WILDLIFE
IN MANAGED FORESTS

Early Seral-Associated Songbirds

Wildlife in Managed Forests – Project Overview

This publication is part of a series from the Oregon Forest Resources Institute that aims to synthesize current research findings and make information available to foresters, wildlife managers and interested parties such as conservation organizations, regulators and policymakers. As part of the Wildlife in Managed Forests Outreach Project, information is disseminated through publications such as this one, as well as workshops, tours and conferences.

PROJECT PARTNERS:

Manulife Investment Management
National Council for Air and Stream Improvement
Oregon Department of Fish and Wildlife
Oregon Department of Forestry
Oregon Forest Industries Council
Oregon Forest Resources Institute
Oregon State University College of Forestry
Oregon State University Department of Fisheries and Wildlife
Starker Forests, Inc.
U.S. Department of Agriculture (USDA) National Wildlife Research Center
US Forest Service Pacific Northwest Research Station
Weyerhaeuser

For copies of this report or further information, contact:

Oregon Forest Resources Institute
9755 SW Barnes Rd., Suite 210
Portland, OR 97225
(971) 673-2944
KnowYourForest.org
OregonForests.org

PREPARED FOR THE OREGON FOREST RESOURCES INSTITUTE BY:

Fran Cafferata, Cafferata Consulting, Scappoose, Ore.
Julie Woodward, Oregon Forest Resources Institute, Silverton, Ore.

© Copyright 2023, Oregon Forest Resources Institute

This publication was made possible in part through a grant from the Partnership for Forestry Education:

Printed on recycled paper

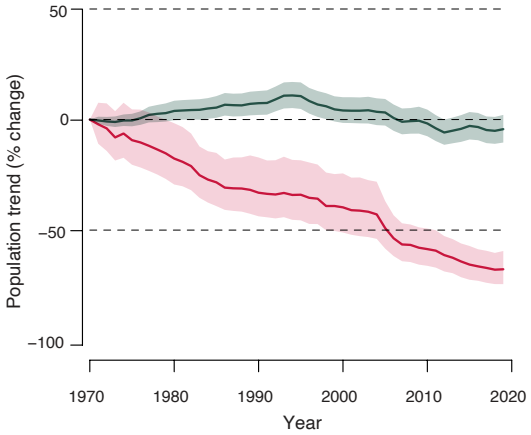
Contents

Swainson's thrush nesting in an early seral forest.

1.0 Introduction

Forest ecologists identify four major seral stages in forest development after a stand replacement event such as a fire or clear-cut: early seral forest with a diversity of plants, including tree seedlings; young forest with a closed forest canopy and little understory community; mature forest with re-establishment of the understory; and old forest with a mix of species and diverse understory community (Franklin and Johnson 2012).

FIGURE 1. BIRD POPULATION INDICATOR IN WESTERN FORESTS



ABOVE: The western forests indicator in this graph is from the 2020 *State of the Birds Report*. The decline is based on 46 obligate breeding birds in western forest habitats. Species such as the rrange-crowned warbler are declining 2 to 4% each year, which is one of the reasons researchers are focusing their work on songbirds.

LEFT: This stand has down logs and leave trees that are important components of early seral forests.

Managed forests can provide habitat for wildlife at all seral stages. Early seral forests are important for some species of songbirds because early seral forests and young plantations provide cover, foraging and nesting habitat required for these species. One of the purposes of this publication is to help managers learn what habitat components are important in young plantations such that they provide the same or similar function as unmanaged early seral forests. This publication will identify early seral-associated songbirds, discuss their habitat needs, summarize current research and provide science-based management recommendations to maintain songbird habitat.

One reason researchers are focusing on songbirds is because, according to the United States Geological Survey (USGS) Breeding Bird Survey, early seral-associated species such as the rufous hummingbird and orange-crowned warbler continue to decline at a rate of 2 to 4% per year. In addition, songbirds that use early seral forests provide numerous ecological functions: Songbirds are seed distributors, and consume and help regulate insect populations (Betts 2014, Swanson et al. 2014).

In ecological terms, a seral stage refers to the series of biotic communities formed by the process of ecosystem development called succession. Seral-stage communities consist of vegetation types adapted to the site's particular set of physical and biotic conditions.

Early seral, or young regenerating forests, are in decline across the Pacific Northwest, especially within federal forests. Estimates are that there has been as much as a 50% decline in early seral forests since the 19th and early 20th centuries (Swanson et al. 2014). Many of the early seral forests now exist primarily on private lands,

due to the emphasis on late-successional and old-growth management goals on federal forestlands.

Forest inventory systems have not documented seral stages across Oregon. However, the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) team (from the U.S. Forest Service and Oregon State University) has created GIS maps to characterize Oregon forests based on several characteristics including tree size class (Oregon Department of Forestry 2010).

The data from these GIS maps can be summarized in tabular and graphical forms. Figure 2 shows a graphical breakdown of tree size classes in Oregon by percent (Cloughesy 2014). The shrub/seedling class includes early seral forest, but not all of it. The sapling/pole class includes some early seral forest and some young forest. If canopy closure occurs at about 4 inches diameter at breast height (dbh), then about one-third of the sapling/pole acres are early seral forest and two-thirds are young forest.

