Moist Closed, Cold Forest	on rocks within splash zone of streams and lakes
VA	*Draba aurea*	Golden draba	WA-SEN	Cold Forest	fellfields, dry to wet subalpine meadows
VA	*Draba cana*	Lance-leaved draba	WA-SEN	Cold forest	alpine and subalpine dry meadows, rock crevices, rocky slopes
VA	*Draba taylorii*	Taylor's draba	WA-SEN	Cold Forest	alpine
VA	*Dryas drummondii var. drummondii*	Drummond's mountain-avens	WA-SEN	Dry open, Dry/Moist Closed, Cold Forest	crevices of rocky, dry cliffs, and on limestone along rivers, low elevation to alpine
VA	*Erigeron salishii*	Salish fleabane	WA-SEN	Cold Forest	alpine
VA	*Eriophorum viridicarinatum*	Green keeled cotton-grass	WA-SEN	Dry/Moist Closed, Cold Forest	cold swamps and bogs at mid to high elevations
VA	*Eritrichium argenteum*	Pale alpine forget-me-not	WA-SEN	Cold Forest	alpine
VA	*Erythranthe patula*	Stalk-leaved monkeyflower	WA-SEN	Dry/Moist Closed	seeps
VA	*Erythranthe pulsiferae*	Pulsifer's monkey-flower	WA-SEN	Dry Open, Dry/Moist Closed	seasonally moist open areas
VA	*Erythranthe suksdorfii*	Suksdorf's monkey-flower	WA-SEN	Dry open, Dry/Moist Closed, Cold Forest	wet to dry open areas, all elevations
VA	*Erythronium quinaultense*	Quinault fawnlily	WA-SEN	Dry/Moist Closed	moist slopes, under conifers
VA	*Eurybia merita*	Arctic aster	WA-SEN	Cold Forest	open, rocky places, rock crevices, unstable slopes
VA	*Gentiana douglasiana*	Swamp gentian	WA-SEN	Dry/Moist Closed	small boggy areas with conifers
VA	*Gentiana glauca*	Glaucous gentian	WA-SEN	Cold Forest	moist subalpine and alpine meadows
VA	*Geum rivale*	Water avens	WA-SEN	Cold Forest	streambanks, lakeshores, bogs, meadows at high elevations
VA	*Geum rossii var. depressum*	Ross' avens	WA-SEN	Dry/Moist Closed, Cold Forest	high elevation rocky areas and deep moist soil
VA	*Githopsis specularioides*	Common blue-cup	WA-SEN	Dry Open	dry open places
VA	*Hackelia cinerea*	Gray stickseed	WA-SEN	Dry Open, Dry/Moist Closed	open forested areas, talus, cliffs, loose streambanks
VA	*Hackelia taylorii*	Taylor's stickseed	WA-SEN	Cold Forest	high elevation scree, talus, gravel
VA	*Hackelia venusta*	Showy stickseed	FE	Dry Open	open PIPO forest, rocky slopes

