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Synthesis of Knowledge on the Effects of Fire and Fire Surrogates on Wildlife in U.S. Dry Forests

Patricia L. Kennedy and Joseph B. Fontaine

A SUMMARY OF KNOWLEDGE FROM THE
Joint Fire Science Program

Special Report 1096

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Special Report 1096
September 2009

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Acknowledgements

This is contribution #87 of the National Fire and Fire Surrogate (FFS) Project, funded by the U.S. Joint Fire Science Program. We thank the the Program for funding this synthesis and Jim McIver for helping conceptualize the final product. Jim also provided us with all available Fire and Fire Surrogate Program information. We thank John Cissel, Tim Swedberg, Kim Verhelst, and Becky Jenison for administrative support. Anne Bartuszevige and Tim Swedberg provided invaluable support in organizing the scoping meeting. We also thank the meeting attendees: Shawn Cochran, Bob Csargo, Jim Gallagher, Robert Skorkowski, and Anne Sprague. They took time out of their impossible schedules to fly to Boise on short notice and share their expertise on wildlife and fire management. Their input was essential to the conceptual development of this project but they are not to blame for any shortcomings. Anne Bartuszevige, Shawn Cochran, Joan Hagar, Larry D. Hedrick, and Warren G. Montague reviewed this document. We also thank the faculty and staff of the School for Environmental Science at Murdoch University, Perth, Western Australia, who provided an office and moral support during Prof. Kennedy's sabbatical leave and spent many hours listening to her ideas about fire management. V. Cramer helped develop several graphics. A big thanks to Colette Coiner who assisted with all aspects of this document and who kept us organized across two hemispheres.

Cover photos: Top left: Small herd of bison in a Yellowstone National Park meadow with ground fire in the background. (Jeff Henry, U.S. National Park Service) Top right: Pacific chorus frog using a pyrogenic structure in a patch of burned (4 years postfire) mixed conifer forest in the B&B Complex Fire, 2007, Oregon. (Garrett Meigs and Dan Donato) Bottom: Riparian areas are refugia for wildlife during wildland fires. East Fork of the Bitterroot River near Sula Montana, during the Bitterroot National Forest Fire, August 6, 2000. (John McColgan, Bureau of Land Managment, Alaska Fire Service)

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The Biscuit Fire in southern Oregon, in 2002. (Stephen Fitzgerald, Oregon State University Extension)

SUMMARY

Dry forests throughout the United States are fire-dependent ecosystems, and much attention has been given to restoring their ecological function. As such, land managers often are tasked with reintroducing fire via prescribed fire, wildland fire use, and fire-surrogate treatments such as thinning and mastication. During planning, managers frequently are expected to anticipate effects of management actions on wildlife species. This document represents a synthesis of existing knowledge on wildlife responses to fire and fire-surrogate treatments, presented in a useful, management-relevant format. Based on scoping meetings and dialogue with public lands managers from throughout the United States, we provide detailed, species-level, summary tables for project biologists and fire managers trying to anticipate the effects of fire and fire-surrogate treatments on local wildlife species.

We performed an extensive survey of the published, peer-reviewed scientific literature on wildlife response to fire and fire-surrogate treatments. In total, we reviewed more than 150 articles, included 90 articles in our database, resulting in 4,937 records of 313 vertebrate species.

We grouped the dry forests of the continental United States into six regions: pine east, pine west, interior mixed-conifer, Pacific mixed-conifer, eastern hardwood, and Great Lakes. Further, studies were categorized on the basis of the following:

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- Fire severity (in which low = 0–60% canopy mortality and high = more than 60% canopy mortality), and
- Time since fire (expressed in ranges of 0–4 years, 5–9 years, and 10 years or more)

Detailed tables summarizing published studies and individual species responses from each of the regions are in the appendixes. These are intended as "look up" tables for land managers engaged in planning.

We found numerous peer-reviewed studies that provided examples of fire-adapted and fire-dependent wildlife species throughout dry forest types (Bachman's sparrow, black-backed woodpecker, gopher tortoise, etc.). These studies clearly showed that many species consistently respond positively to fire, supporting the assumption that these species have evolved with and are dependent on fire (of varying severities and extents) as a regular ecological process. However, not all species respond positively, and some species have no detectable response to the conditions created by fire or fire surrogates. Published literature was most available for birds and small mammals and least abundant for herpetofauna and large mammals (ungulates, carnivores). Moreover, often there were sampling issues associated with the wildlife literature, reducing the strength of inference in many cases. Regional coverage of studies was best for short-term effects of surface fires in eastern pine systems and high-severity fires in the interior mixed-conifer forests of the western United States.

Major gaps in knowledge exist in the current scientific literature. Much ground has been gained by the Fire and Fire Surrogate system of experiments with respect to stand-level knowledge of surface fire and fire surrogates. However, tremendous gaps persist with respect to mixed-severity fire, longer term response to mixed- and high-severity fire, and the effects of repeated fire (all severities) on wildlife.

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INTRODUCTION

Across the United States, increased recognition of the central role of fire in maintaining forest structure and function has contributed to a shift in land management from fire exclusion to fire reintroduction in fire-dependent forests. Reflecting this policy shift are federal initiatives such as the National Fire Plan and Healthy Forest Restoration Act (2003), which directs federal land managers to restore forest structure and function and to reduce risk of wildfire on federal lands (Schoennagel et al. 2004). It is now widely accepted that the return of fire to dry forests restores ecological processes, creates ecologically valuable early successional habitats, and is consistent with management objectives aimed at maintaining biodiversity and decreasing risk of uncharacteristic landscape-scale wildfires (Brawn et al. 2001; Fulé et al. 2004).

Figure 1. A prescribed fire in the Gallatin National Forest, Montana. (USDA Forest Service, fs.fed.us)

Coincident with increased appreciation of the fundamental role fire plays in most forests has been the realization of the degree to which many species of plants and animals are fire dependent. Fire exclusion in a wide range of forest types has played a central role in the decline of species such as red-cockaded woodpecker, northern bobwhite, Kirtland's warbler, and many other species that depend on fire-maintained habitats and/or pyrogenic structures such as snags, shrubs, and bare ground. (All scientific names for U.S. vertebrates are in appendix 2.)

Figure 2. Lightning storm on the Mogollon Rim, Arizona. (Susan Strom, lightninglady.com)

How fire is reintroduced to dry forests is less certain, given dramatically different forest structures, composition, and landscape patterns relative to historic conditions (Covington and Moore 1994; Graham et al. 2004). Across drier forest types of North America, the use of *prescribed fire* (purposeful ignition; figure 1) has steadily increased as well as the application of "let burn" policies via *wildland fire use* (fires ignited by lightning and allowed to burn under predefined conditions; figures 2 and 3). Extensive use of wildland fire, prescribed fire, and *fire surrogates* (nonfire management tools such as thinning and mastication, which are used to reduce fuel loads and mimic some features of wildland

Figure 3. Lightning-ignited wildfire burning. Blue Mountains of Northeastern Oregon. (Dave Powell, USDA Forest Service, Bugwood.org)

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fire; figure 4) has led to increased need for scientific data on ecological responses to fire management plans, to enhance the design and implementation of management treatment types. In designing a fire management plan, managers often must anticipate effects of treatment on wildlife within the project area prior to treatment. However, pulling specific, detailed, quantitative information together describing expected wildlife responses to fire management practices is difficult for wildlife managers, given the time constraints and the vast volume of scientific literature addressing fire and fire surrogate (e.g., thinning) effects on wildlife.

Research on wildland fire and its effects on terrestrial vertebrates (used synonymously with wildlife) has been conducted since the early 1900s. Some of the earliest work documenting the negative effects of fire exclusion was Stoddard's 1931 study linking declines in northern bobwhite with lack of frequent fire in longleaf pine forests of northern Florida (Stoddard 1931; Carle 2002). Since then, a large body of excellent work has developed, but much of the literature is focused on particular ecosystems—for example, longleaf pine (Van Lear et al. 2005), shortleaf pine (*Pinus echinata*; Masters 2007), and central Appalachian deciduous forest (Kirkland et al. 1996)—or on taxa such as birds (Brawn et al. 2001; Kotliar et al. 2002; Saab and Powell 2005a; Saab et al. 2007a) and mammals (Fisher and Wilkinson 2005). Several reviews on the effects of wildland fire on wildlife exist, but all are qualitative reviews and are taxonomically or geographically limited (Smith 2000; Fisher and Wilkinson 2005; Saab and Powell 2005a; Pilliod et al. 2006; Saab et al. 2007a). In addition, the Fire Effects Information System (USDA Forest Service 2008) provides detailed, qualitative descriptions of fire effects on more than 100 North American animal species, but coverage among species is inconsistent.

In terms of the wildlife-fire management literature, Pilliod et al. (2006) wrote a comprehensive qualitative review of the effect of fuels-reduction treatments on

Figures 4a–b. Mechanical thinning operations at the Blue Mountain Fire and Fire Surrogate site in northeastern Oregon: (a) feller-buncher and (b) forwarder. (Elizabeth Dodson Coulter)

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wildlife of western dry forests. There are also excellent reviews focused on particular treatments and taxa (e.g., Hayes et al. 1997; Russell et al. 1999; Hayes et al. 2003; Saab and Powell 2005a; Pilliod et al. 2006; Schieck and Song 2006; Vanderwel et al. 2007; Lindenmayer et al. 2008). However, none of these reviews incorporates the recently published experimental literature generated from the Fire and Fire Surrogate (FFS) program.

The FFS study network is the largest operational-scale experiment ever funded to test silvicultural and prescribed-fire restoration treatments and, thus, is crucial to understanding stand-scale responses of wildlife to fire management strategies. The FFS began in 1999 and currently includes 12 sites on federal- and state-administered lands extending from the Cascade Range in Washington to south Florida (figure 5). (Originally there were 13 sites, but one site in New Mexico experienced a wildfire prior to treatment and was removed from the study network). These 12 sites represent ecosystems with frequent, low- to mixed-severity natural fire regimes. At each site, a common experimental design was used to facilitate broad comparisons of

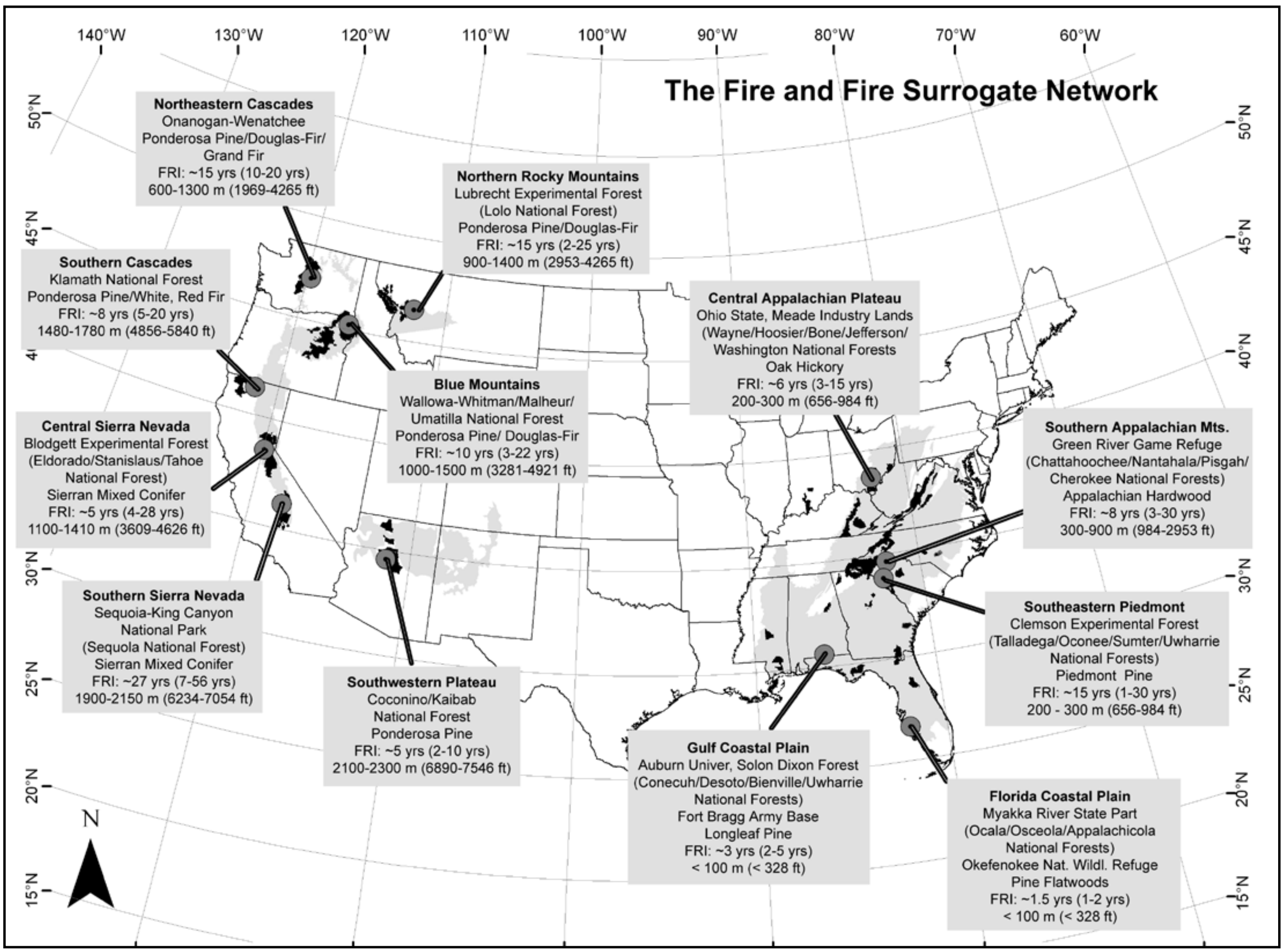

Figure 5. Names and locations of 12 fire and fire surrogate (FFS) sites, showing nearest federal lands, fire-return interval (FRI), and elevational range. The black-shaded areas indicate adjacent federal lands. Other shaded areas indicate representative land base or the area to which FFS results can be most directly applied for each site. Representative land bases are derived from EPA Type III Ecoregions (www.epa.gov/wed/pages/ecoregions/level_iii.htm). (McIver et al. 2008)

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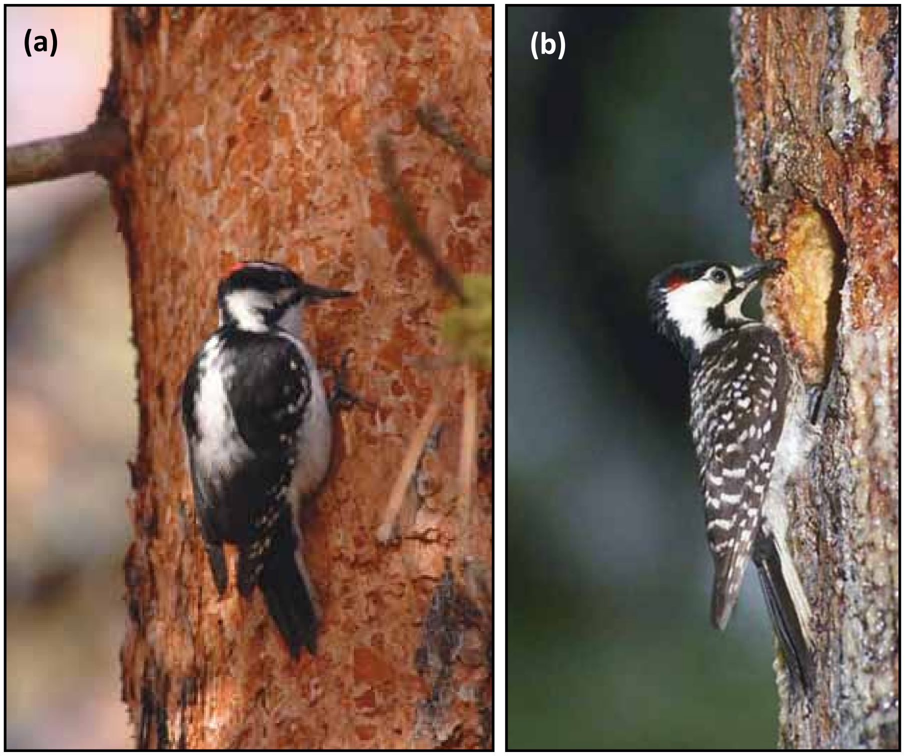

Figures 6a–b. Cavity-nesting birds have been widely studied in fire and fire surrogate investigations. Examples: (a) Hairy woodpecker. (Richard Hutto) (b) Red-cockaded woodpecker. (North Carolina Wildlife Resources Commission, ncwildlife.org)

treatment effects on a wide variety of approximately 400 variables (McIver et al. 2008). Wildlife investigations have been conducted at almost all FFS sites (Youngblood et al. 2007), and publications are being generated from each site. However, few syntheses of FFS results have been published (but see Converse et al. 2006c and Boerner et al. 2009). We do not summarize all FFS studies because many of the wildlife studies associated with FFS sites have not been summarized, but we included what was available as of September 1, 2008.

The scientific literature has a lot to tell us about the short-term response of wildlife at the stand scale to both high-severity wildfire and prescribed surface fires. Some groups of wildlife such as woodpeckers (figure 6) are better studied than others (e.g., terrestrial amphibians, figure 7). The many published studies on the subject have created an extensive, but highly uncoordinated, foundation of data on the response of many taxonomic groups to fire management at local to regional scales. The next step is to evaluate what is known, in a meta-analytical framework, to determine what the literature can tell us quantitatively about species-specific responses to management prescriptions. To our knowledge, there is no such quantitative synthesis of the fire and fire-surrogate literature for

Figure 7a–b. (a) A clouded salamander using coarse woody debris 17 years postfire. Galice Fire, southwestern Oregon. (Joseph B. Fontaine). (b) Pacific chorus frog using a pyrogenic structure in a patch of burned (4 years postfire) mixed conifer forest in the B&B Complex Fire, 2007, Oregon. (Garrett Meigs and Dan Donato)

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wildlife from all U.S. dry forests. Given that managers may need to rely on studies from outside their region when writing management documents, their interpretation of the general significance of individual studies and the application of conclusions from one study to an understanding of fire effects on wildlife in another region require a broad perspective. There is a great deal to be gained by contrasting different regions. One aim of this document is to provide a continent-wide framework on our state of knowledge on the effects of fire and fire surrogates on wildlife in U.S. forests.

GOALS, ORGANIZATION, & SCOPE OF THIS DOCUMENT

Goals

This document attempts to make the very large literature on wildlife and wildland fire, prescribed fire, and fire surrogates accessible to government and nongovernmental wildlife biologists, particularly those who design and implement fire management projects. We approached this as an opportunity to give land managers a resource that would allow them to rapidly look up species-level data pertaining to fire and fire-surrogate responses. We attempted to include as much of the peer-reviewed scientific literature as possible in summary tables containing quantitative results for drier forests of the United States.

The information in this document is intended to be useful for environmental analyses (EAs) of fire management programs that include the goal to maintain, enhance, or restore wildlife habitats in drier, fire-prone forests within the continental United States (mesic forests, woodlands, and shrublands were beyond the scope of this document). When developing EAs, managers need to evaluate the potential impacts of all treatment alternatives to determine which treatment or combination of treatments is best suited to meet project objectives. Part of this evaluation involves summarizing how each species in the project area will respond to the treatment. This is where the manager should be able to rely on the scientific literature to augment his or her expertise and the expertise of other members of the planning team. A manager should be able to use the data in this document to determine the following:

1. Whether information exists on the response of species in this project area to the proposed treatment(s)
2. For species with information, is there a consistent response to a treatment (positive, negative, or no response)
3. The duration of the response—i.e., is it only a short-term response (less than 5 years), or is there evidence of long-term responses to the treatment (more than 10 years)?

By including wildland fire, prescribed fire, and fire-surrogate results in one document, managers can begin evaluating how wildlife respond to various treatments and can use this information to evaluate more controversial, but ecologically viable alternatives of “no action” and “high-severity prescribed fire” (stand-replacing fires; e.g., Fulé et al. 2004) in their analyses.

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Organization

As a prelude to our literature review and synthesis, we provide a brief overview, from a wildlife perspective, on fire as a disturbance agent. In this section we focus on aspects of fire ecology that influence responses of wildlife as documented in the literature. After this introductory material, we detail the methods we used to review and synthesize the literature, present the results of the review, and summarize our conclusions and future research needs.

Scope

Our focus is primarily on wildlands, rather than on the wildland–urban interface (WUI), where wildlife values may be secondary to protecting people and homes (Dellasala et al. 2004; Noss et al. 2006b). Like Saab and Powell (2005b), we took a wildlife-centered approach to the literature, which means our review focuses on papers that presented empirical, quantifiable data on population- and community-level responses (e.g., abundance, vital rates, and distribution) to wildland fire or management treatments. We did not review literature that asked habitat-centered questions such as "How does mechanical thinning affect habitat?" because habitat associations of many wildlife species are not well understood.

We downplayed certain topics that are important but were too extensive to cover in this paper or were better addressed in a different format. For example, our wildland fire section focused on wildlife responses to current fires, not on the effect of changes in fire regimes on wildlife. It is also beyond the scope of this document to make predictions about the following: how climate change will influence fire and the wildlife associated with these fire areas; and wildlife response to postfire rehabilitation treatments.

FIRE AS A DISTURBANCE

A disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment (Pickett and White 1985; Saab and Powell 2005b). Disturbance once was viewed largely as an insult to the "balance of nature" and synonymous with habitat destruction (Botkin 1990). However, the scientific and management communities now recognize many forms of disturbance, such as fire, play a fundamental role in maintaining natural heterogeneity in environmental conditions that plants and animals experience through space and time (Brawn et al. 2001; Fuhlendorf et al. 2006). This disturbance-mediated heterogeneity leads to a mosaic of habitats or successional stages that supports the suite of native wildlife in a landscape (Angelstam 1998). Fire exclusion has reduced this heterogeneity by significantly reducing the acreage of fire-generated early successional forests (Noss et al. 2006a). Given the growing body of evidence that indicates many species have evolved with, are adapted to, and depend upon fire (Engstrom et al. 1984; Bunnell 1995; Brawn et al. 2001), conservation of early-seral species is a growing management concern (Askins 1993; Brawn et al. 2001; Fontaine et al. 2009).

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A notable example of an early successional species of conservation concern is Kirtland's warbler (figure 8), a federally endangered songbird that nests only in areas of young (5–25 years old), fire-prone stands of jack pine (*Pinus banksiana*), or jack pine mixed with northern pin oak (*Quercus ellipsoidallis*). Nesting generally is limited to stands greater than 32 ha (79 acres), characterized by jack pine canopy cover of 20% to 60% and interspersed with numerous small openings. Historically, this characteristic pattern of vegetation was maintained by stand-replacing wildfire, which periodically regenerated young pine–oak stands. These communities have declined as a result of fire exclusion and, thus, so has the warbler; its successful recovery depends on the restoration of this early successional habitat (Walker et al. 2003).

Figure 8. Kirtland's warbler is an example of a federally endangered species that only occurs in early seral stages created by fire. (Joel Trick, US Fish and Wildlife Service, ebird.org)

Reintroducing the fire process is complicated by the fact that species associated with fire do not all use postfire habitats immediately after fire. Indeed, species considered old-growth associates may be dependent on both stand- and landscape-level heterogeneity arising from fire. For example, a recent study by Clark (2007) found annual survival and territory occupancy of northern spotted owl (figure 9a) declined after high-severity wildfire in southwestern Oregon (as the authors noted, study results were somewhat confounded by postfire salvage logging). Within the same region, however, northern spotted owls have higher survival and reproductive rates within heterogeneous stands of mature, mixed-evergreen forest originating from fire (Franklin et al. 2000). Thus, in the short term, high-severity fire may negatively impact northern spotted owls but create suitable habitat at approximately 20 years and high-quality habitat by 60–80 years postfire. Another example is the northern goshawk (figure 9b). Most goshawk populations are in forests that are structured by fire. In southwestern ponderosa pine (*Pinus ponderosa*) populations, fire exclusion has reduced availability of single-canopy forests with open understories, which these birds prefer for nesting. Although the response of goshawks

Figure 9a–b. Species of conservation concern associated with old growth forests: (a) Northern spotted owl. (John and Karen Hollingsworth, US Fish and Wildlife Service, images.fws.gov) (b) Northern goshawk. (David Ponton and Patricia L. Kennedy)

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to low-severity fire has not been investigated, it is predicted that reintroduction of low-severity fire in this type of dry forest would benefit this species. The potential effects of high-severity fire are unclear. Depending on the extent of the fire, nest site availability could be reduced; however, the increased landscape heterogeneity from the fire likely will enhance prey populations (reviewed in Squires and Kennedy 2006).

So, how does the manager determine the species-specific responses to a particular fire management plan? Can he/she rely on ecological theory to help with these complexities? Numerous ecological hypotheses—summarized by Driscoll (2007) and Lindenmayer et al. (2008)—have been developed to predict biotic responses to natural disturbances such as fire. Although a thorough review of these theories is beyond the scope of this document, we will discuss a few as examples.

One of these is the *intermediate disturbance hypothesis* which forecasts highest species diversity at sites subject to intermediate fire frequencies and intensities, because these areas will be a mixture of pioneer and climax species (Connell 1978). Another disturbance hypothesis applicable to fire is the *habitat accommodation model of succession* (Fox 1983) which suggests there should be a predictable sequence of wildlife community recovery following disturbance, and these communities can be linked to the recovery of vegetation structure. In addition, the responses of individual species to natural disturbances like wildfire, should be readily predictable as a function of habitat affinities. For example, leaf-litter-associated reptiles should be slowest to recover after fire, but burrowing reptiles most likely will occur in recently burned areas.

Empirical support for these hypotheses is inconsistent (Driscoll 2007; Lindenmayer et al. 2008), and attempts to use life-history attributes to accurately forecast wildlife response to fire also have met with variable success (Sutherland and Dickman 1999; Whelan et al. 2002; Lindenmayer et al. 2008). Thus, at this point, management of wildlife in fire-prone areas cannot be guided solely by disturbance theory or clear empirical patterns that allow for generalities across many taxa.

So, how do managers blend these sources of information to make informed decisions using the best available science? They will have to evaluate the available species-level information for the species identified in the project plan as being of conservation concern. This document provides those summaries.

DOES WILDFIRE DIRECTLY KILL WILDLIFE?

The immediate and obvious direct effects of fire on wildlife are fire-caused mortality, emigration, and immigration. Our anthropocentric view of the world leads to a common expectation that animals will display widespread panic in the face of fire (figure 10). While some animals invariably are killed by the flaming front, observations made in the vicinity of advancing fire fronts across many ecosystems and continents present a different picture. Large, mobile mammals such as ungulates and adult birds are capable of moving quickly to unburned refugia through fire breaks to relatively safe, unburned ground (figure 11). For example, Clark (2007) documented postfire movements of radio-tagged northern spotted

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Figure 10. A 1953 Smokey the Bear campaign poster. (USDA Forest Service, the National Association of State Foresters, and the Ad Council, smokeybear.com)

owls from their burned territories into adjacent, unburned areas. There also are reports (Quinn 1994; Russell et al. 1999; Smith 2000; Yager et al. 2007) of many smaller, less mobile organisms (e.g., small reptiles and frogs) seeking out and surviving in burrows and crevices (figure 7b). Observations such as these may indeed imply that animals were able to seek out unburned refugia. An alternative explanation is that all animals were killed except those within the patches of vegetation, woody debris, or burrows that escaped the fire. Surprisingly few studies have tried to determine whether refugia hold a concentration of animals postfire or are simply just a remnant population at the original densities (Whelan 1995). In addition, demographic estimates associated with fire rarely separate direct mortality from indirect mortality (i.e., mortality due to habitat modification; see below); so it is not clear whether wildfire per se is a serious cause of mortality in wildlife. But current information suggests fire in general has little direct effect on most wildlife species (Russell et al. 1999; Smith 2000).

Figure 11. Riparian areas are refugia for wildlife during wildland fires. East Fork of the Bitterroot River near Sula Montana, during the Bitterroot National Forest Fire, August 6, 2000. (John McColgan, Bureau of Land Managment, Alaska Fire Service)

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WILDLIFE RESPONSES TO POSTFIRE CONDITIONS

Fires affect animals mainly through habitat modification. For animals, the vegetative structure spatially arranges the resources needed to live and reproduce, including food, shelter, and hiding cover. If a fire reduces the food, shelter, and/or hiding cover of a species, its population is expected to decline. The reverse is also true. Some fires alter the vegetation structure in relatively subtle ways; for example, by reducing litter and dead herbs in variable-size patches. More intense fires change nearly every aspect of vegetation structure: woody plants may be stripped of foliage and killed; litter and duff may be consumed, exposing mineral soil; trees may be killed and their foliage consumed (figure 12). Fox et al. (2003) demonstrated experimentally that effects of fire on small mammals in heath habitat in eastern Australia can be mimicked by physically altering vegetative structure, emphasizing the central role of structure in mediating fauna's response to fire. Also, FFS results suggest that some species of small mammals, (e.g., deer mice) respond similarly to thinning and prescribed fire, suggesting that vegetative structure plays an important role in the postfire responses of some wildlife (Converse et al. 2006a).

Figure 12. Pyrogenic structures in a mixed evergreen/white fir forest 4 years following the 2002 stand replacing Biscuit Fire in southwestern Oregon. Note exposed mineral soil, absence of understory and dead trees. (Willa Veber)

Although studies on bird and mammal succession after fire emphasize that vegetation structure has a strong influence, the plant species that are present may also be important. For example, in tropical Australian woodlands, Woinarski et al. (2004) demonstrated black-footed rats were especially dependent on cycads (*Cycas* spp.) for food during parts of the year. The loss of any one of the five cycad species during late, dry-season fires could result in population extinction of this rare mammal. This demonstrates that plant species composition, and not just structure, can determine the impact of a fire (Woinarski et al. 2004; Driscoll 2007).

Fire does not just simplify vegetative structure and remove plant species; it also creates new habitat features, often referred to as *pyrogenic structures*. During a fire, if soil temperatures stay below 175°C (347°F), nutrient releases enhance plant growth and vigor (Agee 1993); see figure 13. This regrowth often leads to increased abundance of vegetative sprouts, flowers, seeds, and insects (but, see Meehan and George 2003, for negative effects of fire on abundance of aerial insects used by olive-sided flycatchers breeding in northwest California). This increase attracts herbivores, aerial insectivores, nectarivores, and granivores to the fire site for new foraging opportunities (Saab et al. 2007a); see figure 27. Also, several studies have demonstrated that many animals that

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Figure 13. An example of regrowth in a wet Tan Oak/Douglas-fir plant community 5 years after the 2002 Biscuit Fire in southwestern Oregon. The snag in the left foreground has been used as foraging substrate by woodpeckers. The understory is composed of vine maple and myrtlewood. (Joseph B. Fontaine)

Figure 14. Examples of standing and blown-down pyrogenic structures created by the 1988 Yellowstone National Park Fire. (Jeff Henry, U.S. National Park Service, nps.gov)

survive fire become a vulnerable food source for predators due to decreased crypticity as a result of decreased vegetative cover (e.g., Russell et al. 2003; Wilgers and Horne 2007). Fire also creates standing dead and dying trees (figure 14) that are susceptible to attack by bark and wood-boring beetles in the families Scolytidae, Cerambycidae, and Buprestidae (figure 15a), primary food sources for many insectivores such as woodpeckers. Large-diameter snags, wounded trees that subsequently decay, and downed logs are also created. These are particularly important habitat features because they are relatively easy for woodpeckers to excavate (figure 15b) and provide

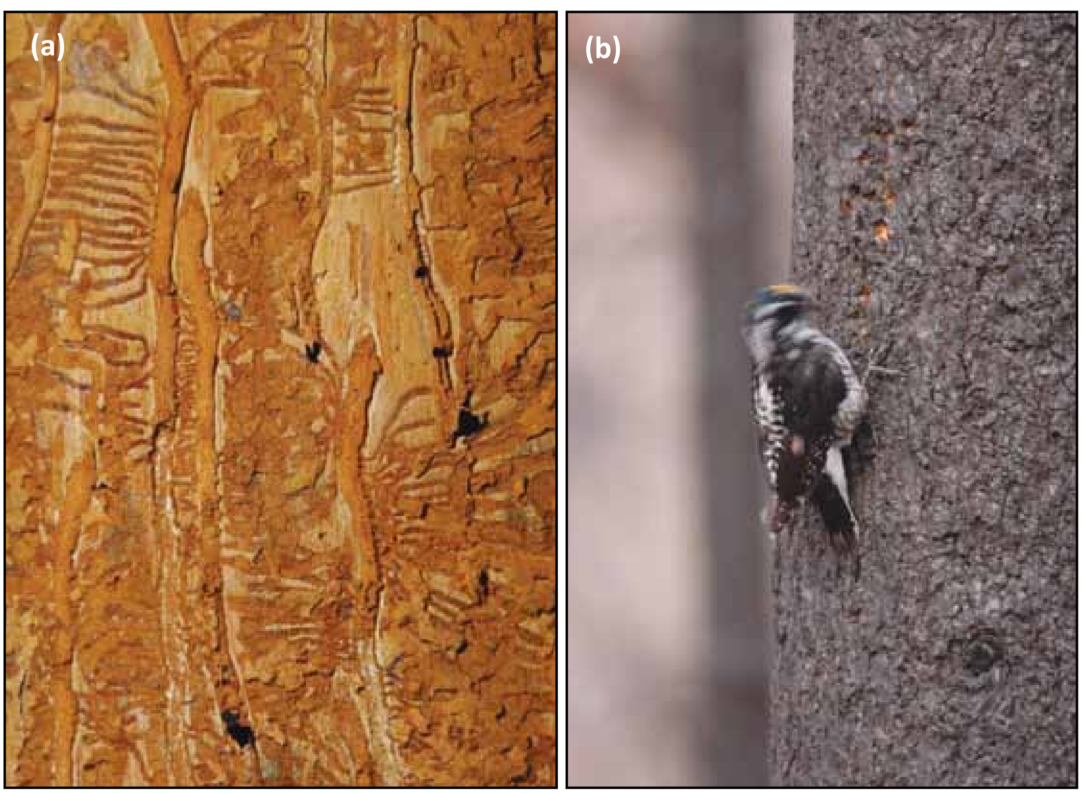

Figure 15a–b. (a) Douglas-fir beetle (*Dendroctonus pseudotsuqae*) galleries, Shoshone National Forest, Wyoming. (William M. Ciesla, Forest Health Management International, Bugwood.org) (b) An American three-toed woodpecker in a feeding frenzy. (Richard Hutto)

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Figure 16. A mountain bluebird bringing nesting material to its nest in a snag in a recently burned forest. (Richard Hutto)

roosting, nesting, and foraging habitat (figure 16) for a variety of wildlife (Saab et al. 2007a; Lyons et al. 2008). As Hutto notes (2006), as much as 45% of native North American bird populations are *snag-dependent* (they need to use snags at some point in their life cycles). The majority of wildlife species associated with U.S. dry forests use deadwood structures or woody debris for some portion of their life cycles (Bull 2002; Hutto 2006).

In addition to the aforementioned stand-level habitat modifications created by fire, in fire-suppressed landscapes a fire will increase landscape heterogeneity by creating a spatially complex mosaic of unburned and burned patches. The public, and even some ecologists, feared the 1988 high-severity Yellowstone fires had produced a desolate area of uniform devastation, but this was not the case. These fires actually produced spatially complex patterns of succession in what is often considered a relatively simple system dominated by lodgepole pine (*Pinus contorta*). One of the most striking features of these fires (figure 17) was the postfire heterogeneity of the burned landscape (Christensen et al. 1989; Turner et al. 2003). A map of postfire burn severity derived from Landsat Thematic Mapper imagery was used to quantify the isolation of burned areas and the relationship between heterogeneity and fire size in Yellowstone National Park (Turner et al. 1994). The majority of high-severity areas were within 50–200 meters (164–719 feet) of unburned or low-severity areas, suggesting that few burned sites were very distant from potential sources of off-site colonization. Spatial heterogeneity was the rule, not the exception, and a synthesis across different disturbance types suggests this characterizes many large, infrequent disturbances (Turner et al. 2003; Donato et al. 2009a).

Figure 17. Thompson Creek Fire in the Gallatin National Forest July 1991. This illustrates the complex mosaic of burned and unburned patches created by a stand replacing fire. Areas of crown fire are black and areas of severe surface fire are brown. (Kenneth E. Gibson, USDA Forest Service, Bugwood.org)

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Why is spatial heterogeneity beneficial to wildlife habitat? Given that most landscapes support specialists that require either early-seral or older forests as well as species that require multiple seral stages throughout their life cycle, it is likely that a mosaic of successional stages is needed in the landscape to maintain its biodiversity. For example, many ungulates forage in early-seral habitat (see figure 27) but require later seral stages for thermal cover and refugia from predators (Singer and Harter 1996; Riggs et al. 2004). To determine the optimal spatial arrangement of successional stages and the frequency at which these should be created will require, first, information on known responses of species to fire and, second, good estimates of the dispersal capacity of these species, particularly for those taxa known to occur in only a limited range of successional stages, such as Kirtland's warbler and the spotted owl (Driscoll 2007). In this document, we summarize the known responses of species; however, the dispersal capacity of these species is beyond the scope of this document.

FACTORS INFLUENCING WILDLIFE RESPONSES

While the effects of fire on species that respond strongly to fire (i.e., species whose abundances are clearly greater or smaller in burned than in unburned areas) are reasonably consistent and unambiguous among studies in U.S. dry forests, generalizations about how fire affects the abundance of many other species are less apparent due to inconsistencies in the literature. As Smucker et al. (2005) note, these inconsistencies across studies are likely a result of undocumented fire effects on wildlife abundance from site-specific factors (e.g., prefire forest structure and composition, seral stage), characteristics of individual fires (e.g., fire severity), or fire history (e.g., fire intervals). In addition, poor understanding of the relationships between vegetation structure and composition and habitat limits our ability to predict fire and fire-surrogate effects. Our perception of effects is also hindered by the inherent spatial and temporal variability associated with animal populations and the difficulties associated with sampling these populations and separating this *noise* (also referred to as *confounding variation*) from the real effects of fire or fire surrogates. We discuss some of these factors in more detail below because of their importance in interpreting the wildlife–fire literature.

Prefire Forest Structure and Composition

The degree to which vegetation structure and composition are altered by fire or fire surrogates is partly a function of the prefire vegetative conditions that influence fire behavior. Heterogeneity in prefire conditions is probably the largest source of noise in published wildlife data. Because of the difficulty in quantifying these habitat features for each species, it is not uncommon to use forest type and seral stage information to characterize forest structure and composition of prefire habitat. Wildlife response to wildfire does vary by forest type and successional stage (Schieck and Song 2006); thus, forest type or some other characterization of prefire habitat conditions needs to be incorporated into any study design, to minimize confounding variation in postfire results. Prefire habitat data can also be used to tease out an apparent lack of demographic response by wildlife to a fire or fire-surrogate treatment. For example,

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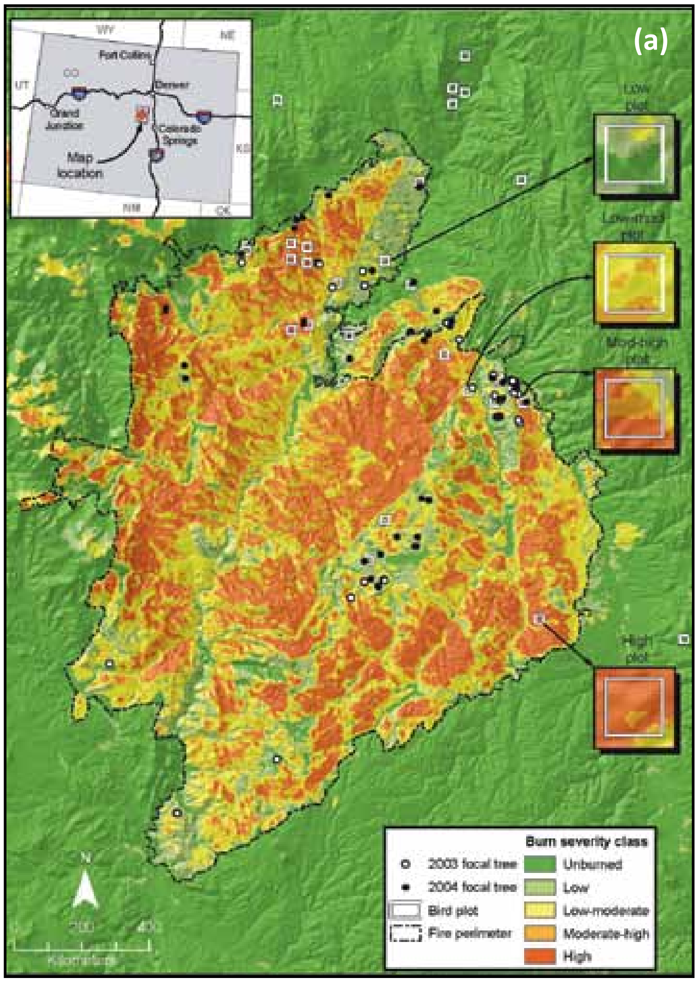

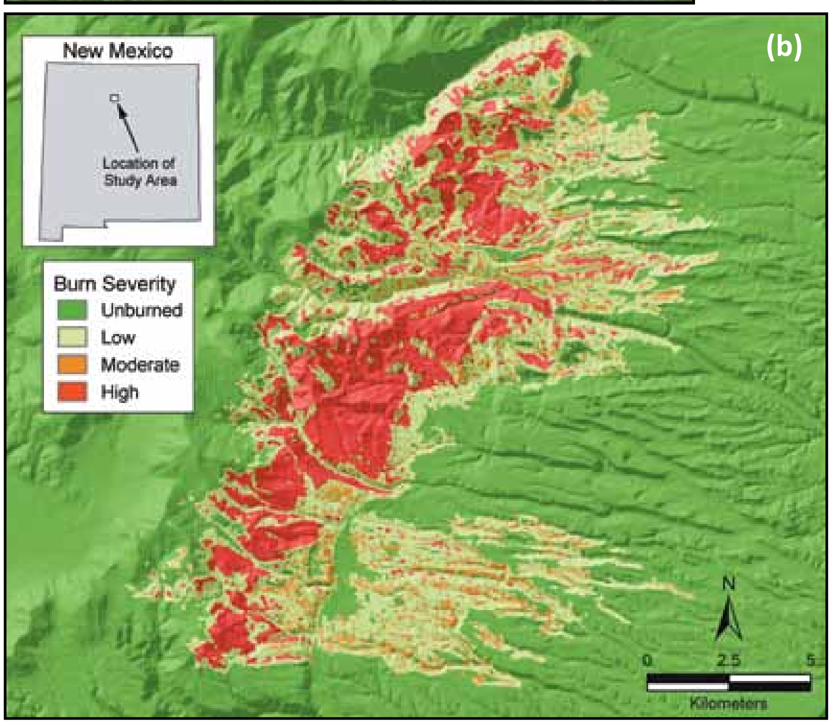

small patch burns may be incorporated into the home ranges of territorial species with high site fidelity (e.g., raptors) and, thus, not result in a change in occupancy or reproductive success.

Characteristics of Individual Fires

The importance of reintroducing fire or mimicking fire effects with fire surrogates has been widely recognized. Yet how this process is to be reintroduced is less certain, particularly given changes in fuel loads in fire-suppressed forests and uncertainties associated with understanding historic fire regimes (Covington and Moore 1994; Baker and Ehle 2001). In the next few sections we summarize some points about fires that influence wildlife responses. These summaries are meant to provide background to managers pondering the question, How can differing intensities, extents, and frequencies of prescribed fire benefit wildlife in this area?

