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EFFECTS OF SILVICULTURAL TREATMENTS IN THE ROCKY MOUNTAINS

SALLIE J. HEJL, RICHARD L. HUTTO, CHARLES R. PRESTON, AND DEBORAH M. FINCH

INTRODUCTION

Neotropical migrants have been affected by the loss and fragmentation of forests in the eastern United States (Askins et al. 1990). Changes in western forests and the effects of these changes on birds may be different from those in the East. While timber harvesting is widespread in the western United States, the purpose of silvicultural systems on public land is to perpetuate forests, not to convert forests to agricultural land or residential areas. Western logging has resulted in landscapes that are primarily composed of forests of different ages and treatments, rarely isolated forests. The silvicultural systems used to manage these forests, however, include timber harvesting, intermediate treatments, and stand-regeneration practices that usually result in forests different from presettlement ones (Thompson et al., Chapter 7, this volume). Managers interested in maintaining western birds need not be as concerned with deforestation as with the loss of old growth and whether managed forests successfully substitute for unmanipulated forests. While baseline studies on birds in most forest types in the Rocky Mountains exist (e.g., Marshall 1957, Salt 1957, Flack 1976, Winternitz 1976, Balda and Masters 1980, Finch and Reynolds 1987, Raphael 1987a,b, Scott and Crouch 1988, Block et al. 1992, Morrison et al. 1993), studies on the effects of silvicultural practices on songbird populations in the Rocky Mountains are relatively rare. Most studies consider only the effects of timber harvesting.

The purpose of this synthesis is to summarize knowledge about the effects of silvicultural practices on birds in Rocky Mountain forests, to suggest future research needs, and to suggest how managers can make decisions based on what we currently know. We offer a description of current forest structure and basic information on bird distribution across forest habitats in the Rockies as background knowledge for understanding the effects of silviculture on birds in these habitats. We also offer a comparison between the effects of silviculture, and the effects of fire and fire suppression on forest birds in an attempt to give a holistic perspective on the health of forest birds in the Rockies.

CURRENT FOREST STRUCTURE

Three major factors contribute to the current forest structure of the Rocky Mountains. These three factors are: (1) floristic composition; (2) natural disturbances, especially fire; and (3) human-induced disturbances, including logging, fire exclusion, and other forest management activities.

Floristic Composition of Rocky Mountain Forests

Plant composition will be discussed in the context of Southern, Central, and Northern Rocky Mountains, as defined by Daubenmire (1943). The Southern Rockies extend from Mexico to the northern borders of Arizona and New Mexico, and the Central Rockies extend from that border to the middle of Wyoming. The Northern Rockies encompass the region from northern Wyoming to central

Alberta and British Columbia. All three provinces share many tree species, but both the Southern and Northern Rockies exhibit some species specific to their region. Many distinctive pine and oak species grow in the southern region. Some of the species unique to the northern region are typical of forests on the western slope of the Cascades in the Pacific Northwest.

The Rocky Mountains are dominated by coniferous forests (Gleason and Cronquist 1964, Peet 1988) with the only widespread and abundant broadleaved tree being quaking aspen (*Populus tremuloides*). Excluding the riparian zone, Peet (1988) recognized nine forest types: (1) madrean pine–oak woodland; (2) pygmy conifer woodland; (3) ponderosa pine woodland; (4) Cascadian forests; (5) Douglas-fir forest; (6) spruce-fir forest; (7) subalpine white pine forests; (8) treeline vegetation; and (9) montane seral forests.

A diverse assemblage of pines and oaks characterize the madrean pine–oak woodlands of the Southern Rocky Mountains. Prominent woodland species include Arizona pine (*Pinus ponderosa* var. *arizonica*), Chihuahua pine (*P. leiophylla*), Mexican pinyon (*P. cembroides*), Gambel oak (*Quercus gambelii*), Arizona white oak (*Q. arizonica*), and Emory oak (*Q. emoryi*).

The *pygmy conifer woodland* of the Central and Southern Rockies often forms the transition between grasslands of the plains and montane forests. Dominant trees in this zone on the eastern slope of the Rockies are pinyon pine (*P. edulis*) and one-seed juniper (*Juniperus monosperma*). On the western slope, pinyon pine or singleleaf pinyon (*P. monophylla*) and Utah juniper (*J. osteosperma*) characterize much of this zone.

Ponderosa pine woodland is widespread in the Rocky Mountains. West of the continental divide in the northern region, the primary tree is Pacific ponderosa pine (*P. ponderosa* var. *ponderosa*). East of the divide and south through the Rockies, Rocky Mountain ponderosa pine (*P. Ponderosa* var. *scopulorum*) is generally dominant. Rocky Mountain ponderosa pine, Arizona pine, Chihuahua pine, or Apache pine (*P. engelmannii*) are characteristic trees in the Southern Rockies.

The *Cascadian forests* of the Northern Rockies, the most mesic forests in the Rockies, are restricted to the Pacific maritime-influenced climate of northern Idaho and adjacent Montana, Washington, and British Columbia. Species typical of the Cascade Mountains in the Pacific Northwest comprise these forests and include western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), and Pacific yew (*Taxus brevifolia*).

Douglas fir (*Pseudotsuga menziesii*) is characteristic of the *Douglas-fir forest* throughout the Rocky Mountains. In the Southern and Central Rockies, white fir (*Abies concolor*), blue spruce (*Picea pungens*), ponderosa pine, limber pine (*Pinus flexilis*), and quaking aspen are associated species in the Douglas-fir forests. Associated species in the Northern Rockies include grand fir, ponderosa pine, and western larch (*Larix occidentalis*). Technically, "mixed coniferous" forests are found in several of these forest types and, where the types abut, but we use the term in reference to mixed Douglas-fir forests.

The subalpine *spruce-fir forest*, dominated by subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*), occurs throughout the Rocky Mountains. In the northernmost Rockies, white spruce (*P. glauca*) replaces Engelmann spruce. Spruce-fir forests are poorly developed in the mountains of Mexico.

Subalpine white pine forests are found on dry ridges and exposed southern slopes of the subalpine zone. Whitebark pine (*Pinus albicaulis*) is the dominant white pine in the Northern Rockies, bristlecone pine (*P. aristata*) in the Central Rockies, and intermountain bristlecone pine (*P. longaeva*) on peaks in the Great Basin. Limber pine ranges across much of the Northern and Central Rockies. Mexican white pine (*P. strobiformis*) replaces limber pine in the Southern Rockies.

Treeline vegetation typically is subalpine fir and Engelmann spruce throughout much of the Rockies. Whitebark pine, bristlecone pine, and limber pine are also important treeline species, especially on dry or exposed ridges. Other pines dominate at treeline in the high mountains of Mexico. Subalpine larch (*Larix lyallii*) and mountain hemlock

(*Tsuga mertensiana*) are characteristic of treeline habitats in the northern Rockies.

Montane seral forests dominate a large portion of the landscape in the Rocky Mountains, since disturbances are common, especially fire. Quaking aspen and lodgepole pine (*P. contorta*) are two species that are important postfire seral tree species. Aspen and lodgepole are often replaced by stands of more shade-tolerant species, such as Douglas fir or subalpine fir in the Douglas fir and spruce-fir zones, respectively. In the absence of other conifer species, aspen can form stable, self-maintained stands (Johnston 1984, Mueggler 1985). Western larch and western white pine (*P. monticola*) are both seral species of the Northern Rockies. Other species (e.g., Douglas fir, ponderosa pine, and limber pine) all act as successional species on sites more mesic than those on which they are typically climax.

Natural Disturbances

Fire, wind, insects, ungulate browsing, avalanches, landslides, extreme weather, and disease are sources of natural disturbance in the Rocky Mountains (Peet 1988). Historically, fire has been the most important and extensive disturbance to vegetation, influencing the development of landscape patterns (Habeck and Mutch 1973, Gruell 1983, Peet 1988). Historic fire regimes ranged from low-intensity, high-frequency fires in lower elevation forests to high-intensity, low-frequency fires in upper elevation forests (Peet 1988). As a consequence of fire suppression, fire frequency has decreased and intensity has increased in many forests since early in the 20th century. Fire suppression has altered the natural fire regimen with the result that the structure of many forests has changed from open to closed stands.

Logging History and Current Silvicultural Recommendations

Some of the logging activities throughout the Rockies in the past 100 years have stemmed from silvicultural prescriptions. Silvicultural suggestions have changed as our knowledge of the ecologies of these forests has increased. Public opinion, political expediency, and individual personalities have also affected how the land has been managed, often irrespective of silvicultural requirements, site conditions, and conflicting objectives (Mustian 1977). Therefore, a great diversity of logging practices has occurred in the Rockies (S. Arno, personal communication), including overstory removal, selection, seed-tree, shelterwood, and clearcut logging (Hejl 1992).

A general rule of historic logging was that the most accessible and commercially valuable trees were logged before less accessible and less valuable trees. The result was that, in general, low elevations and preferred species such as western white pine, ponderosa pine, and western larch were logged before high elevations and Douglas fir, western red cedar, western hemlock, lodgepole pine, subalpine fir, and Engelmann spruce. Some upper-elevation forests were logged early on, because they were accessible. Both even-aged and, to a lesser extent, uneven-aged systems have been used in most forest types.

