Forest Habitat Group

High Elevation Conifer

1) Describe the habitat (Alexander 1987, Arno 1980, Cole 1990, Covington et al. 1994, Green and Conner 1989, Hann 1990, Knight 1994, Montana Bird Conservation Plan 2000, Mumma 1990, Peet 1988, Peterson 1995, Smith 1980):

a) Historic conditions: Historically, fire-free intervals have been long in the high elevation conifer forests, typically 100 to 300 years. Because of the cool, moist climate in the subalpine zone, the risk of fire is less than in warmer climates, and relatively few acres have burned in the last 300 to 400 years. Fires that did occur were usually stand-replacement burns of various sizes. Regeneration after hot burns often required several decades for establishment, and it took 300 years or more for succession to return the forest to its original condition. Patches of native insect and disease outbreaks were part of the normal ecological process. Spruce-fir communities may have contained a larger component of young age classes compared to communities today. Whitebark pine was probably more abundant and widespread in northwestern Wyoming.

b) Present conditions: High elevation conifer forests occupy some of the coldest and wettest sites in the Rocky Mountains. The transition between mid and high elevation habitat occurs between 8,000 and 9,000 feet (2,400 and 2,700 m), depending on moisture levels and location within the state, and extends up to timberline [at about 11,000 feet (3400 m)]. Engelmann spruce and subalpine fir often dominate the subalpine forests because they can tolerate the lower temperatures just below treeline and because they have relatively low water use efficiencies. Some stands are single-storied, others have two or three stories, and multi-storied stands with irregular structure are not uncommon. Most stands are mature and old growth; few are seedling or sapling stands. Typical old spruce-fir stands are homogeneous and simple, with a dominant spruce overstory, a fir understory, and few other tree species present since none can germinate in the shade of spruce and fir. After disturbances, aspen and lodgepole pine are often pioneer species that persist as dominants for a century or more. Whitebark pine is more tolerant of extreme conditions and can colonize high elevation sites unavailable to spruce and fir; in northwestern Wyoming south through the Wind River Range, it often dominates on dry, windy ridges and exposed southern slopes of the subalpine zone. At the highest elevations, where spruce, fir, limber pine, and whitebark pine give way to alpine tundra, the harsh climate restricts these trees to a small, contorted, often ground-hugging growth form known as "krummholz". Typically, few herbaceous species are present in high elevation conifer forests, often not more than 10 in a ¼-acre (0.1-ha) plot. The understory of these forests is strongly dominated by grouse whortleberry, a low-lying shrub. Wind-thrown and fallen trees in spruce-fir forests are common, often making passage through them difficult.

The high elevation zone has had changes similar to those of the mid elevation zone but to a much lesser degree. Recent increases in the growth and density of high elevation conifer species have been documented throughout western North America. The pattern of communities is becoming more homogeneous; old communities are maintained, while adjacent communities that were once young are now becoming old. These stands have greater vulnerability to insects and stand-destroying fire than the mosaic stand condition. Whitebark pine has been reduced throughout its range by disease epidemics and successional replacement by other conifers.

2) Identify the issues:

a) Use: During the early settlement of the late 1800s and early 1900s, the primary uses were mining and forage for sheep. Since the mid-1900s, there has been a steady trend toward a set of values for these ecosystems that are more noncommodity in nature, such as hiking, camping, horseback riding, and viewing wildlife or scenic features. Winter recreation use has especially increased recently due to better equipment such as snowmobiles, snowshoes, and cross-country skis. Because of the diversity and rugged beauty of high elevation lands, people find enjoyment in various activities in these areas. Today the community is considered more important for recreation, wildlife habitat, and watershed protection than as a source of timber, mining, or grazing.

b) Access: Over 2,500,000 acres (1,011,750 ha) of high elevation conifer forest are in public ownership; the remaining 325,000 acres (131,530 ha) are privately owned. A large proportion of these ecosystems is protected as wilderness, which prohibits mechanized equipment, reserves them from commercial timber use, and limits the range of recreational activities. Remoteness and rough terrain have also discouraged exploitation, but difficulty does not preclude use and is attractive to many. Improved equipment like snowmobiles, snowshoes, and cross-country skis has allowed increased access in winter, even in wilderness areas.

c) Problems: Impacts from human developments, pollution, and disturbance to natural processes have been relatively low in the high elevation conifer forests compared to other ecosystems. However, these slow-growing communities are sensitive to disturbance by humans and the consequences can be highly visible. The introduction of white pine blister rust, which attacks whitebark pine, and the introduction of exotic plants (e.g. mountain knotweed) have resulted in significant problems. Trail and campsite degradation, packstock impacts, development of use-created trails around lakeshores, litter, and loss of solitude are all problems or potential problems in some places. There is a potential for increased recreation such as downhill ski areas and off road vehicle travel. Logging activities, though presently limited, could be a potential problem.

d) What has been the cause of change to the habitat: Historic logging, mining, and livestock grazing locally changed high elevation conifer forest community patterns, but these effects have not been broad scale. The results of fire suppression in the subalpine zone, however, have been broad scale, although to a much lesser degree than in other forest communities. Natural fire frequency cycles are relatively long in the high elevation zone and successful ignitions are infrequent. Consequently, fire suppression has been relatively successful. Since fire frequencies are typically 100 to 300 years, the effects of fire suppression on individual communities have not caused a change from what is present naturally. The primary effect is that the pattern of communities is becoming more homogeneous; old communities are maintained, while adjacent communities that were once young are now becoming old. The amount of communities in an early seral stage, compared to mid and late seral stages, is much less. In addition, recent increases in the growth of many high elevation conifer species have been documented throughout western North America. Carbon dioxide fertilization, increased temperature, and changes in snowpack duration are all possible causes for conifer growth increases. However, relatively little is known about the growth and ecological characteristics of high elevation forest ecosystems; the increases may in fact be a normal phenomenon that reflects the natural range of variation in growth of subalpine species. Whitebark pine, on the other hand, has experienced significant reductions. Periodic fires favor whitebark pine regeneration and survival in comparison with subalpine fir and spruce. The lack of fire, combined with white pine blister rust, an exotic disease, has resulted in successional replacement of many whitebark pine populations by other conifers.

3) Priority bird species in High Elevation Conifer habitat in Wyoming:

Level I:
Northern Goshawk

Level II:
Great Gray Owl
Boreal Owl
Three-toed Woodpecker
Black-backed Woodpecker
Olive-sided Flycatcher
Hammond's Flycatcher
Brown Creeper
Golden-crowned Kinglet
Townsend's Solitaire
Townsend's Warbler

Level III:
Blue Grouse
Clark's Nutcracker

Mid Elevation Conifer

1) Describe the habitat (Ferry et al. 1995, Green and Conner 1989, Gruell 1980, Knight 1994, Uchytil 1992):

a) Historic conditions: Pure or mixed stands that included limber pine, Douglas-fir, lodgepole pine, blue spruce, ponderosa pine, and aspen. Historically, the land surface was less forested, in an earlier successional stage, and had more canopy perforation; however, all tree species present today were represented historically. Less frequent (80 to 150 years) but more intense stand replacement fires occurred. The aspen component was greater due to more intense fires. Less ungulate use than in the present. Higher beaver concentrations and more influence than in the present.

b) Present conditions: Mixed conifer; pure or mixed stands that can include limber pine, Douglas-fir, lodgepole pine, blue spruce, and/or ponderosa pine; can include aspen. Lodgepole pine is most common and can cover extensive areas; it covers more acres than any other forest type in Wyoming. In general, there is little understory among the early to mid seral lodgepole pine stands. Trees are mostly 100 to 150 years old. Fire suppression, by precluding the initiation of new stands, is responsible for a change in the distribution of age classes, and may have allowed dwarf mistletoe to increase in intensity and distribution. The aspen component has decreased due to loss of fire. Dead trees are numerous in some areas; most were killed in the 1950s and 1960s by the mountain pine beetle. The pine beetle may not have been able to spread as extensively prior to settlement because of a fire-caused mosaic of younger-aged trees, which confined outbreaks.

2) Identify the issues:

a) Use: Wildlife cover and food (e.g. lodgepole pine seeds are an important food for birds and mammals, and needles are an important winter food for Blue Grouse), timber harvesting (lodgepole pine is one of Wyoming's most important timber species), recreation, oil and gas extraction, grazing.

b) Access: The density of roads from logging and recreation has increased, allowing access to virtually all parts of this habitat type. The majority of this habitat type is publicly owned.

c) Problems: Fragmentation due to roads and trails, timber harvesting, rights-of-way, recreation, and home development; fire suppression; loss or reduction of the aspen component; decreased snag (standing dead tree) density; changing structure of the understory due to grazing and home development; feral and domestic cats; avian displacement due to human activities.

d) What has been the cause of change to the habitat: Fire suppression; timber harvesting and related management; increased recreation, such as downhill ski areas and off-road vehicle travel; increased human use.

3) Priority bird species in Mid Elevation Conifer habitat in Wyoming:

Level I:
Northern Goshawk

Level II:
Great Gray Owl
Calliope Hummingbird
Broad-tailed Hummingbird
Rufous Hummingbird
Williamson's Sapsucker
Three-toed Woodpecker
Black-backed Woodpecker
Olive-sided Flycatcher
Cordilleran Flycatcher
Plumbeous Vireo
Brown Creeper
Townsend's Solitaire
Townsend's Warbler

Level III:
Blue Grouse
Clark's Nutcracker

Low Elevation Conifer

1) Describe the habitat (Arno 1980, Bock et al. 1993, Green and Conner 1989, Idaho Partners In Flight 2000, Knight 1994):

a) Historic conditions: Before 1890, frequent fires confined the low elevation conifer woodlands to rocky sites or the lee sides of slopes. Canopy fires were probably rare before European settlement, but fire scar data suggest that surface fires occurred on average every 10 to 25 years. The effect of fire in the low elevation was to create open savannahs and patchy, park-like woodlands. Frequent surface fires killed young seedlings and saplings but, because of their thick bark, the older trees were not usually killed and stands were dominated by mature and old growth trees. Frequent fires resulted in low heavy-fuel loading of the forest floor and understory that, in turn, reduced the ability of fire to reach the overstory and completely destroy the stand. Insects and diseases were present but usually killed only individuals or small patches of trees. Understory vegetation was dominated by bunchgrasses and forbs.

b) Present conditions: In eastern Wyoming, the low elevation conifer forests are dominated by ponderosa pine. The most extensive ponderosa pine forests are found in the Black Hills and the eastern slopes of the Bighorn and Laramie Mountains. However, ponderosa pine is essentially absent from western Wyoming, perhaps because of a growing season that is too short and dry. The elevation range of Douglas-fir in Wyoming is about the same as ponderosa pine [4,000 to 8,500 feet (1,200 to 2,500 m)], and the foothill woodlands in the western half of Wyoming are dominated by Douglas-fir rather than ponderosa pine. The best examples occur west of the Continental Divide, such as in Sunlight Basin, Jackson Hole, and the Greater Yellowstone Ecosystem. Today, mature forest landscapes are more fragmented, but extremely dense stands dominated by younger trees have developed. These forests no longer exhibit conditions that would support a low intensity understory fire, but have become an increasingly homogeneous landscape characterized by large, stand-replacing fire regimes. Stands that were once a patchy mosaic have coalesced into larger areas capable of supporting very large crown fires. In some areas stands are encroaching into adjacent grasslands. Increased density and multi-storied canopies have led to suppressed growth of the larger trees and contributed to epidemics of insects and diseases.

2) Identify the issues:

a) Use: Livestock grazing, commercial timber harvesting, firewood cutting, wildlife use, recreation (e.g. shooting, rock climbing, off-road vehicle travel, camping, etc.), mineral extraction, home sites, and tree removal for landscaping are major uses.

b) Access: About 500,000 acres (202,000 ha) of the ponderosa pine type are in public ownership; the remaining 905,000 acres (366,000 ha) are privately owned. Most of the 736,000 acres (298,000 ha) of Douglas-fir forest are in the national forests. The community's low elevation and close association with foothill grassland and shrub areas expose it to more intensive activities of humans than most western forest types. Access and use are increasing in association with the urban interface.

c) Problems: Its low elevation and openness expose the habitat to more intensive human activities than most western forest types. Poor silvicultural practices have emphasized economic values over stand health and long-term condition. Fire suppression, livestock grazing, and logging act together to cause increases in tree density, heavy fuel loading, mortality in the oldest age classes of trees, insect and disease outbreaks, and fire severity and size. Other problems include encroachment of nonnative species (especially Canada thistle after ground disturbances), and urbanization (e.g. planting exotics; loss of habitat diversity; habitat fragmentation; domestic dogs and cats; exotic wildlife like European Starlings and House Sparrows; and increased predators like skunks, raccoons, and red foxes).

d) What has been the cause of change to the habitat: Three types of management activities have had the most influence on changing the nature of low elevation conifer forests: fire suppression, livestock grazing, and tree harvesting. In the past century, long-term fire exclusion has brought about dense, overstocked stands and large, continuous buildups of heavy fuel, particularly live-ladder fuels that could allow fires to crown and destroy the stand. Grazing impacts began in the late 1800s and early 1900s when large herds of domestic sheep and cattle were allowed to graze freely in the low elevation forests. The result was substantial damage to soils and vegetation, especially where herds were concentrated. Perennial bunchgrasses, in particular, are still recovering from the severe overgrazing of the early days. Today, grazing occurs at much lower densities, but localized damage to soils and vegetation may still occur where animals concentrate. Even today, livestock grazing removes herbaceous vegetation that provides fine fuels necessary to carry frequent, low intensity fires, causing fires to spread more slowly and burn hotter. Grazing also improves conditions for tree seedling establishment by reducing competition from grasses and forbs. Mature forest landscapes have been fragmented through timber harvesting, which has also selectively removed most of the large trees. Much of the old growth has been lost to logging, and the structure of many of the old growth stands that remain has been compromised by the dense growth of young trees. Many snags have also been removed, which is a loss of an essential resource for cavity-nesting bird species.

3) Priority bird species in Low Elevation Conifer habitat in Wyoming:

Level II:

Merlin
Lewis' Woodpecker
Dusky Flycatcher
Plumbeous Vireo
Pygmy Nuthatch
Western Bluebird

Level III:

Red-headed Woodpecker

Aspen

1) Describe the habitat (Bartos and Campbell 1998; DeByle 1990; DeByle and Winokur 1985; Dieni and Anderson 1997a; Knight 1994; Mueggler 1988, 1989; Schullery 1995; Winternitz 1980; Yellowstone National Park 1997):

a) Historic conditions: Prior to the influence of European American settlers, aspen was probably much more widely distributed than it is now. Aspen thrives on ecological perturbations, and historically was probably regenerated by natural fires caused by either lightning or Native Americans. Blowdowns, landslides, flooding, and even natural pathogens also perpetuated aspen communities, but fire was probably of paramount importance. Aspen reproduces vigorously by root suckers following a disturbance. It may occur as a climax species, or as a successional cover type that can become dominated by conifers over time. Thus, many of today's mixed stands that include decadent aspen and conifers in the overstory were once dominated by aspen. In addition, changes in the grazing pressure of wild and domestic ungulates since European settlement have altered the composition of the aspen community, both in the understory and in the aspen itself.

b) Present conditions: About 467,000 acres (190,000 ha) of aspen is found throughout Wyoming's major mountain ranges. The greatest concentrations of aspen stands are found on the Sierra Madre, Wyoming and associated ranges, Wind River Range, and Gros Ventre Range. Sizable stands are also found in the Medicine Bow and Laramie Mountains of southeastern Wyoming. Relatively little contiguous aspen occurs in the Black Hills and Bear Lodge Mountains, Bighorn Mountains, Absaroka Range, Teton Range, or the Yellowstone Plateau. It is estimated that over half of the historic aspen acreage within Wyoming has converted to other community types through fire suppression and natural succession, or has been lost to urban expansion.

Aspen grows in a wide variety of environmental conditions from the foothills to the subalpine zone. It typically occurs in depressions, ravines, and valley bottoms, or on the lee sides of ridges, where snow accumulates, and where moister and better-developed soils occur. Required site conditions include long growing seasons, deep snows, and annual precipitation exceeding 16 to 20 inches (40 to 50 cm). Considerably less aspen is found in Wyoming than in other parts of the West, such as Utah, but it usually occurs as conspicuous, small, scattered groves that are a highly valued part of the landscape. In Wyoming, aspen is usually a seral constituent of Englemann spruce-subalpine fir, Douglas-fir, blue spruce, lodgepole pine, and ponderosa pine forests. At lower elevations, it is often found as stringers along riparian corridors, or in small mesic (moist) islands surrounded by drier pine uplands. At higher elevations, it functions primarily as a seral dominant species within the lodgepole pine-spruce-fir community. At intermediate elevations and on deep soils, aspen can occur as pure stands of successionally stable woodlands dispersed within a matrix of coniferous forest types.