Fire severity

In the wildlife literature there is some confusion over the terms *fire intensity* and *fire severity*. *Fire intensity* is used by fire ecologists to describe the heat energy released by the fire. *Fire severity* is a function of fire intensity but is used to describe the degrees to which vegetation and sometimes soil have been altered by the fire—a more relevant parameter, from a wildlife perspective. Almost all remotely sensed fire-severity maps are based on LANDSAT images of pre–post vegetation change, and often are in expressed as dNBR, the difference in normalized burn ratio (Key and Benson 2005). Two examples are illustrated: burn severity maps of the 2002 Hayman Fire (figure 18a) and of the 2000 Cerro Grande Fire (figure 18b).

Definition and estimation of fire severity vary widely across ecosystems, institutions, and stated objectives (Safford et al. 2008).

Figure 18 a–b. Burn severity maps of two mixed-severity fires: (a) The 2002, 56,000-ha (138,379-acre) Hayman Fire that occurred in montane forests in the Front Range of Colorado. (modified from Kotliar et al. 2008). (b) The 2000, 17,000-ha (42,008-acre) Cerro Grande Fire that occurred in montane forests of northern New Mexico. (modified from Kotliar et al. 2007). This illustrates the mosaic of burn severities that can occur in a mixed-severity fire. Burn severity was determined from differenced normalized burn ratios (dNBR) calculated from a 100-m (328-ft) radius moving window.

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Relative definitions are much easier to make; for example, defining a high-severity fire as one that kills the vast majority (typically about 90% or more) of the dominant vegetation, and a low-severity fire as one that kills very little of the dominant vegetation (widely defined as a percentage). It is moderate or mixed-severity fire that is the most problematic to define (see figure 19 for historic fire regimes in the regions evaluated in this document; the regions are defined in figure 20). Definitions of a mixed-severity fire can vary from 10% of overstory mortality (Covert-Bratland et al. 2006) such as in a southwestern ponderosa pine forest, to 90% overstory mortality (Odion et al. 2004) such as in a mixed-evergreen forest. Given this wide range in definitions, it is extremely important for practitioners to carefully report actual vegetation mortality rather than use adjectives such as high, moderate, and low (Hutto 2006).

Until recently, most publications on fire's effects on wildlife have not quantified burn severity and, thus, treat fire as a binomial variable comparing burned areas with unburned reference areas (for reviews, see Finch et al. 1997; Kotliar et al. 2002; Saab and Powell 2005a). Different severities produce different postfire structures (e.g., stands of live trees with some snags; stands of 100% snags; or dead shrub copses), and these variations in postfire structure should translate into variation in wildlife responses to fire (Smucker et al. 2005). Recent studies (Kotliar et al. 2002; Smucker et al. 2005; Kotliar et al. 2007; Kotliar et al. 2008) have documented that avifaunal responses to wildland fire in western forests vary as a function of burn severity. For example, Kotliar et al. (2007) evaluated the association of bird densities with burn severity in a large wildland fire in northern New Mexico. For 21 species with sufficient abundance data, they detected a broad range of responses to increasing burn severity (figure 21). Overall, 71% of the species included in their analysis exhibited either positive or neutral density responses to fire effects across all or portions of the severity gradient [responses III–VI, figure 21). They, along with Smucker et al. (2005), make a very strong argument for the need to incorporate burn severity into studies of wildlife responses to fire. This will enhance our understanding of the patterns of response to fire as well as the mechanisms driving these responses.

The finding that different fire severities best meet the needs of different bird species has profound implications for how we manage dry forests. This suggests dry forests should be managed for a range of desired forest conditions that provide habitat for early seral, mid-seral and old-growth species. One way to manage for increased landscape heterogeneity is to increase the range of fire severity applied to landscapes. Fire management that includes a broad range of natural variability, including areas of severe fire, and that accounts for the legacy of past land uses is more likely to preserve a broad range of wildlife habitat than restoration objectives based on narrowly defined historic fire regimes (Allen et al. 2002; Fulé et al. 2004; Kauffman 2004; Schoennagel et al. 2004; Noss et al. 2006b; Kotliar et al. 2007). In areas where fire use is constrained (e.g., in the wildland–urban interface), fire surrogates such as thinning could be used to mimic the effects of fire. However, the degree to which fire surrogates mimic fire effects at the landscape scale is not well understood. The FFS Program is designed to evaluate responses of focal wildlife to different treatments, but the scale of FFS studies limits inference to stand-level comparisons (see "Fire and Fire Surrogates Program" section for more details).

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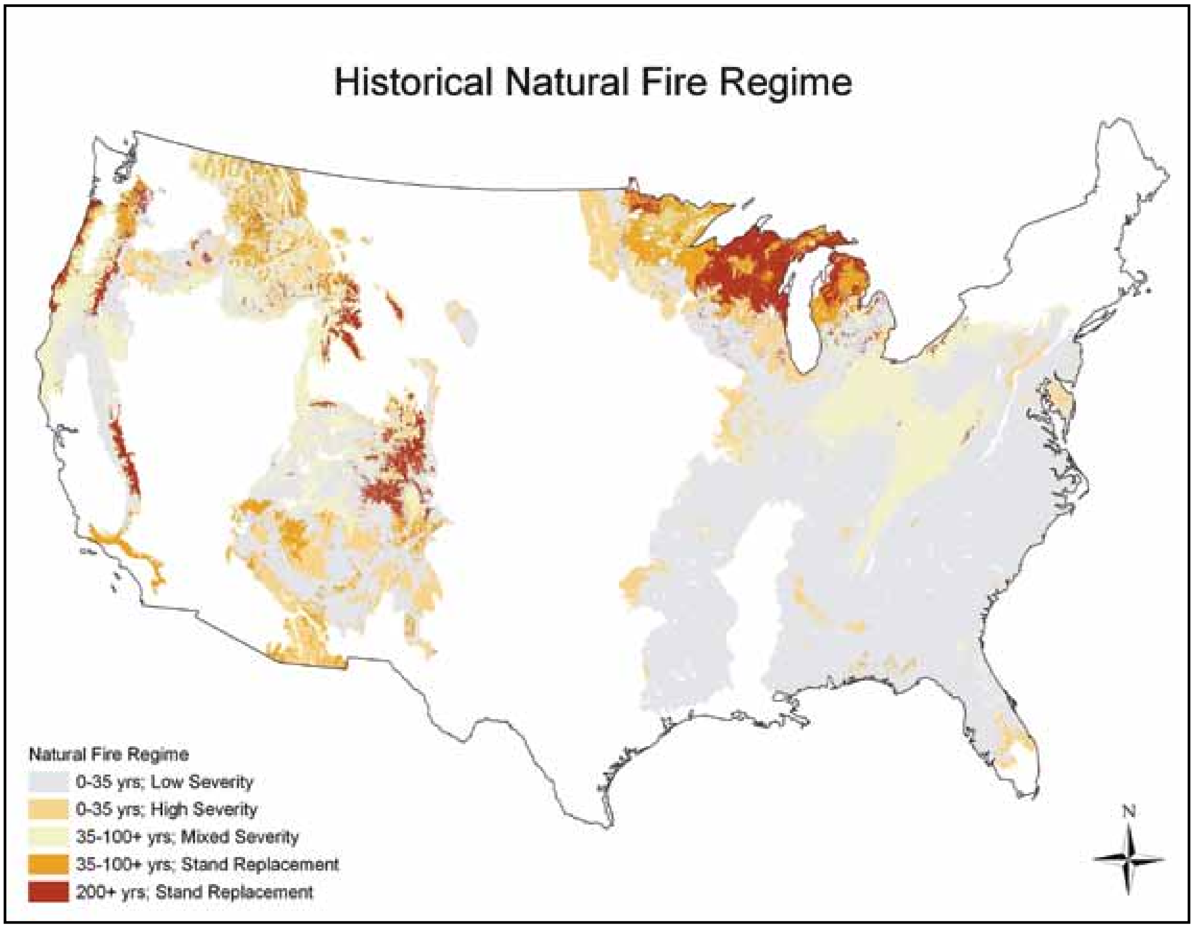

Figure 19. Map of the historical fire regimes for the regions summarized in this document. The historical fire regimes represented were developed from Schmidt et al. (2002).

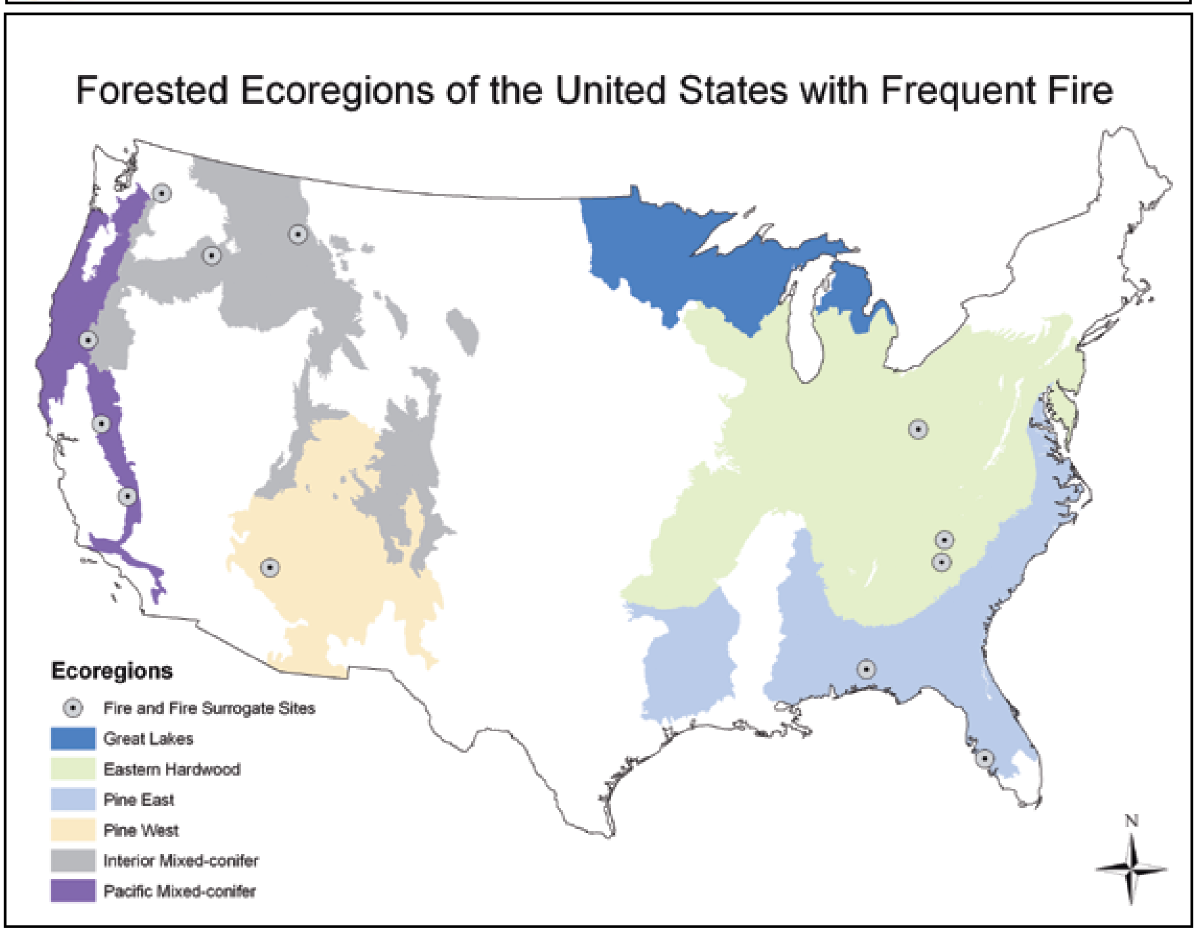

Figure 20. Map of the ecoregions used in this document. The Fire and Fire Surrogate (FFS) sites are also depicted (see figure 5 for more details on the FFS sites).

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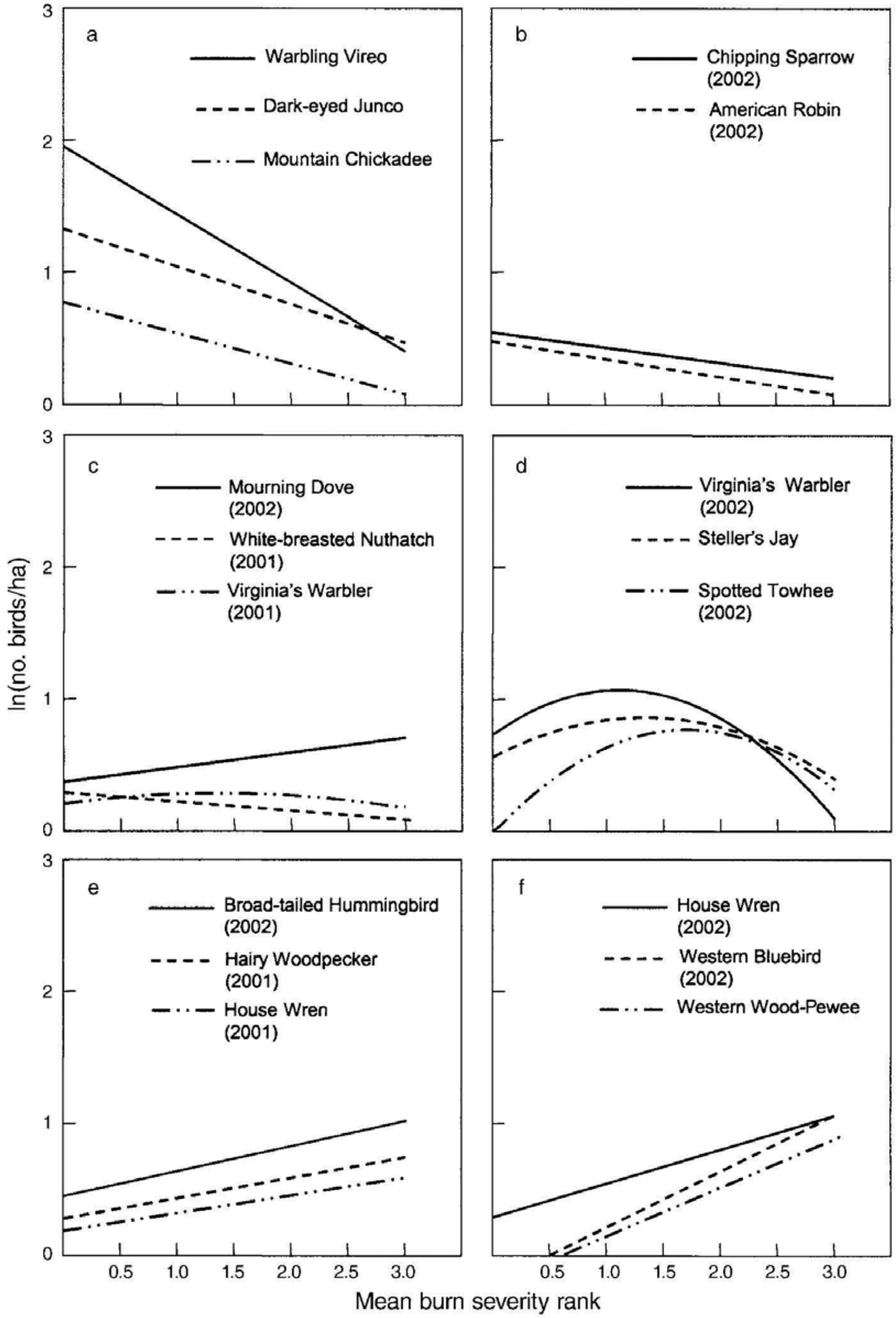

Figure 21. Density of birds breeding in the Cerro Grande Fire location in northern New Mexico (See figure 18b for location) as a function of burn severity. These are data 1-2 years postfire. Based on the density patterns species were assigned to 1 of 6 response classes: (a) response class I represents species with strong declines in density with increasing burn severity; (b) response class II represents species with weak declines; (c) response class III represents species that show no significant differences in densities across the burn severity gradient; (d) response class IV represents species that reach peak densities at low or moderate severity; (e) response class V represents species with weak positive responses across the burn severity gradient; (f) response class VI represents species with strong increases in density with increasing burn severity. (Kotliar et al. 2007)

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Extent of fire

Fire extent is a function of both the total acreage of the burn area and the patchiness or heterogeneity of burn severity within this acreage. There is evidence that the size of wildland fires is increasing (Westerling et al. 2006). For example, in the southwest United States historically, low-severity fires occurred every 2–12 years with burned patches averaging about 1,200 ha (2,965 acres). Every 6–9 year, fires of low and mixed severity would occur over larger scales, in the tens of thousands of hectares (10,000 ha = ~25,000 acres); see Covert-Bratland et al. (2006). Recent wildfires in this region cover areas significantly larger than historical fires and now contain many high-severity patches that each is several hundred hectares (100–200 ha [~250–500 acres]) in size (Allen et al. 2002); see figure 18b.

In most wildland fire studies, investigators report total fire acreage but tend to focus on total area burned rather than on more detailed reporting by burn severity, further obfuscating the broad range of ecological changes that can occur following wildland fires (Stephens and Ruth 2005; Kotliar et al. 2007). When the landscape is considered, real differences show up between areas characterized as having low-, mixed-, or high-severity fire regimes. Patch sizes in landscapes that have experienced low-severity fire regimes generally are small, are intermediate in mixed-severity fire regimes, and are large in high-severity fire regimes (figure 22). According to Agee (2005), this is one of the few characters of landscapes with mixed-severity fire regimes that is intermediate between landscapes with low- and high-severity fire regimes. Edge, for example, tends to be low and relatively "soft" in landscapes experiencing low-severity fire regimes; e.g., the difference between a patch of 200- and 350-year-old ponderosa pine is scarcely noticeable. In landscapes experiencing high-severity fire regimes, edges are easier to identify, and they increase in area with increasing total fire size. Alternatively, the amount of edge is at a maximum in landscapes experiencing mixed-severity fire regimes, and the edge varies in the degree to which it can be clearly identified, particularly in remotely-sensed imagery (figure 22).

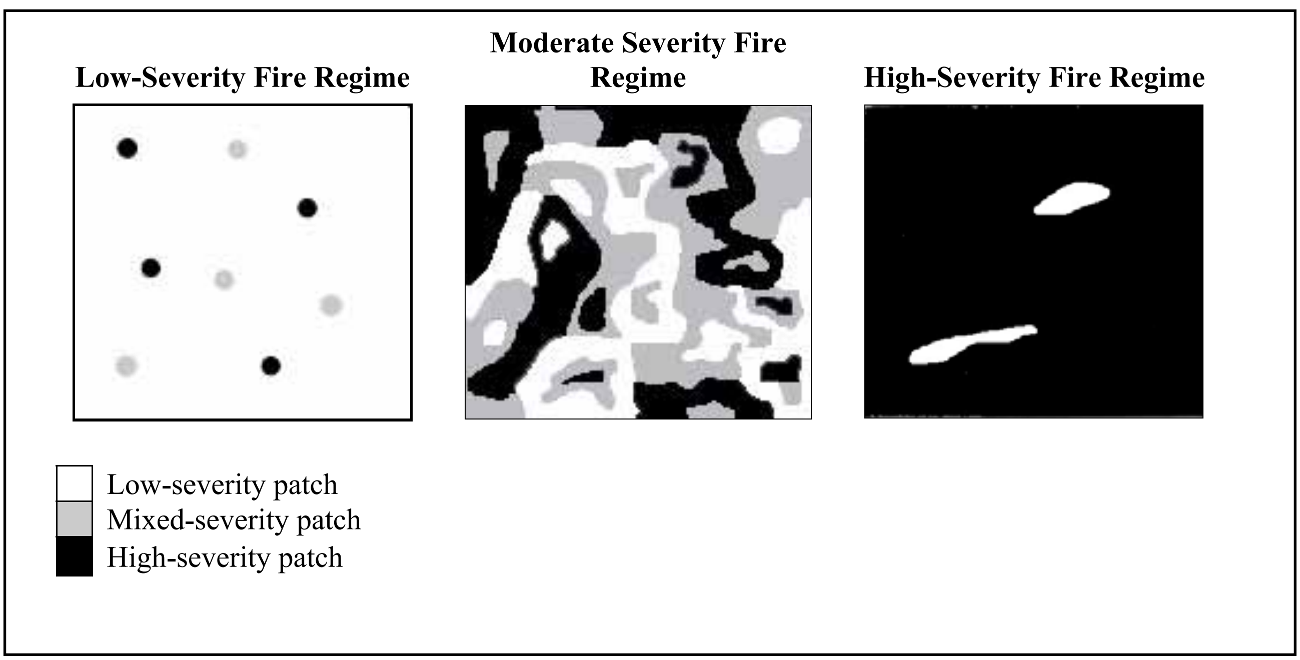

Figure 22. An illustration of patch size and distribution in landscapes that have experienced low-, mixed, and high-severity fire regimes. (developed from Agee 2005)

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Season of burn

When should management prescriptions be applied? Although season of burn is an important management question, we did not explore the topic further in this document. Eric Knapp and colleagues are developing a comparable synthesis on the effects of fire season and fire frequency, which will be available in 2009 (Knapp et al., in press).

Fire History

Fire return interval

Fire frequency and severity are typically thought to be negatively correlated in forested ecosystems; e.g., frequent disturbances are of lower severity. Pine-dominated forests of the southwest and southeast United States are prominent examples of forests where frequent surface fire (at intervals of every 1–10 years) maintains open understories and rarely leads to significant overstory mortality. In other words, individual fire events act to maintain overstory pine dominance and understories of perennial grasses, herbs, and scattered shrubs. The perspective of multiple fire events in pine-dominated forests deserves broader recognition in other forest types as well. Mixed- and high-severity fire events may also occur in rapid succession, and these *reburns* (high-severity fires recurring over short time scales) can generate vegetative conditions different from those created by long-interval fires or recurrent disturbance by low-severity fires (Donato et al. 2009b). High-severity fires recurring over short time scales have received little attention despite their known occurrence in several vegetation types, including mixed-conifer forests. Recent increases in the frequency and extent of large wildfires in western North America raise the probability of reburn occurrence (Westerling et al. 2006). Thus, managers and policy makers have an increased need to better understand the ecological consequences of short-interval, high-severity fire on ecosystems, particularly in light of the stated goal of postfire rehabilitation to reduce the risk of recurrent fires (Brown et al. 2003; USDA Forest Service 2004).

A second fire may simply reset a successional clock, creating wildlife communities indistinguishable from those occurring after just one fire; or, the reburn may provide a novel set of ecological conditions, structuring a community unique from that following a single fire event (referred to as *novel ecosystems* in Seastedt et al. 2008). Limited evidence suggests that repeated short-interval fires may be unique vegetatively (Zedler et al. 1983; Brown et al. 2003; Delitti et al. 2005; Johnstone 2006), although the influence of fire interval, vegetation type, and environmental conditions remains poorly understood. Additionally, it is unknown whether reburn communities and single-fire communities will change into similar communities over time. Rate of change in postfire communities and the time scale over which they retain early successional characteristics are not well understood.

Fontaine et al. (2009) conducted one of the few studies examining the effect of reburns on wildlife populations and communities in dry forests. Using a unique configuration of recent and older fires in the Klamath–Siskiyou mountains of southwest Oregon (a study design commonly referred to as a *space-for-time substitution*). They studied bird community changes after one or two high-severity fires. High-severity fire did not reduce species richness, and bird densities were greater in reburns than in

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once-burned habitats. Broadleaf hardwoods and shrubs appear to play a major role in structuring avian communities in the Klamath–Siskiyou region. In light of these results, Fontaine et al. (2009) concluded that extended periods of early-seral broadleaf dominance and short-interval, high-severity fires may be important to the conservation of avian biodiversity in this region. In a related study in the same area, Fontaine (2007) found similar results for small mammals. Areas experiencing two high-severity fires (separated by 15 years) possessed similar species richness but increased animal densities relative to a single high-severity fire. The applicability of these results to other regions is unknown, given the paucity of information.

The examples cited above highlight the need to include multiple disturbance events into perspectives on fire and forest development. (See "Interactions of fire and ungulate herbivory," page 29, and "Alternative stable states and state-transition models," page 32, for additional discussion of this topic). Additionally, fires occur in stochastic fashion, with a great deal of variation in fire interval. Fire management emphasizing a range of fire intervals might better achieve goals in maintaining biodiversity and forest heterogeneity

Time since fire: Short- and mid-term responses

Wildlife not only responds to the spatial variation that fires create, but their response also varies temporally. One of the best known examples, from multiple forest types, is the rapid increase in woodpecker abundance immediately following a high-severity fire. This rapid increase is then followed by a decrease beginning 2–4 years after fire (Murphy and Lehnhausen 1998; Covert-Bratland et al. 2006; Koivula and Schmiegelow 2007; Saab et al. 2007a). This pattern is nicely illustrated with the results of a study by Covert-Bratland et al. (2006) on the temporal changes in the abundance of hairy woodpeckers wintering in high- and moderate-severity patches created by two wildland fires in northern Arizona (figure 23). This pattern of responding quickly to a pulse of resources is likely driving the pattern observed in other species with high abundances immediately following fire and then declining after 2–3 years postfire; examples include the Bachman's sparrow (Tucker et al. 2004) and several other bird species (Smucker et al. 2005; Kotliar et al. 2007).

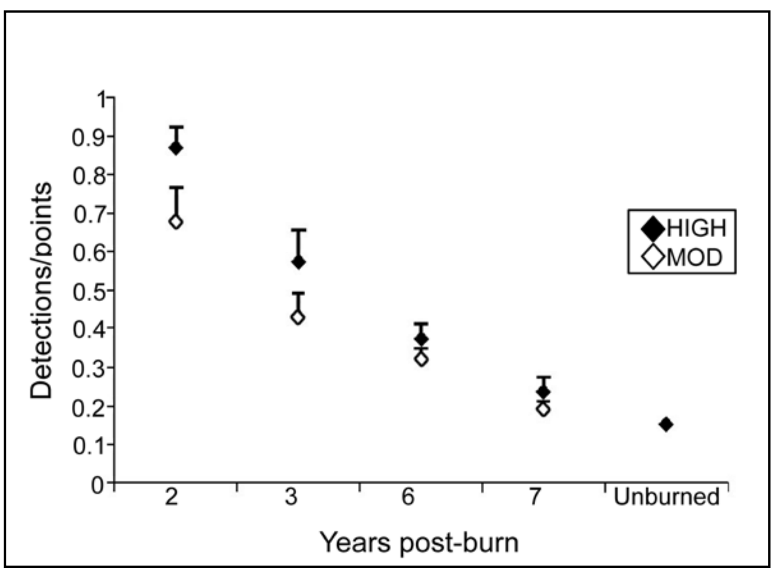

Figure 23. Relative abundance (±SE) of wintering hairy woodpeckers in high- and moderate- severity patches of different ages postfire. Data were collected in the Pumpkin Fire (2 and 3 years postburn) and Horseshoe–Hochderffer Fire (6 and 7 years postburn), Coconino National Forest, Arizona, during winters 2001–2003. Unburned forests adjacent to the burned areas are shown for comparison. (Covert-Bratland et al. 2006)

Although the aforementioned examples suggest a linear decline in populations of fire-dependent wildlife as time since fire increases, alternative response patterns are possible. For example, Smucker et al. (2005) found northern flickers showed no evidence of a fire response until 3 years postfire. Furthermore, breeding densities for many birds varied dramatically 1 and 2 years after the Cerro Grande Fire in northern New Mexico (Kotliar et al. 2007) and 1–4 years postfire in the northern Rocky Mountains (Smucker et al. 2005). In both studies, bird species demonstrated

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linear, curvilinear, humped, and flat response surfaces to fire over time (figure 21). This suggests there are wildlife species that do not respond to a pulse of resources immediately postfire; instead, they respond slowly, as habitat suitability increases. However, the mechanisms behind this pattern have not been investigated, and understanding longer term responses remains a large gap in our current knowledge base.

Time since fire: Long-term responses and potential postfire conditions

Long-term responses of wildlife to fire are poorly understood due to a paucity of long-term data. The few studies that have been conducted (e.g., Engstrom et al. 1984; Johnson and Wauer 1996) suggest wildlife communities follow a direct successional pattern based on the vegetative successional dynamics predicted for that forest type. For example, in a 15-year study of breeding bird abundances after fire exclusion in an annually burned Florida pine woodland, Engstrom et al. (1984) documented progressive changes in habitat structure and floristics as the herbaceous understory was lost and mesophytic hardwoods encroached. Abundances and, thus, avian species composition changed concomitantly, with open-habitat species such as Bachman's sparrow and loggerhead shrike disappearing within 9 years, as species such as wood thrush and hooded warbler, which are characteristic of hardwood forests, colonized the site.

Oliver et al. (1998) developed a conceptual model (figure 24) predicting how a disturbance like fire will likely affect wildlife abundance in three types of animals:

1. Those that reside in structurally complex old-growth stands with abundant understory
2. Those that prefer edges between dense and open vegetation, and
3. Those that prefer open habitat.

This model is consistent with the successional patterns described for both low-severity (figure 25) and stand-replacing fires (figure 26), although it does not account for the complex role of fire in producing pyrogenic structures, nor does it account for reburns or the presence of multiple disturbance agents (see "Interaction of fire and ungulate herbivory," page 29). As a result of the spatial and temporal variability in the occurrence of disturbances, succession in dry forests is not always a gradual, progressive succession that results in a stable, climax community. These systems are dynamic landscapes that likely can occur in alternate states depending on the disturbance history and vegetation type (see "Alternative stable states and state-transition models," page 32). The upshot

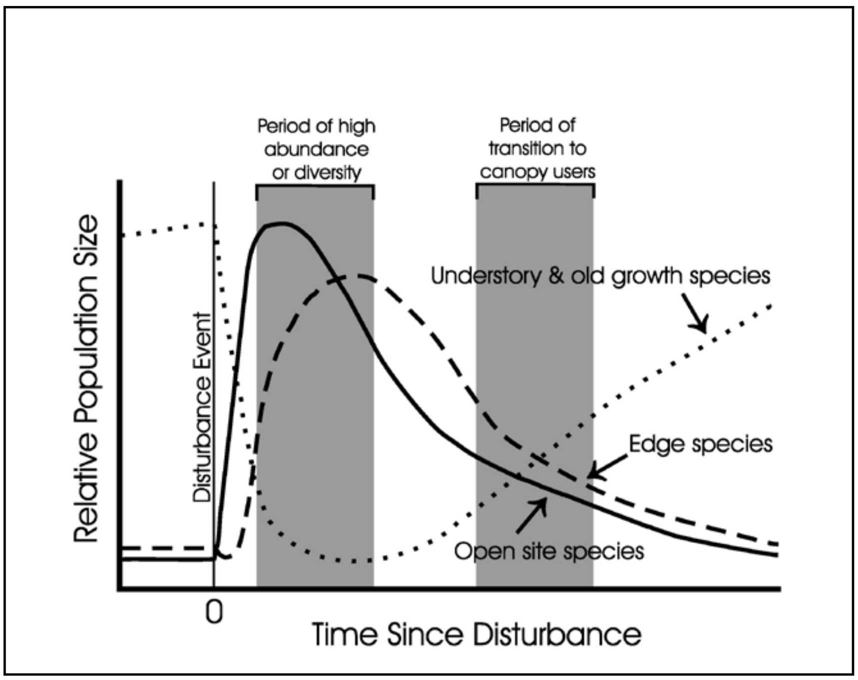

Figure 24. Hypothetical patterns of change in populations of species dependent on three features of forest structure: dense understory/old growth, edge, and open sites. (Smith 2000)

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is that succession (both plant and animal) in U.S. dry forests is very difficult to predict because the long-term trajectory varies depending on forest type and disturbance history, and little is known about the long-term trends in demography of wildlife in these disturbance-mediated habitats.

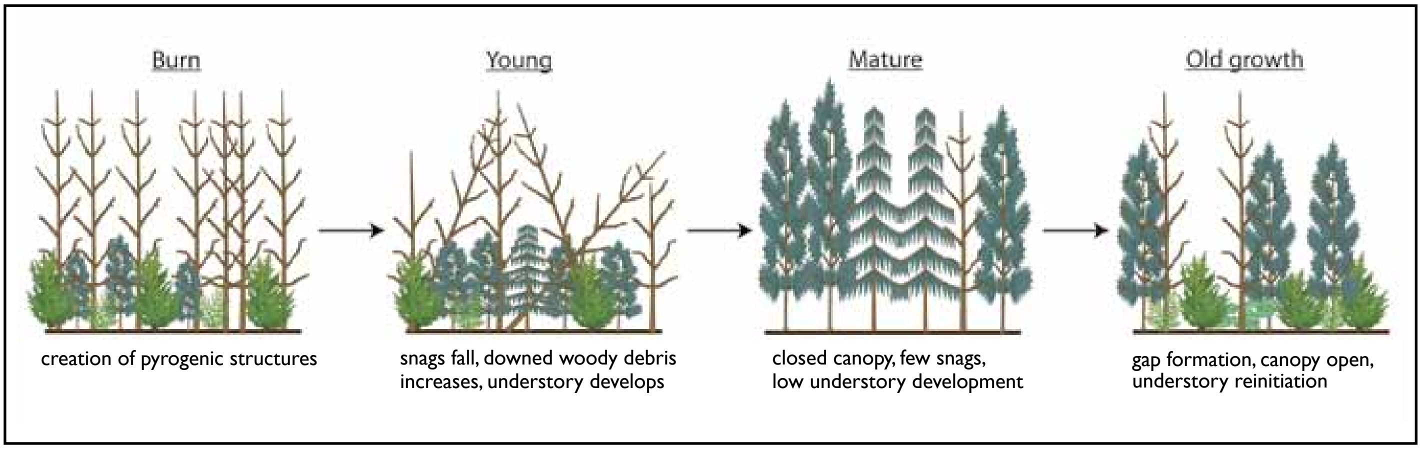

Figure 25. Changes in vegetation and pyrogenic structures after a stand replacing fire in interior mixed conifer forests (see figure 20 for region location).

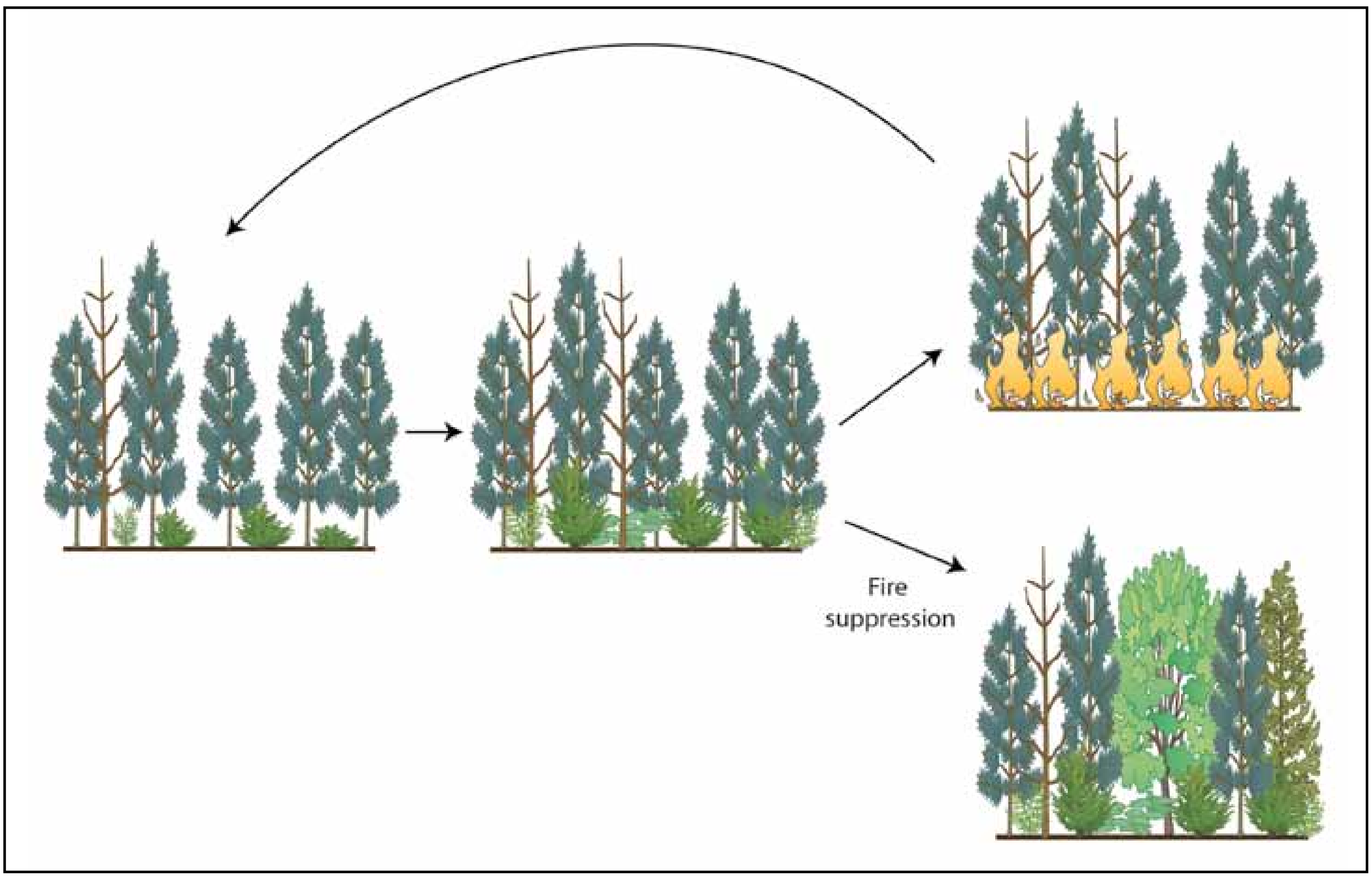

Figure 26. Changes in vegetation and pyrogenic structures in forests with an historic fire regime of frequent, low-severity fires (e.g., Pine East or Pine West forests [see figure 20 for region locations]). Two alternative stable states are depicted: the top trajectory represents forest conditions under frequent fire and the bottom trajectory represents forest conditions under fire suppression.

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Interaction of fire and ungulate herbivory

Like other disturbance agents, fire rarely acts alone. Episodic disturbance agents such as fire, drought and insect defoliation interact with chronic disturbances such as herbivory by native and domestic ungulates (figure 27). Despite the fact that most U.S. dry forests during the past century have been dominated by a combination of fire exclusion (Agee 1993; Smith 2000) and high levels of ungulate herbivory (Hobbs 1996) the interaction of herbivory and fire is poorly understood and represents an obvious management knowledge gap. Wisdom et al. (2006) published an excellent review of this topic, which we summarize here.

Removal of fine fuels by ungulates may reduce frequency of ground fires, but herbivore preferences for palatable woody species can increase opportunities for crown fires by enhancing development of unpalatable trees and, thus, providing ladder fuels. Moreover, the combination of fire exclusion and ungulate herbivory may exacerbate this trend by increasing the density and/or rate of ladder fuel accumulation and elevating crown fire hazard. Such a pattern may partially explain the higher frequency of crown fires in interior forests of the western United States today compared to conditions prior to European settlement.

While scientists and silviculturists recognize the dramatic effects ungulate herbivory can exert on vegetation development (figure 28), current policies of forest management in North America generally do not explicitly recognize

continues

Figure 27. Bull elk grazing on new shoots in a recently burned area in the 1988 Yellowstone Fire. (Jeff Henry, U.S. National Park Service, nps.gov)

Figure 28. Recently burned forest that demonstrates the effects of herbivory by cattle, mule deer, and elk on vegetation development within summer range in eastern Oregon, USA. The area on the left was subjected to extant herbivory by the 3 ungulate species following a wildfire and is dominated by grass species of low palatability, such as pinegrass (*Calamagrostis rubescens*). The area on the right was excluded from ungulate herbivory after the fire and is dominated by highly palatable aspen (*Populus tremuloides*) and snowbrush ceanothus (*Ceanothus velutinus*). The photo was taken 4 years after the wildfire. (Wisdom et al. 2006)

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Interaction of fire and ungulate herbivory, continued

herbivory as a disturbance in U.S. forests. Potential effects of ungulate herbivory on processes of vegetation development are generally known, but the magnitude of effects is neither recognized nor easily predicted under different combinations of episodic disturbance, particularly across large landscapes. This lack of predictability poses a substantial obstacle to effective management of fire and ungulate herbivory. Traditional models of vegetation transition in forested ecosystems have ignored the influences of ungulate herbivory, while research on effects of herbivory typically have excluded other disturbances.

Wisdom et al. (2006) developed a conceptual model of understory development for montane forests in western North America that considers the combined effects of herbivory and episodic disturbances such as fire (figure 29). This model contrasts strongly with models of forest development that typically focus on overstory dynamics (figure 30). The model, detailed in Wisdom et al. (2006), is intended to complement overstory models and to be a starting point for developing hypotheses for empirical testing under new research designed to address some of the key knowledge gaps related to the interaction of fire and herbivory. The implication for fire management plans is that they should not be developed in isolation from other management plans, such as for forest health and range management. This also suggests cumulative-effects assessments of fire should not just evaluate temporal and spatial effects of multiple fires but, rather, cumulative effects of multiple disturbances.