Cutting regimes in the Rocky Mountains have varied from large clearcuts that are often densely spaced in moist forests (e.g., spruce/fir and cedar/hemlock forests) to repeated entries of selective cutting in drier forests (e.g., ponderosa pine, western larch, or Douglas fir forests) (Arno, personal communication). These logging activities along with fire suppression have resulted in changes in overstory and understory species composition, forest structure, and landscape heterogeneity (Thompson et al., Chapter 7, this volume).

A major use of silvicultural treatments is to harvest and regenerate trees to obtain desired species of trees in a stand of suitable structure (Burns 1983, Thompson et al., Chapter 7, this volume). The precise silvicultural practice that is recommended for a particular habitat is constantly changing (Mustian 1977). Current silvicultural recommendations vary for each floristic zone in the Rocky Mountains depending on tree species, site conditions, and management objectives. Recent silvicultural recommendations, primarily for wood production, include: (1) single-tree selection or group selection for pinyon-juniper (Meeuwig and Bassett 1983), and for climax ponderosa pine in the Northern Rockies (Ryker and Losensky 1983); (2) a combination of uneven-aged and even-aged management for ponderosa pine in the Southern Rockies (Ronco and Ready 1983), for Cascadian forests (Graham et al. 1983), for mixed-conifer forests containing inland Douglas fir (Ryker and Losensky 1983), and for spruce-fir forests (Alexander and Engelby 1983); and (3) even-aged management for larch forests (Schmidt et al. 1983), for lodgepole pine (Alexander et al. 1983), and for aspen (Shepperd and Engelby 1983). We have not found any silvicultural suggestions for pine–oak woodlands or whitebark pine forests.

GENERAL BIRD–HABITAT RELATIONS IN NATURAL FORESTS

Methods for Estimating Bird Distribution across Forest Habitats

We created a species list for eight forest habitats (trying to emphasize mature or older stands) with a relative abundance rating for each species during the breeding season. The lists were based on a variety of bird community studies from each habitat (e.g., Marshall 1957, Salt 1957, Flack 1976, Winternitz 1976, Balda and Masters 1980, Raphael 1987a,b, Finch and Reynolds 1987, Scott and Crouch 1988, Block et al. 1992), on the 19 studies examining birds in logged and unlogged habitats, our field experience, and the opinions of other field naturalists. The abundance ratings were subjectively derived from reading the literature and from field experience, since combining information across studies with very different methods precluded our ability to give exactly comparable, objective ratings.

Our ratings also reflect the geographic locations where most studies have been conducted or where we had experience. Many of these habitats span a large geographic area especially from north to south, and we were only able to express some of the differences within habitat use in some forest types (indicated by a superscript c in Table 8-1). In general, pine–oak, pygmy conifer, and ponderosa pine woodlands reflect southern distributions of species, and mixed conifer, primarily Douglas-fir, forests reflect northern distributions. Information was sparse and summarized references spanning 50 years. The purpose of Table 8-1 is to give a general idea of some species commonly found in each of these habitats, not a definitive description of what should be in any one specific locale.

General Bird–Habitat Associations

Of 215 species present in Rocky Mountain forests, 72 (34%) are permanent residents, 69 (32%) are long-distance migrants, 50 (23%) are short-distance migrants, and 24 (11%) are migrants that breed primarily south of the United States/Mexico border (Table 8-1). Twenty-three species (nine residents, four long-distance migrants, and ten short-distance migrants) are found in all eight forest types. No species is common in all eight types, but eight species—Hairy Woodpecker, Northern Flicker, Red-breasted Nuthatch, American Robin, Yellow-rumped Warbler, Chipping Sparrow, Dark-eyed Junco, and Pine Siskin—are common or abundant in all but one type. Forty-six species (13 residents, 11 long-distance migrants, four short-distance migrants, and 18 migrants that breed primarily south of the United States/ Mexico border) are found only in pine–oak and/or pinyon–juniper woodlands; 44 of these species were uncommon and/or rare in one or both of these habitats.

Methods for Evaluating Differences in Birds among Natural Stands of Different Ages

We summarized the results of two studies in natural forests of different ages in the Rocky Mountains to find possible indications of birds associated with particular stand ages. In the Northern Rockies, birds were compared in natural pole-sapling, mature, and old-growth forests in lodgepole–spruce–fir, and in mature and old-growth Douglas fir (Catt 1991, Moore 1992). We used the results of statistical tests if available.

Table 8-1. Relative abundance of species (A = abundant; C = common; U = uncommon; R = rare) in the breeding season in eight forest types [pine–oak woodland = PO; pygmy conifer (pinyon–juniper) = PJ; Cascadian = CA; ponderosa pine = PP; mixed conifer (primarily dominated by Douglas fir) = MC; lodgepole pine = LP; spruce fir = SF; aspen = AS] in the Rockies.

Species	NTMB Status[a]	PO	PJ	CA	PP	MC	LP	SF	AS
Turkey Vulture	B	C	C	—	U	C	—	U	U
Bald Eagle	R	R	R	—	—	—	—	—	R
Sharp-shinned Hawk	B	C	R	—	C	C	U	C	C
Cooper's Hawk	B	C	U	C	C	C	C	U	C
Northern Goshawk	B	U	R	C	C	C	C	C	C
Common Black-Hawk[b]	C	R	R	—	—	—	—	—	—
Swainson's Hawk	A	R	R	—	—	—	—	—	U
Zone-tailed Hawk	C	R	U	—	—	—	—	—	—
Red-tailed Hawk	B	C	C	—	C	U	U	C	C
Ferruginous Hawk	B	R	U	—	U[c]	—	—	—	R
Golden Eagle	B	U	U	—	U	R	U	U	U
American Kestrel	B	U	C	—	C	U	—	C	C
Merlin	A	R	R	—	R	R	—	R	R
Peregrine Falcon	A	R	R	—	R	R	R	—	R
Prairie Falcon	B	—	U	—	U	—	—	—	—
Ring-necked Pheasant	R	R	R	—	—	—	—	—	R
Spruce Grouse	R	—	—	—	—	—	—	C[c]	—
Blue Grouse	R	U	R	—	U	—	—	C	C
Ruffed Grouse	R	—	—	—	—	U[c]	—	U	C
Wild Turkey	R	U	U	—	R	—	—	U	C
Montezuma Quail	R	U	U	—	—	—	—	—	—
Gambel's Quail	R	U	U	—	U	—	—	—	—
Killdeer	B	U	U	—	R	—	—	—	U
Band-tailed Pigeon	A	U	R	—	U	U[c]	—	U	U
White-winged Dove	C	R	U	—	—	—	—	—	—
Mourning Dove	B	C	C	—	U	U	—	U	U
Thick-billed Parrot	R	R	—	—	—	—	—	—	—
Greater Roadrunner	R	R	U	—	R	—	—	—	—
Barn Owl	R	R	R	—	—	—	—	—	—
Flammulated Owl	A	A	U	R	A	C	—	R	R
Western Screech-Owl[b]	R	U	C	U	R	U	—	—	C
Whiskered Screech-Owl	R	C	R	—	—	—	—	—	—
Great Horned Owl	R	C	C	C	C	C	R	U	C
Northern Hawk Owl	R	—	—	—	—	—	—	R	R
Northern Pygmy-Owl	R	U	U	U	C	C	R	C	U
Elf Owl	C	R	R	—	—	—	—	—	—
Spotted Owl (Mexican)	R	C	R	—	U[c]	C[c]	—	R[c]	R[c]
Barred Owl	R	—	—	C	U[c]	C[c]	—	—	—
Great Gray Owl	R	—	—	—	—	U	R	U	R
Long-eared Owl	B	R	U	—	U	U	R	U	U
Boreal Owl	R	—	—	—	—	—	—	C	U
Northern Saw-whet Owl	R	U	R	U	C	C	R	U	C
Lesser Nighthawk	A	—	U	—	—	—	—	—	—
Common Nighthawk	A	U	U	—	C[c]	U	U	C	C
Common Poorwill	B	C	C	—	U[c]	—	—	—	U
Whip-poor-will	A	R	R	—	U[c]	—	—	—	—
Black Swift	A	R	—	—	—	—	—	U	U
Vaux's Swift	A	R	R	R	—	R	—	—	—
White-throated Swift	A	C	U	—	U[c]	R[c]	—	C	C
Broad-billed Hummingbird	C	R	R	—	—	—	—	—	—
White-eared Hummingbird	C	R	—	—	—	—	—	—	—
Berylline Hummingbird	C	R	—	—	—	—	—	—	—
Blue-throated Hummingbord	C	U	R	—	—	—	—	—	—
Magnificent Hummingbird	C	U	U	—	—	—	—	—	—
Lucifer Hummingbird	C	R	R	—	—	—	—	—	—
Black-chinned Hummingbird	A	U	C	—	—	—	—	—	—
Anna's Hummingbird	B	U	U	—	—	—	—	—	—
Costa's Hummingbird	A	—	R	—	—	—	—	—	—