A characteristic element among aspen communities is the luxuriant undergrowth that it supports compared to that in adjacent coniferous forests. This undergrowth frequently consists of three layers: tall shrubs, medium shrubs / tall herbs, and low herbs. Forbs generally dominate the herb component but, occasionally, grasses and sedges are equally abundant. However, changes in the grazing pressure of wild and domestic ungulates since European settlement have altered the nature and structure of the shrub / herbaceous component. Human influences have likely altered the understory community composition and associated use by avian species.

About 88 species of birds potentially use aspen habitats in Wyoming. Breeding bird densities and diversity in aspen are higher than in other montane vegetations. Because of the ecological amplitude of aspen, overstory and understory vegetation composition varies widely across its range, resulting in equally diverse breeding bird assemblages. Bird communities within aspen stands are often composites of aspen-associated species along with many species found in the surrounding habitats. It appears that breeding bird density in aspen is related to surface water and ground moisture levels, large and numerous insects in the aspen understory, edge effect, and nest cavity availability. Perhaps the most important contribution of aspen woodlands to avian nesting habitat is as a substrate for primary and secondary cavity nesters. Aspen trees have soft wood, and are prone to infection from decay fungi, such as the heart rot fungus, which makes them attractive to cavity excavators. In many instances, aspen forests provide the only available nesting habitat for some ground- and shrub-nesting species.

Most aspen regeneration occurs as root suckering; establishment from seed is rare. Therefore, aspen stands consist of a mosaic of clones, within which individual trees are genetically identical and have strong structural uniformity. Despite uniformity within clones, multi-clone stands often exhibit wide structural variation due to genetic and site differences among adjacent clones. Clone size averages ½ acre (0.2 ha) across the species range. Most aspen stands have well-defined overstory layers of relatively uniform height produced by the rapid regeneration of suckers following stand-replacement events. The majority of stems are produced during the first 4 to 6 years after disturbance; thus, stands with an equal representation of multiple age and size classes are rare. Multiple age classes develop when older stands begin to disintegrate or when disease or insects open the canopy and apical dominance declines, releasing understory suckers.

Following severe disturbances, such as stand-replacement fires or clearcutting, aspen usually dominates sites for many decades. On some sites, conversion back to a conifer-dominated stand occurs very quickly (<100 years), while on other sites, conversion may take many aspen generations and extend 300 to 400 years. The rate of stand conversion is determined by disturbance factors, proximity to conifer seed sources, and rate of conifer seedling growth into the stand canopy. Modern fire suppression practices and drought conditions have contributed to the loss of seral aspen stands and the decline of aspen regeneration throughout the mountain West. Remaining stands are often decadent and approaching their maximum age.

As aspen sprouts become less common through succession and fire suppression, livestock and big game in need of browse concentrate on those that remain, which can lead to their further deterioration. Heavy utilization can prevent aspen sprouts from growing into adult height after a fire, as can heavy utilization in combination with a lack of fire. Grazing by cattle and sheep has been the primary consumptive use of aspen in Wyoming. Heavy browsing by livestock, particularly sheep, can adversely impact aspen growth and regeneration. Most livestock use aspen, browsing the leaves and twigs, but it is estimated that sheep consume about four times more aspen sprouts than cattle. In addition, wild ungulates graze the abundant and succulent forage under aspen, often selecting this forage source over others available in the vicinity. Both deer and moose can impact aspen regeneration, but elk are usually the most damaging because elk typically winter in or near mid-elevation zones where aspen forests principally occur. Elk herds, particularly in western Wyoming, have dramatically impacted the ability of aspen stands to regenerate, even after extensive treatments. However, there is some controversy over whether today's heavy elk utilization is or is not representative of presettlement conditions.

2) Identify the issues:

a) Use: Aspen-dominated woodlands provide food, cover, and breeding sites for many wildlife species; produce forage for domestic livestock; produce wood fiber; provide fire protection by acting as living firebreaks for the more flammable conifers; provide watershed protection; provide high yields of water; and are valued for recreation and scenic beauty.

b) Access: Most aspen habitat is on national forest land and is highly accessible to the public. The density of roads from logging and recreation has increased, allowing more access by vehicles.

c) Problems: Because of the decrease in severe fires resulting from modern forest fire prevention and suppression practices, natural succession is replacing aspen with conifers. Human development has brought a loss of habitat diversity, an increase in predators that are attracted to human habitation (e.g. raccoons, skunks, and red foxes), domestic dogs and cats, invasive plant species, and exotic wildlife like European Starlings and House Sparrows. Other problems include heavy grazing and trampling by wild and domestic ungulates; clearing for farming; heavy, high-intensity recreation; and climatic change, through lower moisture levels (which allow succession from aspen to sagebrush) and temperature extremes.

d) What has been the cause of change to the habitat: Fire suppression and over-grazing are the primary causes of change. Climate change to a more arid state, increased recreation, and the issues of human development have contributed to stress on aspen habitat.

3) Priority bird species in Aspen habitat in Wyoming:

<u>Level I:</u>
Northern Goshawk

<u>Level II:</u>
Red-naped Sapsucker
Hammond's Flycatcher
Dusky Flycatcher

Best Management Practices

Wyoming Partners In Flight Best Management Practices for Forests to Benefit Birds in Wyoming.

Introduction

Various bird species that use forests have a diversity of requirements. Bird species respond differently to variation in forest characteristics such as vegetation composition and structure; elevation; hydrology; forest age; patch size; shape; special features such as snags, streams, or cliffs; surrounding land use; and distribution of forest stands across the landscape. A variety of habitats under different or rotating management schemes may be the best strategy across a landscape that encompasses public lands and diverse private lands, and may even cross state boundaries. Maintaining a variety of bird species requires the kind of forest management that maintains plant and habitat diversity. Many of the characteristics of forests can be manipulated to benefit birds; landowners and land managers can take a variety of simple and inexpensive actions to improve habitat for birds and help them nest successfully. By maintaining and restoring habitat for forest-dwelling birds, many other wildlife species will also benefit.

As a landowner or land manager, the actions you take will depend on your goals, resources, and commitment, as well as the physical characteristics of your property, such as soil type, topography, and existing vegetation. The following Best Management Practices (BMPs) should provide some reasonable guidelines for managing forest habitats to benefit a wide variety of resident and Neotropical migratory birds in Wyoming.

Many of the Best Management Practices for forests fall into major categories of land use such as Forestry, Engineering, Grazing, Recreation, etc. The recommended BMPs are broken out into categories for convenience, although some are general enough to cross into other categories.

General

1) Take a conservative approach to management activities in forests. Because most trees take many years to mature, any miscalculations could have long-lasting consequences. Consider both long- and short-term impacts and/or benefits of any activities within or adjacent to forests. Recreation, development, fire suppression, and improper grazing in forests can reduce the multi-aged, multi-layered structure, including snags (standing dead trees) and diseased trees, most beneficial to birds.

2) Develop a long-range forest management plan at a landscape and even regional scale to manage for multiple bird species with different habitat needs while continuing to

meet other resource objectives. For example, the value of an individual 100-acre (40-ha) patch of forest to birds varies greatly, depending on whether it is part of an extensively forested landscape or the only forest patch for miles. Also, landscape-scale land use patterns significantly affect the population levels of cowbirds and avian predators in the area. By managing habitat at the landscape scale, managers can contribute to the health of regional populations through their own local actions on the ground. Thus, a regional goal might be to maintain large tracts of relatively undisturbed or older forest in close proximity to other forest fragments or to tie into large region-wide systems of interconnecting forested habitats that encourage movement of birds within appropriate habitats.

3) Manage local forest stands to address goals set at larger scales. Maximizing diversity at the local scale could compromise landscape and regional diversity by fragmenting mature forest or homogeneous forest habitats. Instead, strive to meet landscape and regional diversity goals for forest types and age classes, and to complement the pattern of the surrounding landscape in a way that best accomplishes local and regional management goals.

4) Maintain all habitats (e.g. vegetation cover types and successional stages) and important habitat components (e.g. snags and forest floor complexity). Strive to mimic, retain, or restore presettlement proportions and distribution of forest types, successional stages, and habitat components.

5) Maintain plant species diversity and manage for a patchwork or mosaic of native plant communities and age classes across the landscape. Although some pieces of the landscape must be managed to the detriment of some species and the benefit of others, always maintain a sufficiently wide range of variability of critical structural characteristics across a broad landscape so that the habitat needs of most bird species can be met. Provide a variety of habitat conditions, but do not sacrifice old growth forests or large areas of contiguous forest and avoid using the same forest treatment everywhere.

6) Ensure that all age classes are present (seedling, young, mature, and decadent) in the forest, with more seedlings present than decadent trees, and more young trees than mature ones. Provide a balanced age structure while protecting and maintaining old growth forest where it occurs. This will provide a variety of structural characteristics that influence the kinds of food and cover available to birds, including density, spacing, and size of living trees; height, profile, and closure of the canopy; density and size of dead trees (standing and on the ground); and density, spacing, and profile of understory vegetation.

7) Provide multiple layers of plants, or “vertical vegetation structure”, in forest habitats. A diversity of bird life within a forest requires a high diversity of microhabitats with

green vegetation at all heights. Many bird species nest and forage within 10 feet (3 m) of the ground, so it is critical to maintain a well-developed woody and herbaceous understory. Healthy forests have young trees, shrubs, and herbaceous plants that provide this layer. Shrubs and herbaceous plants are generally associated with open canopy forests that are of diverse structure and age. However, even in old growth conditions where canopy cover is high, patches of shrubs and herbaceous plants will develop where falling trees have opened the canopy.

8) Within extensive areas of forest habitat, manage for a patchwork or mosaic of different communities across the landscape. These may include wet meadows, bare ridges, aspen stands, healthy riparian vegetation, and interspersed shrub habitats. Mosaics support many bird species with different needs. Many birds that breed in forests utilize non-forested habitats for foraging, molting, migration, and pre-migration staging areas. For example, the Northern Goshawk breeds in mixed conifer forests, but forages in a variety of habitats; the Calliope Hummingbird frequents meadows, canyons, riparian aspen stands, willow thickets, and other shrubby areas within coniferous forests; and the Great Gray Owl nests in forests but often forages in meadows within the forest.

9) Maintain all old growth stands where they exist, and ensure the presence of multiple stages of mature forest on the landscape. Attributes of old growth forest include large snags, large trees, and conifer cones; managing for these attributes, and therefore old growth conditions, will benefit species such as the Brown Creeper, Golden-crowned Kinglet, and Red Crossbill. Provide for the development of future old growth by leaving areas unharvested for 100 to 200 years or more. Maintain large tracts of late-rotation forest which are relatively close to other forest fragments or which are part of large, region-wide networks of forest habitat.

10) Maintain forest in large, contiguous areas and maintain continuity between stands wherever possible to benefit area-sensitive species such as the Ovenbird. (An area-sensitive species is one that requires a large block of unfragmented habitat to successfully breed and survive.) Western forests are naturally patchy and habitat alterations should be designed to promote habitat interspersion and variety, but avoid converting forested land to other uses. Habitat fragmentation can result from land conversion to housing developments, mining, and agriculture. Avoid human-caused fragmentation and adjacent land uses that subsidize cowbirds and avian predators, including intensive livestock grazing, golf courses, human habitation, and recreation areas.

11) In areas with little forest or high levels of disturbance, preserve or restore even the smallest of forest fragments in an effort to provide some habitat for forest specialists and to provide important stopover sites for Neotropical migrants. Riparian bottomlands, ravine bottoms, and patches along lakeshores are particularly important.

Develop a policy of "no net loss" of forest habitat (i.e. discourage loss and conversion of habitat, but when unavoidable, mitigate with equal or greater restoration efforts).

12) Allow or reintroduce natural disturbance patterns, including wildfires and insect outbreaks. As a result of disturbances, ecosystems should consist of a mosaic of patch types in varying stages of recovery, including a sufficiently large area that is in a recovered state. Develop treatments that restore the stand structure, composition, and patterns of presettlement disturbance regimes. Plan the size of treatment units to reflect the range of historic events. Although we do not know every habitat requirement for every species, we can assume that species present today evolved under natural processes in natural habitats, and that by preserving those processes and habitats, we can maintain healthy populations of the species that are associated with them.

13) Provide small-scale openings in the habitat. Openings create a diverse landscape that provides food for both seed-eating and insectivorous birds. Also, small mammal populations increase within cleared areas, which can attract predatory birds. However, openings are not good management for an intact forest community and should only be created in areas where they will not jeopardize a forest interior ecosystem. Openings should not be too large and the forest should not become fragmented. Limit clearing widths to 650 feet (200 m) to maximize use by bird species that nest in adjacent forests and include cleared areas in their territories. In ponderosa pine forests, cut 5- to 7-acre (2- to 3-ha) openings in sapling or small-pole stands (the least preferred by wildlife), and protect junipers, oaks, and all snags. In higher elevation spruce-fir forests, keep openings small (tree length in opening diameter) to avoid extensive wind damage.

14) Limit restoration or management activities such as prescribed burning, forest thinning, firewood removal, livestock grazing, and herbicide application to the non-breeding season. The nesting season is a critical period for the maintenance of bird populations, and some management activities can have serious consequences for breeding songbirds by destroying nests and nesting habitat or causing nest abandonment. When such actions are absolutely necessary during the breeding season, time disturbance to minimize impacts on nesting birds.

15) Protect or restore forests along streams, wide stream bottoms, and ravines, as they are crucial to both breeding and migratory birds.

16) Regardless of the motivation for altering forest habitat, retain all snags (standing dead trees). Snags increase bird density and diversity by providing perching, foraging, and nesting sites. They are an essential habitat component for primary and secondary cavity-nesting birds like woodpeckers, owls, bluebirds, and wrens.

17) Provide a complex forest floor, including downed logs, root wads, and a deep litter layer. Dead and down woody material on the forest floor provides a base for growth of

new trees ("nurse logs"), harbors fungi that aid in nutrient cycling, and provides habitat for wildlife. Birds, like the Ovenbird, Townsend's Solitaire, and Dark-eyed Junco, use downed logs, sticks, and leaf litter as nest sites, and nest in cavities found in root wads, stumps, and downed logs. Conserve forest floor complexity in managed forests (which often lack downed logs and a litter layer) by minimizing understory disturbance during harvest, retaining woody debris during harvest, felling additional trees if down woody debris has not been maintained at sufficient levels during earlier harvests, retaining root wads where they occur, and creating and retaining slash piles of various sizes during harvest.

18) Maintain deciduous components in coniferous forests, especially where they are declining. Encourage aspen regeneration. Deciduous trees provide fruits and foliage insects different than those of conifers, and have a higher density of cavities than conifers. Species that benefit from and are associated with deciduous trees in the canopy of conifer-dominated forests include the Warbling Vireo and Western Tanager.

19) Regulate ungulate grazing levels in aspen stands. Ungulates can cause injuries to overstory trees by stripping the bark and increasing their susceptibility to disease; heavy barking may indicate overutilization in the stand. Ungulates may also affect establishment of seedlings and stand development.

20) Maintain existing and reestablish pure and mixed stands of whitebark pine, dominated by trees that are resistant to blister rust.

21) In ponderosa pine forests, manage for both early (grass / forb and shrub / tree seedling) and late (mature and old growth) forest successional stages. Few wildlife species find their optimum habitats in the intermediate (pole-sapling and young) successional stages of ponderosa pine forests.

22) Create more open stand structures in ponderosa pine and Douglas-fir stands to improve and enhance the growth of large conifers and deciduous species and reduce vulnerability to insects, disease, and severe fire. These low elevation forests are often overly dense and contain numerous small trees. Use a combination of fire and mechanical treatments to reduce densities to levels found historically. Group selection, thinning from below, and shelterwood cuts, along with stand-maintaining fires, are all feasible options. A relatively open canopy in Douglas-fir and ponderosa pine forests would benefit species like the Wilson's Warbler, Swainson's Thrush, Warbling Vireo, Hairy Woodpecker, and Dark-eyed Junco.

23) Use prescribed fire or cutting to reduce the density of lodgepole pine forests. Thinning based on a diameter limit is more desirable for birds in lodgepole pine forests than thinning that retains uniform spacing; it results in a mosaic of habitat types similar to the results of some fires that enhance many desirable features of bird communities.

Thin by diameter limit to fewer than 300 trees per acre (750 per hectare). This will permit ground cover to develop and facilitate stratification in the stand.

24) Protect the forest against exotic plants. When planting trees, select native species and avoid exotic species. Many exotic plants are vigorous species that can be established easily in many areas, but they out-compete native plants and dominate the areas they occupy, often have little value as wildlife habitat, and can quickly degrade existing native wildlife habitat. Monitor forested plots for nonnative, invasive plants, and devise a removal plan, if necessary. Control of any exotic plant species should involve both elimination and simultaneous introduction of a desirable competitor to minimize reinvasion.

25) Avoid attracting or supporting nonnative animal species. Nonnative animals can have a severely negative impact on songbirds. Invasive bird species such as European Starlings and House Sparrows often out-compete native birds for nest sites and have been known to destroy active nests and even kill nesting adults.