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
VA	*Heterotheca oregona var. oregona*	Oregon goldenaster	WA-SEN	Dry open, Dry/Moist Closed	sand and gravel bars along rivers and streams
VA	*Isoetes minima*	Midget quillwort	SEN	Dry open	seasonally moist swales and vernal pools at mid elevations among open conifer forest or shrub steppe
VA	*Juncus howellii*	Howell's rush	WA-SEN	Dry open, Dry/Moist Closed	moist meadows
VA	*Kalmia procumbens*	Alpine azalea	WA-SEN	Cold Forest	alpine slopes
VA	*Lathrocasis tenerrima*	Delicate gilia	WA-SEN	Dry Open, Dry/Moist Closed	rock outcrops, openings in PIPO forests, montane shrub steppe
VA	*Lomatium knokei*	Desert-parsley	WA-SEN	Dry Open, Dry/Moist Closed	open, vernally wet sloped meadows
VA	*Lomatium roneorum*	Leavenworth desert parsley	WA-SEN	Dry Open	Open rocky slopes in openings in PIPO Forest
VA	*Lomatium serpentinum*	Snake canyon desert parsley	WA-SEN	Dry open	basalt talus, silty meadows
VA	*Luzula arcuata ssp. unalaschcensis*	Alaska curved woodrush	WA-SEN	Cold Forest	high elevation, rocky, exposed ridges
VA	*Lycopodium dendroideum*	Treelike clubmoss	WA-SEN	Dry/Moist Closed	rock, talus with thick moss or duff
VA	*Lycopodium lagopus*	One-cone clubmoss	WA-SEN	Dry/Moist Closed, Cold forest	moist open areas montane to subalpine
VA	*Micranthes tischii*	Tisch's saxifrage	WA-SEN	Dry/Moist Closed	moist forest ledges and rock crevices
VA	*Montia diffusa*	Branching montia	WA-SEN	Dry/Moist Closed	moist forest
VA	*Nicotiana attenuata*	Coyote tobacco	WA-SEN	Dry Open	dry open places
VA	*Oxytropis campestris var. gracilis*	Yellowflower locoweed	WA-SEN	Cold Forest	high elevation dry meadow, near whitebark pine
VA	*Packera bolanderi var. harfordii*	Harford's ragwort	WA-SEN	Dry Moist Closed	rocky, shaded streambanks
VA	*Packera porteri*	Porter's butterweed	WA-SEN	Dry Open	volcanic sediments and talus
VA	*Parnassia kotzebuei*	Kotzebue's grass-of-parnassus	WA-SEN	Cold Forest	damp, mossy ledges on north facing cliffs, rocky seeps
VA	*Pedicularis pulchella*	Mountain lousewort	WA-SEN	Cold Forest	gravel fields and slopes above tree line
VA	*Pedicularis rainierensis*	Mt. Rainier lousewort	WA-SEN	Dry/Moist Closed, Cold Forest	moist alpine meadows, open conifer forests, rocky slopes, and near streams and lakes
VA	*Pellaea brachyptera*	Sierra cliffbrake	WA-SEN	Dry Open	dry rock slopes in PIPO, shrub steppe
VA	*Pellaea breweri*	Brewer's cliff-brake	WA-SEN	Dry open, Dry/Moist Closed, Cold Forest	talus slopes, cliff crevices and other rocky places