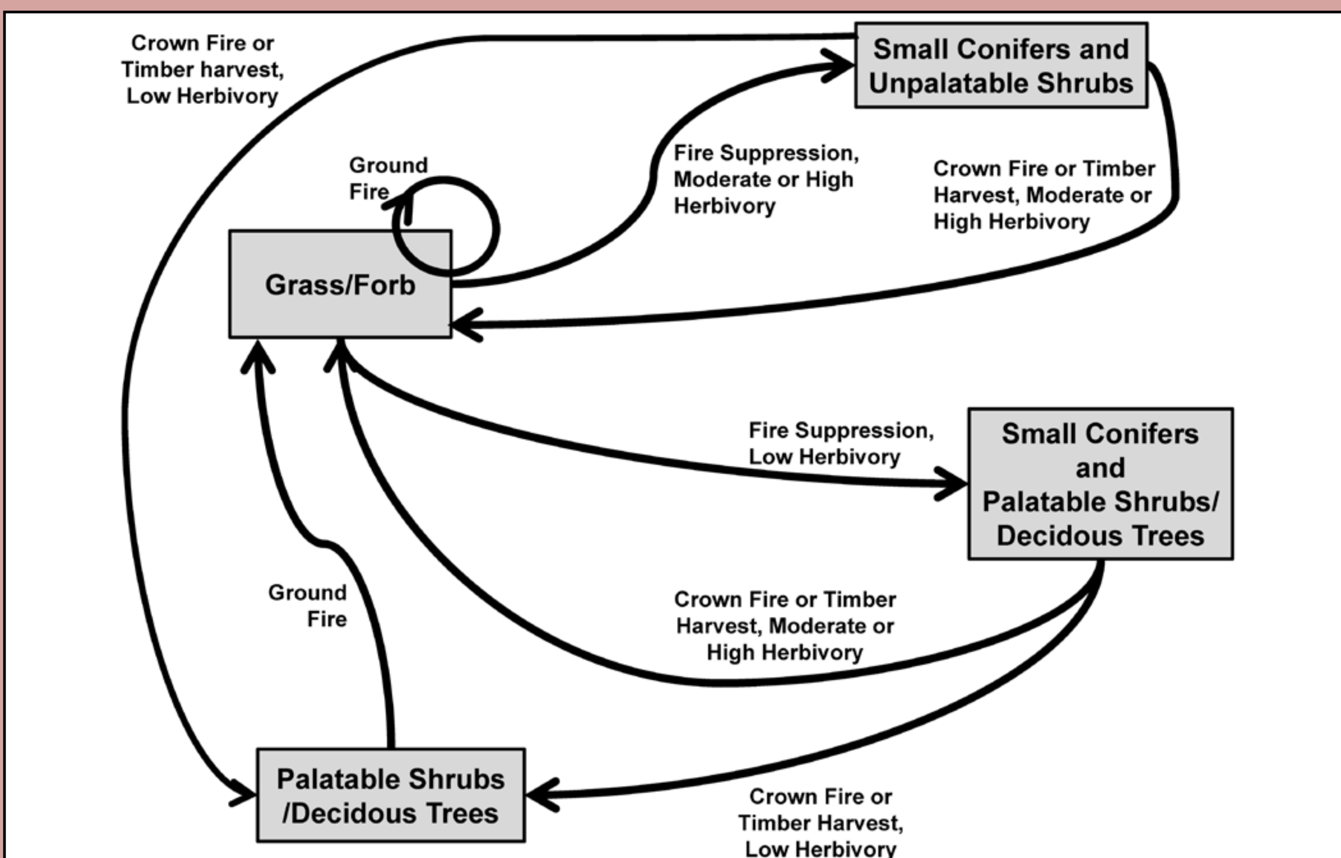

Figure 29. Conceptual model of understory plant development and dominance in montane forests of western North America, as influenced by varying densities of wild or domestic ungulates, interacting with episodic disturbance regimes of fire and timber harvest. Gray boxes are vegetation states, arrows are transitions between states, with the associated disturbance agents of herbivory, fire, and timber harvest that cause transition to the vegetation states. Dominant life forms of plants in each understory state are given. (Wisdom et al. 2006)

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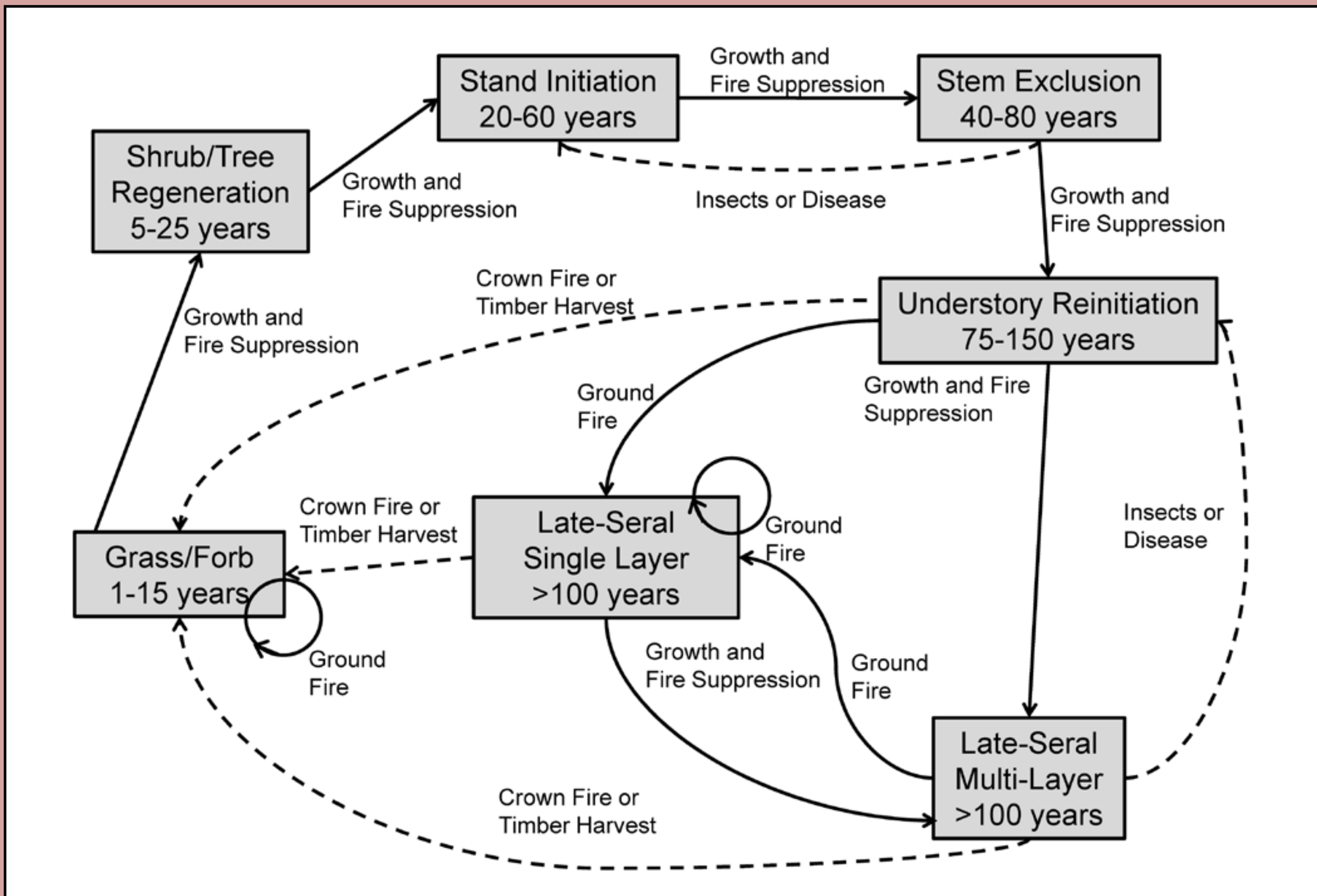

Figure 30. An example of a vegetation-disturbance model for montane forests of western North America, considering the effects of episodic disturbances. (Wisdom et al. 2006). The model is based on concepts of vegetation states and transitions, including multiple steady states, potential threshold effects, and abrupt transitions caused by episodic disturbances. Gray boxes are vegetation states; arrows are transitions between states, with the associated disturbance agents of fire, insects, disease, and timber harvest that cause transitions. Notably absent are transitions caused by ungulate herbivory, alone or in combination with episodic disturbances. Also absent are details about understory composition of vegetation for many of the vegetative states and the potential transitions brought about by the interactions between understory and overstory development of vegetation. Wisdom et al. (2006) hypothesize that the dashed arrows represent transitions and resulting states that are more likely to occur under moderate or high levels of ungulate herbivory. For such transitions, forest managers typically assume that such effects are brought about solely by disturbances of fire, insect, disease, or timber harvest.

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Alternative stable states and state-transition models

The expectation that fire-excluded forests will return to their presuppressed state after fire is reintroduced is based on a model of vegetation dynamics that predicts that, under similar environmental conditions, vegetation will tend toward a single, vegetation community or "climatic climax" and will recover toward this following disturbance (Clements 1936). Ideas on vegetation dynamics, however, have developed considerably since 1936. Recent models of vegetation dynamics suggest multiple successional pathways are possible, and that alternative, stable states of vegetation can exist under the same environmental and climatic conditions. Transitions between these states are often rapid and sometimes irreversible and are caused by particular occurrences of climatic events, disturbances, or changes in management regimes, either individually or in combination (Yates and Hobbs 1997; Beisner et al. 2003; Suding et al. 2004; Standish et al. 2009).

A simplistic example of alternative states in fire-prone forests is presented, in figure 26, for forests with a history of frequent, low-severity fires. The top trajectory represents the predicted changes in vegetation structure where low-severity fires occur every 5–10 years. The bottom trajectory is in the same forest, where one low-severity fire occurs followed by fire exclusion. With repeat disturbances, the plant community will remain as a pine forest with an open understory; some have termed this *fire climax* (Rundel 1971). With fire exclusion, the same forest will change from an open pine forest to a more structurally complex mixed-hardwood forest (in the southeast United States) or mixed-conifer forest (in the southwest United States). Dynamics such as these are summarized in state and transition models. Figure 30 is an example of a state-transition model for a dry montane forest in the western United States. Typically, these types of models are developed to predict vegetation dynamics; but to our knowledge, models have not been developed to predict dynamics of animal communities in U.S. dry forests.

Limited Understanding of Wildlife Habitat Requirements

The wildlife–fire literature we summarize is predominantly focused on patterns of response; i.e., *does the abundance of species X increase or decrease as a function of postfire conditions*? These patterns can be described, but the mechanisms behind them are difficult to elucidate because we don't understand the habitat requirements for most wildlife. Because fire has a dramatic effect on vegetation and can generate an abundance of pyrogenic structures (snags, shrubs, bare ground, etc.), it is not uncommon for investigators to look at a variety of metrics associated with these structures. For wildlife such as woodpeckers, where pyrogenic structures play a well-defined role in providing foraging and nesting substrates (e.g., Saab 2004; Covert-Bratland et al. 2006), this is a very appropriate procedure for identifying habitat changes that occur as a result of fire and for evaluating the effects of the changes on woodpecker demographics. However, in many taxa, the role of pyrogenic structures as habitat features is less clear. For example, fire-surrogate treatments in loblolly (*Pinus taeda*) and shortleaf pine (*Pinus echinata*) led to increases in big brown bat and eastern red bat activities (Loeb and Waldrop 2008). Although snags do provide roosting structures for bats, this positive response is likely partially a response to an increase

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in availability of its prey, aerial invertebrates, but this has not been documented. Wildlife responses may also be a function of changes in abundance of predators and competitors postfire. For example, snakes are major predators of ground-nesting songbird nests. Changes in nest success observed postfire might be attributed to changes in snake abundance, yet measurements of pyrogenic structures would not detect this relationship. The suitability of pyrogenic features as surrogates for wildlife habitat metrics needs more critical evaluation.

Variability in Animal Populations Not Related to Fire

Wildlife populations vary in time and space independent of the effects caused by fire management actions or other disturbances. This confounds our ability to interpret wildlife data in fire studies, because the response to the fire treatment is embedded in this variation—and this variation may swamp any effects due to fire management treatments. This non-fire-related variation in animal populations is typically referred to as *environmental stochasticity* and is usually approximated in most analyses of wildlife data as random, unstructured noise. However, it is likely that some of that non-fire-related variation is in reality a result of ecological processes(s) that influence wildlife populations. For example, there is strong evidence for climatic effects on reproduction and survival, and extremes in climatic variation can function as catastrophic events and have been associated with sudden large-scale mortality (Seavy et al. 2008). So, if a fire occurs during a severe climatic event (e.g., hurricane, late spring snow), it is possible the responses to fire will be less detectable because of the negative responses to the climatic event.

Investigators try to control for this source of temporal, non-fire-related variation by comparing unburned plots (in observational studies) or unburned controls (in experiments) to burned or other treatment areas. The assumption is the non-fire-related variation will be similar in control and treated areas, and any differences can be attributed to the fire or the fire-surrogate treatment. This is a reasonable assumption if spatial variation among areas is low; i.e., habitat suitability of sample sites, pretreatment, is comparable. However, if environmental heterogeneity among sample locations is high (i.e., sample locations provide very different prefire habitat conditions), non-fire-related spatial variation also may be high. To account for spatial variation in habitat quality, one option is to incorporate prefire sampling, also referred to as *pre–post data* (see Kotliar et al. 2007, for more details on this sampling approach in fire studies). Then the investigator can compare the differences between pre- and postfire data among the various treatments.

Pre-post data are difficult to obtain in wildland fire studies where the treatment is not under the control of the investigator. If historical data are available for the project area, they may be useable as prefire data, but interpreting postfire patterns from historical data has limited utility if the data were collected many years before the fire event of interest. In this situation, differences in pre- and postfire abundances may be more a result of long-term trends in the landscape that are not related to fire (e.g., successional changes within cover types, expansion of human developments, changes in climate). A good discussion of this topic is presented by Kotliar et al. (2007), who used an historical prefire dataset to evaluate the effects of a wildland fire in New Mexico on local bird populations and communities.

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Sampling Animal Populations

The aforementioned variation of animal populations in time and space (including responses to fire) is often referred to as *process variation*. This is different from *sampling variation* which is the variation attributable to estimating a parameter, such as abundance, from sample data. Proper estimation of demographic variables and inferences about their process variation require attention to two critical aspects of sampling variation: location of sample plots and detectability (figure 31). In fire studies and monitoring programs, sample plots have to be selected because investigators cannot survey the entire fire or project area because of personnel and other financial constraints. Instead, we must select a sample of locations to which survey methods are applied, and this selection must be done in a manner that accomplishes two requirements. First, select sample plots that provide the best opportunity to discriminate among the competing management treatments (or competing hypotheses, in the case of scientific studies). For example, in studies evaluating the effects of prescribed fire on wildlife, sample plots should be in areas where the prescribed fire will be applied as well as in areas with prefire conditions similar to the treatment plots (controls). Second, once suitable treatment and control areas are identified, select sample plots in a manner that permits inference about the entire management area. Approaches to sampling that accomplish this inferential goal include simple random sampling, unequal probability sampling, stratified random sampling, systematic sampling, cluster sampling, double sampling and various kinds of adaptive sampling (Quinn and Keough 2002; Thompson 2002; MacKenzie et al. 2006).

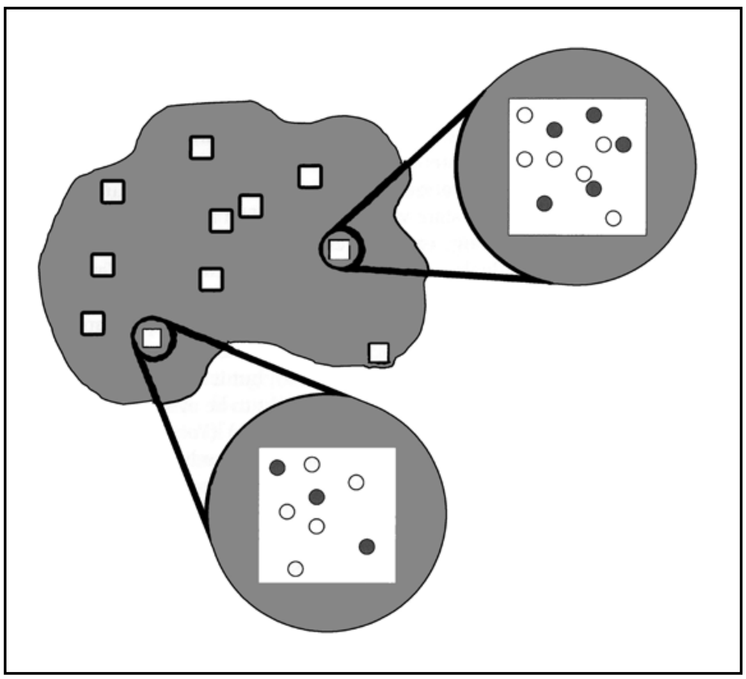

Figure 31. Illustration of the two critical aspects of sampling animal populations: spatial variation and detectability. The shaded regions indicate the area or population of interest (e.g, a recent burn patch), with the small squares representing the locations selected for sampling. Within each sampling location, animals will be detected (filled circles) or undetected (hollow circles) during a survey or count. This also applies to trapping datasets where an animal will be either captured (filled circles) or not captured (hollow circles). (MacKenzie et al. 2006)

Detectability refers to the reality that, even in sample plots, it is very common for individual animals and even entire species to go undetected (figure 31); see Simons et al. (2007) for an excellent empirical example. The variation in detectability and its effect on the estimation of abundance has strong theoretical and empirical support (e.g., MacKenzie et al. 2006), but many investigations of fire effects on wildlife still report count data that are unadjusted for capture or detection probability. Proponents of using these unadjusted count statistics—e.g., relative abundance—typically recommend standardization of survey methods as one means of trying to ensure similar detection probabilities. Standardization involves factors that are under the control of the investigator (e.g., effort, trap type, bait). While standardization of survey methods is usually a good idea, this approach will not produce equal detection probabilities because there are always likely to be unidentified and uncontrollable factors that influence detection, such as the observer's acuity of vision and hearing (Simons et al. 2007). In studies of fire effects, removing the forest canopy may increase the probability of detecting wildlife and potentially inflate abundance estimates in unadjusted counts.

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Substantial amounts of variation in the data we summarize are likely a result of unaccounted-for variation in detection. For example, in a study of fire effects on boreal toads, Hossack and Corn (2007) noted that an apparent postfire increase in toads was, in fact, a product of increased detectability; there were no real changes in toad densities prefire to postfire. Similarly, Converse et al. (2006a; 2006b) and Monroe and Converse (2006) reported substantial changes in the capture probabilities of deer mice following prescribed fires and thinning at FFS sites throughout the U.S. Thus, these issues are not trivial and must be taken into account before attributing changes in unadjusted accounts to an effect of fire on animal populations. However, see Johnson (2008) for a discussion of the merits of unadjusted counts.

Although the literature has limitations, as mentioned above, there is still a plethora of material to use in developing project planning documents. In the next section we describe the approach taken to synthesize the literature with these documents in mind. Following the "Methods" section, we present our synthesis results.

METHODS

Our approach to synthesizing the existing literature on vertebrates and fire proceeded through three stages. First we conducted scoping meetings and interviews with land managers throughout the country, to identify knowledge gaps and useful content. Second, we conducted an extensive search of the literature for original data as well as synthetic publications. Finally, we incorporated all publications containing original data into a relational database which allowed comparison of results within and across species and forest types. Details of the methods used for each stage are presented below.

Scoping Meetings

A 1-day meeting with federal agency personnel was held in Boise, Idaho, in the fall of 2007. Attendees represented the USDA Forest Service from all regions included in this document. Biologists from the U.S. Bureau of Land Management were invited but could not attend due to prior commitments. Meetings focused on identifying knowledge gaps, specific needs, and useful content and organization. The consensus of the workshop was to develop a document that provided tabular summaries of the literature, organized by region and taxa.

Literature Search and Criteria for Inclusion

Literature searching was conducted using online literature search engines (primarily Web of Science) with a focus on all peer-reviewed literature since 1970. To augment our search, we also examined the literature cited sections from recent review articles (e.g., Russell et al. 1999; Smith 2000; Saab and Powell 2005b; Pilliod et al. 2006) and all publications currently available from the FFS network including unpublished student theses. Keywords used in our searches included *fire, fire surrogate, prescribed fire, wildfire, mammal, bird, avian, reptile, amphibian*, as well as names of certain groups (e.g., salamander) and rare species of management interest (e.g., gopher tortoise). We

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limited our online database search to peer-reviewed publications such as journals and government technical reports dealing with vertebrate response to fire or fire surrogate treatments (primarily thinning associated with fire-related studies) from dry forests of the lower 48 states. We utilized data from Alaska, Canada, and Australia to augment cases of sparse or nonexistent information (e.g., mesocarnivores). Articles meeting our criteria were stored using the bibliographic software EndNote (Thomson Reuters 2008).

Stored articles were examined and divided between synthetic or review publications and original-data publications. Synthesis and review articles were used for general information purposes only. Papers reporting original data were set aside and examined in detail for qualitative and quantitative information on the response of wildlife to fire or fire surrogate treatments. For the quantitative portion of our review, original data papers were further divided into those reporting a contrast between treated and untreated forests as measured by wildlife abundance or demographic information versus papers measuring habitat characteristics (the connection between habitat and wildlife abundance is qualitative for most wildlife species) or only measuring treated forest (e.g., papers reporting data exclusively from burned plots). Thus, original data papers reporting wildlife abundance contrasts between treated and untreated forest were used for the quantitative portion of the review.

Not all publications on wildlife and fire were referenced in this synthesis, nor were all published materials considered equally reliable. Not including certain literature does not mean the studies were inferior scientifically. Rather, the results were not directly relevant to our assessment criteria. We preferentially referenced peer-reviewed literature because this is the accepted standard in science. Nonrefereed publications or reports were regarded with greater skepticism but were included if they addressed important information gaps not reported in published literature.

Database Structure

Managing data from a wide variety of study designs, ecosystems, and taxa is a continual challenge for any literature review and especially for quantitative comparisons. Moreover, reviews and meta-analyses lose relevance rapidly as additional studies are published. To address these challenges, we created a relational database to store study results from all the papers containing original data. Applying a formal data storage structure at the outset of our review strengthened our ability to appropriately and rigorously compare studies. Those with stronger design and greater inference space were easily identified using this process and method of data management.

Our database incorporated a wide variety of studies ranging from stand-scale studies (e.g., those from the FFS program) as well as coarse-scale studies from large wildfires. To accommodate such a wide variety of sampling designs, we created a flexible three-tiered database that permitted us to store study-wide information (region, forest types, years, taxa, and methods summary), treatment-level information (replication, treatment intensity, spatial scale of measurement), and species-specific responses (treatment effect, year effect, animal abundance/density) in different data tables. Associated informational tables contained species lists and forest types, allowing us to define disturbance regimes, species distributions, conservation status, and species

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traits. Queries of the database produced species-specific responses (and measures of confidence) for each of the principal treatments of interest (wildfire, prescribed fire, thinning) across the forest types of interest. As new information is entered into the database, queries automatically update and incorporate new information. This approach is well suited to an adaptive management approach (Converse et al. 2006a) in which new information can be readily incorporated and effectively applied.

Study Categorization and Quantitative Comparisons

Each individual species-level response was entered into the database and categorized geographically, by treatment, by spatial scale, and by comparison type. Spatial scale was recorded as total area treated (either size of wildfire or the sum of treatment units). Comparison type included pre–post and after–only contrasts. After–only contrasts employed a space-for-time approach that assumes pretreatment similarity.

Regions and forest types

Published studies were categorized at two spatial scales: region and forest type. We pooled U.S. dry forests into six broad regions, similar to Saab and Powell (2005b), intended to reflect broad trends in climate, biogeography, and historic fire regimes (figure 19). These included Pacific slope mixed-conifer forests, mixed-conifer forests of the interior West, ponderosa-pine-dominated forests of the southwest United States, dry hardwood-dominated forests of the eastern United States, conifer-dominated forests of the Great Lakes, and pine-dominated forests of the Southeast. At a finer scale, we used the Omernik forest type classification scheme (Omernik 1987; U.S. Environmental Protection Agency 2007). Both categories of forest type classification were recorded for each study during data entry.

Treatment classification

One of the largest information needs identified during scoping meetings with managers was a better understanding of fire and fire-surrogate effects across a range of intensities and time scales. To accomplish this, we created eight categories of treatment:

- Low- and moderate-severity fire (0–4 years postfire, 5–9 years postfire, more than 10 years postfire)
- High-severity fire (0–4 years postfire, 5–9 years postfire, more than 10 years postfire)
- Thinning (0–4 years post-treatment)
- Thinning + fire (0–4 years post-treatment)

In the case of thinning and thinning + fire treatments, we presented short-term studies only due to a lack of published longer term studies (more than 5 years). We considered all thinning intensities which, in the case of FFS studies, were qualitatively similar in terms of proportion of basal area removed (McIver et al. 2008). Low- and moderate-severity fires were pooled because neither treatment resulted in major canopy loss (less than about 50% canopy mortality, and less than 25% in almost all cases). High-severity fire was defined as tree mortality exceeding 90%. These categories allow comparison of fire surrogates combined with fire as well as comparison of differing levels of fire severity (as measured by overstory mortality).

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Quantitative comparisons

To compare a diverse set of studies across regions and taxa, we used the relative abundance index (RAI) of Vanderwel et al. (2007) where RAI = (Treatment – Control) ÷ (Treatment + Control).

This index varies from –1 to + 1 and can be calculated from any study that reports treatment and control means. Calculating RAI permitted us to put a broad array of studies on the same scale and average them across studies. RAI values less than –0.40 and more than 0.40 were arbitrarily considered suggestive of negative and positive, respectively, treatment responses. Index values should be interpreted with caution and in the context of standard errors and sample sizes, because they are sensitive to small sample sizes.

Spatial scale

The spatial scale of individual treatments and treatment regimes in a stand or on a landscape are critical to understanding potential influences of fire management on wildlife. Thus, the results of the literature review were organized for each ecoregion into two spatial scales that reflect scales at which land managers have to generate plans and implement actions.

First, we defined a project scale (hereafter referred to as *stand scale*):

- Generally less than 500 ha (1,236 acres)
- Focused on one to several forest stands, and
- The targeted area for a fire management project

The second scale we defined is the landscape within which the project is being implemented (hereafter referred to as the *landscape scale*). This larger scale is the focus of cumulative-impact assessments conducted to evaluate effects of multiple management projects on wildlife. In general, studies on prescribed fire and fire surrogates are conducted at finer spatial scales and, thus, inference of these studies is limited to the stand scale. Although the multistudy experimental design of the FFS program does allow for a broad geographic analysis of stand-scale responses, the inference of these studies is still limited to the stand scale because of the sampling design (nonrandom locations; treatments conducted at the stand scale). Large, manipulative experiments in the fire literature are nonexistent; so inference about landscape-scale effects of fire management is restricted to the results of wildland fire studies. However, depending on the experimental design (e.g., random sampling, scale of measurements of wildlife response variables), some wildland fire studies are included in the stand-scale summaries. Here we focus largely on stand-scale responses because of the general lack of landscape-scale fire studies in the literature.

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RESULTS

Overview

Based on feedback from the scoping meeting and the results of surveys conducted by Youngblood et al. (2007) for the FFS program, the results of our synthesis are presented in a series of "look-up" tables in the appendixes. The appendixes are designed for managers to refer to in project planning when they need regional and national information on the responses of species in their region to different potential management treatments. We took a multitiered approach to developing these tables, to avoid creating cumbersome tables with numerous columns. The types of information presented are restricted to those factors we deemed important for understanding the strengths and weaknesses of the literature. A word of caution about the use of this information; the quantitative data presented in appendixes 3 and 4 are indices that have not been analyzed statistically; thus, care must be taken when using this information, particularly for interregional or cross-species comparisons.

We first briefly summarize the information contained in each appendix and illustrate its use with examples. Next we present regional results, with an emphasis on regional vegetation structure, historical fire regimes, and key examples of species whose response to fire is particularly relevant to a given region. The "Results" section concludes with summaries from the FFS study network and other similar experiments.

Appendix 1 summarizes all the literature we reviewed in this synthesis. In total, we reviewed more than 150 articles, included 90 articles (52 quantitative, 24 qualitative, 14 review) in our database, resulting in 4,937 records of 313 vertebrate species. The vast majority (77%) of the studies have been conducted on birds in four of the six regions: Pacific mixed-conifer, interior mixed-conifer, pine west, and pine east (figure 20). The data in appendix 1 are presented by region; within each region, studies are sorted alphabetically by senior author. Complete references are available in the "References" section. The right-hand columns indicate the treatments and taxa evaluated and the season of the study. The left-hand columns summarize experimental and sampling design features that would impact strength of inference, such as (1) whether it was an experiment or an observational study; (2) total area treated and sampled; (3) availability of pre–post data; and (4) whether response variables such as abundance or survival were adjusted for detection or capture probabilities. Time since fire is indicated for fire studies; this was not necessary for other fire-surrogate treatments because all sampling of fire-surrogate effects began within the first year post-treatment. The literature included in our quantitative analysis is also indicated in this table. For example, Amacher et al. (2008) was an FFS study that investigated effects of prescribed fire and mechanical fuels treatments on small mammal communities at the Central Sierra Nevada FFS site (figure 5). The study was included in our quantitative analysis because it presents abundance estimates for four species of small mammals (California ground squirrels, long-eared chipmunks, brush mice, and deer mice) in an experimental framework. Three fuel treatments and controls were randomly applied to 12 mixed-conifer stands, so the effects of the fuel treatment on small mammal abundance can be quantitatively compared to the controls (or "no action" alternative) using our RAI index. The total area for the 12 experimental units was 556 acres (225 hectares). No attempt was made to account for capture probabilities. Time since fire

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was 1 year: pretreatment data were collected in 2001, treatments were applied 2001–2002, and the authors had 1 year of post-treatment sampling, in 2003.

Appendix 2 is a summary of the federal and regional or state conservation status of all wildlife species studied in the literature in appendix 1. For taxa of particular management concern, we include subspecies-level information (i.e., subspecies listed under the U.S. Endangered Species Act). The species are sorted by vertebrate class and, within a class, listed alphabetically by common name. This appendix is also the source of scientific names for all vertebrate taxa summarized in this document. Conservation status was determined using NatureServe's Conservation Status Ranks (NatureServe 2008); see appendix 2 for detailed rank explanations. To improve organization and readability of appendix 2, we omitted state and regional ranks for taxa with secure (S5), apparently secure (S4), and not applicable (SNA) status, because these categories are not likely to be the focus of project planning. We do include ranks that indicate the species is *unranked* (SNR) or *unrankable* (SU) because those include many locally rare species for which there is little information but that could be impacted by fire-management projects. For example, the global and national conservation status for Allegheny Mountain dusky salamander is demonstrably secure (G5/N5). From a state and regional perspective, it is potentially a species of conservation concern at its northern range boundaries: historical records exist for New Jersey but it is now *presumably extinct* in New Jersey (SH), and it is *unranked* in Ohio (SNR) where it used to occur but historical records are sparse. Information is omitted for states where the species is *apparently secure* (S4) and secure (S5).

Appendix 3 summarizes the results of our quantitative analysis for each region. Within each region, data are sorted by each vertebrate class and, within each class, species are presented alphabetically by common name. For each species within a region, the average RAI is presented for each of the potential treatments; the first parenthetical entry is the standard error (SE), and the second entry is the sample size. The sample size represents the number of independent response measurements, not the number of studies. For example, a study reporting contrasts of burned and unburned plots may present measurements of the same plots before and after treatment (pre–post comparison) as well as contrasts of burned and unburned plots following treatment (after–only comparison). This situation is true for many of the studies from the FFS study system. Fire severity was classified as either low/moderate or high. Generally, data from wildland fires tended to be moderate/high severity while data from prescribed fire were low severity. We found no data for high-severity prescribed fire. All treatments were classified into three temporal categories (0–4 years, 5–9 years and more than 10 years). No fire surrogate studies were conducted more than 4 years post-treatment. Blank cells means there are no treatment data for that species and region. To reiterate the methods, we consider an average RAI of 0.40 or more to be evidence of a positive response to the treatment and an RAI of less than –0.40 to be evidence of a negative response to the treatment. All other values represent either no response or an inconsistent response. These arbitrary criteria will be evaluated in the future in a meta-analysis, but that is beyond the scope of the present synthesis.

For example, in the Pacific mixed-conifer ecoregion (figure 20), one study presents evidence that the American robin has a strong short-term and moderate-term positive response to high-severity fire. Three studies suggest this response is sustained for more than 10 years. In this region, there are no data on the response of American

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robins to low- or moderate-severity fire or to fire surrogates. In the eastern hardwood ecoregion (figure 20), two studies provide evidence that eastern chipmunks have a short-term positive response to low-or moderate-severity fire and the thinning + prescribed fire fuels reduction treatment. However, there is also evidence this species has a short-term negative response to the thinning treatment without prescribed fire. In this region, there are no data on the response of eastern chipmunks to high-severity fire (as expected, given the extremely rare nature of high-severity fire in the region) nor on moderate- and long-term responses to any of the treatments.

Appendix 4 presents the quantitative analysis in another format: the data were pooled over region, and mean RAI values (±SE, N) were calculated for each species. As in the other appendixes, species are sorted by vertebrate class and alphabetized within each class by common name. Appendix 4 allows managers to examine species responses in a broader context. This examination can serve two purposes: (1) highlights information that is available in other regions when no regional data are available; and (2) clearly identifies species that have been studied and, perhaps of equal importance, those that have not been studied.

In the next section, we summarize findings for each region. Like results reported by previous authors (e.g., Kotliar et al. 2002; Smucker et al. 2005; Kotliar et al. 2007; Saab et al. 2007a), tremendous variation existed in the species-specific responses to each treatment, both within and among regions. This variation, and the fact that our data have not been analyzed statistically, precluded us from describing any broad trends associated with the data. However, to assist managers with using our results in their project planning material, we present the major forest communities associated with each region and their disturbance history and management challenges. We then illustrate some observed trends in the data on responses of species of conservation concern associated with these forest communities.

The final results section is a summary of the FFS wildlife studies published to date. The FFS program covers many forest types and, with its consistent experimental design, warrants a national perspective. We also include in the FFS section summaries of similar experiments that were not part of the FFS Program.

Regional Summaries

Pacific mixed-conifer

The Pacific mixed-conifer region (figure 20) spans a wide latitudinal gradient and a correspondingly wide range of forest composition and fire regimes (figure 19). The forests of this ecoregion experience a dry to wet Mediterranean-type climate with hot, dry summers and wet winters; summers are longer in the south and shorter in the north. Topography typically is complex and deeply dissected. Forests are conifer dominated with varying degrees of co-dominance of broadleaf trees such as California black oak (*Quercus kelloggii*), madrone (*Arbutus menziesii*), and bigleaf maple (*Acer macrophyllum*). Typical conifer species in the Sierra Nevada are Jeffrey pine (*Pinus jeffreyi*), Douglas-fir (*Pseudotsuga menziesii*), sugar pine (*Pinus lambertiana*), incense-cedar (*Calocedrus decurrens*), and white fir (*Abies concolor*). Moving north, Douglas-fir increases in dominance, and more mesic species such as western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), and western white pine (*Pinus monticola*)

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may occur. Stand conditions are variable, but mature stands are structurally complex both vertically and horizontally. Levels of woody debris correspond to fire frequency and productivity (i.e., areas with frequent fire have lower amounts of woody debris).

Data on fire history and stand structure show broad variation in stand structure and fire regimes, much of which is associated with latitude, aspect, and elevation (Agee 1993; Taylor and Skinner 2003; Sugihara et al. 2006). The fire regime in the north of this ecoregion is best characterized as mixed-severity, with surface and stand-replacing fires occurring at varying frequencies and extents, leading to a fine-grained, complex mosaic of seral stages and forest types. Fire return intervals for the forests of the Klamath–Siskiyou region are 5–80 years and approaching 100 years in the southern Cascades and Coast ranges (Agee 1993; Arno 2000). Farther south (Sierra Nevada), the historic fire regime is hypothesized to be low to mixed severity with return intervals of 4–20 years. The frequent, small [1–800 ha, or 2.5–1,977 acres), low-severity fire regime resulted in relatively open forest stand structure with pole-size and larger trees (Sugihara et al. 2006).

Nineteen studies met our criteria in this region (appendix 1) including nine quantitative studies. The majority (67%) of the quantitative literature focused on effects of high-severity fire on birds (appendix 2). Of the wildland fire literature with quantitative information, there are data on 70 bird species but no data on other taxa. Three studies provide information on the responses of three small mammal species to prescribed fire and fire surrogates (appendixes 1 and 3). Fire-surrogate results are summarized in the section on the FFS Program.

We found little published data addressing the response of endangered or threatened species in the region; but, see Bond et al. (2002) for data on spotted owls. In comparison, the olive-sided flycatcher, a species of national conservation concern (appendix 2) but with no ESA status, has been fairly well studied in this region. It is the only species in this region with data on responses to both stand-replacing fires and low- or moderate-severity fires. Examination of the regional data as well as the pooled data (appendix 4) indicated this species positively responds to fire at all severities. The fire-created openings and pyrogenic structures, particularly abundant snags (a preferred perch for this species), may increase its access to its preferred prey, aerial insects. These data suggest fire suppression may be a contributory factor to the rangewide declines that have been reported for this species (Altman and Sallabanks 2000). Other species that respond positively to fire include species such as lazuli bunting and MacGillivray's warbler which require dense shrubs (Pitocchelli 1995; Greene et al. 1996) and are likely responding to the increased shrub cover that characteristically follows stand-replacing fires in this region (figure 13). Species that negatively respond to fire in this region include hermit thrush, hermit warbler, and sooty grouse which are associated with dense, mesic conditions typical of old-growth forest in this region (de Juana 1994; Jones and Donovan 1996; Pearson 1997).

Interior mixed-conifer

The interior mixed-conifer ecoregion includes the interior (east of the Cascade Range) Pacific Northwest, northern and central Rocky Mountains, as well as the Wasatch Front of Utah, and the Black Hills of South Dakota and Wyoming (figure 20). Like the Pacific mixed-conifer ecoregion, this area is characterized by a broad array of coniferous forest

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types but with a strong continental climate characterized by cold winters and shorter growing seasons. Elevational gradients combined with monsoonal summertime precipitation drive much of the changes in gross forest structure and composition (Agee 1993). Typical drier forests include ponderosa-pine-dominated stands which transition into co-dominant stands of Douglas-fir and, at higher elevations, transition to lodgepole pine, Engelmann spruce (*Picea engelmannii*), and subalpine fir (*Abies lasiocarpa*). Forests of the northern Rockies and inland Pacific Northwest also include grand fir (*A. grandis*), western larch (*Larix occidentalis*), and western white pine (*Pinus monticola*); see Agee (1993). The region is extremely mountainous, with complex topography and a corresponding wide variety of forest stand structures varying from dense, low-stature forests (high-elevation, lodgepole–spruce forests) to open, parklike stands of ponderosa pine and Douglas-fir.

Historic fire regimes within the interior mixed-conifer ecoregion vary widely and are associated with particular forest types (figure 19) including: ponderosa pine forests with an historic low-severity fire regime; mixed-severity Douglas-fir forests; and lodgepole pine and spruce–fir forests that have an historic regime of infrequent, stand-replacing fires (Agee 1993; Arno 2000; Keane et al. 2002). Transitions between forest types, and often fire regimes, are often driven by shifts in topographic and edaphic (soil) gradients. For example, Heyerdahl et al. (2001) showed strong topographic controls on fire frequency and severity in the Blue Mountains of the inland Pacific Northwest; southerly aspects burned more frequently with lower severity than northerly and easterly aspects, which had higher levels of stand-replacement fires at irregular intervals.

In this region, we found 25 wildlife studies (eight quantitative) matching our criteria for inclusion (appendix 1). Studies ranged across fire severities and time since fire, with a focus on short-term effects of high-severity fire. As in other regions, the bulk of the quantitative literature examined birds, but we did find information on short-term responses of two species of amphibians and one species of small mammal to high-severity fires (appendix 3). Two FFS studies have been conducted in this region (appendix 1).

Of species federally listed under the U.S. Endangered Species Act in this region, there is information on two species: Columbia spotted frog and long-toed salamander. Both amphibians were investigated in one study on the short-term effects of high-severity fire; no effect (positive or negative) was observed for either species. These results support the contention that pond-breeding amphibians are resilient to effects of high-severity fire, at least in the short-term (Hossack and Corn 2007).

The typical pattern described for woodpeckers after stand-replacement fire—short-term increases followed by declines—is demonstrated by regional data on the black-backed and American three-toed woodpeckers. These two species also demonstrate short-term increases in abundance after low- or moderate-severity fires. Data from other regions (appendix 4) suggest the decline in abundance of black-backed woodpeckers may take longer in low- to moderate- severity fires. In contrast, abundances of other woodpeckers (e.g., hairy woodpecker) can be sustained for longer periods; and some species, such as the northern flicker, do not increase in abundance until more than 4 years postfire. Other snag-dependent species such as the mountain bluebird also increase after high-severity fire, and these increases are maintained temporally. Low-severity fires in this region do not result in short-term increases in

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mountain bluebird abundance. The golden-crowned kinglet is an example of a species that negatively responds to fire; it is associated with mesic, closed-canopy older forests (Ingold and Galati 1997).

Pine west

The pine west ecoregion (figure 20) includes the southern Rocky Mountains as well as the plateau and sky island portions of Arizona and New Mexico. The climate in this area is monsoonal, with summer rain and snow in winter. At middle and lower elevations, these semiarid areas support forest communities of pure ponderosa pine stands. Because of highly combustible and continuous fine fuels (grasses, pine needle litter, etc.), a long fire season, and abundant lightning ignitions, the historic fire regime in the ponderosa pine forests were frequent, low-severity fires (Covington and Moore 1994; Brown and Smith 2000). Fire-return intervals of low-severity fires were as frequent as 5–15 years but more typically 20–40 years (Covington and Moore 1994). Stands had an open, parklike appearance, dominated by large, old, fire-resistant trees. Shrubs, understory trees, and downed logs were sparse; undergrowth was primarily fire-resistant grasses and forbs that resprouted and germinated after each burn (Arno 2000); see figure 26. As a result of decades of fire suppression and other land management activities such as grazing and logging these open park-like forests maintained by frequent surface fires have been replaced in many areas by dense stands capable of supporting crown fires (figure 26). Recent fire history evidence also suggests stand-replacing fires are not just a result of current conditions but occurred regularly in low-elevation southwestern ponderosa pine (Allen et al. 2002; Schoennagel et al. 2004).

As moisture increases, frequent, low-severity fire transitions into increasingly mixed-severity fire with irregular intervals which included periodic stand-replacing fires (Schoennagel et al. 2004). This was the historic regime in ponderosa pine communities in the Front Range in Colorado and in the Black Hills of South Dakota and Wyoming. At higher elevations, ponderosa pine is mixed with other, more mesic conifer species such as Douglas-fir, with occasional pure stands of lodgepole pine. These areas were historically mixed- or high-severity fire regimes (Arno 2000).

Twenty-one studies (15 quantitative) met our criteria in this region (appendix 1). With the exception of three FFS studies of small mammals, all studies in this region were conducted on birds (appendix 3). Data are available for a range of burn severities but longer term data are available only for high-severity fire. Five FFS studies have been published on wildlife in this region (appendix 1).

Results suggest that the northern goshawk, a species of national conservation concern in this region (appendix 2), responds positively to high-severity fire 4–9 years postfire. This species appears to not respond to the conditions created by moderate- and low-severity fire. Its congeneric, the Cooper's hawk, a common nesting raptor in these forests, responds negatively to high-severity fire but positively to moderate- and low-severity fire over all time periods. The response differences of these two congenerics to high-severity fire may be partially due to the differences in forest structure used by these species and their prey. The pyrogenic structures created by the fire can be used by the northern goshawk, which will nest in large-diameter snags if they are close to or embedded in unburnt forest (Squires and Kennedy 2006). Also, several species of woodpecker increase in high-severity fires, and these are regularly preyed

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upon by northern goshawks in this region. No data are available on the effects of high-severity fire on medium-size mammals (appendix 4), which are other common prey of northern goshawks in these forests (Kennedy and Cartron, in press). Snags are not a known nesting substrate for the Cooper's hawk (Rosenfield and Bielefeldt 1993; Cartron et al., in press). In this region and in these forest types, the Cooper's hawk commonly nests in stands with smaller diameter trees (Siders and Kennedy 1994 and 1996) which are more likely to combust during a high-severity fire. Thus, a high-severity fire may reduce Cooper's hawk nest site availability, at least for the time periods monitored in this synthesis, and this may offset any positive effects of increasing prey abundance postfire. We surmise the positive response of this species to low- and moderate-severity fire may be related to an increase in medium-size birds—e.g., western bluebird, hairy woodpecker, northern flicker—which are common in its diet in this region (Cartron et al., in press). However, many of these same prey species are also used by goshawks in this region (Squires and Kennedy 2006; Kennedy and Cartron, in press), so the absence of a positive response by goshawks to low- and moderate-severity fire is unclear and requires further investigation.

Species that respond negatively to conditions created by high-severity fire in this region include chipping sparrows and ash-throated flycatchers (a cavity nester). Interestingly, the nest parasite, the brown-headed cowbird, responds positively to all fire severities, and its responses are recorded in all time periods except for high-severity, 4–9 years postfire (this maybe an artifact of small sample sizes). Understanding the mechanism of this response is very important for conservation planning of species whose recovery is hampered by fire suppression and nest parasitism; e.g., Kirtland's warbler (see "Great Lakes" section for more information). The one mammal studied, the deer mouse, did not respond to prescribed fire over the short term.