26) Where possible, restore or rehabilitate degraded and disturbed sites to native plant communities. Initiate actions to improve the quality of degraded forest habitat through appropriate management, particularly the use of natural disturbance regimes such as fire. Use planting, where appropriate, to reestablish conifers, especially where seed sources are gone. Use native species and local seed sources for restoration and rehabilitation.

27) Develop conservation partnerships between landowners, land managers, and private organizations to enhance the quality of forest habitat. Private landowner involvement is critical to the success of avian conservation efforts, and land management of individual ownerships should be coordinated with other ownerships and objectives whenever possible. While landowners need to derive income from the land, this can often be compatible with maintaining regional biological diversity, depending on how the land is used and what land management tools are employed. Identify the habitat needs of the birds in the area and the economic needs of the landowner so a baseline need is established. Important habitat on private land can be protected with conservation easements. In some cases, landowners can derive income from hunters, birders, and naturalists who visit the region.

28) While it is better for birds (and cats) if cats are kept indoors, have domestic “barn” cats spayed or neutered, keep pet food and food bowls indoors so predators like raccoons and feral cats do not have an additional food source, and never intentionally feed feral cats. Cats (even well fed domestic cats) can be devastating to local songbird populations. Natural predators, like owls and hawks, are very efficient at controlling rodent pests, even around human dwellings.

29) Regularly monitor birds to see how the management plan is working, and redirect efforts if necessary (with special emphasis for species that seem to be declining). Implement forest habitat monitoring programs to establish baseline data and identify changes in habitat quality (both positive and negative) through time. Use standardized methods to monitor the habitats and sensitive species in an area, before and at several-year intervals after treatments are applied, to aid in making proper land management decisions in the future.

Forestry

Timber harvesting has sometimes been targeted as having negative effects on biodiversity, and when used indiscriminately, it can. Silvicultural practices alter landscape structure, forest age and structure, and create edges, all of which can adversely affect bird populations. However, timber harvest can be an effective tool for maintaining or restoring biodiversity and ecosystem health when used with both ecological and economic objectives in mind. Silvicultural techniques can remove high forest cover, thin trees, prepare the forest floor for tree regeneration, stimulate the growth of understory vegetation, decrease the incidence of disease and insects, maintain site-adapted species, and recycle nutrients. Innovative uses of silvicultural practices such as species selection, thinning, and biomass removal can go a long way in producing forests that are vigorous and healthy. Silvicultural practices at least partially replace natural disturbances in managed forests, and thus provide the means for producing desired changes in stand composition. Managed forests have the potential to provide suitable habitat for many bird species. These recommendations can help reduce the impacts of forestry on bird populations.

1) Provide a variety of forest habitat conditions and structural characteristics across the landscape to meet the habitat needs of most bird species. Design timber programs to provide the widest diversity of vegetation, allowing some forest plots to grow beyond their maximum productive age while cutting others to provide various stages of regenerating vegetation. However, do not maximize within-stand diversity at the expense of landscape or regional diversity. For example, selective cutting may produce high within-stand diversity, but an entire landscape of selectively cut uneven-aged forest would be lacking some Neotropical migratory birds.

2) Create more complex habitat conditions within logged areas by leaving some live and dead trees or by enhancing the growth of shrubs.

3) Manage for a diversity of tree species to provide habitat for birds that utilize a variety of tree species for foraging. For example, the Brown Creeper makes greater use of forest stands that are diverse in tree species composition. It may forage from a tree species as it occurs in mixed stands, but seldom forages in monotypic stands of the same species.

4) Retain a buffer zone in riparian areas where no timber harvesting and firewood cutting are allowed, to protect the stream channel and provide habitat for birds that depend on mature trees. Buffer zones that are at least 200 feet (60 m) wide can support avifauna similar to that of large forest tracts, while narrower buffer strips [e.g. 65 feet (20 m) wide] are more favorable to ubiquitous species than forest-dwelling species.

5) Maintain mature stands of trees adjacent to meadows to help species like the Olive-sided Flycatcher.

6) Retain snags (standing dead trees), dead-topped trees, and live trees with cavities under any cutting method. These increase bird density and diversity by providing perching, foraging, and nesting sites. They are an essential habitat component for primary and secondary cavity-nesting birds, like woodpeckers, bluebirds, and wrens, and enhance the number of insects available for food. In situations where some snags must be cut, retain larger snags rather than smaller ones. Snags eventually topple and become organic debris, so retain an abundance of mature trees to replace them over time.

7) Avoid post-fire salvage logging. Salvage and sanitation logging and debris disposal remove snags and snag recruits and reduce the amount of dead and down woody material that provide feeding and nesting sites for birds, especially post-fire dependent species like the Black-backed Woodpecker, Three-toed Woodpecker, and Hairy Woodpecker.

8) Maintain a shrubby understory in stands of trees adjacent to meadows and along stream courses to help species like the MacGillivray's Warbler and Yellow Warbler.

9) Maintain some old growth forest for species that nest in large snags or live trees, feed largely on tree seeds, or require large acreages of continuous mature forest cover. The structure of old growth stands varies with forest type but can be characterized by multilayered canopies, large trees, large snags, large logs, and patchiness of overstory and understory vegetation. Leave at least 50 to 100 acres (20 to 40 ha) of old growth forest for every 1,000 acres (400 ha) that are cut. Lengthen rotation ages in even-aged systems and increase the proportion of larger trees in uneven-aged systems to encourage old growth characteristics in logged forests.

10) Use mechanical treatments in combination with prescribed fire to reduce the likelihood of stand-replacing fire and soil sterilization, particularly in low and mid elevation forests.

11) Maintain forest floor complexity, including downed logs, root wads, and a deep litter layer. Birds, like the Ovenbird, Townsend's Solitaire, and Dark-eyed Junco, use downed logs, sticks, and leaf litter as nest sites; nest in the cavities of root wads, stumps,

and downed logs; and eat insects that inhabit logs. To conserve forest floor complexity, implement the following strategies: 1) Protect old growth forests, which usually have deeper litter than younger forests. 2) Retain at least 12 large, uncharred logs per acre (5 per ha) and other woody debris during timber harvest. Particularly retain large logs—those greater than 12 inches (30 cm) in diameter at the large end and greater than 20 feet (6 m) long. 3) If woody debris has not been maintained at sufficient levels from earlier harvests, fell some additional trees to create this attribute. 4) Retain root wads where they occur. 5) Create and retain slash piles of various sizes. 6) Minimize understory disturbance. 7) Since most of a tree's timber value is in the lower 1/3 of the bole, remove this portion and leave the top as a downed log.

12) Use a combination of even-aged and uneven-aged silvicultural systems across the landscape, with a significant portion of the stands managed for an uneven-aged structure, to create a mosaic of forest conditions and to benefit different species of birds. Uneven-aged management (e.g. single-tree selection and group selection) develops vertical complexity by maintaining trees in a variety of size classes, reduces horizontal complexity by not cutting entire stands, and minimizes edges and early successional stages. In contrast, even-aged management (e.g. clearcutting and shelterwood cuts) produces a monoculture of trees approximately the same size and height, increases horizontal complexity (spacing) by creating different successional stages between the various stands or cutting units, reduces vertical complexity of the vegetation, and creates edges where different successional stages meet. Although there is no forestry technique that will benefit all species, and the selection of a silvicultural system must be made on a stand-by-stand basis, uneven-aged management practices are often most suitable for healthy, mixed-aged stands, and often result in a greater number of bird species showing population increases than decreases compared with even-aged systems. However, do not maximize within-stand diversity at the expense of landscape or regional diversity; uneven-aged management may produce a well-developed vertical structure, but an entire landscape of selectively cut uneven-aged forest would be lacking some bird species. Similar bird species diversity can be maintained in both even- and uneven-aged management if the even-aged system is managed for a diversity of tree species, and if a range of stands of different ages (including mature and old growth) are maintained. Enhancing the vertical diversity of even-aged stands is also feasible, but generally more complex. In uneven-aged management systems, take care to prevent a shift in tree species composition.

13) Use a balance of the following cutting systems to create small openings for gap species, large openings for early successional forest migrants, and a balanced age-class distribution to maintain sufficient mature forest habitats.

a) Selective Cutting – Selective cutting of timber involves removing selected trees from a forest stand. This method prevents loss of soils, opens the forest floor to light which increases understory growth useful for cover and as a food source for many wildlife species, leaves much of the natural cover present when the operation is completed, and assures that there will be trees of many different ages within each stand.

i) Group Selection – In group selection cuts, small groups of trees are marked and removed. This method creates small, dispersed openings in forest stands. Group selection might be preferable as a smaller-scale alternative to clearcutting (e.g. to decrease the risk of loss from windthrow).

ii) Individual (or Single-tree) Selection – In single-tree selection cuts, individual trees are marked and cut. This method provides the least difference in horizontal stand structure, and favors species associated with uncut forests and those that require stands with a multi-storied structure. This method may be used where late successional or edge-sensitive bird species are desired.

b) Shelterwood Cutting – Shelterwood cutting involves the removal of all trees from an area except for several large trees that provide shade for developing seedlings. The large trees are removed a few years later, after the seedlings have become established. This method provides a variety of habitats attractive to species that forage in stands with widely spaced trees, and trees are still available for nesting and feeding until final harvest. The presence of mature, residual trees in shelterwood cuts maintains some of the characteristics of mature stands. Consequently, some species of birds generally associated with mature stands can be maintained after the first cutting in a shelterwood sequence.

c) Clearcutting – Clearcutting involves the removal of all trees from an area. Clearcuts or patch cuts that create small, dispersed openings in forests provide a mosaic of stands of different ages and species composition. The use of clearcuts is often criticized but, if used judiciously, clearcuts can provide habitat for early successional species and species like the Boreal Owl and Great Gray Owl that use small openings in the forest for foraging. Smaller clearcuts are more desirable for birds since small open areas favor species like raptors, and are not as detrimental to forest-dwelling and area-sensitive species as large cuts. The more forest habitat in a region, the larger clearcuts can be; determine the maximum size of clearcuts by considering the size of the management unit, the home range requirements of wildlife using the area, and natural disturbance regimes. Leave snags, woody debris, some slash piles, and pockets of vegetation in the form of islands or peninsulas to provide corridors for movement and refuge areas for wildlife.

14) Avoid fragmenting large contiguous forest tracts; these areas have the ability to support the largest number of forest-interior and area-sensitive birds. Although providing a variety of forest conditions is a goal, this should be accomplished at a landscape scale so that large contiguous forest tracts are not sacrificed. Most species have a minimum habitat size below which they cannot exist, so small patches of all ages

and stand structures can result in a reduced number of species present in a region. Reserve some of the least fragmented areas from timber harvest.

15) Consider the regional and landscape context of a forest stand when planning silvicultural treatments at the forest-stand level. In forests that are surrounded by heavily urbanized or agricultural land, plan a lower impact use, such as uneven-aged harvesting or perhaps limited recreational activities, rather than a higher impact use, such as even-aged management. In situations where the surrounding landscape is primarily forested, it may be possible to increase timber production and/or use even-aged harvesting methods, given that large expanses of forest are not limited in the landscape. However, even in highly forested areas, large unbroken forest tracts should be managed carefully to avoid creating a checkerboard of smaller fragments.

16) Aggregate harvested areas within the forest into compact shapes to minimize adverse edge effects.

17) Avoid intensive forest management, which shortens early successional stages; eliminates the final stages by emphasizing stand regeneration, growth, and harvest; and may include brush control, tree planting, fertilization, and thinning—all of which tend to accelerate tree establishment and growth and reduce plant species diversity and structural complexity. Because succession is accelerated and maturity is brief, intensive forest management can decrease bird species diversity. Also, cavity-nesters are likely to decrease due to their requirements for decayed wood, particularly in industrial forests where intensive management favors faster-growing trees and eliminates decayed trees.

18) Avoid clearcutting in high elevation (e.g. spruce-fir) forests. Because regeneration can be slow and the stand initiation stage can last over a century, harvest just enough fir in mature subalpine forests to open the canopy, release suppressed fir saplings, and allow spruce seedlings to establish. Younger stands can be lightly thinned without disrupting processes, but older stands should be harvested by selective cutting methods, which appear to most closely simulate the natural dynamics of these forests. Group selection systems are easier to design and therefore may be preferable, especially in stands that are naturally patchy. All tree sizes, including some very large trees, should be represented in the post-harvest stand. Avoid harvesting the highest elevation [over 10,000 feet (3,000 m)] spruce-fir forests entirely; allow these high elevation areas to overmature and serve as reservoirs for spruce-fir forests at lower elevations.

19) In ponderosa pine forests, use silvicultural cuttings followed by compatible prescribed burning treatments to restore and maintain the old growth character. (Returning fire into dense stands or those with understory fuels could fatally damage overstory trees.) Use mechanical methods to break up the layer of abutting crowns in the overstory, leaving 10- to 30-foot (3- to 9-m) spaces between trees to reduce the potential for fire to spread through the upper canopy, and reduce the density of sapling

and pole-sized trees. Use thinning, shelterwood cutting, and small clearcuts to create openings that enhance understory shrub, grass, and forb cover and to simulate the effects of a wildfire on small patches of seedlings or sapling-sized trees. Generally, between 1/6 and 2/3 of the available foliage of a ponderosa pine forest can be removed without detrimentally affecting the breeding bird community. The total basal area of a stand can be reduced by 15 to 50%; if removal is by uniform thinning, limit basal area removal to 30%. Remove no more than 45% of those trees with a dbh of 9 inches (23 cm) or greater, leaving a minimum of 32 trees per acre (79 per ha). Remove no more than 75% of those trees with a dbh between 6 and 9 inches (15 and 23 cm), leaving a minimum of 17 trees per acre (42 per ha). Remove 80% of the trees with a dbh between 3 and 6 inches (8 and 15 cm), leaving approximately 25 trees per acre (61 per ha). Conserve the old trees that still exist on the landscape and select trees for retention that will grow into an old growth condition in a reasonable amount of time. Leave groups of old growth trees intact to maintain the inherently clumpy nature of the stand. Plan similar cuttings at about 30-year intervals.

20) Periodically thin Douglas-fir stands from below to allow only short periods of crown closure, enhance growth rates of hardwoods and large conifers, enhance development of shrub cover, and benefit birds like the Wilson’s Warbler, Swainson’s Thrush, Warbling Vireo, and Hammond’s Flycatcher. Vary the thinning intensity through the stand to further enhance bird species richness.

21) In lodgepole pine stands, ensure that a seed source is present before applying mechanical treatments. Openings can be large where serotinous cones are present, but need to be small [25 acres (10 ha) or less] when nonserotinous cones are present. (Serotinous cones have scales that are sealed with resin. The seeds are stored in these cones for years until they are exposed to heat that melts the resin and allows the scales to open. This allows the tree to disperse the maximum amount of seeds when the conditions are optimum for germination immediately after a fire.)

22) Maintain and restore stands of deciduous trees (e.g. aspen) within coniferous systems to benefit birds like the Northern Goshawk, Warbling Vireo, Red-naped Sapsucker, and Western Tanager that use them for nesting and foraging. Deciduous trees provide fruits, seeds, mast, and foliage insects different than those of conifers, and have a higher density of cavities than conifers. In managed forests with a deciduous component, extend the rotation age to allow for development of canopy and sub-canopy gaps suitable for foraging habitat. Conduct conifer tree thinning where there is potential for understory development of deciduous trees, particularly in wet sites.

23) Avoid loss of or change in tree-species diversity and fitness by minimizing “high-grading” (the removal of only the most valuable species and the most structurally superior trees).

24) If slash must be burned following a harvest, broadcast burn rather than pile burn to reduce high temperature burns, which are destructive to soil organisms and small mammals.

25) Minimize mechanical treatments that increase susceptibility of the forest to invasion of exotic and noxious weeds and soil erosion.

26) Confine timber operations to noncontiguous drainages, as intervening ridges may reduce disturbance.

Fire

Prior to human settlement and fire suppression policies, fire was an important natural disturbance in most forest ecosystems. Wildfires stimulated renewal of plant cover by creating a mosaic of variable-aged vegetation, including all ages of conifers, herbaceous plants, and deciduous shrubs and trees. As a consequence of fire suppression, fire frequency has decreased and intensity has increased in many forests since the early 20th century. Fire suppression has altered the natural fire regime, resulting in the change in structure of many forests from open to closed stands. Although fires can be detrimental to forest birds during the early summer when eggs and nestlings might be destroyed, the absence of fire for a long period of time can also create problems when unburned forests become dense monocultures with inadequate reproduction of tree species and high fuel accumulation. Except for elevation differences, fire has been the most important factor influencing avian diversity in western forests, but understanding the effects of fire on birds is difficult because fires vary in intensity, duration, frequency, location, shape, and extent. However, birds evolved with forest fires, so it is reasonable to assume that bird species associated either directly with fires or with fire-maintained forest structures have been negatively affected by fire suppression. For example, the Olive-sided Flycatcher is often restricted to post-fire habitat and uses natural openings in the forest canopy, snags, and a mosaic of differing stand heights that fire can provide. Birds like the Black-backed Woodpecker, Lewis' Woodpecker, and Red-naped Sapsucker depend on standing dead trees in burned forests for feeding and nesting. Other species like the Mountain Bluebird and Bewick's Wren are secondary cavity-nesters, which means they depend on cavities excavated by woodpeckers.

