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Rainforest Birds: A Land Manager's Guide to Breeding Bird Habitat in Young Conifer Forests in the Pacific Northwest

Scientific Investigations Report 2006-5304

U.S. Department of the Interior
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Band-tailed Pigeon
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Rainforest Birds: A Land Manager's Guide to Breeding Bird Habitat in Young Conifer Forests in the Pacific Northwest

By Bob Altman and Joan Hagar

Prepared in cooperation with American Bird Conservancy

American Bird Conservancy is a not-for-profit organization whose mission is to conserve wild birds and their habitats throughout the Americas.

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The Cooperative Forest Ecosystem Research (CFER) program works closely with resource managers, researchers, and decision-makers to develop and convey information needed to successfully implement ecosystem-based management at forest stand and watershed scales, especially on lands dominated by young forests and fragmented by multiple ownerships.

The Pacific Coast Joint Venture works to protect and restore wetland ecosystems to benefit birds, fish and other wildlife.

The Oregon Department of Forestry serves the people of Oregon by protecting, managing, and promoting stewardship of Oregon's forests to enhance environmental, economic, and community sustainability.

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Rainforest Birds:
A Land Manager's Guide to Breeding Bird Habitat in Young Conifer Forests in the Pacific Northwest

Bob Altman[1] and Joan Hagar[2]

Purpose of the Guide

This document (hereafter Guide) has been prepared to assist land managers interested in conducting conservation and management activities to benefit breeding birds associated with young conifer forests in the Pacific Northwest. Audiences targeted for use of the Guide include land trusts, watershed councils, non-commercial private land owners, forest products companies, land-managing conservation organizations, government agencies, tribes, and First Nations. We hope the Guide will be a useful and valuable tool to support any of the variety of reasons to manage for bird habitat in young conifer forests (for example, regulatory, biodiversity, bird conservation, and forest certification standards).

Information provided in the Guide is intended to support both the development of conservation or management plans and the implementation of on-the-ground management activities that have the potential to benefit breeding bird populations. *The degree to which a land manager is willing or able to manage for bird habitat is a decision based on many factors which are beyond the scope of the Guide.* We assume users of the Guide already have an interest in managing for bird habitat as one of several objectives that land managers must typically balance. However, it is not our purpose in the Guide to discuss integration of bird habitat management with other management objectives. Our objective is simply to provide those interested in bird conservation with information and recommendations on:

- the habitat conditions and features needed by breeding bird species, and
- how breeding bird species respond to particular management activities.

Much of the information on breeding bird habitat is presented in tabular format in the appendices. Because the latitudinal and elevational coverage of the Guide is extensive, there can be considerable variation in the habitat types and conditions with which bird species are associated. Thus, it is important to recognize that the habitat relationships of a species may vary throughout the Pacific Northwest. Information presented in the appendices that categorizes bird-habitat relationships should not be regarded as absolute, but should be used as a tool to help prioritize conservation efforts toward species that have a significant degree of association with habitat parameters, such as forest type or successional stage.

An underlying premise of the Guide is that forest management has a direct and significant influence on bird populations. Consequently, manipulation of forest conditions as part of forest management can be designed and implemented to achieve bird conservation objectives (Busing and Garman, 2002; Lehmkuhl and others, 2002). It is not our intent to describe all the potential forest management activities that could be conducted to achieve the desired habitat conditions for birds. Those need to be determined locally by assessing the most ecologically appropriate management at each site. However, to assist land managers, the Guide offers some basic forest management activities that are widely accepted for achieving habitat conditions and features which benefit breeding birds.

[1]American Bird Conservancy, Northern Pacific Rainforest BCR Coordinator, 311 NE Mistletoe, Corvallis, OR 97330

[2]USGS Forest & Rangeland Ecosystem Science Center, 777 NW 9th St., Suite 400, Corvallis, OR 97330

Scope of the Guide

Pacific Northwest

The geographic scope of the Guide is the temperate rainforest of the Pacific Northwest. For our purposes, this includes northwestern California; western Oregon, Washington, and British Columbia; and southeast and southcoastal Alaska (Figure 1). This area is referred to as the Northern Pacific Rainforest Bird Conservation Region (BCR 5) under the North American Bird Conservation Initiative (*Sidebar: North American Bird Conservation Initiative*). Hereafter in the Guide, we use Pacific Northwest, Northern Pacific Rainforest Bird Conservation Region, and BCR 5 interchangeably.

Young Conifer Forests

Young forests, for the purpose of the Guide, are defined as forested lands in the early and mid-successional stages of forest development. These forests are typically < 60 years old, although they may be older in some relatively drier or poorer soil areas. Young forests are represented by the period of forest development that begins immediately following a stand-replacing disturbance (for example, harvest or fire) and continues, in unmanaged forests, into the stage of self-thinning or, in most forests managed with even-aged regeneration methods, to the harvest rotation age. The transition between young forest and older forest is subtle and variable. It is often marked by the formation of canopy gaps caused by the death (unmanaged) or removal (managed) of some overstory trees. These gaps allow the reinitiation of understory growth on the forest floor. Important features that distinguish old forests include the presence of a range of tree sizes and ages, shade tolerant tree species, and large (> 50 cm diameter at breast height) snags and logs (Franklin and Spies, 1991).

Information and recommendations provided in the Guide are applicable to all young conifer forests in the Pacific Northwest. However, the emphasis is the vast landscape of coniferous forest outside the lowland and valley ecoregions such as Georgia Depression, Puget Trough, and Willamette Valley. Patches of young conifer forest in lowlands and valleys also provide opportunities for bird habitat management. However, these areas have different management and conservation issues due to the relatively small size of the forest patches (which excludes some larger bird species), the potential impacts of adjacent developed areas on bird populations (for example, increased predation and disturbance), and the ongoing and likely future loss of some of these areas to development.

Riparian habitats are an integral linear feature of the forested landscape in the Pacific Northwest, whether embedded within young or old forest. Although riparian habitats influence the composition of bird communities in conifer forests, especially at lower elevations and in the more arid environments of southwestern Oregon and northwestern California, riparian habitats are not considered independently from young conifer forest in the Guide because the bird species composition at mid to high elevations (our emphasis) is generally similar to adjacent conifer forest. (*Sidebar: Riparian Habitat and Birds in a Temperate Rainforest*).

The Guide does not include information on the habitat or birds that occur in non-forested inclusions within the forest landscape, such as grasslands, wetlands, ponds, and lakes. Although forest management can affect these habitats and the bird species associated with them, the emphasis of the Guide is bird species breeding within the young conifer forest itself, and the forest management activities that directly affect them.

North American Bird Conservation Initiative

Following the lead of the North American Waterfowl Management Plan, the development of bird conservation initiatives for landbirds (Partners in Flight), shorebirds (United States Shorebird Conservation Plan), and waterbirds (Waterbird Conservation for the Americas) throughout the 1990s resulted in a lack of coordination in bird conservation efforts. In the late 1990s, the North American Bird Conservation Initiative (NABCI) (www.nabci-us.org) was formed as a forum to provide more effective communication, coordination, and integration of the many disparate bird conservation efforts. Its goal is "*to deliver the full spectrum of bird conservation through regionally based, biologically driven, landscape oriented partnerships*." The ecological units designated for the delivery and tracking of bird conservation under NABCI are called Bird Conservation Regions (BCRs). There are 67 BCRs within North America and Hawaii including the Northern Pacific Rainforest (BCR 5) which is the emphasis of this document (Figure 1).

Breeding Bird Species

We identified 93 bird species (scientific names of birds, insects, and plant species mentioned in the text are presented in Appendix A) that regularly breed in young conifer forests within at least one of the 15 ecoregions dominated by conifer forests in the Northern Pacific Rainforest Bird Conservation Region (Appendix B). For some of these species, use of young conifer forest is limited relative to their use of other conifer forest successional stages or other habitats outside of conifer forest. However, we consider them in the Guide because young forest habitat is so pervasive in the Pacific Northwest, and management of young conifer forests may measurably affect their populations.

Figure 1. The Northern Pacific Rainforest Bird Conservation Region (BCR 5) under the North American Bird Conservation Initiative.

Cedar Waxwing—photo by Matt Lee

Some examples of species which are more abundant in older conifer forests but will breed in the latter stages of young forests, especially if some older forest components such as large trees or snags have been retained, include Evening Grosbeak, Pine Siskin, Red-breasted Nuthatch, Red Crossbill, and Townsend's Warbler. Other examples of species that use young conifer forests to a limited extent, but are more abundant in their preferred habitat outside of conifer forests include Bushtit, Cedar Waxwing, Warbling Vireo, Western Wood-Pewee, and Yellow-breasted Chat. For our purposes in the Guide, we recognize the use of young conifer forests by all these types of species, but generally do not emphasize their conservation or management which would be most effective in other successional stages or habitats.

Young Conifer Forests and Breeding Birds

The most identifiable public image of the Pacific Northwest is a vast expanse of coniferous rainforest. From the fog-shrouded giant redwoods of northern California to the moss and fern-carpeted, rain-soaked forests of British Columbia and southeast Alaska, these forests are known for the size of the trees and the extent of the landscape they cover. They also are known for their commercial value as one of the largest sources of lumber in the world.

Rainforests of the Pacific Northwest support a diverse assemblage of bird species. Some of the most characteristic

Riparian Habitat and Birds in a Temperate Rainforest

Throughout the arid portions of western North America, riparian habitat is recognized as supporting some of the highest bird species diversity and abundance (Knopf, 1985). These habitats are usually complex in terms of vegetation structure and distinct from adjacent habitats, primarily due to the degree of available water in contrast to adjacent drier upland habitats. Because moisture is generally not a limiting factor in a rainforest, the significance of riparian habitats to birds in Pacific Northwest rainforests is often less than in drier forests (McGarigal and McComb, 1992; Pearson and Manuwal, 2001). This is particularly true at mid-to-high elevations where the riparian corridor is narrower and dominated by similar tree and shrub species as the adjacent uplands. At lower elevations, where the riparian corridor is wider and the soils more alluvial, greater distinctions occur in the vegetative community, particularly in the cover contributed by deciduous trees and shrubs that provide unique and more diverse opportunities for bird species. Where riparian habitats offer unique resources relative to upslope habitats, bird assemblages are likely to reflect vegetative and structural differences between streamside and upland habitats.

Chestnut-backed Chickadee—photo by Matt Lee

species, such as Chestnut-backed Chickadee, Hermit Warbler, and Pacific-slope Flycatcher, breed almost exclusively in Pacific Northwest rainforests. Many other species highly characteristic of the region, such as Band-tailed Pigeon, Steller's Jay, Black-throated Gray Warbler, and Winter Wren, are more abundant in the Pacific Northwest than anywhere else in their range.

In recent years, birds in Pacific Northwest forests have received extensive international attention associated with threatened species, such as Marbled Murrelet and Northern Spotted Owl, and regional attention associated with conservation efforts for declining migratory bird species under the Partners in Flight (PIF) Initiative (*Sidebar: Neotropical Migrants and Partners in Flight*).

Steller's Jay—photo by Matt Lee

Why Young Forests?

The focus of forest management and bird conservation in the Pacific Northwest in the last couple of decades has been on older (that is, late-successional) forests and the birds associated with these forests. Most of this emphasis stems from the reduction of late-successional forest across the landscape, and regulatory issues related to two threatened species, Marbled Murrelet and Northern Spotted Owl. However, the corollary of a reduction in area occupied by late-successional forest has been an increase in area occupied by young forests. Vast acreages of young forest are the legacy of decades of clearcut harvesting on public and private lands. For example, in western Oregon, forests < 80 years old occupy > 70% of the forested landscape (Campbell and others, 2004). Much of this landscape continues to be managed on a short-rotation, clearcut regeneration system, and therefore is maintained as perpetually young forest.

Band-tailed Pigeon—photo by Matt Lee

Managed Forests and Bird Conservation

Public and private Pacific Northwest forests are often "working landscapes" that are managed under a variety of objectives including economic, recreational, ecological, restorative, and aesthetic. For many land managers, conservation of forest birds is one of their objectives. The type and degree of bird conservation that can be achieved depends on compatibility with other objectives and the land manager's commitment to integrating management for bird habitat. Some of the management activities that can be employed within the context of forest management to provide habitat for birds include provision or retention of snags, deciduous trees and shrubs, and fruit- and nectar-producing plants, along with various types of thinning and other density-management prescriptions.

Because young forests currently dominate the Pacific Northwest, interest in their management for multiple resources is high. For our purposes in the Guide, these forests represent an opportunity to manage simultaneously for timber production and breeding bird habitat (*Sidebar: Managed Forests and Bird Conservation*). Furthermore, today's young forests embody a broad range of management options for the future, one of which is the potential to become tomorrow's old forests. Thus, management of young forests is likely to have important implications for bird conservation now and in the future.

Although young conifer forests are a widespread and dominant feature of the Pacific Northwest landscape, many bird species associated with these forests are experiencing serious population declines over recent decades (*Sidebar: The Breeding Bird Survey: Our Tool for Bird Population Trends*). Of the 93 species regularly associated with young conifer forests in the Pacific Northwest, 32 species are experiencing either long-term (1966-2005) or recent (1980-2005) significant ($p < 0.10$) population declines based on a relatively high confidence of Breeding Bird Survey (BBS) data for at least one of the regions in the Pacific Northwest (Sauer and others, 2006) (Table 1). Another 15 species (American Kestrel, Cedar Waxwing, Downy Woodpecker, Dusky Flycatcher, House Wren, Lincoln's Sparrow, Northern Goshawk, Ruby-crowned Kinglet, Ruffed Grouse, Steller's Jay, Townsend's Warbler, Tree Swallow, Vaux's Swift, Western Bluebird, and Western Screech-Owl) also are experiencing significant population declines ($p < 0.10$) but the degree of confidence in the data is lower. Additionally, some of the 93 species, especially owls and rarer birds, are not well-monitored by the BBS, thus, there could be more species with unknown declines. Thus, over half of the breeding bird species associated with young conifer forests are experiencing population declines. Conversely, only 20 species are experiencing significant population increases based on a high level of confidence (Sauer and others, 2006).

Landscape of young, managed forest—photo by Erik Ackerson

Neotropical Migrants and Partners in Flight

The term "neotropical migrant" is often used to refer to those birds that breed in the United States and Canada and winter in the tropics of Mexico or Central/South America. Although the term is satisfactory for most discussions, technically it is incomplete because it only recognizes one endpoint in their migratory cycle, the winter in the neotropics. The correct term for species that breed in the Pacific Northwest (that is, the Nearctic biome) and migrate to winter in Latin America (that is, the Neotropical biome) is Nearctic-Neotropical migrants (Levey, 1994).

In the early 1990s, recognition that numerous long-distance migratory bird species in North America were declining (Robbins and others, 1992) lead to the formation of Partners in Flight (PIF) (www.partnersinflight.org). This international initiative is based on the tenet of voluntary participation to "reverse the trends of declining species" and "keep common birds common." The development of PIF coalitions at state, regional, continental, and international levels has resulted in significant efforts to prioritize species for conservation, conduct extensive research and monitoring activities, and implement policy and management on the ground for these species. These activities are guided by Bird Conservation Plans prepared by each state/province PIF chapter. In the Pacific Northwest, these plans can be accessed at www.absc.usgs.gov/research/bpif/bpif.html (Alaska), www.pifbcyukon (British Columbia), www.orwapif.org (Oregon-Washington), and www.prbo.org/calpif/plans.html (California).

There are many possible reasons for declining populations of so many bird species including factors occurring outside the Pacific Northwest for birds that migrate. However, one potential factor that is relevant to this region is change in young forest habitat resulting from forest management practices. A focus on early and rapid establishment of conifer trees following harvest on forestlands managed for timber production has tended to produce stands that are floristically and structurally homogenous (Hansen and others, 1991). Many avian species associated with young forests use a variety of understory vegetation – herbs, shrubs, and deciduous trees – for foraging, hiding cover, and nesting. Thus, a management emphasis on conifer trees may contribute to a loss of suitable habitat for these species.

Table 1. Declining bird species associated with young conifer forests in the Northern Pacific Rainforest Bird Conservation Region based on Breeding Bird Survey data.[1] L = significant ($p < 0.10$) long-term (1966-2005) population decline; R = significant ($p < 0.10$) recent (1980-2005) population decline.

Species	Bird Conservation Region 5[2]	Northern Pacific Rainforest BBS Region[3]	Southern Pacific Rainforest BBS Region[4]	Cascade Mountains BBS Region[5]
American Goldfinch	L R	L R	L R	
Band-tailed Pigeon	L R	L R		
Bewick's Wren		R		
Blue (Sooty) Grouse	L R	L R		
Brown Creeper			R	L
Bushtit			L R	
Cassin's Vireo		L R		
Chipping Sparrow			L R	
Chestnut-backed Chickadee			L R	
Common Nighthawk				R
Dark-eyed Junco	L R	L R		
Evening Grosbeak	R			
Fox Sparrow				L R
Golden-crowned Kinglet	L R		L R	
Hermit Thrush			R	
MacGillivray's Warbler	L R	R	L R	L
Nashville Warbler			R	
Northern Flicker		R		L
Olive-sided Flycatcher	L R	L R	L R	
Orange-crowned Warbler	L R	L R	L R	
Pacific-slope Flycatcher	R		L R	L R
Pine Siskin	L R	L R	L R	
Purple Finch	L R	L	L R	
Red Crossbill		L R		
Rufous Hummingbird	L R	L R	L	
Song Sparrow	L R	L R	L	
Swainson's Thrush			L	
Varied Thrush				R
White-crowned Sparrow			L R	
Willow Flycatcher	L R	L R	L	L
Wilson's Warbler	L R		L R	
Wrentit			R	

[1] Species with significantly declining trends ($p < 0.10$) and a high degree of confidence (Sauer and others, 2006).

[2] BCR 5 = Bird Conservation Region 5: a NABCI ecological unit which includes northwestern California; western Oregon, Washington, and British Columbia; and southeast and southcoastal Alaska.

[3] NPR = Northern Pacific Rainforest: a BBS Physiographic Province which includes western British Columbia and southeast Alaska.

[4] SPR = Southern Pacific Rainforest: a BBS Physiographic Province which includes northwestern California and western Oregon and Washington (excludes Cascades Mountains).

[5] CAS = Cascades: a BBS Physiographic Province which includes the Cascade Mountains in northern California, Oregon, and Washington.

The Breeding Bird Survey: Our Tool for Bird Population Trends

The Breeding Bird Survey (www.mbr-pwrc.usgs.gov/bbs/bbs.html), a volunteer-based survey initiated in the late 1960s, provides the best data on population trends of forest bird species. Each June, volunteers conduct roadside counts on over 4,000 randomly selected routes across the North American continent. Data are stored and managed by the administering agencies, the U.S. Geological Survey and the Canadian Wildlife Service.

Why Breeding Birds?

The Guide covers native bird species that regularly breed in young conifer forests of the Northern Pacific Rainforest Bird Conservation Region. Because breeding bird species occur in all the habitats and conditions that support non-breeding birds, an assumption in the Guide is that habitat management for breeding birds likely will support most, if not all, of the conservation needs of non-breeding birds.

Viable populations of birds depend on successful reproduction to maintain or increase population levels (*Sidebar: Reproduction and Population Maintenance*). For some of the migratory Pacific Northwest breeding bird species, there also are known or suspected conservation issues occurring during migration or on the wintering grounds that impact the abundance and health of breeding populations. Although the Guide does not address these issues, appropriate conservation actions on the breeding grounds are a stewardship responsibility of a shared natural resource. Consequently, managing for breeding habitat for migratory species is critical to maintain healthy populations in other countries and is our only conservation opportunity in the Pacific Northwest. Thus, land managers of young conifer forests of the Pacific Northwest have a breeding season "responsibility" not only for our resident species, but also for many migratory species.

Dispersed retention of snags in a harvest unit—photo by Bob Altman

Reproduction and Population Maintenance

In order for a bird species to maintain its population level, each adult of reproductive capability must replace itself with an individual that reaches reproductive age. That may not seem difficult when you consider that many forest birds lay 3-4 eggs in each clutch (some even have two clutches per year) over an average life span of 2-3 years. However, the likelihood of any of those eggs becoming a reproducing adult bird is significantly diminished when you consider nest failure rates (often > 40%; Martin, 1995) and mortality of fledged birds during their first year (often > 80%). When these reproductive and fledgling losses are added to the habitat loss or degradation that many species are experiencing, it becomes apparent why so many species have declining population trends.

Nothern Flicker—photo by Matt Lee

Forest Successional Stages and Breeding Birds

Forest succession is the process of change by which young forests develop into old forests, but it is considerably more complex than the growth of small trees into big trees. Succession involves compositional and structural changes in the entire forest community, from the trees and understory plants to the wildlife and insects. Additionally, composition and patterns established in the early successional stages often determine the conditions existing in later successional stages.

There is a large body of literature on the importance of forest structure to birds. Young conifer forest structure is influenced by the elapsed time (that is, successional stage) and the intensity of the last disturbance event. Disturbance intensity determines how much vegetation from the previous stand survives to colonize the new stand. Some bird species associated with older forests are likely to use regenerating stands only if residual trees, snags, and shrubs from the pre-disturbance stand provide the necessary forest structure.

Suitable habitat for breeding birds in young conifer forests is often a combination of the successional stage of the forest at a coarse-scale and the presence of unique structural features or elements at a finer scale. For example, Western Bluebirds like the open overstory and understory of the first few years of succession after a stand-replacing disturbance, but will only breed if suitable cavities in snags are available. Less specialized species, such as Swainson's Thrush, can breed in any young forest successional stage as long as the shrub layer is sufficiently developed.

Young forests that have diverse vegetation composition and complex structure can support a high abundance and diversity of breeding birds (*Sidebar: Vegetation Diversity and Birds*). In fact, bird diversity in Pacific Northwest conifer forests is usually higher in regenerating stands that have early successional vegetation combined with some mature overstory trees, than in either intact mature forest or clearcuts without residual structure (Hansen and Hounihan, 1996; Chambers and others, 1999).

Dark-eyed Junco—photo by Matt Lee

In the Guide we recognize four stages of young managed conifer forests: two early-successional and two mid-successional (Table 2). The actual age and characteristics of each stage varies depending on many site-specific conditions. Changes in vegetation structure and composition that distinguish these stages of forest succession are paralleled by changes in the characteristic avian assemblage (Appendix C). Because each successive stage of development generally lasts for a longer period of time than the one preceding, younger forests also can be thought of as more temporary bird habitat than older forests.

The earliest stage of forest succession, which is dominated by herbaceous vegetation is the most dynamic and short-lived (Kimmins, 1987). Consequently, turnover in bird species diversity and composition tends to be rapid. Birds typically associated with the herbaceous stage include granivorous (seed-eating) species, such as American Goldfinch, Dark-eyed Junco, and White-crowned Sparrow, which take advantage of abundant seed production (Gashwiler and Ward, 1968). Where structure has been retained as a legacy from the older forest (for example, live or dead trees), the bird community is greatly enhanced. For example, Western Bluebirds and Purple Martins use cavities in charred stumps or dead trees in burned or clearcut areas for nesting, and Olive-sided Flycatchers use large live trees for nesting and large dead and live trees for foraging perches.