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
VA	*Penstemon eriantherus var. whitedii*	Whited's penstemon	WA-SEN	Dry Open	dry, rocky places
VA	*Phacelia minutissima*	Dwarf phacelia	SEN	Dry/Moist Closed	ephemeral moist open places
VA	*Pinus albicaulis*	Whitebark pine	FT	Cold Forest	timberline or subapline woodlands
VA	*Platanthera chorisiana*	Choris' bog-orchid	WA-SEN	Dry/Moist Closed	moist edges of streams and bogs
VA	*Polemonium viscosum*	Skunk polemonium	WA-SEN	Cold Forest	open rocky places at high elevations
VA	*Potentilla breweri*	Brewer's cinquefoil	WA-SEN	Dry/Moist Closed, Cold Forest	moist meadows and streambanks to open slopes
VA	*Potentilla nivea*	Snow cinquefoil	WA-SEN	Cold Forest	alpine scree, meadows, fell fields, dry rocky ridges
VA	*Pyrrocoma hirta var. sonchifolia*	Sticky goldenweed	WA-SEN	Dry Open, Dry/Moist Closed	meadows and open slopes
VA	*Ribes oxyacanthoides ssp. irriguum*	Idaho gooseberry	WA-SEN	Dry Open, Dry/Moist Closed	along streams, meadows, moist to dry canyon slopes
VA	*Salix glauca ssp. glauca var. villosa*	Glaucus willow	WA-SEN	Dry/Moist Closed, Cold Forest	moderate to high elevation riparian areas, shrub wetlands, gravel slopes
VA	*Saxifraga cernua*	Nodding saxifrage	WA-SEN	Dry/Moist Closed	stream banks, seeps, moist rocks and cliffs
VA	*Saxifragopsis fragarioides*	Joint-leaved saxifrage	SEN	Dry open, Dry/Moist Closed	cracks and crevices in cliffs, rock outcrops, talus
BR	*Scouleria marginata*	Moss	WA-SEN	Dry/Moist Closed	on bedrock or large boulders at water line of streams
VA	*Sidalcea oregana var. calva*	Wenatchee Mountains checker-mallow	FE	Dry Open	Sagebrush plains, meadows and PIPO forests
VA	*Silene seelyi*	seely's silene	WA-SEN	Dry open, Dry/Moist Closed	Cliffs and talus slopes at mid elevations
VA	*Sisyrinchium sarmentosum*	Pale blue-eyed grass	SEN	Dry open, Dry/Moist Closed	moist grassy areas
VA	*Spiranthes diluvialis*	Ute ladies'-tresses	FT	Dry/Moist Closed	Moist to wet meadows, marshes, and riparian areas
VA	*Spiranthes porrifolia*	Western ladies-tresses	WA-SEN	Dry/Moist Closed	wet meadows, bog, seepage slopes and along streams
VA	*Swertia perennis*	Swertia	SEN	Cold forest	subalpine moist meadows, bogs, stream banks
LI	*Tholurna dissimilis*	Lichen	SEN	Dry/Moist Closed, Cold Forest	on conifer twigs or subalpine rocks
VA	*Trifolium thompsonii*	Thompson's clover	WA-SEN	Dry Open	grassland, open PIPO forest
VA	*Triglochin palustris*	Slender bog arrowgrass	SEN	Cold Forest	sphagnum bogs

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
VA	*Vaccinium myrtilloides*	Velvet-leaf blueberry	WA-SEN	Dry/Moist Closed, Cold Forest	open PIEN forest, sphagnum bogs and swamps
BR	*Schistostega pennata*			Dry/Moist Closed, Cold Forest	
BR	*Tetraphis geniculata*			Dry/Moist Closed, Cold Forest	
BR	*Tritomaria quinquedentata*			Dry/Moist Closed, Cold Forest	
FU	*Acanthophysium farlowii*			Dry/Moist Closed	
FU	*Albatrellus ellisii*			Dry/Moist Closed	
FU	*Baeospora myriadophylla*			Dry/Moist Closed	
FU	*Boletus haematinus (Rubroboleutus haematinus)*			Cold Forest	
FU	*Boletus pulcherrimus*			Dry/Moist Closed	
FU	*Bondarzewia mesenterica (B. montana, B. occidentalis)*			Dry/Moist Closed	
FU	*Cantharellus subalbidus*			Dry/Moist Closed	
FU	*Catathelasma ventricosa*			Dry/Mosit Closed, Cold Forest	
FU	*Chalciporus piperatus (Boletus piperatus)*			Dry/Moist Closed	
FU	*Chamonixia caespitosa*			Dry/Moist Closed	
FU	*Choiromyces alveolatus*			Dry open	
FU	*Choiromyces venosus*- European species (*Mylitta venosa*)			Dry/Moist Closed	
FU	*Chrysomphalina grossula*			Dry Open, Dry/Moist Closed, Cold Forest	

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
FU	*Clavariadelphus ligula*			Dry/Moist Closed	
FU	*Clavariadelphus occidentalis (pistillaris)*			Dry/Moist Closed	
FU	*Clavariadelphus sachalinensis*			Dry/Moist Closed, Cold Forest	
FU	*Clavariadelphus subfastigiatus*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Clavariadelphus truncatus (borealis)*			Dry/Moist Closed	
FU	*Collybia bakerensis*			Dry/Moist Closed	
FU	*Collybia racemosa*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Cortinarius cyanites*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Cortinarius olympianus*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Cortinarius umidicola*			Cold Forest	
FU	*Craterellus tubaeformis (Cantherellus tubaeformis)*			Dry/Moist Closed	
FU	*Entoloma nitidum*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Gastroboletus ruber*			Dry/Moist Closed, Cold Forest	
FU	*Gastroboletus turbinatus*			Dry/Moist Closed	
FU	*Gastroboletus vividus*			Dry/Moist Closed	
FU	*Gomphus bonarii*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Gomphus clavatus*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Gomphus kauffmanii*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Gguepinia helvelloides (tremiscus)*			Dry Open, Dry/Moist Closed, Cold Forest	