FIGURE 2. TREE SIZE CLASS IN OREGON BY PERCENT

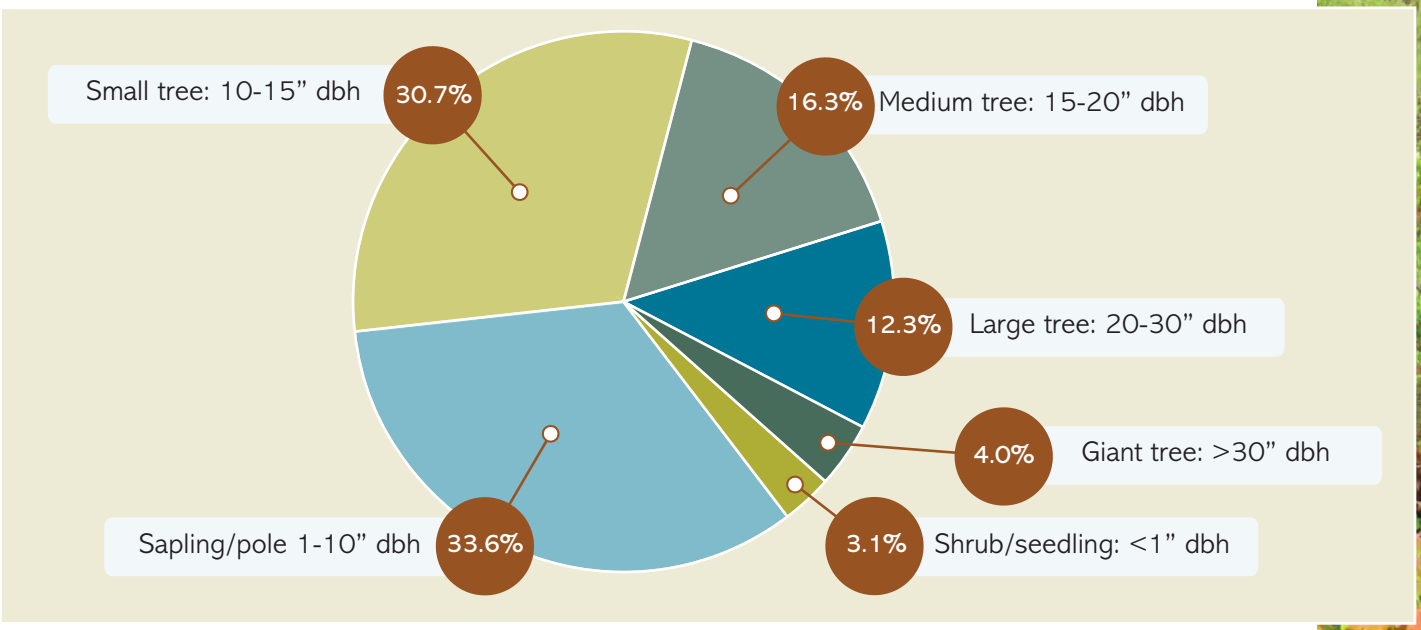


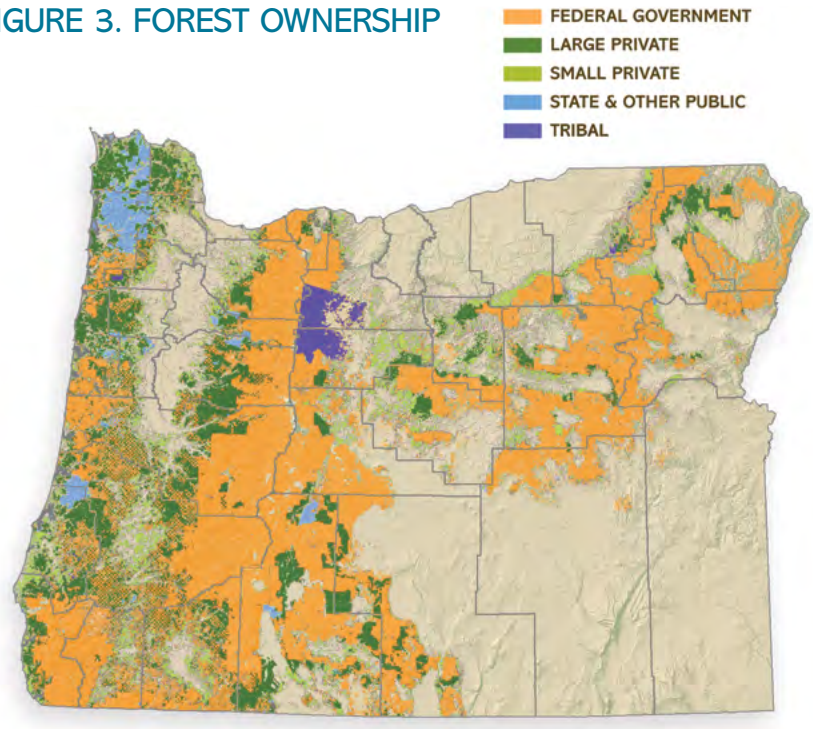
Table 1 shows the estimated area of early seral forest in Oregon by acres and percent. Using the LEMMA tree size class data, we estimate that about 14.3% of forested land in Oregon can be classified as early seral. This is based on the assumption that all the shrub/seedling and one-third of the sapling/pole acres would be classified as early seral.

TABLE 1: ESTIMATED AREA AND PERCENT OF EARLY SERAL FORESTS IN OREGON BY AVERAGE TREE SIZE CLASS

Class	Size Class	Average Tree Size	Acreage	Percent
1	Shrub/seeding	<1" dbh	964,000	3.1%
2	Sapling/pole	1-4" dbh	3,473,000	11.2%
Total Early Seral			4,437,000	14.3%

LEMMA http://lemma.forestry.oregonstate.edu/?project=imap&id=home

FIGURE 3. FOREST OWNERSHIP



Approximately 47% of all land in Oregon is forested. In Oregon, this land is owned and managed by the federal government, state and other public entities, large private landowners, small private landowners, and tribal landowners (Figure 3). Privately owned forests provide the majority of the timber harvest in Oregon (Table 2). This gives land managers of privately owned forests a great opportunity to create early seral forests that many wildlife species depend upon.

TABLE 2. OWNERSHIP OF FORESTED LAND AND TIMBER HARVEST IN OREGON

Owner or Group	Percent of Acreage in Oregon	Percent of Timber Harvest in Oregon
Federal government	60	14
State and other public	4	10
Private	34	76
Tribal	2	<1

Source: *Oregon Forest Facts & Figures 2023-24 Edition* (OFRI 2023)

"Structurally and compositionally diverse early seral forest habitats are now the scarcest habitats in the [Pacific Northwest] region." Thomas et al. 2006 Cons. Biol.

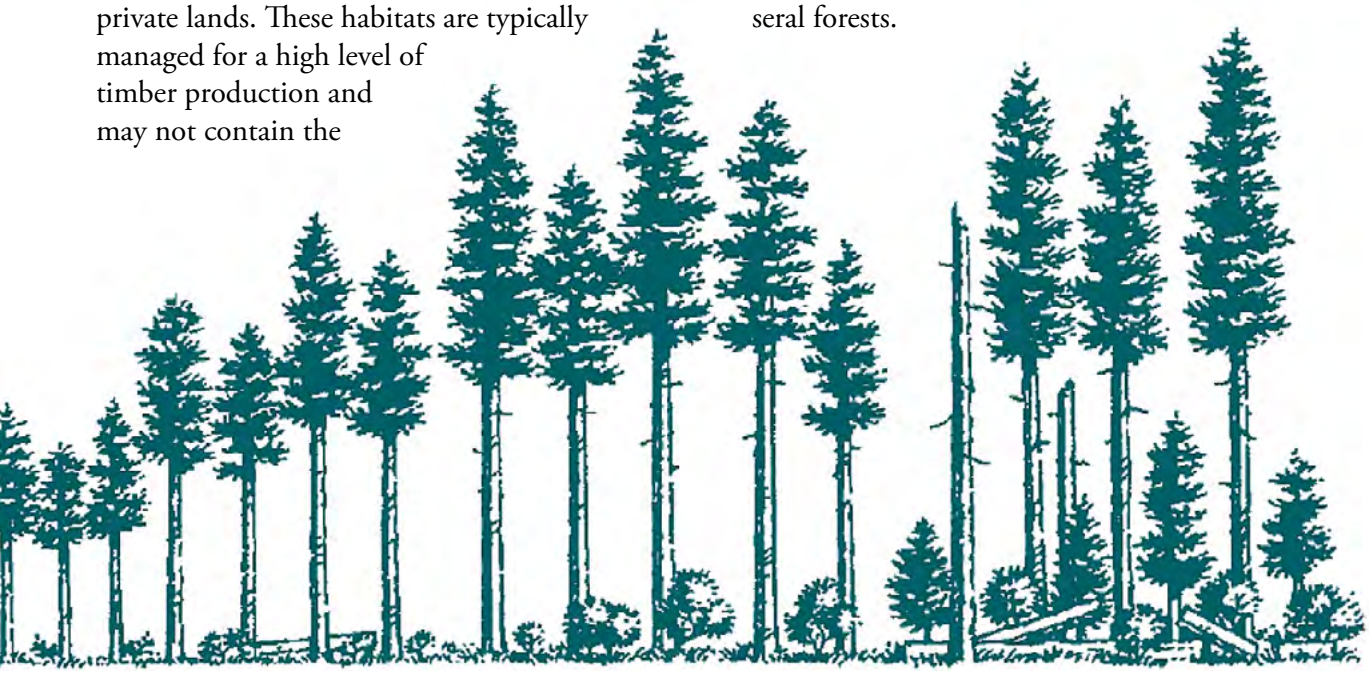
FIGURE 4. FOREST AGE CLASSES

2.0 Historical and Contemporary Creation of Early Seral Habitat

Early seral is the forest stage that occurs immediately following a stand-replacing disturbance event. This stage includes the first three Forest Age Classes shown in Figure 4. Historically, early seral forests were represented across the Pacific Northwest in a shifting mosaic. Disturbances may be natural, such as wildfire, windstorms or other stand-replacing events, or human-caused, such as forest harvest or land use conversion. Early seral forest is typified by young, open stands with a high shrub component and a variety of living and dead legacy structures, such as trees, snags and down wood. Unmanaged early seral forests may exist longer on the landscape, where managers do not manipulate succession and seedlings experience a higher rate of competition than in stands where shrubs and other vegetation are controlled. Early seral forests and young plantations, exist on the landscape for a shorter period of time in stands managed for timber production, including state and many private lands. This is a result of both maximizing timber growth and meeting Oregon Forest Practices Act reforestation requirements that require free-to-grow forest conditions in a relatively short time period.

Today, early seral forests throughout Oregon are often those created by forest harvest activities on private lands. These habitats are typically managed for a high level of timber production and may not contain the characteristics that have historically defined early seral habitat derived from natural disturbances, including abundance and duration of young plants, legacy structures of snags, standing live trees and down wood. Additionally, in an effort to increase wood production, the open, pre-canopy closure stage of most managed forests stands is truncated when compared with natural succession. This means these habitats aren't as available for the species that rely on them (such as songbirds) for very long. The Forest Practices Act requires a certain number of standing live trees, snags where possible, and down logs to be left on the landscape after harvest as components of early seral conditions (see section 5.1, page 21).

The emphasis on conservation and creation of late seral and old-growth forests on federal lands that occurred in the latter part of the last century has likely contributed to the overall decrease in the extent of early seral forests. The management emphasis on creating late seral and old-growth forests on federal lands has resulted in a land use pattern where early seral forests disproportionately occur in areas dominated by private land ownership. Private land ownership, therefore, plays an important role in maintaining and developing early seral forests.