1) Learn about prescribed burning and evaluate the possibility of using this as a management tool. Some of the changes brought about by fire suppression can be reversed by applying controlled or prescribed fires. For example, light surface fires applied under specific conditions reduce the amounts of combustible woody debris and thereby reduce the chance of wildfires. Surface fires also prepare the soil for germination of conifer seeds, thin pine thickets, recycle nutrients, rejuvenate desirable grass and shrub understories, and regenerate both conifers and deciduous trees.

2) Develop and implement approaches to reintroduce natural fire regimes into forest systems. Many forests of western North America, especially at lower elevations, were maintained historically by frequent, low-intensity fires carried by fine herbaceous fuels.

3) Reestablish fire to recreate a heterogeneous landscape mosaic. Fire must be carefully implemented so that it will not establish large areas of the same age and structure, but will leave healthy mosaic patterns of various aged stands. Fires should not remove all trees, but leave stands of unburned trees. Use small, patchy, cool burns and prevent large-scale fires that will eradicate large, continuous areas of forest.

4) In areas known to support nesting birds, conduct prescribed burns in early spring before birds arrive, in fall after nesting is completed, or in winter. Burn size should be scaled appropriately to the landscape so that a portion of the area contains nesting cover and mature forest at all times.

5) Allow wildfires to burn under prescribed conditions rather than suppressing all fires. Avoid suppressing natural fires less than 1,000 acres (400 ha), except when significant stands are threatened or when fragmentation of old growth stands will become too severe. If there is a large increase in fire frequency and areas burned, then review the policy by considering the amount of old growth left and its distribution over the landscape.

6) Keep livestock off recovering sites for at least one to two growing seasons. Grazing after a burn can delay recovery by seriously damaging the soil and vegetation.

7) Develop a fire use plan before burning. It should include the following:

a) Burn Area – Clearly define the boundaries of the burn area. Burn smaller sections within the larger area on a yearly rotational system to maintain habitat diversity.
b) Burn Objectives – Define the purpose of the prescribed burn, when it should be conducted, and the desired results.
c) Burn Prescription – Define the components of the burn that will accomplish your objectives. Time of year is a major burn prescription component for obtaining desired results. To prevent negative impacts to wildlife and still provide habitat benefits, conduct prescribed burns in fall or early spring.
d) Burning Plan – Clearly define how the prescribed burn will be carried out on the ground. Include components such as fuel treatments and fire lines to ensure the fire will carry into all areas to be burned, will not burn too hot or flare up, and will be contained within natural or constructed boundaries.

8) Avoid post-fire salvage logging. Salvage and sanitation logging and debris disposal remove snags and snag recruits and reduce the amount of dead and down woody

material that provide feeding and nesting sites for birds, especially post-fire dependent species like the Black-backed Woodpecker, Three-toed Woodpecker, and Hairy Woodpecker.

9) Encourage a variety of fire intensities appropriate to forest type across the landscape. Moderate- and low-intensity fires show less dramatic immediate affects than high-intensity fires, but a relatively cool fire during the dormant season can greatly increase food resources and leave adequate nest sites for ground- and shrub-nesting birds. Use moderate- to low-intensity fire to maintain a park-like forest habitat for birds that prefer open forest, such as timber-drilling and flycatching birds and raptors. Large, intense burns reduce the number and diversity of tree-foliage-searching and timber-gleaning birds, but may be necessary for long-term maintenance of natural forest succession patterns of some forest types and for habitat diversity in others. Primary and secondary cavity-nesters, flycatchers, and seedeaters all benefit from the habitat created by high-intensity fires.

10) In forests that have high fuel loadings and dense, multi-storied stands as a result of fire suppression, use mechanical treatment prior to prescribed fire to avoid soil sterilization, loss of large trees, and losing control of the fire. Use mechanical treatments such as species selection, thinning, and biomass removal to remove high forest cover, thin trees, and prepare the forest floor for tree regeneration.

11) In ponderosa pine forests, restore periodic low-intensity surface fires that remove ingrowth and achieve an open, park-like condition without killing the old trees. To keep the fire from becoming too intense and uncontrollable, reduce the density of ponderosa pine forests by mechanically removing small trees before using prescribed fire. In dense forests with heavy forest floor accumulations, remove heavy fuels from the base of large, old trees prior to burning, and reestablish native understory species afterward. Two or three prescribed fires at higher moisture levels may be necessary over several years to gradually reduce fuel accumulation.

12) Use prescribed fire in Douglas-fir forests to create a more open, park-like condition. Remove heavy fuels within 6 feet (2 m) of the base of large, old trees. Broadcast burning can be safe and practical when the moisture content of small diameter fuels [less than 4 inches (10 cm)] is between 10 and 17%. When the moisture content is below 10%, fire behavior may become extreme and difficult to control.

13) In low elevation conifer forests (e.g. ponderosa pine and Douglas-fir), prescribe a fire regime of approximately 20-year intervals to perpetuate a mix of tree species; stimulate understory vegetation; and maintain vigorous tree growth with low susceptibility to insect outbreaks, pathogens, and stand-replacing wildfire. Where fires are infrequent, there is often an accumulation of dead wood that fuels intense fires. These fires burn hot, climb to the crowns of the trees, and leave behind a forest of

charred snags. If fires are frequent they tend to be relatively cool ground fires that do not kill many trees. Thus, frequent fires produce a more stable environment, especially in low to mid elevation forests.

14) Use prescribed fire to reduce the “doghair”, monotonous lodgepole pine forests that have developed as a result of fire suppression.

15) Avoid burning spruce-fir forests where possible, especially at the highest elevations. Because regeneration can be slow in subalpine forests and the stand initiation stage can last over a century, fire suppression in general will benefit birds that use spruce-fir forests.

16) If slash must be burned following a harvest, broadcast burn rather than pile burn to reduce high temperature burns, which are destructive to soil organisms and small mammals.

Grazing

Within forested landscapes, the impacts of livestock tend to be concentrated in drainage bottoms, wet meadows, and grassy slopes, although forested areas are frequently used for bedding and shelter. The effects of grazing on these areas vary depending on climate, elevation, and vegetation composition, although generally the result is decreased species diversity and density of herbaceous and shrubby vegetation. Intense grazing pressure can lead to enhanced establishment of conifer seedlings and (in conjunction with fire suppression) conversion of montane shrub, meadow, and grassland areas to forested habitats and the development of denser forests than were present historically. These vegetation changes, in turn, may affect availability of avian foraging sites; food resources such as seeds, mast, and insects; and nesting sites and cover. Additionally, the presence of livestock may influence nesting success of ground-nesting species through direct trampling of nests or nest abandonment from continuous disturbance. Birds most likely to be negatively affected by livestock grazing in forests are species that are dependent on herbaceous and shrubby ground cover for nesting or foraging (such as the Hermit Thrush, Fox Sparrow, and Lincoln’s Sparrow), and species that require open savannahs as opposed to closed-canopy forests (such as the Lewis’ Woodpecker, Violet-green Swallow, and Mountain Bluebird). However, proper stocking levels and grazing regimes can be effective management tools and compatible with maintaining and improving forest habitats. These Best Management Practices for grazing focus on protecting forest habitats during crucial growing periods.

1) Grazing management plans should be developed and evaluated on a case-by-case basis by the managing agency or landowner because no single grazing strategy will fit all situations. Include forest management as an integral part of each grazing management plan. Determine site-specific forest objectives and tailor the grazing

management plan to help meet the objectives. Consider the site's specific factors of concern, such as loss of herbaceous vegetation; the site's potential and capability; its suitability for grazing livestock and the type of stock best suited to the area; and the ideal grazing strategy, including the time, place, amount, duration, and intensity of grazing. Monitor the effects of each grazing strategy on the forest to check progress toward the objectives. Record how key plant species and the overall forest ecosystem respond to grazing management (annual photographs taken from the same point are helpful).

2) Maintain proper stocking rates and livestock distribution to protect forest ecosystems. Incompatible grazing can have harmful long-term effects on survival and regeneration of tree and shrub seedlings; can negatively influence the species, structure, and health of vegetation; and can cause soil compaction and erosion. Manage grazing intensity at a level that will maintain the composition, density, and vigor of desired plants and will not damage soils.

3) Ensure adequate residual vegetation cover is left after grazing; this is essential for maintaining forest ecosystem health.

4) Maintain a well-developed woody and herbaceous understory. Many forest-interior birds depend on the cover, food, and nest sites provided by a diverse and well-developed understory. Coniferous forest birds that are most negatively affected by grazing are those that are dependent on herbaceous and shrubby ground cover for nesting and foraging, such as the Dark-eyed Junco and Orange-crowned Warbler.

5) Allow time for plants to rest and regrow between grazing periods to ensure they remain vigorous and productive. Plants that are continuously grazed during the growth period will lose their vigor and stop producing seeds, and their roots will die back, eventually causing a change in the plant community from more productive, palatable species to less productive and less palatable plants.

6) Manage pastures in a rotation grazing system. Where feasible, use a deferred-rotation or rest-rotation system, whereby no pasture is grazed the same season (spring, summer, or fall) two years in a row.

7) Be aware of the impacts that cowbird nest parasitism has on nesting birds. Increased nest parasitism often results when forests are fragmented or livestock grazing occurs near woody habitats during the nesting season. The cowbird is an open-habitat species that commonly associates with livestock because of the foraging opportunities livestock provide. Due to their nomadic behavior, cowbirds build no nest of their own. Instead, females lay their eggs in the nests of host species, often removing the host's eggs in the process. Cowbird eggs hatch sooner than the hosts' eggs, and cowbird young are larger and more aggressive; therefore, they crowd the hosts' young and receive the majority of

food brought to the nest, at the expense and often demise of the hosts' young. In the West, expansion of livestock into forested areas has allowed cowbird populations to increase and expand their range. Cowbirds are highly mobile, commuting up to 4 miles (7 km) daily between breeding and feeding sites. Therefore, it is necessary to take a landscape-scale approach to planning grazing regimes to benefit birds.

8) Situations that concentrate livestock during the songbird breeding season (April through July) increase the influence of Brown-headed Cowbird brood parasitism on songbird breeding success. When grazing constitutes a significant percentage of the landscape within or near forest habitat [particularly within a ½- to 7-mile (1- to 12-km) distance], eliminate, reduce, or closely manage grazing in spring and during the breeding season to maximize the understory habitat value to wildlife and minimize foraging habitat for cowbirds. Another option is to rotate livestock use in order to rest units from cowbird concentrations in alternate years and to give local songbird populations the opportunity to nest without high parasitism pressure.

9) Changing grazing systems and / or fencing may be effective in maintaining or improving water flow within existing drainages, which will benefit plant production.

10) Reduce stocking level, change timing of grazing, or rotate pastures to reduce or eliminate trampling of ground nests and nestlings (from May through mid-July for most songbirds).

11) Consider temporarily removing livestock from an area that is damaged or otherwise needs protection. Livestock exclusion can be a short- or long-term option for locally or regionally rare vegetation types, sites undergoing restoration, recently burned areas, wet sites (e.g. springs, seeps, wet meadows, and streams), and other areas that are easily degraded. By itself, removing livestock may not reverse the condition of severely damaged habitats and often must be combined with reseeding and other rehabilitation methods to restore site condition.

12) Keep livestock off burned sites for at least one to two growing seasons. Grazing after a burn can delay recovery by seriously damaging the soils and vegetation.

13) In wet years, and near springs and seeps, closely monitor livestock activity to avoid overuse. Decrease damage by ungulates by reducing animal numbers, fencing damaged areas, placing natural barriers such as logs and brush across pathways, and placing salt blocks and feed on uplands.

14) Monitor understory conditions in aspen stands to ensure that grazing does not cause lower value species, such as mules-ears and tarweed, to become dominant. Species such as these lower the soil stability, value for wildlife, and the regeneration ability of the aspen stand.

15) Retrain or cull cattle that have formed a home range in sensitive or degraded habitats. Cattle form definitive groups that occupy the same home range area year to year and, like many other species, will invariably return to their home ranges following disruption of their normal patterns, sometimes even after having been moved great distances. Therefore, herding cattle away from sensitive or degraded habitats may not work if they have developed a home range there. Cattle that are known to have developed a home range in sensitive or degraded habitats may be culled from the herd or can be trained to use other areas. It is also possible to behaviorally bond animals that have not grazed a unit before to an under-utilized area, given that water, forage, shade, and salt are available in that area. Handle the livestock so they disperse when turned on the pasture, avoiding initial concentration on the degraded habitat. Despite these efforts, cattle will continue to avoid certain areas, because of extreme slopes or aspect, unless innovative vegetation or other management manipulations are implemented.

Habitat Fragmentation

Habitat fragmentation—the breaking up of contiguous areas of similar vegetation—occurs when a large, continuous tract of forest is converted to other vegetation types or land uses so that only pieces, or fragments, of the original forest remain. Even prior to European settlement, western forest communities were naturally patchy in time and space and disturbances ranged from the removal of individual trees to the devastation of many square miles. The continual shifting, destruction, and renewal of patches generally assured that many seral stages and community types were maintained simultaneously on a landscape scale. However, in forest systems that are fragmented by humans, both disturbances and lack of disturbance can be threats to forest habitat. For example, a small but intense fire may obliterate a remnant of old growth forest. Habitat fragmentation can also be very detrimental to those species of birds and other wildlife that require these large patches of forest to breed and forage successfully. In fact, habitat fragmentation, along with direct loss of habitat, is one of the main causes of population declines of many species of birds. Groups of species especially impacted by habitat fragmentation include those with large home ranges, very specific habitat requirements at the "micro-habitat" level, and poor dispersal skills. Fragmenting habitats also leads to an increase in "edge effects"—increased rates of nest predation and nest parasitism, higher rates of competition within and between species for limited nesting and foraging sites, reduced pairing and nesting success, and reduced abundance of insect prey in the leaf litter. Thus, forest fragmentation not only causes a net loss of habitat, it can also reduce the suitability of remaining habitat. Characteristics of a forest that can determine its quality as bird habitat include the size and shape of a forest patch, how isolated the patch is from other forests, how much forest remains in the surrounding landscape, land use of the surrounding area, and how much edge habitat exists nearby. Use the suggested Best Management Practices to eliminate or reduce habitat fragmentation wherever possible.

1) Be aware of the problems of fragmentation and avoid fragmenting large contiguous forest tracts. These areas have the ability to support the largest number of forest-interior birds and will also be more likely to provide habitat for area-sensitive species. Birds with large home ranges, such as the Ovenbird, are among the rarer species in forests and woodlots. Consequently, fragmenting the forest is of greater detriment to rarer species than it is to common ones. Also, it is much easier to protect existing forest than to rehabilitate fragmented forest.

2) Maintain or plan for the largest contiguous blocks of forest possible and reserve some of the least fragmented areas from timber harvest or land conversion. The number of bird species that occupy forest patches is positively correlated with patch size, and forest patches that are too small may not offer enough interior habitat to sustain breeding populations of area-sensitive species. Maintain forest patches in areas large enough so that adequate forest remains for birds after natural disturbances (e.g. fires, storms, and floods)—at least 2,500 acres (1,000 ha). In some areas, contiguous forest patches of 7,500 acres (3,000 ha) or even larger may be necessary to maintain viable breeding populations of all species. Forest patches must be larger than the territories of individual breeding pairs in order to support a productive population.

3) Maintain adequate amounts of mature forest for area-sensitive forest-interior bird species at any point in time. Fragmentation by agricultural or urban development typically is more damaging and permanent to forest birds than fragmentation caused by timber harvesting, which creates a mosaic of mature and regenerating stands when implemented correctly. Also, early successional forests do provide habitat for many bird species, including some Neotropical migrants that are declining. Nevertheless, forest-interior species that require mature forests are affected by both sources of fragmentation. In most large landscapes, the needs of early successional species can be met quickly through various sources of disturbance, including timber harvesting. Much more time, however, is required to develop suitable habitat for species that require mature forest.

4) Avoid creating numerous openings in an intact forest community. Small-scale openings do create a landscape mosaic; provide food for certain species, such as seed-eating birds, especially through the winter; are relatively temporary disruptions of the forest canopy; and create internal rather than external forest edges. However, openings and clearcuts that are designed to manage bird species that require them or for timber harvesting should be placed in areas where they will not jeopardize a forest interior ecosystem. Clearing widths should be limited to 650 feet (200 m) to maximize use by species that nest in adjacent forests, yet can include cleared areas in their territories.

5) For birds, a single large reserve is preferable to several small reserves of equal total area and will benefit species that are area-sensitive and only breed in non-edge areas. If

it is necessary to have multiple small reserves, group them as closely as possible to minimize isolation. Arrange small reserves in a cluster, rather than a linear fashion, and connect them with corridors to facilitate movement among the reserves.