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
FU	*Gymnomyces abietis*			Dry/Moist Closed	
FU	*Gyromitra californica (Pseudorhizina californica)*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Helvella crassitunicata*			Dry/Moist Closed	
FU	*Helvella elastica*			Dry/Moist Closed	
FU	*Hygrophorus caeruleus*			Dry/Moist Closed	
FU	*Hypomyces luteovirens*			Dry/Moist Closed	
FU	*Leucogaster citrinus*			Cold Forest	
FU	*Macowanites lymanensis*			Dry/Moist Closed, Cold Forest	
FU	*Mycena hudsoniana*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Mycena overholtsii*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Mycena quinaultensis*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Mycena tenax*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Mythicomyces corneipes*			Dry/Moist Closed	
FU	*Ootidea leporina*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Pachycudonia monticola (cudonia)*			Dry Moist Closed, Cold Forest	
FU	*Phaeocollybia kauffmanii*			Dry/Moist Closed	
FU	*Pholiota albivelata*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Ppolyozellus multiplex*			Dry Moist Closed, Cold Forest	
FU	*Ramaria abietina*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Ramaria amyloidea*			Dry/Moist Closed	
FU	*Ramaria aurantiisiccescens*			Dry/Moist Closed	
FU	*Ramaria celerivirescens*			Dry/Moist Closed	

Taxon	Scientific Name	Common Name	Status	LSRA Forest Types	Habitat notes
FU	*Ramaria conjunctipes var. sparsiramosa*			Dry/Moist Closed	
FU	*Ramaria gracilis*			Dry/Moist Closed	
FU	*Ramaria largentii*			Dry/Moist Closed	
FU	*Ramaria rubribrunnescens*			Dry/Moist Closed	
FU	*Ramaria rubrievanescens*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Ramaria rubripermanens*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Rhizopogon exiguus*			Dry/Moist Closed	
FU	*Sarcodon fuscoindicus*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Sowerbyella rhenana (*)*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Sparassis crispa*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Spathularia flavida*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Stagnicola perplexa*			Dry Open, Dry/Moist Closed, Cold Forest	
FU	*Tricholoma venenatum*			Dry Open, Dry/Moist Closed, Cold Forest	

Appendix I. Methods

This section provides some additional information about methods and data used in the assessment.

Methods for mapping late-successional and old forest habitat

The approach used to map different kinds of late successional and old forest habitats was based on categorizing vegetation into Vegetation Groups based on Vegetation Types as described in WADNR (2022). Table I.1 shows how which vegetation types were placed into the Dry, Moist, and Cold Forest vegetation groups. The vegetation groups were broadly based in vegetation types with similar historical disturbance regimes.

Table I.1-Vegetation types placed into vegetation groups based on WADNR (2022).

Vegetation Group	**Vegetation Type**
Dry	• Oak Pine • Ponderosa Pine • Ponderosa Dry • Dry Mixed Conifer
Moist	• Moist Mixed Conifer • Northern Rocky Mountain Mixed Conifer • Western Redcedar
Cold	• Silver Fir • Mountain Hemlock • Subalpine Parklands • Subalpine-Lodgepole pine • Subalpine-Spruce

The vegetation groups were then combined with forest structure information derived from gradient nearest neighbor data (GNN v2023.1; Bell et al. in review), using forest vegetation structure generally associated with late successional and old forests (Figure I.1, Table I.2, e.g., tree size, canopy cover). The natural range of variability estimates were derived from a combination of state-transition modeling (e.g., Integrated Landscape Assessment Project, ILAP; Halofsky et al. 2014), historical landscape reconstructions (Hessburg et al. 1999), historical inventory data (Halofsky et al. in review), and other published literature (Agee 2003).