Pine east

This ecoregion is the fire-maintained pine forests of the southeastern U.S. (figure 20). At the time of European settlement, these eastern pine forests totaled approximately 37 million ha (about 9.14 million acres) and dominated the coastal plain from southeastern Virginia to eastern Texas. These forests also extended onto the Piedmont, Cumberland Plateau, Ridge and Valley, and Blue Ridge physiographic regions. Today, only about 1.2 million ha (about 3 million acres) of this ecosystem remain, a 97% loss from its original extent (Van Lear et al. 2005). Regional climate is humid subtropical with frequent rain throughout the year. Associated with summer thunderstorms are the high number of lightning strikes, which are important sources of fire ignition.

The most extensive forest type historically was longleaf pine, but other pines such as loblolly, shortleaf, and slash (*Pinus elliottii*) grew with longleaf and also formed pure stands (Wade et al. 2000; Engstrom et al. 2005). In the absence of fire, hardwoods rapidly invade eastern pine forests, and eventually stands succeed into hardwood forests (figure 26). With frequent fire, hardwoods typically are restricted to mesic, fire-protected sites such as riparian zones and coves (Wade et al. 2000). Stand conditions in eastern pine forests are typically open, with a single-layer, pine-dominated canopy and an herbaceous-grass understory. Time since fire, combined with site productivity, tends to be correlated with the extent of woody understory plants.

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Fire return intervals in longleaf pine forests are extremely short, typically 1–5 years. Fire frequency in this system is extremely regular, particularly relative to mixed-severity regimes (Frost 1998). Frequent fires maintain grass and herbaceous understories and promote open stand conditions. Species such as longleaf pine are highly fire resistant and rarely die due to fire. Other pine forests in the region, particularly those at higher elevations in the Ozarks, may have fire return intervals closer to 10 years, but these forests possess similar structure and function with respect to fire.

The effects of fire and fire surrogates on wildlife have been studied most extensively in this region—27 investigations met our criteria for review (13 quantitative; see appendix 1). As in other regions, the majority of papers examined birds, but one species of reptile and four of mammal (three bats and raccoon) were also studied (appendix 3). All fire studies were conducted on low-severity fires, and almost all the data measured responses up to 4 years postfire, coinciding with the historic fire return interval. Five FFS studies on wildlife have been conducted in this region (appendix 1).

Perhaps the species most frequently identified with the longleaf ecosystem (and pine-dominated forests in the southeast in general) is the federally endangered red-cockaded woodpecker. This species positively responds to forest conditions created by frequent, low-severity fire. The open nature of fire-maintained eastern pine forests, with little midstory canopy, provides excellent foraging areas for the woodpecker. Red-cockaded woodpeckers prefer to use older pine stands where trees are big enough to permit cavity excavation; pines with brightly colored bark often indicate active woodpecker foraging and nesting in the area (Van Lear et al. 2005). In longleaf pine, a fire absence of about 10 years or more is associated with a decline and eventual local extirpation of red-cockaded woodpeckers (Engstrom et al. 1984; Jackson 1994).

Another species of conservation concern from this ecoregion is the Bachman's sparrow which has a short-term, positive response to low-severity fire. This sparrow nests in the species-rich grass, herbaceous, and small-shrub layer present in the initial years following fire. It utilizes the small shrubs for singing perches and consumes large quantities of grass seed (Van Lear et al. 2005). However by 5–9 years postfire, Bachman's sparrow no longer showed a detectable response to the initial fire disturbance (appendix 3). This finding is consistent with Tucker et al. (2004) who recommended prescribed fire on a 2–3 year rotation to maximize Bachman's sparrow abundance in longleaf pine stands (about 70 ha [173 acres] in size).

Effects of fire suppression on the diverse herpetofauna in this ecoregion have not been assessed quantitatively on a species-by-species basis. Fire and fire-surrogate data that met our criteria were available only for the federally listed gopher tortoise. The studies that have examined the effect of low-severity fire on tortoise abundance suggest it does not respond to the changed forest conditions created by fire. However, the fires in these studies were single, prescribed fires used to restore areas with a history of fire suppression. Thus, the one-time use of fire to manage tortoise habitat may not rapidly restore the open canopy, sparse woody midstory, and abundant herbaceous vegetation with which this species is associated (Yager et al. 2007).

Many other reptiles and amphibians in this ecoregion are likely fire dependent because ephemeral wetlands important to these fauna are fire maintained. In the absence of fire, vegetation succession tends to draw down water tables, leading to

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wetland decline and eventual loss (Van Lear et al. 2005). However, we lacked strong quantitative data on regional amphibian populations to evaluate in our analytical framework. Several published studies (Greenberg et al. 1994; Schurbon and Fauth 2003) report total abundances of reptiles, amphibians, or all animals without species-specific responses and/or abundances corrected for detection probabilities; so we did not include them in our quantitative analyses.

Eastern hardwood

The eastern hardwood ecoregion represents a large, diverse ecotype in the eastern portion of the United States (figure 20). This region is bounded to the north by the boreal forest, to the west by the prairie grasslands of the Midwest, and to the south and east by the southeastern coastal plain forests (Delcourt and Delcourt 2000). Transitions are driven by temperature (north and south) and moisture (east and west) gradients (Artman et al. 2005) which, in turn, support a diversity of broadleaf, deciduous forest types. The most extensive forest type within the region is oak–hickory (*Quercus–Carya* spp., also referred to as central hardwoods) which covers expansive areas in central and southern portions of the region. Moving south, forests transition to oak–pine and eventually to pine-dominated forests of the pine east ecoregion (Artman et al. 2005; see "Pine east" section). Moving north, oak-dominated forests grade into beech–maple (*Fagus–Acer* spp.) forests which then transition to northern hardwood forests of the Great Lakes ecoregion; see "Great Lakes," page 48). Fires are relatively unimportant in the ecology of the northern hardwood forests (Wade et al. 2000), so we did not include literature from these forest types. (Indeed, we found no fire-related studies from northern hardwood forests.) Our synthesis is focused on the oak-dominated forests, where recurrent fire is an important ecological process.

Fire in oak-dominated forests has been dominated by human ignitions both pre- and post- European settlement (Wade et al. 2000). Various dendrochronological and fire history studies have estimated fire return intervals at 3–10 years depending on method and forest type, as summarized in Artman et al. (2005). Across most of the ecoregion, fires were typically surface fires of low severity that promoted open, parklike conditions with oak-dominated overstories. To the north and east and at high elevations in the Appalachians, increasingly mesic conditions are associated with lower frequencies (fire return intervals approaching 35 years) of higher fire severity (Brown and Smith 2000).

Twentieth-century fire suppression practices have resulted in forests that are increasingly dominated by fire-intolerant, mesic forest species. In the last 10–15 years, concern has increased regarding long-term sustainability of oak-dominated forests. Prescribed fire, alone or in combination with thinning, has been widely advocated for restoring historic fire regimes, particularly in savannahs and oak-dominated forests (Artman et al. 2005). From a wildlife perspective, fire management in this region has some challenges related to the limited land base of forest in reserves; prescribed fire and fire surrogates can provide more favorable conditions for disturbance-dependent species associated with savannahs, woodlands, and early-seral-stage forests. But these same treatments can reduce habitat suitability for forest interior species, at least in the short term (Artman et al. 2005).

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Research on the role of fire in these forests and the use of fire for restoration has lagged behind that of other regions because of perceived risk of damage to economically valuable hardwoods, difficulty of controlling high-intensity fires on slopes, and the potential for soil and/or site damage (Brose et al. 2001; Waldrop et al. 2008). Thirteen studies, four from the FFS Program, met our criteria in this region (appendix 1). Although most information is on birds, this literature is taxonomically more diverse then the literature from other regions; four species of salamander and five species of small mammal have been investigated (appendix 3). All wildlife–fire studies conducted thus far are on short-term responses to low- and/or moderate-severity fire.

Based on our criteria, the majority of bird species studied in this region negatively responded to prescribed fire or were never detected as responding to the changed conditions created by fire (appendix 3). One of the few species that did respond positively to low-severity fire was the eastern wood-pewee; burning likely improved its foraging habitat by creating more open and parklike conditions in the understory, facilitating flycatching. Also, the indigo bunting and American goldfinch, species that prefer brushy thickets and abandoned fields near forests (Payne 1992; Middleton 1993), responded positively to fire, likely using the fire-generated openings in the forest canopy.

Many ground- and low-shrub nesting species were negative responders (at least in the short-term) to low-severity fire in this region. Species included ovenbird, hooded warbler, Kentucky warbler, Carolina wren, and black-and-white warbler. A reduction in ground cover following fire may expose nests and adults to increased predation. Nonresponders include canopy species that may be unaffected by low-severity surface fires with minimal overstory mortality and change in stem size distribution (Artman et al. 2001). These included Carolina chickadee, blue-headed and red-eyed vireos, tufted titmouse, and white-breasted nuthatch (appendix 3).

Of the four salamander species for which there is information on fire effects, one species (Jordan's salamander) is listed as vulnerable globally and nationally (G3/N3). This species is a nonresponder to low- and moderate-severity fire. The restoration fires where this species was studied created watershed-scale mosaics with a high level of fine scale variability. This variability resulted in frequent unburned patches within fire perimeters, which likely provided refugia for Jordan's salamander, which is associated with damp litter and other mesic forest floor conditions in riparian areas (Ford et al. 1999).

Great Lakes

The Great Lakes ecoregion is the southern terminus of the expansive mixed-wood boreal forests typical of southern Canada (figure 20). This region is lower elevation (330–560 meters, or 1,083–1,837 feet), has relatively little topographic relief, and typically experiences cool, wet summers and cold, dry winters. Components include northern hardwood (e.g., birch–aspen or *Betula–Populus* spp.), jack pine, and mixed forests of red pine (*Pinus resinosa*) and eastern white pine (*Pinus strobes*) with minor amounts of black spruce (*Picea mariana*) and white spruce (*Picea glauca*). Aspen (*Populus* spp.) occurs throughout the region at varying levels of dominance. Because these forests share a common climatic condition of harsh, cold winters, forest type is often controlled by soil and topographic position. For example, black spruce is largely

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limited to peat bogs and swamps in this region, while pure jack pine stands are largely on sandy, well-drained, infertile soils (Tester 1995; Duchesne and Hawkes 2000; Boal et al. 2006).

Fire regimes vary strongly by forest type. In northern hardwood forests, fire is rare, occurring at intervals of multiple centuries (Wade et al. 2000). Most northern hardwood tree species are *fire sensitive* (easily killed by fire), and fire events are thought to be largely stand-replacing. Similarly, black spruce stands also experience stand-replacement fire at fairly long intervals, about 100–200 years (Duchesne and Hawkes 2000). Other conifer forest types in the region tend to be maintained by fire. For example, jack pine is a fire-adapted species with *serotinous cones* (a pinecone or other seed case that requires heat from a fire to open and release the seed); the forest type is characterized by stand-replacing fires that occurred every 20–200 years. Red and eastern white pine stands are best characterized as occurring in landscapes with a mixed-severity fire regime. These forests often have components of fire-sensitive hardwoods which are killed by surface fires at 20- to 40-year intervals and stand-replacing events occurring every 100–200 years. Similarly, white spruce forests experience a combination of surface and stand-replacing fires on similar time scales (Duchesne and Hawkes 2000).

The effects of fire on wildlife in these forests within the U.S. have not received as much investigation as in other regions; six studies (three quantitative) met our criteria for inclusion (appendix 1). As in other regions, most quantitative information on fire effects has been on birds (appendix 3). All avian data were collected in areas experiencing high-severity fires, but data exist for three postfire time periods (0–4 years, 5–9 years, more than 10 years). Additionally, information is limited on the short-term response of two species of small mammal to low- and moderate-severity fire. For managers working in boreal forest types, we also recommend two recent reviews of boreal forest research conducted on wildlife in Canada. Schieck and Song (2006) review avian responses to fire and timber harvest, and Fisher and Wilkinson (2005) review mammal response to fire.

To our knowledge, there are no quantitative data comparing burned and unburned forests on the "poster child" of fire exclusion in this region, the federally listed Kirtland's warbler (appendix 3). Kirtland's warbler is well-studied in terms of its habitat preference for large stands of early-seral, fire-generated jack pine (Mayfield 1992). Warblers tend to occupy jack pine stands about 5 years postfire, when young trees are 1.5–2 meters (4.9–6.6 feet) tall and persist until trees are about 6 meters (about 20 feet) tall (Mayfield 1992), which equated to 16 years postfire on warmer, more productive sites (Kashian and Barnes 2000). There also is no regional information on the effects of fire on the brown-headed cowbird, a major nest parasite of the Kirtland's warbler. Data from other regions suggest the brown-headed cowbird has a mixed response to fire, with more positive than negative responses in other regions. This variable response is likely tied to responses of cowbird nest parasites as well as fire effects on ground vegetation where cowbirds feed on seeds and arthropods (Lowther 1993).

A consistent pattern in the data is the negative response of hardwood-associated, canopy-foraging wood warblers (Paurulidae) to high-severity fire during the breeding season (appendix 3). This includes species such as bay-breasted warbler, blackburnian

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warbler, and Cape May warbler. Wood warblers breed in forested habitat, attaining the highest species diversity in forests with both hardwood and coniferous components. Any fire that disrupts the canopy would negatively impact these species at least over the short and moderate term. (Note that other canopy-removing disturbances such as spruce budworm outbreaks may lead to increases in abundances in, for example, Cape May warbler (Crawford and Jennings 1989). As noted for other regions, ground- and shrub-foraging species in these forests responded positively to high-severity fire, although the response may be delayed (e.g., American redstart, black-and-white warbler, Nashville warbler, magnolia warbler). The delay is likely related to the time it takes shrubs and their associated invertebrates to recolonize the area. Species for which we found no response to fire over any of the three time periods included hairy woodpecker and Philadelphia vireo.

Of the two small mammal species, the deer mouse in this region responded positively to low- and moderate-severity fire, and the eastern chipmunk did not demonstrate a response to low- or moderate-severity fire. Mammalian responses to high-severity fire in this region need further investigation.

Fire and Fire Surrogate Program

Overview

The primary goal of the FFS Program is to measure the effectiveness and ecological consequences of commonly used treatments intended to reduce potential fire hazard at each of 12 sites (figure 5): five in eastern forests and seven in western forests (Schwilk et al. 2009). All ecoregions have at least one FFS site except for the Great Lakes ecoregion. The 12 sites vary widely in many attributes, including elevation, tree species composition and productivity, and management history (figure 5; tables 1 and 2). All western sites are conifer-dominated forests, largely Douglas-fir and yellow pine species. The five eastern FFS sites include two hardwood-dominated and three pine-dominated sites. Details of treatments and past management at each site are summarized in table 1. All FFS studies published (or in press and available to us) as of September 1, 2008, are in appendix 1. In a recent summary of the FFS Program, McIver et al. (2008) noted that all FFS site treatments were designed to produce stands in which 80% of the dominant and co-dominant trees would survive a wildfire under 80th percentile fire weather conditions. Additionally, repeated application of prescribed fire and mechanical surrogates (i.e., thinning, mastication) were intended to restore historic stand structure and conditions reflective of pre-European settlement. Site-level treatments included no treatment (control), prescribed fire only, mechanical treatment only, and a mechanical + fire treatment. The mechanical treatment at most sites was thinning the forest canopy; but at one site the mechanical treatment was herbicide, and a second site used shrub removal. We did not evaluate herbicide and shrub removal in this synthesis because they have not been widely applied according to the wildlife and fire literature. Not all treatments were applied at each site, and the number of replicates per treatment varied across sites.

Each of the 12 sites implemented treatments with the help of local experts, including fire management personnel, fuel specialists, and silviculturists (McIver et al. 2008). At each site, treatments were assigned randomly to 1–6 replicate units, each measuring at least 14 ha (35 acres) in size. Thus, the spatial scale of inference is the stand, not the

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Table 1. Past management history and treatment information for the 12 National Fire and Fire Surrogate Study sites. (Schwilk et al. 2009)

Site name and location[1]	Mechanical methods	Burn methods	Data collection years		
			Pre-treat	First	Final
Northeastern Cascades, Okanogan-Wenatchee National Forest, central Washington (Dodson et al. 2008)	2001: Fell, limb and buck with chainsaws; yard with helicopter, residue on site	2004: Spring under-burn using combination of backing and strip head-fires	2000	2004	NA
Blue Mountains, Wallowa-Whitman National Forest, northeastern Oregon (Youngblood et al. 2006)	1998: Fell, limb and buck with tracked single-grip harvester; yard with forwarders; residue left on site	Burn (2000): Fall under-burn, strip head-dire	1998	2001	2004
Northern Rocky Mountains, University of Montana, Lubrecht Experimental Forest, western Montana (Metlen and Fiedler 2006)	2001: Fell, limb and buck with tracked single-grip harvester; yard with forwarders; residue left on site	Burn (2002): Spring under-burn, strip head-fire	2001	2002	2005
Southern Cascades, Klamath National Forest, northeastern California (George and Zack 2008)	Mechanical (2001): Fell with feller-buncher; yard whole trees with rubber-tired or tracked skidders	Burn (2001): Fall under-burn, strip head-fire	NA	2004	NA
Central Sierra Nevada, University of California, Blodgett Forest Experiment Station, central California (Stephens and Moghaddas 2005)	2002: Fell, limb and buck trees >25 cm dbh with chainsaws; lop and scatter tops and limbs; yard with skidders; post harvest masticate 90% of trees <25 cm dbh	2002: Fall under-burn using a combination of backing and strip head-fires	2001	2003	NA
Southern Sierra Nevada, Sequoia National Park, south-central California (Knapp et al. 2005)	None	2002, 2003: Fall and spring under-burn, using strip head-fires	2001	2002	2004
Southwestern Plateau, Kaibab and Coconino National Forests, northern Arizona (Converse et al. 2006c)	2003: Fell, limb, and buck trees > 13 cm dbh with chainsaws; fell and lop trees < 13 cm to waste with chainsaws	2003: Fall under-burns conducted as both backing and strip head-fires	2000	2004	NA
Central Appalachian Plateau, Mead Corporation, Ohio State Lands, southern Ohio (Waldrop et al. 2008)	2001: Fell, limb, buck trees >15 cm dbh with chainsaws	Burn (2001): Spring under-burns conducted as strip head-fires	2000	2002	2004
Southern Appalachian Mountains Green River Wildlife Conservation Lands, western North Carolina (Waldrop et al. 2008)	Late 2001-early 2002: Chainsaw felling all tree stems >1.8m height and <10.2 cm dbh as well as all shrubs, regardless of size.	Burn (2003, 2006): winter ground fires were ignited by hand and by helicopter using the strip head-fire and spot fire techniques	2000,2002	2004	2006
Southeastern Piedmont Clemson University Experimental Forest, western South Carolina (Phillips and Waldrop 2008)	Late 2000-early 2001: Fell with feller buncher, yard whole trees with rubber-tire skidders, slash distributed across the site.	Burn only 2001 and 2004, mechanical + burn 2002 and 2005: Winter ground fires ignited by hand using the strip head-fire technique	2000,2001	2002	2003
Gulf Coastal Plain Auburn University Solon Dixon Experimental Forest, southern Alabama (Outcalt 2005)	2002: Fell with feller-buncher; chainsaw limb, tree yarded with rubber-tire tractor	2002: Spring under-burn, strip head-fire	2001	2002	2003
Florida Coastal Plain Myakka River State Park, west-central Florida (Outcalt and Foltz 2004)	2002: Chop with Marden aerator pulled by 4 wheel drive rubber tired tractor	2000, 2001: Spring under-burn, strip head-fire	2000-2001	2001	2003

[1] Location of each site is depicted in figure 5.

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Table 2. Summary of wildlife studies conducted in the 12 National Fire and Fire Surrogate Study sites[1].

Site name[2]	Region[3]	Forest type	# Wildlife studies[4]	Bird	Bat	Small mammal	Amphibian	Reptile
Northeastern Cascades	Pacific Mixed Conifer	Ponderosa pine/ Douglas-fir/ grand fir	1	X				
Southern Cascades	Pacific Mixed Conifer	Ponderosa pine/ white fir/red fir	2	X		X		
Central Sierra Nevada	Pacific Mixed Conifer	Sierra mixed conifer	1			X		
Southern Sierra Nevada	Pacific Mixed Conifer	Sierra mixed conifer	1			X		
Blue Mountains	Interior Mixed Conifer	Ponderosa pine/ Douglas-fir	1			X		
Northern Rocky Mountains	Interior Mixed Conifer	Ponderosa pine/ Douglas-fir	1			X		
Southwestern Plateau	Pine West	Ponderosa pine	5	X		X		
Central Appalachian Plateau	Eastern Hardwoods	Oak hickory	0					
Southern Appalachian Mountains	Eastern Hardwoods	Appalachian hardwood	4	X		X	X	X
Gulf Coastal Plain	Pine East	Longleaf pine	1			X		
Florida Coastal Plain	Pine East	Pine flatwoods	1			X		
Southeastern Piedmont	Pine East	Piedmont pine	1		X			
Jemez Mountains[5]	Pine West	Ponderosa pine/ Douglas-fir/ southwestern white pine/aspen	2					

[1]Additional experimental design details are provided in Table 1 for each FFS site.

[2] Location of each site is depicted in figure 5.

[3]Regional locations are depicted in figure 20.

[4]This is the number of studies published in the peer-reviewed literature as of September 1, 2008.

[5]This site was discontinued as an FFS site in 2002 due to a wildfire and is not depicted in figure 5. The site is located in north-central New Mexico.

landscape. The use of randomization is an important feature of these experiments; it allows inference beyond sampled stands. Nonrandom sampling—or what Anderson et al. (2001) refer to as *convenience sampling*— is common in the wildlife fire effects literature, and without randomization there is no way to determine whether a sample is representative of the population of interest.

Treatment effects were evaluated for a wide variety of variables at the 12 sites, including trees and other vegetation, the fuel bed, soils (both chemical and physical), bark beetles (pine sites only), and wildlife (table 2). At each site, teams of scientists are attempting to measure and project the consequences of the different treatments on the following:

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1. *Presence or absence of focal vertebrate species* (emphasis is on species that colonize sites in response to fire or fire surrogates and those that tend to disappear following treatment);
2. *Changes in vertebrate abundance* (shifts in abundance of each species in response to the treatments will be assessed both over the short term (1–2 years) and longer term (5 years and longer);
3. *Avian nest productivity* (knowing how production of avian young and nests changes in response to fire and fire-surrogate treatments will be used to predict longer term demographic effects); and
4. *Avian functional responses;* e.g., How will the "bark-gleaners" respond to treatment? (McIver and Erickson 2007). The focal wildlife taxa in this program are birds, small mammals (e.g., shrews, bats, and rodents), and herpetofauna.

The spatial scale of treatments precluded any analyses of wide-ranging animals such as ungulates and mesocarnivores.

Fire and fire-surrogate results

Wildlife investigations have been published from all sites except the Central Appalachian Plateau site (table 2). Ten of 13 wildlife studies conducted at FFS sites contained data on abundance that could be used to compare treatments and controls. In addition, several papers in appendix 1 are listed as fire surrogate studies that were based on similar experiments but were not part of the FFS Program (e.g., Provencher et al. 2002a and 2002b). Eleven of the 13 papers were analyses of single sites, one paper compared two sites, and one paper was a multisite analysis (eight sites).

The results of these experiments clearly indicate the following:

1. Species vary in their response to treatments;
2. Fire-surrogate treatments generate different responses than do fire treatments; and
3. There are substantial year and site effects.

We illustrate these patterns with summaries of a few studies below.

Herpetofauna: Greenberg and Waldrop (2008) have published the only paper on the effects of fuels-reduction treatments on herpetofauna. They conducted their study at the Southern Appalachian Mountains site (figure 5). Relative abundance of total salamanders, three common salamander species (red-spotted newt, Plethodon complex, and northern red salamander), and total amphibians was not changed by any of the fuels-reduction treatments (described in table 1). Total anurans (frogs and toads) and the American toad were most abundant in the prescribed fire and the combined mechanical understory reduction + prescribed fire treatments. Total reptile abundance and northern fence lizard abundance was lower in burn-only stands as compared to the combined treatments, but neither treatment differed from control stands. Greenberg and Waldrop (2008) concluded that a single application of fuels reduction will not negatively impact herpetofauna abundance or diversity in the area they studied (hardwood-dominated southern Appalachian forest). Greenberg and Waldrop (2008) also suggested that mechanical understory reduction combined with a prescribed burn could be used as a management tool to increase reptile abundance (particularly lizards) with no negative short-term impact on amphibians at the stand

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scale. However, the scope of inference of this study is quite limited due to use of abundances and count indices unadjusted for capture probabilities—a major problem with taxa that are difficult to detect, such as amphibians and reptiles. Thus, extension of Greenberg and Waldrop's (2008) results to other sites or forest types should be done cautiously and in an experimental manner permitting rigorous evaluation and testing of hypotheses.

Birds: Five studies have been conducted on avian responses to fuels-reduction treatments; three were included in the quantitative portion of our review (two from the pine west ecoregion and one from the eastern hardwood). To illustrate general trends, we summarize a recent study by Hurteau et al. (2008). We chose this paper because it is the only experimental study that estimates avian densities adjusted for detection probabilities.

Hurteau et al. (2008) found fuel-reduction treatments (thinning) at the Southwestern Plateau site (figure 5) did not affect species richness or evenness of the avian community in treatment stands. However, thinning did affect breeding season densities of five focal species, but effects were inconsistent across species. Dark-eyed junco was insensitive to all treatments. In contrast, density of mountain chickadees was reduced 50% in the thin-only treatment and also decreased in the thin + burn treatment but did not change in the burn-only treatment. Pygmy nuthatch was a positive responder to the thin + burn treatments, where densities increased by more than 500%, and showed no change in thin-only and burn-only treatments. Western bluebird density more than doubled in burn-only and thin + burn treatments, whereas density did not change in the thin-only treatment. Yellow-rumped warbler was not sensitive to the burn-only treatment and responded negatively to thin-only and thin + burn treatments (density within the thin + burn treatment decreased by 100%).

Bats: One FFS study on bats is the only published study we could find on bat response to fire of any type across the U.S. Summer bat activity (as an unadjusted index of abundance) was studied by Loeb and Waldrop (2008) at the Southeastern Piedmont site (figure 5, tables 1 and 2). Activity of the three most common species (big brown bats, eastern red bats, and eastern pipistrelles) was higher in the first year post-treatment than the second year post-treatment. In the first year post-treatment, overall bat activity was greater in the thin-only stands, but bats' positive response to this treatment was not present in the second year post-treatment. Activity of big brown bats and eastern red bats was significantly greater in thin-only stands than in control and burn-only stands, but there was no difference in activity between control and burn-only stands for either species. There was no significant difference in activity of eastern pipistrelles among treatments. These results suggest treatments, particularly thinning, that reduce clutter in understory structure such as saplings, subdominant hardwoods, and large shrubs will increase habitat suitability of pine stands in this area for bats during the first summer post-treatment. However, the effect may not last beyond the first year post-treatment.

Small mammals: Eight FFS studies have been published on small mammal responses to fuels-reduction treatments at nine sites (table 2). Two studies were conducted at the Southern Appalachian Mountains (Greenberg et al. 2006 and 2007a) and Southwestern Plateau sites (Converse et al. 2006a and 2006b); see figure 5. Single studies were conducted at the Central Sierra Nevada (Amacher et al. 2008), Southern Sierra Nevada

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(Monroe and Converse 2006), and the Jemez Mountains (Converse et al. 2006c). One study was a cross-site comparison that evaluated consistency of animal responses across the longitudinal gradient characterized by the FFS network of eight sites (Converse et al. 2006c). Unlike studies on other taxa, abundances of small mammals were generally adjusted for capture probabilities (at least for the common taxa) in these investigations.

The Converse et al. (2006c) cross-site comparison was conducted at six western and two eastern sites. Some of the remaining sites not included in Converse et al. (2006c) are summarized in the aforementioned studies, but their data were not available at the time of the cross-site analysis. Individual species and taxa (e.g., species pooled by genus when insufficient data were available for each species) appear to have variable responses to fuels-reduction treatments in different areas. For example, golden-mantled ground squirrel responded positively to the thin + burn treatment and was a nonresponder to the thin-only and burn-only treatments at the Southern Cascades site. At the Blue Mountain site, this species was a nonresponder to all treatments. However, total small-mammal biomass appears to increase after any type of fuels-reduction treatment.

CONCLUSIONS

So what did we learn? Many published studies examine short-term response of wildlife to both low (surface) and high (stand-replacement) fire. The majority of these studies are on birds and small mammals from the western and southeastern portions of North America. (The large wildlife–fire literature from the boreal forests of Canada were beyond the scope of this document.) While our current capacity to make broad, confident generalizations about species responses remains quite limited, the literature is quite clear on a number of points.

Dry forests of the United States are almost categorically fire dependent. Thus, many of the vertebrate species found in these habitats depend on fire-generated (pyrogenic) features at various scales ranging from individual trees (snags) to patches (edge creation, early seral habitat) to landscapes (mosaic). For example, ground-dwelling and/or -nesting species in longleaf pine forests (Bachman's sparrow, gopher tortoise, etc.) require frequent surface fires to maintain bare ground and herbaceous understory. Tucker et al. (2004) found that fire intervals longer than 3–4 years led to decreases in numbers and nesting success of Bachman's sparrow. Saab and Dudley (1998) and Saab et al. (2007b) documented black-backed and hairy woodpeckers' use of fire-created snags for nesting and foraging sites after stand-replacement fire. Thus, it is clear that many (but not all!) species of wildlife inhabiting dry forests have evolved with, and depend on, the structure and conditions created by fire of differing severities and extents.

Major limitations in our knowledge base exist with respect to particular fire or fire-surrogate prescriptions (but, note the rapidly growing literature from the FFS system) and in certain taxa such as herpetofauna and ungulates. Although literature exists on fire's effects on mesocarnivore and ungulate habitat, we found no studies that examined demographic responses of these mammals to fire or fire surrogates. So, for many projects, managers will be faced with predicting impacts on taxa for which

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information is scant. For this scenario they have several options. First, clearly state that no information is available on fire effects for the species of interest. Then, this less-than-satisfying conclusion can be augmented with information on fire effects of closely related species (*surrogate species*) and/or *guilds*.

Surrogate species are used in a variety of conservation contexts—see Caro and O'Doherty (1999) for details, and Fair et al. (1995) for an example—and are sometimes referred to as *management indicator species*. In the case of fire management effects, a fire manager would use the response of a surrogate species to predict the response of the species of concern to a fire management plan. Thus, the surrogate should have similar ecological requirements to the species of conservation concern but have a more tractable population in terms of ease of monitoring. Also, the surrogate is most useful if it is predicted to respond to fire management in the same manner as the species of concern.

A guild is a group of functionally similar species in an ecological community that exploits the same set of resources in a similar fashion but is not necessarily closely related taxonomically (Root 1967; Simberloff and Dayan 1991). Although identifying surrogate species and guilds is beyond the scope of this document, a plethora of natural history is available for U.S. wildlife that could be used to identify guilds and surrogate species for a project. For example, the natural history of every bird species is available online from The Birds of North America (http://bna.birds.cornell.edu/bna; accessed 12/03/08). Saab et al. (2007a) summarize avian guilds of importance to fire managers in western dry forests. Although guilds are used extensively to group ecologically similar birds, they can be expanded to include vertebrates from multiple classes. For example, a cavity-nesting guild in the Pacific mixed conifer region could include woodpeckers as well as bats and flying squirrels.

In species for which there is quantitative information, responses to treatments varied by taxa, study area, and time since treatment. Even taxa generally viewed as strong positive responders to fire, such as woodpeckers, do not have consistent responses to high-severity fire. For example, some species of woodpeckers (e.g., pileated woodpeckers and red-breasted sapsuckers) are negative responders to high-severity fire in the short term, whereas others (American three-toed and black-backed woodpeckers) are strong positive responders to high-severity fire in the short term (appendix 4). The study area differences are best illustrated in the Converse et al. (2006c) multisite analysis of FFS small mammal data. Sufficient data were available from six FFS sites to evaluate response of deer mice to treatments. At four of the six sites, the deer mouse was a nonresponder to all treatments, but at the Northern Rocky Mountain site it was a positive responder to prescribed fire, a nonresponder to thin-only, and a negative responder to the thin + burn treatment. At the Jemez Mountain site, deer mice were positive responders to the thin-only treatment. These results demonstrate the overwhelming effect site conditions had on FFS study results. In many cases, the site effect overwhelmed any effect of treatment. This is likely caused by the extreme heterogeneity in pretreatment site conditions, which influenced the post-treatment site conditions. The ability to identify consistent treatment effects in the FFS studies is also hindered by a lack of understanding of the treatments' effect on local habitat features that influence local wildlife demography.

Given that responses to treatment vary by taxa and study area, we concur with

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Converse et al. (2006c) that managers' ability to predict short-term responses of individual wildlife species to fuel reduction treatments is limited currently. Predicting longer term responses may be even more difficult. Therefore, it is not possible to make prescriptive recommendations about population management based on our results. When managers are interested in avoiding negative impacts to a particular species from fuel-reduction treatments or want to enhance a population with fire restoration treatments, it is necessary for them to determine which of a suite of possible treatments is most effective in their area. Projects may be implemented as scientific studies of testable hypotheses developed from the species-specific data presented in this document. The hallmark of adaptive management is monitoring species response (or response of the species' surrogates and/or guild members, if its rarity results in sampling difficulties) to the treatments and then incorporating that information into local knowledge and subsequent management. Ideally, results also would be published in the scientific literature so that this knowledge is archived and accessible to other managers. If an impediment to this adaptive management approach is insufficient resources, we suggest partnering with the local university. Many of these types of projects are excellent thesis and dissertation topics.

KNOWLEDGE GAPS

A great deal has been learned about the effects of fire and fire surrogates on wildlife over the past century. Typical of scientific inquiries, more questions have been raised than answered by these investigations. Although the list of questions is endless, there are a few priority areas that need future research. Some are discussed below.

Mixed-Severity Fire

Many forested ecosystems are classified as existing in landscapes characterized as having either low-severity or high-severity fire regimes, but in reality are best characterized as experiencing a mix of high- and low-severity fires of differing intervals and extents. Much remains to be learned of mixed-severity wildfire, including its capacity to generate and maintain a range of seral stages, landscape mosaics, and increased amounts of edge habitat. Applicability of results from existing studies is difficult given the limited information on the spatial pattern of fires and sample points. Future studies examining landscape-scale response to fire would be extremely fruitful.

High-Severity Prescribed Fire

The published scientific literature on wildland fire is extremely valuable, but we still lack adequate knowledge to evaluate wildland fire use in many ecosystems. Currently, our knowledge of high-severity fire effects is limited to the wildland fire studies that are fraught with the normal experimental design limitations of quasi-experiments. To clearly identify responses of wildlife to high-severity fire, we need experimental testing. Adding high-intensity fire as a treatment in the FFS Program should be given serious consideration.

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Long-Term Response to Single and Multiple Fires

We think the FFS Program is a great model for conducting research with national applicability, but like all research programs it does have limitations. From a wildlife perspective, data from this program cannot be used to infer fire effects at landscape scales, the effects of repeated treatments, long-term responses of wildlife to treatments, and effects of prescribed high-severity fire. The current FFS Program could be expanded to obtain long-term response information by repeated sampling every 5–10 years post-treatment for several decades. If additional experiments are conducted in the FFS Program, we recommend they be designed to include larger treatment areas (e.g., 247–494 acres [100–200 hectares]), repeated treatments (two to three), and prescribed high-severity fire as an additional treatment.

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APPENDIX 1. SUMMARY AND DETAILS OF THE SCIENTIFIC LITERATURE

Appendix 1. Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Pacific Mixed																		
Amacher et al. 2008	Forest Ecology and Management	Yes	225 (556)		1	X	X		su		X	X					X	
Bagne et al. 2008	Forest Ecology and Management	No	360 (890)						su		X				X			
Bock and Lynch 1970	Condor	Yes	18,000 (44,479)						su	X					X			
Bock et al. 1978	Wilson Bulletin	Yes	15,800 (39,043)						su	X					X			
Bond et al. 2002	Wildlife Society Bulletin	No						Yes	su	X					X			
Converse et al. 2006c	Ecological Applications	Yes		6.25 (15)	0-2	X	X	Yes			X	X					X	
Fontaine et al. 2009	Forest Ecology and Management	Yes	200,000 (500,000)		2-18			Yes	su	X					X			
George and Zack 2008	Canadian Journal of Forest Research	No	1,200 (2,965)			X			su		X	X			X			
Huff et al. 1985	USDA Forest Service General Technical Report	No	3,000 (7,413)						su	X					X			
Huff et al. 2005	Studies in Avian Biology	Review								X	X				X			
Kotliar et al. 2002	Studies in Avian Biology	Review								X	X				X			
Meehan and George 2003	Auk	Yes	20,000 (49,421)		1-2				su	X					X			
Monroe and Converse 2006	Forest Ecology and Management	Yes	100 (247)	4.5 (11)	1-3	X	X	Yes	su		X						X	

continues

Appendix 1 (continued). Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Pacific Mixed																		
Raphael and White 1984	Wildlife Monographs	Yes	16,000 (39,537)	8.5 (21)	17				su	X					X			
Raphael et al. 1987	Condor	Yes	18,000 (44,479)	8.5 (21)	6-25				su	X					X			
Russell et al. 1999	Wildlife Society Bulletin	Review									X		X	X				
Saab et al. 2007a	USDA Forest Service General Technical Report	Review								X	X				X			
Smith 2000	USDA Forest Service General Technical Report	Review											X	X	X	X	X	X
Wisdom et al. 2006	Wildlife Society Bulletin	Review																X
Interior Mixed																		
Blackford 1955	Condor	No	275 (680)	10 (25)					f	X					X			
Bond et al. 2002	Wildlife Society Bulletin	No						Yes	su	X					X			
Converse et al. 2006c	Ecological Applications	Yes		6.25 (15)	0-2	X	X	Yes			X	X					X	
Dieni and Anderson 1999	Journal of Field Ornithology	Yes	750 (1,853)	0.75 (2)	2-7				su	X	X				X			
Haggard and Gaines 2001	Northwest Science	No	73,000 (180,386)						su	X					X			
Hossack and Corn 2007	Ecological Applications	Yes	9,830 (24,290)		1-3			Yes	su	X			X					
Hutto and Gallo 2006	Condor	No	1,600 (3,954)	24 (59)	2-4				su	X					X			
Hutto 1995	Conservation Biology	No	900,000 (2.2 mil)						su	X					X			
Kotliar et al. 2002	Studies in Avian Biology	Review								X	X				X			

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Appendix 1 (continued). Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Interior Mixed																		
Kreisel and Stein 1999	Wilson Bulletin	Yes	4,000 (9,884)		0-4				w	X					X			
Leidolf et al. 2007	Western North American Naturalist	Yes	800 (1,977)	0.79 (2)	2-3		X		su	X					X			
Lyons et al. 2008	Forest Ecology and Management	No	270 (667)			X			su		X	X			X			
Russell et al. 2007	Journal of Wildlife Management	No	134,000 (331,120)						su	X					X			
Russell et al. 1999	Wildlife Society Bulletin	Review									X		X	X				
Saab et al. 2004	Condor	No	134,000 (331,120)						su	X					X			
Saab et al. 2007b	Condor	No	134,000 (331,120)					Yes	su	X					X			
Saab and Dudley 1998	USDA Forest Service General Technical Report	No	132,000 (326,178)						su	X					X			
Saab et al. 2007a	USDA Forest Service General Technical Report	Review								X	X				X			
Saab et al. 2005	Studies in Avian Biology	Review								X	X				X			
Smith 2000	USDA Forest Service General Technical Report	Review											X	X	X	X	X	X
Smucker et al. 2005	Ecological Applications	Yes	125,000 (308,881)		1-3		X		su	X					X			
Stout et al. 1971	Northwest Science	Yes	22,672 (56,024)	0.09	3				su	X							X	
Taylor and Barmore 1980	USDA Forest Service General Technical Report	Yes	10,000 (24,710)		1-115				su	X					X			
Vierling et al. 2008	Journal of Wildlife Management	No	33,800 (83,521)		1-4				su	X					X			
Wisdom et al. 2006	Wildlife Society Bulletin	Review																X

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Appendix 1 (continued). Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Pine West																		
Blake 1982	Journal of Wildlife Management	Yes	4,800 (11,861)	5.5 (14)	2				f w sp	X					X			
Bock and Bock 1983	Journal of Wildlife Management	Yes	389 (961)		0-1.5				su		X				X		X	
Bock and Block 2005	Studies in Avian Biology	Review								X	X				X			
Converse et al. 2006c	Ecological Applications	Yes		6.25 (15)	0-2	X	X	Yes			X	X					X	
Converse et al. 2006a	Forest Ecology and Management	Yes		0.2 (0.5)	0-2.5	X	X	Yes			X	X					X	
Converse et al. 2006b	Journal of Wildlife Management	Yes		6 (15)		X	X	Yes	su	X		X					X	
Covert-Bratland et al. 2006	Journal of Wildlife Management	Yes	206,000 (509,035)		2-7			Yes	w	X					X			
Dwyer and Block 2000	Tall Timbers Fire Ecology Conference	Yes	17,000 (42,008)	0.8 (2)	1				su	X					X			
Horton and Mannan 1988	Wildlife Society Bulletin	Yes	100 (247)		1		X		su		X				X			
Hurteau et al. 2008	Journal of Wildlife Management	Yes	240 (593)		1-3	X	X	Yes	su		X	X			X			
Hurteau et al., in press	Forest Science	Yes	250 (618)	10 (25)	1-3	X			su		X	X			X			
Jehle et al. 2006	Condor	Yes	135 (334)		3-5			Yes	su		X				X			
Johnson and Wauer 1996	USDA Forest Service General Technical Report	Yes	6,250 (15,444)	40 (99)	1,2,4,6,14		X	Yes	su	X					X			
Kirkpatrick et al. 2006	Journal of Wildlife Management	Yes			6				su	X	X				X			
Kotliar et al. 2007	Ecological Applications	Yes	17,000 (42,008)	10 (25)	1-2		x	Yes	su	X					X			
Kotliar et al. 2002	Studies in Avian Biology	Review								X	X				X			

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Appendix 1 (continued). Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Pine West																		
Russell et al. 1999	Wildlife Society Bulletin	Review									X		X	X				
Saab and Vierling 2001	Condor	Yes	89,000 (219,923)	20 (49)	0-4				su	X					X			
Saab et al. 2007a	USDA Forest Service General Technical Report	Review								X	X				X			
Smith 2000	USDA Forest Service General Technical Report	Review											X	X	X	X	X	X
Wisdom et al. 2006	Wildlife Society Bulletin	Review																X
Pine East																		
Allen et al. 2006	Auk	Yes	40,000 (98,842)		0-3				su		X				X			
Brennan et al. 1998	Transactions of the 63rd North American Wildlife and Natural Resource Conference	Review								X	X		X	X	X		X	X
Converse et al. 2006c	Ecological Applications	Yes		6.25 (15)	0-2	X	X	Yes			X	X					X	
Emlen 1970	Ecology	Yes	400 (988)		0.25				wsp		X				X			
Engstrom and Conner 2006	Acta Zoologica Sinica	Review								X	X				X			
Engstrom et al. 2005	Studies in Avian Biology	Review								X	X				X			
Engstrom 1993	Tall Timbers Fire Ecology Conference	No													X	X	X	X
Engstrom et al. 1984	Wilson Bulletin	Yes	9 (22)						spsu		X				X			
Greenberg et al. 1994	Conservation Biology	No								X				X				

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Appendix 1 (continued). Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Pine East																		
Greenberg et al. 1995	Wilson Bulletin	No							su	X					X			
Guyer and Bailey 1993	Tall Timbers Fire Ecology Conference	No											X	X				
Jones and Chamberlain 2004	Wildlife Society Bulletin	No				X					X				X			
Jones et al. 2004	Wildlife Society Bulletin	Yes			1			Yes	su		X							X
King et al. 1998	Wilson Bulletin	No							w		X				X			
Loeb and Waldrop 2008	Forest Ecology and Management	Yes	168 (415)		1-2	X			su		X	X				X		
Masters et al. 2002	USDA Forest Service General Technical Report	Yes	60,000 (148,263)	0.48 (1)	1-3	X			su		X	X			X		X	
Provencher et al. 2002a	Auk	Yes	2,000 (4,942)		1-2	X			w		X	X			X			
Provencher et al. 2002b	Journal of Wildlife Management	Yes	2,000 (4,942)			X	X		su		X	X			X			
Russell et al. 1999	Wildlife Society Bulletin	Review									X		X	X				
Schurbon and Fauth 2004	Conservation Biology	No							su		X		X					
Smith 2000	USDA Forest Service General Technical Report	Review											X	X	X	X	X	X
Tucker et al. 2004	Journal of Wildlife Management	Yes	1,000 (2,471)		1-10				su		X				X			
Tucker et al. 2006	Wilson Bulletin	Yes	1,600 (3,954)		1-3				su		X				X			
White et al. 1999	Journal of Field Ornithology	Yes	2,500 (6,178)	0.8 (2)	1-3				su		X				X			

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Appendix 1 (continued). Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Pine East																		
Whiting et al. 2007	Tall Timbers Fire Ecology Conference	No	300 (741)						spw		X				X			
Yager et al. 2007	Journal of Wildlife Management	Yes	210 (519)	28 (69)	1	X	X		all		X			X				
Hardwood East																		
Aquilani et al. 2000	Natural Areas Journal	Yes	140 (346)		1-2				su		X				X			
Artman et al. 2001	Conservation Biology	No	300 (741)			X	X		su		X				X			
Artman et al. 2005	Studies in Avian Biology	Review								X	X				X			
Davis et al. 2000	Restoration Ecology	No	210 (519)	4 (10)					su		X				X			
Ford et al. 1999	Forest Ecology and Management	Yes	200 (494)	0.1 (0.2)	0-2				suf w		X		X	X			X	
Greenberg et al. 2006	Forest Ecology and Management	Yes	60 (148)	3 (7)	0.25	X	X	Yes	su		X	X					X	
Greenberg et al. 2007a	Forest Ecology and Management	Yes	60 (148)		0-1.5	X			suf		X	X					X	
Greenberg and Waldrop 2008	Forest Ecology and Management		60 (148)			X			su		X	X	X	X				
Greenberg et al. 2007b	Journal of Wildlife Management	Yes	60 (148)		0-2.5	X			su		X	X			X			
Grundel and Pavlovic 2007	Condor	No								X	X				X			
Russell et al. 1999	Wildlife Society Bulletin	Review									X		X	X				
Smith 2000	USDA Forest Service General Technical Report	Review											X	X	X	X	X	X
Tester 1965	American Midland Naturalist	Yes	6 (15)	6 (15)	0.1		X		sp		X						X	

continues

Appendix 1 (continued). Summary and details of the scientific literature included in this synthesis.