6) Retain or manage for patches that maximize the ratio of forest interior to forest edge. The portions of a forest patch that are most useful to birds that depend on forest interiors might be greater than 1,000 feet (300 m) from the edge. Long, narrow patches [e.g. less than 2,000 feet (600 m) wide] might not provide habitat for these species. Circular plots are best for maximizing forest interior, and square or rectangular plots are better than long, narrow strips.

7) Where fragmentation has already occurred, retain habitat quality in existing fragments and avoid further fragmentation. Particularly in the western forest ecosystems, many species of forest birds are able to persist even in small relict patches of old forest. Although small fragments, particularly those in suburban areas, will probably never provide quality breeding habitat for most area-sensitive species, they are frequently used as stopover and foraging sites during migration and post-breeding dispersal, provide breeding habitat for short distance migrants and permanent residents, and may support non-breeding populations of Neotropical migrants. Small fragments may also be very important for maintaining popular interest in Neotropical migrants, since many people see these birds in small fragments of residential areas, rather than in major reserves.

8) Avoid designs and practices that create or increase the amount of edge between forest habitat and converted or highly altered land. Although edges increase local diversity by attracting a variety of different species, forest-interior species may disappear from areas that contain extensive edge habitat, which can support cowbirds, nest predators, and invasive plants, and expose wildlife to insecticides, shooting, collisions with vehicles, and other hazards. If all lands were managed to enhance local diversity by creating edges, diversity at a regional scale might actually decline because area-sensitive species would disappear from the larger landscape. Try to reach a balance between supporting desirable edge species locally, while protecting the more vulnerable forest-interior birds by considering the landscape context of local forest patches. Since western forests have historically been patchy due to natural fire patterns and elevation gradients, manage or create “soft” edges that mimic historical vegetation patterns, and avoid hard edges with agricultural or urban areas.

9) Minimize isolation of forest patches by promoting reforestation of gaps between disconnected forest tracts. Forest birds generally have higher reproductive success in forest that is either connected to or in close proximity to other forest patches. For nonmigratory species, such as many woodpeckers, the ability of young birds to disperse and establish new territories is greatly reduced when the habitat is isolated. For these reasons, small patches are likely to be more valuable as habitat for birds if they are close

to a large patch. Maintain large tracts of forest that are relatively close to other forest fragments or that are part of large, region-wide networks of intervening habitat that permits movement of individuals between suitable areas.

10) Improve the connectivity of forest habitats. Provide forested corridors to facilitate movement of wildlife among patches when considerable distances separate patches. Corridors could operate at several different scales and could link, for example, large patches of a forest landscape, or even small patches of forest that collectively constitute the habitat needs of a single breeding pair of birds. An alternative to corridors is to manage stands or open lands between patches so that they promote movement of wildlife among patches. If fragments are separated by agriculture or regenerating forest, the possibility for dispersal may be greater than between fragments that are separated by residential or commercial development where movement is limited.

11) Avoid segmenting large blocks of continuous forest with roads, power lines, and other open corridors and clearings. These corridors often connect the forest to open habitat, and potentially serve as a conduit for bringing cowbirds and small predators into the interior of large forests.

12) Consolidate roads, railroads, and utility rights-of-way into a single open corridor, and concentrate disturbance (e.g. buildings, roads, power lines, campgrounds, gas wells, and other development) along the periphery of forests and not within the interior of forest blocks.

13) Promote the reforestation of artificial forest openings, areas surrounding forest peninsulas, gaps between isolated forest tracts, and riparian corridors to create more forest interior for area-sensitive species. Reforestation can be achieved by succession (essentially leaving the area untouched for a number of years) or by planting native trees.

14) Coordinate rotation schedules or spatial arrangement of harvested areas to maintain larger blocks of mature forest rather than scattered small blocks, minimize detrimental edge effects on forest bird populations, and enhance quality and extent of second-growth forest habitats that otherwise may be lacking in an area for species that depend on those habitats.

15) Avoid land uses in the surrounding landscape of forests that support and attract cowbirds and predators (e.g. manicured parks and golf courses, rural homes and ranchettes, permanent and intensive feedlots, and intensive urban or suburban development). Fire, windstorms, and elevation differences create a naturally patchy landscape in western forest ecosystems, so the occurrence of nest predation and parasitism may depend as much on characteristics of the surrounding landscape as on local habitat characteristics such as patch size and edge effect.

Aspen Regeneration

In the prolonged absence of stand-altering disturbance, shade-tolerant conifers eventually begin to dominate aspen, and the shade-intolerant aspen becomes decadent and fails to produce suckers. At this point, it becomes necessary to regenerate the aspen stand artificially to prevent it from dying completely. Intuitively it may seem that the best way to rejuvenate the aspen stand would be to selectively remove the conifers. However, the parent stems in an aspen clone produce a hormone called auxin, which inhibits the production of suckers along its root system. Therefore, it is necessary to kill most of the parent stems in the clone in order to halt apical dominance and maximize suckering.

The other primary successional pathway occurs when there is no conifer seed source in the aspen stand. In these cases, the aspen grow to maturity and beyond, and eventually begin to die. At this point, the root system will respond to the death of the overstory with new sprouting, or an existing sapling understory will be released to continue the clone. In some cases, the root system may be incapable of sufficient suckering to overcome biotic factors that kill new suckers, such as overbrowsing, and the clone will die. Decadent stands are also more susceptible to diseases that can kill the entire tree, including the root system. If sucker reproduction is inadequate, small, and obviously not developing into saplings as openings occur, then management action is required. If browsing by livestock or big game is responsible for the lack of reproduction, then protection from this impact for several years should permit adequate sucker-to-sapling development. Some stable or climax aspen habitat types have been identified throughout Wyoming. Stands possessing uneven-aged overstories, indicative of aspen recruitment, and minimal conifer development should be managed as stable aspen communities.

Animals that depend upon the forage or cover produced in young aspen communities benefit from some treatment for regeneration. Other species—cavity-nesting birds, for example—do well in old, sometimes decadent, aspen stands. For these, treatment may not be necessary for habitat management if the aspen on the site is stable or climax. Clearcutting may improve aspen in some areas by creating a mosaic of different structural stages, which will be differentially attractive across a suite of avian species. However, clearcutting may degrade aspen in other areas by removing or diminishing key habitat components required by obligate or near-obligate aspen-nesting birds. The key is to strike a balance. To provide a diversity of habitats and wildlife species, treatments are usually needed to maintain a mosaic of plant communities and age classes within aspen communities. Regardless of the short-term effects, the regeneration of aspen through treatments such as clearcutting and burning will, in the long run, benefit aspen-associated birds by ensuring clone perpetuation.

Bartos and Campbell (1998) developed a list of risk factors for evaluating aspen communities. Managers should use these factors for identification and prioritization of aspen stands prior to treatment. The five risk factors are:

1) Conifer cover (including understory conifers) >25%
2) Aspen canopy cover <40%
3) Dominant aspen trees >100 years of age
4) Aspen regeneration <500 stems/acre [5 to 15 feet (1.5 to 4.5 m) tall]
5) Sagebrush cover >10%

Any one of these risk factors places the aspen community in a high priority for treatment.

Prescribed burning and clearcutting are the two main management alternatives for halting succession to conifers and regenerating the aspen forest. Burning is a popular method, in part because large areas can be effectively and inexpensively treated. However, although the tree itself is very sensitive to fire and is easily killed when exposed, aspen forests do not readily burn, requiring suitable fuel and flammability conditions which are generally available only during late summer and fall. Grazing of fine fuels pre-treatment can reduce fire behavior potential by 80 to 90% compared to ungrazed conditions. Burning works best in stands with coniferous or shrub understory fuels to carry the fire. When optimal conditions are present, suckering responses can be impressive, depending on the pre-treatment stand condition and the severity of the burn. Prescribed burning may be a better option than clearcutting, or can be used in combination with clearcutting, on sites where the soil has deteriorated and become more acidic and lower in nutrients, because burning increases soil pH and adds organic carbon and nutrients to the soil, which maximizes suckering.

Clearcutting is an effective tool for regenerating aspen, and, unlike burning, has the advantage that the number of overstory trees immediately killed can be precisely controlled, thus ensuring sufficient regeneration for stand replacement. Clearcutting greatly stimulates suckering, and the number of suckers that appear is directly proportional to the number of stems removed. Partial cuttings can seriously inhibit sprouting because apical dominance is retained in standing stems, and shade from standing stems reduces vigor of the few suckers that do appear. However, when the goal is to retain some overstory trees for the benefit of wildlife, partial cutting or thinning may be feasible if enough trees are removed and overstory shade is not an impediment to initial sucker growth. Other mechanical treatments that are sometimes used to regenerate aspen include bark-girdling, which is not particularly effective, and aerial herbicide spraying, which is effective but also kills other woody and herbaceous plants and may have adverse effects on the insect and wildlife populations. Bulldozing appears to be a viable regeneration technique for smaller areas near roads, and may be more cost-effective than clearcutting, as a bulldozer is able to down stems about five times as fast as a six-person saw crew.

A successfully regenerated aspen stand should have several thousand stems per hectare at least 6.5 feet (2 m) tall at the end of the fifth growing season after treatment. The following recommendations for the enhancement of aspen regeneration will benefit birds and other wildlife.

1) Maintain a diversity of structural changes across the landscape. Stands that include many age and size classes of aspen are richest in birds, and various mixes of aspen and conifers appear to be most beneficial to the largest number of wildlife species.

2) Restore the natural fire process. A moderate intensity fire that kills most or all of the overstory will stimulate adequate suckering and have the least effect on subsequent sucker growth. If fire occurs at infrequent intervals (e.g. 50 years) and is moderately intense enough to kill most or all of the aspen and competing conifers, most aspen sites will retain viable stands of aspen. More frequent fires may adversely affect site quality for aspen.

3) Rest the aspen stand from grazing prior to prescribed burning to allow fine fuels to accumulate.

4) Clearcut between mid summer and late fall to avoid destroying songbird nests. Soil compaction and erosion hazards are greatest if logging is done with heavy equipment when soils are saturated in the spring. Logging in the spring is also most damaging to aspen roots, which can reduce suckering, and, because root carbohydrate reserves are lowest in spring, harvesting at this time can further reduce sprouting.

5) Retain snags, some older trees, and / or some trees with heartrot. Prevent indiscriminate removal of standing aspen snags by firewood cutters. Withhold portions of the aspen forest from cutting until it is overmature to preserve natural cavity-nesting habitat.

6) Scattered aspen that are left for perching sites or for cavity-nesters in clearcuts should be dead or killed so that they do not assert apical dominance over the developing aspen suckers. Small, irregularly shaped clearcuts, or clearcuts with islands of mature or overmature leave trees, are better than leaving scattered live parent stems within a clone.

7) Reduce overbrowsing of suckers and overstory plants by domestic and wild ungulates. Make clearcuts and prescribed burn mosaics large enough to overwhelm the resident browsers [at least 500 to 1,000 acres (200 to 400 ha)], kill all or most parent stems in a clone to maximize suckering, and fence vulnerable areas to exclude ungulates. Where the treatment area is not burned, cut trees and slash may be left on the ground as a natural barrier to ungulates. Because of the expense of fencing, elk herd control by hunting may be the only answer if aspen is to be retained on heavily used

ranges. Careful grazing management is necessary for at least 3 to 5 years after treatment to allow suckers to outgrow the reach of livestock. In many cases, rest rotation grazing, good herders, and proper placement of salt blocks and water can sufficiently control livestock use.

8) Avoid damaging the lateral root system of the parent clone or compacting the soil. Minimize skid trails and landings. During bulldozing operations, always keep the dozer blade clear of the ground. Gouging the blade into the soil surface, or disturbing or compacting the lateral roots may result in regeneration failure.

9) Pile or remove slash after clearcutting or bulldozing heavily stocked stands, since large concentrations of slash on the ground can inhibit sprouting.

Snag Management

Snags (standing dead trees) increase bird density and diversity by providing sites for nesting, foraging, perching, loafing, roosting, and storing food. Until recently, modern forest management often removed snags as a means of reducing competition for sunlight and eliminating breeding sites for insects and fungi. However, snags are an essential habitat component for primary and secondary cavity-nesting birds and are considered the limiting factor for some breeding populations. (Primary cavity-nesters include woodpeckers and other bird species that actually excavate cavities; secondary cavity-nesters are incapable of excavating their own cavities and must seek out natural cavities or those made by primary cavity-nesters.) In some forests, birds that nest in cavities in snags make up as much as 30 to 45% of the total bird community, and include birds like woodpeckers, chickadees, nuthatches, wrens, bluebirds, and owls. Snags are also important as habitat for myriad invertebrates, fungi, and microorganisms; the absence of snags deprives many insectivorous birds of an important food resource. Not only are snags critical microhabitats for many species, they are also large reservoirs of organic matter and play an important role in forest nutrient cycling.

1) Regardless of the motivation for altering forest habitat, maintain all snags where they currently exist. In particular, avoid cutting snags that already show evidence of bird use. Snags provide critical habitat for a variety of wildlife species and should be managed in various sizes, ages, and locations to provide optimum wildlife benefits. Protect existing snags and, if possible, create new ones in areas where they are lacking.

2) Maintain mature and old growth forests and allow large, old trees to die naturally as the ideal method for providing snag resources. Providing snags without regard for stand conditions around the snag may not be sufficient for some bird species that may require other old growth characteristics surrounding snags. Manage specific forest stands over long (greater than 100-year) rotations using few or no silvicultural

treatments. Maintain old growth forests as buffer strips within the riparian zone to not only maintain snags but also protect other aspects of critical riparian habitat and protect water quality.

3) Manage for large snags. Most cavity-nesting birds, especially the larger species, require a minimum snag height and diameter for nesting. Larger snags remain standing longer, retain bark longer, contain more cavities per snag, and support a larger variety of wildlife. Maintain as great a density and diversity of large snags in different stages of deterioration as possible.

4) Provide at least 2 currently useable snags per acre (5 per ha) for nesting sites, but regard this number as a lower rather than an upper limit, as more snags will provide more foraging sites and perhaps increase nesting productivity. Provide higher densities of snags where forests are slow growing (e.g. high elevation forests) or snag life is short.

5) Maintain snags both in clusters and evenly distributed to maximize diversity and to mimic historical conditions. Many cavity-nesting birds are territorial and will not allow other members of their species to nest or feed within their own territory. If snags are in short supply, they should be spread over as wide an area as possible to provide a greater number of territories. However, if snags are abundant, small groupings should be created to provide a variety of snag conditions and benefit a variety of wildlife species. Where snags are in short supply, consider concentrating snag recruitment efforts on north-facing slopes, where they tend to average more cavities per snag. Where necessary in even-aged timber harvest units, aggregate snags where they can be most easily avoided during harvest, perhaps along small streams or on the lower edges of logged areas.

6) Where cowbirds are a problem, cluster snags close to the forest edge, rather than scattered through the forest interior, as cowbirds will use snags as perches while searching for songbird nests to parasitize.

7) Maintain a high density of snags that have greater than 40% bark cover, fungal conks, rotting dead branch stubs, old wounds or scars, and/or existing cavities. These characteristics are all signs that snags are suitable for nesting.

8) Retain all existing snags during timber harvesting unless they are safety hazards. Snag retention can be compatible with the objectives of timber production, as snags do not compete with young trees for space, light, moisture, or nutrients. Wherever possible, retain snags; damaged, dying, and defective trees; substantial slash; and some live trees.

9) Avoid short timber rotation periods and intensive timber management, which are designed to maximize timber production; keep loss of wood products to decay at a

minimum; and involve periodic thinning of stands to select against subdominant, low vigor, and silviculturally defective and low quality trees. Trees with these features have the highest potential to become suitable snags. Provide larger snags by having a longer rotation period for part or all of the stand or by leaving some trees to continue to grow. Implement explicit policies to retain and recruit snags in managed stands.

10) Protect snags from firewood cutting, especially high value snags or those in areas with few snags. Make logging slash available to wood gatherers to reduce the pressure on snags. If necessary, limit firewood cutting in certain areas, limit cutting to snags less than a designated diameter or height, limit cutting to downed material only or to certain species (e.g. spruce or subalpine fir) that have relatively lower value as snags, and/or implement road closures and obliteration to limit access to snags.

11) In areas where safety is a concern, cut snags to a height of about 10 feet (3 m), rather than totally removing them. This technique, known as "high-stumping", provides a limited number of possible nesting cavity sites, as well as feeding sites for a number of snag-dependent wildlife species. Woodpeckers, in particular, are often willing to feed on these shorter snags.

12) Provide a variety of snags of different ages in the same area and plan for the replacement of snags over time as existing snags fall. Snags usually do not become suitable for nesting until about 6 years after the tree dies, so plan ahead and provide hard snags (those in the early stages of decay) well before existing snags fall. During timber operations, leave damaged, dying, and defective trees (e.g. trees with dead tops or lightning strikes, and trees with heart-rotting fungi, fungal conks, and insect infestations) for future snags. Kill a few trees (e.g. by girdling) every 5 to 10 years to provide a continuous supply of new snags. Where possible, leave-trees should be windfirm and allowed to grow until they reach a large diameter before they are killed.