Vegetation Diversity and Birds

Each bird species is associated with different types of plants because of the different food, cover, and nesting resources offered. Therefore, conifer forests with a large diversity of plant species present also are likely to support a diverse bird assemblage. Understory and midstory plants contribute most of the vegetative diversity to conifer forests of the Pacific Northwest (Halpern and Spies, 1995). When these plants are removed from a stand by vegetation management (for example, herbicides or manual removal), or as a result of shading from the conifer overstory, fewer niches are available and the bird community is reduced in abundance and diversity. This is why the goal of some forest managers is to create multi-layered forest structure. It is important to realize that having multiple layers of vegetation in a forest stand is much more likely to enhance bird species diversity if a diversity of plant types contributes to the layers (for example, hardwood mid-story beneath conifer overstory) than if strata are composed strictly of coniferous foliage.

The early-successional stage of forest development dominated by shrubs and pioneer trees (when conifers provide < 30% cover) typically supports higher bird diversity than any other stage (Harris, 1984; Hall and others, 1985). In particular, young forest stands that support a high proportion of deciduous vegetation also tend to support a high abundance and diversity of insectivorous birds (Morrison, 1981). Many of migrant species that breed in Pacific Northwest forests are associated with deciduous vegetation, such as MacGillivray's Warbler and Orange-crowned Warbler (Morrison and Meslow, 1983a), and flowering vegetation, such as Rufous Hummingbird (Harrington and others, 2002).

Created snags in regenerating stand used by Purple Martins for nesting——photo by Bob Altman

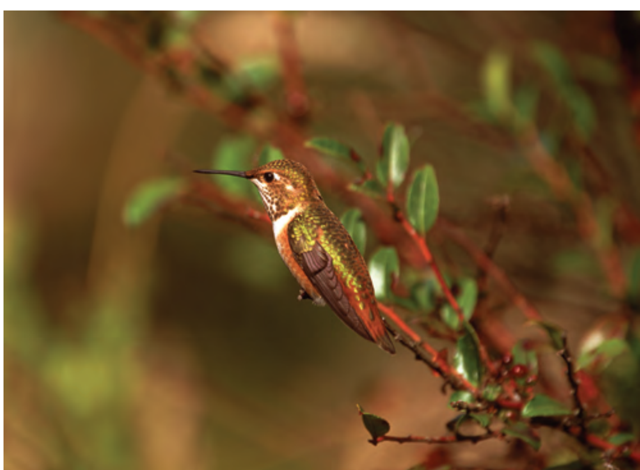
Table 2. General description of successional stages of young conifer forests in the Northern Pacific Rainforest Bird Conservation Region.

Successional Stage [1]		Years Since Disturbance (approximate)	General Habitat Characteristics [2]	Examples of Closely Associated Bird Species [3]
Early Successional	• Stand Initiation • Herbaceous • Grass-Forb	0-5	Dominated by rapidly-growing, short-lived herbaceous vegetation; most trees are small seedlings	American Goldfinch, Spotted Towhee, White-crowned Sparrow
	• Seedling • Shrub-Seedling • Shrub-Sapling • Pioneer Tree	5-20	High vegetative diversity; dense tangle of vegetation; most trees are large seedlings or saplings; shrubs are well-developed	MacGillivray's Warbler, Orange-crowned Warbler, Willow Flycatcher
Mid Successional	• Closed-Canopy Pole • Sapling-Pole • Small Tree	15-30	Conifer trees become dominant; tree diameters generally less than 15 cm (6 inches); understory vegetation may be reduced	Hutton's Vireo, Purple Finch, Swainson's Thrush
	• Stem Exclusion • Self-Thinning • Young Sawtimber • Medium Tree	25-60	Average tree diameters from 15 to 51 cm (6 to 20 inches); shaded understory has limited growth	Golden-crowned Kinglet, Hermit Warbler, Pacific-slope Flycatcher

[1] The terms used to describe successional stages are from a variety of sources and include terms that emphasize both a silvicultural perspective and terms that emphasize an ecological perspective.

[2] Due to natural variability and management, not all stands will have the characteristics associated with each successional stage (for example, use of herbicides in early successional stages will result in different characteristics than those listed).

[3] A full list of species associated with each successional stage is provided in Appendix C.



Rufous Hummingbird—photo by Matt Lee

Once conifers achieve dominance in managed stands (mid-successional pole forest), the shade-intolerant trees and shrubs are likely to decline in vigor as canopies close (Bailey and others, 1998; Thomas and others, 1999) (*Sidebar: Understory Vegetation in Forest Management*). Much of the young managed forest that currently occupies large areas of the landscape was heavily and uniformly stocked with Douglas-fir after logging (Curtis and others, 1998). These conditions lead to the development of deep shade under closed canopies (typically > 90%), limiting the growth of understory vegetation and creating forests that lack structural and compositional diversity of vegetation and wildlife. Dense young stands, which are essentially just one layer of coniferous canopy, support the fewest number of bird species of any stage of forest development (Meslow and Wight, 1975).

Without thinning, competition results in the mortality of suppressed trees in a stage of succession known as "stem exclusion" or "self-thinning" (Oliver and Larson, 1990). As the trees become larger and the canopy more closed and conifer-dominant, bird species such as Golden-crowned Kinglet, Hermit Warbler, and Townsend's Warbler become more abundant (Bettinger, 1996). However, young stands that retain some structural diversity even after conifers achieve dominance (for example, openings, snags, and shrub cover) may support a more diverse bird assemblage (Chambers and others, 1999).

Forest Vegetation Types and Breeding Birds

Plant community types are a useful way to categorize forests as bird habitats. Plant communities are defined by their dominant species and how the size, age, and growth habits of the component plant species influence community structure. Many classification schemes for the scores of plant community types in the Pacific Northwest have been developed (for example, Franklin and Dyrness, 1988; Grossman and others, 1998). It is beyond the scope of the Guide to include

Table 3. Preferred plant species selected as a nesting substrate for some young conifer forest bird species in the Northern Pacific Rainforest Bird Conservation Region.

Species	Preferred Nesting Vegetation [1]	Source
Band-tailed Pigeon	Douglas-fir (OR)	Leonard (1998)
Hermit Warbler	Douglas-fir (OR and WA)	Pearson (1997); Janes (2003)
Olive-sided Flycatcher	Hemlocks and true firs (OR)	Altman and Sallabanks (2000)
Pacific-slope Flycatcher	Red alder (WA)	Leu (2000)
Swainson's Thrush	Salmonberry (OR and WA)	B. Altman (unpubl.)
Townsend's Warbler	White spruce (AK)	Matsuoka and others (1997)
Willow Flycatcher	Bracken fern (OR)	Campbell and others (1997); Altman and others (2003)
Wilson's Warbler	Western sword fern (OR and WA)	B. Altman and J. Hagar (unpubl.)

[1] Selection may be based on degree of use or degree of nest success and may vary regionally.

Willow flycatcher nest in bracken fern in early successional forest—photo by Bob Altman

the breeding bird assemblages of every plant community type within each forest type. Sources for that type of information include Campbell and others (1997), Johnson and O'Neil (2001), Marshall and others (2003), and Wahl and others (2005). However, coarse-level breeding bird associations with forest vegetation types of the Pacific Northwest are presented in Appendix D to assist land managers interested in bird conservation.

Most forest breeding bird species only have a coarse-scale association with a particular vegetation growth form (for example, shrub or tree) while using a variety of plant species within that context based on what is available in the local landscape. Although there are few obligate or near-obligate relationships between plant species and birds, some bird species have demonstrated a preference for particular plant species for nesting (Table 3).

Understory Vegetation in Forest Management

In forests managed for timber production, conifer dominance is achieved early in stand development by means of vegetation management and the maintenance of a high density of conifer seedlings at stand initiation. These practices typically reduce the abundance and distribution of shrubs, and therefore shorten the period of shrub dominance (Hansen and others, 1991; Kennedy and Spies, 2004). Understory shrubs in conifer forests provide unique food resources for birds in the form of flowers, fruits, seeds, and abundant and diverse insect prey (Willson and Comet, 1996; Hagar, 2004). Many bird species also require understory cover for nesting. Birds that depend on the resources provided by shrubs, including many long-distance migrant species, will be absent from forests that do not have adequate understory development to support them.

Intimate Relationships Betweens Birds and Forest Plants

Plants provide food, shelter, and nesting substrates for birds; birds influence plant reproduction and distribution through the processes of pollination, seed dispersal, and seed caching. Plants, such as currant, salmonberry, and Pacific madrone, entice Rufous Hummingbirds to transfer pollen from one individual to another by offering a nectar reward. Flowering trees and shrubs, such as salal, salmonberry, huckleberry, and Oregon-grape, provide fruits for American Robin, Cedar Waxwing, and Swainson's and Varied Thrushes that, in turn, disperse viable seeds. Another way in which birds disperse seeds is by caching surplus food. Gray Jay, Red-breasted Nuthatch, and Steller's Jay, are renowned for their habit of storing or "caching" seeds and nuts in the autumn to be recovered and consumed during the lean winter months (Erlich and others, 1988). Typically, not all of the cached seeds are found again, allowing some of them to germinate and grow future food sources for the bird species that "planted" them.

Forest Food Resources and Breeding Birds

Food is a critical habitat component that greatly influences the reproductive success and survival of breeding birds (Martin, 1987). Seeds, fruits, and flowers provide a direct source of food for many bird species, while arthropod prey that live on plants indirectly link avian insectivores to vegetation (*Sidebar: Intimate Relationships Betweens Birds and Forest Plants*). Some species are highly selective in what they eat. For example, Red Crossbills are granivores that have beaks especially adapted to extract seeds from conifer cones (Adkisson, 1996). Warbling Vireos are insectivores that primarily eat caterpillars from deciduous trees (Gardali and Ballard, 2000). Fruit becomes an important food resource during the latter part of the breeding season for species such as Swainson's Thrush (Hagar 2004).

A forest provides many foraging substrates for breeding birds. One of the most significant is the foliage associated with the vegetation. Deciduous foliage supports different resources than coniferous foliage, and is available at different times of the year. In the spring and summer, deciduous trees and shrubs support a diverse assemblage of herbivorous insects, such as caterpillars (Hammond and Miller, 1998) and aphids (Doolittle, 2000), creating an abundant food supply for nesting foliage-gleaning birds (*Sidebar: The Importance of Insects*).

Patch of red alder along forest road—photo by Bob Altman

Caterpillars, in particular, provide a high energy resource for breeding forest birds (*Sidebar: Caterpillars: A Package of Energy for Breeding Birds*).

Other significant differences between coniferous and deciduous trees for foraging birds include branch structure, seed and fruit production, bark characteristics, and associated arthropod communities. Hardwoods support a dramatically

The Importance of Insects

Most songbirds require insect food resources during the breeding season for feeding developing nestlings. Some species, such as flycatchers, swallows, and swifts, subsist entirely on aerial insects, and other insectivores, such as warblers, vireos, and wrens, glean insects from vegetation. Even hummingbirds and granivores, such as finches and sparrows, feed their nestlings insects for the protein necessary for growth (for example, Brice and Grau, 1991; Nolan and others, 2002). For these reasons, insects are an important consideration for managing forests for breeding birds. However, managing directly for insect taxa that are important prey to each bird species would be a daunting task for most managers. The most pragmatic approach to managing for adequate arthropod prey resources for forest birds is to maximize diversity of native vegetation within the ecological constraints of the site. Vegetative diversity is important because each plant species supports a characteristic assemblage of herbivorous insects, and plant species vary in the amount and type of insect prey they support. Thus, plant diversity cascades through food chains to affect bird diversity.

higher diversity of lichens and other epiphytes than conifers because their branch structure and deciduous foliage present a favorable growing substrate (Neitlich and McCune, 1997). Forest epiphytes are known to support diverse arthropod communities (Gerson and Seaward, 1977; Neitlich, 1993), and invertebrates inhabiting epiphytic lichens are an important food source for some birds (Pettersson and others, 1995). However, the stems and bark of conifer trees also are important foraging substrates for forest birds (Jackson, 1979). Many bark foraging species spend most of their time on conifers (Weikel and Hayes, 1999). Chickadees, nuthatches, creepers, and woodpeckers all glean spiders, grubs, and other arthropods from crevices in bark on the boles and branches of trees. The deeper the crevices, the more prey they are likely to contain (Mariani and Manuwal, 1990), so older conifers with deeply fissured bark are preferred foraging habitat for species such as the Brown Creeper (Weikel and Hayes, 1999).

Some bird species forage mainly on flying insects snatched out of the air while on the wing. These aerial insectivores prey on many kinds of flying insects including flies, moths, beetles, and ballooning spiders and caterpillars (Beaver and Baldwin, 1975). In forested habitats, flying insects can be abundant in canopy gaps (Hagar, 2004), where elevated light and temperature may provide the best environment for activity (Shure and Philips, 1991). The abundance of aerial arthropods in temperate coniferous forests also has been positively correlated with understory vegetation, in particular, deciduous shrubs (Jokimaki and others, 1998; Humphrey and

Caterpillars: A Package of Energy for Breeding Birds

For many species of insectivorous birds that breed in Pacific Northwest forests, caterpillars (the larval stage of butterflies and moths [Lepidoptera]) are the choicest of food items. Compared to most arthropods, which are mainly wings, legs, or indigestible exoskeleton, caterpillars represent a relatively large package of energy and nutrients for a foraging bird. Several characteristics of caterpillars make them a favorite prey item. First, although caterpillars typically are not abundant, they are large relative to other insects. Caterpillars typically weigh at least 10 times as much as the average insect in a forest understory community (Hagar, 2004), and most of that weight is easily digested by avian predators because caterpillars lack tough exoskeletons. Secondly, as slow and sedentary creatures, caterpillars are easy to capture compared to many more agile arthropods. The large size and ease of capture make caterpillars an efficient prey item because birds can maximize energy gained while minimizing energy expended on feeding. Finally, caterpillars have higher calcium concentrations than most other insects (Schowalter and Crossley, 1983), providing insectivorous birds with an essential resource for egg-laying. The consumption by birds of at least two caterpillar pests, western spruce budworm and Douglas-fir tussock moth, can be economically important.

In coniferous forests in western Oregon, more than half of all butterfly and moth species, and more than two-thirds of their abundance, are associated with deciduous trees and shrubs (Hammond and Miller, 1998). MacGillivray's Warbler and Wilson's Warbler, both species that consume caterpillars and are associated with deciduous shrubs, were found to be rare in Oregon Coast Range stands that averaged < 35% cover of deciduous shrubs (Hagar, 2004). Therefore, enhancing the growth of deciduous shrubs is an excellent means of ensuring the availability of caterpillars as prey for breeding birds.

Oceanspray is a tall, deciduous shrub that supports an abundance of caterpillars, and is therefore an important source of prey for insectivorous birds—photo by Bob Altman

Wilsons Warbler—photo by Barth Schorre

others, 1999). Natural treefall gaps and small openings created by partial harvesting may be ideal foraging habitat for aerial insectivores, such as Hammond's and Pacific-slope Flycatcher, because they support concentrations of airborne insects near perches.

A final group of insects that are particularly important as food for forest birds includes beetles and ants. Swainson's Thrushes frequently forage for ground-dwelling ants and beetles in litter on the forest floor (Mack and Yong, 2000). Woodpeckers feed extensively on the beetle larvae and ant eggs that they find beneath the sloughing bark and within the decaying wood of dead trees (Otvos, 1965; Bull and others, 1986). Many beetle taxa and some species of ants are associated with dead and dying wood (Borror and others, 1989). Thus, in addition to providing shelter for cavity-nesting species, woody debris should also be recognized for its importance in supporting insects that are prey for many species of birds.

Profuse shrub development in a 50-year-old thinned stand, Oregon Coast Range—photo by Joan Hagar

Priority Birds

Although the Guide recognizes 93 breeding bird species regularly associated with young conifer forests, some species have been identified as being of high conservation and management concern (*Sidebar: Species Prioritization: Are Some Species Really More Important Than Others?*). Conservation concern may stem from a variety of factors including declining or small populations, threats to habitat, degree of ecological specialization, degree of association with important habitat features or conditions, or a region's responsibility based on a high percent of the species population or range.

Different degrees of emphasis on these and other factors by various agencies and organizations have resulted in numerous lists that identify the most important bird species for conservation. However, the Guide emphasizes the lists gener-

Song Sparrow—photo by Stephen Dowlan

ated through Partners in Flight (PIF) as being most relevant to young conifer forests because of PIF's emphasis on landbirds, the existing prioritization of landbirds in state and provincial bird conservation plans (*Sidebar: Priority and Focal Species*), and the widely-used and published process for prioritizing landbird species (Beissinger and others, 2000; Carter and others, 2000).

Table 4 summarizes the current PIF state, regional, and continental priority/focal bird lists for species associated with young conifer forests. Some of these species are most closely associated with late-successional forests, but all have at least a low degree of association with young conifer forests (Appendix C). We recommend that land managers throughout the Pacific Northwest consider the 13 species highlighted in Table 4 as a part of any bird habitat management efforts because of regional recognition of these species on most priority lists (assuming appropriate habitat, successional stage, distribution, etc. [see Appendices B,C,D]). Additionally, at the more local level, we recommend consideration of the 33 additional species listed in Table 4 where the geographic emphasis is appropriate.

Spotted Towhee—photo by Stephen Dowlan

Planning and Designing for Bird Habitat

Before conducting on-the-ground management for birds, it is important to consider some practical realities and ecological principles about birds and forest management. In particular, objectives for the desired bird species or habitat conditions need to be set within the constraints of factors that affect what outcomes are reasonable and ecologically achievable.

Managing for birds, like managing for timber, is based on shaping forest development. Within this context, it is important to recognize that young forests are successional and the conditions only remain for a finite period of time. Thus, management decisions should consider not only short-term objectives, but also what opportunities currently exist to put the site on a trajectory that will meet future objectives. The sections that follow discuss some important considerations for planning and designing of bird habitat in young conifer forests.

Hutton's Vireo—photo by Stephen Dowlan

Know What is Ecologically Appropriate

As part of the planning process, it is essential to understand the ecological capacity or "potential native vegetation" of the site to support particular habitat conditions or bird species (*Sidebar: Avoiding Square Pegs and Round Holes: Be Ecologically Appropriate*). This is influenced by a variety of conditions, such as soils, aspect, slope, elevation, latitude, disturbance history, etc. If the potential native vegetation is not readily known, the assistance of a professional ecologist or forester can be beneficial. Some examples of the importance of knowing what is ecologically appropriate include: a relatively dry south-facing slope may provide limited opportunities for understory structural diversity compared to a north-facing slope; regeneration of alder patches is less likely to occur in mid to high elevations; and wet micro-sites (for example, seeps) are most conducive to the establishment of big leaf maple trees.

Target the Appropriate Bird Species

In addition to knowing what is ecologically appropriate for a site, it is also important to target the appropriate bird species. This information can be gleaned from evaluating Appendices B, C, and D. For example, it is not appropriate to manage for snag retention or creation for Western Bluebird in southeast Alaska (out of their range), or to emphasize deciduous tree management for Pacific-slope Flycatcher at 1,200 meters (4,000 feet) in the Cascades of Washington (elevation too high). Conversely, at the former site, retention or creation of large snags for Red-breasted Sapsucker or Vaux's Swift is appropriate; and at the latter site, it may be appropriate to promote deciduous tree regeneration (if ecological conditions are appropriate) to create habitat for Ruffed Grouse.

Consider the Landscape Context

As discussed earlier, the age and vegetative structure within a forest patch are important factors in determining the bird species that it will support. A land manager can manage these stand-level characteristics to achieve objectives for resource management and bird conservation. However, stand-level objectives ideally should be set in the context of landscape conditions to be most effective (Beese and Bryant, 1999).

Species Prioritization: Are Some Species Really More Important Than Others?

Basic ecology tells us that each species has its role or niche in a properly functioning ecosystem. When parts of that ecosystem are removed or altered, the entire system is affected. Thus, each species is uniquely important to maintain the balance. However, most young conifer forest ecosystems today have been altered by human activities and don't necessarily function as they did prior to our actions. This is especially true in young conifer forests being managed for timber production. When alteration is significant enough, changes occur in the composition and abundance of bird species. Some species benefit by experiencing increased populations or finding new opportunities for suitable habitat. Other species are lost from the area or suffer decreased populations. The latter group often consists of species that end up on various "lists" as priorities for conservation. *Prioritization of these species indicates a more urgent need for their conservation.*

Priority and Focal Species

Partners in Flight (PIF) bird conservation plans use the terms priority species and focal species to identify species that are considered to be the most important to address in conservation and management activities. Priority species are typically identified based solely on factors related to each species' *vulnerability or at-risk status or dependence on the geographic area being considered*. The most widely used source for scoring and prioritizing species for conservation is the PIF Species Assessment Database (www.rmbo.org/pif/pifdb.html). Scores from this database are frequently used in the development of other (that is, non-PIF) priority bird lists of agencies and organizations. In BCR 5, priority species have been used as the conservation focus in PIF Bird Conservation Plans for Alaska and British Columbia (Table 4).

Focal species are designated as being of management concern based on their association with particular habitats or habitat conditions (Lambeck, 1997). The emphasis is on the *representativeness of the species relative to a habitat or habitat condition*. The rationale for emphasizing focal species is to draw immediate attention to the habitats and habitat conditions most in need of conservation or most important to bird conservation in a functioning ecosystem. The underlying assumption is that conservation efforts directed towards a suite of focal species will capture the habitat needs of most other species associated with these habitats. In BCR 5, focal species have been used as the conservation focus in PIF Bird Conservation Plans for California, and Oregon-Washington (Table 4).

Bewick's Wren—photo by Stephen Dowlan

The occurrence or abundance of some bird species is dependent not only on the habitat conditions of a forest patch but also the surrounding landscape (Franklin, 1993; Petit and others, 1995). Such landscape-level influences on bird habitat might include adjacent land use/habitat type or degree of isolation from or connectivity with similar habitats. Therefore, it is important to recognize that the potential for meeting bird conservation objectives can be influenced by the habitat and management on adjacent lands (both forest and non-forest) and at scales larger than the forest patch (McAllister and others, 1999). Some examples include species that have relatively large area-requirements for a mosaic of habitat types, such as Northern Goshawk or Band-tailed Pigeon; species like Great Gray Owl and Red-tailed Hawk which require the juxtaposition of two different habitat types, one for nesting (closed-canopy) and one for foraging (open canopy); or species like Winter Wren with reduced abundance in fragmented forest landscapes (McGarigal and McComb, 1995). Coordination and cooperation with adjacent landowners may be necessary to optimize conditions for bird species requiring landscape-level habitat management.

Timing of Management Activities

An important consideration in planning for bird habitat is the timing of management activities. A general rule of thumb is that management should be conducted outside the breeding season, if at all possible, to minimize impacts on reproduction. Any manipulations of habitat that take place during the breeding season will likely result in a loss of bird productivity for that year, thereby reducing the number of individuals that can potentially be recruited into the breeding population in future years.

Avoiding Square Pegs and Round Holes: Be Ecologically Appropriate

Habitat management for forest bird conservation often involves some manipulation of the environment to create conditions suitable for the bird species or habitat conditions you are targeting. However, our ability to create those conditions is dependent on a suite of biotic and abiotic factors that we cannot manipulate, such as soil type, aspect, slope, local weather, etc. Thus, knowing what is possible or "ecologically appropriate" should guide your management activities. Once you know the potential native vegetation for the site, you can evaluate bird species or suites of species that have habitat requirements that your site can reasonably provide.