Closed sapling, pole | Mature | Old-growth

3.0 Early Seral-Associated Songbirds

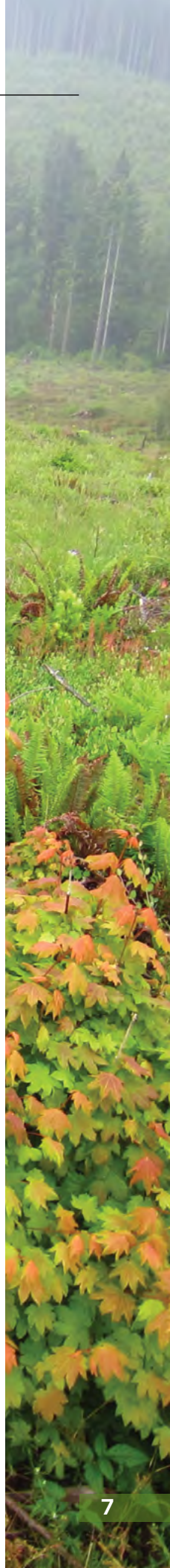
A variety of species are commonly found in and strongly associated with early seral forests, including a multitude of songbirds. Several common Oregon species are known to be strongly associated with early seral forests, including MacGillivray's warblers, orange-crowned warblers and white-crowned sparrows. Profiles of these species, including a brief discussion of their habitat requirements, are discussed in this section. Table 3 lists many of the songbirds found in Oregon that are associated with early seral forests. Some of these species may also be found in other habitats. Many of the songbirds listed in Table 3 (e.g., orange-crowned warblers) are migratory (meaning they leave during the winter months); some species of songbirds live here all year (e.g., dark-eyed juncos).

TABLE 3. EARLY SERAL-ASSOCIATED SONGBIRDS LIST

Early seral-associated songbirds		Oregon distribution
Wood warblers		
MacGillivray's warbler	*Geothlypis tolmiei*	Statewide
Nashville warbler	*Oreothlypis ruficapilla*	Primarily southwest and northeast Oregon
Orange-crowned warbler	*Oreothlypis celata*	Statewide
Wilson's warbler	*Cardellina pusilla*	Statewide
Yellow warbler	*Setophaga petechia*	Statewide
Yellow-rumped warbler	*Setophaga coronata*	Statewide
Cardinals, grosbeaks and allies		
Black-headed grosbeak	*Pheucticus melanocephalus*	Statewide
Lazuli bunting	*Passerina amoena*	Statewide
Hummingbirds		
Rufous hummingbird*	*Selasporus rufus*	Statewide
Tyrant flycatchers		
Olive-sided flycatcher	*Contopus cooperi*	Primarily western and northeast Oregon
Willow flycatcher	*Empidonax traillii*	Statewide
Vireos		
Warbling vireo	*Vireo gilvus*	Statewide
Swallows		
Purple martin	*Progne subis*	Western Oregon

*Not a songbird, but strongly associated with early seral habitats in Oregon. Other non-songbird species that use early seral forest include mountain quail, California quail and American kestrel.

Early seral-associated songbirds		Oregon distribution
Swallows (continued)		
Tree swallow	*Tachycineta bicolor*	Statewide
Violet-green swallow	*Tachycineta thalassina*	Statewide
Bushtits		
Bushtit	*Psaltriparus minimus*	Primarily western Oregon, but occurs east of the Cascades
Wrens		
Bewick's wren	*Thryomanes bewickii*	Primarily western Oregon and the Columbia Gorge
House wren	*Troglodytes aedon*	Statewide
Kinglets		
Ruby-crowned kinglet	*Regulus calendula*	Statewide
Thrushes		
American robin	*Turdus migratorius*	Statewide
Mountain bluebird	*Sialia currucoides*	Eastern Oregon
Swainson's thrush	*Catharus ustulatus*	Statewide, but uncommon in central and southeast Oregon
Townsend's solitaire	*Myadestes townsendi*	Statewide
Western bluebird	*Sialia mexicana*	Statewide, but uncommon in southeast Oregon
New-world sparrows and allies		
Chipping sparrow	*Spizella passerina*	Statewide
Dark-eyed junco	*Junco hyemalis*	Statewide
Fox sparrow	*Passerella iliaca*	Primarily central Oregon
Song sparrow	*Melospiza melodia*	Statewide
Spotted towhee	*Pipilo maculatus*	Statewide
White-crowned sparrow	*Zonotrichia leucophrys*	Primarily western Oregon, but found statewide
Finches and allies		
American goldfinch	*Spinus tristis*	Statewide



Species Group Accounts

WOOD WARBLERS

(MacGillivray's warbler, Nashville warbler, Orange-crowned warbler, Wilson's warbler, Yellow warbler and Yellow-rumped warbler)

- Often found in early seral forests; need deciduous brush cover for nesting, feeding and raising young.
- Forage for insects (including leaf-hoppers, moths, spiders, ants, weevils and caterpillars) in dense shrubs and on foliage of deciduous trees and conifer saplings.
- Occasionally, orange-crowned warblers will also feed on nectar and use sapwells made by sapsuckers (Dillingham 2006).

Wilson's warbler

Management recommendations include enhancing and maintaining shrub components in clearcuts, including salmonberry, thimbleberry, blackberry, vine maple, salal, bitterbrush, manzanita, Woods' rose and sword fern (Dowlan 2006, The Cornell Lab of Ornithology 2014b); protecting shrubs, especially along streams; planting or preserving willow, quaking aspen and other native, deciduous saplings and shrubs (The Cornell Lab of Ornithology 2014a); creating small patch harvests, leaving large riparian buffers (Hagar 2006); and retaining existing madrone trees. Early colonizers such as red alder and bigleaf maple can take over a site and limit a diverse and vigorous shrub community that is best for these species.

Orange-crowned warbler

MacGillivray's warbler

CARDINALS, GROSBEAKS AND ALLIES

(Lazuli bunting and Black-headed grosbeak)

- Found in a variety of habitats, but they're strongly associated with early seral forests containing deciduous shrubs, tall trees and snags.
- Nest in dense, well-shaded herbaceous weeds (cover), shrubs or saplings.
- Feed on seeds, fruits and insects.

Management recommendations include maintaining an herbaceous understory with shrubs including snowbrush and chokecherry, and leaving tall trees within clearcuts.

Black-headed grosbeak

HUMMINGBIRDS

(Rufous hummingbird)

- Strongly associated with early seral forests.
- Breed in forest edges, clearings and brushy second growth.
- Use streamsides and mountain meadows for foraging (Kaufman 2014).

Feed mostly on nectar and tiny insects, including gnats, flies, midges and aphids (The Cornell Lab of Ornithology 2014).

Management recommendations include planting and maintaining flowering plants, especially those with red, tubular flowers, such as penstemons, scarlet gilia, red flowering currant, salmonberry and honeysuckle.

Rufous hummingbird

TYRANT FLYCATCHERS

(Olive-sided flycatcher and Willow flycatcher)

- Found at forest edges between early seral and late successional forests (olive-sided).
- Use tall, singular trees and snags for perching, singing and foraging (olive-sided).
- Forage from tall singular trees (olive-sided).
- Feed on flying ants, beetles, moths, dragonflies, and bees and wasps.
- Strongly associated with shrub-dominated habitats, especially riparian willow thickets (willow).
- Nest in riparian zones dominated by willows and in shrubs within clearcuts.
- Use shrub areas for foraging.

Willow flycatcher

Management recommendations include maintaining tall trees and snags in clearcuts, especially adjacent to older stands of timber, and maintaining riparian buffers, especially those with willows.

VIREOS

(Warbling vireo)

- Found in deciduous trees or shrubs, often near riparian areas.
- Forage in small branches in deciduous trees and shrubs.
- Primarily feed upon insects, particularly caterpillars.

Management recommendations include maintaining deciduous trees such as red alder and bigleaf maple, and maintaining and establishing shrubs within clearcuts, especially near water.

Warbling vireo

SWALLOWS

(Purple martin, Tree swallow, Violet-green swallow)

- Nest in cavities, often in snags, and will use nest boxes.
- Forage during the day over open areas.
- Feed on flying insects (tree swallows will also eat berries and small seeds when insects are not available).

Juvenile purple martin

Management recommendations include maintaining snags for nesting opportunities and maintaining deciduous trees such as Oregon white oak (Insects associated with the canopy of deciduous trees, especially oak, provide an abundant prey base for swallows).