Table 8-1 *(cont.)*

Species	NTMB Status[a]	PO	PJ	CA	PP	MC	LP	SF	AS
Calliope Hummingbird	A	—	—	—	—	U	R	C	C
Broad-tailed Hummingbird	A	C	U	—	C	U	C	C	C
Rufous Hummingbird	A	—	—	U	U[e]	U	—	C	C
Elegant Trogon	C	U	R	—	—	—	—	—	—
Eared Trogon	C	R	R	—	—	—	—	—	—
Lewis' Woodpecker	B	U	R	—	U[e]	—	—	—	R
Acorn Woodpecker	R	U	U	—	U[e]	—	—	—	—
Yellow-bellied Sapsucker	B	R	—	—	—	—	—	—	R
Red-naped Sapsucker	B	C	U	C	—	U	R	C	C
Williamson's Sapsucker	B	R	—	—	C[e]	U	U	U	U
Ladder-backed Woodpecker	R	—	R	—	—	—	—	—	—
Downy Woodpecker	R	U	R	—	U[e]	R	—	C	C
Hairy Woodpecker	R	C	C	C	C	C	U	C	C
Strickland's Woodpecker	R	C[e]	U[e]	—	—	—	—	—	—
White-headed Woodpecker	R	—	—	—	U[e]	U[e]	—	—	—
Three-toed Woodpecker	R	R	—	R	U[e]	R	U	U	U
Black-backed Woodpecker	R	R	—	—	—	R	R	R	R
Northern Flicker	B	C	C	U	C	C	C	C	C
Pileated Woodpecker	R	—	—	C	—	U	—	U	U
Olive-sided Flycatcher	A	U	R	U	U	U	R	C	C
Greater Pewee	C	C	R	—	C[e]	C[e]	—	—	—
Western Wood-Pewee	A	C	R	U	C	U	—	C	C
Willow Flycatcher[b]	A	R	R	C	—	R	—	U	U
Hammond's Flycatcher	A	U	R	A	—	C	—	C	C
Dusky Flycatcher	A	U	U	R	—	C	—	C	C
Gray Flycatcher	A	U	U	—	U[e]	—	—	—	—
Cordilleran Flycatcher	A	U	R	U	U	C	C	U	U
Buff-breasted Flycatcher	C	U	R	—	—	—	—	—	—
Black Phoebe[b]	R	U	U	—	—	—	—	—	—
Say's Phoebe	B	R	U	—	—	R	—	—	—
Vermilion Flycatcher[b]	A	U	U	—	—	—	—	—	R
Dusky-capped Flycatcher	C	U	R	—	R	U[e]	—	—	—
Ash-throated Flycatcher	A	C	A	—	U	R[e]	—	—	—
Brown-creasted Flycatcher[b]	C	U	U	—	R	—	—	—	—
Sulphur-bellied Flycatcher	A	C	R	—	—	R[e]	—	—	—
Cassin's Kingbird	A	U	C	—	U	—	—	—	—
Thick-billed Kingbird[b]	C	R	R	—	—	—	—	—	—
Western Kingbird	A	U	U	—	R	—	—	—	R
Rose-throated Becard	C	U	R	—	—	—	—	—	—
Horned Lark	B	—	R	—	—	—	—	—	—
Purple Martin	A	R	—	—	R	—	—	R	R
Tree Swallow[b]	B	U	U	U	U	R	—	C	C
Violet-green Swallow	A	C	U	—	C	R	—	U	U
Cliff Swallow	A	—	R	—	—	—	—	—	—
Gray Jay	R	R	R	C	—	C	A	C	C
Steller's Jay	R	C	U	U	C	U	U	C	C
Blue Jay	R	—	—	—	U[e]	—	—	—	—
Scrub Jay	R	U	C	—	R	—	—	—	—
Gray-breasted Jay	R	C[e]	R[e]	—	—	—	—	—	—
Pinyon Jay	R	C	C	—	U	—	—	—	—
Clark's Nutcracker	R	—	—	—	U[e]	U	C	A	C
Black-billed Magpie	R	U	U	—	U	—	—	R	—
American Crow	R	U	U	—	U	R	—	R	U
Common Raven	R	C	C	C	U[e]	U	U	C	C
Black-capped Chickadee	R	—	C	C	C[e]	C	—	C	C
Mexican Chickadee	R	C[e]	R[e]	—	U[e]	—	—	—	—
Mountain Chickadee	R	U	R	A	A	A	A	C	A
Boreal Chickadee	R	—	—	—	—	—	—	A[e]	C[e]
Chestnut-backed Chickadee	R	—	—	A	—	R	—	—	—
Bridled Titmouse	R	C[d]	U[e]	—	R[e]	—	—	—	—

(continued)

Table 8-1 (*cont.*)

Species	NTMB Status[a]	PO	PJ	CA	PP	MC	LP	SF	AS
Plain Titmouse	R	U	C	—	—	—	—	—	—
Bushtit	R	R	C	—	—	—	—	—	—
Red-breasted Nuthatch	R	C	R	A	C[c]	C	C	C	C
White-breasted Nuthatch	R	C	U	—	C	U	—	C	C
Pygmy Nuthatch	R	C	U	—	A	U	—	U	R
Brown Creeper	B	U	R	C	C	C	C	C	C
Rock Wren	B	U	C	—	R	—	—	R	U
Canyon Wren	R	R	U	—	U[c]	—	—	—	R
Bewick's Wren	R	C	C	—	U	—	—	—	—
House Wren	A	C	R	—	C	U	—	C	A
Winter Wren	R	R	—	C	—	U	—	C	—
American Dipper[b]	R	—	—	—	—	—	—	U	U
Golden-crowned Kinglet	R	—	R	A	—	C	U	A	C
Ruby-crowned Kinglet	B	C	U	A	—	A	C	A	C
Blue-gray Gnatcatcher	A	U	C	—	—	R[c]	—	—	—
Western Bluebird	B	U	R	—	A[c]	R[c]	—	—	R
Mountain Bluebird	B	U	C	—	U	U	—	U	U
Townsend's Solitaire	B	U	U	C	U	C	C	C	C
Swainson's Thrush	A	R	R	A	—	C	C	C	C
Hermit Thrush	B	C	—	U	C	C	A	C	C
American Robin	B	C	U	C	C	A	A	C	C
Varied Thrush	R	R	—	A	—	U	—	U	U
Northern Mockingbird	B	R	C	—	R	—	—	—	R
Curve-billed Thrasher	R	—	C	—	—	—	—	—	—
Bohemian Waxwing	R	—	—	—	—	—	—	C	U
Cedar Waxwing	B	U	R	—	—	R	—	R	R
Loggerhead Shrike	B	R	R	—	R	—	—	—	—
European Starling	R	—	—	—	—	R	—	—	—
Gray Vireo	A	R	C	—	—	—	—	—	—
Solitary Vireo	A	C	R	C	C	C	U	—	—
Hutton's Vireo	R	U[c]	—	—	—	—	—	—	—
Warbling Vireo	A	U	—	U	C	C	—	C	A
Red-eyed Vireo	A	—	—	U	U[c]	—	—	—	—
Tennessee Warbler	A	—	—	—	—	—	—	R[c]	—
Orange-crowned Warbler	A	U	R	U	—	C	—	U	U
Nashville Warbler	A	—	—	R	—	U	—	—	—
Virginia's Warbler	A	C	C	—	U[c]	U[c]	—	—	—
Lucy's Warbler[b]	C	R	R	—	—	—	—	—	—
Northern Parula	A	R	—	—	—	—	—	—	—
Yellow Warbler[b]	A	R	R	U	—	U	—	C	C
Yellow-rumped Warbler	B	C	U	A	C	A	A	A	A
Black-throated Gray Warbler	A	C	C	—	U	C[c]	—	U	U
Townsend's Warbler	A	—	—	A	—	C	—	C	C
Hermit Warbler	A	—	—	—	—	R[c]	—	—	—
Grace's Warbler	A	C[c]	—	—	A[c]	C[c]	—	—	—
American Redstart[b]	A	—	—	—	—	U	—	—	R
Ovenbird	A	—	—	—	C[c]	R	—	R	U
Northern Waterthrush[b]	A	—	—	R	—	U	—	U	—
MacGillivray's Warbler	A	R	—	C	U	C	—	U	U
Common Yellowthroat[b]	A	—	—	—	—	—	—	—	R
Wilson's Warbler	A	—	—	U	—	U	—	C	U
Red-faced Warbler	C	C	—	—	U[c]	C[c]	—	—	—
Painted Redstart	C	C	U	—	—	C[c]	—	—	—
Olive Warbler	C	R	—	—	A[c]	U[c]	—	—	—
Hepatic Tanager	A	C	R	—	U[c]	R[c]	—	—	—
Summer Tanager	A	U	—	—	—	—	—	—	—
Western Tanager	A	C	R	C	C	A	U	C	C
Northern Cardinal	R	R	U	—	R	—	—	—	—
Yellow Grosbeak	C	R	R	—	—	—	—	—	—
Black-headed Grosbeak	A	C	U	U	U[c]	C	—	R	U
Lazuli Bunting	A	U	U	—	—	U	—	U	U