Table 4. A summary of state/provincial, regional, and continental Partners in Flight priority/focal bird species associated with young conifer forests in the Northern Pacific Rainforest Bird Conservation Region. [1]

Species	State/Provincial		Regional	Continental
	Focal in Bird Conservation Plan [2]	Priority in Bird Conservation Plan [3]	BCR 5 PIF Database [4]	North American Landbird Conservation Plan [5]
Band-tailed Pigeon	OW	BC	RC, RS	SCI
Black-headed Grosbeak		BC		
Black-throated Gray Warbler	CA, OW	BC	RS	SCI
Blue (Sooty) Grouse		AK, BC	RC, RS	SCI
Brown Creeper	CA, OW	BC		
Cassin's Vireo		BC	RC	
Chestnut-backed Chickadee		AK, BC	RS	SCI
Cooper's Hawk		BC	RC	
Dark-eyed Junco	CA			
Dusky Flycatcher			RC	
Fox Sparrow	CA			SCI
Golden-crowned Kinglet	CA	BC	RC, RS	
Gray-cheeked Thrush		AK		
Hairy Woodpecker		BC		
Hammond's Flycatcher	OW	AK, BC		
Hermit Thrush		BC		
Hermit Warbler [6]	OW		RS	SCI
Hutton's Vireo	OW	BC	RS	
MacGillivray's Warbler	CA	AK, BC	RS	
Mountain Quail				SCI
Northern Goshawk		BC		
Northern Pygmy-owl		BC	RS	
Northern Saw-whet Owl		BC	RS	
Olive-sided Flycatcher	CA, OW	AK, BC	RC, RS	SCI
Orange-crowned Warbler	OW	BC		
Pacific-slope Flycatcher	OW	AK, BC	RS	SCI
Pileated Woodpecker	CA, OW			
Purple Finch		BC	RC	
Red-breasted Nuthatch	CA			
Red-breasted Sapsucker		AK, BC	RC, RS	SCI
Red Crossbill	OW	BC	RC, RS	
Ruffed Grouse		BC	RC	
Rufous Hummingbird	OW	AK, BC	RS	SCI
Spotted Towhee			RS	
Steller's Jay		AK, BC	RS	SCI
Townsend's Warbler		AK, BC	RS	
Varied Thrush	CA, OW	AK, BC	RS	SCI
Vaux's Swift	CA, OW	AK, BC	RS	

Table 4. A summary of state/provincial, regional, and continental Partners in Flight priority/focal bird species associated with young conifer forests in the Northern Pacific Rainforest Bird Conservation Region.[1]—Continued

Species	State/Provincial		Regional	Continental
	Focal in Bird Conservation Plan[2]	Priority in Bird Conservation Plan[3]	BCR 5 PIF Database[4]	North American Landbird Conservation Plan[5]
Western Screech-owl		AK, BC		
Western Bluebird	OW	BC		
Western Tanager	CA			
Western Wood-pewee		BC		
Willow Flycatcher		BC	RC, RS	SCI
Wilson's Warbler	OW	BC		
Winter Wren	OW			SCI
Wrentit				SCI

[1] Species in shaded rows are recommended as a high regional priority because they are priority or focal species on at least 4 of the 6 PIF lists (that is, the 4 state/province bird conservation plans, the BCR 5 priority list from the PIF Species Assessment Database, and the National PIF Species of Continental Importance list for the Pacific Avifaunal Biome).

[2] CA = California Coniferous Forest Bird Conservation Plan (California Partners in Flight, 2002); OW = Oregon/Washington Westside Coniferous Forest Bird Conservation Plan (Altman, 1999).

[3] AK = Alaska Bird Conservation Plan (southeast and southcoastal regions) (Boreal Partners in Flight Working Group, 1999); BC = British Columbia (www.pifbcyukon.org/3e.html).

[4] RC = Regional Concern; RS = Regional Stewardship (www.rmbo.org/pif/jsp/BCRmap.asp).

[5] SCI = Species of Continental Importance in the Pacific Avifaunal Biome (Rich and others, 2004).

[6] Included as a high regional priority despite only being on three lists because it does not occur in Alaska or British Columbia, thus, could not make those lists.

Latitude, elevation, weather, and migratory status all contribute to considerable variability in the timing of nesting activities among bird species that breed in young conifer forests. For example, resident species, such as Chestnut-backed Chickadee and Red-breasted Sapsucker, and short-distance migrants, such as Varied Thrush and Western Bluebird, tend to initiate nesting in April and early May, whereas long-distance migrants, such as MacGillivray's Warbler, Pacific-slope Flycatcher, and Western Tanager, don't initiate nesting till late May or June.

The length of the breeding season also is variable among species. Among resident species that nest early, some like Dark-eyed Junco and Spotted Towhee can produce two or three broods and may still be nesting in July. Conversely, resident species like Hutton's Vireo and Wrentit usually produce only one brood and are generally done by June. Some long-distance migrants like Olive-sided Flycatcher and Willow Flycatcher may still have many active nests in August (B. Altman, unpub. data).

As a consequence of the variability in the timing of nesting activities, it is important for land managers to be aware of the potential for management activities to negatively impact reproductive success (*Sidebar: Bird Nests and the Migratory Bird Treaty Act*). In general, we recommend that management activities that might affect birds nesting in young conifer forests be avoided or minimized during the period from April 15 to July 31. These dates generally ensure that management will occur after nesting has been completed for > 90% of the individuals of > 90% of the species in most places in the Pacific Northwest (exceptions are mostly due to latitude or elevation). When considering management outside these dates (for example, early April or early August), land managers should evaluate the potential for nesting species at these times, in particular priority or focal species (see Table 4).

Western Tanager—photo by Matt Lee

Bird Nests and the Migratory Bird Treaty Act

Most bird species in young conifer forests are non-colonial and highly secretive about their nests. Because of their quiet demeanor and well-camouflaged nests, it can be easy to destroy one without knowing it. Destruction of active bird nests is a violation of federal law. Under the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703), it is illegal to "take" migratory birds, their eggs, feathers or nests without a permit. "Take" includes by any means or in any manner, any attempt at hunting, pursuing, wounding, killing, possessing or transporting any migratory bird, nest, egg, or part thereof. The MBTA does not distinguish between "intentional" and "unintentional" take. All native birds except galliformes (for example, quail and grouse) are protected under the MBTA.

The U.S. Fish and Wildlife Service (Service) is the federal agency responsible for administering the MBTA. Permitted take under the MBTA is allowed for a variety of activities including scientific collecting, falconry, tribal uses, hunting, etc., but in general there is no exception for "take" associated with land management activities. The Service does not issue permits for incidental take of migratory birds under the MBTA. It is important to remember that final responsibility for compliance rests with the individual conducting the activity.

Forest Fragmentation

Forest fragmentation is a landscape-level process (McGarigal and McComb, 1995) that involves both the reduction of forest area, and the isolation of forest patches (Harris, 1984). In the Pacific Northwest, the reduction and isolation of patches of older forest that have become surrounded by young stands managed for timber production has been referred to fragmentation (Bunnell and others, 1999). However, forest fragmentation does occur naturally and should not be interpreted solely in terms of negative impacts (Franklin and others, 2002).

There is an extensive amount of literature on the effects of forest fragmentation on wildlife in western North America, including summary publications on wildlife (Rochelle and others, 1999) and birds (George and Dobkin, 2002). The negative effects of forest fragmentation observed in eastern and midwestern North America from increased nest predation and parasitism have not been reported as significant in western forests (Schieck and others, 1995; Manuwal and Manuwal, 2002) (*Sidebar: Forest Fragmentation and Birds in the Pacific Northwest*). However, one concern in the Pacific Northwest regarding fragmentation is the reduction of the size of forest patches, particularly late-successional forest (McGarigal and McComb, 1999), and potentially, the older stages of young forests. This and other potential consequences of fragmentation on birds in young conifer forests are briefly described in the following sections.

Patch Size

Every pair of breeding birds requires some minimum area of habitat to meet its daily requirements for food, shelter and nesting. For most bird species that breed in young conifer forests, this area is usually < 5 hectares (12 acres) per pair, although some species have much larger requirements (Table 5).

Patchwork of young and regenerating stands characteristic of managed forest landscapes in the Pacific Northwest—photo by Bob Altman

Among most bird species that breed in early-successional forests, patch size for occupancy generally is not as limiting a factor as it is for late-successional species. For example, species like Orange-crowned Warbler, Rufous Hummingbird, and Willow Flycatcher will nest in patches of suitable habitat as small as 2 hectares (< 5 acres) in size even if embedded in a landscape of older forest (B. Altman, unpub. data). However, for a few species, such as Olive-sided Flycatcher, Townsend's Solitaire, and Western Bluebird, the size of the young forest patch can be important. For example, a single pair of Olive-sided Flycatchers requires at least 16 hectares (40 acres) and may require up to 40 hectares (100 acres) (Altman and Sallabanks, 2000).

Some forest bird species require patches of contiguous habitat much larger than their territory to be able to maintain a presence or a viable population. These species are referred to as forest-interior or area-sensitive species. In the Pacific Northwest, there is recent evidence at the forest patch scale to support this status during the breeding season for 10 bird species in late-successional forests (summarized in George and

Table 5. Categories of breeding season territory sizes for some bird species associated with young conifer forests in the Northern Pacific Rainforest Bird Conservation Region.

Average Territory Size	Species Examples
< 1 hectare (2.5 acres)	Hermit Warbler, Rufous Hummingbird, Willow Flycatcher
1-5 hectares (2.5-12 acres)	Chestnut-backed Chickadee, Pacific-slope Flycatcher, Swainson's Thrush
5-10 hectares (12-25 acres)	Hairy Woodpecker, Red-breasted Sapsucker, Western Tanager
10-25 hectares (25-62 acres)	Northern Flicker, Townsend's Solitaire, Varied Thrush
25-50 hectares (62-124 acres)	Olive-sided Flycatcher
> 50 hectares (124 acres)	Gray Jay
> 100 hectares (248 acres)	Pileated Woodpecker

Brand, 2002). The species for which there is the most evidence of area sensitivity include Brown Creeper, Chestnut-backed Chickadee, Golden-crowned Kinglet, Pileated Woodpecker, Red-breasted Nuthatch, Varied Thrush, and Winter Wren. Additionally, demographic monitoring and landscape analyses strongly suggest area-sensitivity for Pacific-slope Flycatcher (Nott and others, 2005). All these species also occur in lower abundance in the latter stages of young forests (that is, mid-successional) where it is suspected that the same area-sensitivity is applicable.

Edge

One of the outcomes of increased fragmentation is a higher ratio of edge to interior habitat (Primack, 1998). Edges occur where two vegetation communities of dissimilar composition, structure, or age adjoin (Thomas and others, 1979). While it is true that a higher diversity of bird species often can be found in edge habitats (Kremaster and Bunnell, 1999), and some edge species like Olive-sided Flycatcher (McGarigal and McComb, 1995; Altman and Sallabanks, 2000) and Western Wood-Pewee (Hagar and others, 1995; Bemis and Rising, 1999) need the juxtaposition of forest openings and older forest, edge habitats are widely available throughout forested landscapes of the Pacific Northwest. Thus, the creation of edge need not be a management objective for land managers. Furthermore, where the creation of edge is necessary (for example, a clear-cut harvest), the benefits to edge species like Olive-sided Flycatcher and Western Wood-Pewee can be enhanced by feathering or buffering harvest unit edges to decrease contrast with adjacent forest (Hunter, 1990).

Bird response to edges is highly variable and dependent on numerous factors ranging from changes in microclimatic conditions (Franklin and Forman, 1987; Chen and others, 1999) to major changes in interspecific interactions among species (Sisk and Battin, 2002), including the potential for increased nest parasitism, especially in urbanized landscapes (Marzluff and Restani, 1999). However, few negative effects have been consistently documented for edges in western forests (Kremaster and Bunnell, 1999). Where the landscape matrix is regenerating forest, our understanding of edge effects on bird communities is limited and often site-specific (Nott and others, 2005), and potentially different for the same species at different sites (Kremaster and Bunnell, 1999).

Forest Fragmentation and Birds in the Pacific Northwest

In eastern and midwestern North America, where forest fragmentation has occurred in a landscape of agricultural and suburban development, significant negative effects have been reported on bird populations in the form of increased nest predation and parasitism along edges of and within forest patches (Thompson and others, 2002). However, in the Pacific Northwest, the landscape associated with forest fragmented by management is most often composed of forest, just different age classes. Limited studies suggest there is little evidence to support broad-scale negative effects of nest predation or parasitism on bird populations in these fragmented forests (Schieck and others, 1995; Manuwal and Manuwal, 2002). Despite a lack of compelling evidence of broad-scale effects, some studies have reported local decreases in nest success due to predation where fragmentation has occurred (for example, Swainson's Thrush; George and Brand, 2002). Additionally, where fragmentation has occurred at low elevations near the juxtaposition of forest and agricultural habitats, parasitism by Brown-headed Cowbird may be a concern (Chambers and others, 1999).

Connectivity

If the forest landscape is characterized by a mosaic of patches of different forest age classes, birds may need to move from one habitat patch to another in order to secure sufficient suitable habitat. Although birds are very mobile compared to animals that can't fly, some are reluctant to venture across unsuitable habitat. For species associated with older forest, a strip of older forest or regularly scattered older trees across an area of early successional forest may help to provide connectivity to make intervening habitat more suitable. Although this connectivity may not be essential (*Sidebar: Forest Connectivity and Birds: How Important Is It?*) it does facilitate movement and some birds will use these areas rather than fly across open areas or areas of less suitable habitat. For birds associated with young conifer forests, there is less concern about connectivity unless the intervening habitat is non-forest.

While strips of forest connecting larger forest blocks may facilitate the dispersal of some bird species, managers should be aware of a potential negative impact. If connecting corridors of habitat can function as conduits for dispersing birds, they can similarly concentrate predators and elevate levels of predation (Hess, 1994). The jury is still out on the efficacy of connective corridors (With, 1999), and research is needed to determine the optimal pattern of connectivity for different bird species in Pacific Northwest conifer forests.

Black-headed Grosbeak—photo by Matt Lee

Forest Connectivity and Birds: How Important Is It?

A topic frequently discussed by wildlife managers in Pacific Northwest conifer forests is the importance of maintaining connectivity among forest patches. Linkages among habitat patches may be necessary for some forest animals (for example, small mammals) because of their reluctance to traverse unsuitable habitat when dispersing in search of resources. Although this may be true for some wildlife, there is less support for the need for connectivity of forest patches for birds (With 1999). Most species of birds that breed in temperate forests are capable of flying long distances and negotiating a wide variety of habitat types. Even those species that are strongly associated with closed-canopy forests and are reluctant to cross openings may not require full corridors of intact forest in order to move between forest patches. What seems to be of greatest importance is the nature of the intervening area between the forest patches. As long as that gap remains as forest with a moderate degree of retained habitat structure suitable for a particular species (for example, big trees, snags, and shrubs), even if it is of low to marginal habitat quality for the species, it may be sufficient to support movement and dispersal of most bird species (McComb, 1999). However, anecdotal evidence suggests the need for relatively contiguous older forest patches by the Brown Creeper. This resident species is a small, relatively weak flier that prefers to make short flights from one large tree to the next beneath the forest canopy rather than to cross open areas (Hejl and others, 2002). Therefore, a connecting patch of older forest or regularly scattered large trees across a forest clearing would be necessary to facilitate crossing for this species.

Deciduous Vegetation

The presence of deciduous trees within young conifer forests greatly enhances bird species abundance and richness (Huff and Raley, 1991; Willson and Comet, 1996). Two principal reasons for this are enhanced cavity and enhanced insect availability over conifer trees. Hardwood trees, such as bigleaf maple, Oregon white oak (Gumtow-Farrior, 1991), and Pacific madrone (Raphael, 1987) provide disproportionately greater habitat availability for natural cavity development or cavity excavation than conifer trees. As described earlier (see Forest Food Resources and Breeding Birds), deciduous trees and shrubs provide diverse and abundant insect resources that complement those of conifer trees, and are especially important early in the nesting season. Maintaining components of deciduous vegetation would greatly enhance habitat for several bird species highly associated with these conditions including Black-headed Grosbeak, Black-throated Gray Warbler, Pacific-slope Flycatcher, Ruffed Grouse, and Warbling Vireo.

Fire and Bird Habitat

Wildfire is an occasional natural occurrence that can affect breeding bird habitat in young conifer forests, especially in southwestern Oregon and northwestern California. Wildfire cycles are highly variable throughout Pacific Northwest rainforests (Agee, 1993). Management after wildfire has an important influence on breeding bird habitat in the developing young forest. In general, management to create habitat conditions that support the bird-habitat relationships described throughout the Guide is also applicable to post-fire young conifer forest.

There is little information on the response of birds to wildfire in the Pacific Northwest (Huff and others, 2005). Most data come from studies in forests of the arid west or from late-successional Pacific Northwest forests (Bond and others, 2002). Some data on bird response to wildfire are beginning to emerge from studies of recent fires in southwest Oregon. Of particular concern is the practice of salvage logging which removes some amount of dead and/or dying trees and has the potential to negatively affect a number of cavity-nesting bird species associated with the abundance of these features after a wildfire (Hutto, 1995).

In general, prescribed fire is not used as a management technique for bird conservation in conifer forests in the Pacific Northwest (Huff and others, 2005). However, it is being used for other management purposes such as fuels reduction, and can support some bird habitat objectives. For example, fuels reduction in young conifer forests of southwest Oregon could open up the understory to provide suitable habitat for Chipping Sparrow and Common Nighthawk depending on the degree of canopy forest trees present (specifically, few for Common Nighthawk, few to many for Chipping Sparrow) and the degree of fuels reduction (specifically, slight with patchy remnants for Chipping Sparrow, extensive for Common Nighthawk).

Strategizing Among Desired Habitat Features and Bird Species

After considering all the information above, a habitat management strategy can be developed to meet bird conservation objectives. Initially, we recommend consideration of the approach put forth by PIF – that management objectives be driven by the habitat needs of the species of greatest conservation concern (see Table 4). This approach recognizes the need to emphasize some bird species over others because of their current and/or projected future status. It also provides opportunities to manage for relatively specific habitat conditions to support these species needs.

Another strategy is to provide for the diversity of native bird species that should occur within the area and within the current and future habitat types. For this strategy, it is important to consider providing and maintaining a diversity of appropriate habitat components at the proper scale and condition, including: snags, big trees, old shrubs, shrub patches, berry or nectar producing shrubs, deciduous trees, and structural diversity. However, it is important to recognize that objectives for diversity are scale-dependent (*Sidebar: Bird Species Richness: A Matter of Scale*).

A sound strategy that combines these two approaches (i.e., priority species and habitat diversity) is to manage for species diversity at larger scales, and emphasize the habitat conditions that meet the more specialized needs of priority or focal species at smaller scales. This is often referred to as the coarse-filter/fine-filter approach to conservation. An example would be thinning to open up the canopy and promote development of a dense understory for a variety of understory-associated species, and then within a portion of the area emphasize the development of berry-producing shrubs/small trees like cascara or elderberry for Band-tailed Pigeon. Additionally, given sufficient space, the open canopy in a large patch of the forest could be expanded leaving scattered trees to provide suitable habitat for Olive-sided Flycatcher. The outcome of this combined strategy would be a coarse-scale emphasis on a variety of species that use a dense understory along with finer-scale emphasis on the habitat features required by priority species Band-tailed Pigeon and Olive-sided Flycatcher.

Bird Species Richness: A Matter of Scale

One of the most frequently used means of evaluating bird populations is species richness - the total number of bird species in the community or place of interest. This metric can be valuable when used to compare avian communities over large and naturally heterogeneous landscapes where diversity of habitats and bird species is to be expected. However, misuse often occurs when the scale of the evaluation is relatively small. At smaller scales, the individual habitats or habitat components of the larger-scale diversity often are the most ecologically appropriate conservation target, thus, habitat diversity and species richness are likely to be inappropriate targets or metrics. Managing a forest patch for a mixture of age classes and conditions or managing to emphasize edge habitats may result in high species richness, but these situations are likely to favor more generalist species to the exclusion of area-sensitive and often priority species. Meeting the needs of the greatest number of species (that is, biodiversity) should not be a standard goal at small scales (Hansen and others, 1995), particularly if that approach fails to address conservation of priority species or habitat conditions. Thus, for most management, except at large scales such as watersheds, we recommend an emphasis on management to maintain populations of focal or priority species rather than an emphasis on the number of species that can be achieved.

Planning Ahead: Development of Old Forest Habitat

Forest structural composition and patterns established in the early successional stages often determine conditions in the later stages. Driven by increasing concern for the habitat needs of species associated with old forests, land managers and researchers are working together to refine techniques for promoting the development of old forest habitat from young forests in the shortest possible time frame (Franklin and others, 1997). Thus, in young forests, one management objective for breeding bird habitat often is to provide the more diverse structure characteristic of older forests, than the simplified structure typical of even-aged management (*Sidebar: Young Forests to Old Forests: It's More Than Just Time*).

Many bird species associated with older forests require particular habitat features that take long periods of time to develop, such as large trees and snags, and understory shrubs with stems large enough to support lush epiphyte mats. Although no studies have been ongoing for more than 10 years, initial monitoring results show that some bird species associated with older forests, such as Olive-sided Flycatcher and Hairy Woodpecker, may respond positively to management of young forest to promote development of old-forest habitat (Hayes and others, 2003; Hagar and others, 2004).

Addressing the conservation of older forests and/or the species associated with them at a site where the forest is in early or mid successional stages and old forest structural features have not been retained is a long-term commitment. However, the site can be managed in the early stages to set it on a trajectory to achieve desired older forest conditions and associated species. One of the most effective ways to do this is to manage tree density early in stand development (that is, before canopy closure) to help maintain a diverse stand structure throughout the life of the stand (Curtis and others, 1998). This is because the older a tree becomes, the less ability it has to respond with increased vigor to changes in the environment (Tappeiner and others, 2002). Over 70% of the height growth and crown development of most conifers in the Pacific Northwest occurs before the trees are 60 years old (Tappeiner and others, 2002). The shaping of stand structural features must therefore begin long before the fifth decade, when trees are still able to respond positively to a decrease in density.

Working on the Ground

Management of young conifer forests for birds requires an understanding of how the management will change the vegetation and the corresponding changes that may occur in bird populations. Bird response to forest management practices is dependent upon many factors - there is no "one size fits all" prescription for management to provide bird habitat. In general, the greater the change in the vegetation, the greater the change in the bird community. Intensive management such as clearcut logging can change nearly the entire bird community, while less intensive types of management such as thinning or retention of certain structural features will change bird species composition and abundance to a lesser degree.

The following section provides some recommendations for management actions that can be used to shape stand-level forest structure and composition for some of the desired habitat features or conditions for birds in young conifer forests. The desired features highlighted in Table 6 are those most often associated with priority or focal birds in young conifer forests and are features strongly influenced by management.

Young Forests to Old Forests: It's More Than Just Time

It seems intuitive to assume that young forests will eventually become old forests given enough time. However, it may come as a surprise to many that this assumption is not necessarily valid for all young stands. Many contemporary old-growth stands developed under conditions unlike those in today's young stands (Curtis and others, 1998). In particular, trees typically grew at much lower densities (typically < 50/hectare [20/acre]) than are common today (Tappeiner and others, 1997; Poage and Tappeiner, 2005). Tree regeneration following a natural disturbance, such as fire, came in at low densities and was more patchily distributed than in today's planted forests. Without management, trees that were able to become established through natural processes following a disturbance may have had to contend with fierce competition from vigorous early successional vegetation. But once they topped the understory, these trees could put on a spurt of growth in the absence of competition from neighboring conifers. Trees growing rapidly in the open produced the large lateral limbs, deep crowns, and large-diameter, tapered stems that are signature characteristics of old-growth. In contrast, stands developing at high densities produce trees with small lateral limbs, short crowns, uniformly narrow stems, and low resistance to wind, disease, and insects (Tappeiner and others, 1997). Because these traits will only become more accentuated throughout the life of a stand, there is considerable doubt that dense plantations will ever achieve the defining habitat characteristics of old-growth without significant silvicultural intervention early in the life of the stand (Curtis and others, 1998).