Table I.2-Vegetation groups, vegetation types (both based on WADNR 2022) and Gradient Nearest Neighbor (GNNv2023.1) structure data (Bell et al. in review) used to map late-successional and old forest habitats, and HRV estimates.

Vegetation Group	Vegetation Type	GNN Forest Structure[1]	HRV Estimates
Dry Forest - Open	Oak Pine Ponderosa Pine Ponderosa Dry Dry Mixed Conifer	Tree Size: Medium, large, giant Canopy Cover: <50%	Dry Large-Tree Open-Canopy: 33-47%
Dry-Moist-Closed	Oak Pine Ponderosa Pine Ponderosa Dry Dry Mixed Conifer Moist Mixed Conifer Northern Rocky Mountain Mixed Conifer Western Redcedar	Tree Size: Medium, large, giant Canopy Cover: >50%	Dry-Moist Forest-Tall-Closed Canopy: 18-24% Dry Large-Tree Closed-Canopy: 2-15% Moist Large-Tree Closed-Canopy: 15-30%
Cold-Closed	Silver Fir Mountain Hemlock Subalpine Parklands Subalpine-Lodgepole pine Subalpine-Spruce	Tree Size: Medium, large, giant Canopy Cover: >50%	Cold-Medium-Large-Tree Closed-Canopy: 20-60%

[1]Tree size classes used: Medium Tree=QMD ≥15-<20 in.; Large Tree=QMD ≥20-<29.5 in.; Giant Tree=QMD ≥29.5.

