Part 8: Effects on Species of Concern

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Temporal and Spatial Scales for Evaluating Fire Effects

Conclusions about the effects of fire on species of concern will depend on the temporal and spatial scales of analysis. Populations of some species may decline in abundance immediately postfire due to alteration or destruction of habitat, but over larger spatial and temporal scales, fire contributes to a shifting mosaic of habitat conditions across the landscape. Whether or not a fire results in persistent and significant population changes depends on a number of factors including fire size and severity, dispersal capabilities and other life history traits, availability of refugia within or outside the burn, postfire successional pathways. Thus, fire effects should be considered across a range of temporal and spatial scales.

Assessment of fire effects must be made within the context of the natural disturbance regime of a system. The historic fire regime for this area can be characterized as mixed-severity (Brown and others 1999; Veblen and others 2000), which includes both understory and crown fires. Local factors such as elevation, topography, and aspect affect the frequency to which the system experiences understory, mixed-severity, or large crown fire events (part 1, this chapter). Reference conditions for evaluating fire effects in montane forests of the Colorado Front Range, therefore, are dynamic forests composed of patches that vary with time since disturbance and severity. Yet, fire effects on wildlife are typically evaluated by simply comparing recently burned and unburned forests (Kotliar and others 2002).

To evaluate the effects of the Hayman Fire on species of concern, we consider both short- (less than 10 years) and long-term (greater than 50 to 100 years) postfire time frames. Likewise, we consider spatial scales that range from habitat patches within the 56,000-ha Hayman Fire perimeter to ponderosa pine landscapes that encompass the Pike National Forest. We also evaluate fire effects within the framework of a mixed-severity fire regime.

Although most fire experts agree that mixed-severity fires (including small crown fires) characterize the system, the historical occurrence of large crown fires remains equivocal and controversial. At the Hayman burn, a severe fire burned approximately half of the area (hereafter called the "severe fire"), whereas a mixed-severity fire burned the remaining area (hereafter called the "mixed-severity fire"). Within the severe, tree mortality is high, although live trees remain in isolated patches that escaped severe fire. These remnant patches are important seed sources and may serve as animal refugia. In addition, plants are rapidly resprouting in many areas, whereas bare mineral soil is all that remains elsewhere (Kotliar, personal observation). In the area burned by mixed-severity fire, there is variation among patches in tree mortality, resulting in a heterogeneous mixture of live and dead trees. Because of the differences in burn severity, and consequently landscape structure (for example, size of high-severity patches, distance to unburned forest), we consider the effects of these two fire "landscapes" (that is, severe versus mixed-serverity) on species of concern separately.

Effects on Species of Concern

Species of concern, for this discussion, are those Federally listed, or proposed, as endangered or threatened, and species designated as sensitive by Region 2 of the USDA Forest Service (table 16). Evaluating the effects of the Hayman Fire on species of concern is a difficult undertaking for several reasons. First, information on the effects of fire is quite limited for most species. Second, a number of factors can alter how species respond to burns including burn severity, as well as the spatial heterogeneity of burn-severity patterns, time since fire, cover type, context, postfire rehabilitation, and prefire management (Kotliar and others 2002). Other factors may compound or overshadow the effects of fire, such as the severe drought in 2002, disease outbreaks, or previous habitat losses caused by human activities. Finally, the magnitude of fire effects on species of concern will depend, in part, on the proportion of the species' range and total population that occurs within the burned area.

Here, we evaluate the effects of the Hayman Fire on species listed as sensitive by the Pike National Forest (Ryke and Madsen 2002). None of the Federally listed endangered species occurring on the Pike are known to occur within the Hayman Fire perimeter, but six Federally listed threatened species (Canada lynx, bald eagle, Mexican spotted owl, Preble's meadow jumping mouse, Pawnee montane skipper, Ute ladies'-tresses orchid) have occurrences or potential habitat within the burn (see table 16 for a list of scientific names). In addition, there are a number of amphibians, birds, fishes, invertebrates, mammals, and plants listed as Forest Sensitive Species or Management Indicator Species. Of the total 59 species of concern, we eliminated 26 species that are known not to occur in the burn area (table 17). We determined that several species (Canada lynx, boreal owl, golden-crowned kinglet, wolverine, marten, dwarf shrew), which are primarily associated with higher elevation lodgepole pine or spruce/fire forests, had minimal potential habitat (less than 2 percent of burn area) within the burn

Table 16—Species of Concern occurring or potentially occurring on the Hayman burn (Ryke and Madsen 2002).