13) If snags are in short supply and live trees are abundant, consider creating snags by killing live trees. Treatments to create snags include girdling trees with an ax or chainsaw, removing treetops with dynamite or a chainsaw, and inoculating trees with heart rot.

14) Maintain a variety of tree species as snags, including both deciduous and coniferous trees, to accommodate the preferences of different bird species.

15) Where possible, introduce fire into stands with large snags to create post-fire conditions required by cavity-nesting species like the Black-backed Woodpecker.

16) Avoid post-fire salvage logging. Salvage and sanitation logging and debris disposal remove snags and snag recruits and reduce the amount of dead and down woody material that provide feeding and nesting sites for birds, especially post-fire dependent

species like the Black-backed Woodpecker, Three-toed Woodpecker, and Hairy Woodpecker.

17) In forests where the availability of cavities limits the breeding distribution and density of cavity-nesting birds but food resources are available, nest boxes may be a temporary option while snags are being established. Populations of secondary cavity-nesting birds (e.g. American Kestrels, bluebirds, and owls) can be enhanced by disseminating nest boxes, but woodpeckers (except flickers) rarely use them. Keep in mind that nest boxes do not substitute for snags in all ways (e.g. providing habitat for insects), and erecting and maintaining them on large areas can be expensive and time-consuming. Consider the unique nesting criteria for each target bird species when constructing nest boxes (e.g. the entrance hole diameter is critical to a successful nest box). Nest boxes with entrance holes less than 1-9/16 inches in diameter will exclude European Starlings, and entrance holes less than 1-1/8 inches will exclude House Sparrows. Place predator guards on all nest boxes. Monitor nest boxes regularly throughout the nesting season to evict House Sparrows, rodents, and insects, and to clean out "dummy" nests built by wrens.

Old Growth Management

Old growth stands are those that have developed over a long period essentially free of catastrophic disturbance. In large tracts of old growth forest, however, natural disturbance creates a "shifting-mosaic steady state," a dynamic but regionally persistent ecosystem complex containing a variety of community types, from meadows and wetlands to shrubs and climax forests. The high vertical and horizontal complexity of this old growth supports a correspondingly high diversity of wildlife. Within climax or old growth stands, the structure varies with forest type, but usually the most important features to birds are large dominant trees, large snags, mixed tree species composition, multi-layered canopy, irregular crown structure, patches of dense foliage, and forest floor complexity. Loss of old growth forest can be devastating to species that nest in cavities, feed largely on seed trees, or require solitary habitats with continuous forest cover.

1) Maintain old growth habitat where it exists to benefit birds that require it, such as the Brown Creeper, Golden-crowned Kinglet, Red-breasted Nuthatch, Red Crossbill, and Hammond's Flycatcher. Ensure the presence of multiple stages of mature forest across the landscape. Preservation of even small tracts of old growth forest helps promote diversity by providing habitats not otherwise present. Habitat alterations should be designed to promote habitat interspersion but not to the detriment of old growth stands.

2) Develop a long-range forest management plan at as large a scale as possible. Designate tracts that will be mature at each stage in the management plan and maintain

corridors between regenerating forests and mature tracts to facilitate repopulation by birds. Management plans for old growth forests should be conservative to preserve the greatest number of options for future management efforts.

3) Where old growth forest does not exist at present, provide for its future development by leaving areas undisturbed or unharvested for at least 100 to 200 years, thinning dense stands of trees to encourage more rapid growth to large tree stages, and allowing artificial successional areas to mature.

4) Develop strategies for replacing existing old growth stands, because those stands that are reserved today eventually will succumb to various natural disturbances (e.g. disease, fire, and insects). Designate very large tracts for old growth or old growth development to accommodate the "shifting-mosaic steady state" created by natural disturbances.

5) Develop partnerships between landowners, land managers, and private organizations to enhance the quality of old growth forest habitat. Coordinate rotation schedules or spatial arrangement of harvested sites to maintain larger blocks of mature forest rather than scattered small blocks.

6) Manage for large trees by extending rotation ages, retaining large trees and recruiting replacements at each harvest entry, and conducting early and frequent thinning to accelerate individual tree growth and faster development of large trees.

7) Avoid even-aged forest management. Even-aged stands that regenerate after harvest do not develop old growth characteristics, even after 100 years, because crown closure is complete, preventing sunlight from reaching the forest floor; tree sizes are relatively uniform; and forage in the understory is sparse. Conduct single-tree harvests in old growth stands to increase interspersion and slow stand decadence.

8) Incorporate important components of old growth forests (e.g. snags and forest floor complexity) into managed forests, and maintain patches of undisturbed old growth habitat in managed forest systems. Manage specific forest stands over long (at least 100- to 200-year) rotations with few or no silvicultural treatments and intersperse these among younger, intensively managed forests. Provide at least 50 to 100 acres (20 to 40 ha) of old growth within each 1,000-acre (400-ha) harvest unit. Provide corridors of old growth to connect the units to provide travel routes and maximize bird diversity. Old growth units generally should be roughly square, but linear strips at least 300 feet (90 m) wide are suitable along streams. In fact, riparian areas are ideal places to locate reserves of old growth.

9) In low elevation (e.g. ponderosa pine and Douglas-fir) forests, use thinning from below and other mechanical treatments in combination with prescribed burning to

maintain the historical park-like nature of old growth. Because of increased fuel as a result of fire suppression, fires have the potential to burn low elevation forests with great intensity and magnitude, which could destroy the remaining old growth. Restore existing old growth or large trees where they occur, reduce the density of trees by removing small trees, and carefully reintroduce fire where possible.

Engineering

1) Design roads with adequate structures to prohibit vehicles from leaving the roads and off-roading in vulnerable habitats.

2) Avoid building roads in riparian areas, open meadows, and on south- and west-facing slopes.

3) Identify all roads as permanent or temporary and close temporary roads after their objective has been achieved. Designate drainages where no permanent roads will be built.

4) Maintain buffer zones between important habitat and mining, oil, gas, sand/gravel, and geothermal activities, including structures, roads, and support facilities.

5) Restore disturbed areas with native vegetation, prevent grazing by livestock while plants recover, and eliminate the invasion of nonnative plants during the reclamation period.

6) Concentrate disturbance (e.g. buildings, roads, campgrounds, and other development) along the edges and not within the interior of forest blocks.

7) Minimize collisions between birds and power lines by avoiding constructing power lines in areas where birds concentrate during migration, breeding, or winter. However, if problems exist after construction, reduce the potential for collisions by using natural vegetation or human-made structures to shield power lines, modifying habitat near power lines to change its attractiveness to birds, and/or modifying land use to reduce disturbance (i.e. flushing birds near power lines). Some of the possibilities for line modification include enhancing the visibility of lines (e.g. flags or marker balls), burying the line, removing overhead groundwires, and removing small lightning shield wires in sensitive areas. Other possible mitigations include constructing lines parallel to the prevailing wind, constructing lines lower than flight corridors, and placing lines across rivers at oblique rather than right angles. To minimize avian mortality, power lines should be constructed to the most current standards using publications such as those from the Avian Power Line Interaction Committee (APLIC) (1994). For details on power line mitigation to benefit birds, please refer to these publications.

8) Minimize the electrocution of raptors on power lines by constructing and retrofitting power lines to the most current standards. Raptor electrocution can be addressed by a variety of mitigation measures, through design and retrofitting existing lines. Possible mitigation includes using insulating materials; gapping groundwires; adding pole-top extensions; lowering crossarms; and adding elevated perches, depending on the nature of the pole and the problem. Also, nest platforms may be installed on power line structures to enhance populations of raptors while minimizing the risk of electrocution and the risk to service. Nest platforms may be provided on the poles themselves or on "dummy" poles placed near those poles where nests have been built. To minimize avian mortality, power lines should be constructed and retrofitted to the most current standards using publications such as those from the Avian Power Line Interaction Committee (APLIC) (1996). For details on power line mitigation to benefit birds, please refer to these publications.

9) Where possible, avoid construction activities and other temporary disturbances during the breeding season in areas where priority bird species occur. Avoid noisy disturbances within ½ to 1 mile (0.8 to 1.6 km) of active or occupied raptor nests, depending on the species, during the period from February 1 through July 31 to prevent nest abandonment.

Recreation

Recreation activities, such as camping, hiking, biking, and off-road travel, can degrade forest habitats. Recreationists also may increase the incidence of fire, weed invasion, and roadkills; and disrupt bird breeding activities, causing nest failures or decreased production of young. Vegetation trampling and firewood gathering also affect birds. The recommendations below can help minimize negative effects associated with recreation.

1) Consider potential disturbances to birds and habitat (and other wildlife) when planning or locating camping sites, picnic areas, and other sites of human activity. Design recreation sites so they reduce impact on native vegetation and do not contribute to erosion or contaminate water.

2) Concentrate disturbance (e.g. buildings, trails, campgrounds, and other development) along the edges and not within the interior of forest blocks. Confine as much recreational use as possible to established trails and campsites. Where packstock use is allowed, provide facilities for concentrating impacts in small areas (e.g. hitching rails and corrals).

3) Maintain existing shrubs and saplings in campgrounds and retain a diversity of shrub species interspersed throughout the campsites to benefit birds like flycatchers,

Lazuli Buntings, Song Sparrows, and Fox Sparrows that are negatively associated with vegetation removal.

4) Keep pets under control in recreation areas. Free-roaming dogs and cats can be devastating to birds that nest on or just above the ground.

5) Encourage the use of established sites and promote "Tread Lightly" recreation ethics. Educate recreationists about problems humans can cause in forest habitat and how they can avoid damaging these areas.

6) Avoid using foggers for mosquito control, especially during the nesting season, so a food source remains available for birds.

7) In sensitive areas, hikers, mountain bikers, and horseback riders can damage vegetation and contribute to soil erosion. Reduce impacts by keeping these users to established trails.

8) Limit the number of roads, and reclaim unused roadbeds with native vegetation. This will reduce weed invasion, roadkills, and fragmentation.

9) Restrict target practice to established shooting and archery ranges to avoid irresponsible or inadvertent killing of living targets.

10) Avoid upgrading trails (e.g. trail maps, bridges, and trailheads) in important forest bird habitat, as they attract more activity.

11) Minimize and rehabilitate user-created trails.

12) Designate trail-less areas, particularly within the interior of large contiguous blocks of forest.

13) Minimize timing and extent of human recreation in important forest bird habitat during the nesting season.

<u>Pesticides</u>

Pesticides can harm bird populations if used incorrectly and should have only a limited role in modern forest pest management. Insecticides can negatively affect bird populations for the very reason they were created—to kill insects. Birds, even seedeaters, depend on insects to feed their young. Loss of insect prey during the nesting season can be devastating, and can turn a habitat that regularly produces birds into one that does not. The control of insect pest outbreaks with the use of pesticides is a common silvicultural practice, but several species of wood warblers and other

Neotropical migrants are specialists on cyclical "outbreak" types of forest insects, and their populations closely track these outbreaks. Improperly used pesticides can directly kill birds, or weaken them and make them more susceptible to disease or unable to produce young. Herbicides change the composition of the vegetation, which causes loss of nesting sites and declines in prey abundance. If pesticides must be used, label directions should always be carefully followed.

1) Strictly limit pesticide application in forests and adjacent sites to activities that improve or maintain the native vegetation (e.g. elimination of competitive noxious weeds). Where pesticides are needed, use them as part of an Integrated Pest Management (IPM) program. IPM involves closely monitoring pest populations of both plants and animals, and using chemicals only when and where pests are likely to cause economically or ecologically important damage. This reduces exposure of wildlife to harmful chemicals and reduces the destruction of non-target insects and plants.

2) If available, use biological control for specific noxious species, rather than chemical control.

3) When possible, apply pesticides by hand to target weeds and other pests as specifically as possible.

4) Consider allowing insect outbreaks to run their course without the use of pesticides. There is probably greater overall risk to birds in widespread application of pesticides than through habitat alteration if an insect outbreak is allowed to proceed with no intervention.

5) Use silvicultural techniques as an alternative to pesticides for reducing the damage to forests caused by insect outbreaks and to conserve bird populations. Forestry techniques involve eliminating trees that are likely to die in an outbreak, and increasing the vigor of remaining trees, so that stand vigor and resistance to severe insect losses are increased. To prepare for western spruce budworm outbreaks, use thinnings to increase the density of nonhost species, and harvesting to achieve an intermediate seral stage. These silvicultural techniques are more environmentally acceptable than pesticides; they cost less; and while the insect outbreak is not halted, and some trees die, pest populations do not achieve the explosive growth patterns observed in some outbreaks; a pulse of food is still provided for birds, which are part of the natural control of most pest populations anyway; and the outbreak is allowed to run its course, usually in an abbreviated time frame. Apply treatments at least 5 years before the outbreak occurs to give the forest time to respond to the treatment. Silvicultural methods generally do not work if they are applied at the time of the outbreak.

6) If it is necessary to further protect the forest, spray just a buffer area around the silviculturally treated forest to help prevent immigration of insects to the forest from high populations in surrounding areas.

7) Avoid spraying at all for insects that irrupt only occasionally and are not economically important, since their impact on forests is minimal but their importance to birds is great.

8) Herbicide control of shrub competition with regenerating forest stands should be confined to the area immediately surrounding affected trees so some shrub cover is retained for birds and other wildlife.

Wildlife Management

1) Maintain beaver populations in locations where they currently occur. Encourage and promote reintroduction into areas that were historically occupied by beavers and provide suitable habitat for reintroduced animals. Although beavers cut down trees, they also create suitable sites for establishing new growth of trees and shrubs. Where beaver populations are stable, their activities help store water, buffer floods, raise water tables, and provide a diversity of habitats.

2) Be aware of the impacts that cowbird nest parasitism and predators have on nesting birds. Increased nest parasitism results when forests are fragmented or livestock grazing occurs near woody habitats during the nesting season, and predators like raccoons, skunks, and crows often increase in number around human developments. Manage nest parasite and predator issues where negative impacts to birds occur.

3) Avoid attracting or supporting nonnative animal species. Nonnative animals can have a severely negative impact on songbirds. Invasive bird species such as European Starlings and House Sparrows are aggressive, often out-compete native birds for nest sites, and have been known to destroy active nests and even kill nesting adults.

Residential and Urban Development

Urban and residential environments can be particularly hazardous for breeding birds. Nest predators such as crows, squirrels, raccoons, skunks, and domestic cats are common, as are nest parasites, Brown-headed Cowbirds. Human impacts on the environment and on birds can also be intense. Individual houses result in habitat loss and fragmentation, human disturbance, and introduction of exotic plant species and predators like cats. However, careful planning can conserve native habitats even within and near developed landscapes. The kinds and abundance of wildlife such areas can support will depend on their size and proximity to other native habitats. The recommendations below will help reduce the impact of human developments on both birds and habitat.

1) Retain and plant vegetation that is native to your area when landscaping, including a natural distribution of vegetation in the ground, shrub, and tree layers. This will result in a more natural-looking landscape, and will provide food, shelter, and nest sites for birds. Avoid planting aggressive exotic species because these species tend to out-compete valuable native species and often have relatively little value to wildlife.

2) Where possible, keep snags and dying trees in place. If safety is a concern, cut them to a height of about 10 feet (3 m), rather than totally removing them.

3) Clump housing into a small area and leave the rest of the forested area as "open space" to reduce habitat fragmentation. Conservation easements can be used to protect the open space in perpetuity.

4) When designing open space of native habitats, plan for large areas to increase interior habitat, minimize fragmentation, and reduce edges and ecotones between native and nonnative habitats. Design open spaces so they connect with surrounding native habitats. Avoid creating small patches or narrow strips of habitat except as possible corridors between larger habitat patches. Although the ideal width is unknown, wide habitat corridors are better than narrow ones.

5) Confine all construction-related disturbance to immediate construction areas to avoid destroying adjacent forest habitat. Restore areas disturbed by construction, using native plant species.

6) Control Brown-headed Cowbirds in residential areas if nest parasitism becomes a problem.

7) Keep domestic cats indoors or leashed when outside, and never feed feral cats. Keep pet food bowls indoors and tightly cover all outdoor garbage cans so predators like raccoons do not have an additional food source.

8) Avoid or minimize insecticide and herbicide use on lawns and gardens. As alternatives, landscape with native plants, and encourage birds, bats, and beneficial insects to help control insect pests.

9) Minimize collisions between birds and windows by breaking up the reflection on the outside of windows with a non-reflective window coating, window screens, flash tape, or bird netting. Covering windows with netting is most effective when cost and appearance are acceptable. Single objects such as falcon silhouettes, owl decals, or large eye patterns may not be effective deterrents because they cover only part of the glass

and are not applied in sufficient numbers to alert the birds to the glass barrier. Glass surfaces should be uniformly covered with objects or patterns to turn them into obstacles that birds can recognize and avoid. Objects or patterns may have to be separated by as little as 2 to 4 inches (5 to 10 cm) to successfully protect hummingbirds and the smallest passerines. Birds in flight are more apt to give vertical objects wider clearance than horizontal ones, so tapes or cloths should be placed vertically.