Table 8-1 (*cont.*)

Species	NTMB Status[a]	PO	PJ	CA	PP	MC	LP	SF	AS
Green-tailed Towhee	A	U	U	—	—	R	—	C	C
Rufous-sided Towhee	B	C	C	—	R	U[c]	—	—	R
Canyon Towhee	R	R[c]	U[c]	—	—	—	—	—	—
Chipping Sparrow	A	C	C	C	C	A	U	C	C
Brewer's Sparrow	A	—	R	—	—	—	—	—	—
Black-chinned Sparrow	A	—	U	—	—	—	—	—	—
Vesper Sparrow	B	R	U	—	—	R	—	R	R
Lark Sparrow	A	—	C	—	—	—	—	—	—
Black-throated Sparrow	B	—	U	—	—	—	—	—	—
Sage Sparrow	B	—	R	—	—	—	—	—	—
Fox Sparrow	B	—	—	C	—	U	—	U[c]	R
Song Sparrow[b]	B	R	—	C	U[c]	U	—	U	U
Lincoln's Sparrow	A	—	—	—	—	R	C	U	U
White-crowned Sparrow	B	R	—	—	—	R	—	C	U
Dark-eyed Junco	B	C	U	A	A	A	A	A	A
Yellow-eyed Junco	R	C[c]	U[c]	—	A[c]	—	—	—	—
Western Meadowlark	B	R	U	—	—	—	—	—	R
Yellow-headed Blackbird[b]	A	R	U	—	—	—	—	—	R
Brewer's Blackbird	B	U	C	—	U[c]	R	—	—	U
Common Grackle	R	—	U	—	—	R	—	—	R
Bronzed Cowbird	C	R[c]	U[c]	—	—	—	—	—	—
Brown-headed Cowbird	B	C	C	—	R	C	R	R	C
Hooded Oriole	A	U	U	—	—	—	—	—	—
Northern Oriole	A	R	U	—	—	—	—	—	R
Scott's Oriole	A	C	U	—	—	R[c]	—	—	—
Pine Grosbeak	R	—	—	—	U[c]	U	C	C	U
Purple Finch	B	R	—	—	—	—	—	C[c]	—
Cassin's Finch	B	U	R	U	C[c]	C	U	U	U
House Finch	R	U	U	—	—	—	—	—	R
Red Crossbill	R	R	R	C	C	C	C	C	U
White-winged Crossbill	R	—	—	—	—	—	R	R	—
Pine Siskin	B	U	C	C	A	A	A	C	C
Lesser Goldfinch	B	U	U	—	R	—	—	—	—
American Goldfinch	B	U	U	—	U[c]	R	—	—	R
Evening Grosbeak	R	U	U	U	U	C	—	C	U
House Sparrow	R	U	U	—	R	—	—	—	R

[a] As designated by the *Partners in Flight* preliminary list: A = long-distance migrant species, those that breed in North America and spend their nonbreeding period primarily south of the United States; B = short-distance migrant species, those that breed and winter extensively in North America; C = migrants whose breeding range is primarily south of the United States/Mexican border, and enter the United States along the Rio Grande Valley or where the Mexican highlands extend across the United States border. These populations largely vacate the United States during the winter months. R = permanent resident species that primarily have overlapping breeding and nonbreeding areas.
[b] Species associated with wet areas in these habitats.
[c] Species at least locally found in that habitat type. While there is probably a north/south difference in bird species in most habitats, it is most notable in ponderosa pine and mixed conifer.

Differences in Birds among Natural Stands of Different Ages

No common results for any one species nor obvious trends for any particular migrant group were found in the two studies comparing natural stands of different ages (Catt 1991, Moore 1992). From his study of forest succession in spruce-fir forests, Catt (1991) found 12 species in all four forested successional stages (pole-sapling, young, mature, and old-growth forests), while six species were associated with the three oldest stages. Two of these species (Golden-crowned Kinglet and Townsend's Warbler) were more abundant in mature and old-growth forests. Three-toed Woodpeckers, Winter Wrens, and White-winged Crossbill were only found in mature and old-growth forests, with Winter Wrens being clearly more abundant in old-growth stands. A few species were found only in one stand age. Lincoln's Sparrow and Evening Grosbeaks were only present in mature forests. Dusky

Flycatcher and Townsend's Solitaire were only found in pole-sapling stands.

Of 24 common species in mature and old-growth Douglas-fir forests in Montana, White-crowned Sparrow was only present in, and American Robin and Chipping Sparrow were more abundant in, old-growth stands (Moore 1992). No common species was significantly more abundant in the mature stands. Of 19 uncommon species, three were found only in mature and six in old-growth forests. Three-toed Woodpecker was the only uncommon species seen on all four old-growth sites.

COMPARISONS OF BIRDS AMONG LOGGING TREATMENTS

Methods for Evaluating Effects of Silvicultural Treatments on Forest Birds

Since most of the ornithological literature describes the effects of silvicultural practices on birds in Cascadian, ponderosa pine, mixed-conifer (primarily dominated by Douglas fir), lodgepole pine, spruce-fir, and aspen forests, we concentrated our efforts on these habitats. We searched through federal publications, university dissertations and theses, and the major ornithological and ecological journals for studies on effects of timber harvesting on birds. We also included unpublished data. We classified data from a given study site in community-wide studies into one of the following forest cover types: (1) Cascadian; (2) ponderosa pine; (3) mixed conifer; (4) lodgepole pine; (5) spruce fir; or (6) aspen. The cover type was also classified into one of seven disturbance categories: (1) uncut; (2) group selection; (3) overstory removal; (4) shelterwood cut (before re-entry to remove the remaining overstory trees); and (5) three ages of clearcuts. Because few studies (most with very few replicates in any one treatment) had been conducted in any one forest type (those from conifer forests are listed in Table 8-2) or for any particular silvicultural method, we combined data from all of the studies in conifer forests and made comparisons between birds in uncut forests with those in four developmental classes: low shrub clearcuts (from grass-forb to small shrub stage, in general, 0–10 years old), tall shrub clearcuts (including tall shrubs and seedlings, in general from 11–20 years old), pole-sapling clearcuts (in general 21–40 years old), and partial cuts (any cutting treatment besides clearcut; categories 2–4 above). We preferentially used descriptions of the vegetation to determine how to categorize each site. We do not know if the "uncut"

Table 8-2. Distribution of study sites by habitat and logging treatment from 19 studies[a] on the effects of logging treatments on birds in conifer forests throughout the Rocky Mountains. A study was required to have a control as well as a treated area to be included in our analyses. Several studies compared several treatments with one control. The five forest types include Cascadian (CA), ponderosa pine (PP), mixed conifer (dominated primarily by Douglas fir; MC), lodgepole pine (LP), and spruce fir (SF).

Logging Treatment	Forest Types					
	CA	PP	MC	LP	SF	Total
Group selection	0	0	2	0	2	4
Overstory removal	0	3	4	0	0	7
Shelterwood cut	0	0	2	0	0	2
Low-shrub clearcut	3	1	4	2	3	13
Tall-shrub clearcut	3	0	1	2	0	6
Pole-sapling clearcut	2	0	0	1	0	3
Total	8	4	13	5	5	35

[a] Studies include: Austin and Perry (1979), Brawn and Balda (1988), Case and Hutto (1980, unpublished field notes), Catt (1991), Davis (1976), Franzreb and Ohmart (1978), Hallock (1989–1990), Holmes et al. (1991, unpublished field notes), Keller and Anderson (1992), McClelland (1980), Medin (1985), Medin and Booth (1989), Mitchell and Bratkovich (1992), Peterson (1982), Scott and Gottfried (1983), Scott et al. (1982), Siegel (1989), Tobalske et al. (1991), and Wetmore et al. (1985).

sites or "control" sites from most studies were truly never cut. We assumed that, if anything, they were lightly cut. We also do not know the age of all of these uncut stands but we assume that they were mature or old-growth forests. Studies were conducted in British Columbia, Idaho, Montana, Wyoming, Utah, Colorado, and Arizona.

To evaluate the effect of timber harvesting on birds in conifer forests, we analyzed only those community-wide studies specifically designed for that purpose. We scored each bird species as one that was less abundant (−1), similarly abundant (0), or more abundant (+1) in each logged site compared to an unlogged site from the same study. We used the results of significance tests when they were available but most studies had not used statistical tests. One tally was used for each treatment from studies that included multiple treatments. We assumed that differences resulted from the timber harvesting activity. Our methods were subjective, but we minimized the effect of analyzer bias by having just one of us (RLH) make the decision as to whether a species was more, less or similarly abundant in treated than in untreated areas. The potential effect of each timber harvest activity on each species was determined by calculating the average score over all such studies, resulting in an index. Thus, an index of 1.0 indicates that every study reported more birds in the treated than in the untreated areas, and an index of −1.0 indicates that every study reported more birds in the untreated areas. An index of 0.0 indicates either that a species had similar abundances in treated and untreated areas in every study, or that no obvious trend held across studies. Species that were encountered in at least three studies are emphasized in results. The original sampling effort varied among the studies—from one site to many sites per treatment, from one to many years, and from one to several observers. A few studies had data from study sites before and after a treatment, but most compared data from sites that had been treated to those that had not been. These differences among studies add sources of variation to the analyses. The power of our analyses comes from comparing many studies.