Violet-green swallow

Tree swallow

BUSHTITS

(Bushtit)

- Often found in young plantation forests with a well-developed component of deciduous shrubs and saplings.
- Forage from foliage and small branches of trees and shrubs.
- Feed mostly on insects and spiders.

Management recommendations include maintaining a deciduous shrub component in clearcuts and lengthening the time it takes to reach canopy closure.

Bushtit

WRENS

(Bewick's wren and House wren)

- Often found in clearcuts when enough cover is available. Strongly associated with brushy habitats.
- Prefer low cavities for nesting (use cavities created by woodpeckers).
- Forage on insects from within thickets from leaves, bark and occasionally leaf litter.

Bewick's wren

Management recommendations include establishing or maintaining deciduous shrubs within clearcuts, leaving large wildlife trees for future snag recruitment and leaving existing snags.

KINGLETS

(Ruby-crowned kinglet)

- Often found in shrubby habitats.
- Forage almost exclusively in brushy understory habitats consisting of wild crabapple, elderberry, Indian plum, salmonberry, willow and snowberry.
- Feed primarily on arthropods, but will also eat fruit, herbaceous seeds, poison oak seeds and leaf galls.

Management recommendations include retaining a brushy understory within young plantations such that habitat for the Ruby-crowned kinglet is maintained through all forest stages.

Ruby-crowned kinglet

THRUSHES

These species feed mostly on invertebrates and fruits, including beetles, ants, spiders, moths, butterflies, elderberries, blackberries, salmonberries, mountain ash, viburnum, and currant.

American robin

- Found in most seral stages, but avoid areas of dense undergrowth.
- Nest in low shrubs.

Mountain bluebird

- Strongly associated with early seral and other open habitats.
- Nest in cavities.

Swainson's thrush

- Found in most seral stages and seek areas of dense undergrowth.
- Nest in low shrubs.

Townsend's solitaire

- Found in early seral habitat, use canopies of retained trees and open understory for foraging.
- Often nest on cutbanks.

Western bluebird

- Strongly associated with early seral and other open habitats.
- Nest in cavities.

Western bluebird

Swainson's thrush

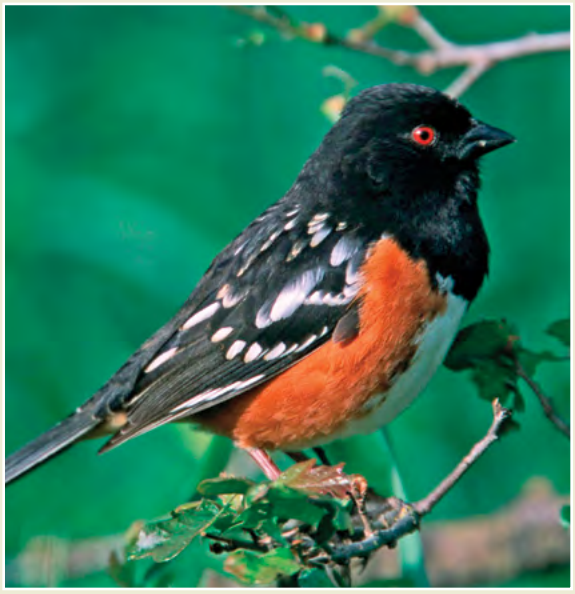
Management recommendations include maintaining some overstory trees; removing timber in small patches (<1.5 acres) and/or maintaining wide riparian buffers; maintaining or creating large down wood (>16 inches in diameter) as sources of arthropod prey; maintaining existing saplings and shrubs to promote thrush habitat (Hagar 2006); and retaining snags for nesting opportunities for mountain and western bluebirds.

NEW WORLD SPARROWS AND ALLIES

(Chipping sparrow, Dark-eyed junco, Fox sparrow, Song sparrow, Spotted towhee and White-crowned sparrow)

- Found in open shrubby habitats, including riparian areas, upland meadows, fields, forests with dense and low thickets, open woodlands, forest edges and agricultural fields (Herlyn 2006, Nehls 2006, The Cornell Lab of Ornithology 2014c & 2014d).
- Feed upon a variety insects, seeds, wild berries and fruit (Nehls 2006). Prey includes weevils, beetles, caterpillars, dragonflies, grasshoppers, midges, spiders, snails and earthworms (The Cornell Lab of Ornithology 2014c & 2014d).

Spotted towhee



Management recommendations include preserving shrub components, especially along streams; retaining species such as elderberries and blackberries; maintaining or creating large down wood; and seeding with a wildlife-friendly, weed-free seed mix high in grasses (where practicable).

FINCHES AND ALLIES

(American goldfinch)

- Found in many habitats including early seral forests.
- Nest in deciduous shrubs.
- Feed almost exclusively on seeds, particularly thistles. Other important food plants include grasses and small seeded trees such as elm, alder and birch.

Management recommendations include preserving a shrub component in clearcuts and providing a wildlife-friendly seed mix.

American goldfinch

4.0 What Does Research Tell Us about Songbirds and Early Seral Forests?

Several recent and ongoing research projects explore early seral forest conditions, management strategies and the impact these actions have on the songbirds dependent on early seral forests. The next few pages summarize these studies relative to control no-spray stands.

4.1 THE INTENSIVE FOREST MANAGEMENT (IFM) STUDY: INITIAL, EXPERIMENTAL EFFECTS OF INTENSIVE FOREST MANAGEMENT ON AVIAN ABUNDANCE AND DEMOGRAPHY

Key researchers: Matt Betts (Oregon State University), James Rivers (Oregon State University), Jake Verschuyl (National Council for Air and Stream Improvement), Thomas Stokely (Oregon State University) and A.J. Kroll (Weyerhaeuser)

Overview: The Intensive Forest Management (IFM) Study is an experimental study across 32 stands in the Oregon Coast Range. Researchers are investigating how changes in early-seral vegetation resulting from a gradient of herbicide application influences biodiversity, including songbirds. Researchers involved in this study are looking at biodiversity responses to light, moderate, and intensive herbicide treatments relative to control no-spray stands. (Figure 5).

Birds were sampled in all 32 stands, including eight stands for each of the three herbicide treatments and eight stands that had no herbicide applied. Early results show that in very early seral plantations (one to two years following site preparation), intensive forest management (i.e., the use of herbicides) has a negative impact (i.e., abundance) on some species associated with hardwoods, especially those that use hardwoods for nesting and foraging (Betts et al. 2013). In contrast, some species (such as the violet-green swallow and western bluebird) were higher in abundance in more intensively managed stands.

The IFM study is ongoing, and current research shows that songbird responses to the herbicide-driven changes in vegetation are reduced by six years after herbicide treatment. Researchers separated bird responses into leaf-gleaning (e.g., warblers and vireos) and non-leaf-gleaning species (e.g., goldfinch, swallows, towhee, and robin) as foraging habits lead to varying levels of sensitivity to the herbicide treatments. Leaf-gleaning bird species showed greater sensitivity to herbicide treatments. Abundance of leaf-gleaning species was lower in the treated stands when compared to the

FIGURE 5. EFFECTS OF HERBICIDES ON EARLY SERAL SPECIES

Researchers used a control (no herbicide) light, moderate, and intensive (no competing vegetation remaining) treatments to evaluate the effects of herbicides on early seral species.

control during the first five years of stand growth. By year six of stand growth, abundance of leaf-gleaning birds was similar between control and treated stands. For non-leaf-gleaners, a reduction in abundance in treated stands occurred, but was shorter (three years) and of reduced magnitude (Verschuyl et al., in prep). Treated stands also supported fewer species while treatments were ongoing (years one to four). Treated stands had similar numbers of species to untreated stands by year five of stand growth (Kroll et al. 2020).

Initial negative effects of the herbicide treatments on the abundance of some early seral-associated songbird species were substantially reduced or not present by year six of stand growth for most species (Kroll et al. 2020). However, herbicide treatments had a lingering influence on one species, the Wilson's warbler, through year eight of stand growth.

What does this mean for management? Retaining hardwood cover, including trees and shrubs, especially in young plantations, will help provide habitat for some early seral-dependents such as the Wilson's warbler.