10) Bird attractants such as feeders, watering areas, and nutritious vegetation in front of windows increases the density of birds near windows and can increase the hazard. Either move attractants such as feeders a considerable distance away from windows or place them very close to the glass surface to slow birds down and lessen the effect of impact.

11) Plant trees and install window awnings to block the sun from hitting windows and eliminate some reflection.

12) Enact a building policy of minimum night lighting, especially during migration, to alleviate bird attraction and confusion around tall buildings and towers, and to reduce light pollution.

13) In new or remodeled buildings, install windows at an angle so that the pane reflects the ground instead of the surrounding habitat and sky. Birds will avoid flying into a reflection of the ground, but are easily deceived by and strike reflected images of habitat and sky on windows installed in the conventional vertical position.

14) For more information on landscaping for wildlife, contact the Wyoming Game and Fish Department's Nongame Program (1-800-654-7862 or 307-332-2688).

Mining and Oil/Gas Development

Mining and oil/gas development should only be a short-term habitat conversion. Land reclamation, initiated concurrently with mining operations, can restore forest habitat for birds.

1) Avoid placing mines, oil and gas drill sites, sand or gravel pits, geothermal sites, and roads in or next to sensitive habitats such as raptor nest sites or riparian areas, springs, and other wetland habitats.

2) Ensure that ponds containing mining wastes are closed off to exclude birds, bats, and other wildlife attracted to the water. Flagging, reflectors, and strobes are not effective because animals become habituated to these deterrents. It is necessary to employ a technique, such as complete covering with metal or polypropylene mesh or eliminating ponds, that will reduce or eliminate the possibility of wildlife entering disposal pits.

3) Reclaim areas as soon as possible after activities are completed. This reduces the amount of habitat converted at any one time and speeds up the recovery of the habitat.

4) Avoid planting monocultures. Carefully plan for a complex of vegetation that reflects the diversity of plant species and habitats in the surrounding area. Reseed with local genetic seed stock, if available, and avoid using nonnative plant species that compete with native species. Provide topography similar to the surrounding area to provide microsites that promote a mosaic pattern.

5) To minimize the effects of continuous noise on bird populations, reduce noise levels to 49 dBA or less, particularly during the bird nesting season. Constant noise generators should be located far enough away from sensitive habitats such as grouse leks and raptor nests that the noise that reaches those habitats is less than 49 dBA. For example, the noise impact from drill rigs is greater than 49 dBA when the rig is closer than about 800 feet (250 m) to a receptor; impact from a 26,000 horsepower compressor station is greater than 49 dBA when located closer than about 2,500 feet (750 m) to a receptor. Avoid placing well pads, roads, and any other facilities requiring human presence within 825 feet (250 m) of raptor nests to prevent flushing adults from the nest. This buffer zone should be expanded in areas where prey are scarce, as raptors must spend more time searching for prey and may be less tolerant of disturbances. If necessary, implement mitigation measures to decrease continuous noise levels. For example, enclose compressor engines with buildings and install additional suppression around muffler exhausts. Noise barriers can be constructed at drilling and testing operations, and noise dampening around engines should be considered (including foam insulation around drilling rigs).

<u>Information and Education</u>

1) Establish public education goals and implement programs to inform users of public lands and owners of private lands of the value, sensitivity, and importance of forests to resident and Neotropical migratory birds and other species. This could range anywhere from interpretive signs on public lands, to distribution of Best Management Practices to landowners, to presentations at local grade schools, etc.

References and Additional Reading

Adams, E. M., and M. L. Morrison. 1993. Effects of forest stand structure and composition on Red-breasted Nuthatches and Brown Creepers. Journal of Wildlife Management 57(3):616-629.

Alexander, R. R. 1977. Cutting methods in relation to resource use in central Rocky Mountain spruce-fir forests. Journal of Forestry 75(7):395-400.

Alexander, R. R. 1987. Ecology, Silviculture, and Management of the Engelmann Spruce-Subalpine Fir Type in the Central and Southern Rocky Mountains. USDA Forest Service, Washington, D.C. Agriculture Handbook 659. 144pp.

Alexander, R. R., and O. Engelby. 1983. Engelmann spruce-subalpine fir. Pages 59-62 *in* R. M. Burns, technical compiler. Silvicultural Systems for the Major Forest Types of the United States. USDA Forest Service, Washington, D.C. Agriculture Handbook 445. 191pp.

Aplet, G. H. 1994. Beyond even- vs. uneven-aged management: toward a cohort-based silviculture. Pages 423-433 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors. Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Arno, S. F. 1980. Forest fire history in the northern Rockies. Journal of Forestry 78(8):460-465.

Arno, S. F. 1996. The concept: restoring ecological structure and process in ponderosa pine forests. Pages 37-38 *in* C. C. Hardy and S. F. Arno, editors. The Use of Fire in Forest Restoration: A General Session at the Annual Meeting of the Society for Ecological Restoration; Seattle, WA; 14-16 September 1995. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-GTR-341. 86pp.

Askins, R. A. 1994. Open corridors in a heavily forested landscape: impact on shrubland and forest-interior birds. Wildlife Society Bulletin 22(2):339-347.

Askins, R. A. 2000. Restoring North America’s Birds: Lessons From Landscape Ecology. Yale University Press, New Haven, CT. 320pp.

Avian Power Line Interaction Committee (APLIC). 1994. Mitigating Bird Collisions with Power Lines: The State of the Art in 1994. Edison Electric Institute, Washington, D.C.

Avian Power Line Interaction Committee (APLIC). 1996. Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996. Edison Electric Institute/Raptor Research Foundation, Washington, D.C.

Barrett, S. W., and S. F. Arno. 1982. Indian fires as an ecological influence in the northern Rockies. Journal of Forestry 80(10):647-651.

Bartos, D. L. 1979. Effects of burning on the aspen ecosystem. Pages 47-58 *in* K. L. Johnson, editor. Wyoming Shrublands: Proceedings of the Eighth Wyoming Shrub Ecology Workshop; Jackson, WY; 30-31 May 1979. Division of Range Management, Laramie, WY. 70pp.

Bartos, D. L., and R. B. Campbell. 1998. Decline of quaking aspen in the interior West. Rangelands 20(1):17-24.

Bartos, D. L., and W. F. Mueggler. 1981. Early succession in aspen communities following fire in western Wyoming. Journal of Range Management 34(4):315-318.

Bartos, D. L., and W. F. Mueggler. 1982. Early succession following clearcutting of aspen communities in northern Utah. Journal of Range Management 35(6):764-768.

Beidleman, C. A. 2000. Colorado Partners In Flight Land Bird Conservation Plan. 319pp.

Benson, P. C. 1979. Land Use and Wildlife with Emphasis on Raptors. USDA Forest Service, Intermountain Region. 32pp.

Blake, J. G., and J. R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68(6):1724-1734.

Bock, C. E., V. A. Saab, T. D. Rich, and D. S. Dobkin. 1993. Effects of livestock grazing on Neotropical migratory landbirds in western North America. Pages 296-309 *in* D. M. Finch and P. W. Stangel, editors. Status and Management of Neotropical Migratory Birds. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-229. 422pp.

Bock, J. H., and C. E. Bock. 1984. Effects of fires on woody vegetation in the pine-grassland ecotone of the southern Black Hills. American Midland Naturalist 112(1):35-42.

Boldt, C. E., R. R. Alexander, and M. J. Larson. 1983. Interior ponderosa pine in the Black Hills. Pages 80-83 *in* R. M. Burns, technical compiler. Silvicultural Systems for the Major Forest Types of the United States. USDA Forest Service, Washington, D.C.

Agricultural Handbook 445. 191pp.

Bollinger, E. K., and E. T. Linder. 1994. Reproductive success of Neotropical migrants in a fragmented Illinois forest. Wilson Bulletin 106(1):46-54.

Boulinier, T., J. D. Nichols, J. E. Hines, J. R. Sauer, C. H. Flather, and K. H. Pollock. 1998. Higher temporal variability of forest breeding bird communities in fragmented landscapes. Proceedings of the National Academy of Science, USA 95:7497-7501.

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. Point Reyes Bird Observatory, Stinson Beach, CA. Online http://www.prbo.org/calpif/plans.html. 114pp.

Clary, W. P. 1987. Overview of ponderosa pine bunchgrass ecology and wildlife enhancement with emphasis on southwestern United States. Pages 11-21 *in* H. G. Fisser, editor. Wyoming Shrublands: Proceedings of the Sixteenth Wyoming Shrub Ecology Workshop; Sundance, WY; 26-27 May 1987. Department of Range Management, Laramie, WY. 71pp.

Cline, S. P., A. B. Berg, and H. M. Wight. 1980. Snag characteristics and dynamics in Douglas-fir forests, western Oregon. Journal of Wildlife Management 44(4):773-786.

Cole, D. N. 1990. Recreation in whitebark pine ecosystems: demand, problems, and management strategies. Pages 305-309 *in* W. C. Schmidt, and K. J. McDonald, compilers. Proceedings—Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource; 29-31 March 1989; Bozeman, MT. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-270. 386pp.

Covington, W. W., R. L. Everett, R. Steele, L. L. Irwin, T. A. Daer, and A. N. D. Auclair. 1994. Historical and anticipated changes in forest ecosystems of the inland West of the United States. Pages 13-63 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors. Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Covington, W. W., P. Z. Fule, M. M. Moore, S. C. Hart, T. E. Kalb, J. N. Mast, S. S. Sackett, and M. R. Wagner. 1997. Restoring ecosystem health in ponderosa pine forests of the Southwest. Journal of Forestry 95(4):23-29.

Covington, W. W., and M. M. Moore. 1994a. Postsettlement changes in natural fire regimes and forest structure: ecological restoration of old-growth ponderosa pine forests. Pages 153-181 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors.

Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Covington, W. W., and M. M. Moore. 1994b. Southwestern ponderosa forest structure: changes since Euro-American settlement. Journal of Forestry 92(1):39-47.

Crouch, G. L. 1983. Aspen regeneration after commercial clearcutting in southwestern Colorado. Journal of Forestry 83(5):316-319.

Darveau, M., P. Beauchesne, L. Belanger, J. Juot, and P. Larue. 1995. Riparian forest strips as habitat for breeding birds in boreal forest. Journal of Wildlife Management 59(1):67-78.

DeByle, N. V. 1985. Wildlife. Pages 135-152 *in* N. V. DeByle and R. P. Winokur, editors. Aspen: Ecology and Management in the Western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-119. 283pp.

DeByle, N. V. 1990. Aspen ecology and management in the western United States. Pages 11-20 *in* R. D. Adams, editor. Aspen Symposium '89: Proceedings. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN. General Technical Report NC-140. 348pp.

DeByle, N. V., and R. P. Winokur, editors. 1985. Aspen: Ecology and Management in the Western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-119. 283pp.

Dickson, J. G., R. N. Conner, J. H. Williamson. 1983. Snag retention increases bird use of a clearcut. Journal of Wildlife Management 47(3):799-804.

Diem, K. L., and S. I. Zeveloff. 1980. Ponderosa pine bird communities. Pages 170-197 *in* R. M. DeGraaf and N. G. Tilghman, compilers. Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-86. 535pp.

Dieni, J. S., and S. H. Anderson. 1997a. Ecology and Management of Aspen Forests in Wyoming: Literature Review and Bibliography. Wyoming Cooperative Fish and Wildlife Research Unit, Laramie. 123pp.

Dieni, J. S., and S. H. Anderson. 1997b. Plant and Avian Community Characteristics in Aspen Stands of the National Elk Refuge Following Clearcutting. Wyoming Cooperative Fish and Wildlife Research Unit, Laramie. 46pp.

Dobkin, D. S. 1992. Neotropical Migrant Landbirds in the Northern Rockies and Great Plains. USDA Forest Service, Northern Region, Missoula, MT. Publication No. R1-93-34.

Erickson, J. R., and D. E. Toweill. 1994. Forest health and wildlife habitat management on the Boise National Forest, Idaho. Pages 389-409 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors. Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Esmoil, B. J., and S. H. Anderson. 1995. Wildlife mortality associated with oil pits in Wyoming. Prairie Naturalist 27(2):81-88.

Faaborg, J., M. Brittingham, T. Donovan, and J. Blake. 1993. Habitat fragmentation in the temperate zone: a perspective for managers. Pages 331-338 *in* D. M. Finch and P. W. Stangel, editors. Status and Management of Neotropical Migratory Birds. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-229. 422pp.

Ferry, G. W., R. G. Clark, R. E. Montgomery, R. W. Mutch, W. P. Leenhouts, and G. T. Zimmerman. 1995. Altered fire regimes within fire-adapted ecosystems. Pages 222-224 *in* E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. USDI National Biological Service, Washington, D.C. 530pp.

Fiedler, C. E. 1996. Silvicultural applications: restoring ecological structure and process in ponderosa pine forests. Pages 39-40 *in* C. C. Hardy and S. F. Arno, editors. The Use of Fire in Forest Restoration: A General Session at the Annual Meeting of the Society for Ecological Restoration; Seattle, WA; 14-16 September 1995. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-GTR-341. 86pp.

Finch, D. M. 1991. Population Ecology, Habitat Requirements, and Conservation of Neotropical Migratory Birds. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-205. 26pp.

Fisher, R. F., and M. J. Jenkins. 1987. Fire and the prairie-forest mosaic of Devils Tower National Monument. American Midland Naturalist 117(2):250-257.

Flake, L. D. 2000. Habitat of birds in ponderosa pine and aspen/birch forest in the Black Hills, South Dakota. Journal of Field Ornithology 71(2):187-206.

Franzreb, K. E., D. M. Finch, P. B. Wood, and D. E. Capen. Management Strategies for the Conservation of Forest Birds. Online http://cornell.edu/pifcapemay/franzreb.html.

Freemark, K., and B. Collins. 1992. Landscape ecology of birds breeding in temperate forest fragments. Pages 443-454 *in* J. M. Hagan, III, and D. W. Johnston, editors. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, D.C. 609pp.

Goguen, C. B., and N. E. Mathews. 1998. Songbird community composition and nesting success in grazed and ungrazed pinyon-juniper woodlands. Journal of Wildlife Management 62(2):474-484.

Graham, R. T. 1994. Silviculture, fire, and ecosystem management. Pages 339-235 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors. Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Graham, R. T., R. L. Rodriguez, K. M. Paulin, R. L. Player, A. P. Heap, and R. Williams. 1999. The Northern Goshawk in Utah: Habitat Assessment and Management Recommendations. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT. General Technical Report RMRS-GTR-22. 48pp.

Green, A. W., and R. C. Conner. 1989. Forests in Wyoming. USDA Forest Service, Intermountain Research Station, Ogden, UT. Resource Bulletin INT-61. 91pp.

Gruell, G. E. 1980. Fire's Influence on Wildlife Habitat on the Bridger-Teton National Forest, Wyoming. Vol. II—Changes and Causes, Management Implications. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. Research Paper INT-252. 35pp.

Hagar, J. C., W. C. McComb, and W. H. Emmingham. 1996. Bird communities in commercially thinned and unthinned Douglas-fir stands of western Oregon. Wildlife Society Bulletin 24(2):353-366.

Hall, F. C. 1980. Western forest types and avian management practices. Pages 27-37 *in* R. M. DeGraaf and N. G. Tilghman, compilers. Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-86. 535pp.

Hamann, B., H. Johnston, P. McClelland, S. Johnson, L. Kelly, and J. Gobielle. 1999. Birds. Pages 3.1-3.34 *in* G. Joslin and H. Youmans, coordinators. Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307pp.

Hann, W. J. 1990. Landscape- and ecosystem-level management in whitebark pine ecosystems. Pages 335-339 *in* W. C. Schmidt, and K. J. McDonald, compilers. Proceedings—Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource; 29-31 March 1989; Bozeman, MT. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-270. 386pp.

Harrington, M. G. 1996. Prescribed fire: restoring ecological structure and process in ponderosa pine forests. Page 41 *in* C. C. Hardy and S. F. Arno, editors. The Use of Fire in Forest Restoration: A General Session at the Annual Meeting of the Society for Ecological Restoration; Seattle, WA; 14-16 September 1995. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-GTR-341. 86pp.

Haufler, J. B. 1994. An ecological framework for planning for forest health. Pages 307-316 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors. Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Hayward, G. D., P. H. Hayward, and E. O. Garton. 1993. Ecology of Boreal Owls in the northern Rocky Mountains, USA. Wildlife Monographs 124:1-59.

Hein, D. 1980. Management of lodgepole pine for birds. Pages 238-246 *in* R. M. DeGraaf and N. G. Tilghman, compilers. Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-86. 535pp.

Hejl, S. J. A Strategy for Maintaining Healthy Populations of Western Coniferous Forest Birds. Online http://birds.cornell.edu/pifcapemay/hejl.htm.