We summarized the effects of silviculture on birds in aspen and the effects of chaining on birds in pinyon–juniper separately. Information was sparse on the effects of silviculture in aspen forests, so we simply noted a few potentially relevant facts. There was no information on the effects of silvicultural practices from madrean pine–oak woodlands, pygmy-conifer woodlands, or whitebark pine. Some information, however, was available on the effects of chaining (knocking down trees) on birds in pygmy-conifer woodlands. While chaining is not a silvicultural method, chaining initially affects the landscape in some similar ways to logging and is an important source of human-induced change in pinyon–juniper forests. We therefore included a brief summary of the effects of chaining on birds in pinyon-juniper. While we could not find any studies examining silvicultural effects in whitebark pine or associated communities, it is important to realize that whitebark pine is sometimes logged (more extensively in the past; Losensky 1990) and is an important but endangered resource for some bird species (Kendall and Arno 1990).

To find possible indications of old-growth associates, we summarized the results of four community-wide studies in the Rocky Mountains (Peterson 1982, Mannan and Meslow 1984, Mannan and Siegel 1988, Hejl and Woods 1991, Hejl, unpublished data). These studies compared birds in uncut or lightly cut "old-growth" forests with those in immature or mature second-growth stands. Three were conducted in Cascadian or mixed-conifer forests in the Northern Rockies, and one in ponderosa pine in the southern Rockies. We used the results of statistical tests if available, but most categorizations were subjective.

Finally, we used additional methods for evaluating the effects of silvicultural treatments on raptors. Most community-wide studies are not useful for evaluating raptor abundance or occurrence. We include raptors in our syntheses of community studies, if raptors were mentioned in the bird list, but we realize that they are more inadequately sampled than are the other species by these methods. The results from community studies may even be misleading, since many raptors are secretive birds and are more likely to be seen from an edge, opening, or clearcut, even if they rarely frequent these habitats. Therefore, we also searched the literature separately for specific studies addressing raptors and silvicultural treatments, and we describe those results separately.

Effects of Silvicultural Treatments on Birds in Conifer Forests

From community-wide studies, 26 species were less abundant in treated areas as compared to unlogged areas in general (Table 8-3). In contrast, 15 species were generally more abundant in treated areas than in unlogged ones.

Comparing recent, low-shrub clearcuts to unlogged forests, we found that 17 species were less abundant in the clearcuts in every case and 25 species in some cases (Table 8-3). All resident species were less abundant in these recent clearcuts than in uncut forests. Sixty-eight per cent of long-distance migrants and 52% of short-distance migrants were less abundant in recent clearcuts in most studies. In contrast, 13 species were generally more abundant in recent clearcuts. No species was more abundant in low-shrub clearcuts in all studies, but 21% of long-distance migrants and 43% of short-distance migrants were more abundant in most cases.

In a comparison of partially logged and unlogged areas, three species were less abundant in partially logged areas in all cases and 26 species in some cases (Table 8-3). Ninety-four per cent of the resident species were less abundant in partially logged forests in most studies. Thirty-three per cent of long-distance migrants and 42% of the short-distance migrants were usually less abundant in partially logged forests. In contrast, 19 species were sometimes more abundant in partially logged areas and two species always more abundant. Sixty-one per cent of long-distance migrants and 50% of the short-distance migrants were sometimes to always more abundant in partially logged forests.

Each species responded uniquely to the harvesting treatments. Brown Creeper exhibited the clearest difference between harvested and unharvested treatments; creepers were always less abundant in clearcuts or partially logged forests than in uncut areas (Table 8-3). Red-breasted Nuthatch was always less abundant in any age of clearcut than in uncut forest. Seven other species (e.g., Golden-crowned Kinglet and Swainson's Thrush) were always less abundant in low- and tall-shrub clearcuts than in uncut forests, but not always so in partially cut forests. Five other species were less abundant in low-shrub clearcuts in all studies in which they were present. Pygmy Nuthatch and Pine Grosbeak were always less abundant in partially logged areas, but Pine Grosbeak was more abundant in clearcuts in some studies.

While many species were noticeably more abundant in one or two of the categories of harvested areas, no species was always more abundant in all classes (Table 8-3). Mountain Bluebirds were more abundant in low-shrub clearcuts in almost all studies. Nine species (e.g., Warbling Vireo, MacGillivray's Warbler and Rufous Hummingbird) were more abundant in tall-shrub clearcuts in all cases. Four species were always more abundant in pole-sapling clearcuts. Calliope Hummingbird and Rock Wren were always more abundant in partially logged areas than in uncut forest. All of the species that were consistently more abundant in logged areas were migrant species. For example, 69% of the species more abundant in recent clearcuts were short-distance migrants; the rest were long-distance migrants. Forty-three per cent of the species more abundant in partially cut areas were short-distant migrants and 52% were long-distant migrants. Hairy Woodpecker, Steller's Jay, and Clark's Nutcracker were the only resident species that were sometimes more abundant in treated than in untreated areas.

Some species did not seem to be negatively or positively affected by a particular silvicultural treatment. Rufous Hummingbird, Cassin's Finch, and Lincoln's Sparro were equally abundant in recent clearcuts and uncut areas (Table 8-3). Williamson's Sapsucker and Cordilleran Flycatcher were equally abundant in partially logged and uncut areas.

There are a few species for which sample size (number of studies) was too low to include in the table (we chose three studies

Table 8-3. Indices of the tendency for a bird species to be more or less abundant in clearcut or partially cut forest than in uncut forest. A species was scored as being more abundant (+1), less abundant (−1), or similarly abundant (0) in treated vs. untreated areas. Values in the table are averages of these scores over all studies on which the species was recorded. Species are ranked in ascending order from −1.00 based on low-shrub clearcut column. Sample sizes in parentheses (we only included sample sizes ≥ 3).

Species	NTMB Status[a]	Clearcuts			Partially Cut
		Low Shrub	Tall Shrub	Pole-sapling	
Mountain Chickadee	R	−1.00 (10)	−1.00 (5)	0.00 (3)	−0.77 (13)
Red-breasted Nuthatch	R	−1.00 (10)	−1.00 (5)	−1.00 (3)	−0.70 (10)
Brown Creeper	B	−1.00 (10)	−1.00 (4)	—	−1.00 (12)
Golden-crowned Kinglet	R	−1.00 (9)	−1.00 (3)	—	−0.60 (10)
Ruby-crowned Kinglet	B	−1.00 (9)	−1.00 (4)	—	−0.40 (10)
Winter Wren	R	−1.00 (7)	—	—	−0.20 (5)
Swainson's Thrush	A	−1.00 (7)	−1.00 (3)	—	−0.50 (6)
Varied Thrush	R	−1.00 (7)	−1.00 (3)	—	−0.75 (4)
Townsend's Warbler	A	−1.00 (7)	−1.00 (3)	—	−0.40 (5)
Three-toed Woodpecker	R	−1.00 (6)	—	—	−0.50 (6)
Black-capped Chickadee	R	−1.00 (6)	−0.67 (3)	—	−0.67 (3)
Solitary Vireo	A	−1.00 (5)	0.33 (3)	—	0.33 (9)
Hammond's Flycatcher	A	−1.00 (4)	−1.00 (4)	—	—
Evening Grosbeak	R	−1.00 (4)	—	—	—
Pileated Woodpecker	R	−1.00 (3)	−0.67 (3)	—	—
Chestnut-backed Chickadee	R	−1.00 (3)	—	—	—
White-breasted Nuthatch	R	−1.00 (3)	—	—	−0.14 (7)
Pygmy Nuthatch	R	—	—	—	−1.00 (5)
Western Tanager	A	−0.86 (7)	−1.00 (4)	—	0.09 (11)
Hermit Thrush	B	−0.71 (7)	—	—	−0.80 (10)
Steller's Jay	R	−0.67 (6)	0.33 (3)	—	−0.29 (7)
Clark's Nutcracker	R	−0.67 (6)	—	—	0.33 (3)
Warbling Vireo	A	−0.67 (6)	1.00 (4)	—	0.33 (9)
Yellow-rumped Warbler	B	−0.67 (12)	−0.50 (6)	1.00 (3)	−0.46 (13)
Gray Jay	R	−0.60 (10)	−0.50 (4)	0.00 (3)	−0.25 (4)
Black-headed Grosbeak	A	−0.62 (8)	0.40 (5)	—	0.22 (9)
Orange-crowned Warbler	A	−0.60 (5)	—	—	−0.50 (4)
Violet-green Swallow	A	—	—	—	−0.60 (5)
Pine Grosbeak	R	−0.50 (4)	—	—	−1.00 (3)
Pine Siskin	B	−0.45 (11)	0.00 (6)	0.00 (3)	−0.08 (12)
Western Wood-pewee	A	−0.43 (7)	—	—	−0.50 (4)
House Wren	A	−0.40 (5)	0.00 (3)	—	0.86 (7)
Hairy Woodpecker	R	−0.36 (11)	−0.33 (6)	0.33 (3)	−0.25 (12)
Cooper's Hawk	B	−0.33 (3)	—	—	−0.67 (3)
Common Raven	R	−0.33 (9)	−0.25 (4)	—	−0.17 (6)
Brown-headed Cowbird	B	−0.33 (3)	—	—	—
Red Crossbill	R	−0.33 (3)	−0.25 (4)	—	−0.33 (3)
Common Nighthawk	A	−0.25 (4)	−0.33 (3)	—	−0.50 (4)
Northern Flicker	B	−0.18 (11)	0.67 (6)	0.67 (3)	−0.17 (12)
Wilson's Warbler	A	−0.17 (6)	0.67 (3)	—	—
Fox Sparrow	B	−0.17 (6)	0.67 (3)	—	—
Red-naped Sapsucker	B	−0.14 (7)	0.00 (5)	0.67 (3)	0.17 (6)
MacGillivray's Warbler	A	−0.12 (8)	1.00 (4)	—	0.17 (6)
American Robin	B	−0.08 (13)	0.50 (6)	1.00 (3)	0.15 (13)
Rufous Hummingbird	A	0.00 (6)	1.00 (3)	—	0.33 (3)
Cassin's Finch	B	0.00 (5)	−0.20 (5)	0.67 (3)	0.60 (5)
Lincoln's Sparrow	A	0.00 (3)	0.67 (3)	—	—
Cordilleran Flycatcher	A	—	—	—	0.00 (6)
Williamson's Sapsucker	B	—	—	—	0.00 (5)
Chipping Sparrow	A	0.18 (11)	0.67 (6)	1.00 (3)	0.60 (10)
Western Bluebird	B	—	—	—	0.20 (5)
Olive-sided Flycatcher	A	0.25 (12)	0.25 (4)	—	0.67 (9)
Broad-tailed Hummingbird	A	0.33 (3)	1.00 (3)	—	0.25 (4)
Tree Swallow	B	0.40 (5)	—	—	—