4.1A – Assessing herbicide impacts on songbird demography in early seral forests of the Pacific Northwest

Key researchers: James Rivers (Oregon State University), Matt Betts (Oregon State University), Jake Verschuyl (National Council for Air and Stream Improvement), Carl Schwarz (Simon Fraser University), and A.J. Kroll (Weyerhaeuser)

Overview: As part of the IFM Study, researchers are studying the influence of herbicide treatments on songbird demography (nest survival and fledgling survival of juvenile birds) in early seral forests. Population recruitment is influenced by both nest and fledgling survival, so researchers are investigating how both change with increased herbicide use in plantations. Preliminary analyses for the focal species in this study (white-crowned sparrow) show no difference in nest survival among the herbicide treatments used in this study (control, light, moderate and intensive). This result is interesting because competing hardwood vegetation is strongly influenced by herbicides.

What does this mean for management? Hardwood cover is important for songbirds, but this study showed that herbicide treatments targeting hardwoods do not appear to have an impact on nest survival for the white-crowned sparrow.

This study showed that herbicide treatments targeting hardwoods do not appear to have an impact on nest survival for the white-crowned sparrow.

4.1B – Moth abundance and diversity in intensively managed early seral forests of Oregon

Key researchers: Jake Verschuyl (National Council for Air and Stream Improvement), Heather Root (Weber State University), Paul Hammond (Oregon State University), Melissa Scherr (Northwest Entomological Research Center) and Matt Betts (Oregon State University)

Overview: Researchers in this study investigated the effects of herbicide treatments on total moth abundance, the number of different species of moth and the abundance of moths by group in terms of plant specialists (i.e., groups of moths known to prefer specific plants). Moth larvae are a key food source for many songbird species. Researchers trapped moths at three locations in each of 32 stands for a total of 2,560 trap nights over a two-year period. Researchers found that moth diversity and abundance high in all treatment stands; they found 316 moth species, 30 of which were new species records for the Oregon Coast Range. A comparison of the species composition of moths captured in treatment stands with previous sampling in older forests shows that the early seral moth community is unique in the Coast Range and is likely sustained by the continuous availability of newly disturbed habitat. Researchers found moth diversity was strongly influenced by total plant diversity in a stand, with weak effects of herbicide treatments evident. Intensively managed stands with lower broadleaf and herbaceous plant cover still supported a diverse moth community (Root et al. 2017).

What does this mean for management? This study provided evidence that common forest management practices are compatible with high levels of moth species diversity. Management practices and site conditions that result in high tree, shrub, herb and grass diversity within stands are most likely to maintain moth diversity.

Researchers used moth traps like this one at three locations in each of 32 stands for a total of 2,560 trap nights over a two-year period. Researchers found 316 moth species, 30 of which were new species records for the Oregon Coast Range!

4.2 HOW EARLY SERAL HARDWOOD VEGETATION AFFECTS ADULT AND FLEDGING BIRD ABUNDANCE IN DOUGLAS-FIR PLANTATIONS OF THE OREGON COAST RANGE

Key researchers: Tana Ellis (Oregon State University), A.J. Kroll (Weyerhaeuser), and Matt Betts (Oregon State University)

Overview: This retrospective study explored the relationships between vegetation structure resulting from intensive forest management practices and the abundance of five species of early seral songbirds: orange-crowned warbler, Wilson's warbler, MacGillivray's warbler, Swainson's thrush and black-headed grosbeak. To investigate this relationship, researchers conducted surveys from 2008 to 2009 on state and private forestlands. They sampled 27 early seral Douglas-fir plantations and one alder plantation, representing stand ages from five to nine years and tree heights from 6.5 feet to 13 feet.

The results indicate that hardwood cover within managed plantations has a consistently positive association with the relative abundance of the bird species sampled in this study that breed in early seral forests. In fact, in plantations from 10 to 13 years old, there is a strong threshold in bird abundance as a function of percentage of hardwoods in the stand. Bird abundance nearly doubled if approximately 10% of the plantation consisted of hardwoods (bird abundance then plateaued above 10% hardwood composition). This indicates that plantations can provide sufficient hardwood cover for some species of songbirds (for example, orange-crowned warbler, Swainson's thrush and Wilson's warbler), while still growing timber (Ellis and Betts 2011).

What does this mean for management? Retaining hardwood cover, including trees and shrubs, especially in young plantations, will help provide habitat for early seral songbirds such as the Swainson's thrush and orange-crowned warbler.

Hardwood cover, including shrubs like this elderberry, especially in young plantations, will help provide nesting habitat for early seral songbirds.

4.3 AVIAN SPECIES RICHNESS IN RELATION TO INTENSIVE FOREST MANAGEMENT PRACTICES IN EARLY SERAL TREE PLANTATIONS

Key researchers: Jay E. Jones (Weyerhaeuser), A. J. Kroll (Weyerhaeuser), Jack Giovanini (Weyerhaeuser), Steven D. Duke (Weyerhaeuser), Tana Ellis (Oregon State University) and Matt Betts (Oregon State University)

Overview: This study (Jones et al. 2012) used a model to evaluate relationships between the number of bird species present in a stand and the amount of vegetation left at various levels of stand management intensity (through herbicide application) on 212 tree plantations in the Coast Range of Oregon. Researchers estimated the influence of broadleaf hardwood vegetation cover on the number of birds present in a stand and the presence of individual species. Broadleaf hardwood vegetation is often reduced in managed stands to limit competition with growing conifer trees. Results showed that individual and community responses were positively associated with both conifer and hardwood cover.

Both hardwood and conifer trees are important nesting habitat for early seral songbirds.

What does this mean for management? This study indicated that some bird species use both conifer and hardwood species for cover. Both conifer and hardwood cover are important for early species.

4.4 THRESHOLDS IN FOREST BIRD OCCURRENCE AS A FUNCTION OF THE AMOUNT OF EARLY SERAL BROADLEAF FOREST AT LANDSCAPE SCALES

Key researchers: Matt Betts (Oregon State University), Joan Hagar (U.S. Geological Survey), James Rivers (Oregon State University), John Alexander (Klamath Bird Observatory), Kevin McGarigal (University of Massachusetts) and Brenda McComb (Oregon State University).

Overview: This study used a large dataset of bird observations from southwest and northwest Oregon to test for thresholds in bird occurrence as a function of broadleaf cover in mature forests and broadleaf cover in early seral forests at local and landscape scales. The stands in this study are dominated by Douglas-fir, western hemlock, western red cedar, red alder and bigleaf maple. Understory vegetation

Maintaining deciduous shrubs, such as snowberry, on even a small percentage of the landscape in early seral forest will go a long way toward providing songbird habitat at all seral stages.

is highly variable, but common species include salmonberry, salal, vine maple, Oregon grape, huckleberry and sword fern. All 12 bird species examined showed positive response to broadleaf cover in general, and specifically broadleaf cover in early seral forests. There was a lot of variability in the data, but results showed support for the hypothesis that reductions in broadleaf-dominated early seral forest due to succession and intensive forest management have led to population declines of the species included in this study in the Pacific Northwest (Betts et al. 2010). Early seral species in this study were the black-throated gray warbler, lazuli bunting, MacGillivray's warbler, Nashville warbler, orange-crowned warbler, olive-sided flycatcher, rufous hummingbird, spotted towhee and warbling vireo (Betts et al. 2010).

What does this mean for management? Forest management actions or treatments that maintain or restore broadleaf vegetation, even in small amounts at landscape scales, could help provide habitat for species such as those listed in this study.

4.5 ARTHROPOD PREY OF WILSON'S WARBLERS IN THE UNDERSTORY OF DOUGLAS-FIR FORESTS

Key researchers: Joan Hagar (U.S. Geological Survey), Katie Dugger (Oregon State University) and Edward Starkey (U.S. Geological Survey)

Overview: Establishing deciduous shrubs in the early seral stage of forests and maintaining these shrubs into future seral stages helps provide the food, cover and nesting space needed by many songbirds, including the Wilson's warbler.

Researchers studied the availability of food resources and its importance in bird habitat selection. Food resources for songbirds are often closely related to vegetation structure and composition (Hagar et al. 2007). Identification of plant species important in supporting food resources may facilitate vegetation management to achieve objectives for providing bird habitat. Researchers used fecal analysis to describe the diet of adult Wilson's warblers that foraged in the understory of Douglas-fir forests in western Oregon during the breeding season. Researchers sampled arthropods at the same sites where diet data were collected, and compared abundance and biomass of prey among seven common shrub species. Wilson's warblers ate more caterpillars, flies and beetles than expected based on availability. Deciduous shrubs supported higher abundances of species used as prey by Wilson's warblers than did evergreen shrubs.