Thinning

Thinning is a traditional and versatile silvicultural practice used to manipulate forest stand structure. Traditionally, the goal of thinning was to maximize timber production and increase harvest efficiency by channeling resources from many small stems to fewer large stems. This was usually accomplished by removing just enough stems to increase the growth of the remaining trees, and favoring only commercially valuable species. Stands managed with this type of thinning tend to be homogenous in structure and composition (DeBell and others, 1997). It may seem surprising then, that thinning is currently receiving much attention as a valuable tool for increasing structural diversity in young conifer forests. Because stand density has such a large influence on characteristics such as tree size, crown depth, and understory development, (Tappeiner and others, 2002), the control of density through thinning is a practical means of manipulating these structural features for birds and other wildlife. However, modification of traditional evenly spaced, low intensity thinning is necessary to achieve goals related to enhancing bird habitat. Below are some considerations for using thinning to manage habitat for birds.

Retained trees contributing to structural diversity of developing conifer monoculture—photo by Bob Altman

Short and Long-Term Goals and Objectives

As a tool that can be used to shape the development of young forest stands, thinning should have both short- and long-term goals and objectives. Short-term goals may be to increase structural diversity to increase the niches available for birds, or to create habitat for a particular species or set of species (for example, shrub-associates). Specific objectives that will help achieve these goals may include creating sufficient openings in the canopy to promote development of understory and mid-story vegetation, and retaining a representative mixture of tree and shrub species.

Long-term goals of thinning may include creating structural features typical of old forests. A specific objective related to this goal might be to accelerate the growth of residual trees. Thinning to enhance creation of late-successional forest habitat is a relatively new concept, but has the potential to accelerate development of habitat for birds associated with late successional conditions (Garman and others, 2003).

Spacing Considerations

Thinning to create habitat for birds requires a modification of the traditional even spacing grid to determine which trees to harvest. The disadvantage of a traditional, even-spaced grid is that it can create homogenous structure that limits bird species diversity. As an alternative, variable density thinning (Carey and Wilson, 2001) uses criteria that are more biologically meaningful than spacing. An example would be leaving trees according to desired species composition or tree characteristics, such as size, or presence of cavities or large limbs. The flexibility of variable density thinning supports the rationale for leaving trees of low economic but high ecological value (for example, limby "wolf" trees).

Effects of Thinning on Understory Conditions

Thinning has the potential to significantly increase habitat availability for shrub-associated birds. However, the benefits are conditional on the impact of harvest and the time required for recovery of understory shrubs. In order to minimize the immediate negative impacts of thinning on habitat for species associated with a well-developed understory, it will be necessary to protect shrub patches during harvest operations.

The high productivity of most Pacific Northwest rainforest sites can result in the shading and suppression of understory vegetation. Maintaining suitable understory conditions for birds beneath young forest canopies can be a challenge. Sites with rapid growth may need heavy thinning or multiple thinning entries if long-term maintenance of understory vegetation is desired (Alaback and Herman, 1988). Additionally, some pruning of limbs from retained trees can further open up the forest floor to sunlight and help sustain the positive response of understory shrub development longer, while simultaneously retaining tree stems and canopy.

Managing for Multiple Tree Species

Thinning is an effective way to manipulate tree species composition to favor tree species preferred by birds that are management targets. For example, thinning to develop large Douglas-fir trees will promote habitat in the long-term for Brown Creepers (Weikel and Hayes, 1999) and Hermit Warblers (Pearson, 1997). Another approach is to manipulate the density around leave trees to favor growth. In particular, shade-intolerant tree species (for example, Oregon white oak) are likely to respond more noticeably to a heavy thinning.

Table 6. Desired habitat features for breeding birds in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region, and management activities that may be used at various stages of stand development to achieve those features.

Desired Feature	Early Successional Management	Mid Successional Management	Examples of Bird Species to Benefit (successional stage)[1]
Large Conifer Trees	□ Retain existing large trees □ Establish stands at low densities (< 500 trees per hectare [200/acre]) to maximize individual tree growth □ Thin to maintain growth rates	□ Thin to accelerate growth rates □ Use long rotations to maximize growth □ Recruit and maintain replacement large trees	Brown Creeper (mid); Chestnut-backed Chickadee (mid); Hermit Warbler (mid); Olive-sided Flycatcher (early)
Large Snags	□ Retain existing large snags □ Create snags through topping, girdling, etc. of residual green trees	□ Create snags through topping/girdling etc. of residual green trees □ Use long rotations to maximize time for snags to develop	American Kestrel (early); Chestnut-backed Chickadee (mid); Pileated Woodpecker (mid); Purple Martin (early); Western Bluebird (early)
Deciduous Trees	□ Retain existing deciduous trees □ Plant deciduous trees and manage for their survival □ Thin competing conifers to open the canopy and enhance deciduous tree development	□ Protect deciduous trees and patches when thinning conifers □ Thin competing conifers to open the canopy and enhance hardwood development	Black-throated Gray Warbler (mid); MacGillivray's Warbler (early); Pacific-slope Flycatcher (mid); Red-breasted Sapsucker (mid); Wilson's Warbler (early)
Berry and Nectar Producing Trees and Shrubs	□ Retain existing berry and nectar producing trees and shrubs □ Plant berry and nectar producing trees and shrubs and manage for their survival	□ Maintain low percent canopy cover for a light-rich environment □ Protect shrub patches when thinning	Band-tailed Pigeon (early and mid); Cedar Waxwing (early and mid); Rufous Hummingbird (early and mid)
Mixture of Tree Species	□ Retain a diversity of tree species □ Conduct mixed species plantings	□ Retain a diversity of species in thinning prescriptions	Band-tailed Pigeon (mid); Black-throated Gray Warbler (mid); Varied Thrush (mid)
Multi-layered Structure	□ Retain a mixture of leave tree and shrub species □ Maintain low percent canopy cover to encourage diverse understory □ Conduct mixed species plantings □ Cut some hardwoods to encourage sprouting	□ Thin to low relative densities □ Favor mid-story hardwoods in thinning prescriptions □ Use long rotations to maximize time for multi-layered structure to develop □ Protect pockets of natural regeneration □ Retain live trees at final entry to provide greater canopy layering in subsequent stands	Band-tailed Pigeon (mid); Red-breasted Sapsucker (mid); Varied Thrush (mid)
Old Shrubs	□ Retain and protect old shrubs □ Maintain low percent canopy cover to encourage understory development	□ Protect old shrubs during thinning □ Thin to low relative densities to maintain open canopy	MacGillivray's Warbler (early and mid); Rufous Hummingbird (early and mid); Swainson's Thrush (early and mid); Wilson's Warbler (early and mid)
Shrub Patches	□ Retain and protect shrub patches □ Thin to encourage understory development □ Cut some hardwoods to encourage sprouting	□ Protect shrub patches during thinning □ Thin to low relative densities to maintain open canopy	Blue (Sooty) Grouse (early and mid); MacGillivray's Warbler (early and mid)
Large Woody Debris on Forest Floor	□ Retain and protect existing down logs, especially large ones □ Recruit live trees for large down logs	□ Thin to accelerate growth, then create logs □ Use long rotations to maximize time for trees to grow; □ Fell and leave some trees as logs	Blue (Sooty) Grouse (early and mid); Pileated Woodpecker (early and mid); Winter Wren (early and mid)

Table 6. Desired habitat features for breeding birds in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region, and management activities that may be used at various stages of stand development to achieve those features.—Continued

Desired Feature	Early Successional Management	Mid Successional Management	Examples of Bird Species to Benefit (successional stage)[1]
Variation in Overstory and Understory Cover (patchiness and edges)	□ Thin to encourage diversity in the overstory and understory □ Conduct variable density planting of conifer and hardwood species	□ Conduct variable density and variable spaced thinning □ Conduct single tree and group selection harvests	Blue (Sooty) Grouse (early and mid); Olive-sided Flycatcher (early and mid)

[1] The emphasis is on birds identified in Table 4 because of their recognition as priority or focal by Partners in Flight at different levels (i.e., state/provincial, regional, international).

On the other hand, shade-tolerant tree species (for example, western hemlock) may experience less shock and better growth in a lightly thinned environment.

Effect of Thinning on Snags and Logs

Thinning can have a short-term negative effect on the availability of dead wood because, by its very nature of decreasing competition among leave trees, thinning reduces or eliminates the source of woody debris provided by competition mortality. One possible measure to overcome this is to kill some trees during or after the thinning process to create snags and logs. Topping trees to create snags contributes to both standing and downed dead wood habitat if the tops are left on site. Trees that are injured during the thinning process also may become snags, and managers may plan where to accept greater risk of tree injury in order to increase potential for snag recruitment. Trees in thinned stands are likely to achieve large diameters sooner than trees in dense stands, making thinning a useful strategy for recruiting large snags over the long term. Once trees have attained a suitable size to support cavity-nesting species, large snags may be created. Another solution to the problem of woody debris shortage in thinned stands is to use variable density thinning to maintain some dense patches of trees as sources of competition mortality.

Shrub development in Douglas-fir stand after partial harvest—photo by Bob Altman

Achieving Old Forest Structure Through Thinning

Modified thinning of young stands can produce two results that promote the development of the complex structure characteristic of late-successional forests:

- By reducing competition and creating space, thinning affects stem size, crown characteristics, and vigor of trees (Curtis and others, 1998). First, thinning can promote the development of thick, tapered stems characteristic of old-growth trees. Such stems are more resistant to windthrow and remain standing longer after they are dead (providing habitat for snag-associated species) than narrow cylindrical stems. Thinning also can promote the retention of lateral branches, which become thicker with age (providing substrate for nests and epiphytes). Conifers that grow free from competition with close neighbors form deep, wide crowns. Thick lateral branches and deep crowns are unique features of old-growth trees that are important to several bird species, both in late-successional forests and as legacy structures in younger forests. Like conifers, hardwood trees may also respond to thinning with increased crown development (Tappeiner and others, 2002). Finally, by reducing competition for resources, thinning can maintain or enhance tree vigor. Vigorous trees are more resistant to insects and disease, and are more likely to survive, grow rapidly, and provide structurally complex habitat.
- By opening the canopy and allowing light to reach understory vegetation, thinning can increase stand-level structural diversity (Bailey and Tappeiner, 1998). Understory shrubs respond to increased light with greater production of stems, foliage, flowers, fruits, and seeds, providing important food and cover resources for many bird species. Tree seedlings also become established under canopies opened by thinning, creating the option of managing for multi-storied structure.

Bird Response to Thinning

Much has been learned about bird response to thinning of young forests in the Pacific Northwest over the last decade. As might be expected, individual species respond differently depending on their habitat requirements and the intensity of the thinning (Hansen and others, 1995). Results from the nine thinning studies presented in Appendix E and summarized here (*Sidebar: Summary of Bird Response to Thinning*) should provide land mangers with a good baseline of data from which to evaluate effects of their thinning activities.

Retention of Forest Structure

Forest retention, (for example, leaving trees, snags, shrubs, or patches of forest during harvest or other management activities) is a management practice that is mostly conducted at rotation harvest (USDA Forest Service and USDI Bureau of Land Management, 1994) and can have a large effect on bird habitat in the subsequent young conifer forest (Hansen and others, 1995). This practice has been referred to in a variety of ways, such as structural retention, green-tree retention, residual structure, legacy structure, wildlife trees, leave trees or leave snags or leave islands, wildlife tree patches, etc. The emphasis in forest retention is on what is left behind after management.

The concept of retention of forest structure during management, especially "legacy structures" from old forests, has recently been promoted as a way to maintain biodiversity and the structural and ecological elements of older forests (which have been reduced across the Pacific Northwest landscape in the last 50 years) throughout all stages of forest succession (Franklin and others, 1997). This can be particularly effective where harvest rotations are otherwise too short to allow these characteristics to develop. The premise is that if older forest components are "left behind" then these areas may become

Summary of Bird Response to Thinning

- In general, thinning does not change habitat so dramatically that some species are no longer able to occupy it (that is, species are usually not "lost" as a result of thinning).
- Species that nest in closed forest canopies generally decline in abundance, and species associated with open forest canopies generally increase.
- hinning often creates habitat for species that are rarely, if ever, observed in dense, young stands (for example, Chipping Sparrow, Dusky Flycatcher, Olive-sided Flycatcher, Townsend's Solitaire, Western Wood-Pewee).
- Although the abundance of some priority and/or declining species is often reduced in thinned stands in the short-term (for example, Golden-crowned Kinglet, Hermit Warbler, Pacific-slope Flycatcher, Varied Thrush), most of these species show similar or increased abundance in the longer-term (that is, within 10 to 20 years).
- Some species consistently show a pattern of initial change in abundance in the first few years after thinning followed by a return to their pre-thinning abundance. For example, American Robin and Hairy Woodpecker typically show an initial increase in abundance, while Hermit Warbler and Varied Thrush typically decrease in abundance initially; all often return to pre-thinning abundance over time.
- Some species consistently show no response to thinning with abundance similar in the short and long-term (for example, Black-headed Grosbeak, Steller's Jay).
- Some species show no consistent pattern of response to thinning (for example, Brown Creeper, Hutton's Vireo, Swainson's Thrush, Wilson's Warbler, Winter Wren). Most of these are understory associates indicating the importance and variability of local conditions both pre- and post-thinning.
- Some species appear to respond to thinning intensity. Abundances of Golden-crowned Kinglet, Pacific-slope Flycatcher, and Varied Thrush are less in heavily thinned stands than in moderately or lightly thinned stands. Showing the opposite response, Evening Grosbeak tends to have higher abundance in heavily thinned stands than in moderately or lightly thinned stands.
- Species that generally respond positively to thinning represent a broad range of successional stage associations, from early- (for example, Dark-eyed Junco, MacGillivray's Warbler, Townsend's Solitaire), to mid- (for example, Western Tanager), and even late-successional species (for example, Hammond's Flycatcher, Red-breasted Nuthatch).
- Species that generally respond positively to thinning represent a variety of foraging guilds, including the ground-foraging Dark-eyed Junco, foliage-gleaning Western Tanager, bark-foraging Red-breasted Nuthatch, and aerial insectivore Hammond's Flycatcher.

refugia where species that depend on these features may be able to persist. Thus, there is inherent value in retaining desirable features that might otherwise take many years or decades to achieve through management.

Forest retention, in the context of young forest management, can be an important tool to provide increased structural heterogeneity in younger forests (Hansen and others, 1995). Additionally, these retained features may facilitate connectivity between areas of older forest for species that have limited incentive to move across a clearcut.

Factors to Consider

There are several components to forest retention that determine the value to bird species. These include the pattern of retention, the amount of retention, the size of the retained components, and the age and existing conditions of the retention components. A few of the major factors for consideration follow.

Generally, there are three patterns of retention at the stand-level:

- Dispersed (scattered) – individually retained forest components are more or less evenly distributed across the harvested area
- Grouped (clumped or aggregate) – small groups or patches of forest components are retained
- Mixed – a combination of the first two which can be relatively uniform or preferably somewhat random (*Sidebar: Sloppy Forestry*)

The amount of retention refers to the percent of the forest canopy or volume of wood that is retained relative to the area harvested. Government regulations (for example, federal, state, provincial, and county) often stipulate how much forest is to be retained on harvest units and in ecologically sensitive areas (for example, riparian buffer zones). Suggestions in the Guide are intended for land managers who want to retain forest elements for bird habitat beyond what is required by policy. However, it may be desirable to design the retention to complement regulatory requirements or other management if it can meet some broader objectives, such as connectivity or increased size of patches of contiguous forest for area-sensitive species.

The Guide only discusses dispersed retention because the retained forest components become part of the subsequent young forest. As presented above, retention of intact patches of forest is more applicable to a discussion of bird species associated with older forests because the retained forest patch is forest of harvest age and thus, is beyond the scope of the Guide. Additionally, the Guide focuses on bird response to dispersed forest retention of live trees or “green-tree retention” because nearly all of the dispersed retention studies have focused on live trees.

Sloppy Forestry

The natural world is generally devoid of straight lines and neat edges. Natural disturbances often leave a chaotic patchwork of dead, damaged, and surviving vegetation in their wake. Forestry practices that mimic these natural patterns are more likely to provide habitat that is similar to that with which birds associated with young conifer forest have evolved.

How Much and Where?

After recognizing the value of retaining particular habitat features during management, decisions are necessary regarding how much to leave (the level of retention) and where to leave it (the pattern of retention). These decisions largely depend on the bird species being targeted and the existing habitat conditions. For example, the existing locations of snags and shrub patches will limit options because they are usually not as well distributed across the area as trees. Where options exist, trees left dispersed relatively evenly across the area will make it more permeable to movement for forest interior species, such as Brown Creeper (Rosenberg and Raphael, 1986; Brand and George, 2001). Trees left in clumps, especially if adjacent to the existing stand, may provide a larger area of contiguous habitat more suitable for area-limited species, such as Varied Thrush (McGarigal and McComb, 1995; Schieck and others, 1995). For some species associated with older forests that do not seem to be area-limited, such as Hermit and Townsend’s Warbler, the pattern of retention is less important than how much forest cover is retained for these cover-limited foliage gleaners. Some species, like Pacific-slope Flycatcher, tend to be both area-limited and cover-limited, so clumping of retained forest patches is probably the best strategy if targeting this species.

Snags and Down Wood

It may be more efficient to retain snags than create them for at least two reasons. First, the cost to create snags can be avoided if a sufficient density of snags is retained to accomplish wildlife objectives. Secondly, it is not currently known if created snags provide comparable habitat to natural snags. Given this uncertainty, it is safest to assume that natural snags provide the most appropriate habitat for native species that have evolved with the natural processes that cause tree mortality.

Natural and created snags are continually being lost and degraded through disturbance and decay. Therefore, snag recruitment is an on-going process requiring forethought and planning for the retention of green trees for future snags. Knowing the snag requirements for cavity-nesting birds can assist in these decisions (Table 7).

Table 7. Relationships between cavity-nesting birds and snags in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region.[1]

Species	Nesting or Roosting in Snags	Foraging on Snags
American Kestrel	Near obligate cavity-nester in cavities created by cavity excavators or through other natural processes [2]	None
Barred Owl	Opportunistic cavity or platform nester in large snags and live trees	None
Bewick's Wren	Opportunistic cavity-nester using a variety of cavity or semi-cavity situations	None
Black-backed Woodpecker	Obligate cavity-nester and excavator in snags or dying trees (for example, heartrot)	Moderate use; also live trees
Boreal Chickadee	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes; also excavates cavities in soft heartwood	None
Brown Creeper	Semi-obligate cavity-nester in cavities created by cavity excavators or through other natural processes; often in crevices between trunk and loose bark	Minimal; mostly in live trees
Chestnut-backed Chickadee	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes; also excavates cavities in soft wood of large trees	None
Flammulated Owl	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes; mostly in snags	None
Great-horned Owl	Opportunistic cavity or platform nester in large snags and live trees	None
Hairy Woodpecker	Obligate cavity-nester and excavator in soft or hard snags	Mostly on soft snags
House Wren	Near-obligate cavity-nester in cavities created by cavity excavators or cavities or crevices created through other natural processes	None
Mountain Bluebird	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None
Mountain Chickadee	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes	Minimal; mostly in live trees
Northern Flicker	Near-obligate cavity-nester and excavator in soft or hard snags; will occupy any type of natural cavity	Moderate use
Northern Pygmy-Owl	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None
Northern Saw-whet Owl	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None
Pileated Woodpecker	Obligate cavity-nester and excavator in hard wood of dead or dying trees	Near obligate
Purple Martin	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None
Red-breasted Nuthatch	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes; also excavates cavities in soft wood of large trees	Minimal; mostly in live trees
Red-breasted sapsucker	Obligate cavity-nester and excavator in soft or hard snags	Mostly on soft snags
Tree Swallow	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None
Vaux's Swift	Obligate nester along walls of large hollow snags with heartwood decay	None
Violet-green Swallow	Near-obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None
White-headed Woodpecker	Obligate cavity-nester and excavator in snags (mostly) or dying trees (for example, heartrot)	Moderate use; also live trees
Western Bluebird	Obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None

Table 7. Relationships between cavity-nesting birds and snags in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region.[1]—Continued

Species	Nesting or Roosting in Snags	Foraging on Snags
Western Screech-Owl	Near-obligate cavity-nester in cavities created by cavity excavators or through other natural processes	None
Winter Wren	Opportunistic "nook and cranny" nester in cavities created by cavity excavators or through other natural processes	Opportunistic

[1] Detailed information on specific snag diameters and densities used by species of cavity-nesters is available at the Decayed Wood Advisor (DecAID) webpage – http://wwwnotes.fs.fed.us:81/pnw/DecAID/DecAID.nsf.

[2] "Other natural processes" refers specifically to tree development processes, such as broken limbs, disease, or old age.

Safety concerns associated with harvest operations around dead trees are often a barrier to snag retention. One approach to reduce these concerns is maintaining patches of snags or snags within patches of live trees where they can be safely avoided during management activities. An alternative long-term approach is to create snags (see below) from retained green trees after the harvest.

Deciduous Trees and Shrubs

As discussed earlier, the presence of deciduous trees is essential for some breeding birds in young conifer forests. Even a single large big leaf maple tree (*Sidebar: Big Leaf Maple: A Magnet for Early Spring Migrants*) or small patches of deciduous vegetation (for example, 15-20 meters square) (Morrison, 1982) can provide important habitat. Some sites with existing deciduous vegetation may have little impact on forest management for timber, and they provide excellent opportunities to manage for breeding bird habitat. For example, trees such as big leaf maple, red alder, and elderberry tend to thrive in seeps, wet depressions, small wetlands, or along permanent or intermittent stream courses. Red alder also is a fast-growing invader along forest roads, edges and logging landings. In drier parts of the Pacific Northwest, especially southwestern Oregon and northwestern California, retention of deciduous trees, such as oak or broad-leafed evergreens such as Pacific madrone, is important in young conifer forests because these trees provide hard mast (oak), berries (Pacific madrone) and cavities (oak and Pacific madrone) (Raphael, 1987).

Big Leaf Maple: A Magnet for Early Spring Migrants

A critical habitat need for many early spring forest migrants is the availability of insects to replenish fat expended during migration, get them through unpredictable spring weather, and ensure they are in good condition for breeding. Often, this need can be met through the presence of big leaf maple trees. This species is among the earliest to leaf-out in the spring and thus, is one of the first trees to support herbivorous insects. Furthermore, nutrients in the new leaves provide for a diversity of insects (Niemiec and others, 1995). The retention of individual big leaf maple trees, or small patches of trees, in the conifer-forest matrix, especially at low elevations, provides critical habitat for early-spring migrant foliage-gleaning insectivores. Even species that are strongly associated with conifer trees during the breeding season, such as Hermit Warbler, Townsend's Warbler, and Yellow-rumped Warbler, take advantage of the insect availability and forage extensively in big leaf maples during spring migration.