(*continued*)

Table 8-3 (*cont.*)

Species	NTMB Status[a]	Clearcuts			Partially Cut
		Low Shrub	Tall Shrub	Pole-sapling	
Dark-eyed Junco	B	0.46 (13)	1.00 (6)	1.00 (3)	0.38 (13)
Northern Goshawk	B	0.50 (4)	−0.60 (5)	0.00 (3)	—
Red-tailed Hawk	B	0.50 (4)	0.33 (3)	—	0.33 (3)
Mourning Dove	B	0.50 (4)	—	—	0.67 (3)
White-crowned Sparrow	B	0.50 (6)	—	—	—
Townsend's Solitaire	B	0.57 (7)	0.25 (4)	—	−0.25 (8)
American Kestrel	B	0.67 (3)	1.00 (4)	0.67 (3)	—
Dusky Flycatcher	A	0.67 (3)	1.00 (3)	—	—
Mountain Bluebird	B	0.90 (10)	1.00 (5)	0.33 (3)	0.67 (6)
Song Sparrow	B	—	1.00 (3)	—	—
Calliope Hummingbird	A	—	—	—	1.00 (3)
Rock Wren	B	—	—	—	1.00 (3)

[a] See footnote a of Table 8-1.

as a cutoff) but for which we guess that there are likely to be real differences among treatments. For example, Boreal Chickadee and Pygmy Nuthatch were always less abundant in recent clearcuts in the literature we searched. Flammulated Owl, Pileated Woodpecker, and Grace's Warbler were always less abundant in partially logged forests. Also, Virginia's Warbler, Grace's Warbler, Red-faced Warbler, and Olive Warbler were not present in clearcuts in a multiyear study but were present in treated or uncut forests (Brawn and Balda 1988).

Differences in Birds between Cut and Uncut Aspen Forests

Only a few avian species are more closely associated with aspen than other forest habitats in the Rockies (Table 8-1). They include Red-naped Sapsucker, Black-capped Chickadee, House Wren, Warbling Vireo (Finch and Reynolds 1987, Scott and Crouch 1988), and perhaps the Northern Saw-whet Owl in some areas. Results of two studies on the effects of logging treatments on birds in aspen forests (DeByle 1981, Scott and Crouch 1987) serve to underscore the need for more specific, practical information for managers. The two studies were conducted in different areas (Utah, Colorado), and involved treatments on vastly different scales (50% of a 4 ha site clearcut in Utah, 25% of a 930 ha site clearcut in Colorado). The combined results are equivocal; therefore, no assessments can be made as to the effects of cutting aspen on any particular migrant group. For example, the House Wren declined in abundance after clearcutting in Utah, but increased in Colorado. The Warbling Vireo and Dark-eyed Junco declined in Utah, but showed essentially no response in Colorado. Cordilleran Flycatchers declined in the Colorado study, but were not present in the Utah study. Estimated bird density increased in the Colorado site, but decreased in Utah after clearcutting. Both studies indicate that bird species richness increased after clearcutting and that Hermit Thrushes were adversely affected whereas Song Sparrows and Mountain Bluebirds benefited from clearcutting, but the evidence is more anecdotal than analytic.

Differences in Birds between Chained and Unchained Pinyon–Juniper Woodland

The effects of chaining on birds in pinyon–juniper woodland are similar to the effects of clearcutting on birds in other Rocky Mountain forests (O'Meara et al. 1981, Sedgwick and Ryder 1987). In one study in Colorado, the 8- and 15-year-old chained areas had no breeding species in common with unchained areas (O'Meara et al. 1981). Only ground- and shrub-nesters were found on the chained areas; the 10 species found only in the unchained area typically require trees for nesting and foraging. In the other study in

Colorado, more similar ties in bird presence were noted between the recently chained and adjacent, unchained plots (Sedgwick and Ryder 1987). Some ground-searchers or ground-nesters used the chained plot, but this use varied by year. Foliage-and-timber searchers, aerial foragers, foliage nesters, and cavity nesters mainly used the unchained plot. Gray Flycatcher, White-breasted Nuthatch, Mountain Bluebird, Hermit Thrush, Solitary Vireo, and Black-throated Gray Warbler were more abundant in unchained areas and Rock Wren was more abundant in chained areas in both studies. Differences in abundances between chained and unchained areas did not obviously correlate with the migratory status of the birds.

Old-growth and Second-growth Associates

Although 15 species were more abundant in old growth in at least one study, no species was consistently more abundant in old growth in all four studies that compared old-growth with old second-growth stands (Peterson 1982, Mannan and Meslow 1984, Mannan and Siegel 1988, Hejl and Woods 1991, Hejl, unpublished data) (Table 8-4). Woodpeckers, nuthatches, and thrushes, however, were more abundant in old growth in general, and six species (Brown Creeper, Golden-crowned Kinglet, Varied Thrush, Swainson's Thrush, Hermit Thrush, and Townsend's Warbler) were relatively more abundant in old-growth stands in two studies. Of 13 species that were more abundant in second-growth forests, Chipping Sparrow was most abundant in mature second growth in three studies that compared such stands to old growth. Two species (Dusky Flycatcher, Brown-headed Cowbird) were relatively more abundant in mature, second-growth stands in two studies. Contrary to these trends, Brown Creepers were more abundant in mature second-growth in Idaho. Six other species also had conflicting trends. No trends were obvious for any particular migrant group.

Peterson's (1982) study of ten different stand ages (spanning from recent clearcuts to old-growth forests) gives additional information not found in the other three studies that compared just older-aged stands (forests older than 60 years). In Table 8-4, we compared bird abundances from Peterson's mature and old-growth stands to provide a comparison with other studies that had compared only older stand ages. In this comparison, some species proved to be more abundant in mature or old-growth stands when only those two stand ages were compared. Upon comparing abundances among all ten ages of logged stands as Peterson did, however, no bird species was obviously more abundant in old-growth or mature stands than in all other stand ages in Idaho. For example, while Golden-crowned Kinglets would be considered old-growth associates in a comparison with just mature stands, they were as abundant in pole stands as they were in old growth. This fact reminds us to realize the limitation of data from only two types of stands (i.e., the other three studies in Table 8-4).

Peterson's (1982) results, however, may simply underscore the uniqueness of each species' relation to stand age, depending on forest type or geographic area. Whereas Swainson's Thrushes were old-growth associates in mixed-coniferous forests in Oregon and Montana, Peterson found them in somewhat similar abundances in all forested stages of Cascadian forests. Townsend's Warblers, an old-growth associate in mixed-coniferous forests in Oregon and Montana, were most abundant in tall shrubs mixed with some conifers and in sapling conifers in Peterson's Cascadian forests in Idaho.