What does this mean for management? This research highlights the importance of developing and maintaining a deciduous understory in conifer forests. Maintaining deciduous shrubs on even a small percentage of the landscape in early seral forest will go a long way toward providing songbird habitat at all seral stages.

5.0 What Are Practical Ways to Improve Habitat for Early Seral Songbirds?

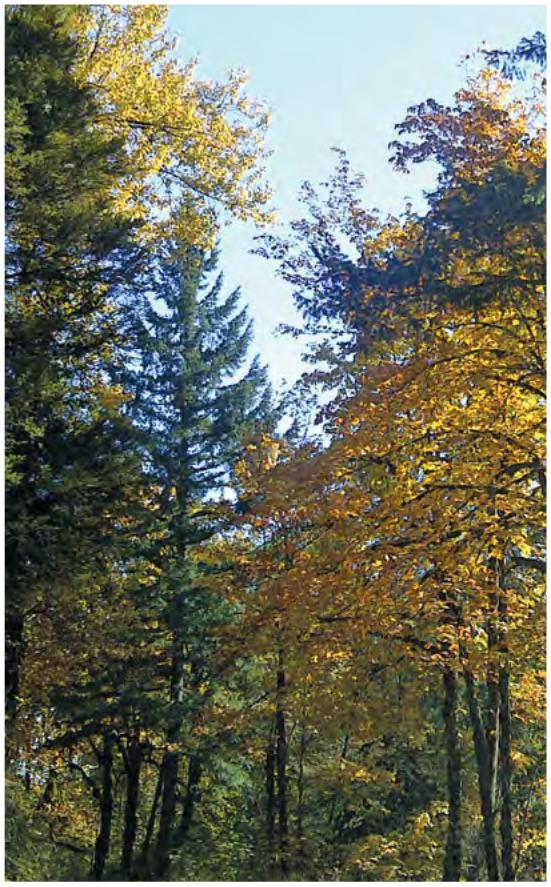
Managed forests have a tremendous opportunity to provide the key components of early seral forest for early seral songbirds. Society's needs for lumber and other forest products are large, and privately managed forests provide the largest percentage of timber for forest products. Contributing to the world's wood supply while still promoting biodiversity on the landscape is challenging, but essential. The following section describes some of the rules associated with early seral forests and offers further suggestions for improving habitat for early seral-associated songbirds. Following these rules and including one or more of the suggestions when managing forests will go a long way toward providing habitat for early seral songbirds.

5.1 OREGON FOREST PRACTICES RULES

In 1971, Oregon became the first state to pass a comprehensive law to regulate forest practices and help safeguard water, fish and wildlife habitat, soil and air. The rules of the Oregon Forest Practices Act are continually reviewed and updated to keep pace with the most current scientific research. For harvest units greater than 25 acres, landowners must do the following for wildlife:

- Leave standing live trees or snags, at least two per acre of harvest, each at least 30 feet tall and 11 inches in diameter.
- Leave at least two logs on the ground per acre of harvest, each at least 10 cubic feet.

This should be considered a minimum for leave trees and down wood. Note that safety should be considered when determining where to retain live standing trees and snags, as these can be a hazard.



5.2 BROADLEAF TREES

Broadleaf trees provide essential habitat for many early seral-dependent species. However, broadleaf trees also shade out and compete with young Douglas-fir trees. The research shows that leaving approximately 6 to 10% of a stand of timber with hardwoods will greatly increase the number and variety of bird species present. Hardwood trees need not be left on every acre, every time, but leaving behind hardwood trees as opportunities arise will greatly benefit many species of wildlife, including early seral-dependent songbirds. Leaving behind islands of mixed hardwoods (wildlife-friendly hardwoods are mentioned throughout this publication and are listed in the summary) is a good way to provide habitat for songbirds while minimizing impact on growing conifers.

The best hardwood trees to leave to maximize the benefit to wildlife species include: bigleaf maple, dogwood, madrone, Oregon white oak, willows, cherry and Pacific crabapple. In central and eastern Oregon, leave quaking aspen, black cottonwood and willows.

Broadleaf trees provide essential habitat for many early seral-dependent species.

Deciduous shrubs provide sources for food, cover and nesting space for songbirds.

5.3 DECIDUOUS SHRUBS

Deciduous shrubs are essential for songbirds. Shrubs provide a source of food, cover and nesting space. As with broadleaf trees, shrubs are often in competition with young Douglas-fir trees, especially in the first two years after planting. However, maintaining shrubs in a plantation greatly increases the plantation's suitability for early seral songbirds as well as other wildlife species. Designating clumps of shrubs pre-harvest is a good way to maintain shrubs on the landscape and decrease competition with young Douglas-fir trees (i.e., shrubs are concentrated in one area).

Deciduous shrubs that are especially beneficial to songbirds include: cascara, ocean spray, Indian plum, red-osier dogwood, snowberry, hazel, elderberry, red flowering currant, serviceberry, thimbleberry and salmonberry. In central and eastern Oregon, also consider leaving bitterbrush, manzanita, bunchgrasses and Woods' rose.

5.4 DOWN WOOD

Dead and down woody material in the form of root wads, bark, limbs and logs plays a critical function in the forest ecosystem. This material is important in nutrient cycling, natural regeneration and habitat for many wildlife species, including arthropods (a main food source for songbirds). More than 80 terrestrial wildlife species use down wood as either a primary or secondary component of their habitat requirements in the Pacific Northwest. Down wood is used for feeding sites, nest cavities within and under the wood, food sources, and hiding and thermal cover. The following management strategies may be useful for recruiting down wood into a plantation:

Down wood is used by songbirds for feeding sites, nest cavities, food sources, hiding and thermal cover.

- Avoid harvesting or moving large-diameter logs intended for down wood to landings; instead leave large-diameter down wood distributed throughout the unit.
- Keep large-diameter down logs distributed throughout harvest units instead of piling them into slash piles, where practicable.
- Leave large-diameter logs during commercial thinning operations. This will increase the amount of down wood as the stand ages.
- Avoid mechanical damage of existing down logs and retain them in the landscape.
- Place skid trails around large down wood when possible, and when not feasible, move the large down wood to the side with as little disturbance to the log as possible.
- Look for opportunities to use un-merchantable portions of large-diameter logs as down wood, placing it within the unit and away from landings.

5.5 SNAGS

As with down wood, snags are hugely important for wildlife. In early seral forests, snags are used for perching, as a source of food and as nesting habitat. The following management strategies may be useful for snag recruitment:

- Retain existing snags where safe to do so.
- Leave "extra" wildlife trees for future snag recruitment (consider leaving the big wildlife trees that are of low economic value).
- Consider snag creation in areas lacking a snag component. There are many methods for snag creation. For more information: http://wdfw.wa.gov/living/snags.

In early seral forests, snags are used for perching, as a source for food and for nesting habitat.

5.6 LIVE, STANDING CONIFERS

A minimum of two standing live trees or snags are required per acre of harvest. Live, standing conifers or "green recruitment trees" provide food, cover and nesting structure for songbirds and encourage age diversity, and will eventually be snags or down wood within a stand. Leave green recruitment trees both scattered throughout a harvest unit and in clumps (> 15 trees). When selecting retention trees, opt for legacy trees (retained from prior entries) and deformed trees. Retaining live trees above the Forest Practices Act minimum requirement provides additional habitat for some songbird species.

5.7 RIPARIAN BUFFERS

The Oregon Forest Practices Act has specific requirements for harvest activities near streams. Many times buffers are required along fish streams. Riparian buffers also provide habitat for songbirds. Leaving riparian buffers that are wider than the Forest Practices Act minimum requirement where shrubs are well developed may be beneficial for some early seral-associated songbird species.

A well-vegetated stream buffer with plenty of deciduous trees and shrubs provides habitat for many songbird species.

Balancing wood production and wildlife habitat is challenging. Prolonging canopy closure (below) is one way to provide habitat for this wren hatchling (above).

5.8 WILDLIFE-FRIENDLY SEED MIXES

Some early seral songbirds need grasses, and others need flowering plants. Land managers with goals to maximize habitat for early seral songbirds may choose to seed harvest units with weed-free, bird-friendly grass-forb mixes. Seeding throughout the harvest unit may not be practical. Consider seeding the landings, cutbanks, edges and other areas that do not readily compete with young Douglas-fir trees.