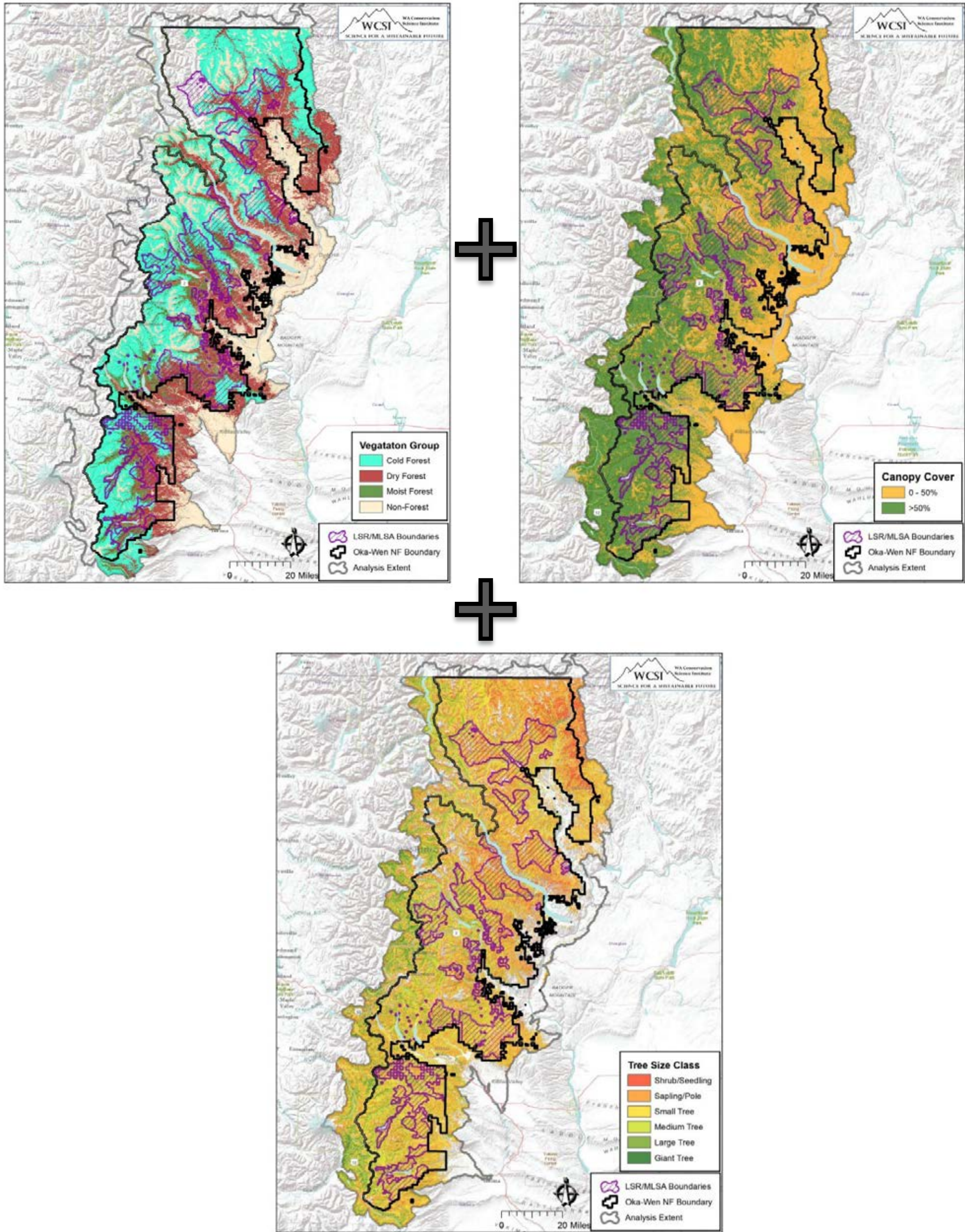

Figure I.1-Distribution of data compiled to estimate late-successional and old forest habitats within the Okanogan-Wenatchee National Forest. Data layers included: forest group, canopy cover, and tree size class.

Methods to assess habitat connectivity

The following information describes the process used to assess habitat connectivity.

Purpose: Evaluate changes to landscape connectivity from 1993 to 2021 for guilds of low mobility and moderate mobility wildlife species. Summarize changes across the LSR/MLSA network for moderate mobility species. Summarize changes within individual LSRs/MLSAs for low mobility species.

Step 1: Create resistance surfaces for years 1993 and 2021 using assigned resistance values (Table I.3) for landscape characteristics for both guilds.

Step 2: For the moderate mobility guild, using resistance surfaces for 1993 and 2021 and calculate cost-weighted distance (CWD) using the LSR network as core areas. The CWD outputs represent the relative difficulty for animals to move across the landscape to and from each LSR/MLSA. CWD values are represented as weighted distance of resistance in kilometers from each core area (LSR/MLSA).

Step 4: Evaluate changes of habitat connectivity to the LSR network between 1993 and 2021.

> Step 4a – For low mobility species, sum the resistance values within the LSR/MLSA network and compare the change (%) of total resistance between 1993 and 2021.
>
> Step 4b - For moderate mobility species, use a CWD threshold of 200,000 km and calculate the area (acres) within that threshold that is present outside the LSR/MLSA network and compare the change (%) in area between 1993 and 2021.

Note - only evaluating changes to forest structure and using the current building density for both bookends.

Table I.3-Landscape characteristic resistance values and class names for development of landscape resistance surfaces for guilds of low mobility and moderate mobility species.