Hermit Warbler—photo by Stephen Dowlan

Flowers of bigleaf maple—photo by Bob Altman

Shrub retention during management activities also has the potential to enhance bird habitat in young conifer forests. Although shrubs may dominate early stages of succession, clear-cutting a forest stand does not immediately create quality habitat for shrub-associated bird species because shrub age and type are important. Older shrubs have more foliage (thus, provide more cover) and support more epiphytes (Rosso, 2000). Furthermore, maximum flower and fruit production by many shrub species occurs only after a certain stage of maturity is attained (Harrington and others, 2002; Kerns and others, 2004). The type of shrubs also is important in determining the resources provided (evergreen vs. deciduous; Hagar, 2004).

Bird Response to Forest Retention

Our knowledge of bird response to retention of forest structure is still in its infancy due to the relative newness of the management practice and the high potential variability in the spatial configuration and amount of retained forest structure. Additionally, most studies have been conducted within the first few years after retention (for example, Vega, 1993; Chambers and others, 1999; Chan-McLeod and Bunnell, 2003; Leu and others, unpub. data, 2006). Thus, cumulative and long-term effects of forest retention on bird species and populations are largely undocumented.

Summary of Bird Response to Forest Retention

- Of the species that remain in retention forest, their degree of use may only be for some of their life requisites (for example, foraging and dispersal), but perhaps not for nesting (for example, Brown Creeper; Chambers and others, 1999).
- Of the closed-canopy associated species that do persist in retention forest patches, their density is usually less than that of the pre-harvest closed-canopy forest (Beese and Bryant, 1999).
- The enhanced structural complexity in green-tree retention stands will likely provide habitat for late-successional specialists such as Chestnut-backed Chickadee or Hammond's Flycatcher, or edge specialists such as Western Tanager (Hansen and others, 1995).
- Edge species, such as Olive-sided Flycatcher, are likely to increase in abundance in forest leave patches because of the increase in edge habitat (Beese and Bryant, 1999; Chambers and others, 1999).

Varied thrush—photo by Stephen Dowlan

Pacific madrone with berries—photo by Bob Altman

Despite limited research on forest retention, some preliminary patterns are emerging in the response of breeding birds (*Sidebar: Summary of Bird Response to Forest Retention*). Much of the bird response is similar to that for thinning. For example, in the short-term, retention of forest canopy does not ameliorate the negative effects on the abundance of canopy dwelling species, such as Golden-crowned Kinglet and Hermit Warbler (Chambers and others, 1999; Leu and others, unpub. data, 2006). However, retention may improve habitat over complete canopy removal for species, such as Winter Wren and Western Tanager (Vega, 1993; Chambers and others, 1999; Chan-McLeod and Bunnell, 2003, Leu and others, unpub. data, 2006). Similar to thinning, some species, such as Black-headed Grosbeak and Black-throated Gray Warbler, show similar abundance pre- and post-dispersed retention (Chambers and others, 1999). However, initial data for some species indicate different responses between thinning and forest retention. For example, Chestnut-backed Chickadee and Red-breasted Nuthatch decreased in abundance in forest retention (Chambers and others, 1999; Leu and others, unpub. data, 2006) but have similar or increased abundance in thinning (Appendix E). Clearly, more data are needed to assess consistent patterns of bird response to forest retention.

An important unanswered question regarding forest retention is the viability of bird populations using retained forest. For this reason, it is important to distinguish the type of bird use that is occurring in association with these retained features. For example, birds may be “hanging on” in retention patches but not finding mates, or some may be paired and nesting, but are unsuccessful in raising young due to insufficient resources or increased levels of predation. However, even if retained features are insufficient for successful nesting, they may be valuable as bird habitat for foraging or dispersal, which would have been unavailable had the retention not occurred.

There also are some concerns about the value of retained live trees for breeding birds in young conifer forests. Both Vega (1993) and Chambers (1996) reported increased nest predation rates on some species in green-tree retention stands, potentially due to the increased surveillance opportunities provided by dispersed live trees used as perch sites by avian predators. Chambers and others (1999) also noted the regular use of retention trees by Brown-headed Cowbirds in low elevation forests, and the consequent potential for increased nest parasitism. Finally, forest tree retention may function as suboptimal habitat that attracts breeding pairs of forest interior species that fail to reproduce. These types of situations, referred to as ecological sinks, not only do not contribute to the population, but actually may be diminishing the population by attracting birds away from other areas where they may be more likely to be nesting successfully and contributing to the population.

Understory development in young (50-year-old) thinned stand in Oregon Cascades—photo by Joan Hagar

Fox Sparrow—photo by Stephen Dowlan

Managing Non-Native Vegetation

Most breeding bird species use vegetation that provides suitable structural characteristics independent of the species composition (that is, native versus non-native). Some exceptions are Rufous Hummingbirds that feed on nectar provided by certain species of plants such as flowering currant and columbine. Also, Band-tailed Pigeons and Cedar Waxwings feed on the berries of trees and shrubs such as elderberry and Pacific madrone. However, many non-native plants, such as Himalayan blackberry and scotch broom, are aggressive to the point of excluding other native forest vegetation, which then reduces the diversity of vegetative structure that many birds need. Thus, there is a negative impact on bird species from aggressive non-native vegetation, even though it may provide some resources in the short-term. Of course, there are many reasons beyond bird habitat for land managers to maintain and promote native vegetation in young conifer forests. Where non-native vegetation is being managed, short-term impacts on breeding birds can be minimized by conducting activities outside of the breeding season (see Timing of Management Activities).

Tree and Shrub Planting

Perhaps the most direct way to establish the desired trees and shrubs for birds is to plant what you want and manage for its survival. This is particularly appropriate if you are working in a situation where these features have not been retained from previous management or may be difficult to achieve even with management. The main advantage of planting is that you can create the species composition and structural conditions you want through designed plantings and maintenance. The major disadvantages of planting are the patience required to see the plantings grow into the desired forest structure, and the additional expense of the plantings themselves.

Habitat Augmentation

Brush/Slash Piles

Brush/slash piles created as a result of management activities may provide limited, short-term habitat in young conifer forests. Their primary use is as singing perches for species associated with open, early successional forest such as American Robin, Dark-eyed Junco, or Western Bluebird. Species, such as House Wren, Song Sparrow, and Winter Wren may use them as cover and short-term foraging sites, but brush piles provide minimal nesting habitat for birds in young conifer forests.

Harvested stand with retained trees, snags, and shrubs —photo by Bob Altman

Snag Creation

Numerous studies demonstrate that snags are essential, not only to the wildlife that use them directly for foraging or nesting, but also for the healthy functioning of the ecosystem in which they occur. Intensive forest management practices of the past have altered the abundance, size, distribution, and recruitment rates of snags in Pacific Northwest forests. The result is a lower density of snags, especially large diameter snags, in managed forests than would be expected under a natural disturbance regime. This deficit of snags over much of the landscape jeopardizes dozens of species associated with dead wood. Therefore, although killing a perfectly good tree to create a snag may seem like an anathema to many silviculturists, snag creation may be a necessary tool for maintaining populations of native birds. Furthermore, dead wood has such a critical role in the function of Pacific Northwest forests that the creation of snags can be thought of as an investment in maintenance or improvement of ecosystem health.

Snags can be created from live trees using a number of techniques, including topping with chainsaw, girdling, injection with herbicide, and inoculation with fungus. Topping of trees with a chainsaw can allow for subsequent salvage of tops, which may offset the cost of snag creation or create down woody debris for ecological purposes. Defective trees that are of low economic value make good candidates for snag creation by minimizing lost revenue and because such trees often have features that are valuable to wildlife, such as preformed cavities, hollow stems, and/or forks and crooks in the stem. Snags may be evenly dispersed throughout a stand, or clumped in distribution. Creating snags in patches along with retained green trees can minimize conflict with harvest operations, reduce susceptibility to windthrow, and provide for future snag recruitment.

House Wren—U. S. Fish & Wildlife image archive.

Dense shrub-sapling successional stage—photo by Bob Altman

Nest Boxes

There are 27 species of cavity-nesting birds associated with young conifer forests (Table 7). Under natural forest development and succession, many sources of mortality (for example, fire, disease, and competition) contribute to the abundance of dead or dying trees conducive to the development or excavation of cavities. However, in managed forests, one of the frequent deficiencies in bird habitat is the presence and/or abundance of snags. From a practical standpoint, some land managers remove them because the space they occupy reduces the number of young trees that can be planted. Other land managers may remove them due to worker safety concerns. Some even consider them unsightly and remove them for aesthetic reasons.

Nest boxes at the edge of a clearcut—photo by Erik Ackerson

The long-term solution for snag scarcity is to manage for more snags across the landscape through natural succession or longer harvest rotations and then retain snags as the forest ages. However, this approach, even when supplemented with snag creation, can take many years. Many of the conifer forest bird species associated with snags continue to experience population declines (25% of the declining species).

A short-term solution to augment snag deficiency (until a sustainable, succession-driven source of snags can be established) and support conservation of several declining bird species is to provide nest boxes for those cavity-nesting species that will use them. There is considerable information available on which species use nest boxes and how to build and place the boxes. A particularly useful book is *Birds in Nest Boxes* by Charlotte Corkran (Naturegraph Publishing, Inc. 2004).

Readers should be aware that there are some important considerations before establishing a nest box program. First, not all cavity-nesting species will use nest boxes. In particular, most woodpeckers do not use them or use them only infrequently. Additionally, nest boxes only provide for one aspect of the function of snags for birds – nesting and roosting cavities. This may be sufficient for species like American Kestrel, House Wren, Tree Swallow, Western Bluebird, and Western Screech-Owl which do not forage in association with snags. However, for most woodpeckers, snags also provide critical foraging habitat which is not addressed through the use of nest boxes. Finally, nest boxes should be monitored for use and need to be maintained over time. These activities add time and costs that need to be considered before initiating a nest box program.

Monitoring your Progress

To assess whether habitat management is resulting in the desired conditions for birds, some level of monitoring will be necessary. Monitoring should be designed to measure the change that is occurring over time to assess progress towards your goals. This may range from simply keeping a bird list for the site to systematic surveys designed to track progress of desired conditions for both the vegetation and the birds.

The response to habitat management varies with both the habitat and bird species. In addition, some management activities require significant time for the habitat and birds to respond, such as thinning to develop a dense, mature understory shrub layer for MacGillivray's Warbler or a structurally complex midstory and understory for Varied Thrush. Conversely, Olive-sided Flycatcher may respond quickly to management that creates an open canopy and edge habitat.

If access to qualified individuals to conduct the monitoring is limited, it may be necessary to seek the assistance of a professional to conduct the work. Local government agencies focused on natural resource or wildlife management can likely provide the information needed to initiate a monitoring program.

Complex structure from residual trees, created snags, and shrubs in Douglas-fir stand managed for timber production and habitat diversity —photo by Bob Altman

Vegetation Monitoring

The initial desired response of vegetation to management is the development of suitable habitat for the target bird species. Since most birds respond to vegetative structure and can be somewhat flexible in their association with that structure, it is usually sufficient to select some basic structural measurements applicable to your desired conditions, such as plant growth rates, stem densities, percent cover, etc. If plantings are a part of your management, it is important to track survival over time. There are a number of publications that have summarized information and recommendations on vegetation monitoring objectives, methods, and data analyses, especially related to bird populations and habitat (for example, Noon, 1981; Ralph and others, 1993). Additionally, the assistance of local expertise on vegetation monitoring may be sought to ensure the most effective and efficient use of your time and resources.

Bird Monitoring

The ultimate measure of successful habitat management is the response of bird populations. Regardless of monitoring intensity, the most important consideration is a consistent method of data collection. Fortunately, there are standardized protocols that are widely accepted for bird monitoring that not only allow a systematic approach, but also provide data that can be used by others at larger scales. There are a number of publications that have summarized information and recommendations on bird monitoring objectives, methods, and data analyses (for example, Ralph and others, 1993; Nur and others, 1999; NABCI Monitoring Subcommittee, 2006).

Adaptive Management

It is important to recognize that despite our significant knowledge about Pacific Northwest conifer forests, they are very dynamic and complex ecosystems that may not develop according to our projections. Thus, it becomes important to track the conditions associated with management so that adjustments can be made if necessary. This is referred to as adaptive management. Monitoring is an essential component of the adaptive management process, providing not only the feedback on progress toward goals, but also information on the outcomes of different management strategies to provide options for future management. Because bird conservation requires a significant investment of time and land, it seems wise to increase the likelihood of success by monitoring and making changes as necessary.

Literature Cited

Adkisson, C.S., 1996, Red Crossbill (*Loxia curvirostra*), *in* Poole, A., and Gill, F., eds., The Birds of North America, No. 256: The Birds of North America, Inc., Philadelphia, Pa.

Agee, J.K., 1993, Fire ecology of Pacific Northwest forests: Washington, D.C., Island Press, 490 p.

Alaback, P.B., and Herman, F.R., 1988, Long-term response of understory vegetation to stand density in *Picea-Tsuga* forests: Canadian Journal of Forest Research, v. 18, p. 1522-1530.

Altman, B., 1999, Conservation strategy for landbirds in coniferous forests of western Oregon and Washington, Version 1.0: Oregon-Washington Partners in Flight, www.orwapif.org/pdf/western_forest.pdf.

Altman, B., and Sallabanks, R., 2000, Olive-sided Flycatcher (*Contopus cooperi)*, *in* Poole, A., and Gill, F., eds., The Birds of North America, No. 502: Philadelphia, Pa., The Birds of North America, Inc.

Altman, B., Boulay, M., Dowlan, S., Crannell, D., Russell, K., Beal, K., and Dillion, J., 2003, Willow Flycatcher nesting ecology and habitat relationships in the Willamette Basin, Oregon, *in* Sogge, M., Kus, B., Sferra, S., and Whitfield, M., eds., Ecology and Conservation of the Willow Flycatcher: Studies in Avian Biology, v. 26, p. 73-80.

Artman, V.L., 1990, Breeding bird populations and vegetation characteristics in commercially thinned and unthinned western hemlock forests of Washington: Seattle, University of Washington, M.S. thesis, 55 p.

Bailey, J.D., and Tappeiner, J.C., 1998, Effects of thinning on structural development in 40- to 100-year-old Douglas-fir stands in western Oregon: Forest Ecology and Management, v. 108, p. 99-113.

Bailey, J.D., Mayrsohn, C., Doescher, P.S., St. Pierre, E., and Tappeiner, J.C., 1998, Understory vegetation in old and young Douglas-fir forests of western Oregon: Forest Ecology and Management, v. 112, no. 3, p. 289-302.

Beaver, D.L., and Baldwin, P.H., 1975, Ecological overlap and the problem of competition and sympatry in western and Hammond's flycatchers: Condor, v. 77, no. 1, p 1-13.

Beese, W.J., and Bryant, A.A., 1999, Effect of alternative silvicultural systems on vegetation and bird communities in coastal montane forests of British Columbia, Canada: Forest Ecology and Management, v. 115, p. 231-242.

Beissinger, S.R., Reed, J.M., Wunderle, J.M., Jr., Robinson, S.K, and Finch, D.M., 2000, Report of the AOU conservation committee on the Partners in Flight species prioritization plan: The Auk, v. 117, no. 2, p. 549-561.

Bemis, C., and Rising, J.D., 1999, Western Wood-Pewee (*Contopus sordidulus*), *in* Poole, A., and Gill, F., eds., The Birds of North America, No. 451: Philadelphia, Pa., The Birds of North America, Inc.

Bettinger, K.A, 1996, Bird communities in 5- to 34-year-old managed Douglas-fir stands on the Willamette National Forest, Oregon Cascades: Corvallis, Oregon State University, M.S. thesis, 110 p.

Bond, M.L., Gutierrez, R.J., Franklin, A.B., LaHaye, W.S., May, C.A., and Seamans, M.E., 2002, Short-term effects of wildfires on Spotted Owl survival, site fidelity, mate fidelity, and reproductive success: Wildlife Society Bulletin, v. 30, p. 1022-1028.

Boreal Partners in Flight Working Group, 1999, Landbird conservation plan for Alaska biogeographic regions, Version 1.0: Boreal Partners in Flight, www.absc.usgs.gov/research/bpif/conservation.pdf.

Borror, D.J., Triplehorn, C.A., and Johnson, N.F., 1989, An introduction to the study of insects (6th ed.): Philadelphia, Saunders College Publishing, 875 p.

Bosakowski, T., 1997, Breeding bird abundance and habitat relationships on a private industrial forest in the western Washington Cascades: Northwest Science, v. 71, p. 244-253.

Brand, L.A., and George, T.L., 2001, Response of passerine birds to forest edge in coast redwood forest fragments: The Auk, v. 118, no. 3, p. 678-686.

Brice, A.T., and Grau, C.R., 1991, Protein requirements of Costa’s hummingbirds *Calypte costae*: Physiol. Zool, v. 64, p. 611– 626.

Brown, E.R, ed., 1985, Management of wildlife and fish habitats in forests of western Oregon and Washington: U.S. Department of Agriculture Forest Service Publication R6-F&WL-192-1985.

Bull, E.L., Peterson, S.R., and Thomas, J.W., 1986, Resource partitioning among woodpeckers in northeastern Oregon: U.S. Department of Agriculture, Forest Service Research Note PNW-444, Pacific Northwest Research Station, Portland, Or., 19 p.

Bunnell, F.L., Kremsater, L.L., and Wells, R.W., 1997, Likely consequences of forest management on terrestrial, forest-dwelling vertebrates in Oregon: Report M-7, Centre for Applied Conservation Biology, University of British Columbia.

Bunnell, F.L., Wells, R.W., Nelson, J.D., and Kremsater, L.L., 1999, Patch sizes, vertebrates, and effects of harvest policy in southeastern British Columbia, *in* Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, p. 271-293.

Busing, R.T., and Garman, S.L., 2002, Promoting old-growth characteristics and long-term wood production in Douglas-fir forests: Forest Ecology and Management, v. 160, p.161-175.

California Partners in Flight, 2002, The draft coniferous forest bird conservation plan: a strategy for protecting and managing coniferous forest habitats and associated birds in California, Version 1.0 (J. Robinson and J. Alexander, lead authors): Point Reyes Bird Observatory, Stinson Beach, Ca., http://www.prbo.org/calpif/plans.html.

Campbell, S., Dunham, P., and Azuma, D., 2004, Timber resource statistics for Oregon: U.S. Department of Agriculture, Forest Service Resource Bulletin PNW-RB-242, Pacific Northwest Research Station, Portland, Or., 67 p.

Campbell, W.R., Dawe, N.K., McTaggart-Cowan, I., Copper, J.M., Kaiser, G.W., McNall, M.C.E., and Smith, G.E.J., 1997, The birds of British Columbia. Volume 3. Passerines: Flycatchers through Vireos: Vancouver, B.C., University of British Columbia Press, 693 p.

Carey A.B., and Wilson, S.M., 2001, Induced spatial heterogeneity in forest canopies: responses of small mammals: Journal of Wildlife Management, v. 65, no. 4, p. 1014–1027.

Carter, M.F., Hunter, W.C., Pashley, D.N., and Rosenberg, K.V., 2000, Setting conservation priorities for landbirds in the United States: The Partners in Flight approach: The Auk, v. 117, no 2, p. 541-548.

Chambers, C.L., 1996, Response of terrestrial vertebrates to three silvicultural treatments in the central Oregon Coast Range: Corvallis, Oregon State University, Ph.D. dissertation.

Chambers, C.L., McComb, W.C., and Tappeiner, J.C., 1999, Breeding bird responses to three silvicultural treatments in the Oregon Coast Range: Ecological Applications, v. 9, no. 1, p. 171-185.

Chan-McLeod, A., and F. Bunnell, 2003, Effects of variable-retention harvest techniques on bird communities in coastal British Columbia: 2002-2003 annual progress report: Forest Sciences Centre, University of British Columbia, Vancouver, http://www.for.gov.bc.ca/hfd/library/FIA/2003/FIA2003MR059.pdf.

Chen, J., Franklin, J.F., and Spies, T.A., 1999, Microclimate pattern and basic biological responses at the clearcut edges of old-growth Douglas-fir stands, Northwest Environmental Journal, v. 6, p. 424-425.

Cotter, P.A., and Andres, B.A., 2000, Breeding bird habitat associations on the Alaska Breeding Bird Survey: U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD/ITR – 2000-0010.

Curtis, R.O., DeBell, D.S., Harrington, C.A., Lavender, D.P., St. Clair, J.B., Tappeiner II, J.C., and Walstad, J.D., 1998, Silviculture for multiple objectives in the Douglas-fir region: U.S. Department of Agriculture, Forest Service Gen. Tech. Rept. PNW-GTR-435, Pacific Northwest Research Station, Portland, Or., 123 p.

DeBell, D.S., Curtis, R.O., Harrington, C.A., and Tappeiner II, J.C., 1997, Shaping stand development through silvicultural practices, *in* Kohm, K.A., and Franklin, J.F., eds., Creating a Forestry for the 21st Century: the Science of Ecosystem Management: Washington, D.C., Island Press, p. 141-149.

Dellasala, D.A., Hagar, J.C., Engel, K.A., McComb, W.C., Fairbanks, R.L., and Campbell, E.G., 1996, Effects of silvicultural modifications of temperate rainforests on breeding and wintering bird communities, Prince of Wales island, southeast Alaska: Condor, v. 98, no. 4, p. 706-721.

Doolittle, A.M., 2000, Arthropod communities on understory plants in thinned and unthinned Douglas-fir forests in the Oregon Coast Range: Corvallis, Oregon State University, M.S. thesis, 83 p.

Erlich, P.R., Dobkin, D.S., and Wheye, D., 1988, The birders handbook: New York, Simon & Schuster Inc., 785 p.

Franklin, J.F. and Spies, T.A., 1991, Composition, function, and structure of old-growth Douglas-fir forests, *in* Ruggiero, L. F., Aubry, K.B., Carey, A.B., and Huff, M.H., tech. eds., Wildlife and vegetation of unmanaged Douglas-fir forests: U.S. Department of Agriculture, Forest Service General Technical Report PNW-GTR-285, Portland, Or., p. 71-80.

Franklin, J.F., Berg, D.R., Thornburgh, D.A., and Tappeiner, J.C., 1997, Alternative silvicultural approaches to timber harvesting: variable retention harvest systems, *in* Kohm, K.A., and Franklin, J.F, eds., Creating a Forestry for the 21st Century: The Science of Ecosystem Management: Washington, D.C., Island Press, p.111-139.

Franklin, J.F., Spies, T.A., Van Pelt, R., Carey, A.B., Thornburgh, D.A., Berg, D.R., Lindenmayer, D.B., Harmon, M.E., Keeton, W.S., Shaw, D.C., Bible, K., and Chen, J, 2002, Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example: Forest Ecology and Management, v. 155, no. 1-3, p. 399-423.

Franklin, J.F., and Forman, R.T.T., 1987, Creating landscape pattern by forest cutting: Ecological consequences and principles: Landscape Ecology, v. 1, no. 1, p. 5-18.

Franklin, J.F., and Dyrness, C.T., 1988, The natural vegetation of Oregon and Washington: Corvallis, Or., Oregon State University Press, 452 p.

Franklin, J.F., 1993, Preserving biodiversity: species, ecosystems, or landscapes?: Ecological Applications, v. 3, no. 2, p. 202-205.

Gardali, T., and Ballard, G., 2000, Warbling vireo (*Vireo gilvus*), *in* Poole, A. and Gill, F., eds., The Birds of North America, No. 551: Philadelphia, Pa., The Birds of North America, Inc.