5.9 TREE SPACING

Young plantations provide essential habitat for many species of wildlife, including some species that are dependent on this forest type. One of the best ways to provide for species needing this forest type is to prolong the period of time a plantation is in this early seral stage. This may conflict with wood production goals, but for some landowners delaying crown closure is an option. Consider balancing wildlife goals with timber production when selecting tree spacing width. Note that the Oregon Forest Practices Act requires reforestation after harvest. Key reforestation rules include:

- Planting: Landowners must complete replanting of harvested ground within two years.
- Ensuring success: Within six years of harvest, the young trees must be "free to grow." That means they must be vigorous and tall enough to out-compete grass and brush.
- Trees per acre: Depending on site productivity, the rules require that a minimum of 100 to 200 well-distributed trees per acre must survive following replanting.
- Selective harvest or thinning: Even after a partial harvest, a landowner may be required to replant additional seedlings to ensure a sufficient number of trees per acre.

For more information, check out KnowYourForest.org.

6.0 Summary

Early seral forests are just as important for wildlife as old-growth forests (Swanson et al. 2014). That means we need early seral forests for wildlife just as much as we need old-growth forests. Privately owned and managed forests have the greatest potential to provide early seral forests across Oregon landscapes. However, for young plantations to be effective early seral forests for wildlife, especially early seral-dependent songbirds, they need to contain key habitat components: down wood, hardwood trees and shrubs, and snags.

Land managers have the challenge of balancing the increasing demand for wood and the need to provide habitat for wildlife. By implementing some of the management ideas outlined in this publication, land managers can increase habitat for wildlife while still growing timber.

Early seral-dependent songbirds have been declining in Oregon and other areas of the Pacific Northwest. According to the USGS breeding bird survey, many of the early seral-dependent species are declining at a rate of 2 to 4% per year. An emphasis on conservation and creation of late seral and old-growth forests on federal lands that occurred in the latter part of the last century has likely contributed to the overall decrease in the extent of early seral forests. The management emphasis on creating late seral and old-growth forests on federal lands has resulted in a land use pattern where early seral forests are disproportionately in areas dominated by private land ownership. Private land ownership therefore plays an important role in maintaining and developing early successional forests. The steep declines in early seral-dependent songbirds is one reason researchers continue to study the effects of forest management on these populations.

The research presented here is diverse, but the key findings are:

- Retaining hardwood cover, including trees and shrubs in young plantations, will help provide habitat for early seral-dependents such as rufous hummingbirds, orange-crowned warblers and Swainson's thrushes.

House wrens like the one pictured here and many other species need early seral forests.

- Some species of songbird such as violet-green swallows are higher in abundance in intensively managed stands, exhibiting no negative effects associated with the use of herbicides.
- Hardwood cover is important for songbirds, but this study showed that herbicide treatments targeting hardwoods do not appear to have an impact on nest survival for the white-crowned sparrow.
- In the Oregon Coast Range, plant diversity is a strong driver of moth abundance and diversity in early seral plantations. This study provided evidence that common forest management practices are compatible with high levels of moth species diversity.
- Bird species use both conifer and hardwood species for cover. Both conifer and hardwood cover are important for early seral-associated species.
- Forest management actions or treatments that maintain or restore broadleaf vegetation even in small amounts could help provide habitat for early seral-associated songbird species.
- Developing and maintaining deciduous shrubs in early seral forests will go a long way toward providing songbird habitat at all seral stages.

Land managers may use a variety of methods to provide habitat for early seral-dependent songbirds. We suggest a combination of the following, depending on individual site conditions and landowner objectives:

- Leave approximately 10% of the landscape with hardwoods.

SOME OF THE BEST TREE AND SHRUB SPECIES TO LEAVE BEHIND FOR WILDLIFE INCLUDE:

Bigleaf maple	Oregon ash
Bitterbrush	Oregon white oak
Black cottonwood	Quaking aspen
Cascara	Red alder
Cherry	Red flowering currant
Crabapple	Red-osier dogwood
Dogwood	Salmonberry
Elderberry	Serviceberry
Hazel	Snowberry
Indian plum	Thimbleberry
Madrone	Vine maple
Manzanita	Willows
Ocean spray	Woods' rose

An orange-crowned warbler fledging.

- Maintain shrubs in plantations. Consider designating clumps of shrubs for retention before harvest to maintain shrubs on the landscape and decrease competition with young Douglas-fir trees.
- Avoid moving large-diameter logs that are intended for down wood to the landing. Distribute large-diameter down wood from landings back into the plantation, if practicable.
- Keep large-diameter down logs distributed throughout the plantation instead of piling them into slash piles, where practicable.
- Leave large-diameter logs during commercial thinning operations. This will increase the amount of down wood as the stand ages.
- Avoid mechanical damage of existing down logs and retain them on the landscape.
- Place skid trails around large down wood when possible, and when not feasible, move the large down wood to the side with as little disturbance to the log as possible.
- Look for opportunities to use un-merchantable portions of large-diameter logs as down wood, placing it within the unit and away from landings.
- Retain existing snags where safe to do so.
- Leave "extra" wildlife trees for future snag recruitment (consider leaving the big wildlife trees that are of low economic value).
- Consider snag creation in areas lacking a snag component.
- Leave green recruitment trees both scattered throughout a harvest unit and in clumps.
- Leave wider riparian buffers, especially around areas with an abundance of shrubs.
- Consider seeding bare areas with a wildlife-friendly seed mix.
- Consider wider tree spacing when planning replanting efforts.

7.0 Resources

Betts, M.G., Hagar, J.C., Rivers, J.W., Alexander, J.D., McGarigal, K. and McComb, B.C. 2010. Thresholds in forest bird occurrence as a function of the amount of early-seral broadleaf forest at landscape scales: Ecological Applications, v. 20, no. 8, p. 2116-2130.

Betts, M.G., Verschuyl, J., Giovanini, J., Stokely, T. and Kroll, A.J. 2013. Initial experimental effects of intensive forest management on avian abundance. Forest Ecology and Management. 310: 1036-1044.

Betts, Matthew. 2014, November. Introduction to the Intensive Forest Management Study. Presentation at Wildlife in Managed Forests: Songbirds in Early Seral Habitats, Albany, Oregon. www.knowyourforest.org/sites/default/files/documents/Intro%20to%20Intensive%20Forest%20Mgmt%20Study.pdf.

Cloughesy, Mike. 2014. Are there many big trees in Oregon? Oregon Forest Resources Institute. Portland, Oregon. http://oregonforests.org/blog/are-there-many-big-trees-oregon.

Dillingham, Colin. 2006. Orange-Crowned Warbler. Pp. 503-505 in Birds of Oregon: A General Reference. D.B. Marshall, M.G. Hunter and A.L. Contreras, Eds. Oregon State University Press, Corvallis, Oregon.

Dowlan, Stephan G. 2006. MacGillivray's Warbler. Pp. 522-524 in Birds of Oregon: A General Reference. D.B. Marshall, M.G. Hunter and A.L. Contreras, Eds. Oregon State University Press, Corvallis, Oregon.

Ellis, T. and Betts, M.G. 2011. Bird abundance and diversity across a hardwood gradient within early seral plantation forest. Forest Ecology and Management 261: 1372-1381.

Ellis, T.M., Kroll, A.J. and Betts, M.G. 2012. Early seral hardwood vegetation increases adult and fledgling bird abundance in Douglas-fir plantations of the Oregon Coast Range. Canadian Journal of Forest Research. 4: 918-933.

Franklin, Jerry F. and Johnson, K. Norman. 2012. A restoration framework for Federal forests in the Pacific Northwest. Journal of Forestry. 110(8): 429-439.

Hagar, Joan C. 2006. Swainson's Thrush. Pp. 481-483 in Birds of Oregon: A General Reference. D.B. Marshall, M.G. Hunter and A.L. Contreras, Eds. Oregon State University Press, Corvallis, Oregon.

Hagar, Joan C. 2006. Wilson's Warbler. Pp. 526-528 in Birds of Oregon: A General Reference. D.B. Marshall, M.G. Hunter and A.L. Contreras, Eds. Oregon State University Press, Corvallis, Oregon.

Hagar, Joan C., Dugger, Katie M. and Starkey, Edward E. 2007. Arthropod prey of Wilson's warblers in the understory of Douglas-fir forests. The Wilson Journal of Ornithology. 119(4): 533-546.