Hejl, S. J. 1994. Human-induced changes in bird populations in coniferous forests in western North America during the past 100 years. Studies in Avian Biology No. 15: 232-246.

Hejl, S. J., R. L. Hutto, C. R. Preston, and D. M. Finch. 1995. Effects of silvicultural treatments in the Rocky Mountains. Pages 220-244 *in* T. E. Martin and D. M. Finch, editors. Ecology and Management of Neotropical Migratory Birds. Oxford University Press, New York. 489pp.

Hoover, R. L., and D. L. Wills, editors. 1984. Managing Forested Lands for Wildlife. Colorado Division of Wildlife, Denver. 459pp.

Howard, J. L. 1996. *Populus tremuloides*. *In*: USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Fire Effects Information System. Online http://www.fs.fed.us/database/feis/.

Howard, J. L. 2001. *Pinus ponderosa* var. *scopulorum*. *In* USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Fire Effects Information System. Online http://www.fs.fed.us/database/feis/.

Huckaby, L. S., M. R. Kaufmann, J. M. Stoker, and P. J. Fornwalt. 2001. Landscape patterns of montane forest age structure relative to fire history at Cheesman Lake in the Colorado Front Range. Pages 19-27 *in* R. K. Vance, C. B. Carleton, W. W. Covington, and J. A. Blake, compilers. Ponderosa Pine Ecosystems Restoration and Conservation: Steps Toward Stewardship; 25-27 April 2000; Flagstaff, AZ. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT. Proceedings RMRS-P-22. 188pp.

Hunter, M. L., Jr. 1990. Wildlife, Forests, and Forestry: Principles of Managing Forests for Biological Diversity. Prentice Hall Career and Technology, Englewood Cliffs, NJ. 370pp.

Hutto, R. L. 1998. Using landbirds as an indicator species group. Pages 75-92 *in* J. M. Marzluff and R. Sallabanks, editors. Avian Conservation: Research and Management. Island Press, Washington, D.C. 563pp.

Hutto, R. L., S. J. Hejl, C. R. Preston, and D. M. Finch. 1993. Effects of silvicultural treatments on forest birds in the Rocky Mountains: implications and management recommendations. Pages 386-391 *in* D. M. Finch and P. W. Stangel, editors. Status and Management of Neotropical Migratory Birds. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-229. 422pp.

Idaho Partners In Flight. 2000. Idaho Bird Conservation Plan. Version 1.0.

Johnston, B. C., and L. Hendzel. 1985. Examples of Aspen Treatment, Succession, and Management in Western Colorado. USDA Forest Service, Rocky Mountain Region, Lakewood, CO.

Jones, J. R., and N. V. DeByle. 1985a. Climates. Pages 57-64 *in* N. V. DeByle and R. P. Winokur, editors. Aspen: Ecology and Management in the Western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-119. 283pp.

Jones, J. R., and N. V. DeByle. 1985b. Fire. Pages 77-81 *in* N. V. DeByle and R. P.

Winokur, editors. Aspen: Ecology and Management in the Western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-119. 283pp.

Jones, J. R., and W. D. Shepperd. 1985. Harvesting. Pages 219-222 *in* N. V. DeByle and R. P. Winokur, editors. Aspen: Ecology and Management in the Western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-119. 283pp.

Kaufmann, M. R., P. J. Fornwalt, L. S. Huckaby, and J. M. Stoker. 2001. Cheesman Lake—a historical ponderosa pine landscape guiding restoration in the South Platte Watershed of the Colorado Front Range. Pages 9-18 *in* R. K. Vance, C. B. Carleton, W. W. Covington, and J. A. Blake, compilers. Ponderosa Pine Ecosystems Restoration and Conservation: Steps Toward Stewardship; 25-27 April 2000; Flagstaff, AZ. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT. Proceedings RMRS-P-22. 188pp.

Keane, R. E., S. F. Arno, and J. K. Brown. 1990. Simulating cumulative fire effects in ponderosa pine / Douglas-fir forests. Ecology 71(1):189-203.

Klem, D., Jr. 1990. Collisions between birds and windows: mortality and prevention. Journal of Field Ornithology 61(1):120-128.

Knight, D. H. 1994. Mountains and Plains: The Ecology of Wyoming Landscapes. Yale University Press, New Haven, CT. 338pp.

Larson, F. R., P. F. Ffolliott, and W. P. Clary. 1986. Managing wildlife habitat: in southwestern ponderosa pine forests, diverse treatments are the key. Journal of Forestry 84(3):40-41.

Mannan, R. W., R. N. Conner, B. Marcot, and J. M. Peek. 1994. Managing forestlands for wildlife. Pages 689-721 *in* T. A. Bookhout, editor. Research and Management Techniques for Wildlife and Habitats. The Wildlife Society, Bethesda, MD. 740pp.

Mannan, R. W., and E. C. Meslow. 1984. Bird populations and vegetation characteristics in managed and old growth forests, northeastern Oregon. Journal of Wildlife Management 48(4):1219-1238.

Mannan, R. W., E. C. Meslow, and H. M. Wight. 1980. Use of snags by birds in Douglas-fir forests, western Oregon. Journal of Wildlife Management 44(4):787-797.

Manuwal, D. A., and M. H. Huff. 1987. Spring and winter bird populations in a Douglas-fir forest sere. Journal of Wildlife Management 51(3):586-595.

Martin, T. E. 1993. Nest predation and nest sites. BioScience 43(8):523-532.

McClelland, B. R., S. S. Frissell, W. C. Fischer, and C. H. Halvorson. 1979. Habitat management for hole-nesting birds in forests of western larch and Douglas-fir. Journal of Forestry 77(8):480-483.

Means, J. E., J. H. Cissel, and F. J. Swanson. 1996. Fire history and landscape restoration in Douglas-fir ecosystems of western Oregon. Pages 61-67 *in* C. C. Hardy and S. F. Arno, editors. The Use of Fire in Forest Restoration: A General Session at the Annual Meeting of the Society for Ecological Restoration; Seattle, WA; 14-16 September 1995. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-GTR-341. 86pp.

Mills, T. R., and M. A. Rumble. 2000. Habitat of birds in ponderosa pine and aspen/birch forest in the Black Hills, South Dakota. Journal of Field Ornithology 71(2):187-206.

Montana Bird Conservation Plan. 2000. Version 1.0. Online http://biology.umt.edu/landbird/mbcp/mtpif.

Mueggler, W. F. 1985. Vegetation associations. Pages 45-55 *in* N. V. DeByle and R. P. Winokur, editors. Aspen: Ecology and Management in the Western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-119. 283pp.

Mueggler, W. F. 1988. Aspen Community Types of the Intermountain Region. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-250. 135pp.

Mueggler, W. F. 1989. Status of aspen woodlands in the West. Pages 32-37 *in* V. E. Scott and G. L. Crouch, editors. Response of Breeding Birds to Commercial Clearcutting of Aspen in Southwestern Colorado. USDA Forest Service, Research Note RM-475.

Mumma, J. W. 1990. High-mountain resources on national forest lands. Pages 49-52 *in* W. C. Schmidt, and K. J. McDonald, compilers. Proceedings—Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource; 29-31 March 1989; Bozeman, MT. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-270. 386pp.

Mutch, R. W. 1994. Fighting fire with prescribed fire: a return to ecosystem health. Journal of Forestry 92(11):31-33.

Niemi, G. J., and J. M. Hanowski. 1984. Relationships of breeding birds to habitat characteristics in logged areas. Journal of Wildlife Management 48(2):438-443.

Noss, R. F. 1983. A regional landscape approach to maintain diversity. BioScience 33(1):700-706.

Oliver, C. D., D. E. Ferguson, A. E. Harvey, H. S. Malany, J. M. Mandzak, and R. W. Mutch. 1994. Managing ecosystems for forest health: an approach and the effects on uses and values. Pages 113-133 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors. Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Oliver, C. D., C. Harrington, M. Bickford, R. Gara, W. Knapp, G. Lightner, and L. Hicks. 1994. Maintaining and creating old growth structural features in previously disturbed stands typical of the eastern Washington Cascades. Pages 353-387 *in* R. N. Sampson, D. L. Adams, and M. J. Enzer, editors. Assessing Forest Ecosystem Health in the Inland West. Food Products Press, Binghamton, NY. 461pp.

Oneale, E. Snag and Den Tree Habitats for Wildlife. Habitat Extension Bulletin No. 46. Habitat Extension Services, Wyoming Game and Fish Department. 4pp.

Oregon-Washington Partners In Flight. Landbird Conservation Plans. Online http://community.gorge.net/natres/pif.html.

Pashley, D. N., C. J. Beardmore, J. A. Fitzgerald, R. P. Ford, W. C. Hunter, M. S. Morrison, and K. V. Rosenburg. 2000. Partners In Flight: Conservation of the Land Birds of the United States. American Bird Conservancy, The Plains, VA. 92pp.

Peet, R. K. 1988. Forests of the Rocky Mountains. Pages 63-101 *in* M. G. Barbour and W. D. Billings, editors. North American Terrestrial Vegetation. Cambridge University Press, Cambridge. 434pp.

Peterson, D. L. 1995. Subalpine forests of western North America. Pages 314-319 *in* E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. USDI National Biological Service, Washington, D.C. 530pp.

Petit, L. J., D. R. Petit, and T. E. Martin. 1995. Landscape-level management of migratory birds: looking past the trees to see the forest. Wildlife Society Bulletin 23(3):420-429.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, Jr., G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management Recommendations for the Northern Goshawk in the Southwestern United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-217. 90pp.

Roath, L. R., and W. C. Krueger. 1982. Cattle grazing and behavior on a forested range. Journal of Range Management 35(3):332-338.

Robbins, C. S., J. R. Sauer, and B. G. Peterjohn. 1993. Population trends and management opportunities for Neotropical migrants. Pages 17-23 *in* D. M. Finch and P. W. Stangel, editors. Status and Management of Neotropical Migratory Birds. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-229. 422pp.

Robinson, S. K., F. R. Thompson, III, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987-1990.

Robinson, W. L., and E. G. Bolen. 1989. Wildlife Ecology and Management. Second edition. MacMillan Publishing Company, New York. 574pp.

Rosenburg, K. V., R. W. Rohrbaugh, Jr., S. E. Barker, R. S. Hames, J. D. Lowe, and A. A. Dhondt. 1999. A Land Manager's Guide to Improving Habitat for Scarlet Tanagers and Other Forest-Interior Birds. The Cornell Laboratory of Ornithology. 23pp.

Rotenberry, J. T., R. J. Cooper, J. M. Wunderle, and K. G. Smith. 1995. When and how are populations limited? The roles of insect outbreaks, fire, and other natural perturbations. Pages 55-84 *in* T. E. Martin and D. M. Finch, editors. Ecology and Management of Neotropical Migratory Birds. Oxford University Press, New York. 489pp.

Rudnicky, T. C., and M. L. Hunter, Jr. 1993. Avian nest predation in clearcuts, forests, and edges in a forest-dominated landscape. Journal of Wildlife Management 57(2):358-364.

Ryker, R. A., and J. Losensky. 1983. Ponderosa pine and Rocky Mountain Douglas-fir. Pages 53-55 *in* R. M. Burns, technical compiler. Silvicultural Systems for the Major Forest Types of the United States. USDA Forest Service, Washington, D.C. Agriculture Handbook 445. 191pp.

Saab, V. A., C. E. Bock, T. D. Rich, and D. S. Dobkin. 1995. Livestock grazing effects in western North America. Pages 311-353 *in* T. E. Martin and D. M. Finch, editors.

Ecology and Management of Neotropical Migratory Birds. Oxford University Press, New York. 489pp.

Saab, V. A., and J. G. Dudley. 1998. Responses of cavity-nesting birds to stand-replacement fire and salvage logging in ponderosa pine / Douglas-fir forests of southwestern Idaho. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT. Research Paper RMRS-RP-11. 17pp.

Sallabanks, R., E. Arnett, T. B. Wigley, and L. Irwin. 2001. Accommodating Birds in Managed Forests of North America: A Review of Bird-Forestry Relationships. National Council for Air and Stream Improvement, Inc., Research Triangle Park, NC. Technical Bulletin No. 822. 91pp.

Sanderson, H. R., E. L. Bull, and P. J. Edgerton. 1980. Bird communities in mixed conifer forests of the Interior Northwest. Pages 224-237 *in* R. M. DeGraaf and N. G. Tilghman, compilers. Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-86. 535pp.

Schier, G. A., J. R. Jones, and R. P. Winokur. 1985. Vegetative regeneration. Pages 29-33 *in* N. V. DeByle and R. P. Winokur, editors. Aspen: Ecology and Management in the Western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-119. 283pp.

Schullery, P. 1995. The Greater Yellowstone Ecosystem. Pages 312-314 *in* E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. USDI National Biological Service, Washington, D.C. 530pp.

Scott, V. E. 1978. Characteristics of ponderosa pine snags used by cavity-nesting birds in Arizona. Journal of Forestry 76(1):26-28.

Scott, V. E. 1979. Bird response to snag removal in ponderosa pine. Journal of Forestry 77(1):26-28.

Scott, V. E., and G. L. Crouch. 1988. Summer Birds and Mammals of Aspen-Conifer Forests in West-Central Colorado. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. Research Paper RM-280. 6pp.

Shepperd, W. D. 1990. Management of aspen in the central Rocky Mountains: an application of multiple use silviculture. Pages 73-78 *in* R. D. Adams, editor. Aspen Symposium '89: Proceedings. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN. General Technical Report NC-140. 348pp.

Shepperd, W. D. 1996. Response of Aspen Root Suckers to Regeneration Methods and Post-Harvest Protection. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. Research Paper RM-RP-324. 8pp.

Smith, B. L., and R. L. Rogers. 1990. Aspen management of the National Elk Refuge. Pages 15-18 *in* H. G. Fisser, editor. Wyoming Shrublands: Aspen, Sagebrush, and Wildlife Management: Proceedings of the Seventeenth Wyoming Shrub Ecology Workshop; Jackson, WY; 21-22 June 1988. Department of Range Management, Laramie, WY. 76pp.

Smith, J. K., editor. 2000. Wildland Fire in Ecosystems: Effects of Fire on Fauna. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT. General Technical Report RMRS-GTR-42-vol. 1. 83pp.

Smith, K. G. 1980. Nongame birds of the Rocky Mountain spruce-fir forests and their management. Pages 258-279 *in* R. M. DeGraaf and N. G. Tilghman, compilers. Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-86. 535pp.

Stewart, C. 1996. Restoring historic landscape patterns through management: restoring fire mosaics on the landscape. Pages 49-50 *in* C. C. Hardy and S. F. Arno, editors. The Use of Fire in Forest Restoration. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-GTR-341. 86pp.

Tewksbury, J. J., S. J. Hejl, and T. E. Martin. 1998. Breeding productivity does not decline with increasing fragmentation in a western landscape. Ecology 79(8):2890-2903.

Thompson, III, F. R., J. R. Probst, and M. G. Raphael. 1995. Impacts of silviculture: overview and management recommendations. Pages 201-219 *in* T. E. Martin and D. M. Finch, editors. Ecology and Management of Neotropical Migratory Birds. Oxford University Press, New York. 489pp.

USDA Forest Service. 1980. Non-game Species Bird Habitat Management Resume. Intermountain Region. 45pp.

Uchytil, R. J. 1992. *Pinus contorta* var. latifolia. *In* USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Fire Effects Information System. Online http://www.fs.fed.us/database/feis/.

Uchytil, R. J., and M. Crane. 1991. *Pseudotsuga menziesii* var. glauca. *In* USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Fire Effects Information System. Online http://www.fs.fed.us/database/feis/.

Veblen, T. T. 1986. Treefalls and the coexistence of conifers in subalpine forests of the central Rockies. Ecology 67(3):644-649.

Verner, J. 1980. Bird communities of mixed-conifer forests of the Sierra Nevada. Pages 198-223 *in* R. M. DeGraaf and N. G. Tilghman, compilers. Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-86. 535pp.

Weaver, T., J. Lichthart, and D. Gustafson. 1990. Exotic invasion of timberline vegetation, northern Rocky Mountains, USA. Pages 208-213 *in* W. C. Schmidt and K. J. McDonald. Proceedings—Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource; 29-31 March 1989; Bozeman, MT. USDA Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT-270. 386pp.

Whipple, S. A., and R. L. Dix. 1979. Age structure and successional dynamics of a Colorado subalpine forest. American Midland Naturalist 101(1):142-158.

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66(4):1211-1214.

Winternitz, B. L. 1980. Birds in aspen. Pages 247-257 *in* R. M. DeGraaf and N. G. Tilghman, compilers. Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-86. 535pp.

Yellowstone National Park. 1997. Yellowstone's Northern Range: Complexity and Change in a Wildland Ecosystem. National Park Service, Mammoth Hot Springs, WY. 148pp.

Zarnowitz, J. E., and D. A. Manuwal. 1985. The effects of forest management on cavity-nesting birds in northwestern Washington. Journal of Wildlife Management 49(1):255-263.