Region/author[1]	Journal	Quantitative[2]	Total area Treated, ha(ac)[3]	Plot area, ha(ac)	Time since fire (years)	Experiment	PrePost[4]	p(detect)?[5]	Season[6]	Wildfire	Rx Fire[7]	FFS[8]	Amphibian	Reptile	Bird	Bat	Small mammal	Large mammal
Great Lakes																		
Apfelbaum and Haney 1981	Condor	Yes	1,368 (3,380)						su	X					X			
Davis et al. 2000	Restoration Ecology	No	210 (519)	4 (10)					su		X				X			
Haney et al. 2008	American Midland Naturalist	Yes	1,368 (3,380)	9 (22)	1-30		X		su	X					X			
Russell et al. 1999	Wildlife Society Bulletin	Review									X		X	X				
Smith 2000	USDA Forest Service General Technical Report	Review											X	X	X	X	X	X
Tester 1965	American Midland Naturalist	Yes	6 (15)	6 (15)	0.1		X		sp		X						X	

[1]Year = Year of study publication

[2]Quantitative = Whether the study was included in the quantitative portion of our review (see methods for more details) and contributed data to appendices 3-4.

[3]Total area treated = For wildland fires, the total area burned and for fire surrogate treatments the total area of treatment units (rounded to the nearest whole number).

[4]PrePost = Whether the study included pre-treatment data (rounded to the nearest whole number).

[5]p(detect)? = Whether the study adjusted wildlife abundance for detection or capture probabilities.

[6]Season = Season of study; sp = spring, su = summer, f = fall, w = winter.

[7]Rx fire = Prescribed fire

[8]FFS = Fire and Fire Surrogate

APPENDIX 2. SCIENTIFIC NAMES AND CONSERVATION STATUS (FEDERAL, REGIONAL, AND STATE) OF WILDLIFE TAXA

Appendix 2 provides national and state-level conservation status of the vertebrate species (and some subspecies) included in the literature surveyed for this synthesis document. Conservation status was determined using NatureServe's Conservation Status Ranks (www.natureserve.org/explorer/ranking.htm). The NatureServe code has two parts, a numeric status rank ranging from critically impaired (1) to demonstrably secure (5) and a letter code referring to the scale of the assessment (G = global; N = national; S = state). Additional codes provide information on the quality of the information or status (e.g., NR = not ranked; U = unrankable; NA = not applicable, "?" = ranking uncertain; H = extirpated, etc). The data used to generate ranks as well as many other types of information are available from NatureServe (www.natureserve.org/explorer/ranking.htm).

To improve organization and readability of this appendix, we omitted state and regional ranks for taxa with secure (S5), apparently secure (S4), and not applicable (SNA) status. These categories are not likely to be the focus of project planning. We do include ranks that indicate the species is unranked (SNR) or unrankable (SU) because this includes many locally rare species for which there is little information but could be impacted by fire management projects. For example, the global and national conservation status for the Alleghany Mountain dusky salamander is demonstrably secure (G5/N5). From a state and regional perspective it is only potentially a species of conservation concern at its northern range boundaries: it has been recorded in New Jersey but is now presumably extinct (SH) and it is unranked in Ohio (SNR) where it used to occur. Information omitted from appendix 2 includes KY, VA and WV where the species is apparently secure (S4) and MD, NY, PA, and TN where the species is secure (S5; NatureServe 2008).

CODE KEY

NUMBERS: Numbers have the following meaning: 1 = critically imperiled, 2 = imperiled, 3 = vulnerable to extirpation or extinction, 4 = apparently secure, 5 = demonstrably widespread, abundant, and secure.

FIRST LETTER: The scale of the assessment: G = global, N = National, S = subnational (state)

OTHER LETTERS & SYMBOLS: NR = unranked, U = unrankable, X = extinct, H = presumed extinct, ? = uncertain numeric rank, B = breeding, M = migrant, N = nonbreeding.

Appendix 2. Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Amphibian			
Allegheny Mountain dusky salamander	*Desmognathus ochrophaeus*	G5 / N5	NJ(SH), OH(SNR)
American toad	*Bufo americanus*	G5 / N5	IN(SNR), LA(S3S4), MN(SNR), MO(SNR), NE(S1), ND(SNR), OH(SNR), SC(SNR), SD(SU), TX(S3)
barking treefrog	*Hyla gratiosa*	N5	DE(S1), FL(SNR), KY(S3), LA(S3S4), MD(S1), NC(S3S4), SC(SNR), TN(S3), VA(S1)
black-bellied salamander	*Desmognathus quadramaculatus*	G5 / N5	SC(SNR), WV(S3)
Blue Ridge two-lined salamander	*Eurycea wilderae*	G5 / N5	VA(S2)
boreal toad	*Bufo boreas boreas*	G4 / T4	CO(SNR), NV(S3S4), NM(SH), WY(S1)
Brimley's chorus frog	*Pseudacris brimleyi*	N5	GA(S1), NC(S3S4), SC(SNR),
Carolina gopher frog	*Rana capito*	G3 / N3	AL(S2), FL(S3), GA(S3), NC(S2), SC(S1), TN(S1)
Columbia spotted frog	*Rana luteiventris*	G4 / N4	AK(S2), ID(S3S4), NV(S2S3), OR(S2S3), UT(S1), WY(S3)
eastern narrowmouth toad	*Gastrophryne carolinensis*	G5 / N5	FL(SNR), IL(S2), KS(S1), MD(S1S2), MO(SNR), SC(SNR)
eastern newt	*Notophthalmus viridescens*	G5 / N5	DC(S3), FL(SNR), IL(S3S4), IN(SNR), IA(S2), KS(S1), MN(SNR), MO(SNR), NJ(SNR), OH(SNR), OK(S3), SC(SNR)
flatwoods salamander	*Ambystoma cingulatum*	G2 / N2N3	AL(S1), FL(S2), GA(S2), SC(S1)
gray treefrog	*Hyla versicolor*	G5 / N5	KY(S2S3), MN(SNR), MS(SNR), MO(SNR), NC(S1?), OH(SNR), OK(SNR), SC(SNR), SD(S2)
green frog	*Rana clamitans*	G5 / N5	IN(SNR), KS(S1), MN(SNR), MO(SNR), NJ(SNR), OH(SNR), SC(SNR),
Jordan's salamander	*Plethodon jordani*	G3 / N3	NC(S3?), TN(S2), VA(S3)
little grass frog	*Pseudacris ocularis*	G5 / N5	AL(S1), FL(SNR), SC(SNR), VA(S3)
long-toed salamander	*Ambystoma macrodactylum*	G5 / N5	AK(S3), CA(S3),
Mabee's salamander	*Ambystoma mabeei*	G4N4	NC(S3), VA(S1S2)
mole salamander	*Ambystoma talpoideum*	G5 / N5	AR(S3), FL(SNR), IL(S3), IN(S1), KY(S3), MO(S2), NC(S2), OK(S1), SC(SNR), TX(S3), VA(S2)
northern dusky salamander	*Desmognathus fuscus*	G5 / N5	AR(S2), FL(SNR), IL(SNR), NJ(SNR), OH(SNR), SC(SNR)
northern red salamander	*Pseudotriton ruber*	G5 / N5	DE(S3), DC(S3), FL(SNR), IN(SNR), LA(S2), MS(S3), NJ(SNR), NY(S3S4), OH(SNR), SC(SNR), WV(S3)
oak toad	*Bufo quercicus*	N5	FL(SNR), LA(S3S4), M NC(S3), SC(SNR), VA(S1S2)
ornate chorus frog	*Pseudacris ornata*	N5	FL(SNR), LA(S1), MS(S2S3), NC(S3), SC(SNR)
pickerel frog	*Rana palustris*	G5 / N5	IL(S3S4), KS(SH), MO(SNR), OH(SNR), OK(S2S3), SC(SNR), WI(S3S4)
pine woods treefrog	*Hyla femoralis*	G5 / N5	FL(SNR), SC(SNR)
seal salamander	*Desmognathus monticola*	G5 / N5	FL(S1), SC(SNR)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Amphibian			
seepage salamander	*Desmognathus aeneus*	G3G4 / N3N4	AL(S2), GA(S3), NC(S3), SC(SNR), TN(S1)
South Carolina slimy salamander	*Plethodon variolatus*		None
southern chorus frog	*Pseudacris nigrita*	G5 / N5	FL(SNR), LA(SNR), SC(SNR), VA(S2)
southern leopard frog	*Rana sphenocephala*	G5 / N5	DC(S2S3), FL(SNR), MO(SNR), NY(S1S2), PA(S1), SC(SNR)
southern toad	*Bufo terrestris*	G5 / N5	FL(SNR), SC(SNR)
spring salamander	*Gyrinophilus porphyriticus*	G5 / N5	CT(S2), ME(S3), MA(S3S4), MS(S1), NJ(SNR), OH(SNR), RI(S1), SC(SNR)
squirrel treefrog	*Hyla squirella*	N5	FL(SNR), OK(SNR), SC(SNR)
striped newt	*Notophthalmus perstriatus*	N2N3	FL(S2S3), GA(S2)
tiger salamander	*Ambystoma tigrinum*	G5 / N5	AL(S3), AR(S3), DE(S1), FL(S3), GA(S3S4), LA(S1), MD(S2), MI(S3S4), MN(SNR), MS(S1), MO(SNR), NJ(SNR), NY(S1S2), NC(S2), ND(SNR), OH(S3), OR(S2?), PA(SX), SC(SNR), VA(S1), WA(S3)
western toad	*Bufo boreas*	G4 / N4	AK(S3S4), CO(S1), MT(S2), NM(SH), OR(S3), UT(S2S3), WA(S3S4), WY(S1)
wood frog	*Rana sylvatica*	G5 / N5	AL(S2), AR(S3), CO(S3), DC(S2?), ID(SH), IL(S3), MN(SNR), MO(S3), ND(SNR), OH(SNR), OK(SNR), SC(S3), SD(S1), WY(S1)
Reptile			
black racer	*Coluber constrictor*	G5 / N5	AZ(S1), AR(SNR), FL(SNR), IN(SNR), ME(S2), MN(S3), MO(SNR), NH(S3), NM(S3), ND(SNR), OH(SNR), SC(SNR), VT(S1), WI(S2),
black rat snake	*Elaphe obsoleta*	G5 / N5	FL(SNR), IL(SNR), IN(SNR), MD(SNR), MA(S1), MI(SNR), MN(S3), MO(SNR), NJ(SNR), OH(SNR), RI(S2), SC(SNR), VT(S2), WV(SNR), WI(S2S3)
broad-headed skink	*Eumeces laticeps*	G5 / N5	DE(SH), DC(S1), FL(SNR), KS(S2), MO(SNR), OH(SNR), OK(S3), PA(S1), SC(SNR), WV(S2)
coal skink	*Eumeces anthracinus*	G5 / N5	AL(S3), FL(S3), GA(S2), IN(SNR), KY(S2), MD(SU), MS(S3S4), MO(SNR), NY(S2S3), NC(S2S3), OH(S1), OK(S3), PA(S3), SC(S1), TN(S1), VA(S2S3), WV(S2)
common snapping turtle	*Chelydra serpentina*	G5 / N5	IN(SNR), MN(S3), MO(SNR), MT(S3), NJ(SNR), ND(SNR), OH(SNR), SC(SNR),
copperhead	*Agkistrodon contortrix*	G5 / N5	AR(SNR), CT(S3), DE(S1), DC(S1), FL(S2), IN(SNR), IA(S1), MA(S1), NE(S2), NJ(SNR), NY(S3), OH(SNR), SC(SNR),
eastern box turtle	*Terrapene carolina*	G5 / N5	DC(S3), IN(SNR), IA(SU), ME(S1), MA(S3), MI(SNR), MO(SNR), NY(S3), SC(SNR)
eastern diamondback	*Crotalus adamanteus*	N4	AL(S3), FL(S3), LA(S1), MS(S3S4), NC(S1), SC(S3)
eastern fence lizard	*Sceloporus undulatus*	G5 / N5	AZ(SNR), DC(SH), FL(SNR), MO(SNR), NJ(SNR), NY(S1), OH(SNR), PA(S3S4), SC(SNR), SD(S2), WY(S3)
eastern garter snake	*Thamnophis sirtalis*	G5 / N5	CO(S3), FL(SNR), IN(SNR), MN(SNR), MO(SNR), NV(S3), ND(SNR), OH(SNR), SC(SNR), UT(S2S3)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Reptile			
eastern hognose snake	*Heterodon platirhinos*	G5 / N5	CT(S3S4), DC(SH), FL(SNR), IN(S3), MI(S3S4), MO(SNR), NH(S3), NY(S3), PA(S3S4), RI(S2), SC(SNR), SD(S2), WV(S3)
eastern worm snake	*Carphophis amoenus*	G5 / N5	AR(SNR), IL(SNR), IN(SNR), IA(S2), MA(S1S2), NJ(SNR), NY(S2), OH(SNR), PA(S3), RI(S1), SC(SNR), WV(S3)
five-lined skink	*Eumeces fasciatus*	G5 / N5	CT(S1), FL(SNR), MA(SX), MI(S3), MN(S3), MO(SNR), NE(S1), NJ(S3), NY(S3), OH(SNR), SC(SNR), SD(SU), VT(S1)
Florida crowned snake	*Tantilla relicta*	N5	FL(SNR), GA(S1)
gopher tortoise	*Gopherus polyphemus*	G3 / N3	AL(S3), FL(S3), GA(S2), LA(S1), MS(S2), SC(S1)
mimic glass lizard	*Ophisaurus mimicus*	N3	AL(S2), FL(SNR), GA(S2), MS(S2), NC(S2), SC(SNR)
mole skink	*Eumeces egregius*	N5	GA(S3)
northern water snake	*Nerodia sipedon*	G5 / N5	FL(SNR), IL(SNR), IN(SNR), MN(SNR), MO(SNR), OH(SNR), SC(SNR), SD(S1), TX(S1), VT(S3)
pine woods snake	*Rhadinaea flavilata*	N4	AL(S2), FL(SNR), GA(S2), LA(S1), MS(S3?), NC(S3), SC(SNR)
red-bellied snake	*Storeria occipitomaculata*	G5 / N5	DE(S1), DC(SH), FL(SNR), IN(SNR), IA(S3), KS(S2), MN(SNR), MO(SNR), NE(S2), NJ(SNR), ND(SNR), OH(SNR), OK(S3), RI(S2), SC(SNR), SD(S3), WY(S3)
ringneck snake	*Diadophis punctatus*	G5 / N5	CO(S2), ID(S1?), IL(SNR), IN(SNR), MN(SNR), MO(SNR), NV(S3), OH(SNR), RI(SNR), SC(SNR), SD(S2), UT(S2S3), WA(S3), WI(SNR)
short-tailed snake	*Stilosoma extenuatum*	N3	FL(S3)
southern black racer	*Coluber constrictor priapus*	G5T5 / N5	FL(SNR)
southern hognose snake	*Heterodon simus*	N2	AL(SH), FL(S2), GA(S2), MS(SX), NC(S2), SC(SNR)
timber rattlesnake	*Crotalus horridus*	G4 / N4	CT(S1), DC(SH), FL(S3), IL(S3), IN(S2), IA(S3), KS(S3), LA(S3S4), ME(SX), MD(S3), MA(S1), MN(S2), NE(S1), NH(S1), NJ(SNR), NY(S3), NC(S3), OH(S1), OK(S3), PA(S3S4), RI(SX), SC(SNR), VT(S1), WV(S3), WI(S2S3)
Bird			
Acadian flycatcher	*Empidonax virescens*	N5B	FL(SNRB), IA(S3B, S3N), KS(S3B), MA(S2B), MI(S3S4), MN(S3B), MO(SNRB), NY(S3), RI(S1B, S1N), SD(SH), WI(S3B)
acorn woodpecker	*Melanerpes formicivorus*	G5 / N5	NN(S3S4), NM(S3B, S3N), OR(S3), WA(S1)
American crow	*Corvus brachyrhynchos*	G5 / N5B, N5N	AK(S2B), FL(SNR), MN(SNR), MO(SNR), NN(S3), ND(SNRB, SNRN), SC(SNR), UT(S3S4B, S5N)
American goldfinch	*Carduelis tristis*	N5	AZ(S1B, S5N), CA(SNR), D FL(SNRN), MN(SNR), MO(SNR), NN(S1B, S4N), NM(S2B, S5N), ND(SNRB), SC(SNR), TX(S2B, S5N)
American kestrel	*Falco sparverius*	G5 / N5B, N5N	AL(S2B, S5N), AR(S3S4B, S5N), CA(SNR), CT(S2), DE(S3B, S5N), DC(S2B, S3N), FL(SNRB, SNRN), GA(S3S4), LA(S3S4B, S5N), ME(S3N, S5B), MA(S3), MN(SNRB, SNRN), MS(S4?B), MO(SNRB, SNRN), NJ(S3B, SNRN), NC(S3B, S5N), ND(SNRB, SNRN), OK(SNR), UT(S4S5B, S4N)
American redstart	*Setophaga ruticilla*	G5 / N5B	AK(S3B), AZ(S1), AR(S3S4B, S5N), CA(SNRB), CO(S1B), DE(S1B), DC(S1B, S4N), FL(S2), KS(S2B), LA(S3B), MN(SNRB), ND(SNRB), OK(S3B), OR(SU), SC(SNRB), TX(S2B), UT(SHB), WY(S4B, S5N)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
American robin	*Turdus migratorius*	G5 / N5	FL(SNRB, SNRN), ID(S5B, S3N), MN(SNRB, SNRN), ND(SNRB), SC(SNR)
American three-toed woodpecker	*Picoides dorsalis*	G5 / N5	AZ(S3), CO(S3S4), ID(S3?), ME(S3), MI(SNRN), MN(SNRB, SNRN), MT(S3S4), NN(S3), NV(S2), NH(S1), NM(S3B, S3N), NY(S2), OR(S3), SD(S2), UT(S2S3), WA(S3), WY(S3)
ash-throated flycatcher	*Myiarchus cinerascens*	N5B, N4N	ID(S3S4B), KS(S1B), OK(S2B), TX(S3B), WA(S2B), WY(S3B)
Bachman's sparrow	*Aimophila aestivalis*	N3B, N3N	AL(S3), AR(S3B), DC(SXB), FL(S3), GA(S2), IL(SXB, SHN), IN(SXB), KY(S1B), LA(S3), MD(SHB), MS(S3?B), MO(S2), NC(S3B, S2N), OH(SX), OK(S2?), PA(SX), SC(S3), TN(S2), TX(S3B), VA(S1B), WV(SHB)
band-tailed pigeon	*Patagioenas fasciata*	N4B, N4N	AK(S3B), CA(SNR), NN(S3B), NV(S3), NM(S3B, S4N), OR(S3B), UT(S3?B), WA(S3S4B, S4N)
bay-breasted warbler	*Dendroica castanea*	G5 / N5B	DC(S3N), GA(SNRN), IA(S2N), MI(S2S3), MN(SNRB), NE(SNRN), NY(S2), OK(S2N), VT(S1B),
Bewick's wren	*Thryomanes bewickii*	N5B	AL(SHB, S1N), AR(S2B, S3N), DC(SHN), GA(SH), IL(S1), IN(S1B), IA(S2B, S2N), KY(S3B), LA(S1S2N), MD(S1B), MI(SNRN), MS(S2S3B), MO(S3), o NC(SHB), OH(S1), OK(SNR), PA(SHB), SC(S1?), TN(S1), U VA(S1), WV(S1B, S1N), WI(SXB), WY(S3S4)
black-and-white warbler	*Mniotilta varia*	G5 / N5B, N4N5N	AL(S5B, S3N), AZ(S1B, S1N), DE(S3B), FL(SNRN), IL(S2S3), IN(S1S2B), KS(S3B), MN(SNRB), MO(SNRB), MT(S2S3B), NE(S3), NC(S5B, S1N), ND(SNRB), SC(SNRB, SNRN), SD(S2S3B)
black-backed woodpecker	*Picoides arcticus*	G5 / N4	AK(S3), CA(S3), ID(S3), MA(S1N), MI(S2), MN(SNR), MT(S2), NV(S1), NH(S3S4), NY(S3), OR(S3), SD(S3), VT(S2B, S2N), WA(S3), WI(S2B), WY(S1)
black-billed magpie	*Pica hudsonia*	G5 / N5	AZ(S3), MN(SNR), ND(SNR), OK(S3),
blackburnian warbler	*Dendroica fusca*	G5 / N5B	DC(S3N), IA(S3N), KY(S1S2B), MD(S1S2B), MN(SNRB), NE(SNRN), NJ(S2B), OH(S1), OK(S2N), RI(S1B, S1N), SC(S2?), TN(S3B, S4N), TX(S3), VA(S2B), WV(S3B), WI(S3S4B)
black-capped chickadee	*Poecile atricapillus*	G5 / N5	AZ(S1N), CA(S3), DC(S1N), MN(SNR), MO(SNR), NN(S2N), NM(S3B, S4N), NC(S3), ND(SNR), TN(S2B),
black-headed grosbeak	*Pheucticus melanocephalus*	G5 / N5B	CA(SNRB), KS(S3B), ND(SNRB), OK(S1N), WY(S4B, S5N) **Pine West—continued**
black-throated blue warbler	*Dendroica caerulescens*	G5 / N5B	AZ(S1M), KY(S3S4B), MD(S3S4B), MN(SNRB), NE(SNRN), NJ(SNRB), OK(S1N), RI(S1B, S3N), TX(S3), WI(S3B)
black-throated gray warbler	*Dendroica nigrescens*	N5B	CA(SNRB), ID(S3?B), NE(SNRN), NM(S3B, S4N), OK(S1N), TX(S3N, SHB), WY(S2)
black-throated green warbler	*Dendroica virens*	N5B	AR(S2B, S5N), IN(S2B), MN(SNRB), NE(SNRN), NJ(S3B), OH(S3), OK(S3N),
blue grosbeak	*Passerina caerulea*	N5B	CA(SNRB), DC(S2B, S2N), FL(SNRB), ID(S1B), IN(S3B), IA(S3B, S3N), MA(S1N), MN(SNRB), MO(SNRB), NN(S2S3B), NV(S3B), NY(SNR), ND(SU), OH(S3?), SC(SNRB), UT(S3B), WY(S3B)
blue jay	*Cyanocitta cristata*	G5 / N5B, N5N	FL(SNR), ID(S2N), MN(SNR), ND(SNRB, SNRN), SC(SNR)
blue-gray gnatcatcher	*Polioptila caerulea*	N5B, N5N	AL(S5B, S3N), DC(S3B, S3N), FL(SNRB, SNRN), ID(S3?), LA(S3N, S4B), ME(S2S3), MN(SNRB), MO(SNRB), MT(S1B), NE(S3), NC(S5B, S2N), OR(S3B), SC(SNRB, SNRN), SD(S1B), TX(S3B), VT(S3B), WY(S3?B)
blue-headed vireo	*Vireo solitarius*	G5 / N5B, N5N	AL(S2B, S4N), DC(S2N), FL(SNRN), IL(S1), IA(S3N), KY(S3S4B), MD(S3S4B), MN(SNRB), NJ(S3B), NC(S5B, S3N), OH(S2), OK(S2N), RI(S3B), SC(SNRB, SNRN), WI(S3B)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
boreal chickadee	*Poecile hudsonica*	G5 / N5	ID(S1?), MA(S1N), MI(S3S4), MN(SNR), MT(S1S2), NY(S3), VT(S3S4B, S3S4N), WA(S3), WI(S2B, S3B)
Brewer's sparrow	*Spizella breweri*	G5 / N5B, N5N	CA(S3), KS(S1B), MT(S2B), NE(S3), NM(S3B, S4N), ND(S3), OK(S2N), SD(S2B), WA(S3B)
bridled titmouse	*Baeolophus wollweberi*	N4	None
broad-tailed hummingbird	*Selasphorus platycercus*	G5 / N5B	CA(S2), MT(S1B), NE(SNRN), OR(S2?B), SD(S3B), TX(S3B), UT(S3?B)
broad-winged hawk	*Buteo platypterus*	N5B	AZ(S2M), DE(S1B), DC(S1B, S4N), FL(SNRB, SNRN), IL(S3), IN(S3B), IA(S3B), KS(S1B), M MN(SNRB), MO(S3), NE(SU), NJ(S3B), ND(SNRB), SD(S2B), TX(S3B)
brown creeper	*Certhia americana*	G5 / N5	AR(S1B, S5N), DE(S1B, S4N), DC(S3N), FL(SNRN), IL(S3), IN(S2B), IA(S3B), KS(S3N), KY(S1S2B, S4S5N), MN(SNRB, SNRN), MO(SU), NN(S3S4), NE(S3), NC(S3B, S5N), ND(SNRN), OH(S3), RI(S3B), SD(S2B, S3N), TN(S2B, S4N), VA(S3B, S5N), WV(S3B, S4N)
brown thrasher	*Toxostoma rufum*	N5	AZ(S1N), DC(S3B, S3N), FL(SNR), I MD(S5B, S2N), MN(SNRB), M MO(SNRB, SNRN), NH(S3), N ND(SNRB), SC(SNR), UT(S2S3N), WV(S3N, S5B)
brown-headed cowbird	*Molothrus ater*	G5 / N5	AK(S3B), CA(SNRB, SNRN), FL(SNR), ME(S4N, S4S5B), MN(SNRB), MO(SNR), ND(SNRB), SC(SNR), UT(S5B, S3N)
brown-headed nuthatch	*Sitta pusilla*	N5	DE(S2), FL(SNR), MD(S3S4), MO(SX), OK(S1), TN(S2B), VA(S3S4)
bushtit	*Psaltriparus minimus*	G5 / N5	OK(S3), WY(S1)
California spotted owl	*Strix occidentalis occidentalis*	G3 / N3	CA(S3), NV(S1B)
calliope hummingbird	*Stellula calliope*	G5 / N5B	UT(S3?B), WY(S3)
Canada warbler	*Wilsonia canadensis*	G5 / N5B	IL(S1), IN(S2B), IA(S3N), KY(S3B), MD(S3B), MN(SNRB), NE(SNRN), NJ(S3B), ND(SU), OH(S2), OK(S1N), SC(S3), TN(S3B, S4N), VA(S3S4B), WI(S3B)
canyon wren	*Catherpes mexicanus*	N5	SD(S3), WY(S2S3)
Cape May warbler	*Dendroica tigrina*	G5 / N5B	DC(S2S3N), GA(SNRN), IA(S2N), MA(S3N), MI(S3S4), MN(SNRB), NE(SNRN), NH(S3B), NY(S2), OK(S1N), TX(S2), VT(S2S3B), WI(S3B)
Carolina chickadee	*Poecile carolinensis*	N5	FL(SNR), MO(SNR), SC(SNR),
Carolina wren	*Thryothorus ludovicianus*	N5	CO(S1), FL(SNR), IA(S3B, S3N), ME(S1B?, S1N?), MI(S2), MN(SXB), MO(SNR), NE(S2), NH(S2S3), SC(SNR), VT(S1S2B, S2N)
Cassin's finch	*Carpodacus cassinii*	G5 / N5	CA(SNR), NN(S3), NE(SNRN), NM(S3B, S5N), SD(S2B, S2N), UT(S4S5B, S4N)
Cassin's Kingbird	*Tyrannus vociferans*	N5B	KS(S1?B), MT(S2B), NE(S3), NV(S3B), N OK(S2B), SD(S2B), TX(S3B), UT(S2S3B), WY(S3B)
Cassin's vireo	*Vireo cassinii*	G5 / N3N, N5B	AZ(S3N), CA(SNRB), NV(S3B), OR(S4?B)
cedar waxwing	*Bombycilla cedrorum*	G5 / N5	AL(S2B, S5N), AK(S3B), AZ(S3S4N), AR(S1B, S5N), DC(S1S2B, S4N), FL(SNRN), ID(S5B, S3N), KS(S2B), ME(S3S4N, S5B), MN(SNRB, SNRN), MO(SNRB, SNRN), NE(SNRN), NV(S2B, S4N), ND(SNRB, SNRN), OK(SNR), SD(S5B, S3N), UT(S3B, S4N), WA(S2S4N)
chestnut-backed chickadee	*Poecile rufescens*	G5 / N5	None
chestnut-sided warbler	*Dendroica pensylvanica*	G5 / N5B	AZ(S1N), AR(S1B, S5N), CO(S2B), DE(S1B), IL(S2S3), IN(S3B), IA(S3B, S4N), KY(S3S4B), MN(SNRB), MO(S3), NE(SNRN), NJ(S3B), ND(S3), OH(S3), OK(S2N), SC(SNR), SD(S1B)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
chipping sparrow	*Spizella passerina*	G5 / N5B, N5N	CA(S3S4), DE(S3N, S5B), DC(S3B, S4N), FL(SNRN), KS(S3B), ME(S3N, S5B), MD(S5B, S1N), MN(SNRB), MO(SNRB), ND(SNRB), OK(SNR), SC(SNRB, SNRN), WV(S3N, S5B)
Clark's nutcracker	*Nucifraga columbiana*	G5 / N5	CA(SNR), NE(SNRN), SD(S2B, S2N)
common grackle	*Quiscalus quiscula*	G5 / N5	FL(SNR), ID(S2B), MN(SNRB, SNRN), MO(SNR), ND(SNRB), SC(SNR), UT(S3B), WV(S3N, S5B)
common nighthawk	*Chordeiles minor*	G5 / N5B	AR(S3B, S4N), CA(S3), CT(S1B), DE(S2B), FL(SNRB), MD(S3S4B), MA(S2B, S5M), MN(SNRB), MO(SNRB), NH(S2B), NJ(S3B), ND(SNRB), PA(S3S4B), RI(S1B), SC(SNRB), VT(S2S3B), WV(S3B)
common poorwill	*Phalaenoptilus nuttallii*	N5B, NNRN	CA(S2S3), KS(S3B), MT(S3S4B), NE(S2), OK(S2B), OR(SNRB), SD(S3B), WA(S3S4B)
common raven	*Corvus corax*	G5 / N5	AL(SX), CT(S2B), GA(S2), IL(SX), IN(SXB), KY(S1S2), MD(S2), MN(SNR), MO(SX), NE(SXB, S1N), NJ(S1B), NC(S3), ND(SX), OH(SX), OK(S1), SD(SX), TN(S2), TX(S3B)
common yellowthroat	*Geothlypis trichas*	G5 / N5	AR(S3N, S4B), CA(S3), DC(S3B, S4N), FL(SNR), LA(S3S4N, S5B), MN(SNRB), MO(SNRB), NN(S2S3B), NV(S3B), ND(SNRB), SC(SNR), UT(S3S4B), WV(S2N, S5B)
Cooper's hawk	*Accipiter cooperii*	G5 / N5B, N5N	AL(S3B, S4N), AR(S1B, S3N), CA(S3), CO(S3S4B, S4N), CT(S2B), DE(S1B), DC(S3N, SHB), FL(S3), GA(S3S4), IL(S3), IN(S3B), IA(S3B), KS(S3B, S4N), LA(S2B, S3N), ME(S3S4B, S3?N), MI(S3S4), MN(SNRB, SNRN), MS(S3?B), MO(S3), NE(S1), NV(S3), NH(S2B), NJ(S3B, S4N), NC(S3S4B, S4N), ND(SU), OH(S3S4), OK(SNR), RI(S1B, S3N), SC(S3?), SD(S3B, SZN), TN(S3B), TX(S4B, S3N), UT(S4B, S3S4N), VT(S2S3B), VA(S3B, S3N), WV(S3B, S4N), WI(S4B, S2N)
cordilleran flycatcher	*Empidonax occidentalis*	G5 / N5B	AZ(S2S3B), NE(S1), OR(SNRB), TX(S3B), UT(S3S4B), WA(S3B?)
dark-eyed junco	*Junco hyemalis*	G5 / N5	CA(SNR), FL(SNRN), KY(S2S3B, S5N), MD(S2B, S5N), MN(SNRB, SNRN), MO(SNRN), NJ(S1B, S5N), OH(S2), RI(S2B), SC(SNRB, SNRN), WI(S3B)
downy woodpecker	*Picoides pubescens*	G5 / N5	FL(SNR), MN(SNR), MO(SNR), NN(S3), ND(SNR), SC(SNR)
dusky flycatcher	*Empidonax oberholseri*	G5 / N5B	OK(S1N), TX(S3N, S1B)
dusky grouse	*Dendragapus obscurus*	G5 / N5	AZ(S3), CA(SNR), NN(S1), NV(S3), NM(S3B, S3N), SD(SX)
dusky-capped flycatcher	*Myiarchus tuberculifer*	N4B	NM(S3B, S4N)
eastern bluebird	*Sialia sialis*	N5B, N5N	CO(S2B), FL(SNR), MA(S3B, S4N), MN(SNRB), MO(SNR), MT(S2B), NE(S3S4), NM(S1B, S5N), ND(SU), RI(S3B), SC(SNR), WY(S2)
eastern kingbird	*Tyrannus tyrannus*	N5B	AK(S2M), AZ(S1S2M), CA(S1), FL(SNRB), MN(SNRB), MO(SNRB), NV(S1B), ND(SNRB), SC(SNRB), UT(S3?B)
eastern meadowlark	*Sturnella magna*	N5	DE(S3), DC(S1B, S4N), FL(SNR), IN(S3N, S4B), ME(S3S4B), MD(S5B, S3N), MA(S3S4B), MN(SNRB), MO(SNR), NH(S3B), NJ(S3B, S4N), RI(S3B), SC(SNR), SD(S2B)
eastern phoebe	*Sayornis phoebe*	N5B, N5N	AZ(S1N), CA(SNRB, SNRN), CO(S3B), DC(S3B), FL(SNRN), LA(S3S4B, S5N), MN(SNRB), MO(SNRB), NM(S3B, S4N), ND(SNRB), SC(SNR), WV(S3N, S5B)
eastern towhee	*Pipilo erythrophthalmus*	N5	AR(S3), DC(S4B, S4S5N), FL(SNR), KS(S3B), MN(SNRB), M MO(SNRB, SNRN), ND(SNRB), OK(SNR), SC(SNR), SD(S3B), TX(S2B, S5N)
eastern wood-pewee	*Contopus virens*	G5 / N5B	FL(SNRB), MN(SNRB), MO(SNRB), ND(SNRB), SD(S3B)
European starling	*Sturnus vulgaris*	G5 / NNA	None

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird—continued			
evening grosbeak	*Coccothraustes vespertinus*	G5 / N5	AL(S3N), AZ(S3), CA(SNR), DC(S1N), IN(S3N), MD(S2N), MA(S2B, S3S4N), MN(SNRB, SNRN), NE(SNRN), NV(S2), OH(SNRN), OK(S2N), SC(SNRN), TX(S2N), UT(S3?B), VT(S4B, S4S5N), WI(S3B)
field sparrow	*Spizella pusilla*	N5	CO(S1B), DC(S2B, S4N), FL(SNRB, SNRN)
fox sparrow	*Passerella iliaca*	G5 / N5B, N5N	AK(S5B, S3N), AZ(S2N), CA(SNR), DC(S3N), IN(S2N), IA(S2N), KS(S3N), ME(S2B, S2N?), MD(S2N), MI(SNRN), MN(SNRN), MO(SNRN), NN(S2N), NE(SNRN), NY(SNRN), OH(SNRN), OK(S3N), PA(S3N), SC(SNRN), TN(S3N), UT(S2S3B), WV(S3N)
golden-crowned kinglet	*Regulus satrapa*	G5 / N5	AZ(S3), CT(S2B), DC(S3S4N), FL(SNRN), IL(S1), KS(S3N), MD(S2B, S4N), MA(S2B, S5N), MN(SNRB, SNRN), MO(SNRN), NN(S2B, S3N), NE(SNRN), NC(S3S4B, S5N), OK(S3N), PA(S3S4B, S5N), RI(S1B), TN(S3B, S4N), VA(S2B, S5N), WI(S3B), WY(S3B, S4N)
Grace's warbler	*Dendroica graciae*	G5 / N5B	CO(S3B), NV(S2B), NM(S3B, S4N), TX(S3B), UT(S2S3B)
grasshopper sparrow	*Ammodramus savannarum*	G5 / N5B, N5N	AL(S3), AZ(S3), AR(S3B), CA(S2), CO(S3S4B), CT(S1B), DE(S3B), DC(S3N), FL(SNRN), ID(S3B), LA(S3N), ME(S1B), MA(S3B), MI(S3S4), MN(SNRB), MO(S3S4), MT(S3B), NV(SU), NH(S1B), NJ(S2B), NM(S3B, S3N), NC(S3B, S1N), ND(SNRB), OR(S2B), RI(S1B, S1N), SC(SNRB, SNRN), TX(S3B), UT(S1B), VT(S2B), WA(S3B), WV(S3B)
gray catbird	*Dumetella carolinensis*	N5B, N5N	AZ(S1), AR(S3B, S4N), D FL(SNRB, SNRN), LA(S2N, S4B), MD(S5B, S1N), MA(S5B, S2N), MN(SNRB), M MO(SNRB), NM(S3B, S4N), N ND(SNRB), OR(S4?B), PA(S5B, S3N), SC(SNR), UT(S1?B), WV(S1N, S5B)
gray jay	*Perisoreus canadensis*	G5 / N5	AZ(S2), CA(S3), MN(SNR), NE(SNRN), NH(S3S4), NY(S3), UT(S3S4), VT(S1S2B, S1S2N), WI(S3B)
gray-cheeked thrush	*Catharus minimus*	G5 / N5B	DC(S3N), GA(SNRN), IA(S3N), ME(S4?N), MA(S2N), MI(SNRN), NE(SNRN), OK(S2N),
great crested flycatcher	*Myiarchus crinitus*	N5B	DC(S3B), FL(SNRB), MN(SNRB), MO(SNRB), ND(SNRB)
great horned owl	*Bubo virginianus*	N5	CA(SNR), DC(S2), FL(SNR), MN(SNR), ND(SNR)
greater pewee	*Contopus pertinax*	G5 / N4B	NM(S3B, S3N)
green-tailed towhee	*Pipilo chlorurus*	G5 / N5B, N5N	AZ(S3B, S4N), CA(SNRB), NE(SNRN), NM(S3B, S4N), OK(S1N), WA(S2B)
hairy woodpecker	*Picoides villosus*	G5 / N5	DE(S3), DC(S3), FL(S3), MN(SNR), MO(SNR), ND(SNR)
Hammond's flycatcher	*Empidonax hammondii*	G5 / N5B	AZ(S1B, S2S3N), NN(S1S2B), NV(S3B), TX(S3), UT(S3S4B)
hepatic tanager	*Piranga flava*	N5B	CA(S1), CO(S1B), NN(S2B),
hermit thrush	*Catharus guttatus*	G5 / N5	DC(S3N), FL(SNRN), IA(S3N), KY(S3S4N), MD(S3S4B, S4N), MN(SNRB), MO(SNRN), NE(SNRN), NC(S2B, S5N), OH(S1), OK(S3N), SC(S4?N), TN(S2B, S4N), UT(S4B, S2N), VA(S1B, S5N), WV(S3B, S4N)
hermit warbler	*Dendroica occidentalis*	G4G5 / N4N5B, NNRN	CA(S3?), NV(S2B), TX(S3)
hooded warbler	*Wilsonia citrine*	N5B	AZ(S2M), DE(S1B), DC(S3S4N), FL(SNRB), IL(S3S4), IN(S3B), IA(S1B, S2N), KS(S1B), MA(SXB, S2N), MI(S3), MN(S3B), MO(S3), NE(SNRN), NJ(S3B), OK(S2B), RI(S3B), SC(S4?B), WI(S2B, S3B)
house finch	*Carpodacus mexicanus*	N5	CA(SNR), NE(S3), NSD(S4B, S3N),