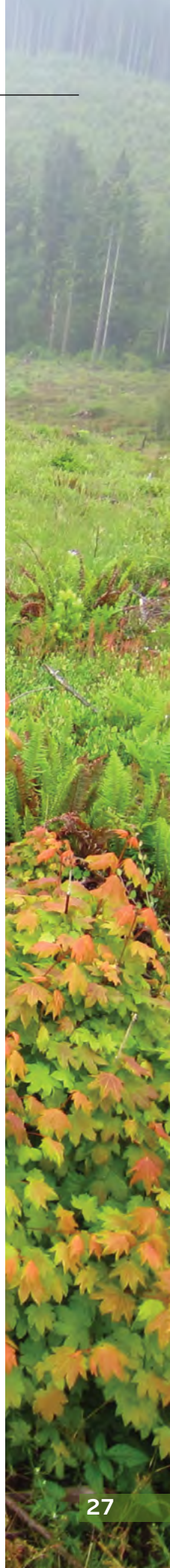
Hammond, Paul, Jake Verschuyl, Heather Root, Melissa Scherr, and Matt Betts. 2014. Moth abundance and diversity in intensively managed early-seral forests of Oregon. Presentation at the OFRI Wildlife in Managed Forests: Songbirds in Early Seral Habitats Symposium. www.knowyourforest.org/sites/default/files/documents/Anthropods%20and%20Early%20Seral%20Habitats.pdf.

Herlyn, Hendrik G. 2006. White-crowned Sparrow. Pp. 562-565 in Birds of Oregon: A General Reference. D.B. Marshall, M.G. Hunter and A.L. Contreras, Eds. Oregon State University Press, Corvallis, Oregon.

Jones, J.E., Kroll, A.J., Giovanini, J., Duke S.D., Ellis, T.M. et al. 2012. Avian Species Richness in Relation to Intensive Forest Management Practices in Early Seral Tree Plantations. PLoS ONE 7(8): e43290. doi:10.1371/journal.pone.0043290.

Kaufman, Kenn. 2014. Rufous Hummingbird: *Selasphorus rufus*. The National Audubon Society, New York, New York. Accessed online at www.audubon.org/field-guide/bird/rufous-hummingbird on Jan. 30, 2015.

Kroll, A. J., A. Springford, and J. Verschuyl. 2020. Conservation and Production Responses Vary by Disturbance Intensity in a Long-Term Forest Management Experiment. Bull Ecol Soc Am 101(3):e01721. https://doi.org/10.1002/bes2.1721



Kroll, A. J., J. Verschuyl, J. Giovanini, and M. Betts. 2016. Assembly dynamics of a forest bird community depend on disturbance intensity and foraging guild. Journal of Applied Ecology. DOI:10.1111/1365-2664.12773

Nehls, Harry B. 2006. Song Sparrow. Pp. 556-558 in Birds of Oregon: A General Reference. D.B. Marshall, M.G. Hunter and A.L. Contreras, Eds. Oregon State University Press, Corvallis, Oregon.

Oregon Department of Forestry. 2010. Oregon Forest Atlas – 2010 Online Edition. www.oregon.gov/ODF/RESOURCE_PLANNING/forestatlas.shtml

Oregon Forest Resources Institute (OFRI). 2023. Oregon Forest Facts 2023-24 Edition. OFRI, Portland, Oregon.

Oregon Forest Resources Institute Wildlife in Managed Forests: Songbirds in Early Seral Habitats Symposium, November 2014, Albany, Oregon. www.knowyourforest.org/events/conferences.

Rivers, James., J. Verschuyl, C. Schwartz, A. Kroll, and M. Betts. 2019. No evidence of a demographic response to experimental herbicide treatments by the white-crowned sparrow, an early successional forest songbird. The Condor, Volume 121, Issue 2.

Root, Heather, J. Verschuyl, T. Stokely, P. Hammond, M. Scherr, and M. Betts. 2016. Plant diversity enhances moth diversity in an intensive forest management study. Ecological Applications 27(1), pp 134- 142.

Sekercioglu, Cagan H., 2006. Increasing awareness of avian ecological function. Trends in Ecology & Evolution. 21: 464-471.

Stokely, Thomas., U. Kormann, J. Verschuyl, A. Kroll, D. Frey, S. Harris, D. Mainwaring, D. Maguire, J. Hatten, J. Rivers, S. Fitzgerald, and M. Betts. 2021. Experimental evaluation of herbicide use on biodiversity, ecosystem services and timber production trade-offs in forest plantations. Journal of Applied Ecology. DOI: 10.1111/1365-2664.13936

Swanson, M.E., Studevant, N.M., Campbell, J.L. and Donato, D. C. 2014. Biological associates of early-seral preforest in the Pacific Northwest. Forest Ecology and Management. 324 (2014): 160-171.

The Cornell Lab of Ornithology. 2014. Rufous Hummingbird: *Selasphorus rufus*. The Cornell Lab of Ornithology: All About Birds, Ithaca, New York. Accessed online at: www.allaboutbirds.org/guide/rufous_hummingbird/lifehistory on Jan. 30, 2015.

The Cornell Lab of Ornithology. 2014a. Orange-crowned Warbler: *Oreothlypis celata*. The Cornell Lab of Ornithology: All About Birds, Ithaca, New York. Accessed online at: www.allaboutbirds.org/guide/orange-crowned_warbler/lifehistory on Feb. 3, 2015.

The Cornell Lab of Ornithology. 2014b. MacGillivray's Warbler: *Geothlypis tolmiei*. The Cornell Lab of Ornithology: All About Birds, Ithaca, New York. Accessed online at: www.allaboutbirds.org/guide/MacGillivrays_Warbler/lifehistory on Feb. 3, 2015.

The Cornell Lab of Ornithology. 2014c. Song Sparrow: *Melospiza melodia*. The Cornell Lab of Ornithology: All About Birds, Ithaca, New York. Accessed online at: www.allaboutbirds.org/guide/song_sparrow/lifehistory on Feb. 3, 2015.

The Cornell Lab of Ornithology. 2014d. White-crowned Sparrow: *Zonotrichia leucophrys*. The Cornell Lab of Ornithology: All About Birds, Ithaca, New York. Accessed online at: http: www.allaboutbirds.org/guide/white-crowned_sparrow/lifehistory on Feb. 3, 2015.

Thomas, J.W., Franklin, J.F., Gordon, J., Johnson, K.N., 2006. The northwest forest plan: Origins, components, implementation experience, and suggestions for change. Conservation Biology. 20: 277-287.

Oregon Forest
Resources Institute

About the Oregon Forest Resources Institute (OFRI)

The Oregon Forest Resources Institute supports and enhances Oregon's forest products industry by advancing public understanding of forests, forest management and forest products.

Thank you to all our contributors

OFRI is grateful to the many people who gave their time, expertise, insights and comments during the development of this publication: *Jenniffer Bakke, Manulife Investment Management; Seth Barnes, Oregon Forest Industries Council; Matthew Betts, Oregon State University; Herman Biederbeck, Oregon Department of Fish and Wildlife; Joan Hager, U.S. Geological Survey; Paul Hammond, Oregon State University; Anne Hanschu, Oregon Forest Resources Institute Board of Directors; A.J. Kroll, Weyerhaeuser; Christine Maynard, Cafferata Consulting; James Rivers, Oregon State University; Mike Rochelle, Weyerhaeuser; Nicole Strong, Oregon State University; Ron Stuntzner, Stuntzner Engineering and Forestry; Jake Verschuyl, National Council for Air and Stream Improvement; Jennifer Weikel, Oregon Department of Forestry.*

Designed by: *Carlee Justis, State of Oregon Publishing & Distribution*

Photo credits

Jenniffer Bakke, Manulife Investment Management: Pages 21, 23 (snag)
Steve Cafferata, Cafferata Family Forest: Cover (lower), page 24 (lower)
Kristen Jones, Oregon State University: Page 29
Jake Verschuyl, National Council for Air and Stream Improvement: Page15
ODFW: Page 11 (juvenile purple martin), (tree swallow)
James Rivers, Oregon State University: Cover (upper), TOC, pages 2, 8 (lower), 9 (upper), 10 (warbling vireo), 11 (violet-green swallow), 12 (wren), 13, 16, 17, 18, 19, 20, 22 (upper), 23 (lower), 24 (upper), 25, 26, and page borders
Timothy Lawes, Wildlife Photographer: Pages 8 (upper), 9 (lower), 10 (upper), 14 (lower)
Thomas Stokely, Oregon State University: Page 15
USFWS: Pages 11 (bushtit), 12 (kinglet)
Garret Yarbrough, Giustina Land and Timber Company: Page 22 (lower)

Follow OFRI on Facebook, Twitter and Instagram.

Oregon Forest
Resources Institute