The Effects of Silvicultural Treatments on Raptors

Only four raptor species were sampled adequately enough in community-wide studies to be listed in our assessment of the presence of birds in various logging treatments across forests in the Rocky Mountains (Table 8-3). Cooper's Hawks were less abundant in low-shrub clearcuts and partially cut forests than in uncut forests in most studies. Northern Goshawks appeared to be negatively affected by clearcuts in some studies but not others; they were less abundant in tall-shrub clearcuts but more abundant in low-shrub clearcuts than in uncut areas. Red-tailed Hawks and American

Table 8-4. Locations in the Rocky Mountains where individual species were found to be old-growth (O) or second-growth (M = mature; I = immature) associates in comparisons of birds in old-growth and second-growth stands. Some species were present but not clearly associated with any habitat (P) and other species were not recorded in that location (—).

Species	NTMB Status[a]	Locations[b]			
		ID	OR	MT/ID	AZ
Common Nighthawk	A	—	P	P	I
Williamson's Sapsucker	B	—	P	P	O
Hairy Woodpecker	R	P	P	P	O
Three-toed Woodpecker	R	—	—	P	O
Pileated Woodpecker	R	P	P	O	—
Western Wood-pewee	A	O	—	M	P
Hammond's Flycatcher	A	P	P	O	—
Dusky Flycatcher	A	—	M	M	—
Clark's Nutcracker	R	—	—	M	P
Black-capped Chickadee	R	P	—	M	—
Chestnut-backed Chickadee	R	M	—	—	—
Mountain Chickadee	R	P	P	P	I
Red-breasted Nuthatch	R	M	O	P	—
White-breasted Nuthatch	R	—	P	P	O
Pygmy Nuthatch	R	—	—	—	O
Brown Creeper	B	M	O	P	O
Golden-crowned Kinglet	R	O	O	P	—
Ruby-crowned Kinglet	B	O	M	P	—
Western Bluebird	B	—	—	P	O
Townsend's Solitaire	B	P	P	P	I
Varied Thrush	R	O	P	O	—
Swainson's Thrush	A	P	O	O	—
Hermit Thrush	B	—	O	P	O
American Robin	B	P	P	P	I
Solitary Vireo	A	P	P	M	O
Warbling Vireo	A	—	—	P	O
Yellow-rumped Warbler	B	M	P	P	P
Townsend's Warbler	A	P	O	O	—
Grace's Warbler	A	—	—	—	O
Chipping Sparrow	A	M	M	M	P
Dark-eyed Junco	B	P	M	P	I
Brown-headed Cowbird	B	—	M	M	—
Cassin's Finch	B	—	M	P	O
Red Crossbill	R	—	P	M	P
Evening Grosbeak	R	—	P	M	O

[a] See footnote a of Table 8-1.
[b] Idaho (ID) study from Peterson (1982), Oregon (OR) study from Mannan and Meslow (1984), Montana and Idaho (MT/ID) study reported in Hejl and Woods (1991) and unpublished data from Hejl, and Arizona (AZ) study from Mannan and Siegel (1988).

Kestrels were more abundant in treated areas than in uncut forests in most studies. Flammulated Owls were not mentioned in our summary of old-growth associates, since they were present in very low numbers, but they were only found in old-growth stands in community studies from mixed-conifer forests in the Northern Rockies (Mannan and Meslow 1984, Hejl and Woods 1991).

General literature suggests that accipiters may be more affected than other hawks by intensive silvicultural activity in the short term. Northern Goshawks seem to prefer a 20–30 acre stand of large trees and high canopy closure surrounding their nest sites (Reynolds et al. 1982, Moore and Henny 1983, Reynolds 1983, Crocker-Bedford 1990, Reynolds et al. 1992). All three accipiters forage in the forest canopy (Reynolds and Meslow 1984) or for a limited distance into openings (R. Reynolds, personal communication), so foraging habitat would probably be reduced by clearcutting large openings, but not necessarily by partial cutting. Cooper's Hawks may be more capable of nesting in fragmented forests than the other accipiters (Beebe 1974, Evans 1982). Often, American Kestrels (Palmer 1988, Johnsgard 1990) and Red-tailed Hawks (Schmutz et al. 1980) are found in association with forest openings.

General literature suggests that at least four owl species may be associated with old-growth components and habitats in the Rocky Mountains. Male Flammulated Owls tend to establish territories in mature to old-growth stands of ponderosa pine, aspen, Douglas fir, or ponderosa pine mixed with Douglas fir (Richmond et al. 1980, Webb 1982, Howie and Ritcey 1987, Reynolds and Linkhart 1987, 1992, Jones 1987, 1991, Bull et al. 1990). Some of these forests have been selectively harvested (Howie and Ritcey 1987, Bull et al. 1990). In a study in ponderosa pine and mixed-conifer forests in northern Arizona (Ganey and Balda 1989), all Mexican Spotted Owls had activity centers located in old-growth forests and visited other portions of the home range infrequently. Great Gray Owls nest most often in mature and older stands (Bull et al. 1988), and they sometimes forage along edges of openings and clearcuts (G. Hayward, personal communication). Boreal Owls seem to be associated with mature and old-growth forests in spruce fir in central Idaho (Hayward 1989, Hayward et al. 1993), western Montana (Holt and Hillis 1987), and Colorado (Palmer 1986, Ryder et al. 1987). Mature and old-growth spruce-fir may provide optimum nesting habitat for Boreal Owls (G. Hayward, personal communication), but nests have also been found in old mixed-conifer, old Douglas-fir, and aspen forests. In contrast, the Great Horned owl and Barred Owl may successfully use fragmented areas in the Rockies, as has been suggested, but not substantiated, for these owls in the Pacific Northwest (Thomas et al. 1990). No relationships were found between any particular migratory group of raptors and distribution in certain habitats.

EFFECTS OF FIRE AND FIRE SUPPRESSION ON FOREST BIRDS

Methods for Evaluating Effects of Fire and Fire Suppression on Birds

Since fire is the most important natural disturbance in the Rocky Mountains (Peet 1988), we briefly summarize the literature on the importance of fire to birds in these forests (for additional information, see Rotenberry et al., Chapter 3, this volume).

Effects of Fire and Fire Suppression on Forest Birds

Teasing apart the effects of fires on forest birds is difficult, since fires vary in intensity, duration, frequency, location, shape, and extent (Rotenberry et al., Chapter 3, this volume). In spite of this fact, we attempted to make a few generalizations. These generalizations are based on limited and often anecdotal data.

Fire seems to affect birds in the Rocky Mountains differently depending on its intensity (Hejl 1994). High-intensity fires often create habitat for primary and secondary cavity nesters (Taylor and Barmore 1980), and one species (Black-backed Woodpecker) seems to be nearly restricted in distribution to recently burned forests (Hutto 1995). Primary cavity nesters often dramatically increase for the first few years following an intense burn, with secondary cavity nesters increasing in following years. The benefits may be short term, as snags fall down and are not replaced (for an example in the Sierra Nevada, see Raphael et al. 1987).

Moderate and low-intensity burns show less dramatic immediate effects than high-intensity burns. For the first few years after a moderate burn, birds characteristic of severely burned and unburned forests were present (Taylor and Barmore 1980). Low-intensity fires may have their greatest effect on forest birds in the long term. The cumulative effect of low intensity fires is the maintenance of park-like forests, resulting in habitats for birds that prefer open forests (Marshall 1963). Open forest species may be lost with fire suppression (Marshall 1963). Burns and fire exclusion may even have the opposite effects on many forest birds (Hejl 1994).

COMPARISON OF THE EFFECTS OF LOGGING AND FIRE ON FOREST BIRDS

Landbird communities associated with the standing dead "forests" remaining after high-intensity fires are unique and distinctly different from those associated with clearcuts (Hutto 1995). The distinction is largely due to the relative abundance of species that are nearly restricted in their habitat distribution within the Rocky Mountains to early postfire conditions (e.g., Black-backed Woodpecker), and to species that are not restricted to, but are relatively abundant in, early postfire habitats (e.g., Olive-sided Flycatcher). These patterns have been well documented in the western United States, if anecdotally (Blackford 1955, Bock and Lynch 1970, Bock and Bock 1974, Davis 1976, Pfister 1980, Taylor and Barmore 1980, Harris 1982, Raphael et al. 1987, Skinner 1989; but see Blake 1982).

Logging the trees and snags remaining in a burn after a fire affects the quality of the habitat for many species. Cavity-nesting bird density is likely to decline after snag removal in burns, as has been shown in the Sierra Nevada (Raphael and White 1984, Raphael et al. 1987). Logging burns may also decrease the quality of the habitat for tree nesters (e.g., Western Wood-Pewee, Overturf 1979).

DISCUSSION

We cannot offer managers as complete a synthesis as we would like. Too few studies have been conducted on the effects of silvicultural practices on birds in forests in the Rocky Mountains to make robust conclusions. Our results are limited in that they focus on short-term distributional changes as the result of two broad categories of timber harvesting (clearcutting and partial logging) lumped across conifer forests. The data indicate that many forest birds were less abundant in clearcuts than in uncut forests, and species that frequent open forests or open habitats were more abundant in clearcuts than in uncut forests. Most permanent residents were less abundant after either kind of harvesting treatment, whereas about half of the migrant species were less abundant and half more abundant in harvested areas. The effects of partial cutting were less dramatic than those of clearcutting; these results may be partly due to the fact that partial cutting included many different kinds of harvesting treatments.