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
house wren	*Troglodytes aedon*	G5 / N5B, N5N	AL(S1B, S5N), FL(SNRN), MN(SNRB), MO(SNRB), NN(S4B, S2N), ND(SNRB), OK(SNR), SC(SNRB, SNRN), TX(S2B, S5N), UT(S5B, S3N)
Hutton's vireo	*Vireo huttoni*	G5 / N3N4	TX(S3B)
indigo bunting	*Passerina cyanea*	N5B	AL(S2N, S5B), AZ(S3), CA(SNRB), CO(S3S4B), FL(SNRB, SNRN), MN(SNRB), MO(SNRB), MT(S2S4B), NN(S3B), NV(S2S3), ND(SNRB), SC(SNRB), UT(S2S3B), WY(S3B)
juniper titmouse	*Baeolophus ridgwayi*	N5	CA(SNRN), OK(SNR), OR(SNRB, SNRN), TX(S2B), WY(S1)
Kentucky warbler	*Oporornis formosus*	N5B	AZ(S1M), CT(S3B), DE(S3B), DC(S3S4N), FL(SNRB), IA(S1B, S3N), KS(S3B), MA(S2N), MI(SNRN), NE(S3), NJ(S3B), NY(S2), TX(S3B), WI(S1B, S2B)
Kirtland's warbler	*Dendroica kirtlandii*	G1 / N1B	FL (S1), GA (SNRN), IN (SNA), MI (S1), OH (S1N), PA (SNA), VA (SNA)
lazuli bunting	*Passerina amoena*	G5 / N5B	CA(SNRB), KS(S1?B), NN(S2S3B), ND(SNRB), OK(S2B), TX(S3)
least flycatcher	*Empidonax minimus*	G5 / N5B	DE(SHB), DC(S2S3N), GA(S3), IL(S3), IN(S3B), IA(S1B, S4N), KY(S1B), MD(S3S4B), MN(SNRB), MO(SU), NE(SU), NJ(S3B), NC(S3B), ND(SNRB), OH(S3), OR(SU), RI(S3B), SC(S3?), TN(S3), VA(S3S4B)
lesser goldfinch	*Carduelis psaltria*	N5	CA(SNRB, SNRN), ID(S1B), NN(S3S4B, S1N), OK(S2B), UT(S3S4B, S3N), WA(S2B)
Lewis's woodpecker	*Melanerpes lewis*	G4 / N4B, N4N	CA(SNR), MT(S2B), NE(S1), NV(S3), NM(S3B, S3N), OK(S2), OR(S2S3B), SD(S3B, S3N), UT(S2), WA(S3B), WY(S2)
Lincoln's sparrow	*Melospiza lincolnii*	G5 / N5B, N5N	AL(S3N), AZ(S3B, S5N), CA(SNRB, SNRN), IN(S1S2N), IA(S3B, S3N), KS(S3N), MA(S1B, S3M), MN(SNRB), NN(S1N), NE(SNRN), NV(S2B, S4N), NM(S2B, S5N), NC(S2N), TN(S3N), UT(S4B, S3N), WI(S3B)
loggerhead shrike	*Lanius ludovicianus*	N4	AL(S3B, S5N), CO(S3S4B), CT(SXN), DE(SHB), DC(SHN, SXB), FL(SNR), ID(S3), IL(S3), IN(S3B), IA(S3B, S3N), ME(SHB, S1?N), MD(S1B, S1N), MA(SXB, S1N), MI(SNR), MN(S2B), MO(S2), MT(S3B), NH(SHB), NM(S3B, S4N), NY(S1B), NC(S3B, S3N), ND(SU), OH(S1), OR(S3B, S2N), PA(SNRB), SC(S3), SD(S3S4B), TN(S3), UT(S4B, S3S4N), VT(SHB), VA(S2B, S3N), WA(S3B), WV(S1B, S2N), WI(S1B), WY(S3)
MacGillivray's warbler	*Oporornis tolmiei*	G5 / N5B	CA(SNRB), NE(SNRN), OK(S2N), SD(S3B)
magnolia warbler	*Dendroica magnolia*	G5 / N5B	AK(S2B), GA(SNRN), MD(S3S4B), MN(SNRB), NE(SNRN), NJ(S1B), NC(S1S2B), OH(S1), OK(S2N), SC(SNRN), TN(S1B, S4N), VA(S2B), WI(S3B)
merlin	*Falco columbarius*	G5 / N4B, N4N	AK(S4B, S3N), CA(S3), CO(SHB, S4N), DC(S1N), FL(S2), GA(S3S4), ID(S1B, S2N), IL(SXB), IN(S1N), IA(SXB), ME(S3B), MD(S1N), MI(S1S2), MN(SNRB, SNRN), NE(S1), NV(S3N), NH(S3B), NC(S3N), ND(S2), OH(SX), OK(SNRN), OR(SHB), SD(S3B, S3N), TN(S3N), TX(S3N), UT(SHB, S2S3N), VT(S1B), WA(S3B, S4N), WV(S1N), WI(S3B, S2N),
Mexican spotted owl	*Strix occidentalis lucida*	G3 / N3	AZ(S3S4), CO(S1B, SUN), NN(S2S3), NM(S2B, S2N), TX(S1B), UT(S2)
mountain bluebird	*Sialia currucoides*	G5 / N5	AK(S3B), ND(SNRB), OK(S2N), TX(S3B, S4N), UT(S4S5B, S3S4N)
mountain chickadee	*Poecile gambeli*	G5 / N5	OK(S1N),
mountain quail	*Oreortyx pictus*	G5 / N5	CA(SNR), ID(S2), NV(S3), WA(S1)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
mourning dove	*Zenaida macroura*	G5 / N5	AK(S3N), CA(SNR), FL(SNR), MN(SNRB, SNRN), MO(SNR), NN(S5B, S3N), ND(SNRB), SC(SNR), UT(S5B, S3N)
mourning warbler	*Oporornis philadelphia*	G5 / N5B	DC(S2N), GA(SNRN), IL(S1S2), IA(S3N), MD(S1B), MA(S2B, S2N), MN(SNRB), NE(SNRN), OH(S1), OK(S2N), PA(S3S4B), TN(S3N), VA(S1B), WV(S3B)
Nashville warbler	*Vermivora ruficapilla*	G5 / N5B	CA(SNRB), DC(S2N), GA(SNRN), IL(S1), MD(S1S2B), MN(SNRB), NE(SNRN), NV(S3B), NJ(S1B), PA(S3S4B), RI(S3B), WV(S1B)
northern bobwhite	*Colinus virginianus*	N5	AZ(S1), DC(S1), FL(SNR), MA(S2), MN(SU), NH(SX), PA(S1), TN(S2S3), WV(S3B, S3N), WI(S3B), WY(S1)
northern cardinal	*Cardinalis cardinalis*	N5	CA(S1), FL(SNR), MN(SNR), SC(SNR), SD(S4B, S3N)
northern flicker	*Colaptes auratus*	G5, N5B, N5N	DC(S2S3N, S5B), FL(SNR), KY(S4S5B, S4S5N), MN(SNRB), MO(SNR), ND(SNRB), OK(SNR), SC(SNR), SD(S5B, S3N), TX(S3B, S4N)
northern goshawk	*Accipiter gentilis*	N4B, N4N	AZ(S3), CA(S3), CO(S3B), ME(S3?B, S3?N), MD(S1B), MA(S3), MI(S3), MN(SNRB, SNRN), MT(S3), NN(S3), NE(SNRN), NV(S2), NH(S3), NJ(S1B, S4N), NM(S2B, S3N), NY(S4B, S3N), NC(SUB), OH(SNRN), OK(S2N), OR(S3B), PA(S2S3B, S3N), RI(S1B, S1N), SD(S3B, S2N), TN(S2N), UT(S3?), VT(S3S4B), WA(S3B, S3N), WV(S1B, S1N), WI(S2B, S2N), WY(S3)
northern mockingbird	*Mimus polyglottos*	N5	FL(SNR), ID(S1B), IA(S3B), MO(SNR), NN(S5B, S2N), ND(SU), SC(SNR), SD(S3B), UT(S4S5B, S3N), WY(S3S4B)
northern parula	*Parula americana*	N5B	AZ(S2N), CT(S1B), DE(S1B), DC(S3B, S3N), FL(SNRB), IA(S3B, S3N), MA(S1B, S4M), MN(SNRB), MO(SNRB), NJ(S3B), NY(S3S4), OH(S3), OK(S3B), RI(S1B, S1N), SC(SNRB), WI(S3B)
northern pygmy-owl	*Glaucidium gnoma*	N4N5	AK(S3), CA(SNR), CO(S3B), UT(S3S4B), WY(S2)
northern spotted owl	*Strix occidentalis caurina*	N3	CA(S2S3), OR(S3), WA(S1)
olive-sided flycatcher	*Contopus cooperi*	G4 / N4B	AK(S3S5B), CO(S3S4B), CT(S2B), DC(S1N), GA(SNRN), IA(S3N), MD(SHB), MA(SXB?, S2N), MN(SNRB), MT(S3B), NN(S2?B), NE(SNRN), NV(S2B), NM(S3B, S4N), NC(SUB), OH(SH), OK(S2N), OR(S3B), PA(SXB), SD(SUB), TN(S1), TX(S3B, S4N), UT(S3S4B), VA(SHB), WV(S1B), WI(S2B)
orange-crowned warbler	*Vermivora celata*	G5 / N5B, N5N	AZ(S3B, S5N), CA(SNR), DC(S1N), FL(SNRN), IA(S3N), MA(S2N), MI(SNRN), NN(S3S4B, S2N), NE(SNRN), NY(SNRN), NC(S3N), SC(SNRN), TN(S3N), UT(S4S5B, S3N)
ovenbird	*Seiurus aurocapillus*	G5 / N5B	AL(S5B, S2N), AZ(S2M), CO(S2B), DC(S2B, S3N), KS(S1B), MN(SNRB), MS(S1B), MO(SNRB), MT(S3S4B), NC(S5B, S1N), ND(SNRB), OK(S2B), SC(SNRB), SD(S3B), WY(S3B)
pacific-slope flycatcher	*Empidonax difficilis*	G5 / N5B	NV(S3M)
palm warbler	*Dendroica palmarum*	N4B, N5N	AZ(S1M), DC(S3N), FL(SNRN), MD(S2N), MI(S1S2), MN(SNRB), NE(SNRN), NH(S3B), NY(S1), NC(S3N), OK(S1N), SC(SNRN), TX(S3), VT(S1B), WV(S1N), WI(S3B)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
peregrine falcon	*Falco peregrinus*	N4B, N4N	AL(SHB, S3N), AK(S3B, S3N), AR(S1N), CA(S2B, SNRN), CO(S2B), CT(S1B), DE(S1N), DC(S1B, S1N), FL(S2), GA(S1), ID(S1B), IL(S1), IN(S2B), IA(S1B), KS(S1B, S3N), KY(S1B), LA(S2N), ME(S1S2N, S2B), MD(S2B, S3N), MA(S2B, S3N), MI(S1), MN(S2B), MO(S1), MT(S2B), NN(S3S4), NE(S3), NV(S2), NH(SNR), NJ(S1B), NM(S2B, S3N), NY(S3B), NC(S1B, S2N), ND(SNR), OH(S1), OK(SNRN), OR(S1), PA(S1B, S1N), RI(S1B), SC(SHB, SNRN), SD(SXB), TN(S1N), TX(S3), UT(S2S3), VT(S2B, S2N), VA(S1B, S2N), WA(S2B, S3N), WV(S1B, S2N), WI(S1B, S2B), WY(S1B, S3N)
Philadelphia vireo	*Vireo philadelphicus*	G5 / N4B, N4N	AR(S2N), DC(S1N), GA(SNRN), IA(S2N), MA(S2N), MI(S3), MN(SNRB), NE(SNRN), NH(S3B), NY(S3), ND(S3), OK(S1N), TN(S3N), VT(S2S3B), WI(SUB)
pileated woodpecker	*Dryocopus pileatus*	G5 / N5	CA(S3), DE(S3), DC(S3), FL(SNR), IA(S3B), KS(S3), MN(SNR), MO(SNR), NE(S1), NV(S1), ND(S3), OK(S3), RI(S1B, S1N), SC(SNR), SD(S1), WI(S3B)
pine grosbeak	*Pinicola enucleator*	G5 / N5	AZ(S1), CA(SNR), IN(S1S2N), ME(S3?B, S4S5N), MA(S2N), MI(SNRN), MN(SNRN), NN(S2N), NE(SNRN), NV(S2), NM(S2B, S3N), NY(SNRN), OR(S2?), SD(S3N), UT(S3S4), VT(S2S3N), WA(S3B, S3N), WY(S4B, S5N)
pine siskin	*Carduelis pinus*	G5 / N5	CA(SNR), DC(S1N), IL(S2), IN(S3N), MD(S1S2N), MA(S3B, S5N), MN(SNRB, SNRN), NN(S3S4), NE(S3), NC(SUB, S4N), SC(SNRN), TX(S2B, S5N), WV(S2B, S4N), WI(S3B)
pine warbler	*Dendroica pinus*	N5B, N5N	DC(S1B, S1S3N), FL(SNR), IL(S3S4), IN(S3B), IA(S1N), MD(S4B, S2N), MN(SNRB), MO(SNRB, SNRN), NE(SNRN), OH(S3S4), PA(S3S4B), SC(SNR), VT(S3B), WV(S2N, S4B), WI(S3B)
pinyon jay	*Gymnorhinus cyanocephalus*	N5	ID(S2?), NE(S3), NV(S3S4), NM(S3B, S3N), OK(S2), OR(S3S4)
plumbeous vireo	*Vireo plumbeus*	G5 / N5B, NNRN	CA(SNRB), CO(SNRB), ID(S2S3B), LA(S2N), MT(S3S4B), NE(S2), UT(S3S4B)
prairie warbler	*Dendroica discolor*	N5B, NNRN	DC(S1B, S2N), FL(SNR), IA(S2N), KS(SHB), MA(S3S4B), MI(S1), MO(SNRB), NE(SNRN), NC(S5B, S1N), OK(S3B), TN(S3S4), TX(S3B), VT(S3B)
purple finch	*Carpodacus purpureus*	G5 / N5B, N5N	AZ(S1S2N), CA(SNR), DC(S3N), IN(S3N), MD(S3B, S3N), MN(SNRB, SNRN), MO(SNRN), NE(SNRN), NJ(S3B, S4N), ND(SNRB), OH(S3), RI(S3B), SC(SNRN), TN(S3S4N), VA(S1B, S5N)
pygmy nuthatch	*Sitta pygmaea*	G5 / N5	ID(S2S3), NE(S3), NV(S3), NM(S3B, S3N), SD(S2S3), TX(S3B), UT(S3S4), WA(S3S4), WY(S2)
red crossbill	*Loxia curvirostra*	G5 / N5	AL(S1B), AR(S3N), CA(SNR), DC(S1N), GA(SU), IL(S1), IN(S1N), IA(S2N), ME(S3S4B, S3S4N), MA(S1B, S4N), MI(S3), MN(SNRB, SNRN), NN(S3S4), NY(S3), NC(S3B, S3N), OH(SNRN), OK(S1N), SD(S4B, S3N), TN(S1B, S2N), TX(S3), UT(S2S3), VT(S1S2B, S3N), VA(S1B), WV(S2N), WI(S2?B)
red-bellied woodpecker	*Melanerpes carolinus*	N5B, N5N	FL(SNR), MN(SNR), MO(SNR), NH(S2), ND(SU), RI(S2B, S2N), SC(SNR)
red-breasted nuthatch	*Sitta canadensis*	G5 / N5	DC(S1S2N), FL(SNRN), IL(S1), IN(S1B), IA(S3N), KY(S1B), MD(S1B, S3N), MN(SNR), MO(SNRN), NC(S3B, S4N), OK(S2N), PA(S3S4B, S5N), RI(S3B), TN(S2B, S4N), TX(S2B, S4N), VA(S2B, S4N)
red-breasted sapsucker	*Sphyrapicus ruber*	G5 / N5	AZ(S1N), CA(SNR), NV(S3), WA(S4S5)
red-cockaded woodpecker	*Picoides borealis*	N3	AL(S2), AR(S2), FL(S2), GA(S2), KY(SX), LA(S2), MD(SHB), MS(S1), MO(SX), NC(S2), OK(S1), SC(S2), TN(SX), TX(S2B), VA(S1)
red-eyed vireo	*Vireo olivaceus*	G5 / N5B	AK(S2B), AZ(S1M), CO(S3B), FL(SNRB), KS(S3B), MN(SNRB), MO(SNRB), ND(SNRB), SC(SNRB), WA(S3B), WY(S3B)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
red-headed woodpecker	*Melanerpes erythrocephalus*	N5B, N5N	AR(S4B, S4S5N), CO(S3B), CT(S1), DE(S1), DC(S1N, SHB), FL(SNR), MA(S1B, S2N), MN(SNRB, SNRN), M MO(SNRB, SNRN), MT(S3B), NJ(S2B, S2N), NM(S3B, S3N), ND(SNRB), OK(SNR), RI(S1B, S1N), SC(SNR), TX(S3B), VT(S1S2B), WV(S2B, S3N), WI(S3B), WY(S3B)
red-naped sapsucker	*Sphyrapicus nuchalis*	G5 / N5B, NNRN	CA(S3), LA(S2N), NN(S4B, S3N), NM(S3B, S5N), TX(S3B, S4N), UT(S4B, S3N)
red-shouldered hawk	*Buteo lineatus*	N5B, N5N	AR(S3), CA(SNRB), CT(S3B), DE(S2B, S3N), DC(S2B, S3N), FL(SNR), IL(S2S3), IN(S3), IA(S2B), KS(S2), ME(S3N, S4B), MD(S4S5B, S4N), MI(S3S4), MN(S3B, SNRN), NE(S1), NV(S1), NH(S3), NJ(S1B, S2N), OH(S3), OR(S3N), PA(S4B, S3S4N), RI(S3B, S3N), SC(SNR), SD(SUB), VT(S3S4B), WI(S3S4B, S1N)
red-tailed hawk	*Buteo jamaicensis*	G5 / N5B, N5N	DC(S3N), FL(SNR), KY(S4S5B, S4S5N), ME(S3N, S5B), MN(SNRB, SNRN), ND(SNRB, SNRN), SC(SNRB, SNRN)
red-winged blackbird	*Agelaius phoeniceus*	G5 / N5	AK(S3B), DC(S3B, S4S5N), FL(SNR), ID(S5B, S3N), ME(S4S5B, S4S5N), MN(SNRB, SNRN), NN(S3S4B, S5N), ND(SNRB), SC(SNRB, SNRN)
rock wren	*Salpinctes obsoletus*	G5 / N5	AR(S2N), KS(S3B), NN(S5B, S3N), ND(SNRB), UT(S4S5B, S3N)
ruby-crowned kinglet	*Regulus calendula*	G5 / N5B, N5N	FL(SNRN), MD(S3N), MA(SXB, S5N), MN(SNRB), MO(SNRN), NE(SNRN), NY(S3), SC(SNRN), VA(SNRN), WV(S3N), WI(S3B)
ruby-throated hummingbird	*Archilochus colubris*	N5B	DC(S3B, S3N), FL(SNRB, SNRN), MN(SNRB), MO(SNRB), NE(S3), ND(SNRB), RI(S3B), SC(SNRB), SD(S2B)
ruffed grouse	*Bonasa umbellus*	G5 / N5	AL(S1), CO(SU), DE(SX), DC(SX), IL(S3), KS(S2), MN(SNR), MO(SU), NE(S1), ND(SNR)
rufous hummingbird	*Selasphorus rufus*	G5 / N5B	AR(SU), CA(S1S2), LA(S2N), NE(SNRN), NV(S3M), OK(S1N), SD(SU), TX(S3N), WY(S2B)
scarlet tanager	*Piranga olivacea*	N5B	DC(S2B, S4N), KS(S3B), MN(SNRB), MS(S2?B), MO(SNRB), ND(SU), OK(S2B), SC(SNRB), SD(S2B)
sharp-shinned hawk	*Accipiter striatus*	N5B, N5N	AL(S3B, S4N), AK(S4B, S3N), AR(S1S2B), CA(S3), CO(S3S4B, S4N), CT(S2B), DC(S3N, SHB), FL(SNRN), IL(S1S2), IN(S2B), IA(S3N), KS(S1B, S4N), KY(S3B, S4N), LA(S1S2B, S4N), ME(S3S4B, S2S3N), MD(S1S2B, S4N), MA(S2B, S5N), MI(S3), MN(SNRB), MS(S1?B), MO(S3), NN(S3S4), NE(S1), NV(S3), NJ(S2B, S3N), NC(S2B, S4N), ND(SNRB), OH(S3), P RI(SHB), SC(S2N), SD(S3B, S3N), TN(S3B), TX(S2B, S3N), VA(S3S4), WA(S3S4B, S4N), WV(S3B, S4N), WI(S2N, S3S4B)
song sparrow	*Melospiza melodia*	G5 / N5	AL(S3B, S5N), CA(SNR), FL(SNRN), KS(S3B, S4N), ME(S4N, S4S5B), MN(SNRB, SNRN), MO(SNR), NN(S3S4N), ND(SNRB), SC(SNRB, SNRN)
sooty grouse	*Dendragapus fuliginosus*	G5 / N5	CA(SNR), OR(SNR), WA(SNR)
spotted towhee	*Pipilo maculates*	G5 / N5	CA(SNR), KS(S2B, S3N), LA(S2S3N), NE(SNRB, SNRN), ND(SNRB), UT(S4S5B, S4N)
spruce grouse	*Falcipennis canadensis*	G5 / N5	MI(S2S3), MN(SNR), NH(S3), NY(S2), OR(S3), VT(S1B), WI(S1S2B, S1S2N)
Steller's jay	*Cyanocitta stelleri*	G5 / N5	NE(SNRN)
summer tanager	*Piranga rubra*	N5B	CA(S2), DE(S3B), DC(S1S2B, S1S2N), FL(SNRB), IA(S3B, S3N), MA(S1N), MI(SNRN), MO(SNRB), NV(S2B), PA(S3B), UT(S1B)
Swainson's thrush	*Catharus ustulatus*	G5 / N5B	AZ(S1), GA(SNRN), MD(SXB), MA(S2B, S5N), MI(S3S4), MN(SNRB), NN(S1S2B), NE(SU), NV(S3B), NM(S3B, S4N), PA(S2S3B, S5N), UT(S3S4B), VA(S1B), WV(S3B), WI(S2B)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
swamp sparrow	*Melospiza georgiana*	G5 / N5B, N5N	AZ(S2S3N), DE(S3B, S4N), DC(S2S3N), FL(SNRN), IN(S3N, S4B), IA(S3B, S5N), KS(S3N), MN(SNRB), NN(S2S3N), NE(S3), ND(S3), OK(S2N), OR(S3N), SC(S3N), UT(S3N), VA(S1B, S4S5N), WV(S3B, S4N)
Tennessee warbler	*Vermivora peregrina*	G5 / N5B	AK(S2S3B), AZ(S1M), DC(S2S3N), GA(SNRN), MN(SNRB), MT(S2S4B), NE(SNRN), NH(S3B), NY(S2), VT(S2S3B)
Townsend's solitaire	*Myadestes townsendi*	G5 / N5	AK(S3S4B), IA(S3N), MI(SNRN), MN(SNRN), NN(S3B, S4N), NE(S2), OK(S2N), TX(S3N)
Townsend's warbler	*Dendroica townsendi*	G5 / N5B, NNRN	AZ(S4M, S1S2N), CA(SNRN), NE(SNRN), OK(S1N), WA(S4N, S5B)
tree swallow	*Tachycineta bicolor*	G5 / N5B, N5N	AZ(S3), DC(S1B), FL(SNRN), KS(S1B), KY(S3S4B), MN(SNRB), MO(SNRB), NN(S2B), NE(SNRN), NM(S3B, S4N), NC(S3B, S4N), ND(SNRB), OK(S2N), TX(S3B, S4N)
tufted titmouse	*Baeolophus bicolor*	N5	FL(SNR), MN(SNR), MO(SNR), NE(S3), SC(SNR), SD(SUB), VT(S3S4B, S3S4N), WI(S3B)
turkey vulture	*Cathartes aura*	N5B, N5N	DC(S3N), FL(SNR), IN(S1N, S4B), MN(SNRB), MO(SNRB, SNRN), NE(S3), RI(S2B, S2N), SC(SNR), UT(S3?B), VT(S3B, S4N)
varied thrush	*Ixoreus naevius*	G5 / N5	AZ(S1N), IA(S2N), MN(SNRN), NE(SNRN), NY(SNRN)
veery	*Catharus fuscescens*	G5 / N5B	AZ(S1), AR(S2N), CO(S3B), DE(S2B), DC(S2B, S3N), IL(S3), IN(S3B), IA(S3N), KY(S3S4B), MN(SNRB), NN(SNR), NE(SNRN), NJ(S3B), NM(S1B, S4N), ND(SNRB), OR(S4?B), SD(S2B), UT(SHB), WA(S3S4B)
vesper sparrow	*Pooecetes gramineus*	G5 / N5B, N5N	AR(S3N), CA(SNR), CT(S1B), DE(S3B), DC(S3N), FL(SNRN), KS(S2B), KY(S1B), ME(S3S4B), MD(S3S4B, S2N), MA(S1S2B, S3N), MN(SNRB), MO(SNRB), NH(S2S3B), NJ(S1B, S2N), NC(S2B, S2N), ND(SNRB), RI(SHB, S1N), SC(SNRN), TN(S1B, S4N), UT(S5B, S2N), VT(S3B), WV(S3B, S2N)
violet-green swallow	*Tachycineta thalassina*	G5 / N5B	NE(S3), NM(S3B, S4N),
Virginia's warbler	*Vermivora virginiae*	G5 / N5B	CA(S2S3), ID(S2B), NM(S3B, S4N), OK(S1N), SD(S3B), TX(S3B), WY(S1)
warbling vireo	*Vireo gilvus*	G5 / N5B	AL(S1B), DE(S2B), DC(S1B, S1S2N), GA(SNRN), LA(S1B), MN(SNRB), MO(SNRB), NC(S2B), ND(SNRB), RI(S3B), TX(S3B)
western bluebird	*Sialia mexicana*	G5 / N5	NV(S3), TX(S3B, S4N), UT(S2S3), WA(S3B), WY(SHB)
western meadowlark	*Sturnella neglecta*	G5 / N5	CA(SNR), ID(S5B, S3N), IN(S2B), LA(S2N), MN(SNRB), MO(SNR), NY(SNR), ND(SNRB), OH(S2), TN(S2N), WA(S4N, S4S5B), WI(S2B)
western scrub jay	*Aphelocoma californica*	N5	CA(SNR), ID(S2?), OK(S1S2), WY(S1)
western tanager	*Piranga ludoviciana*	G5 / N5B	AK(S3B), CA(SNRB), ND(SU), OK(S1N)
Western wood-pewee	*Contopus sordidulus*	G5 / N5B	KS(S1?B), NN(S3B), OK(S1B)
whip-poor-will	*Caprimulgus vociferus*	N5B, NNRN	AL(S5B, S3N), CA(SNRN), CT(S3B), DC(S3N), FL(SNRN), KS(S3B), ME(S3B), MD(S3S4B), MA(S2S3B, S3N), MN(SNRB), MS(S2?B), MO(SNRB), NE(S2), NV(S1B), NH(S3B), ND(SU), OK(S2B), SD(S2B), TN(S3S4), VT(S2B), WV(S3B), WI(S3B)
white-breasted nuthatch	*Sitta carolinensis*	G5 / N5	DE(S3), DC(S3B, S3N), FL(S2), LA(S2), MN(SNR), MO(SNR), NE(S3), ND(SNR), SC(SNR), TX(S3B), UT(S3S4)
white-crowned sparrow	*Zonotrichia leucophrys*	G5 / N5B, N5N	AZ(S1B, S5N), CA(SNRB, SNRN), DC(S3N), FL(SNRN), IA(S3N), MD(S3S4N), MI(SNRN), MO(SNRN), NE(SNRN), NY(SNRN), OH(SNRN), PA(S3N), SC(SNRN)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
white-eyed vireo	*Vireo griseus*	N5B, N5N	AL(S5B, S3N), DC(S1B, S2S4N), FL(SNR), IA(S2B, S3N), KS(S2B), MA(S2S3B, S4N), M MO(SNRB), NE(S2), NC(S5B, S1N), SC(S4?B)
white-headed woodpecker	*Picoides albolarvatus*	G4 / N4	CA(SNR), ID(S2B), NV(S2), OR(S2S3), WA(S2S3)
white-throated sparrow	*Zonotrichia albicollis*	G5 / N5B, N5N	AZ(S2S3N), CA(SNRN), FL(SNRN), KS(S3N), ME(S4S5B, S4S5N), MN(SNRB, SNRN), MO(SNRN), NN(S3S4N), NE(SNRN), ND(S3), OH(SH), OR(S2N), PA(S3S4B, S5N), RI(S1B), SC(SNRN), UT(S3S4N), VA(SNRN), WV(S1B, S4N)
white-throated swift	*Aeronautes saxatalis*	N5B, N4N	NM(S3B, S4N), WA(S3S4B)
wild turkey	*Meleagris gallopavo*	N5	FL(SNR), MO(SNR), ND(SNR), OK(S3B), SC(SNR), W
Williamson's sapsucker	*Sphyrapicus thyroideus*	G5 / N5B, N5N	CA(S3), MT(S3S4B), NV(S2), OR(S4B, S3N), TX(S2N), UT(S2B), WA(S3S4B), WY(S2)
Wilson's snipe	*Gallinago delicata*	G5 / N5B, N5N	AZ(S1B, S4N), CA(SNR), DC(S2S3N), FL(SNRN), IL(S3), IN(S1S2B), IA(S2B, S5N), KS(S3N), KY(S3S4N), MD(S2N), MA(S1S2B, S4N), MN(SNRB), MO(SNRN), NN(S1S2N), NE(S2), NJ(S3S4), NM(S2B, S5N), ND(SNRB), OH(S3), PA(S3B, S3N), SC(SNRN), SD(S3B), UT(S4B, S3N), VA(SNRN), WV(S3B, S3N), WY(SNR)
Wilson's warbler	*Wilsonia pusilla*	G5 / N5B	CA(SNRB), DC(S2S3N), GA(SNRN), ME(S3S4B), MI(S2), MN(SNRB), NE(SNRN), NV(S2B, S5M), NH(S3B), NM(S2B, S5N), NY(SNR), TN(S3N), UT(S3S4B), VT(S1B), WI(SUB)
winter wren	*Troglodytes troglodytes*	G5 / N5	AZ(S2S3N), DC(S2S3N), MD(S2B, S3N), MN(SNRB), MO(SNRN), NN(S3N), NE(SNRN), NV(S1), NJ(S3B, S4N), NM(S3N), NC(S3B, S5N), OH(S2), OK(S2N), RI(S1B, S2N), SC(S4?N), SD(SUB, S4N), TN(S3B, S4N), UT(S3N), VA(S2B, S4N), WI(S3B)
wood thrush	*Hylocichla mustelina*	N5B	DC(S3B, S4N), FL(SNRB), KS(S3B), MN(SNRB), ND(SU), OK(S2B), SC(S3?), SD(S2B)
worm-eating warbler	*Helmitheros vermivorum*	N5B	AL(S3B), DE(S3B), DC(S2N), FL(S1), IN(S3B), IA(S2B, S2N), MA(S2B), MO(SNRB), NE(SNRN), NJ(S3B), OH(S3S4), OK(S1B), RI(S2B), TX(S3B), WI(S1B)
wrentit	*Chamaea fasciata*	G5 / N5	None
yellow warbler	*Dendroica petechia*	G5 / N5B, N5N	AR(S3B, S5N), CA(SNRB), DC(S2N), FL(SNRB, SNRN), KS(S3B), MN(SNRB), MO(SNRB), NN(S3B), NV(S3S4B, S4M), ND(SNRB), OK(S3B), SC(SNR), TX(S2B, S5N)
yellow-bellied flycatcher	*Empidonax flaviventris*	G5 / N5B	AK(S2B), DC(S1S2N), GA(SNRN), IA(S3N), MA(S3N), MN(SNRB), NE(SNRN), NY(S3), NC(SUB), OK(S2N), PA(S1S2B), SC(SUB), TN(S3N), VA(S1B), WV(S1B)
yellow-bellied sapsucker	*Sphyrapicus varius*	N5B, N5N	AK(S3B), AZ(S1N), DC(S2N), FL(SNRN), IL(S1S2), IN(S2B), IA(S1B, S3N), KS(S3N), KY(S3S4N), MD(SHB, S3N), MN(SNRB), MO(SNRN), NN(S2N), NE(SNRN), NC(S3B, S5N), ND(SNRB), OH(S1), OK(S3N), PA(S4B, S3N), SC(SNRN), SD(S3B), TN(S1B, S4N), VA(S1B, S4N), WV(S1B, S3N)
yellow-billed cuckoo	*Coccyzus americanus*	N5B	AZ(S3), CA(SNRB), CO(S3B), DC(S2B, S3N), FL(SNRB), ID(S1B), IA(S3B), ME(S3?B), MN(SNRB), MO(SNRB), MT(S3B), NN(S1B), NV(S1B), NM(S3B, S3N), ND(SU), OR(SHB), SD(S3B), UT(S1B), WA(SH), WI(S3B), WY(S1)
yellow-breasted chat	*Icteria virens*	N5B	AL(S5B, S2N), CA(S3), CT(S1B), DE(S3B), DC(S3S4N), FL(SNRB), IA(S3B, S3N), KS(S3B), MA(S1B, S1N), MI(S3), MO(SNRB), NN(S2S3B), NV(S3B), NJ(S3B), NM(S3B, S4N), NY(S3), ND(SU), RI(S1B, S1N), UT(S3S4B), WA(S3S4B), WI(S2B)
yellow-rumped warbler	*Dendroica coronata*	G5 / N5B, N5N	CA(SNRB, SNRN), FL(SNRN), MA(S5B, S5M, S3N), MN(SNRB), MO(SNRN), NC(SUB, S5N), ND(SNRB), PA(S3S4B, S2N), RI(S2B), SC(SNRN), UT(S4S5B, S3N), WV(S3B, S3N), WI(S3B)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Bird			
yellow-throated vireo	*Vireo flavifrons*	N5B, N4N	DE(S3B), DC(S2S3B, S2S3N), FL(SNRB), KS(S3B), ME(S3B), MN(SNRB), MO(SNRB), NE(S2), ND(SNRB), OK(S2B), SC(S3?B), SD(S2B)
yellow-throated warbler	*Dendroica dominica*	N5B	AL(S5B, S3N), DE(S2B), DC(S1N), FL(SNRB, SNRN), IA(S3B, S3N), KS(S1B), MA(S1N), MI(S1), MO(SNRB), NE(SNRN), NY(SNR), OK(S2B), SC(S3?), WI(S1B)
Bat			
big brown bat	*Eptesicus fuscus*	G5 / N5	FL(S3), LA(S1S2), MN(SNR), MO(SNR), ND(SNR), OH(SNR), SC(SNR)
eastern pipistrelle	*Perimyotis subflavus*	G5 / N5	FL(SNR), ME(SU), MA(S3), MI(S2), MN(S3), MO(SNR), NE(S1), NH(S1N, SUB), NJ(SU), NY(S3), OH(SNR), SC(SNR), VT(S2S3), WI(S3S4)
eastern red bat	*Lasiurus borealis*	G5 / N5	CO(S2B), CT(S3), DE(SU), FL(SNR), ME(SU), MA(S3M), MN(SNR), MO(SNR), MT(S2S3), NH(S3?B), NJ(SU), ND(SNR), OH(SNR), RI(SNR), SC(SNR), WI(S3)
Small mammal			
American water shrew	*Sorex palustris*	G5 / N5	AZ(S1), CT(S3S4), GA(S1), MD(S1), MA(S3), NV(S2), NJ(SU), NM(S3), NC(S2), PA(SNR), RI(S1), SC(SNR), SD(SH), TN(S2), VT(S3), VA(S1), WV(S1), WI(S2S3)
brush mouse	*Peromyscus boylii*	G5 / N5	NV(S3), OK(S3), UT(S4S5)
California ground squirrel	*Spermophilus beecheyi*	G5 / N5	None
Cinereus Shrew	*Sorex cinerus*	G5 / N5	GA(S2S3), IA(SNR), KY(S3), NM(S2), ND(SNR), SC(SNR), UT(S3?)
deer mouse	*Peromyscus maniculatus*	G5 / N5	AK(SNR), CT(S3), MN(SNR), MO(SNR), NJ(SU), ND(SNR), OH(SNR), SC(SNR), WI(S3S4)
eastern chipmunk	*Tamias striatus*	G5 / N5	FL(S2), KS(S1), LA(S3S4), MN(SNR), MO(SNR), NE(S1), ND(SNR), OH(SNR), SC(SNR), SD(S3)
eastern woodrat	*Neotoma floridana*	N5	CO(S3S4), IL(S1), MS(SNR), MO(S3S4), NE(S3), NC(S3), SC(S3S4), TN(SNR)
golden mouse	*Ochrotomys nuttalli*	G5 / N5	FL(SNR), IL(S2), MS(SNR), MO(S3?), OK(S1), SC(SNR), WV(S2)
golden-mantled ground squirrel	*Spermophilus lateralis*	G5 / N5	None
gray-collared chipmunk	*Tamias cinereicollis*	G4 / N4	NM(S3)
heather vole	*Phenacomys intermedius*	G5 / N5	CA(S3S4), NM(S3), UT(S2?)
Hispid cotton rat	*Sigmodon hispidus*	N5	CA(S2), IA(SU), KY(S3S4), MO(SNR), NE(S3), SC(SNR)
least chipmunk	*Tamias minimus*	G5 / N5	MN(SNR), NN(S3S4), NE(S1), ND(SNR)
lodgepole chipmunk	*Neotamias speciosus*	G4 / N4	None
long-eared chipmunk	*Tamias quadrimaculatus*	G4G5 / N4N5	None
long-tailed shrew	*Sorex dispar*	G4 / N4	GA(S1), KY(S1), MD(S2), MA(S3), NJ(S1), NC(S3), PA(S3), TN(S2), VT(S2), VA(S3), WV(S2S3)
masked shrew	*Sorex cinereus lesueurii*	G5TNR / NNR	KY(S2)
Mexican woodrat	*Neotoma mexicana*	G5 / N5	OK(S1), UT(S3)
northern short-tailed shrew	*Blarina brevicauda*	G5 / N5	MO(SNR), NE(S3), ND(SNR), SC(SNR)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Small mammal			
pygmy shrew	*Sorex hoyi*	G5 / N5	AL(S1), CO(S2), GA(S2), ID(S2), IL(SH), IN(S2), IA(SU), MD(SNR), MA(S1?), MN(SNR), NJ(SNR), NC(S3), ND(SU), OH(SNR), PA(SNR), SC(S3S4), SD(S2), TN(S2), VT(S2), WA(S2S3), WV(S2S3), WI(S3S4), WY(S1)
rock shrew	*Sorex dispar blitchi*	G4T3T4 / N3?	KY(S1)
smoky shrew	*Sorex fumeus*	G5 / N5	GA(S3?), IN(S2), MD(S2S3), MI(S1), MN(S3), NJ(SU), OH(SNR), RI(S2)
southeastern shrew	*Sorex longirostris*	N5	AR(S2), DC(S3), IL(S3S4), IN(S3), LA(S2S3), MD(S3S4), SC(SNR), WV(SU)
southern flying squirrel	*Glaucomys volans*	N5	FL(SNR), KS(S3), ME(SU), MN(SNR), MO(SNR), NE(S1), OH(SNR), OK(S3), SC(SNR)
southern red-backed vole	*Myodes gapperi OR Clethrionomys gapperi*	G5 / N5	AZ(S3), GA(S3S4), IA(S2), KY(S3), MN(SNR), NM(S3), ND(SNR), OH(SH), SC(S2S3), UT(S2S3)
white-footed mouse	*Peromyscus leucopus*	G5 / N5	MN(SNR), MO(SNR), ND(SNR), OH(SNR), SC(SNR), WY(S3)
woodland jumping mouse	*Napaeozapus insignis*	G5 / N5	GA(S3), MN(SNR), OH(S3), WI(S2S3)
woodland vole	*Microtus pinetorum*	G5 / N5	FL(SNR), IA(S3), ME(S1), MI(S3S4), MN(S3), MO(SNR), NE(S1), OH(SNR), RI(SU), SC(SNR), TX(S3), VT(S3), WI(S1)
yellow pine chipmunk	*Tamias amoenus*	G5 / N5	UT(S1)
Mid-large mammal			
American black bear	*Ursus americanus*	G5 / N5	AL(S2), CT(S3), DE(SX), DC(SX), IL(SX), IN(SX), IA(SX), KS(SX), KY(S2), LA(S2), MD(S3S4), MN(SNR), MS(S1), MO(S3), NE(SX), NJ(S3), ND(SX), OH(S1), OK(S1), RI(SX), SC(S3?), SD(S1), TN(S3), TX(S3), UT(S3)
American marten	*Martes americana*	G5 / N5	CA(S3S4), DC(SX), IL(SX), MD(SX), MA(SX), MI(S3), NN(SNR), NV(S2S3), NH(S2), NM(S2), NY(S3), ND(SX), OH(SX), OR(S3S4), PA(SX), UT(S2), VT(S1?), WI(S3), WY(S3)
bobcat	*Lynx rufus*	G5 / N5	CT(S2?), DE(SNR), DC(SH), FL(SNR), IL(S3), IN(S1), IA(S3), MD(S3), MN(SNR), NJ(S3), ND(SU), OH(S1), PA(S3S4), RI(SU), SC(SNR)
brown bear	*Ursus arctos*	G4 / N3N4	AZ(SX), CA(SX), CO(SX), ID(S1), KS(SX), MN(SX), MT(S2S3), NN(SX), NE(SX), NV(SX), NM(SX), ND(SX), OK(SX), OR(SX), SD(SX), TX(SX), UT(SX), WA(S1), WY(S1)
Canadian lynx	*Lynx canadensis*	G5 / N4?	CO(S1), ID(S1), IN(SX), ME(S2), MA(SX), MI(S1), MN(SNR), MT(S3), NV(SX), NH(S1), NY(SX), ND(SU), OH(SX), OR(S1?), PA(SX), UT(S1), VT(SH), WA(S1), WY(S1)
elk	*Cervus canadensis*	G5 / N5	AL(SX), AZ(SNR), AR(S3), DE(SX), DC(SX), GA(SX), IL(SX), IN(SX), IA(SX), KS(S1), KY(SNR), LA(SX), ME(SX), MD(SX), MA(SX), MI(S3), MN(S3), MO(SX), NE(S3), NH(SX), NM(S3), NY(SX), NC(S1), ND(SU), OH(SX), OK(SX), PA(SNR), SC(SX), TN(SX), TX(S2S3), VT(SX), VA(SX), WV(SX), WI(SX)
fisher	*Martes pennanti*	G5 / N5	CA(S3S4), CT(S2), ID(S1), IL(SX), IN(SX), IA(SX), MD(S3S4), MN(SNR), MT(S3), NJ(SX), NC(SX), ND(S2), OH(SX), OR(S2), PA(S2S4), RI(S1), TN(S1), VA(S1), WA(SH), WV(S3), WY(S1)
gray wolf	*Canis lupus*	G4 / N4	AZ(SH), AR(SX), CA(SX), CO(SX), CT(SX), DE(SX), DC(SX), FL(SX), GA(SX), ID(S1), IL(S1), IN(SX), IA(SX), KS(SX), KY(SX), ME(SH), MD(SX), MA(SX), MI(S3), MN(S3), MO(SX), MT(S3), NN(SX), NE(SX), NV(SH), NH(SX), NJ(SX), NM(S1), NY(SX), NC(SX), ND(SX), OH(SX), OK(SX), OR(SH), PA(SX), RI(SX), TN(SX), TX(SX), UT(SX), VT(SX), VA(SX), WA(S1), WV(SX), WI(S2), WY(S1)

continues

Appendix 2 (continued). Scientific names and conservation status (federal, regional, and state) of wildlife taxa considered.