Garman, S.L., Cissel, J.H., and Mayo, J.H., 2003, Accelerating development of late-successional conditions in young managed Douglas-fir stands: A simulation study: U.S. Department of Agriculture, Forest Service General Technical Report PNW-GTR-557, Portland, Or., 113 p.

Gashwiler, J.S., and Ward, A.L., 1968, Oregon junco foods in coniferous forests: The Murrelet, v. 49, no. 3, p. 29-36.

George, T.L., and Brand, L.A., 2002, The effects of habitat fragmentation on birds in Coast Redwood forests, *in* George, T.L. and Dobkin, D.S., eds., Effects of habitat fragmentation on birds in western landscapes: Contrasts with paradigms from the eastern U.S.: Studies in Avian Biology, v. 25, p. 92-102.

George, T.L. and Dobkin, D.S., eds., 2002, Effects of habitat fragmentation on birds in western landscapes: contrasts with paradigms from the eastern United States: Studies in Avian Biology, v. 25, 270 p.

Gerson, U., and Seaward, M.R.D., 1977, Lichen-invertebrate associations, *in* Seaward, M.R.D., editor, Lichen ecology: London, Academic Press, p. 69-119.

Grossman, D.H., Faber-Langendoen, D., Weakley, A.S., Anderson, M., Bourgeron, P., Crawford, R., Goodin, K., Landaal, S., Metzler, K., Patterson, K.D., Pyne, M., Reid, M., and Sneddon, L., 1998, International classification of ecological communities: terrestrial vegetation of the United States. Volume I, The National Vegetation Classification System: development, status, and applications: Arlington, Va., The Nature Conservancy, 139 p.

Gumtow-Farrior, D.L., 1991, Cavity resources in Oregon white oak and Douglas-fir stands of western Oregon: Corvallis, Oregon State University, M.S. thesis, 89 p.

Hagar, J.C., 2004, Functional relationships among songbirds, arthropods, and understory vegetation in Douglas-fir forests, western Oregon: Corvallis, Oregon State University, Ph.D. dissertation, 143 p.

Hagar, J.C., McComb, W.C., and Chambers, C.C., 1995, Effects of forest practices on wildlife, Chapter 9, *in* Beschta, R.L., Boyle, J.R., Chambers, C.C., and others, eds., Cumulative effects of forest practices in Oregon: literature and synthesis: Corvallis, Oregon State University.

Hagar, J.C., McComb, W.C., and Emmingham, W.H., 1996, Bird communities in commercially thinned and unthinned Douglas-fir stands of western Oregon: Wildl. Soc. Bull., v. 24, no. 2, p. 353-366.

Hagar, J.C., Howlin, S., and Ganio, L.M., 2004, Short-term response of songbirds to experimental thinning of young Douglas-fir forests in the Oregon Cascades: Forest Ecology and Management, v. 199, no. 2-3, p. 333-347.

Hall, F.C., Brewer, L.W., Franklin, J.F., and Werner, R.L., 1985, Plant communities and stand conditions, Part 1: Chapter narratives, *in* Brown, E.R., technical editor, Management of wildlife and fish habitats in forests of western Oregon and Washington: U.S. Department of Agriculture, Forest Service Publication R6-F&WL-192-1985, Pacific Northwest Region, Portland, Or., p. 17–31.

Halpern, C.B., and Spies, T.A., 1995, Plant species diversity in natural and managed forests of the Pacific Northwest: Ecological Applications, v. 5, no. 4, p. 913-934.

Hammond, P.C., and Miller, J.C., 1998, Comparison of the biodiversity of lepidoptera within three forested ecosystems: Annals of the Entomological Society of America, v. 91, no. 3, p. 323-328.

Hansen, A.J., and Hounihan, P., 1996, Canopy tree retention and avian diversity in the Oregon Cascades, *in* Szaro, R.C., and Johnston, D.W., eds., Biodiversity in managed landscapes: theory and practice: New York, Oxford University Press, p. 401-421.

Hansen, A.J., Spies, T.A., Swanson, F.J., and Ohmann, J.L., 1991, Conserving biodiversity in managed forests: BioScience, v. 41, no. 6, p. 382-392.

Hansen, A.J., McComb, W.C., Vega, R., Raphael, M.G., and Hunter, M., 1995, Bird habitat relationships in natural and managed forests in the west Cascades of Oregon: Ecological Applications, v. 5, no. 3, p. 555-569.

Harrington, C.A., Buermeyer, K.R., Brodie, L.C., and Wender, B.W., 2002, Factors influencing growth and flowering of understory plants in conifer stands in western Washington, *in* Johnson A.C., Haynes, R.W., and Monserud, R.A., eds., Congruent management of multiple resources: Proceedings from the Wood Compatibility Initiative workshop: U.S. Department of Agriculture, Forest Service General Technical Report PNW-GTR-563, Pacific Northwest Research Station, Portland, Or., p. 159–168.

Harris, L.D., 1984, The fragmented forest: Island biogeographic theory and the preservation of biotic diversity: Chicago, Il., University of Chicago Press, 211 p.

Hayes, J.P., Weikel, J.M., and Huso, M., 2003, Response of birds to thinning young Douglas-fir forests: Ecological Applications, v. 13, no. 5, p. 1222-1232.

Hejl, S.J., Newlon, K.R., McFadzen, M.E., Young, J.S., and Ghalambor, C.K., 2002, Brown Creeper (*Certhia americana*), *in* Poole, A., and Gill, F., eds., The Birds of North America, No. 669: Philadelphia, Pa., The Birds of North America, Inc.

Hess, G.R., 1994, Conservation corridors and contagious disease: a cautionary note: Conservation Biology, v. 8, no. 1, p. 256-262.

Huff, M.H., and Raley, C.M., 1991, Regional patterns of diurnal breeding bird communities in Oregon and Washington, *in* Ruggiero, L.F., Aubry, K.B., Carey A.B., and Huff, M.H., tech. eds., Wildlife and vegetation of unmanaged Douglas-fir forests: U.S. Department of Agriculture, Forest Service Gen. Tech. Rept. PNW-GTR-285, p. 177-205.

Huff, M.H., Seavy, N.E., Alexander, J.D., and Ralph, C.J., 2005, Fire and birds in the maritime Pacific Northwest: Studies in Avian Biology, v. 30, p. 46-62.

Humphrey, J.W., Hawes, C., Peace, A.J., Ferris-Kaan, R., and Jukes, M.R, 1999, Relationships between insect diversity and habitat characteristics in plantation forest: Forest Ecology and Management, v. 113, p. 11-21.

Hunter, J.E., Fix, D., Schmidt, G.A., and Power, J.C., 2005, Atlas of the breeding birds of Humboldt County, California: Eureka, Ca., Redwood Region Audubon Society, 440 p.

Hunter, M.L., Jr., 1990, Wildlife, forests, and forestry: principles of managing forests for biological diversity: Englewood Cliffs, N.J., Prentice-Hall, 370 p.

Hutchison, O.K., 1968, Alaska's forest resource: Institute of Northern Forestry, U.S. Department of Agriculture Forest Service, Pacific Northwest Forest and Range Experiment Station, 74 p.

Hutto, R.L., 1995, Composition of bird communities following stand-replacement fires in the Northern Rocky Mountain (U.S.A.) conifer forests: Conservation Biology v. 9, p. 1041-1058.

Jackson, J.A., 1979, Tree surfaces as foraging substrates for insectivorous birds, *in* Dickson, J.G., Conner, R.N., Fleet, R.R., Kroll, J.C., and Jackson, J.A., eds., The role of insectivorous birds in forest ecosystems: New York, Academic Press, p 69-93.

Janes, S.W., 2003, Hermit Warbler *Dendroica occidentalis*, *in* Marshall, D., Hunter, M., and Contreras, A., eds., Birds of Oregon: A general reference: Corvallis, Or., Oregon State University Press, p 515 – 517.

Johnson, D.H., and O'Neil, T.A., (managing directors), 2001, Wildlife-habitat relationships in Oregon and Washington: Corvallis, Or., Oregon State University Press, 768 p.

Jokimäki, J., Huhta, E., Itämies, J., and Rahko, P., 1998, Distribution of arthropods in relation to forest patch size, edge, and stand characteristics: Canadian Journal of Forest Research, v. 28, no. 7, p. 1068-1072.

Kennedy, R.S.H., and Spies, T.A., 2004, Forest cover changes in the Oregon Coast Range from 1939 to 1993: Forest Ecology and Management, v. 200, no. 1-3, p. 129-147.

Kerns, B.K., Alexander, S.J., and Bailey, J.D., 2004, Huckleberry abundance, stand conditions, and use in western Oregon: Evaluating the role of forest management: Economic Botany, v. 58, no. 4, p. 668-678.

Kessel, B., and Gibson, D.D., eds., 1978, Status and distribution of Alaska birds: Studies in Avian Biology, v. 1, 100 p.

Kessler, W.B., and Kogut, T.E., 1985, Habitat orientations of forest birds in southeastern Alaska: Northwest Science, v. 59, p. 58-65.

Kimmins, J.P., 1987, Forest Ecology: New York, Macmillan Publishing Company, 531 p.

Knopf, F.L., 1985, Significance of riparian vegetation to breeding birds across an altitudinal cline, *in* Johnson, R.R., Ziebell, C.D., Patten, D.R., Ffolliot, P.F., and Hamre, R.H., tech. eds., Riparian ecosystems and their management: reconciling conflicting uses: U.S. Department of Agriculture, Forest Service General Technical Report RM-120, Rocky Mountain Research Station, p. 105-111.

Kremsater, L., and Bunnell, F.L., 1999, Edge effects: theory, evidence and implications to management of western forests, *in* Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, p. 117-153.

Lambeck, R.J., 1997, Focal species: a multi-species umbrella for nature conservation: Conservation Biology, v. 11, no. 4, p. 849-856.

Lehmkuhl, J.F., Loggers, C.O., and Creighton, J.H., 2002, Wildlife considerations for small diameter timber harvesting, *in* Baumgartner, D.M., Johnson, L.R., and DePuit, E.J., eds., Small diameter timber: resource management, manufacturing, and markets: Pullman, Wa., Washington State University Cooperative Extension, MISC0509, p. 85-92.

Leonard, J.P., 1998, Nesting and foraging ecology of Band-tailed Pigeons in western Oregon: Corvallis, Oregon State University, Ph.D. dissertation.

Leu, M., 2000, Breeding territory settlement patterns and mate choice in a monochromatic tyrannid flycatcher: Seattle, University of Washington, Ph.D. dissertation.

Levey, D.J., 1994, Why we should adopt a broader view of Neotropical migrants: The Auk, v. 111, no. 1, p. 233-236.

Mack D. E., and Yong, W., 2000, Swainson's thrush (*Catharus ustulatus*), *in* Poole, A., and Gill, F., eds., The Birds of North America, No. 540: Philadelphia, Pa., The Birds of North America, Inc.

Manuwal, D.A., Huff, M.H., Bauer, M.R., Chappell, C.B., and Hegstad, K., 1987, Summer birds of the upper subalpine zone of Mount Adams, Mount Rainer, and Mount Saint Helens, Washington: Northwest Science, v. 61, p. 82-92.

Manuwal, D.A., and Manuwal, N.J., 2002, Effects of habitat fragmentation on birds in the coastal coniferous forests of the Pacific Northwest, *in* George, T.L. and Dobkin, D.S, eds., Effects of habitat fragmentation on birds in western landscapes: Contrasts with paradigms from the eastern U.S: Studies in Avian Biology, v. 25, p. 103-112.

Manuwal, D.A., and Pearson, S., 1997, Bird populations in managed forests in the western Cascade Mountains, Washington, *in* Aubry, K.B., West, S.D., Manuwal, D.A., Stringer, A.B., Erickson, J.L., and Pearson, S.F., eds., Wildlife use of managed forests: a landscape perspective: Timber, Fish and Wildlife Technical Report TFW-WL4-98-002, p. 1-61.

Manuwal, D.A., and Palazzotto, N., 2004, Final report: Bird community response to thinning in coniferous forests at Fort Lewis, Washington: Unpublished report submitted to U.S. Army, Department of Defense, Fort Lewis, Washington, 101 p.

Marcot, B.G, 1985, Habitat relationships of birds and young-growth Douglas-fir in northwestern California: Corvallis, Oregon State University, Ph.D. dissertation, 282 p.

Mariani, J.M., and D.A. Manuwal, 1990, Factors influencing brown creeper *Certhia americana* abundance patterns in the southern Washington Cascade Range, *in* Morrison, M.L., Ralph, C.J., Verner, J., and Jehl, J.R., Jr., eds., Avian foraging: theory, methodology, and applications: Studies in Avian Biology, v. 13, p. 53-57.

Marshall, D.B., Hunter, M.G., and Contreras, A.L., eds., 2003, Birds of Oregon: A general reference: Corvallis, Or., Oregon State University Press, 768 p.

Martin, T.E., 1987, Food as a limit on breeding birds: a life-history perspective: Annual Review of Ecology and Systematics, v. 18, p. 453-487.

Martin, T.E., 1995, Avian life history evolution in relation to nest sites, nest predation and food: Ecological Monographs, v. 65, no. 1, p. 101-127.

Marzluff, J.M. and Restani, M., 1999, The effects of forest fragmentation on avian nest predation, *in* Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, p. 155-169.

Matsuoka, S.M., Handel, C.M., Roby, D.D., and Thomas, D.L., 1997, The relative importance of nesting and foraging sites in selection of breeding territories by Townsend's warblers: The Auk, v. 114, no. 4, p. 657-667.

Mayer, K.E., and Laudenslayer, W.F., Jr., 1988, A guide to the wildlife habitats of California: State of California, Department of Forestry and Fire Protection, Sacramento, Ca.

McAllister, D.C., Holloway, R.W., and Schnee, M.W., 1999, Using landscape design principals to promote biodiversity in a managed forest, *in* Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, p. 247-270.

McComb, W.C., 1999, Forest fragmentation: wildife and management implications synthesis of the conference, *in* Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, p. 295-301.

McGarigal, K., and McComb, W.C., 1992, Streamside versus upslope breeding bird communities in the central Oregon Coast Range: Journal of Wildlife Management, v. 56, no. 1, p. 10-21.

McGarigal, K., and McComb, W.C., 1995, Relationships between landscape structure and breeding birds in the Oregon Coast Range: Ecological Monographs, v. 65, no. 3, p 235-260.

McGarigal, K. and McComb, W.C., 1999, Forest fragmentation effects on breeding bird communities in the Oregon Coast Range, *in* Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, p. 223-246.

Meslow, E.C., and Wight, H.M., 1975, Avifauna and succession in Douglas-fir forests of the Pacific Northwest, *in* Smith, D.R., tech. coord., Proceedings of the symposium on management of forest and rangeland habitats for non-game birds: U.S. Department of Agriculture, Forest Service Gen. Tech. Rept. WO-1, p. 266-271.

Morrison, M.L., 1981, The structure of western warbler assemblages: analysis of foraging behavior and habitat selection in Oregon: The Auk, v. 98, no. 3, p. 578-588.

Morrison, M.L., 1982, Response of avian communities to herbicide-induced vegetation changes, western Oregon: Corvallis, Oregon State University, Ph.D. dissertation, 77 p.

Morrison, M.L., and Meslow, E.C., 1983a, Bird community structure on early-growth clearcuts in western Oregon: American Midland Naturalist, v. 110, no. 1, p. 129–137.

Morrison, M.L., and Meslow, E.C., 1983b, Avifauna associated with early growth vegetation on clearcuts in the Oregon coast ranges: U.S. Department of Agriculture, Forest Service, Res. Pap. PNW-305, Pacific Northwest Forest and Range Experiment Station, 12 p.

Muir, P.S., Mattingly, R.L., Tappeiner II, J.C., Bailey, J.D., Elliott, W.E., Hagar, J.C., Miller, J.C., Peterson, E.B., and Starkey, E.E., 2002, Managing for biodiversity in young Douglas-fir forests of western Oregon: U.S. Geological Survey, Biological Resources Division, Biological Sciences Report USGS/BRD/BSR-2002-0006, 76 p.

NABCI Monitoring Subcommittee, 2006, Opportunities for improving North American avian monitoring. Draft interim report: North American Bird Conservation Initiative Monitoring Subcommittee, www.nabci-us.org/monitoring.html

Neitlich, P.N., 1993, Lichen abundance and biodiversity along a chronosequence from young managed stands to ancient forest: Burlington, University of Vermont, M.S. thesis.

Neitlich, P. N. and McCune, B., 1997, Hotspots of epiphytic lichen diversity in two young managed forests: Conservation Biology, v. 11, no. 1, p. 172-182.

Niemiec, S.S., Ahrens, G.R., Willits, S., and Hibbs, D.E., 1995, Hardwoods of the Pacific Northwest: Oregon State University Forest Research Laboratory, Research Publication no. 8, 115 p.

Nolan, V., Jr., Ketterson, E.D., Cristol, D.A., Rogers, C.M., Clotfelter, E.D., Titus, R.C., Schoech, S.J., and Snajdr, E., 2002, Dark-eyed Junco (*Junco hyemalis*), *in* Poole, A., and Gill, F., eds., The Birds of North America, No. 716: Philadelphia, Pa., The Birds of North America, Inc.

Noon, B.R., 1981, Techniques for sampling avian habitats, *in* Capen, D.E., ed., The use of multivariate statistics in studies of wildlife habitat: U.S. Forest Service General Technical Report RM-87, Rocky Mountain Research Station, p. 42-52.

Nott, M.P., DeSante, D.F., Pyle, P., and Michel, N., 2005, Managing landbird populations in forests of the Pacific Northwest: Publication No. 254 of The Institute for Bird Populations, http://www.birdpop.org/publications/NWFExecReport.pdf.

Nur, N., Jones, S.L., and Geupel, G.R., 1999, A statistical guide to data analysis of avian monitoring programs: U.S. Fish and Wildlife Service BTP-R6001-1999, Washington. D.C.

Oliver, C.D., and Larson, B.C., 1990, Forest stand dynamics: New York, McGraw-Hill, Inc., 467 p.

Otvos, Immre S., 1965, Studies on avian predators of *Dentroctonus brevicomis* LeConte (Coleoptera: Scolytidae) with special reference to Picidae: The Canadian Entomologist, v. 97, p. 1184-1199.

Pearson, S.F, 1997, Hermit Warbler (*Dendroica occidentalis*), *in* Poole, A., and Gill, F., eds., The Birds of North America, No. 303: Philadelphia, Pa., The Academy of Natural Sciences, and Washington, D.C., The American Ornithological Union.

Pearson, S.F. and Manuwal, D.A., 2001, Breeding bird response to riparian buffer width in managed Pacific Northwest Douglas-fir forests: Ecological Applications, v. 11, no. 3, p. 840-853.

Petit, L.J., Petit, D.R., and Martin, T.E., 1995, Landscape-level management of migratory birds: looking past the trees to see the forest: Wildlife Society Bulletin, v. 23, p. 420-429.

Pettersson, R.B., Ball, J.P., Renhorn, K.-E., Esseen, P.-A., and Sjöberg, K., 1995, Invertebrate communities in boreal forest canopies as influenced by forestry and lichens with implications for passerine birds: Biological Conservation, v. 74, no. 1, p. 57-63.

Poage, N.J., and Tappeiner II, J.C., 2005, Tree species and size structure of old-growth Douglas-fir forests in central western Oregon, USA: Forest Ecology and Management, v. 204, no 2-3, p. 329-343.

Primack, R.B., 1998, Essentials of conservation biology: Sunderland, Ma., Sinauer Associates.

Ralph, C.J., Geupel, G.R., Pyle, P., Martin, T.E., DeSante, D.F., 1993, Handook of field methods for monitoring landbirds: U.S. Department of Agriculture, Forest Service General Technical Report PSW-GTR-144, Pacific Southwest Research Station.

Raphael, M.G, 1987, Use of Pacific-madrone by cavity-nesting birds, *in* Plumb, T.R., tech. coord., Symposium on multiple-use management of California's hardwood resources: U.S. Department of Agriculture, Forest Service General Technical Report PSW-100, Berkeley, Ca., p. 198-201.

Rich, T. D., Beardmore, C.J., Berlanga, H., Blancher, P. J., Bradstreet, M. S. W., Butcher, G. S., Demarest, D. W., Dunn, E. H., Hunter, W. C., Iñigo-Elias, E. E., Kennedy, J. A., Martell, A. M., Panjabi, A. O., Pashley, D. N., Rosenberg, K. V., Rustay, C. M., Wendt, J. S., Will, T. C., 2004, Partners in Flight North American Landbird Conservation Plan: Ithaca, N.Y., Cornell Lab of Ornithology, http://www.partnersinflight.org/cont_plan/.

Robbins, C.S., Sauer, J.R., and Peterjohn, B.G., 1992, Population trends and management opportunities for neotropical migrants, *in* Finch, D.M., and Stangel, P.W., eds., Status and management of neotropical migratory birds: U.S. Department of Agriculture, Forest Service General Technical Report RM-229, Fort Collins, Co., p. 17-23.

Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., 1999, Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, 301 p.

Rosenberg, K.V., and Raphael, M.G., 1986, Effects of forest fragmentation on vertebrates in Douglas-fir forests, *in* Verner, J., Morrison, M.L., and Ralph, C.J., eds., Wildlife 2000: modeling habitat relationships of terrestrial vertebrates: Madison, Wi., University of Wisconsin Press, p. 263-272.

Rosso, A.L., 2000, Shrub epiphyte communities in relation to stand management in forests of western Oregon: Corvallis, Oregon State University, Ph.D. dissertation.

Sallabanks, R., and Quinn, T., 2000, Can we infer habitat quality from the results of wildlife surveys?: Washington Department of Fish and Wildlife TFW-LWAG6-01-001, Olympia, Wa., 187 p.

Sauer, J. R., Hines, J. E., and Fallon, J., 2006, The North American Breeding Bird Survey, Results and Analysis 1966 - 2005. Version 2006.2: Laurel, Md., USGS Patuxent Wildlife Research Center, http://www.mbr-pwrc.usgs.gov/bbs/bbs.html.

Schieck, J.K., Lertzman, B., Nyberg, B., and Page, R., 1995, Effects of patch size on birds in old-growth montane forests: Conservation Biology, v. 9, no. 5, p. 1072-1084.

Schowalter, T.D., and Crossley, D.A., Jr., 1983, Forest canopy arthropods as sodium, potassium, magnesium and calcium pools in forests: Forest Ecology and Management, v. 7, p. 143-148.

Seigel, R.B., and DeSante, D.F., 2003, Bird communities in thinned versus unthinned Sierran mixed conifer stands: Wilson Bulletin, v. 115, no. 2, p. 155-165.

Shure, D.J., and Phillips, D.L., 1991, Patch size of forest openings and arthropod populations: Oecologia, v. 86, p. 325-334.

Sidle, W.B., 1985, Habitat management for forest birds in southeast Alaska: U.S. Forest Service, Wildlife and Fisheries Habitat Management Notes, Alaska Region Administrative Document No. 146, 21 p.

Sisk, T.D., and Battin, J., 2002, Habitat edges and avian ecology: geographic patterns and insights for western landscapes, *in* George, T.L. and Dobkin, D.S, eds., Effects of habitat fragmentation on birds in western landscapes: Contrasts with paradigms from the eastern U.S: Studies in Avian Biology, v. 25, p. 30-48.

Smith, M.R., Mattocks, P.W., Jr., and Cassidy, K.M., 1997, Breeding birds of Washington state, Volume 4, *in* Cassidy, K.M., Grue, C.E., Smith, M.R., and Dvornich, K.M., eds., Washington State Gap Analysis – Final Report: Seattle Audubon Society Publications in Zoology No. 1, Seattle, 558 p.