Our information was limited to how distribution and abundance during the breeding season in general may be affected by clearcutting and partial cutting. We do not know what the actual effects of these harvest practices are on individual species (e.g., if nesting success for any individual species is lower in clearcuts than in uncut forests), what the effects of other silvicultural treatments are, how effects vary among forest-cover types and regions, and what landscape effects these treatments are creating. Because we examined studies of breeding habitat, studies on reproductive success in these habitats would help us interpret distributional patterns. We could not summarize results from other seasons because we found too little information on birds in other seasons. Understanding the effects of silvicultural practices on the distribution of individual species during nonbreeding seasons may be as critical in the maintenance of viable populations of these species.

Our clearest results were for common species. Whereas cumulative effects on each common species may be important in the long-term viability of that species, short-term effects may be greatest on uncommon species whose declines go unnoticed for lack of an adequate sample size. To demonstrate the effects of forest management on raptors, woodpeckers, and other species that are difficult to detect and/or have large home ranges will require intensive, individual species' studies of their density and demographics in treated and untreated areas (Hejl 1994). Therefore, our statements about those species should be viewed with caution. The effects of timber harvesting on rare species might be of even graver concern than we now know.

Neither long- nor short-distant migrants can be treated as a guild for managing forests.

Each species responded individually to silvicultural treatments. For example, some long-distance migrants (Swainson's Thrush and Townsend's Warbler) are found more often in unlogged forests and others (Broad-tailed Hummingbird and Dusky Flycatcher) in clearcuts when these areas are compared. Emphasizing any one silvicultural practice would favor some birds at the expense of others. Our results suggest that proportionally more resident than migrant species will be deleteriously affected by the loss of uncut forests.

The greatest effect of silvicultural practices may come through changes in landscape pattern. Unfortunately, too few studies have examined the effects on forest birds of silvicultural changes in Rocky Mountain landscapes for any conclusions to be made (Freemark et al., Chapter 14, this volume). Indeed, it is difficult to isolate the relative contribution of stand-level and landscape-level factors to a particular species' distribution in a logged area (Dobkin 1994). Some of the patterns that we noted for silvicultural treatments might be attributable to changes in the landscapes caused by those treatments.

Our dissatisfaction with this synthesis stems from the inadequate number of studies on the effects of silvicultural treatments on bird populations in the Rocky Mountains. We could only find studies that examined timber harvesting, not other silvicultural treatments. Within those studies, we did not have enough information to make specific conclusions for any logging treatment or stand age in a particular forest type or region. Not only are there too few studies in any one habitat or about a particular silvicultural treatment, but individual studies are often based on few replicates. Most authors did not deal with potential interpretive problems associated with observer differences. A large amount of variation or "noise" enters into our analysis as a result of having to lump across conifer habitats, harvesting methods, and studies based on different sampling methods and sample sizes. We could not examine increasing or decreasing trends that may be evident with gradations in severity of treatment.

We had enormous problems summarizing the literature, because the authors of studies often did not describe their control or treated areas very well. Patterns are undoubtedly confounded not only because of having to group survey data from all conifer forests into only two broad classes of harvesting methods, but because of the variety of postharvest treatments that may have been applied. Unfortunately, most studies failed to describe postharvest treatments. Indeed, we could not determine the preharvest age of the stand in many instances. To tease apart effects of all these variables over a broad range of vegetation cover types will take a lot more thoroughly described data than have been collected to this point in time.

Long-term study sites with many replicates in all habitats throughout the Rockies would help us assess the short-term and long-term effects of various silvicultural practices on as many individual species as possible. We need studies that are designed to distinguish between effects due to timber harvesting at the stand level versus the landscape level. Because most studies on western forest birds have shown great yearly fluctuations in bird numbers (Raphael and White 1984, Szaro and Balda 1986, Hejl et al. 1988), long-term studies at various locations are necessary to identify avifaunal changes due to timber management practices independent of weather and other factors. Basic autecological studies are needed to determine why a species responds as it does to habitat alteration. Of particular concern are species' responses to truncated succession, loss of early-successional and old-growth forests, loss of snags, especially in burns, and loss of all types of burned habitats [similar concerns to those in Thomas et al. (1975)].

Our judgment of an "effect" of timber harvesting is colored by the fact that we are comparing limited data from only one uncut and two cut vegetation types across the Rocky Mountains. Knowledge of the complete distribution of a species among habitats (more rigorously derived than our Table 8-1) and the distribution of habitats is required before we could say whether or not a local population decline in response to timber harvesting translates into a serious population problem. A certain level of decline presumably is much less serious a concern for a species that occurs over a broad range of additional habitat types than it is for a species confined to a single uncut forest type. We have presented preliminary information on species' distributions based on at least a few known, reported studies in each habitat, but more information is needed on bird distribution across habitats and the distribution of habitats themselves to assess which species are truly of concern.

Philosophically, determining the "effects of timber harvesting" is very complicated. The "effect" can be measured as either a short-term or a long-term consequence of the harvesting activity and on small or large spatial scales. Our review deals with short-term, small-scale consequences but the managers' goal should be one of placing these results in a long-term, broad-scale perspective (Bartlett and Jones 1992, Kessler et al. 1992) with a focus on managing the land in an ecological manner that will serve to sustain natural populations, abiotic and biotic interactions, patterns, and processes. We agree with the recommendation of Thompson et al. (Chapter 7, this volume) to make management decisions first at the large scale and secondarily at the small scale. From such a perspective, a manager might want to consider that a timber-harvesting practice that might immediately cause a relatively great amount of change from preharvest conditions may be one component of a strategy for maintaining populations of all wildlife species for the long term. In other words, we suggest that any one individual piece of a landscape might be managed to the detriment of some species and benefit of others, with the goal of maintaining enough variety within the different pieces of the landscape (i.e., in the constantly shifting mosaic of logging treatments and successional stages) that all native species are being managed simultaneously over a broad landscape [for an example from the Pacific Northwest, see Hof and Raphael (1993)]. While it is clearly important to emphasize the maintenance and restoration of old-growth forests, it is similarly important to consider the maintenance of early successional and other ages of forests. This concept may be especially important for areas that experience frequent and widespread disturbance, but such judgments require more knowledge of the way birds are affected by natural processes. Rather than simply asking what the short-term effect of a given harvest method is, we should also be asking which methods best operate to mimic natural patterns and processes, and how we can manage for those species that do not benefit from this approach; for a review of some information for the Northern Rockies, see Hejl (1992).

To illustrate the point of mimicking natural patterns and processes, consider that the Northern Rocky Mountain conifer forests are part of fire-maintained systems (Hejl 1992). Much less vegetation cover in early successional stages exists now than prior to fire control in some cover types (Gruell 1983). If, of all timber-harvesting practices, clearcuts come closest to matching the pattern of a naturally intense fire regime, then perhaps the method affecting the greatest change from preharvest conditions in an immediate sense (i.e., clearcuts) is the best practice in a long-term sense. We caution that we need hard data to answer this question, but to many bird species, clearcuts are *not* the same as intense canopy burns (Hutto 1995). "Sloppy" clearcuts (some snags and trees remaining) or selection cutting may come the closest to mimicking intense burns, depending upon forest cover type. Nonetheless, current thinking and current research efforts need to be directed along these lines if we are to make progress in managing the land for the maintenance of migratory landbirds, resident landbirds, all other plant and animal species, and their interactions (i.e., biological diversity).

We think that fire is so important as a creator of variety in landscapes that the conservation of native diversity may only be accomplished through the maintenance of fire as a process. Some bird species may simply need the maintenance of open forests as occurs with low-intensity fires (Marshall 1963). Frequent, low-intensity understory fires, however, do not satisfy the needs of all fire-dependent species. Some of these species probably rely on the presence of large, high-intensity crown fires that characterize the historical fire regime of many conifer forest types (Loope and Gruell 1973; Heinselman 1981, 1985).

Finally, we suggest the following goal for managing forests: to maintain natural bird populations, ecological patterns, and ecological processes over broad landscapes. Suggested steps to work toward that goal include: (1) maintain all habitats (e.g., forest-cover types and successional stages) and important habitat components (e.g., snags); (2) strive to mimic (either retain or restore within the range of variation of) presettlement ("natural") proportions and distribution of forest types, successional stages, and habitat components; (3) allow or reintroduce natural disturbance patterns (e.g., let fires burn or use prescribed fire); and (4) constantly monitor birds to see how this plan is working and redirect efforts if need be (with special emphasis for species that seem to be declining).

We emphasize sustaining species and ecosystems within a flexible framework (i.e., use adaptive management; Holling 1978), while acknowledging the constraints imposed by current landscape patterns. Current landscape patterns are the result of continual habitat modification. Burns have been salvage logged. Fire suppression has led to the change in forest structure and composition in many habitats in the Rocky Mountains and, in addition, a great proportion of old-growth forests have been logged. We merely suggest the above steps as goals. In future research efforts, we need to determine whether or not these steps will lead to the maintenance of forest bird populations in the Rocky Mountains.

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