Taxon/common name[1]	Scientific name	Federal conservation status[2]	State/regional conservation status[3]
Mid-large mammal			
mountain lion (Cougar)	*Puma concolor*	G5 / N5	AL(SX), CT(SH), DE(SX), DC(SX), GA(SH), IL(SX), IN(SNR), IA(SX), KY(SX), LA(S1), ME(SH), MD(SH), MA(SX), MI(SH), MN(S3), MS(S1), MO(SX), NN(S3), NE(S1), NH(SH), NJ(SNR), NM(S3?), NY(SX), NC(SH), ND(S2), OH(SX), OK(S1), PA(SNR), RI(SH), SC(SH), SD(S2), TX(S2), VT(SH), VA(SNR), WV(SH)
mule deer/black-tailed deer	*Odocoileus hemionus*	G5 / N5	ND(SNR), OK(S1)
raccoon	*Procyon lotor*	G5 / N5	MN(SNR), MO(SNR), ND(SNR), OH(SNR), SC(SNR)
red fox	*Vulpes vulpes*	G5 / N5	AZ(S3), CA(S1), FL(SNR), MN(SNR), MO(SNR), NV(S3), NM(S3), ND(SNR), OH(SNR), OK(S3), SC(SNR)
striped skunk	*Mephitis mephitis*	G5 / N5	FL(SNR), MN(SNR), MO(SNR), ND(SNR), OH(SNR), SC(SNR)
white-tailed deer	*Odocoileus virginianus*	G5 / N5	MN(SNR), ND(SNR), OH(SNR), OR(SNR), SC(SNR), UT(S1)

[1]For species of conservation concern, some subspecific taxa are included in this appendix.

[2]Global, federal, and state/regional conservation status based on ranks obtained from natureserve.org. See http://www.natureserve.org/explorer/ranking.htm for additional information on rankings. A brief explanation: Conservation status of a species is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = global, N = national, and S = subnational). Numbers have the following meaning: 1 = critically imperiled, 2 = imperiled, 3 = vulnerable to extirpation or extinction, 4 = apparently secure, 5 = demonstrably widespread, abundant, and secure.

[3]State/regional conservation ranks obtained from natureserve.org. State abbreviations are followed by each taxon's status within that state. For brevity, secure (S4 and S5) and unapplicable (SNA) ranks were omitted. See http://www.natureserve.org/explorer/ranking.htm for additional information on rankings. A brief explanation: S = subnational, NR = unranked, U = unrankable, X = extinct, H = presumed extinct, ? = uncertain numeric rank, B = breeding, M = migrant, N = nonbreeding.

continues

APPENDIX 3. WILDLIFE RESPONSE TO FIRE AND FIRE SURROGATE TREATMENTS WITHIN EACH ECOREGION

Appendix 3 summarizes the results of our quantitative analysis for each region. To compare a diverse set of studies across regions and taxa we used the relative abundance index (RAI) of Vanderwel et al. (2007) where RAI = (Treatment – Control) / (Treatment + Control).

This index varies from -1 to +1 and can be calculated from any study that reports treatment and control means. Calculation of RAI permitted us to put a broad array of studies on the same scale and average across studies. Relative Abundance Index values <-0.40 and >0.40 were arbitrarily considered suggestive of negative and positive, respectively, treatment responses. Index values should be interpreted with caution and in the context of standard errors and sample sizes because they are sensitive to small sample sizes.

Within each region, data are sorted by each vertebrate class (amphibians, reptiles, birds, and mammals) and within each class the species are presented alphabetically by common name. For each species within a region the average RAI is presented for each of the potential treatments; the first parenthetic entry is the standard error (SE) and the second entry is the sample size. The sample size represents the number of independent response measurements, not the number of studies. For example, a study reporting contrasts of burned and unburned plots may present measurements of the same plots before and after treatment (pre-post comparison) as well as contrasts of burned and unburned plots following treatment (after-only comparison). This situation is true for many of the studies from the Fire-Fire Surrogate study system. Fire severity was classified as either low/moderate or high. Generally, data from wildland fires tended to be moderate/high severity while data from prescribed fire were low fire severity. All treatments were classified into 3 temporal categories (0-4 years, 5-9 years and > 10 years) classes. Currently, there are no fire surrogate studies conducted > 4 years post-treatment. Blank cells mean there are no treatment data for that species in that region. We consider an average RAI ≥ 0.40 to be evidence of a positive response to the treatment and an RAI < -0.40 to be evidence of a negative response to the treatment. All other values represent either no response or an inconsistent response. These arbitrary criteria will be evaluated in the future in a meta-analysis but is beyond the scope of the present synthesis.

For example, in the Pacific Mixed Conifer Region, one study presents evidence the American robin has a strong short-term and moderate-term positive response to high-severity fire. Three studies suggest this response is sustained for > 10 years. In this region there are no data on the response of American robins to low or moderate severity fire or fire surrogates.
In the Hardwood East Region, there are 2 studies that provide evidence eastern chipmunks have a short-term positive response to low/moderate severity fire and the thinning + prescribed fire fuels reduction treatment. However, there is also evidence this species has a short-term negative response to the thinning treatment without prescribed fire. In this region there are no data on the response of eastern chipmunks to high-severity fire (as expected given the extremely rare nature of high-severity fire in the region) nor on moderate and long-term responses to any of the treatments.

Appendix 3. Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pacific Mixed Conifer (Amphibian)								
No Quantitative Data								
Pacific Mixed Conifer (Bird)								
acorn woodpecker	0.00 (NA, 1)		1.00 (NA, 1)					
American kestrel		0.00 (NA, 1)	0.50 (0.50, 2)					
American robin	0.82 (NA, 1)	0.78 (NA, 1)	0.48 (0.25, 3)					
Bewick's wren	0.00 (NA, 1)		1.00 (NA, 1)					
black-backed woodpecker		0.75 (NA, 1)	-1.00 (0.00, 3)					
black-headed grosbeak	-0.29 (NA, 1)		0.58 (NA, 1)					
black-throated gray warbler	-1.00 (NA, 1)		-0.80 (NA, 1)					
Brewer's sparrow		1.00 (NA, 1)	0.50 (0.50, 2)					
brown creeper	-0.27 (NA, 1)	-0.33 (NA, 1)	-1.00 (0.00, 3)					
brown-headed cowbird		0.00 (NA, 1)	1.00 (0.00, 2)					
bushtit	-1.00 (NA, 1)		0.20 (NA, 1)					
calliope hummingbird		0.00 (NA, 1)	0.49 (0.29, 2)					
Cassin's finch		0.13 (NA, 1)	0.25 (0.05, 2)					
Cassin's vireo	-1.00 (NA, 1)	-1.00 (NA, 1)	0.07 (0.07, 3)					
chestnut-backed chickadee	-0.96 (NA, 1)		-0.73 (NA, 1)					
chipping sparrow		1.00 (NA, 1)	0.67 (0.33, 2)					

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pacific Mixed Conifer (Bird)—continued								
common nighthawk		0.00 (NA, 1)	1.00 (0.00, 2)					
common raven	-1.00 (NA, 1)		-1.00 (NA, 1)					
Cooper's hawk		0.00 (NA, 1)	-0.50 (0.50, 2)					
dark-eyed junco	0.55 (NA, 1)	0.01 (NA, 1)	-0.26 (0.05, 3)					
downy woodpecker	0.80 (NA, 1)		-1.00 (NA, 1)					
dusky flycatcher	0.00 (NA, 1)	-0.29 (NA, 1)	0.32 (0.35, 3)					
evening grosbeak		0.00 (NA, 1)	-0.39 (0.39, 2)					
fox sparrow	0.00 (NA, 1)	0.20 (NA, 1)	1.00 (0.00, 3)					
golden-crowned kinglet	-1.00 (NA, 1)	-1.00 (NA, 1)	-1.00 (0.00, 3)					
green-tailed towhee	0.00 (NA, 1)	1.00 (NA, 1)	0.67 (0.33, 3)					
hairy woodpecker	0.95 (NA, 1)	0.50 (NA, 1)	-0.13 (0.36, 5)					
Hammond's flycatcher	0.45 (NA, 1)		0.52 (NA, 1)					
hermit thrush	-0.97 (NA, 1)	-1.00 (NA, 1)	-0.94 (0.06, 3)					
hermit warbler	-0.97 (NA, 1)		-0.56 (NA, 1)					
house wren	1.00 (NA, 1)	1.00 (NA, 1)	0.67 (0.33, 3)					
Hutton's vireo	-1.00 (NA, 1)		-0.78 (NA, 1)					
lazuli bunting	1.00 (NA, 1)	1.00 (NA, 1)	0.67 (0.33, 3)					
Lewis's woodpecker		0.00 (NA, 1)	-0.50 (0.50, 2)					

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pacific Mixed Conifer (Bird)—continued								
MacGillivray's warbler	0.43 (NA, 1)		0.82 (NA, 1)					
mountain bluebird		1.00 (NA, 1)	1.00 (0.00, 2)					
mountain chickadee		-0.50 (NA, 1)	0.04 (0.01, 2)					
mountain quail	0.71 (NA, 1)	0.00 (NA, 1)	0.33 (0.33, 3)					
mourning dove	0.00 (NA, 1)	0.00 (NA, 1)	1.00 (0.00, 3)					
Nashville warbler	-0.64 (NA, 1)	-1.00 (NA, 1)	-0.21 (0.47, 3)					
northern flicker	0.43 (NA, 1)	0.75 (NA, 1)	0.33 (0.37, 5)					
olive-sided flycatcher	0.73 (NA, 1)	1.00 (NA, 1)	0.94 (0.06, 3)	0.34 (0.11, 3)				
orange-crowned warbler	0.00 (NA, 1)		1.00 (NA, 1)					
pacific-slope flycatcher	-0.94 (NA, 1)		-1.00 (NA, 1)					
pileated woodpecker	0.00 (NA, 1)		-0.33 (NA, 1)					
pine siskin	0.27 (NA, 1)	0.00 (NA, 1)	-0.35 (0.21, 3)					
purple finch	0.85 (NA, 1)		0.88 (NA, 1)					
pygmy nuthatch		1.00 (NA, 1)	0.75 (0.25, 4)					
red crossbill	0.45 (NA, 1)	0.00 (NA, 1)	-0.41 (0.51, 3)					
red-breasted nuthatch	-0.67 (NA, 1)	-1.00 (NA, 1)	-0.88 (0.13, 4)					
red-breasted sapsucker	-1.00 (NA, 1)	-0.50 (NA, 1)	-0.46 (0.31, 4)					
rufous hummingbird	0.33 (NA, 1)		0.54 (NA, 1)					

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pacific Mixed Conifer (Bird)—continued								
song sparrow	1.00 (NA, 1)		1.00 (NA, 1)					
sooty grouse	-0.33 (NA, 1)	0.00 (NA, 1)	-0.67 (0.33, 3)					
spotted towhee	-1.00 (NA, 1)		0.94 (NA, 1)					
Steller's jay	-0.49 (NA, 1)	-1.00 (NA, 1)	-0.40 (0.22, 3)					
Townsend's solitaire	0.96 (NA, 1)	-0.14 (NA, 1)	-0.58 (0.29, 3)					
warbling vireo	-0.71 (NA, 1)		0.59 (NA, 1)					
western bluebird	1.00 (NA, 1)		1.00 (NA, 1)					
western tanager	-0.43 (NA, 1)	-0.71 (NA, 1)	-0.63 (0.27, 3)					
western wood-pewee	1.00 (NA, 1)	0.71 (NA, 1)	0.67 (0.33, 3)					
white-breasted nuthatch		0.67 (NA, 1)	0.29 (0.04, 2)					
white-crowned sparrow	1.00 (NA, 1)		0.00 (NA, 1)					
white-headed woodpecker		0.33 (NA, 1)	0.58 (0.25, 4)					
Williamson's sapsucker		1.00 (NA, 1)	-0.72 (0.13, 4)					
Wilson's warbler	-1.00 (NA, 1)		-1.00 (NA, 1)					
winter wren	-1.00 (NA, 1)		-1.00 (NA, 1)					
wrentit	-1.00 (NA, 1)		0.89 (NA, 1)					
yellow warbler		0.00 (NA, 1)	1.00 (0.00, 2)					
yellow-rumped warbler	0.39 (NA, 1)	-0.11 (NA, 1)	-0.46 (0.21, 3)					

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pacific Mixed Conifer (Mammal)								
brush mouse				0.37 (0.50, 2)			0.14 (0.26, 2)	-0.50 (0.30, 2)
California ground squirrel				0.22 (0.07, 2)			0.47 (0.15, 2)	0.30 (0.13, 2)
deer mouse				0.41 (0.19, 2)			-0.15 (0.11, 2)	0.56 (0.28, 2)
Pacific Mixed Conifer (Reptile)								
No Quantitative Data								
Interior Mixed Conifer (Amphibian)								
Columbia spotted frog	0.03 (NA, 1)							
long-toed salamander	-0.01 (NA, 1)							
Interior Mixed Conifer (Bird)								
American robin	0.39 (0.21, 5)	0.68 (0.16, 2)	0.20 (0.21, 12)	0.02 (0.10, 8)				
American three-toed woodpecker	0.88 (0.09, 4)	-1.00 (0.00, 2)	-1.00 (0.00, 12)	0.86 (0.03, 3)				
black-backed woodpecker	0.80 (0.07, 4)	-1.00 (0.00, 2)	-1.00 (0.00, 12)	0.82 (0.04, 3)				
black-billed magpie	1.00 (NA, 1)							
black-capped chickadee	-0.47 (0.29, 3)			0.31 (0.28, 4)				
brown creeper	0.03 (0.35, 6)	-1.00 (0.00, 2)	-1.00 (0.00, 12)	0.63 (0.10, 7)				
brown-headed cowbird	-0.12 (0.01, 2)			-0.02 (0.10, 5)				
calliope hummingbird	0.22 (0.78, 2)			0.32 (0.40, 4)				
Cassin's finch	0.43 (0.19, 5)	0.50 (0.50, 2)	0.33 (0.14, 12)	0.33 (0.11, 8)				
Cassin's vireo	-0.86 (0.03, 2)			-0.44 (0.12, 4)				

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Interior Mixed Conifer (Bird)—continued								
chipping sparrow	-0.04 (0.16, 5)	-0.08 (0.17, 2)	-0.06 (0.17, 12)	0.13 (0.18, 8)				
Clark's nutcracker	0.20 (0.28, 6)	0.96 (0.00, 2)	-0.25 (0.27, 12)	-0.30 (0.21, 7)				
common nighthawk	0.00 (0.00, 3)	0.50 (0.50, 2)	0.08 (0.08, 12)	0.00 (0.00, 3)				
common raven	-0.40 (NA, 1)							
dark-eyed junco	0.15 (0.06, 5)	-0.25 (0.75, 2)	0.03 (0.15, 12)	0.19 (0.06, 8)				
downy woodpecker	1.00 (NA, 1)							
dusky flycatcher	-0.34 (0.12, 2)			-0.04 (0.19, 5)				
dusky grouse	1.00 (NA, 1)							
golden-crowned kinglet	-0.95 (0.03, 6)	-1.00 (0.00, 2)	-1.00 (0.00, 12)	-0.50 (0.10, 7)				
gray jay	-0.52 (0.16, 6)	-0.41 (0.59, 2)	-0.17 (0.13, 12)	-0.43 (0.16, 7)				
green-tailed towhee				0.09 (NA, 1)				
hairy woodpecker	0.48 (0.30, 6)	0.73 (0.08, 2)	-0.14 (0.26, 12)	0.36 (0.11, 8)				
Hammond's flycatcher	0.06 (0.68, 2)			0.15 (0.43, 4)				
hermit thrush	-0.81 (0.12, 5)	-1.00 (0.00, 2)	-0.35 (0.23, 12)	-0.25 (0.21, 7)				
house wren	0.25 (0.25, 4)	0.50 (0.50, 2)	0.08 (0.08, 12)	0.37 (0.16, 8)				
lazuli bunting	0.65 (0.16, 3)			0.58 (0.15, 5)				
MacGillivray's warbler	-0.18 (0.15, 2)			-0.05 (0.08, 4)				
mountain bluebird	0.95 (0.03, 5)	1.00 (0.00, 2)	0.50 (0.15, 12)	0.18 (0.19, 8)				

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Interior Mixed Conifer (Bird)—continued								
mountain chickadee	-0.59 (0.13, 6)	-0.52 (0.15, 2)	-0.60 (0.09, 12)	-0.08 (0.10, 8)				
northern flicker	0.03 (0.42, 5)	0.94 (0.02, 2)	-0.54 (0.24, 12)	-0.22 (0.25, 8)				
olive-sided flycatcher	0.26 (0.26, 2)			0.14 (0.24, 4)				
orange-crowned warbler	-0.27 (0.24, 2)			-0.18 (0.16, 5)				
pileated woodpecker	-1.00 (NA, 1)							
pine grosbeak	-1.00 (0.00, 3)	-1.00 (0.00, 2)	-0.62 (0.20, 12)	-1.00 (0.00, 3)				
pine siskin	0.08 (0.06, 5)	-0.47 (0.53, 2)	-0.64 (0.15, 12)	0.26 (0.08, 8)				
red crossbill	-0.27 (0.26, 6)	-1.00 (0.00, 2)	-0.71 (0.15, 12)	0.09 (0.21, 7)				
red-breasted nuthatch	-0.82 (0.11, 6)	-1.00 (0.00, 2)	-0.89 (0.11, 12)	-0.11 (0.07, 7)				
red-naped sapsucker	0.00 (0.00, 3)	0.00 (0.00, 2)	0.08 (0.08, 12)	-0.06 (0.06, 4)				
ruby-crowned kinglet	-0.85 (0.06, 5)	-0.77 (0.23, 2)	-0.67 (0.11, 12)	-0.37 (0.15, 7)				
ruffed grouse	-1.00 (0.00, 5)	-1.00 (0.00, 2)	-0.25 (0.23, 12)	-0.49 (0.19, 7)				
song sparrow	0.00 (0.00, 3)	0.00 (0.00, 2)	0.08 (0.08, 12)	0.00 (0.00, 3)				
Steller's jay	-0.76 (0.15, 3)			0.42 (0.16, 4)				
Swainson's thrush	-0.77 (0.06, 5)	-1.00 (0.00, 2)	-0.96 (0.03, 12)	-0.11 (0.13, 7)				
Townsend's solitaire	0.17 (0.11, 5)	0.50 (0.50, 2)	0.00 (0.00, 12)	-0.02 (0.05, 7)				
Townsend's warbler	-0.94 (0.02, 2)			-0.14 (0.18, 4)				
tree swallow	0.33 (0.33, 3)	1.00 (0.00, 2)	0.50 (0.15, 12)	0.28 (0.24, 4)				

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Interior Mixed Conifer (Bird)—continued								
varied thrush	-1.00 (NA, 1)							
warbling vireo	-0.49 (0.09, 2)			-0.33 (0.07, 5)				
western tanager	-0.57 (0.14, 5)	-1.00 (0.00, 2)	-0.97 (0.03, 12)	0.07 (0.13, 7)				
western wood-pewee	0.90 (0.06, 3)	-0.11 (0.89, 2)	-0.41 (0.25, 12)	0.51 (0.36, 4)				
white-breasted nuthatch	1.00 (NA, 1)							
white-crowned sparrow	0.00 (0.00, 3)	0.00 (0.00, 2)	0.08 (0.08, 12)	-0.01 (0.01, 4)				
Williamson's sapsucker	-0.23 (0.14, 5)	0.00 (0.00, 2)	0.08 (0.08, 12)	-0.05 (0.09, 7)				
winter wren	-1.00 (0.00, 3)			-0.55 (0.26, 4)				
yellow warbler				0.26 (NA, 1)				
yellow-rumped warbler	-0.54 (0.16, 5)	-0.63 (0.37, 2)	-0.61 (0.09, 12)	-0.16 (0.06, 8)				
Interior Mixed Conifer (Mammal)								
deer mouse	1.00 (NA, 1)							
Interior Mixed Conifer (Reptile)								
No Quantitative Data								
Pine West (Amphibian)								
No Quantitative Data								
Pine West (Bird)								
acorn woodpecker	0.00 (0.00, 4)		1.00 (NA, 1)	0.02 (0.08, 5)	0.50 (0.50, 2)	0.50 (0.50, 2)		
American kestrel	0.67 (0.33, 3)	1.00 (NA, 1)	1.00 (NA, 1)	0.25 (0.25, 4)	0.50 (0.50, 2)	1.00 (0.00, 2)		
American robin	0.06 (0.26, 8)	1.00 (NA, 1)	1.00 (NA, 1)	-0.15 (0.08, 14)	-0.19 (0.01, 2)	-0.05 (0.13, 2)		

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine West (Bird)—continued								
American three-toed woodpecker	0.67 (0.33, 3)	1.00 (NA, 1)	0.00 (NA, 1)	0.51 (0.32, 6)	0.82 (0.18, 2)	-0.50 (0.50, 2)		
ash-throated flycatcher	-0.38 (0.13, 4)	-0.33 (NA, 1)	-0.87 (NA, 1)	0.00 (0.26, 6)	0.00 (NA, 1)	0.00 (NA, 1)		
band-tailed pigeon	0.00 (0.00, 4)	1.00 (NA, 1)	1.00 (NA, 1)	-0.33 (0.33, 6)	0.42 (0.58, 2)	-0.50 (0.50, 2)		
Bewick's wren	0.00 (0.00, 4)	1.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 4)	0.00 (NA, 1)	0.00 (NA, 1)		
black-capped chickadee				0.01 (0.09, 2)				
black-headed grosbeak	0.13 (0.33, 7)	0.33 (NA, 1)	0.20 (NA, 1)	0.20 (0.14, 12)	-0.27 (0.38, 2)	-0.74 (0.26, 2)		
black-throated gray warbler	0.00 (0.00, 4)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
blue-gray gnatcatcher	0.33 (0.33, 3)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
bridled titmouse				0.00 (NA, 1)				
broad-tailed hummingbird	0.55 (0.09, 7)	-1.00 (NA, 1)	0.49 (NA, 1)	0.39 (0.05, 12)	0.57 (0.07, 2)	0.74 (0.10, 2)		
brown creeper	-0.25 (0.25, 4)	1.00 (NA, 1)	0.00 (NA, 1)	-0.18 (0.19, 10)	0.16 (0.04, 2)	-0.44 (0.56, 2)		
brown-headed cowbird	0.49 (0.19, 4)	-1.00 (NA, 1)	0.56 (NA, 1)	0.68 (0.17, 8)	1.00 (0.00, 2)	1.00 (0.00, 2)		
canyon wren	0.25 (0.25, 4)	0.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
Cassin's finch	0.40 (0.24, 5)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.50 (0.50, 2)	1.00 (0.00, 2)		
Cassin's Kingbird	0.00 (0.00, 4)	0.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
cedar waxwing	-1.00 (NA, 1)							
chipping sparrow	-0.28 (0.15, 8)	-0.70 (NA, 1)	-0.70 (NA, 1)	-0.05 (0.11, 14)	-0.10 (0.35, 2)	-0.27 (0.73, 2)		

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine West (Bird)—continued								
Clark's nutcracker	0.09 (0.55, 3)	0.93 (NA, 1)	0.89 (NA, 1)	0.80 (0.20, 5)	1.00 (NA, 1)	1.00 (NA, 1)		
common nighthawk	-0.29 (0.36, 3)	-1.00 (NA, 1)	-0.20 (NA, 1)	0.00 (0.00, 3)	0.50 (0.50, 2)	0.50 (0.50, 2)		
common poorwill	0.25 (0.25, 4)	0.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
common raven	0.18 (0.18, 3)	-1.00 (NA, 1)	0.74 (NA, 1)	0.03 (0.15, 6)	0.21 (0.32, 2)	0.18 (0.36, 2)		
Cooper's hawk	-0.68 (0.32, 3)	-1.00 (NA, 1)	-1.00 (NA, 1)	0.40 (0.24, 5)	0.50 (0.50, 2)	0.50 (0.50, 2)		
cordilleran flycatcher	0.30 (0.43, 5)	1.00 (NA, 1)	0.00 (NA, 1)	-0.38 (0.13, 12)	-0.59 (0.12, 2)	-0.69 (0.31, 2)		
dark-eyed junco	-0.12 (0.21, 7)	-1.00 (NA, 1)	-1.00 (NA, 1)	0.19 (0.08, 14)	0.15 (0.01, 2)	-0.34 (0.03, 2)	0.11 (0.15, 2)	0.19 (0.27, 2)
downy woodpecker	0.00 (0.00, 3)	1.00 (NA, 1)	0.00 (NA, 1)	-0.29 (0.23, 6)	-0.50 (0.50, 2)	0.00 (0.00, 2)		
dusky flycatcher	-1.00 (0.00, 3)	-1.00 (NA, 1)	-1.00 (NA, 1)	-0.50 (0.22, 6)	-0.50 (0.50, 2)	0.02 (0.02, 2)		
dusky-capped flycatcher				0.00 (NA, 1)				
evening grosbeak	0.33 (0.33, 3)	0.00 (NA, 1)	0.00 (NA, 1)	0.75 (0.11, 6)	0.73 (0.27, 2)	-0.28 (0.28, 2)		
fox sparrow	0.00 (NA, 1)							
golden-crowned kinglet	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)	-0.50 (0.22, 6)	-0.50 (0.50, 2)	-0.50 (0.50, 2)		
Grace's warbler	-0.43 (0.15, 4)	-1.00 (NA, 1)	-0.51 (NA, 1)	0.37 (0.29, 6)	0.22 (0.78, 2)	-0.07 (0.07, 2)		
grasshopper sparrow				-0.50 (0.50, 2)				
gray jay				-0.88 (0.13, 2)				
great horned owl	0.33 (0.33, 3)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine West (Bird)—continued								
green-tailed towhee	0.33 (0.33, 3)	1.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	1.00 (0.00, 2)	1.00 (0.00, 2)		
hairy woodpecker	0.64 (0.10, 11)	0.24 (0.11, 3)	-0.29 (NA, 1)	0.53 (0.08, 17)	0.25 (0.05, 4)	0.40 (0.17, 2)		
Hammond's flycatcher	-0.49 (0.08, 3)	-0.79 (NA, 1)	-0.46 (NA, 1)	0.06 (0.12, 6)	-0.09 (0.09, 2)	-0.12 (0.14, 2)		
hepatic tanager	1.00 (NA, 1)							
hermit thrush	-0.69 (0.15, 6)	-0.47 (NA, 1)	-1.00 (NA, 1)	-0.52 (0.07, 10)	-0.71 (0.14, 2)	-0.85 (0.15, 2)		
house finch	0.33 (0.33, 3)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
house wren	0.66 (0.17, 7)	0.00 (NA, 1)	1.00 (NA, 1)	0.43 (0.18, 12)	1.00 (0.00, 2)	1.00 (0.00, 2)		
juniper titmouse	0.00 (NA, 1)							
lesser goldfinch	0.37 (0.25, 4)	0.74 (NA, 1)	-0.14 (NA, 1)	-0.50 (0.22, 6)	-0.50 (0.50, 2)	0.00 (1.000, 2)		
Lewis's woodpecker	0.04 (0.04, 7)	1.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
loggerhead shrike	0.00 (NA, 1)							
MacGillivray's warbler	0.00 (0.00, 3)	1.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
mountain bluebird	0.67 (0.33, 3)	0.00 (NA, 1)	0.00 (NA, 1)	0.37 (0.20, 6)	0.50 (0.50, 2)	0.00 (NA, 1)		
mountain chickadee	-0.71 (0.18, 9)	-0.22 (NA, 1)	-0.52 (NA, 1)	-0.27 (0.07, 18)	-0.78 (0.22, 2)	-0.55 (0.23, 2)	-0.42 (0.09, 2)	-0.41 (0.11, 2)
mourning dove	0.13 (0.24, 6)	-0.17 (NA, 1)	0.22 (NA, 1)	0.12 (0.18, 14)	0.00 (1.000, 2)	0.79 (0.21, 2)		
northern flicker	-0.20 (0.11, 7)	-0.33 (NA, 1)	0.08 (NA, 1)	0.20 (0.16, 16)	0.71 (0.29, 2)	0.60 (0.40, 2)		
northern goshawk	0.33 (0.33, 3)	1.00 (NA, 1)	0.00 (NA, 1)	0.25 (0.25, 4)	0.00 (NA, 1)	0.00 (NA, 1)		

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine West (Bird)—continued								
northern pygmy-owl	-1.00 (0.00, 3)	-1.00 (NA, 1)	-1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
olive-sided flycatcher	0.00 (0.41, 4)	0.00 (NA, 1)	1.00 (NA, 1)	0.83 (0.17, 6)	1.00 (0.00, 2)	1.00 (0.00, 2)		
orange-crowned warbler	0.00 (0.00, 3)	0.00 (NA, 1)	1.00 (NA, 1)	-0.12 (0.25, 6)	-0.50 (0.50, 2)	-0.15 (0.15, 2)		
ovenbird				-0.33 (0.67, 2)				
peregrine falcon	0.33 (0.33, 3)	1.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
pine siskin	-0.12 (0.37, 4)	-1.00 (NA, 1)	-1.00 (NA, 1)	-0.55 (0.18, 6)	0.06 (0.44, 2)	0.06 (0.28, 2)		
pinyon jay	0.33 (0.33, 3)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
plumbeous vireo	0.28 (0.26, 4)	0.07 (NA, 1)	-0.24 (NA, 1)	0.10 (0.10, 8)	0.00 (0.38, 2)	-0.13 (0.13, 2)		
pygmy nuthatch	-0.49 (0.13, 7)	-0.73 (NA, 1)	-0.61 (NA, 1)	-0.23 (0.07, 14)	-0.44 (0.16, 2)	-0.06 (0.09, 2)	0.00 (0.18, 2)	0.31 (0.21, 2)
red crossbill	-0.71 (0.29, 3)	-1.00 (NA, 1)	0.18 (NA, 1)	-0.24 (0.20, 8)	-0.35 (0.08, 2)	0.74 (0.04, 2)		
red-breasted nuthatch	0.00 (0.00, 3)	1.00 (NA, 1)	0.00 (NA, 1)	0.30 (0.22, 8)	0.50 (0.50, 2)	0.50 (0.50, 2)		
red-headed woodpecker	0.33 (0.33, 3)	1.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
red-naped sapsucker	-0.25 (0.25, 4)	0.00 (NA, 1)	0.00 (NA, 1)	0.40 (0.24, 5)	0.00 (NA, 1)	0.00 (NA, 1)		
red-tailed hawk	-0.67 (0.33, 3)	0.86 (NA, 1)	-1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.50 (0.50, 2)		
rock wren	0.50 (0.29, 4)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
ruby-crowned kinglet	-0.50 (0.22, 6)	0.00 (NA, 1)	0.00 (NA, 1)	-0.02 (0.22, 6)	-0.31 (0.31, 2)	-0.25 (0.25, 2)		
sharp-shinned hawk	0.00 (0.00, 3)	1.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	0.50 (0.50, 2)	0.00 (NA, 1)		
spotted towhee	-0.14 (0.25, 7)	-0.94 (NA, 1)	0.49 (NA, 1)	0.38 (0.14, 9)	0.50 (0.50, 2)	1.00 (0.00, 2)		

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine West (Bird)—continued								
Steller's jay	-0.19 (0.13, 8)	-1.00 (NA, 1)	-0.21 (NA, 1)	0.43 (0.08, 12)	0.31 (0.11, 2)	0.50 (0.23, 2)		
Townsend's solitaire	0.17 (0.17, 3)	0.75 (NA, 1)	-1.00 (NA, 1)	0.13 (0.08, 8)	0.23 (0.34, 2)	-0.63 (0.38, 2)		
Townsend's warbler	-1.00 (NA, 1)							
turkey vulture	0.00 (0.00, 3)	1.00 (NA, 1)	1.00 (NA, 1)	0.40 (0.24, 5)	0.00 (NA, 1)	0.50 (0.50, 2)		
vesper sparrow				0.01 (0.51, 2)				
violet-green swallow	-0.09 (0.07, 5)	-1.00 (NA, 1)	-0.31 (NA, 1)	-0.02 (0.12, 10)	0.42 (0.23, 2)	0.49 (0.13, 2)		
Virginia's warbler	-0.38 (0.13, 7)	0.24 (NA, 1)	0.10 (NA, 1)	-0.16 (0.24, 11)	-0.64 (0.36, 2)	-0.31 (0.14, 2)		
warbling vireo	0.06 (0.41, 5)	1.00 (NA, 1)	1.00 (NA, 1)	0.04 (0.13, 10)	-0.47 (0.53, 2)	-0.34 (0.01, 2)		
western bluebird	0.71 (0.13, 10)	0.00 (NA, 1)	0.48 (NA, 1)	0.37 (0.08, 22)	0.85 (0.15, 2)	0.91 (0.09, 2)	0.11 (0.06, 7)	0.16 (0.07, 7)
western meadowlark				-1.00 (0.00, 2)				
western scrub jay	0.00 (0.00, 4)	0.00 (NA, 1)	1.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		
western tanager	0.04 (0.10, 6)	0.42 (NA, 1)	-0.42 (NA, 1)	0.21 (0.08, 13)	0.43 (0.14, 2)	0.06 (0.31, 2)		
western wood-pewee	0.47 (0.15, 7)	0.07 (NA, 1)	-0.22 (NA, 1)	0.40 (0.13, 14)	0.50 (0.31, 2)	0.26 (0.07, 2)		
white-breasted nuthatch	-0.15 (0.15, 9)	-1.00 (NA, 1)	0.14 (NA, 1)	0.01 (0.11, 16)	0.20 (0.05, 2)	0.03 (0.03, 2)		
white-crowned sparrow	1.00 (NA, 1)							
white-throated swift	0.09 (0.26, 3)	0.62 (NA, 1)	-1.00 (NA, 1)	-0.42 (0.20, 6)	-0.50 (0.50, 2)	-0.50 (0.50, 2)		
Williamson's sapsucker	0.00 (0.00, 3)	1.00 (NA, 1)	0.00 (NA, 1)	-0.01 (0.22, 6)	0.48 (0.52, 2)	-0.36 (0.36, 2)		
yellow warbler	0.33 (0.33, 3)	0.00 (NA, 1)	0.00 (NA, 1)	0.00 (0.00, 3)	0.00 (NA, 1)	0.00 (NA, 1)		

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine West (Bird)—continued								
yellow-rumped warbler	-0.35 (0.17, 7)	-1.00 (NA, 1)	-0.50 (NA, 1)	-0.02 (0.09, 14)	-0.29 (0.32, 2)	-0.44 (0.38, 2)	-0.13 (0.15, 2)	-0.03 (0.07, 2)
Pine West (Mammal)								
deer mouse				0.16 (0.16, 6)				
Pine West (Reptile)								
No Quantitative Data								
Pine East (Amphibian)								
No Quantitative Data								
Pine East (Bird)								
Acadian flycatcher				-0.50 (0.22, 7)			-0.20 (NA, 1)	-0.05 (0.23, 3)
American crow				0.19 (0.19, 2)			-0.85 (NA, 1)	-0.56 (0.04, 3)
American goldfinch				0.08 (0.27, 7)			0.36 (NA, 1)	0.74 (0.03, 3)
American kestrel				-1.00 (NA, 1)				
American redstart							1.00 (NA, 1)	0.33 (0.33, 3)
American robin				0.00 (NA, 1)				
Bachman's sparrow				0.55 (0.11, 14)	0.00 (0.00, 2)		1.00 (NA, 1)	1.00 (0.00, 3)
black-and-white warbler				-0.65 (0.09, 7)			-0.18 (NA, 1)	-0.63 (0.08, 3)
blue grosbeak							0.00 (NA, 1)	0.33 (0.33, 3)
blue jay				-0.19 (0.07, 8)			-0.21 (NA, 1)	-0.63 (0.09, 3)
blue-gray gnatcatcher				-0.20 (0.21, 10)			0.25 (0.32, 3)	0.65 (0.16, 3)
blue-headed vireo				0.06 (0.06, 5)			-0.13 (0.06, 2)	

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine East (Bird)—continued								
broad-winged hawk							0.68 (NA, 1)	-0.67 (0.33, 3)
brown thrasher				-0.66 (NA, 1)			-1.00 (NA, 1)	-1.00 (0.00, 3)
brown-headed cowbird				0.09 (0.23, 7)			0.76 (NA, 1)	0.70 (0.09, 3)
brown-headed nuthatch				0.66 (0.08, 11)			0.60 (0.31, 3)	1.00 (0.00, 3)
Carolina chickadee				-0.20 (0.13, 11)			-0.23 (0.13, 3)	-0.11 (0.15, 3)
Carolina wren				-0.12 (0.12, 8)			0.81 (NA, 1)	0.46 (0.02, 3)
cedar waxwing							0.00 (NA, 1)	0.33 (0.33, 3)
chipping sparrow				0.45 (0.13, 11)			0.92 (0.04, 3)	0.94 (0.00, 3)
common grackle				0.71 (NA, 1)			0.00 (NA, 1)	0.33 (0.33, 3)
common yellowthroat				0.53 (0.12, 8)			1.00 (NA, 1)	1.00 (0.00, 3)
Cooper's hawk							1.00 (NA, 1)	0.33 (0.33, 3)
dark-eyed junco				0.11 (0.42, 4)			0.07 (0.07, 2)	
downy woodpecker				-0.01 (0.10, 5)			0.13 (0.07, 3)	0.67 (0.33, 3)
eastern bluebird				0.53 (0.20, 10)			0.75 (0.22, 2)	
eastern kingbird				1.00 (NA, 1)				
eastern meadowlark				-0.60 (NA, 1)				
eastern phoebe				0.03 (0.14, 5)			0.02 (0.20, 2)	
eastern towhee				0.27 (0.13, 8)				

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine East (Bird)—continued								
eastern wood-pewee				0.63 (0.14, 7)			1.00 (NA, 1)	1.00 (0.00, 3)
field sparrow				0.96 (NA, 1)				
golden-crowned kinglet				-0.76 (0.24, 2)			-0.77 (NA, 1)	
gray catbird				0.00 (NA, 1)			1.00 (NA, 1)	0.00 (0.00, 3)
great crested flycatcher				-0.25 (0.08, 8)			0.42 (NA, 1)	0.22 (0.18, 3)
hairy woodpecker				0.30 (0.20, 6)			0.67 (0.08, 3)	-0.30 (0.36, 3)
hermit thrush				-0.67 (0.22, 4)			-0.62 (0.09, 2)	
hooded warbler				-0.19 (0.18, 6)				
house wren				0.39 (0.35, 5)			0.58 (0.07, 2)	
indigo bunting				0.39 (0.24, 7)			0.85 (NA, 1)	0.82 (0.03, 3)
Kentucky warbler				0.16 (NA, 1)			0.33 (NA, 1)	-0.07 (0.47, 3)
mourning dove				0.20 (0.25, 7)			0.00 (NA, 1)	0.67 (0.33, 3)
northern bobwhite				0.05 (0.15, 2)			1.00 (NA, 1)	0.67 (0.33, 3)
northern cardinal				-0.35 (0.19, 8)			0.19 (NA, 1)	-0.41 (0.30, 3)
northern flicker				0.29 (0.13, 8)			0.00 (NA, 1)	1.00 (0.00, 3)
northern mockingbird				1.00 (NA, 1)				
northern parula				0.47 (NA, 1)				
ovenbird				-0.73 (0.14, 6)			-1.00 (NA, 1)	-1.00 (0.00, 3)

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine East (Bird)—continued								
palm warbler				0.60 (0.15, 4)			0.46 (0.30, 2)	
pileated woodpecker				-0.02 (NA, 1)			-0.27 (NA, 1)	-0.47 (0.13, 3)
pine warbler				0.25 (0.06, 12)			0.18 (0.09, 3)	0.23 (0.01, 3)
prairie warbler				0.54 (0.14, 7)			1.00 (NA, 1)	1.00 (0.00, 3)
red-bellied woodpecker				0.12 (0.13, 12)			0.10 (0.05, 3)	1.00 (0.00, 3)
red-cockaded woodpecker				0.69 (0.11, 11)			0.43 (0.22, 3)	1.00 (0.00, 3)
red-eyed vireo				-0.47 (0.15, 7)			0.09 (NA, 1)	-0.06 (0.08, 3)
red-headed woodpecker				0.46 (0.18, 7)			1.00 (NA, 1)	1.00 (0.00, 3)
red-shouldered hawk				0.00 (NA, 1)			0.00 (NA, 1)	0.33 (0.33, 3)
ruby-crowned kinglet				-0.26 (0.10, 5)			-0.20 (0.08, 2)	
ruby-throated hummingbird							0.50 (NA, 1)	0.42 (0.21, 3)
scarlet tanager							-0.27 (NA, 1)	-0.37 (0.11, 3)
summer tanager				-0.12 (0.07, 7)			0.19 (NA, 1)	0.11 (0.03, 3)
tufted titmouse				-0.47 (0.15, 11)			-0.32 (0.06, 3)	-0.42 (0.22, 3)
turkey vulture							1.00 (NA, 1)	0.33 (0.33, 3)
whip-poor-will							-1.00 (NA, 1)	-1.00 (0.00, 3)
white-breasted nuthatch							0.90 (NA, 1)	0.88 (0.02, 3)
white-eyed vireo				0.42 (0.21, 7)			1.00 (NA, 1)	0.00 (0.00, 3)

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Pine East (Bird)—continued								
wild turkey				-0.82 (NA, 1)			0.00 (NA, 1)	0.33 (0.33, 3)
wood thrush				-0.74 (0.16, 7)				
yellow-bellied sapsucker				0.04 (0.17, 5)			0.06 (0.29, 2)	
yellow-billed cuckoo				-0.08 (0.08, 2)			0.65 (NA, 1)	0.51 (0.08, 3)
yellow-breasted chat				0.88 (NA, 1)			1.00 (NA, 1)	1.00 (0.00, 3)
yellow-rumped warbler				-0.53 (0.31, 4)			-0.83 (0.17, 2)	
yellow-throated vireo				-0.44 (0.22, 7)			-1.00 (NA, 1)	0.53 (0.05, 3)
yellow-throated warbler				-0.38 (0.23, 7)				
Pine East (Mammal)								
bat activity				0.44 (0.22, 2)			0.61 (0.09, 3)	0.64 (NA, 1)
big brown bat				0.51 (NA, 1)			0.86 (NA, 1)	
eastern pipistrelle				0.00 (NA, 1)			0.67 (NA, 1)	
eastern red bat				-0.29 (NA, 1)			0.18 (NA, 1)	
raccoon				-0.25 (0.04, 2)				
Pine East (Reptile)								
gopher tortoise				0.14 (0.08, 4)				
Hardwood East (Amphibian)								
Allegheny Mountain dusky salamander				-0.32 (0.13, 7)				
Blue Ridge two-lined salamander				0.40 (0.19, 8)				

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Hardwood East (Amphibian)—continued								
Jordan's salamander				0.01 (0.11, 9)				
seepage salamander				0.37 (0.30, 6)				
Hardwood East (Bird)								
American goldfinch				0.81 (0.19, 3)			0.29 (0.36, 3)	0.81 (0.19, 3)
black-and-white warbler				-0.76 (0.12, 5)			-0.46 (0.29, 3)	-0.72 (0.18, 3)
black-throated green warbler				-0.39 (0.30, 3)			-0.17 (0.32, 3)	-0.37 (0.27, 3)
blue jay				0.49 (0.29, 3)			0.06 (0.50, 3)	-0.01 (0.51, 3)
blue-gray gnatcatcher				-0.17 (0.42, 3)			-0.26 (0.19, 3)	0.28 (0.36, 3)
blue-headed vireo				-0.13 (0.13, 3)			0.17 (0.01, 3)	-0.13 (0.06, 3)
brown-headed cowbird				0.06 (0.12, 5)			-0.33 (0.33, 3)	0.62 (0.31, 3)
Carolina chickadee				0.01 (0.13, 3)			-0.16 (0.37, 3)	0.21 (0.10, 3)
Carolina wren				-0.41 (0.59, 3)			-0.67 (0.33, 3)	0.17 (0.59, 3)
cedar waxwing				0.33 (0.33, 3)			0.00 (0.00, 3)	0.33 (0.33, 3)
downy woodpecker				-0.41 (0.23, 3)			-0.93 (0.07, 3)	0.01 (0.19, 3)
eastern bluebird				0.33 (0.33, 3)			0.00 (0.00, 3)	1.00 (0.00, 3)
eastern towhee				-0.33 (0.67, 3)			0.15 (0.45, 3)	0.15 (0.60, 3)
eastern wood-pewee				0.67 (0.33, 3)			0.33 (0.33, 3)	1.00 (0.00, 3)
hooded warbler				-0.51 (0.11, 5)			-0.49 (0.15, 3)	-0.77 (0.19, 3)