Tappeiner, J.C., Huffman, D., Marshall, D., Spies, T.A., and Bailey, J.D., 1997, Density, ages, and growth rates in old-growth and young-growth forests in coastal Oregon: Canadian Journal of Forest Research, v. 27, no. 5, p. 638-648.

Tappeiner, J.C., Lavender, D.P., Walstad, J.D., Curtis, R.O., and DeBell, D.S., 1997, Silvicultural systems and regeneration methods: Current practices and new alternatives, *in* Kohm, K.A., and Franklin, J.F., eds., Creating a Forestry for the 21st Century: The Science of Ecosystem Management: Washington, D.C., Island Press, p. 151-164.

Tappeiner, J.C. II, Emmingham, W.H., and Hibbs, D.E., 2002, Silviculture of Oregon Coast Range forests, *in* Hobbs, S.D., Hayes, J.P., Johnson, R.L., Reeves, G.H., Spies, T.A., Tappeiner, J.C. II, and Wells, G.E., eds., Forest and stream management in the Oregon Coast Range: Corvallis, Or., Oregon State University Press, p. 172–190.

Thomas, J.W., Maser, C., and Rodiek, J.E., 1979, Edges, Chapter 4 *of* Thomas, J.W., ed., Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington: Washington D.C., Wildlife management Institute, U.S. Department of Agriculture Forest Service Agricultural Handbook 533.

Thomas, S.C., Halpern, C.B., Falk, D.A., Liguori, D.A., and Austin, K.A., 1999, Plant diversity in managed forests: understory responses to thinning and fertilization: Ecological Applications, v. 9, no. 3, p. 864–879.

Thompson, F.R., Donovan, T.M., DeGraff, R.M., Faaborg, J., and Robinson, S.K., 2002, A multi-scale perspective of the effects of forest fragmentation on birds in eastern forests, *in* George, T.L. and Dobkin, D.S, eds., Effects of habitat fragmentation on birds in western landscapes: Contrasts with paradigms from the eastern U.S: Studies in Avian Biology, v. 25, p. 8-19.

USDA Forest Service and USDI Bureau of Land Management, 1994, Record of Decision for amendments to Forest Service and Bureau of Land Management Planning Documents within the range of the Northern Spotted Owl, Standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the Northern Spotted Owl: USDA Forest Service and USDI Bureau of Land Management.

Vega, R.M.S., 1993, Bird communities in managed conifer stands in the Oregon Cascades: habitat associations and nest predation: Corvallis, Oregon State University, M.S. thesis.

Wahl, T.R., Tweit, B., and Mlodinow, S.G., eds., 2005, Birds of Washington: Status and Distribution: Corvallis, Oregon State University Press, 436 p.

Weikel, J.M., 1997, Habitat use by cavity-nesting birds in young thinned and unthinned Douglas-fir forests of western Oregon: Corvallis, Oregon State University, M.S. thesis.

Weikel, J.M., and Hayes, J.P., 1999, The foraging ecology of cavity-nesting birds in young forests of the northern Coast Range of Oregon: Condor, v. 101, no. 1, p. 58-66.

Willson, M.F., and T.A. Comet, 1996, Bird communities of northern forests: ecological correlates of diversity and abundance in the understory: Condor, v. 98, no. 2, p. 350-362.

With, K.A., 1999, Is landscape connectivity necessary and sufficient for wildlife management? *in* Rochelle, J.A., Lehmann, L.A., and Wisniewski, J., eds., Forest fragmentation: wildlife and management implications: The Netherlands, Brill Publications, p 97-115.

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Appendix A

Scientific names of birds, insects, and plant species mentioned in the text, tables, or appendices.

Birds

Common Name	Scientific Name
Alder Flycatcher	*Empidonax alnorum*
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Carduelis tristis*
American Kestrel	*Falco sparverius*
American Robin	*Turdus migratorius*
Band-tailed Pigeon	*Columba fasciata*
Barred Owl	*Strix varia*
Bewick's Wren	*Thryomanes bewickii*
Black-backed Woodpecker	*Picoides arcticus*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Black-throated Gray Warbler	*Dendroica nigrescens*
Blue (Sooty) Grouse	*Dendragapus fuliginosus*
Boreal Chickadee	*Poecile hudsonica*
Brown Creeper	*Certhia americana*
Bushtit	*Psaltriparus minimus*
Calliope Hummingbird	*Stellula calliope*
Cassin's Finch	*Carpodacus cassinii*
Cassin's Vireo	*Vireo cassinii*
Cedar Waxwing	*Bombycilla cedorum*
Chestnut-backed Chickadee	*Poecile rufescens*
Chipping Sparrow	*Spizella passerina*
Common Nighthawk	*Chordeiles minor*
Common Raven	*Corvus corax*
Common Yellowthroat	*Geothlypis trichas*
Cooper's Hawk	*Accipiter cooperii*
Dark-eyed Junco	*Junco hyemalis*
Dusky Flycatcher	*Empidonax oberholseri*
Evening Grosbeak	*Coccothraustes vespertinus*
Flammulated Owl	*Otus flammeolus*
Fox Sparrow	*Passerella iliaca*
Golden-crowned Kinglet	*Regulus satrapa*
Gray Jay	*Perisoreus canadensis*
Gray-cheeked Thrush	*Catharus minimus*
Great-gray Owl	*Strix nebulosa*
Great-horned Owl	*Bubo virginianus*
Green-tailed Towhee	*Pipilo chlorurus*
Hairy Woodpecker	*Picoides villosus*
Hammond's Flycatcher	*Empidonax hammondii*
Hermit Thrush	*Catharus guttatus*
Hermit Warbler	*Dendroica occidentalis*
House Wren	*Troglodytes aedon*
Hutton's Vireo	*Vireo huttoni*
Lazuli Bunting	*Passerina amoena*
Lincoln's Sparrow	*Melospiza lincolnii*
MacGillivray's Warbler	*Oporornis tolmiei*
Marbled Murrelet	*Brachyramphus marmoratus*
Merlin	*Falco columbarius*
Mountain Bluebird	*Sialia currucoides*

Birds

Common Name	Scientific Name
Mountain Chickadee	*Poecile gambeli*
Mountain Quail	*Oreotyx pictus*
Nashville Warbler	*Vermivora ruficapilla*
Northern Flicker	*Colaptes auratus*
Northern Goshawk	*Accipiter gentilis*
Northern Pygmy-Owl	*Glaucidium gnoma*
Northern Saw-whet Owl	*Aegolius acadicus*
Northern Spotted Owl	*Strix occidentalis*
Orange-crowned Warbler	*Vermivora celata*
Olive-sided Flycatcher	*Contopus cooperi*
Pacific-slope Flycatcher	*Empidonax difficilis*
Pileated Woodpecker	*Dryocopus pileatus*
Pine Grosbeak	*Pinicola enucleator*
Pine Siskin	*Carduelis pinus*
Purple Finch	*Carpodacus purpureus*
Purple Martin	*Progne subis*
Red Crossbill	*Loxia curvirostra*
Red-breasted Nuthatch	*Sitta canadensis*
Red-breasted Sapsucker	*Sphyrapicus ruber*
Red-tailed Hawk	*Buteo jamaicensis*
Ruby-crowned Kinglet	*Regulus calendula*
Ruffed Grouse	*Bonasa umbellus*
Rufous Hummingbird	*Selasophorus rufus*
Sharp-shinned Hawk	*Accipiter striatus*
Song Sparrow	*Melospiza melodia*
Spotted Towhee	*Pipilo maculatus*
Steller's Jay	*Cyanocitta stelleri*
Swainson's Thrush	*Catharus ustulatus*
Townsend's Warbler	*Dendroica townsendi*
Townsend's Solitaire	*Myadestes townsendi*
Tree Swallow	*Tachycineta bicolor*
Varied Thrush	*Ixoreus naevius*
Vaux's Swift	*Chaetura vauxi*
Violet-Green Swallow	*Tachycineta thalassina*
Warbling Vireo	*Vireo gilvus*
Western Bluebird	*Sialia mexicana*
Western Tanager	*Piranga ludoviciana*
Western Screech-Owl	*Otus kennicottii*
Western Wood-Pewee	*Contopus sordidulus*
White-crowned Sparrow	*Zonotrichia leucophrys*
White-headed Woodpecker	*Picoides albolarvatus*
Willow Flycatcher	*Empidonax traillii*
Wilson's Warbler	*Wilsonia pusilla*
Winter Wren	*Troglodytes troglodytes*
Wrentit	*Chamaea fasciata*
Yellow-breasted Chat	*Icteria virens*
Yellow-rumped Warbler	*Dendroica coronata*

Scientific names of birds, insects, and plant species mentioned in the text, tables, or appendices.—Continued

Insects

Common Name	Scientific Name
Western spruce budworm	*Choristoneura occidentalis*
Douglas-fir tussock moth	*Orgyia pseudotsugata*

Plants

Common Name	Scientific Name
Bigleaf maple	*Acer macrophyllum*
Bracken fern	*Pteridium aquilinum*
Cascara	*Rhamnus purshiana*
Columbine	genus *Aquilegia*
Currant spp.	genus *Ribes*
Douglas-fir	*Pseudotsuga menziesii*
Elderberry spp.	genus *Sambucus*
Himalayan blackberry	*Rubus procerus*
Huckleberry spp.	genus *Vaccinium*
Mountain hemlock	*Tsuga mertensiana*
Oregon-grape	*Mahonia nervosa*
Oregon white oak	*Quercus garryana*
Pacific silver fir	*Abies amabilis*
Pacific madrone	*Arbutus menziesii*
Red alder	*Alnus rubra*
Redwood	*Sequoia sempervirens*
Salal	*Gaultheria shallon*
Salmonberry	*Rubus spectabilis*
Scotch broom	*Cytisus scoparius*
Shasta red fir	*Abies magnifica shastensis*
Sitka spruce	*Picea sitchensis*
True fir spp.	genus *Abies*
Western hemlock	*Tsuga heterophylla*
Western red cedar	*Thuja plicata*
White spruce	*Picea glauca*

Appendix B

Ecoregion associations of breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).[1]

Species	Ecoregion [2,3]															
	Alaska		British Columbia				Washington				Oregon				Calif
	SC	SE	NMC	SMC	QCI	WVI	NC	SC	OP	CR	CR	WC	HC	KM	KB
Alder Flycatcher															
American Crow															
American Goldfinch															
American Kestrel															
American Robin															
Band-tailed Pigeon															
Barred Owl															
Bewick's Wren															
Black-backed Woodpecker															
Black-headed Grosbeak															
Black-throated Gray Warbler															
Blue (Sooty) Grouse															
Boreal Chickadee															
Brown Creeper															
Bushtit															
Calliope Hummingbird															
Cassin's Finch															
Cassin's Vireo															
Cedar Waxwing															
Chestnut-backed Chickadee															
Chipping Sparrow															
Common Nighthawk															
Common Raven															
Common Yellowthroat															
Cooper's Hawk															
Dark-eyed Junco															
Dusky Flycatcher															
Evening Grosbeak															
Flammulated Owl															
Fox Sparrow															
Golden-crowned Kinglet															
Gray Jay															
Gray-cheeked Thrush															
Great-gray Owl															
Great-horned Owl															
Green-tailed Towhee															
Hairy Woodpecker															

Ecoregion associations of breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species	Ecoregion [2,3]														
	Alaska		British Columbia				Washington				Oregon				Calif
	SC	SE	NMC	SMC	QCI	WVI	NC	SC	OP	CR	CR	WC	HC	KM	KB
Hammond's Flycatcher															
Hermit Thrush															
Hermit Warbler															
House Wren															
Hutton's Vireo															
Lazuli Bunting															
Lincoln's Sparrow															
MacGillivray's Warbler															
Merlin															
Mountain Bluebird															
Mountain Chickadee															
Mountain Quail															
Nashville Warbler															
Northern Flicker															
Northern Goshawk															
Northern Pygmy-Owl															
Northern Saw-whet Owl															
Orange-crowned Warbler															
Olive-sided Flycatcher															
Pacific-slope Flycatcher															
Pileated Woodpecker															
Pine Grosbeak															
Pine Siskin															
Purple Finch															
Purple Martin															
Red Crossbill															
Red-breasted Nuthatch															
Red-breasted Sapsucker															
Red-tailed Hawk															
Ruby-crowned Kinglet															
Ruffed Grouse															
Rufous Hummingbird															
Sharp-shinned Hawk															
Song Sparrow															
Spotted Towhee															
Steller's Jay															
Swainson's Thrush															

Ecoregion associations of breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species	Ecoregion [2,3]														
	Alaska		British Columbia				Washington				Oregon				Calif
	SC	SE	NMC	SMC	QCI	WVI	NC	SC	OP	CR	CR	WC	HC	KM	KB
Townsend's Warbler	High	High	High	High	High	High	High	Moderate	Moderate			Low	Moderate		
Townsend's Solitaire	Moderate					Low	Low	Moderate	Low			Low	Moderate	Moderate	Moderate
Tree Swallow	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate
Varied Thrush	High	High	High	High	High	Moderate	High	High	Moderate	High	High	High	High	Moderate	Moderate
Vaux's Swift		Moderate	Moderate	Moderate		Low	Moderate	Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate	Moderate
Violet-Green Swallow	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Warbling Vireo		Moderate	Low	Moderate		Low	Moderate	Moderate	Low	Moderate	Moderate	Low	Low	Moderate	Moderate
Western Bluebird								Moderate	Low	Low	Low	Low	Low	Moderate	Low
Western Tanager		Moderate	Low	Moderate		Moderate	Moderate	Moderate	Low	Moderate	Moderate	High	Moderate	High	Moderate
Western Screech-Owl	Low	Moderate	Low	Moderate		Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	High	Moderate
Western Wood-Pewee	Low	Moderate	Moderate	Moderate		Low	Moderate	Moderate	Moderate	High	High	Moderate	Moderate	Moderate	Moderate
White-crowned Sparrow	Low	Low	Low	Moderate		Low	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Low	Moderate	Low
White-headed Woodpecker														Low	Low
Willow Flycatcher				Moderate		Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Low
Wilson's Warbler	High	Moderate	Moderate	Moderate	High	Moderate	Moderate	Moderate	High	High	High	Moderate	Moderate	High	High
Winter Wren	Moderate	High	Moderate	Moderate	High	High	High	High	High	High	High	High	High	Moderate	Moderate
Wrentit											Moderate	Low		Moderate	Moderate
Yellow-breasted Chat											Low	Low		Low	Low
Yellow-rumped Warbler	Moderate	Low	Moderate	Moderate		Low	Moderate	Moderate	Low		Low	Moderate	High	Moderate	Moderate

[1] The relationships presented here are for breeding season nesting habitat only. Primary sources include: Breeding Bird Survey relative abundance maps www.mbr-pwrc.usgs.gov/bbs/bbs.html [relative abundance maps]), the Birds of North America species accounts, Campbell and others (1997), Smith and others (1997), Cotter and Andres (2000), Johnson and O'Neil (2001), Marshall and others (2003), Hunter and others (2005), and Wahl and others (2005).

[2] Ecoregions are based on the following sources (includes only ecoregions dominated by conifer forest): Alaska (Kessel and Gibson, 1978); British Columbia (Ministry of Forests adapted from Campbell and others, 1997); Oregon and Washington (Franklin and Dyrness, 1988; modified); California (California Biodiversity Council, http://ceres.ca.gov/biodiversity/bioregions.html). SC = southcoastal Alaska; SE = southeastern Alaska; NMC = northern mainland coast, British Columbia; SMC = southern mainland coast, British Columbia; QCI = Queen Charlotte Islands, British Columbia; WVI = western Vancouver Island, British Columbia; NC = northern Cascades, Washington; SC = southern Cascades, Washington; OP = Olympic Peninsula, Washington; CR = Coast Ranges, Washington and Oregon; WC = western Cascades, Oregon; HC = high Cascades, Oregon; KM = Klamath Mountains, Oregon; KB = Klamath Bioregion, California.

[3] The subjective categorizing of breeding bird species use of ecoregions is provided to assist land managers to prioritize conservation towards ecoregions most important for that species. Cells are shaded to indicate the degree of importance. Darker shading indicates relatively higher degrees of association with that ecoregion, and therefore greater conservation importance.

	High Association		Moderate Association		Low Association		No Association

High Association = species is highly associated with this ecoregion (that is, breeding population in young conifer forests of high abundance relative to other ecoregions) and this is the most appropriate ecoregion to target for conservation activities for this species provided other factors are suitable (for example, habitat, successional stage, vegetation zone, range within the ecoregion).

Moderate Association = species is moderately associated with this ecoregion (that is, breeding population in young conifer forests of moderate abundance relative to other ecoregions) and it is appropriate to target this ecoregion for conservation activities for this species provided other factors are suitable (for example, habitat, successional stage, vegetation zone, range within the ecoregion).

Low Association = species has a low association with this ecoregion (that is, breeding population in young conifer forests of low abundance relative to other ecoregions) and it is not appropriate to target this ecoregion for conservation activities for this species, although recognition of the limited use of this ecoregion by the species is appropriate.

No Association = species either does not occur or only occasionally occurs as a breeding species in this ecoregion and conservation activities are not recommended.

Appendix C

Successional stage nesting habitat relationships of breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).[1]

Species	Successional Stage [2,3]					Finer-Scale Nesting Habitat Associations or Conditions [4]
	Early		Mid		Rip	
	GF/SI	SS/PT	CP/ST	SE/YS		
Alder Flycatcher						deciduous trees and shrubs, especially willow and alder
American Crow						young/mature trees for nesting; forest edges and openings
American Goldfinch						patchy shrub/tree cover with extensive herbaceous; forest openings
American Kestrel						snags with large cavities for nesting; open forest or forest openings
American Robin						tree/shrub nest; open or semi-open forest and edges
Band-tailed Pigeon						closed-canopy forest for nesting; berry trees and shrubs for foraging
Barred Owl						large trees in semi-open forest; forages in grass/forb of forest openings
Bewick's Wren						stumps or snags with cavity/crevices for nesting
Black-backed Woodpecker						snags or dying trees for cavity excavation; open or semi-open forest
Black-headed Grosbeak						broad-leaf canopy and subcanopy trees; forest edges
Black-throated Gray Warbler						broad-leaf canopy and subcanopy trees; moderate canopy cover
Blue (Sooty) Grouse						mesic sites with deciduous cover; open and closed forests
Boreal Chickadee						snags or dying trees with small cavities for nesting
Brown Creeper						large snags/trees with loose bark crevices for nesting
Bushtit						dense shrubs and sapling trees, especially deciduous vegetation
Calliope Hummingbird						deciduous and nectar producing vegetation; open forests and edges
Cassin's Finch						mature trees in open or semi-open forest; high conifer cover
Cassin's Vireo						deciduous trees in canopy/subcanopy, especially drier forest types
Cedar Waxwing						trees/shrubs at forest edges and openings; berry shrubs for foraging
Chestnut-backed Chickadee						large snags with small cavities; high conifer foliage volume
Chipping Sparrow						sapling trees for nesting; open forest, especially drier forest types
Common Nighthawk						bare to sparsely vegetated ground; open forest or forest openings
Common Raven						large conifer trees for nesting; forest interior and edges
Common Yellowthroat						dense shrub, tall herbaceous layer, especially wet areas
Cooper's Hawk						mature trees for nesting; open and closed forests
Dark-eyed Junco						mixed bare ground and low herbaceous; open forest or forest openings
Dusky Flycatcher						dense shrub layer in forest openings; especially drier forest types
Evening Grosbeak						forest edges and openings with moderate conifer cover
Flammulated Owl						snags or dying trees with cavities; open forest, especially drier forest types
Fox Sparrow						dense shrub layer; forest edges and openings
Golden-crowned Kinglet						high percent conifer canopy cover and foliage volume
Gray Jay						high percent conifer canopy cover and foliage volume
Gray-cheeked Thrush						dense, tall shrub layer
Great Gray Owl						large trees in semi-open forest; forages in grass/forb of forest openings
Great-horned Owl						large snags or live trees with large cavities or nesting platforms
Green-tailed Towhee						dense shrub patches, especially in drier forest types
Hairy Woodpecker						snags or dying trees for cavity excavation; forest edges, interior, openings
Hammond's Flycatcher						open mid-story with high conifer canopy cover

Successional stage nesting habitat relationships of breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species	Successional Stage [2,3]					Finer-Scale Nesting Habitat Associations or Conditions [4]
	Early		Mid			
	GF/SI	SS/PT	CP/ST	SE/YS	Rip	
Hermit Thrush						dense shrub patches with open ground cover; forest edges and openings
Hermit Warbler						high percent conifer canopy cover and foliage volume
House Wren						snags or stumps with cavities for nesting; open forest or forest openings
Hutton's Vireo						broad-leaf sub-canopy, especially oak and madrone; drier sites
Lazuli Bunting						shrub/small tree patches with extensive herbaceous; drier forest types
Lincoln's Sparrow						herbaceous/low shrub edges and wet areas within forest canopy gaps
MacGillivray's Warbler						dense shrub layer, especially wet sites or wetter forest types
Merlin						mature trees in semi-open forest and forest edges
Mountain Bluebird						snags or dying trees with cavities; open forest or forest openings
Mountain Chickadee						snags or dying trees with cavities; high conifer foliage volume
Mountain Quail						dense shrub patches with herbaceous areas; forest openings
Nashville Warbler						dense shrub layer, especially broad-leaf vegetation; drier forest types
Northern Flicker						snags or dying trees for cavity excavation; forest edges and openings
Northern Goshawk						mature stands with large trees and high canopy closure
Northern Pygmy-Owl						snags or dying trees with cavities for nesting
Northern Saw-whet Owl						snags or dying trees with cavities for nesting
Orange-crowned Warbler						dense shrub layer, especially deciduous vegetation and mesic sites
Olive-sided Flycatcher						forest edges and openings with large residual trees and snags
Pacific-slope Flycatcher						deciduous canopy and subcanopy trees, especially alder
Pileated Woodpecker						large snags and dying trees for cavity excavation; forest interior
Pine Grosbeak						mature trees in open or semi-open conifer forest
Pine Siskin						semi-open to closed forest; high percent conifer cover
Purple Finch						open to semi-open mixed coniferous/deciduous forest and edges
Purple Martin						large snags with cavities for nesting; forest openings with little vegetation
Red Crossbill						mature trees with high foliage volume of cone-producing conifer trees
Red-breasted Nuthatch						snags with small cavities; high conifer foliage volume
Red-breasted Sapsucker						snags or dying trees for cavity excavation, especially deciduous trees
Red-tailed Hawk						large area with at least a few large trees at edges or forest openings
Ruby-crowned Kinglet						mature conifer trees; open or closed-canopy forests
Ruffed Grouse						deciduous trees and shrubs, especially alder; forest openings and edges
Rufous Hummingbird						dense shrub layer with nectar vegetation; forest openings and interior
Sharp-shinned Hawk						dense stands of young trees
Song Sparrow						dense ground/low shrub vegetation, especially wet areas
Spotted Towhee						dense shrub layer; forest openings and edges
Steller's Jay						multi-layers of conifer trees; high conifer foliage volume
Swainson's Thrush						dense shrub layer, especially wetter sites
Townsend's Warbler						high percent conifer canopy cover and foliage volume
Townsend's Solitaire						sparsely vegetated ground or rocky outcrops; open forest or forest openings

Successional stage nesting habitat relationships of breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species	Successional Stage [2,3]					Finer-Scale Nesting Habitat Associations or Conditions [4]
	Early		Mid			
	GF/SI	SS/PT	CP/ST	SE/YS	Rip	
Tree Swallow	Moderate				Moderate	snags or dying trees with cavities; forest openings, especially near water
Varied Thrush				Low	Low	structural complexity, especially mid-story layer and deciduous trees
Vaux's Swift				Low		large, hollow snags or dying trees with cavities/openings for nesting
Violet-green Swallow	Moderate				Low	cliffs or snags with crevices/cavities for nesting; forest openings or edges
Warbling Vireo		Moderate	Low	Low	High	broad-leaf canopy or sub-canopy trees, especially wet sites
Western Bluebird	Moderate					snags with cavities for nesting; forest openings with little vegetation
Western Tanager			Low	Moderate		large conifer trees; forest edges and retention trees in forest openings
Western Screech-Owl				Moderate		snags or dying trees with cavities for nesting
Western Wood-Pewee				Low	Moderate	deciduous trees in canopy or sub-canopy; forest edges and openings
White-crowned Sparrow	High	Low				few trees/shrubs with extensive low herbaceous; forest openings
White-headed Woodpecker				Low		large snags for cavity excavation; drier forest and tree types
Willow Flycatcher		High	Moderate		High	dense shrub layer, especially deciduous shrubs or small trees
Wilson's Warbler		High	Moderate	Moderate	Moderate	dense shrub layer, especially wetter sites
Winter Wren			Low	Moderate	Moderate	low understory complexity, especially stumps, down logs, root wads
Wrentit		High	Moderate		Moderate	dense, tall shrub layer
Yellow-breasted Chat		Low			Moderate	dense shrub layer; especially deciduous and wet sites
Yellow-rumped Warbler			Low	Moderate	Low	high percent forest cover (conifer and mixed); open or semi-open forests

[1] The relationships presented here are for breeding season nesting habitat only. Primary sources include: Meslow and Wight (1975), Morrison and Meslow (1983b), Brown (1985), Kessler and Kogut (1985), Marcot (1985), Sidle (1985), Bettinger (1996), Bosakowski (1997), Bunnell and others (1997), Manuwal and Pearson (1997), Sallabanks and Quinn (2000), and Johnson and O'Neil (2001).