Landscape Characteristics	Data Source	Grid Value	Class Name	Low Mobility Species Resistance Values	Moderate Mobility Species Resistance Values
Forest Structure	GNNv2023.1	1	Non-Forest	5,000	1,000
Forest Structure	MTBS	2	High/Very Severity Fire	2,500	500
Forest Structure	NWFP 25YR NSO Data (Davis et al 2022)	3	NSO Non-Dispersal Habitat/Forested	1,000	250
Forest Structure	NWFP 25YR NSO Data (Davis et al 2022)	4	NSO Dispersal Habitat	50	10

Landscape Characteristics	Data Source	Grid Value	Class Name	Low Mobility Species Resistance Values	Moderate Mobility Species Resistance Values
Forest Structure	GNNv2023.1	5	LSOF Dry/Moist Closed Canopy	1	1
Waterbodies	NLCD 2016	1	No Waterbodies	1	1
Waterbodies	NLCD 2016	2	Major Waterbodies/Lakes	10,000	10,000
Slope	USGS	1	Low Slope (0-50 degrees)	1	1
Slope	USGS	2	Moderate Slope (50-70 degrees)	50	20
Slope	USGS	3	High Slope (>70 degrees)	10,000	500
Freeway	WWHWG	1	Area outside of buffer	1	1
Freeway	WWHWG	2	500m to 1,000m buffer	1	1
Freeway	WWHWG	3	0m to 500m buffer	1	10
Freeway	WWHWG	4	Centerline grid cells	10,000	10,000
Major Highway	WWHWG	1	Area outside of buffer	1	1
Major Highway	WWHWG	2	500m to 1,000m buffer	1	1
Major Highway	WWHWG	3	0m to 500m buffer	1	10
Major Highway	WWHWG	4	Centerline grid cells	10,000	5,000
Secondary Highway	WWHWG	1	Area outside of buffer	1	1
Secondary Highway	WWHWG	2	500m to 1,000m buffer	1	1
Secondary Highway	WWHWG	3	0m to 500m buffer	1	10
Secondary Highway	WWHWG	4	Centerline grid cells	10,000	1,000
Building Density	Global ML Building Footprints	1	No Buildings (0/sq mile)	1	1
Building Density	Global ML Building Footprints	2	Low Density Buildings (1-50/sq mile)	1,000	100

Landscape Characteristics	Data Source	Grid Value	Class Name	Low Mobility Species Resistance Values	Moderate Mobility Species Resistance Values
Building Density	Global ML Building Footprints	3	Moderate Density Buildings (51-100/sq mile)	5,000	5,000
Building Density	Global ML Building Footprints	4	High Density Buildings (>100/sq mile)	10,000	10,000

Data Sources:

NLCD 2016 | U.S. Geological Survey (usgs.gov)

GIS Data Download | U.S. Geological Survey (usgs.gov)

Washington Wildlife Habitat Connectivity Working Group » Statewide Analysis (waconnected.org)

GitHub - microsoft/GlobalMLBuildingFootprints: Worldwide building footprints derived from satellite imagery

Methods to Determine Wildfire Burn Severity Classifications

Table I.4 describes the wildfire burn severity classifications used to assess impacts to vegetation and habitat (WADNR 2022, p. 10). Burn severity was estimated by calculating the Relative difference Normalized Burn Ratio (RdNBR), with an offset, for all fires in the DNR Large Fires database (1985 – present) using Landsat 4, 5, 7, and 8 imagery in Google Earth Engine. Burn severity was categorized (unburned, low, mixed, high, and very high severity) using thresholds based on % basal area (BA) mortality, from a collection of field plots over Washington and Oregon (University of Washington, Saberi and Harvey 2023). The unburned threshold is based on the Composite Burn Index (CBI) instead of basal area. See WADNR 2022 for additional detail.

Table I.4-Burn severity classifications and thresholds based on Saberi & Harvey 2023.

Severity	BA Loss or CBI Change	RdNBR cutoff	
		Eastside	Westside
Unburned/ Very Low	<5% CBI Change	<-43	<-135
Low	>5% & <25% BA Loss	>-43 & <262	>-135 & <159
Moderate	>25% & <75% BA Loss	>262 & <600	>159 & <536
High	>75% & <95% BA Loss	>600 & <856	>536 & <835
Very High	>95% BA Loss	>856	>835