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Hardwood East (Bird)—continued								
indigo bunting				0.67 (0.33, 3)			0.00 (0.00, 3)	1.00 (0.00, 3)
Kentucky warbler				-0.87 (0.13, 2)				
ovenbird				-0.62 (0.15, 5)			0.09 (0.08, 3)	-0.88 (0.06, 3)
pileated woodpecker				0.33 (0.33, 3)			0.67 (0.33, 3)	1.00 (0.00, 3)
red-eyed vireo				-0.22 (0.11, 3)			-0.27 (0.09, 3)	-0.22 (0.06, 3)
ruby-throated hummingbird				0.00 (0.00, 3)			-0.16 (0.26, 3)	0.03 (0.33, 3)
scarlet tanager				0.16 (0.35, 3)			0.27 (0.30, 3)	0.47 (0.15, 3)
summer tanager				0.00 (0.00, 3)			0.00 (0.00, 3)	0.33 (0.33, 3)
tufted titmouse				0.10 (0.08, 3)			-0.18 (0.16, 3)	0.22 (0.10, 3)
white-breasted nuthatch				0.15 (0.45, 3)			0.25 (0.38, 3)	0.35 (0.37, 3)
wild turkey				0.33 (0.33, 3)			0.00 (0.00, 3)	0.67 (0.33, 3)
wood thrush				0.26 (0.26, 3)			-1.00 (0.00, 3)	-0.20 (0.42, 3)
worm-eating warbler				-0.10 (0.22, 5)			-0.16 (0.19, 3)	-0.49 (0.51, 3)
Hardwood East (Mammal)								
cotton rat				1.00 (NA, 1)			0.00 (NA, 1)	1.00 (NA, 1)
deer mouse				0.12 (0.10, 6)				
eastern chipmunk				0.80 (0.17, 2)			-0.51 (0.11, 2)	0.61 (0.39, 2)
eastern woodrat				-0.09 (0.09, 2)			0.30 (0.70, 2)	-0.40 (NA, 1)

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Hardwood East (Mammal)—continued								
golden mouse				0.25 (0.29, 7)			0.43 (0.17, 2)	-0.77 (NA, 1)
Hardwood East (Reptile)								
No Quantitative Data								
Great Lakes (Amphibian)								
No Quantitative Data								
Great Lakes (Bird)								
American crow	0.50 (0.50, 2)	0.00 (NA, 1)	0.50 (0.29, 4)					
American redstart	0.00 (0.00, 2)	0.00 (NA, 1)	0.50 (0.29, 4)					
American robin	1.00 (0.00, 2)	0.00 (NA, 1)	0.50 (0.29, 4)					
bay-breasted warbler	-0.97 (0.02, 4)	-1.00 (0.00, 2)	-1.00 (0.00, 8)					
black-and-white warbler	0.00 (0.00, 2)	0.00 (NA, 1)	1.00 (0.00, 4)					
black-backed woodpecker	1.00 (0.00, 2)	1.00 (NA, 1)	0.00 (0.00, 4)					
blackburnian warbler	-0.50 (0.27, 4)	-0.98 (0.00, 2)	-0.89 (0.06, 8)					
black-capped chickadee	0.19 (0.45, 4)	-0.50 (0.50, 2)	0.30 (0.26, 8)					
black-throated blue warbler	0.00 (0.00, 2)	0.00 (NA, 1)	0.25 (0.25, 4)					
blue jay	0.00 (0.41, 4)	-0.50 (0.50, 2)	0.25 (0.25, 8)					
blue-headed vireo	-0.71 (0.24, 4)	-1.00 (0.00, 2)	-0.86 (0.12, 8)					
boreal chickadee	-0.35 (0.43, 4)	-1.00 (0.00, 2)	-0.90 (0.09, 8)					
brown creeper	-0.86 (0.09, 4)	0.16 (0.20, 2)	-1.00 (0.00, 8)					
Canada warbler	-0.50 (0.29, 4)	0.37 (0.63, 2)	0.15 (0.29, 8)					

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Great Lakes (Bird)—continued								
Cape May warbler	-0.50 (0.29, 4)	-0.50 (0.50, 2)	-0.50 (0.19, 8)					
cedar waxwing	-0.50 (0.29, 4)	-0.50 (0.50, 2)	0.38 (0.24, 8)					
chestnut-sided warbler	-0.50 (0.29, 4)	0.99 (0.01, 2)	-0.21 (0.26, 8)					
chipping sparrow	0.17 (0.44, 4)	0.07 (0.93, 2)	-0.50 (0.19, 8)					
common grackle	1.00 (0.00, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
common raven	-0.50 (0.29, 4)	-0.50 (0.50, 2)	-0.25 (0.25, 8)					
common yellowthroat	-0.50 (0.29, 4)	-0.50 (0.50, 2)	-0.50 (0.19, 8)					
Cooper's hawk	0.50 (0.50, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
dark-eyed junco	1.00 (0.00, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
downy woodpecker	0.00 (0.00, 2)	0.00 (NA, 1)	0.25 (0.25, 4)					
eastern wood-pewee	0.00 (0.00, 2)	1.00 (NA, 1)	0.00 (0.00, 4)					
European starling	0.50 (0.50, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
evening grosbeak	0.08 (0.42, 4)	-0.50 (0.50, 2)	0.08 (0.27, 8)					
golden-crowned kinglet	-0.50 (0.29, 4)	-0.50 (0.50, 2)	-0.27 (0.25, 8)					
gray jay	0.17 (0.10, 4)	0.17 (0.17, 2)	0.17 (0.06, 8)					
gray-cheeked thrush	0.50 (0.50, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
hairy woodpecker	0.00 (0.00, 2)	0.00 (NA, 1)	0.25 (0.25, 4)					
hermit thrush	0.00 (0.41, 4)	-0.50 (0.50, 2)	0.25 (0.25, 8)					

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Great Lakes (Bird)—continued								
least flycatcher	-0.50 (0.29, 4)	0.08 (0.92, 2)	0.37 (0.24, 8)					
magnolia warbler	0.08 (0.42, 4)	0.98 (0.02, 2)	0.98 (0.01, 8)					
merlin	0.00 (0.00, 2)	0.00 (NA, 1)	0.25 (0.25, 4)					
mourning warbler	0.00 (0.00, 2)	1.00 (NA, 1)	0.00 (0.00, 4)					
Nashville warbler	-0.23 (0.47, 4)	0.49 (0.51, 2)	0.58 (0.16, 8)					
northern flicker	0.08 (0.42, 4)	0.67 (0.33, 2)	-0.21 (0.26, 8)					
olive-sided flycatcher	0.50 (0.50, 2)	1.00 (NA, 1)	0.25 (0.25, 4)					
ovenbird	-0.24 (0.47, 4)	-0.50 (0.50, 2)	0.11 (0.28, 8)					
Philadelphia vireo	0.00 (0.00, 2)	0.00 (NA, 1)	0.25 (0.25, 4)					
pine siskin	-0.50 (0.29, 4)	-0.50 (0.50, 2)	-0.50 (0.19, 8)					
purple finch	0.67 (0.19, 4)	-0.50 (0.50, 2)	0.08 (0.27, 8)					
red-breasted nuthatch	-1.00 (0.00, 4)	-1.00 (0.00, 2)	-0.90 (0.04, 8)					
red-eyed vireo	-0.74 (0.25, 4)	-0.47 (0.47, 2)	0.37 (0.21, 8)					
red-winged blackbird	0.50 (0.50, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
ruby-crowned kinglet	-0.19 (0.20, 4)	-1.00 (0.00, 2)	-0.82 (0.10, 8)					
ruffed grouse	0.50 (0.50, 2)	0.00 (NA, 1)	0.25 (0.25, 4)					
song sparrow	0.50 (0.50, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
spruce grouse	-1.00 (0.00, 4)	-1.00 (0.00, 2)	-1.00 (0.00, 8)					

continues

Appendix 3 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments within 6 ecoregions and multiple points in time.

Region (taxon)/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Great Lakes (Bird)—continued								
Swainson's thrush	0.82 (0.16, 4)	-0.50 (0.50, 2)	0.98 (0.01, 8)					
swamp sparrow	-0.50 (0.29, 4)	0.60 (0.40, 2)	-0.50 (0.19, 8)					
Tennessee warbler	-0.50 (0.29, 4)	-0.50 (0.50, 2)	-0.23 (0.25, 8)					
tree swallow	1.00 (0.00, 2)	0.00 (NA, 1)	0.00 (0.00, 4)					
veery	0.00 (0.00, 2)	0.00 (NA, 1)	1.00 (0.00, 4)					
white-throated sparrow	0.96 (0.03, 4)	0.98 (0.02, 2)	0.87 (0.06, 8)					
Wilson's snipe	0.00 (0.00, 2)	1.00 (NA, 1)	0.00 (0.00, 4)					
winter wren	0.00 (0.41, 4)	0.90 (0.10, 2)	0.81 (0.12, 8)					
yellow warbler	0.00 (0.00, 2)	1.00 (NA, 1)	0.50 (0.29, 4)					
yellow-bellied flycatcher	0.00 (0.00, 2)	0.00 (NA, 1)	0.75 (0.25, 4)					
yellow-rumped warbler	0.57 (0.06, 4)	-0.87 (0.04, 2)	0.00 (0.21, 8)					
Great Lakes (Mammal)								
deer mouse				0.85 (NA, 1)				
eastern chipmunk				0.00 (NA, 1)				
Great Lakes (Reptile)								
No Quantitative Data								

[1]Scientific names are listed in appendix 2.

Notes: Values in each cell represent the mean relative abundance index (RAI) calculated from published studies in the peer-reviewed literature. See methods section for the formula and explanation of the RAI.

APPENDIX 4. WILDLIFE RESPONSE TO FIRE AND FIRE SURROGATE TREATMENTS ACROSS ECOREGIONS

Appendix 4 presents the quantitative analysis in another format; the data were pooled over region and mean RAI values (±SE, N) were calculated for each species. Similar to Appendices 2 and 3, species are sorted by vertebrate class (amphibian, reptile, bird, and mammal) and alphabetized within each class by common name. Appendix 4 allows managers to examine species responses in a broader context. This examination can serve 2 purposes: (1) highlights information that is available in other regions when there are no regional data available and (2) clearly identifies species that have been studied and perhaps more importantly, not studied.

To compare a diverse set of studies across regions and taxa we used the relative abundance index (RAI) of Vanderwel et al. (2007) where RAI = (Treatment – Control) / (Treatment + Control).

This index varies from -1 to +1 and can be calculated from any study that reports treatment and control means. Calculation of RAI permitted us to put a broad array of studies on the same scale and average across studies. Relative Abundance Index values <-0.40 and >0.40 were arbitrarily considered suggestive of negative and positive, respectively, treatment responses. Index values should be interpreted with caution and in the context of standard errors and sample sizes because they are sensitive to small sample sizes.

For each species the average RAI is presented for each of the potential treatments; the first parenthetic entry is the standard error (SE) and the second entry is the sample size. The sample size represents the number of independent response measurements, not the number of studies. For example, a study reporting contrasts of burned and unburned plots may present measurements of the same plots before and after treatment (pre-post comparison) as well as contrasts of burned and unburned plots following treatment (after-only comparison). This situation is true for many of the studies from the Fire-Fire Surrogate study system. Wildland fires are pooled into 2 severity classes (high or moderate) and prescribed fire treatments are low-severity. There are no data on wildlife responses to low-severity wildland fire nor high-severity prescribed fire. All treatments were classified into 3 temporal categories (0-4 years, 5-9 years and > 10 years) classes. Currently, there are no fire surrogate studies conducted > 4 years post-treatment. Blank cells mean there are no treatment data for that species in that region. We consider an average RAI ≥ 0.40 to be evidence of a positive response to the treatment and an RAI < -0.40 to be evidence of a negative response to the treatment. All other values represent either no response or an inconsistent response. These arbitrary criteria will be evaluated in the future in a meta-analysis but is beyond the scope of the present synthesis.

Appendix 4. Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Amphibian								
Allegheny Mountain dusky salamander				-0.32 (0.13,7)				
Blue Ridge two-lined salamander				0.40 (0.19,8)				
Columbia spotted frog	0.03 (NA,1)							
Jordan's salamander				0.01 (0.11,9)				
long-toed salamander	-0.01 (NA,1)							
seepage salamander				0.37 (0.30,6)				
Reptile								
gopher tortoise				0.14 (0.08,4)				
Bird								
Acadian flycatcher				-0.50 (0.22,7)			-0.20 (NA,1)	-0.05 (0.23,3)
acorn woodpecker	0.00 (0.00,5)		1.00 (0.00,2)	0.02 (0.08,5)	0.50 (0.50,2)	0.50 (0.50,2)		
American crow	0.50 (0.50,2)	0.00 (NA,1)	0.50 (0.29,4)	0.19 (0.19,2)			-0.85 (NA,1)	-0.56 (0.04,3)
American goldfinch				0.30 (0.22,10)			0.31 (0.25,4)	0.78 (0.09,6)
American kestrel	0.67 (0.33,3)	0.50 (0.50,2)	0.67 (0.33,3)	0.00 (0.32,5)	0.50 (0.50,2)	1.00 (0.00,2)		
American redstart	0.00 (0.00,2)	0.00 (NA,1)	0.50 (0.29,4)				1.00 (NA,1)	0.33 (0.33,3)
American robin	0.33 (0.16,16)	0.63 (0.17,5)	0.34 (0.15,20)	-0.08 (0.06,23)	-0.19 (0.01,2)	-0.05 (0.13,2)		
American three-toed woodpecker	0.79 (0.14,7)	-0.33 (0.67,3)	-0.92 (0.08,13)	0.63 (0.22,9)	0.82 (0.18,2)	-0.50 (0.50,2)		
ash-throated flycatcher	-0.38 (0.13,4)	-0.33 (NA,1)	-0.87 (NA,1)	0.00 (0.26,6)	0.00 (NA,1)	0.00 (NA,1)		

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
Bachman's sparrow				0.55 (0.11,14)	0.00 (0.00,2)		1.00 (NA,1)	1.00 (0.00,3)
band-tailed pigeon	0.00 (0.00,4)	1.00 (NA,1)	1.00 (NA,1)	-0.33 (0.33,6)	0.42 (0.58,2)	-0.50 (0.50,2)		
bay-breasted warbler	-0.97 (0.02,4)	-1.00 (0.00,2)	-1.00 (0.00,8)					
Bewick's wren	0.00 (0.00,5)	1.00 (NA,1)	0.50 (0.50,2)	0.00 (0.00,4)	0.00 (NA,1)	0.00 (NA,1)		
black-and-white warbler	0.00 (0.00,2)	0.00 (NA,1)	1.00 (0.00,4)	-0.69 (0.07,12)			-0.39 (0.22,4)	-0.68 (0.09,6)
black-backed woodpecker	0.87 (0.06,6)	-0.06 (0.54,4)	-0.79 (0.10,19)	0.82 (0.04,3)				
black-billed magpie	1.00 (NA,1)							
blackburnian warbler	-0.50 (0.27,4)	-0.98 (0.00,2)	-0.89 (0.06,8)					
black-capped chickadee	-0.09 (0.30,7)	-0.50 (0.50,2)	0.30 (0.26,8)	0.21 (0.19,6)				
black-headed grosbeak	0.08 (0.29,8)	0.33 (NA,1)	0.39 (0.19,2)	0.20 (0.14,12)	-0.27 (0.38,2)	-0.74 (0.26,2)		
black-throated blue warbler	0.00 (0.00,2)	0.00 (NA,1)	0.25 (0.25,4)					
black-throated gray warbler	-0.20 (0.20,5)	0.00 (NA,1)	-0.40 (0.40,2)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
black-throated green warbler				-0.39 (0.30,3)			-0.17 (0.32,3)	-0.37 (0.27,3)
blue grosbeak							0.00 (NA,1)	0.33 (0.33,3)
blue jay	0.00 (0.41,4)	-0.50 (0.50,2)	0.25 (0.25,8)	0.00 (0.13,11)			-0.01 (0.36,4)	-0.32 (0.27,6)
blue-gray gnatcatcher	0.33 (0.33,3)	0.00 (NA,1)	0.00 (NA,1)	-0.16 (0.14,16)	0.00 (NA,1)	0.00 (NA,1)	0.00 (0.20,6)	0.46 (0.19,6)
blue-headed vireo	-0.71 (0.24,4)	-1.00 (0.00,2)	-0.86 (0.12,8)	-0.01 (0.07,8)			0.05 (0.08,5)	-0.13 (0.06,3)
boreal chickadee	-0.35 (0.43,4)	-1.00 (0.00,2)	-0.90 (0.09,8)					

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
Brewer's sparrow		1.00 (NA,1)	0.50 (0.50,2)					
bridled titmouse				0.00 (NA,1)				
broad-tailed hummingbird	0.55 (0.09,7)	-1.00 (NA,1)	0.49 (NA,1)	0.39 (0.05,12)	0.57 (0.07,2)	0.74 (0.10,2)		
broad-winged hawk							0.68 (NA,1)	-0.67 (0.33,3)
brown creeper	-0.30 (0.18,15)	-0.17 (0.32,6)	-0.96 (0.04,24)	0.15 (0.15,17)	0.16 (0.04,2)	-0.44 (0.56,2)		
brown thrasher				-0.66 (NA,1)			-1.00 (NA,1)	-1.00 (0.00,3)
brown-headed cowbird	0.29 (0.18,6)	-0.50 (0.50,2)	0.85 (0.15,3)	0.25 (0.10,25)	1.00 (0.00,2)	1.00 (0.00,2)	-0.06 (0.36,4)	0.66 (0.15,6)
brown-headed nuthatch				0.66 (0.08,11)			0.60 (0.31,3)	1.00 (0.00,3)
bushtit	-1.00 (NA,1)		0.20 (NA,1)					
calliope hummingbird	0.22 (0.78,2)	0.00 (NA,1)	0.49 (0.29,2)	0.32 (0.40,4)				
Canada warbler	-0.50 (0.29,4)	0.37 (0.63,2)	0.15 (0.29,8)					
canyon wren	0.25 (0.25,4)	0.00 (NA,1)	1.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
Cape May warbler	-0.50 (0.29,4)	-0.50 (0.50,2)	-0.50 (0.19,8)					
Carolina chickadee				-0.16 (0.11,14)			-0.20 (0.17,6)	0.05 (0.11,6)
Carolina wren				-0.20 (0.17,11)			-0.30 (0.44,4)	0.31 (0.27,6)
Cassin's finch	0.41 (0.15,10)	0.28 (0.24,4)	0.30 (0.12,15)	0.24 (0.09,11)	0.50 (0.50,2)	1.00 (0.00,2)		
Cassin's Kingbird	0.00 (0.00,4)	0.00 (NA,1)	1.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
Cassin's vireo	-0.90 (0.05,3)	-1.00 (NA,1)	0.07 (0.07,3)	-0.44 (0.12,4)				
cedar waxwing	-0.60 (0.24,5)	-0.50 (0.50,2)	0.38 (0.24,8)	0.33 (0.33,3)			0.00 (0.00,4)	0.33 (0.21,6)
chestnut-backed chickadee	-0.96 (NA,1)		-0.73 (NA,1)					
chestnut-sided warbler	-0.50 (0.29,4)	0.99 (0.01,2)	-0.21 (0.26,8)					
chipping sparrow	-0.11 (0.13,17)	0.05 (0.33,6)	-0.18 (0.13,23)	0.16 (0.08,33)	-0.10 (0.35,2)	-0.27 (0.73,2)	0.92 (0.04,3)	0.94 (0.00,3)
Clark's nutcracker	0.17 (0.24,9)	0.95 (0.01,3)	-0.17 (0.26,13)	0.16 (0.22,12)	1.00 (NA,1)	1.00 (NA,1)		
common grackle	1.00 (0.00,2)	0.00 (NA,1)	0.00 (0.00,4)	0.71 (NA,1)			0.00 (NA,1)	0.33 (0.33,3)
common nighthawk	-0.14 (0.17,6)	0.00 (0.41,4)	0.19 (0.11,15)	0.00 (0.00,6)	0.50 (0.50,2)	0.50 (0.50,2)		
common poorwill	0.25 (0.25,4)	0.00 (NA,1)	1.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
common raven	-0.32 (0.19,9)	-0.67 (0.33,3)	-0.23 (0.24,10)	0.03 (0.15,6)	0.21 (0.32,2)	0.18 (0.36,2)		
common yellowthroat	-0.50 (0.29,4)	-0.50 (0.50,2)	-0.50 (0.19,8)	0.53 (0.12,8)			1.00 (NA,1)	1.00 (0.00,3)
Cooper's hawk	-0.21 (0.37,5)	-0.33 (0.33,3)	-0.29 (0.18,7)	0.40 (0.24,5)	0.50 (0.50,2)	0.50 (0.50,2)	1.00 (NA,1)	0.33 (0.33,3)
cordilleran flycatcher	0.30 (0.43,5)	1.00 (NA,1)	0.00 (NA,1)	-0.38 (0.13,12)	-0.59 (0.12,2)	-0.69 (0.31,2)		
dark-eyed junco	0.16 (0.14,15)	-0.30 (0.30,5)	-0.07 (0.11,20)	0.18 (0.07,26)	0.15 (0.01,2)	-0.34 (0.03,2)	0.09 (0.07,4)	0.19 (0.27,2)
downy woodpecker	0.26 (0.17,7)	0.50 (0.50,2)	0.00 (0.26,6)	-0.22 (0.12,14)	-0.50 (0.50,2)	0.00 (0.00,2)	-0.40 (0.24,6)	0.34 (0.23,6)
dusky flycatcher	-0.61 (0.18,6)	-0.64 (0.36,2)	-0.01 (0.41,4)	-0.29 (0.16,11)	-0.50 (0.50,2)	0.02 (0.02,2)		
dusky grouse	1.00 (NA,1)							
dusky-capped flycatcher				0.00 (NA,1)				

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
eastern bluebird				0.49 (0.17,13)			0.30 (0.20,5)	1.00 (0.00,3)
eastern kingbird				1.00 (NA,1)				
eastern meadowlark				-0.60 (NA,1)				
eastern phoebe				0.03 (0.14,5)			0.02 (0.20,2)	
eastern towhee				0.11 (0.20,11)			0.15 (0.45,3)	0.15 (0.60,3)
eastern wood-pewee	0.00 (0.00,2)	1.00 (NA,1)	0.00 (0.00,4)	0.64 (0.13,10)			0.50 (0.29,4)	1.00 (0.00,6)
European starling	0.50 (0.50,2)	0.00 (NA,1)	0.00 (0.00,4)					
evening grosbeak	0.19 (0.26,7)	-0.25 (0.25,4)	-0.01 (0.21,11)	0.75 (0.11,6)	0.73 (0.27,2)	-0.28 (0.28,2)		
field sparrow				0.96 (NA,1)				
fox sparrow	0.00 (0.00,2)	0.20 (NA,1)	1.00 (0.00,3)					
golden-crowned kinglet	-0.62 (0.13,14)	-0.67 (0.21,6)	-0.72 (0.11,24)	-0.53 (0.10,15)	-0.50 (0.50,2)	-0.50 (0.50,2)	-0.77 (NA,1)	
Grace's warbler	-0.43 (0.15,4)	-1.00 (NA,1)	-0.51 (NA,1)	0.37 (0.29,6)	0.22 (0.78,2)	-0.07 (0.07,2)		
grasshopper sparrow				-0.50 (0.50,2)				
gray catbird				0.00 (NA,1)			1.00 (NA,1)	0.00 (0.00,3)
gray jay	-0.25 (0.15,10)	-0.12 (0.30,4)	-0.03 (0.09,20)	-0.53 (0.14,9)				
gray-cheeked thrush	0.50 (0.50,2)	0.00 (NA,1)	0.00 (0.00,4)					
great crested flycatcher				-0.25 (0.08,8)			0.42 (NA,1)	0.22 (0.18,3)
great horned owl	0.33 (0.33,3)	0.00 (NA,1)	0.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
green-tailed towhee	0.25 (0.25,4)	1.00 (0.00,2)	0.75 (0.25,4)	0.02 (0.02,4)	1.00 (0.00,2)	1.00 (0.00,2)		
hairy woodpecker	0.54 (0.11,20)	0.38 (0.11,7)	-0.07 (0.17,22)	0.44 (0.07,31)	0.25 (0.05,4)	0.40 (0.17,2)	0.67 (0.08,3)	-0.30 (0.36,3)
Hammond's flycatcher	-0.15 (0.24,6)	-0.79 (NA,1)	0.03 (0.49,2)	0.10 (0.17,10)	-0.09 (0.09,2)	-0.12 (0.14,2)		
hepatic tanager	1.00 (NA,1)							
hermit thrush	-0.57 (0.14,16)	-0.75 (0.17,6)	-0.25 (0.16,24)	-0.46 (0.09,21)	-0.71 (0.14,2)	-0.85 (0.15,2)	-0.62 (0.09,2)	
hermit warbler	-0.97 (NA,1)		-0.56 (NA,1)					
hooded warbler				-0.33 (0.11,11)			-0.49 (0.15,3)	-0.77 (0.19,3)
house finch	0.33 (0.33,3)	0.00 (NA,1)	0.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
house wren	0.55 (0.14,12)	0.50 (0.29,4)	0.25 (0.11,16)	0.40 (0.12,25)	1.00 (0.00,2)	1.00 (0.00,2)	0.58 (0.07,2)	
Hutton's vireo	-1.00 (NA,1)		-0.78 (NA,1)					
indigo bunting				0.47 (0.19,10)			0.21 (0.21,4)	0.91 (0.04,6)
juniper titmouse	0.00 (NA,1)							
Kentucky warbler				-0.52 (0.35,3)			0.33 (NA,1)	-0.07 (0.47,3)
lazuli bunting	0.74 (0.14,4)	1.00 (NA,1)	0.67 (0.33,3)	0.58 (0.15,5)				
least flycatcher	-0.50 (0.29,4)	0.08 (0.92,2)	0.37 (0.24,8)					
lesser goldfinch	0.37 (0.25,4)	0.74 (NA,1)	-0.14 (NA,1)	-0.50 (0.22,6)	-0.50 (0.50,2)	0.00 (1.0,2)		
Lewis's woodpecker	0.04 (0.04,7)	0.50 (0.50,2)	0.00 (0.58,3)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
loggerhead shrike	0.00 (NA,1)							

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
MacGillivray's warbler	0.01 (0.10,6)	1.00 (NA,1)	0.91 (0.09,2)	-0.03 (0.04,7)	0.00 (NA,1)	0.00 (NA,1)		
magnolia warbler	0.08 (0.42,4)	0.98 (0.02,2)	0.98 (0.01,8)					
merlin	0.00 (0.00,2)	0.00 (NA,1)	0.25 (0.25,4)					
mountain bluebird	0.84 (0.12,8)	0.75 (0.25,4)	0.53 (0.13,15)	0.26 (0.14,14)	0.50 (0.50,2)	0.00 (NA,1)		
mountain chickadee	-0.66 (0.12,15)	-0.44 (0.09,4)	-0.51 (0.09,15)	-0.21 (0.06,26)	-0.78 (0.22,2)	-0.55 (0.23,2)	-0.42 (0.09,2)	-0.41 (0.11,2)
mountain quail	0.71 (NA,1)	0.00 (NA,1)	0.33 (0.33,3)					
mourning dove	0.11 (0.20,7)	-0.08 (0.08,2)	0.81 (0.19,4)	0.15 (0.14,21)	0.00 (1.0,2)	0.79 (0.21,2)	0.00 (NA,1)	0.67 (0.33,3)
mourning warbler	0.00 (0.00,2)	1.00 (NA,1)	0.00 (0.00,4)					
Nashville warbler	-0.31 (0.37,5)	-0.01 (0.58,3)	0.37 (0.19,11)					
northern bobwhite				0.05 (0.15,2)			1.00 (NA,1)	0.67 (0.33,3)
northern cardinal				-0.35 (0.19,8)			0.19 (NA,1)	-0.41 (0.30,3)
northern flicker	-0.03 (0.16,17)	0.60 (0.21,6)	-0.25 (0.16,26)	0.12 (0.11,32)	0.71 (0.29,2)	0.60 (0.40,2)	0.00 (NA,1)	1.00 (0.00,3)
northern goshawk	0.33 (0.33,3)	1.00 (NA,1)	0.00 (NA,1)	0.25 (0.25,4)	0.00 (NA,1)	0.00 (NA,1)		
northern mockingbird				1.00 (NA,1)				
northern parula				0.47 (NA,1)				
northern pygmy-owl	-1.00 (0.00,3)	-1.00 (NA,1)	-1.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
olive-sided flycatcher	0.25 (0.21,9)	0.67 (0.33,3)	0.60 (0.18,8)	0.51 (0.14,13)	1.00 (0.00,2)	1.00 (0.00,2)		
orange-crowned warbler	-0.09 (0.08,6)	0.00 (NA,1)	1.00 (0.00,2)	-0.15 (0.15,11)	-0.50 (0.50,2)	-0.15 (0.15,2)		

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
ovenbird	-0.24 (0.47,4)	-0.50 (0.50,2)	0.11 (0.28,8)	-0.63 (0.12,13)			-0.18 (0.28,4)	-0.94 (0.04,6)
pacific-slope flycatcher	-0.94 (NA,1)		-1.00 (NA,1)					
palm warbler				0.60 (0.15,4)			0.46 (0.30,2)	
peregrine falcon	0.33 (0.33,3)	1.00 (NA,1)	0.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
Philadelphia vireo	0.00 (0.00,2)	0.00 (NA,1)	0.25 (0.25,4)					
pileated woodpecker	-0.50 (0.50,2)		-0.33 (NA,1)	0.24 (0.25,4)			0.43 (0.33,4)	0.27 (0.33,6)
pine grosbeak	-1.00 (0.00,3)	-1.00 (0.00,2)	-0.62 (0.20,12)	-1.00 (0.00,3)				
pine siskin	-0.13 (0.14,14)	-0.49 (0.23,6)	-0.57 (0.10,24)	-0.09 (0.14,14)	0.06 (0.44,2)	0.06 (0.28,2)		
pine warbler				0.25 (0.06,12)			0.18 (0.09,3)	0.23 (0.01,3)
pinyon jay	0.33 (0.33,3)	0.00 (NA,1)	0.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
plumbeous vireo	0.28 (0.26,4)	0.07 (NA,1)	-0.24 (NA,1)	0.10 (0.10,8)	0.00 (0.38,2)	-0.13 (0.13,2)		
prairie warbler				0.54 (0.14,7)			1.00 (NA,1)	1.00 (0.00,3)
purple finch	0.70 (0.15,5)	-0.50 (0.50,2)	0.17 (0.26,9)					
pygmy nuthatch	-0.49 (0.13,7)	0.13 (0.87,2)	0.48 (0.33,5)	-0.23 (0.07,14)	-0.44 (0.16,2)	-0.06 (0.09,2)	0.00 (0.18,2)	0.31 (0.21,2)
red crossbill	-0.33 (0.20,10)	-0.75 (0.25,4)	-0.60 (0.15,16)	-0.09 (0.15,15)	-0.35 (0.08,2)	0.74 (0.04,2)		
red-bellied woodpecker				0.12 (0.13,12)			0.10 (0.05,3)	1.00 (0.00,3)
red-breasted nuthatch	-0.69 (0.11,14)	-0.67 (0.33,6)	-0.86 (0.06,25)	0.11 (0.13,15)	0.50 (0.50,2)	0.50 (0.50,2)		
red-breasted sapsucker	-1.00 (NA,1)	-0.50 (NA,1)	-0.46 (0.31,4)					

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
red-cockaded woodpecker				0.69 (0.11,11)			0.43 (0.22,3)	1.00 (0.00,3)
red-eyed vireo	-0.74 (0.25,4)	-0.47 (0.47,2)	0.37 (0.21,8)	-0.39 (0.11,10)			-0.18 (0.11,4)	-0.14 (0.06,6)
red-headed woodpecker	0.33 (0.33,3)	1.00 (NA,1)	0.00 (NA,1)	0.32 (0.14,10)	0.00 (NA,1)	0.00 (NA,1)	1.00 (NA,1)	1.00 (0.00,3)
red-naped sapsucker	-0.14 (0.14,7)	0.00 (0.00,3)	0.08 (0.08,13)	0.19 (0.15,9)	0.00 (NA,1)	0.00 (NA,1)		
red-shouldered hawk				0.00 (NA,1)			0.00 (NA,1)	0.33 (0.33,3)
red-tailed hawk	-0.67 (0.33,3)	0.86 (NA,1)	-1.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.50 (0.50,2)		
red-winged blackbird	0.50 (0.50,2)	0.00 (NA,1)	0.00 (0.00,4)					
rock wren	0.50 (0.29,4)	0.00 (NA,1)	0.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
ruby-crowned kinglet	-0.53 (0.12,15)	-0.71 (0.20,5)	-0.69 (0.08,21)	-0.22 (0.10,18)	-0.31 (0.31,2)	-0.25 (0.25,2)	-0.20 (0.08,2)	
ruby-throated hummingbird				0.00 (0.00,3)			0.00 (0.25,4)	0.22 (0.20,6)
ruffed grouse	-0.57 (0.30,7)	-0.67 (0.33,3)	-0.13 (0.19,16)	-0.49 (0.19,7)				
rufous hummingbird	0.33 (NA,1)		0.54 (NA,1)					
scarlet tanager				0.16 (0.35,3)			0.13 (0.25,4)	0.05 (0.20,6)
sharp-shinned hawk	0.00 (0.00,3)	1.00 (NA,1)	1.00 (NA,1)	0.00 (0.00,3)	0.50 (0.50,2)	0.00 (NA,1)		
song sparrow	0.33 (0.21,6)	0.00 (0.00,3)	0.12 (0.08,17)	0.00 (0.00,3)				
sooty grouse	-0.33 (NA,1)	0.00 (NA,1)	-0.67 (0.33,3)					
species richness, avian				-0.04 (0.01,2)				
spotted towhee	-0.24 (0.24,8)	-0.94 (NA,1)	0.71 (0.22,2)	0.38 (0.14,9)	0.50 (0.50,2)	1.00 (0.00,2)		

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
spruce grouse	-1.00 (0.00,4)	-1.00 (0.00,2)	-1.00 (0.00,8)					
Steller's jay	-0.36 (0.12,12)	-1.00 (0.00,2)	-0.36 (0.16,4)	0.43 (0.07,16)	0.31 (0.11,2)	0.50 (0.23,2)		
summer tanager				-0.08 (0.05,10)			0.05 (0.05,4)	0.22 (0.16,6)
Swainson's thrush	-0.07 (0.29,9)	-0.75 (0.25,4)	-0.18 (0.22,20)	-0.11 (0.13,7)				
swamp sparrow	-0.50 (0.29,4)	0.60 (0.40,2)	-0.50 (0.19,8)					
Tennessee warbler	-0.50 (0.29,4)	-0.50 (0.50,2)	-0.23 (0.25,8)					
Townsend's solitaire	0.26 (0.12,9)	0.40 (0.28,4)	-0.17 (0.09,16)	0.06 (0.05,15)	0.23 (0.34,2)	-0.63 (0.38,2)		
Townsend's warbler	-0.96 (0.02,3)			-0.14 (0.18,4)				
tree swallow	0.60 (0.24,5)	0.67 (0.33,3)	0.38 (0.13,16)	0.28 (0.24,4)				
tufted titmouse				-0.35 (0.13,14)			-0.25 (0.08,6)	-0.10 (0.18,6)
turkey vulture	0.00 (0.00,3)	1.00 (NA,1)	1.00 (NA,1)	0.40 (0.24,5)	0.00 (NA,1)	0.50 (0.50,2)	1.00 (NA,1)	0.33 (0.33,3)
varied thrush	-1.00 (NA,1)							
veery	0.00 (0.00,2)	0.00 (NA,1)	1.00 (0.00,4)					
vesper sparrow				0.01 (0.51,2)				
violet-green swallow	-0.09 (0.07,5)	-1.00 (NA,1)	-0.31 (NA,1)	-0.02 (0.12,10)	0.42 (0.23,2)	0.49 (0.13,2)		
Virginia's warbler	-0.38 (0.13,7)	0.24 (NA,1)	0.10 (NA,1)	-0.16 (0.24,11)	-0.64 (0.36,2)	-0.31 (0.14,2)		
warbling vireo	-0.17 (0.27,8)	1.00 (NA,1)	0.79 (0.21,2)	-0.08 (0.10,15)	-0.47 (0.53,2)	-0.34 (0.01,2)		
western bluebird	0.74 (0.12,11)	0.00 (NA,1)	0.74 (0.26,2)	0.37 (0.08,22)	0.85 (0.15,2)	0.91 (0.09,2)	0.11 (0.06,7)	0.16 (0.07,7)

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
western meadowlark				-1.00 (0.00,2)				
western scrub jay	0.00 (0.00,4)	0.00 (NA,1)	1.00 (NA,1)	0.00 (0.00,3)	0.00 (NA,1)	0.00 (NA,1)		
western tanager	-0.25 (0.11,12)	-0.57 (0.34,4)	-0.87 (0.07,16)	0.16 (0.07,20)	0.43 (0.14,2)	0.06 (0.31,2)		
western wood-pewee	0.64 (0.12,11)	0.14 (0.41,4)	-0.19 (0.22,16)	0.42 (0.12,18)	0.50 (0.31,2)	0.26 (0.07,2)		
whip-poor-will							-1.00 (NA,1)	-1.00 (0.00,3)
white-breasted nuthatch	-0.04 (0.18,10)	-0.17 (0.83,2)	0.24 (0.06,3)	0.03 (0.11,19)	0.20 (0.05,2)	0.03 (0.03,2)	0.41 (0.31,4)	0.62 (0.20,6)
white-crowned sparrow	0.40 (0.24,5)	0.00 (0.00,2)	0.08 (0.08,13)	-0.01 (0.01,4)				
white-eyed vireo				0.42 (0.21,7)			1.00 (NA,1)	0.00 (0.00,3)
white-headed woodpecker		0.33 (NA,1)	0.58 (0.25,4)					
white-throated sparrow	0.96 (0.03,4)	0.98 (0.02,2)	0.87 (0.06,8)					
white-throated swift	0.09 (0.26,3)	0.62 (NA,1)	-1.00 (NA,1)	-0.42 (0.20,6)	-0.50 (0.50,2)	-0.50 (0.50,2)		
wild turkey				0.05 (0.37,4)			0.00 (0.00,4)	0.50 (0.22,6)
Williamson's sapsucker	-0.15 (0.10,8)	0.50 (0.29,4)	-0.11 (0.11,17)	-0.03 (0.11,13)	0.48 (0.52,2)	-0.36 (0.36,2)		
Wilson's snipe	0.00 (0.00,2)	1.00 (NA,1)	0.00 (0.00,4)					
Wilson's warbler	-1.00 (NA,1)		-1.00 (NA,1)					
winter wren	-0.50 (0.27,8)	0.90 (0.10,2)	0.60 (0.23,9)	-0.55 (0.26,4)				
wood thrush				-0.44 (0.20,10)			-1.00 (0.00,3)	-0.20 (0.42,3)
worm-eating warbler				-0.10 (0.22,5)			-0.16 (0.19,3)	-0.49 (0.51,3)

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Bird								
wrentit	-1.00 (NA,1)		0.89 (NA,1)					
yellow warbler	0.20 (0.20,5)	0.33 (0.33,3)	0.57 (0.20,7)	0.06 (0.06,4)	0.00 (NA,1)	0.00 (NA,1)		
yellow-bellied flycatcher	0.00 (0.00,2)	0.00 (NA,1)	0.75 (0.25,4)					
yellow-bellied sapsucker				0.04 (0.17,5)			0.06 (0.29,2)	
yellow-billed cuckoo				-0.08 (0.08,2)			0.65 (NA,1)	0.51 (0.08,3)
yellow-breasted chat				0.88 (NA,1)			1.00 (NA,1)	1.00 (0.00,3)
yellow-rumped warbler	-0.15 (0.14,17)	-0.68 (0.16,6)	-0.38 (0.10,24)	-0.14 (0.07,26)	-0.29 (0.32,2)	-0.44 (0.38,2)	-0.48 (0.22,4)	-0.03 (0.07,2)
yellow-throated vireo				-0.44 (0.22,7)			-1.00 (NA,1)	0.53 (0.05,3)
yellow-throated warbler				-0.38 (0.23,7)				
Mammal								
bat activity				0.44 (0.22,2)			0.61 (0.09,3)	0.64 (NA,1)
big brown bat				0.51 (NA,1)			0.86 (NA,1)	
brush mouse				0.37 (0.50,2)			0.14 (0.26,2)	-0.50 (0.30,2)
California ground squirrel				0.22 (0.07,2)			0.47 (0.15,2)	0.30 (0.13,2)
cotton rat				1.00 (NA,1)			0.00 (NA,1)	1.00 (NA,1)
deer mouse	1.00 (NA,1)			0.22 (0.09,15)			-0.15 (0.11,2)	0.56 (0.28,2)
eastern chipmunk				0.53 (0.28,3)			-0.51 (0.11,2)	0.61 (0.39,2)
eastern pipistrelle				0.00 (NA,1)			0.67 (NA,1)	

continues

Appendix 4 (continued). Wildlife response [mean (SE, n)] to fire and fire surrogate treatments and multiple points in time.

Taxon/species[1]	High-severity 0-4 years	High-severity 5-9 years	High-severity >10 years	Low-moderate-severity 0-4 years	Low-moderate-severity 5-9 years	Low-moderate-severity >10 years	Thinning 0-4 years	Thinning + prescribed fire 0-4 years
Mammal								
eastern red bat				-0.29 (NA,1)			0.18 (NA,1)	
eastern woodrat				-0.09 (0.09,2)			0.30 (0.70,2)	-0.40 (NA,1)
golden mouse				0.25 (0.29,7)			0.43 (0.17,2)	-0.77 (NA,1)
heather vole	1.00 (NA,1)							
long-eared chipmunk				0.21 (0.21,2)			0.36 (0.19,2)	0.55 (0.45,2)
masked shrew				-0.08 (0.07,6)				
northern short-tailed shrew				0.08 (0.26,8)			-0.05 (0.05,2)	-0.26 (0.02,2)
pygmy shrew				0.62 (0.16,8)			0.51 (0.11,2)	-0.61 (0.39,2)
raccoon				-0.25 (0.04,2)				
smoky shrew				0.03 (0.15,8)			0.19 (0.19,2)	-0.13 (0.28,2)
southeastern shrew				0.01 (0.12,2)			0.14 (0.19,2)	-0.32 (0.15,2)
southern flying squirrel				0.77 (0.23,2)			0.30 (0.70,2)	0.71 (0.29,2)
southern red-backed vole				-0.11 (0.17,7)				
water shrew				0.33 (0.33,3)				
white-footed mouse				0.33 (0.16,8)			0.22 (0.07,2)	0.57 (0.05,2)
woodland jumping mouse				0.14 (0.23,8)			-0.50 (0.50,2)	-0.50 (0.50,2)
woodland vole				-0.41 (0.19,5)			1.00 (NA,1)	1.00 (NA,1)

[1]Scientific names are listed in appendix 2.

Notes: Values in each cell represent the mean relative abundance index (RAI) calculated from published studies in the peer-reviewed literature. See methods section for the formula and explanation of the RAI.