[2] GF/SI/ = Grass-forb, Stand initiation (0-5 years); SS/PT = Shrub-seedling, Shrub-sapling, Pioneer tree (5-20 years); CP/ST = Closed-canopy pole, Small tree (15-30 years); SE/YS = Stem exclusion, Young sawtimber (25-60 years); Rip = Riparian.

[3] The subjective categorizing of breeding bird species use of successional stages is provided to assist land managers to prioritize conservation towards the successional stage(s) most important for that species. Cells are shaded to indicate the degree of importance. Darker shading indicates relatively higher degrees of association with that successional stage, and therefore greater conservation importance:

High Association | Moderate Association | Low Association | No Association

High Association = species is highly associated with this successional stage (that is, breeding population in young conifer forest of high abundance relative to other successional stages or other habitats) and this is the most appropriate successional stage to target for conservation activities for this species provided other factors are suitable (for example, range, vegetation zone, habitat features, etc.).

Moderate Association = species is moderately associated with this successional stage (that is, breeding population in young conifer forest of moderate abundance relative to other successional stages or other habitats) and it is appropriate to target this successional stage for conservation activities for this species provided other factors are suitable (for example, range, vegetation zone, habitat features, etc.).

Low Association = species has a low association with this successional stage (that is, breeding population in young conifer forest of low abundance relative to other successional stages or other habitats) and it is not appropriate to target this successional stage for conservation activities for this species, although recognition of the limited use of this successional stage by this species is appropriate.

No Association = species either does not occur or only occasionally occurs as a breeding species in this successional stage and conservation activities are not recommended.

[4] Comments provide additional information on finer-scale nesting habitat associations or conditions beyond that characteristic of successional stage.

Appendix D

Forest type associations for breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).[1]

Species	Forest Type [2,3]											
	Alaska		British Columbia		Oregon and Washington					California		Elevation
	SS	WH	CWH	MH	SS	WH	SF	MH	MC	RD	KMC	
Alder Flycatcher												Low-mid
American Crow												Low-mid
American Goldfinch												Low-mid
American Kestrel												All
American Robin												All
Band-tailed Pigeon												Low-mid
Barred Owl												All
Bewick's Wren												Low-mid
Black-backed Woodpecker												High
Black-headed Grosbeak												Low-mid (S=All)
Black-throated Gray Warbler												Low-mid (S=All)
Blue (Sooty) Grouse												Mid-high (N=All)
Boreal Chickadee												All
Brown Creeper												All
Bushtit												Low-mid
Calliope Hummingbird												Mid-high
Cassin's Finch												High
Cassin's Vireo												Low-mid (S=All)
Cedar Waxwing												Low-mid
Chestnut-backed Chickadee												All
Chipping Sparrow												Mid-high (N=All)
Common Nighthawk												Low-mid (S=All)
Common Raven												Mid-high (S=All)
Common Yellowthroat												Low-mid
Cooper's Hawk												Low-mid
Dark-eyed Junco												Mid-high (N=All)
Dusky Flycatcher												Mid-high

Forest type associations for breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species	Forest Type [2,3]											
	Alaska		British Columbia		Oregon and Washington					California		Elevation
	SS	WH	CWH	MH	SS	WH	SF	MH	MC	RD	KMC	
Evening Grosbeak												Mid-high
Flammulated Owl												Mid-high
Fox Sparrow												N=Low;S=High
Golden-crowned Kinglet												All (N=Low-mid)
Gray Jay												Mid-high (S=All)
Gray-cheeked Thrush												Low-mid
Great-gray Owl												Mid-High
Great-horned Owl												All
Green-tailed Towhee												High
Hairy Woodpecker												All
Hammond's Flycatcher												Mid-high
Hermit Thrush												Mid-high (N=All)
Hermit Warbler												All
House Wren												S=All; N=Low
Hutton's Vireo												Low-mid (N=Low)
Lazuli Bunting												S=All; N=Low
Lincoln's Sparrow												High (N=All)
MacGillivray's Warbler												Mid-high
Merlin												Low-mid
Mountain Bluebird												High
Mountain Chickadee												High
Mountain Quail												Mid-high
Nashville Warbler												Mid-high
Northern Flicker												All
Northern Goshawk												Mid-high (N=All)
Northern Pygmy-Owl												All (N=Mid-high)
Northern Saw-whet Owl												All
Orange-crowned Warbler												All (N=Low-mid)
Olive-sided Flycatcher												All (S=Mid-high)

Forest type associations for breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species	Forest Type [2,3]											
	Alaska		British Columbia		Oregon and Washington					California		Elevation
	SS	WH	CWH	MH	SS	WH	SF	MH	MC	RD	KMC	
Pacific-slope Flycatcher												Low-mid
Pileated Woodpecker												Low-mid
Pine Grosbeak												N=Low;S=High
Pine Siskin												Mid-high (N=All)
Purple Finch												Low-mid
Purple Martin												Low (S=Low-mid)
Red Crossbill												All
Red-breasted Nuthatch												All
Red-breasted Sapsucker												Low-mid (S=All)
Red-tailed Hawk												Low-mid
Ruby-crowned Kinglet												Mid-high (N=All)
Ruffed Grouse												All
Rufous Hummingbird												All
Sharp-shinned Hawk												All
Song Sparrow												Low-mid
Spotted Towhee												Low-mid
Steller's Jay												All
Swainson's Thrush												Low-mid
Townsend's Warbler												Mid-high (N=All)
Townsend's Solitaire												Mid-high
Tree Swallow												Low-mid
Varied Thrush												Mid-high (N=All)
Vaux's Swift												Low-mid (S=All)
Violet-Green Swallow												All (N=Low)
Warbling Vireo												Low-mid (S=All)
Western Bluebird												Low-mid
Western Tanager												Mid-high (N=Low-mid)
Western Screech-Owl												Low-mid
Western Wood-Pewee												Low-mid (S=All)

Forest type associations for breeding bird species in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species	Forest Type [2,3]											Elevation
	Alaska		British Columbia		Oregon and Washington					California		
	SS	WH	CWH	MH	SS	WH	SF	MH	MC	RD	KMC	
White-crowned Sparrow	Low Association	Low Association	Low Association	Low Association	Moderate Association	Moderate Association	Low Association	Low Association	Moderate Association	Moderate Association	Low Association	All
White-headed Woodpecker	No Association	No Association	No Association	No Association	No Association	No Association	No Association	No Association	Low Association	No Association	Low Association	High
Willow Flycatcher	No Association	No Association	Low Association	No Association	Low Association	Moderate Association	Low Association	No Association	Low Association	No Association	Low Association	All
Wilson's Warbler	High Association	Moderate Association	High Association	Moderate Association	High Association	High Association	Moderate Association	Moderate Association	Moderate Association	High Association	Moderate Association	Low-mid (N=All)
Winter Wren	High Association	Moderate Association	High Association	Moderate Association	Moderate Association	High Association	Moderate Association	Moderate Association	Moderate Association	High Association	Moderate Association	All
Wrentit	No Association	No Association	No Association	No Association	High Association	Moderate Association	No Association	No Association	High Association	Moderate Association	High Association	Low-mid
Yellow-breasted Chat	No Association	No Association	No Association	No Association	No Association	Low Association	No Association	No Association	No Association	No Association	Low Association	Low
Yellow-rumped Warbler	Moderate Association	Moderate Association	Moderate Association	Moderate Association	Low Association	Low Association	Moderate Association	Moderate Association	Moderate Association	Low Association	Moderate Association	Mid-high (N=Low-mid)

[1] The relationships presented here are for breeding season nesting habitat only. Primary sources include: Manuwal and others (1987), Campbell and others (1997), Smith and others (1997), Cotter and Andres (2000), Johnson and O'Neil (2001), Marshall and others (2003), Hunter and others (2005), and Wahl and others (2005).

[2] Only conifer-dominated forest types are considered. SS=Sitka Spruce; WH=Western Hemlock (includes Western Red-cedar and Douglas-Fir); CWH = Coastal Western Hemlock (includes Douglas-fir, Western Red-cedar, and Sitka Spruce); MH = Mountain Hemlock (includes Interior Cedar-Hemlock); SS = Sitka Spruce; WH = Western Hemlock (includes Western Red-cedar and Douglas-Fir); SF = Pacific Silver Fir; MH = Mountain Hemlock; MC = Mixed Conifer (includes Shasta Red Fir); RD = Redwood; KMC = Klamath Mixed Conifer. Sources; Alaska (Hutchison, 1968); British Columbia (BC Ministry of Forests adapted from Campbell and others, 1997), Oregon and Washington (Franklin and Dyrness, 1980); California (Mayer and Laudenslayer, 1988).

[3] The subjective categorizing of breeding bird species use of forest types is provided to assist land managers to prioritize conservation towards the forest type(s) most important for that species. Cells are shaded to indicate the degree of importance. Darker shading indicates relatively higher degrees of association with that forest type, and therefore greater conservation importance:

	High Association		Moderate Association		Low Association		No Association

High Association = species is highly associated with this forest type (that is, breeding population in young conifer forest of high abundance relative to other forest types) and this is the most appropriate forest type to target for conservation activities for this species provided other factors are suitable (for example, range, successional stage, habitat features, etc.).

Moderate Association = species is moderately associated with this forest type (that is, breeding population in young conifer forest of moderate abundance relative to other forest types) and it is appropriate to target this forest type for conservation activities for this species provided other factors are suitable (for example, range, successional stage, habitat features, etc.).

Low Association = species has a low association with this forest type (that is, breeding population in young conifer forest of low abundance relative to other forest types) and it is not appropriate to target this forest type for conservation activities for this species, although recognition of the limited use of this forest type by this species is appropriate.

No Association = species either does not occur or only occasionally occurs as a breeding species in this forest type and conservation activities for this species are not recommended.

[4] Elevations identify where the species is most abundant and where conservation should be emphasized. The subjective elevation categories of low, mid, and high should be considered relative to the range of elevations that occur within the area of interest. For species with distinct differences in their range, N = northern part of their range in BCR 5, S = southern part of their range in BCR 5.

Appendix E

Relationships between thinning and breeding bird species abundance in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).

Species [1]	Higher Abundance In Thinned [2]	Similar Abundance Thinned and Unthinned [3]	Lower Abundance in Thinned [2]	Comments
American Robin	B,C,D,E [4]	F,G,H		Thinning usually results in higher abundance in the short-term (1-5 years), with no change in abundance in the mid to long-terms (5-15 years). Heavier intensity thinning appears more likely to result in increased abundance than lighter intensity thinning.
Band-tailed Pigeon		G		Limited data suggests thinning results in no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Black-headed Grosbeak		B,F,H		Limited data suggests thinning results in no change in abundance in the short, mid, or long-terms (1-15 years).
Black-throated Gray Warbler		B,F	C,H	Mixed results suggest thinning results in lower abundance or no change in abundance in the short and mid to long-term (1-15 years); thus local effects and/or thinning intensity may result in variability in response.
Brown Creeper	G,H	E,F,J	C	Mixed results suggest thinning usually results in lower abundance in the short-term (1-5 years) and no change in abundance in the mid and long-term (5-20 years) or higher abundance in the mid to long-term (5-15 years); thus local effects and/or thinning intensity may result in variability in response.
Calliope Hummingbird		F		Limited data suggests thinning results in no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Cassin's Vireo	F			Limited data suggests thinning results in higher abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Chestnut-backed Chickadee	E,G	A,B,C,D,H,J		Mixed results suggest thinning usually results in no change in abundance in the short and mid to long-term (1-15 years), or higher abundance in the mid-term (5-10 years); thus local effects and/or thinning intensity may result in variability in response.
Chipping Sparrow	F			Limited data suggests thinning results in higher abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.

Relationships between thinning and breeding bird species abundance in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species [1]	Higher Abundance In Thinned [2]	Similar Abundance Thinned and Unthinned [3]	Lower Abundance in Thinned [2]	Comments
Dark-eyed Junco	B,C,D,E,H	F	G	Thinning usually results in higher abundance in the short-term (1-5 years) and mid to long-term (5-15 years); although local effects may result in no change or lower abundance in the mid-term (5-10 years). Thinning intensity (light to heavy) does not appear to make much of a difference.
Dusky Flycatcher	F			Limited data suggests thinning results in higher abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Evening Grosbeak	C,G,H	E,F		Mixed results suggest thinning results in higher abundance or no change in abundance in the short and mid to long-terms (1-15 years); thus local effects and/or thinning intensity may result in variability in response.
Fox Sparrow		D,F		Limited data suggests thinning results in no change in abundance in the short-term (1-5 years) or mid-term (5-10 years); long-term effects on abundance not reported.
Golden-crowned Kinglet		D,E,G,J	B,C,H	Mixed results suggest thinning usually results in lower abundance in the short-term (1-5 years) and mid to long-term (5-15 years) or no change in abundance in the mid and long-term (5-20 years). Heavier intensity thinning appears more likely to result in reduced abundance than lighter intensity thinning.
Gray Jay	B	C,G,H		Thinning usually results in no change or an increase in abundance in the short-term (1-5 years) and no change in abundance in the mid to long-term (5-15 years).
Hairy Woodpecker	A,B,C,H,J	F,G		Thinning usually results in higher abundance in the short, mid, and long-terms (1-20 years); although local effects and/or thinning intensity may result in no change in abundance in the mid-term (5-10 years).
Hammond's Flycatcher	B,C,F,H,J			Thinning usually results in higher abundance in the short, mid, and long-terms (1-20 years). Thinning intensity (light to heavy) does not appear to make a difference.
Hermit Thrush		F	B,D	Limited data suggests thinning results in lower abundance in the short-term (1-5 years), with no change in abundance in the mid-term (5-10 years); long-term effects on abundance not reported.

Relationships between thinning and breeding bird species abundance in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species [1]	Higher Abundance In Thinned [2]	Similar Abundance Thinned and Unthinned [3]	Lower Abundance in Thinned [2]	Comments
Hermit Warbler	F	E,G,H,J	B,C	Mixed results suggest thinning usually results in lower abundance in the short to mid-term (1-10 years), with local effects resulting in no change in abundance or higher abundance in the mid to long-term (5-20 years). Heavier intensity thinning appears more likely to result in reduced abundance than lighter intensity thinning.
Hutton's Vireo	G	B,J	C,E,H	Mixed results suggest thinning results in lower abundance or no change in abundance in the short, mid and long-terms (1-20 years) or higher abundance in the mid-term (5-10 years); thus local effects and/or thinning intensity may result in variability in response.
Lazuli Bunting		F		Limited data suggests thinning results in no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
MacGillivray's Warbler	B,G	F		Limited data suggests thinning results in higher abundance in the short-term (1-5 years) with no change or higher abundance in the mid-term (5-10 years); long-term effects on abundance not reported.
Mountain Chickadee	F			Limited data suggests thinning results in higher abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Mountain Quail		F		Limited data suggests thinning results in no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Nashville Warbler		F		Limited data suggests thinning results in no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Northern Flicker	F			Limited data suggests thinning results in higher abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Orange-crowned Warbler		D		Limited data suggests no change in abundance in the short-term (1-5 years); mid and long-term effects on abundance not reported.

Relationships between thinning and breeding bird species abundance in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species [1]	Higher Abundance In Thinned [2]	Similar Abundance Thinned and Unthinned [3]	Lower Abundance in Thinned [2]	Comments
Pacific-slope Flycatcher		B,D,E	C,G,H,J	Mixed results suggest thinning results in no change in abundance in the short term (1-5 years) or lower abundance in the short, mid, and long-term (1-20 years); thus local effects and/or thinning intensity may result in variability in response.
Pileated Woodpecker		F		Limited data suggests thinning results in no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Purple Finch		B,F		Limited data suggests thinning results in no change in abundance in the short and mid-term (1-10 years); long-term effects on abundance not reported.
Red-breasted Nuthatch	E,F,G,H,J	A,C		Mixed results suggest thinning results in no change in abundance in the short-term (1-5 years), but higher abundance in the mid and long-terms (5-20 years).
Red-breasted Sapsucker	B	D,F		Limited data suggests thinning results in higher abundance in the short-term (1-5 years) with no change in abundance in the mid-term (5-10 years); long-term effects on abundance not reported.
Rufous Hummingbird	B			Limited data suggests thinning results in higher abundance in the short-term (1-5 years); mid and long-term effects on abundance not reported.
Song Sparrow	G	D		Limited data suggests thinning results in no change in abundance in the short-term (1-5 years) and higher abundance in the mid-term (5-10 years); long-term effects on abundance not reported.
Spotted Towhee	G	F		Limited data suggests thinning results in higher abundance or no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Steller's Jay		D,F,G,J	C	Thinning usually results in no change in abundance in the short, mid, and long-term (1-20 years), although local effects and/or thinning intensity may result in lower abundance in the short-term (1-5 years).

Relationships between thinning and breeding bird species abundance in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species [1]	Higher Abundance In Thinned [2]	Similar Abundance Thinned and Unthinned [3]	Lower Abundance in Thinned [2]	Comments
Swainson's Thrush	G,J	B,D,H	C	Mixed results suggest thinning most often results in no change in abundance in the short and mid to long-terms (1-15 years), although local effects and/or thinning intensity may result in lower abundance in the short-term (1-5 years) and higher abundance in the mid and long-term (5-20 years).
Townsend's Solitaire	B,C,F			Limited data suggests thinning usually results in higher abundance in the short and mid-term (1-10 years); long-term effects on abundance not reported.
Townsend's Warbler		G	D	Limited data suggests thinning results in lower abundance in the short-term (1-5 years) and no change in abundance in the mid-term 5-10 years); long-term effects on abundance not reported.
Varied Thrush		D,E,J	B,C	Thinning usually results in lower abundance in the short-term (1-5 years) and no change in abundance in the mid-term (5-10 years) and long-term (10-20 years). Heavier intensity thinning appears more likely to result in reduced abundance than lighter intensity thinning.
Warbling Vireo	C,F,H	B		Mixed results suggest thinning results in higher abundance or no change in abundance in the short-term (1-5 years) with higher abundance in the mid to long-term (5-15 years).
Western Tanager	B,C,G,H	F,J		Mixed results suggest thinning results in higher abundance in the short-term (1-5 years) and higher abundance or no change in abundance in the mid to long-term (5-15 years); thus local effects and/or thinning intensity may result in variability in response.
White-headed Woodpecker	F			Limited data suggests thinning results in higher abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Wilson's Warbler	G,J	B,C,H	D	Mixed results suggest thinning most often results in no change in abundance in the short and mid to long-term (1-15 years); although local effects and/or thinning intensity may result in lower abundance in the short-term (1-5 years) and higher abundance in the mid and long-term (5-20 years).

Relationships between thinning and breeding bird species abundance in young conifer forests in the Northern Pacific Rainforest Bird Conservation Region (BCR 5).—Continued

Species [1]	Higher Abundance In Thinned [2]	Similar Abundance Thinned and Unthinned [3]	Lower Abundance in Thinned [2]	Comments
Winter Wren	E,H	C,J	B,G	Mixed results suggest thinning results in lower abundance in the short and mid-term (1-10 years) or no change in abundance in the short-term (1-5 years) or long-term (10-20 years) and higher abundance in the mid to long-term (5-15 years); thus local effects and/or thinning intensity may result in variability in response.
Western Wood-Pewee		F		Limited data suggests thinning results in no change in abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.
Yellow-rumped Warbler	F			Limited data suggests thinning results in higher abundance in the mid-term (5-10 years); short and long-term effects on abundance not reported.

[1] Species listed here are those cited in the studies below that are considered to be associated with young conifer forests in the Guide.

[2] Higher and lower abundances in thinned stands reflect statistically significant differences as reported in the studies.

[3] Similar abundance between thinned and unthinned indicates there was no significant difference reported in the studies.

[4] Letters correspond to studies listed in the table below (ordered by years post-thin).

Reference	Study Type [5]	Years Post-Thin	Level of thinning [6]	Location
A – Weikel (1997)	experimental	1-2	Moderate to Heavy	Northern Coast Range, OR
B – Hagar and others (2004)	experimental	1-4	Moderate to Heavy	West-central Cascades, OR
C – Hayes and others (2003)	experimental	1-6	Moderate to Heavy	Northern Coast Range, OR
D – Dellasalla and others (1996)	observational	3-5	Light to Moderate	Southeast AK (Prince of Wales Island)
E – Artman (1990)	observational	4-6	Moderate to Heavy	West-central Cascades, WA
F – Siegel and DeSante (2003)	observational	5-11	Light to Moderate	Northwestern Sierra Nevada, CA
G – Manuwal and Palazotto (2004)	observational	8-11	Light and Heavy	Puget Lowlands, WA
H – Hagar and others (1996)	observational	5-15	Light to Moderate	Central and Northern Coast Range, OR
J – Muir and others (2002)	observational	10-24	Light to Moderate	Central Coast Range, OR

[5] The summary includes both experimental studies (that is, ones with pre- and post-thinning in the same stand) and observational studies (that is, ones comparing thinned and unthinned stands in two different places).

[6] The description of the level of thinning was taken from the study or modified slightly to be relative to the other studies. It is based generally on the volume removed and remaining tree densities, although data presented in the studies were not always sufficient to apply consistent standards of light, moderate, and heavy thinning.

Altman and Hagar

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