Methods to Access Impacts of Insects and Diseases

Annual aerial detection survey (ADS) data for insects and disease were used to access the impacts of insects and disease from 1993 to 2021. The total amount of acres and proportion impacted by insects and disease (without overlap) were calculated and displayed by recorded severity within Vegetation Groups on the Okanogan-Wenatchee NF and LSR Network. Damage agents from ADS analyzed include the following by Vegetation group:

*Table I.5-Damage agents mapped by Aerial Detection Surveys from 1993 to 2021 on the Okanogan-Wenatchee National Forest and the forest types where damage agents are found. Aerial detection surveys do not attribute damage caused by root diseases or dwarf mistletoes. *All insects listed are native with the exception of balsam woolly adelgid. Data source: USDA Forest Service, Forest Health Protection and its partners*

Vegetation Group	Damage causing agents
Dry Forest	Bark beetles • Western pine beetle • Douglas-fir beetle • Fir engraver • Mountain pine beetle Defoliators • Western spruce budworm • Douglas-fir tussock moth
Moist Forest	Bark beetles • Western pine beetle • Douglas-fir beetle • Fir engraver • Mountain pine beetle Defoliators • Western spruce budworm • Douglas-fir tussock moth • Balsam woolly adelgid*
Cold Forest	Bark beetles • Mountain pine beetle • Western Balsam Bark beetle • Spruce beetle • Balsam woolly adelgid • Silver fir beetle • Fir engraver

Defoliators

- Balsam woolly adelgid

To assess future risks, information from the National Insect and Disease Risk Map (NIDRM, Krist et al. 2014) was used to project the total acres across the Forest and within the LSR network that could be impacted by forest insects and disease. NIDRM is a nationwide spatial assessment of the hazard of tree mortality due to insects and diseases. Insect and disease risk, or hazard, is defined as: the expectation that, without remediation, at least 25% of standing live basal area greater than one inch in diameter will die over a 15-year time frame (2013 to 2027) due to insects and diseases (Krist et al. 2014). Acres of projected percentage loss of basal area from all agents. Predicted basal area loss > 25% is considered “at risk”. Risk is summarized at the 240-m pixel scale. In more productive sites or stands dominated by mature or old forests, lower basal area (< 25%) mortality may still represent a considerable loss, especially if that mortality is concentrated in a single species or larger size class.

Appendix J. LSRA Consistency Checklist

☐ A landscape evaluation for the project planning area has been completed.

☐ A departure assessment for vegetation conditions, focal species habitats, existing large remnant tree structure and LSOF patches has been completed.

☐ A risk assessment of fire risk, insect & disease risk, and drought vulnerability has been completed.

☐ A treatment priority layer has been generated that weighs different resource concerns and priorities within the project area.

☐ Treatment priorities have been confirmed to exist within the LSR boundary within the project area.

☐ Existing large tree structure has been mapped within the LSR (using DAP, Lidar, aerial imagery, or combination of tools).

☐ A departure assessment of large-closed and large-open tree structure has indicated a departure from NRV for dry and/or moist forest types in the LSR.

☐ In **dry forests** within the LSR, this departure assessment indicates that:

- ☐ Conditions are above NRV for large, dense forest.
- ☐ Conditions are below NRV for large, open forest.
- ☐ Existing large tree structure is mapped as low or very low sustainability (using the large, dense forest sustainability layer described in Section 4.2).
- ☐ Existing large tree structure is mapped as moderate or high sustainability (using the large, dense forest sustainability layer described in Section 4.2).

☐ In **moist forests** within the LSR, this departure assessment indicates that:

- ☐ Existing large tree structure is mapped as low or very low sustainability (using the large, dense forest sustainability layer described in Section 4.2).
- ☐ Stands identified for potential treatment present a risk to nearby high priority habitat.
- ☐ Conditions are above NRV for large, dense forest.

☐ If treatments are proposed under the risk reduction criteria of the NWFP (ROD C-12), insect and disease or fire risk modeling has been completed to demonstrate the efficacy of treatments.

☐ Stand level treatments in dry or moist forest stands follow the guidelines within Section 6.3: Stand-Scale Design Considerations