A. Vertebrate Species associated with wetland habitats

Species	Scientific name	Occurrence category[1]	Status[2]	Habitat types[3]
Northern leopard frog	*Rana pipiens*	Occurs	S	RSS, WET, AQ
Tiger salamander	*Ambystoma tigrinum preblii*	Occurs	S	RSS, WET, AQ
Osprey	*Pandion haliaetus*	Occurs	S	RSS,
Bald Eagle	*Haliaeetus leucocephalus*	Occurs	T	RSS
Common loon	*Gavia immer*	Occurs	S	RSS, AQ
Fox sparrow	*Passerella iliaca*	Occurs	S	RIP
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	Occurs	T, PCH	MG, RSS, RIP
Lewis' s woodpecker	*Melanerpes lewis*	Occurs	S	RIP

B. Vertebrate and Invertebrate Species Associated with montane forested habitats

Mexican spotted owl	*Strix occidentalis lucinda*	Occurs	T, CH	PJ, MC, RO
Northern goshawk	*Accipiter gentilis*	Occurs	S	PP, MC, AS, LPP, SF
Flammulated owl	*Otus flammeolus*	Occurs	S	PP, MC, AS
Three-toed woodpecker	*Picoides tridactylus*	Occurs	S	MC, LPP, SF
Pygmy nuthatch	*Sitta pygmaea*	Occurs	S	PP, AS
Olive-sided flycatcher	*Contopus cooperi*	Occurs	S	MC, SF
Pawnee montane skipper	*Hesperia leonardus montana*	Occurs	T	PP, MC, MG
Townsend's big-eared bat	*Corynorhinus townsendii*	Occurs	S	RO, PP, MC, MS, PJ
Fringed-tailed bat	*Myotis thysanodes*	Occurs	S	RO, PP, MS, PJ, MC

C. Vertebrate Species associated with subalpine and alpine habitats

Boreal toad	*Bufo boreas*	No Known Populations	S, C	RSS, AQ, WET, SF
Boreal owl	*Aegolius funereus*	No Known Populations	S	LPP, SF
Golden crowned kinglet	*Regulus satrapa*	Subalpine	S	MC, SF
Marten	*Martes americana*	Subalpine	S	MC, LPP, SF, AL
Lynx	*Lynx rufus*	Subalpine	T	LPP, SF, AL, RO
Wolverine	*Gulo gulo*	Subalpine	S	LPP, SF, AL
Dwarf shrew	*Sorex palustris*	Subalpine	S	SF, AL, MG, RO, MS, WET, MC

D. Plant species of concern

Ute ladies'-tresses orchid	*Spiranthes diluvialis*	Habitat occurs	T	RSS, RIP
Narrow-leaved moonwort	*Botrychium lineare*	Habitat occurs	S, C	MG, RSS
Reflected moonwort	*Botrychium echo*	Habitat occurs	S	MG, RO
Pale moonwort	*Botrychium pallidum*	Habitat occurs	S	MG
Livid sedge	*Carex livida*	Habitat occurs	S	WET
Smith's whitlow grass	*Draba smithii*	Habitat occurs	S	RO
Altai cottongrass	*Eriophorum altaicum* var. *neogaeum*	Habitat occurs	S	WET
Colorado tansy-aster	*Machaeranthera coloradoensis*	Habitat occurs	S	AL, MG, RO
White adder's-mouth orchid	*Malaxis brachyopoda*	Habitat occurs	S	RSS, RIP
Weber's monkey-flower	*Mimulus gemmiparus*	Occurs	S	SF, AS, RIP
Greenland primrose	*Primula egaliksensis*	Habitat occurs	S	RSS, WET
Rocky Mtn. Cinquefoil	*Potentilla rupincola*	Habitat occurs	S	PP, RO
Porter feathergrass	*Ptilagrostis mongholica* ssp. *porteri*	Habitat occurs	S	WET
Northern blackberry	*Rubus arcticus* ssp. *acaulis*	Habitat occurs	S	RSS, WET
Rolland's bulrush	*Scirpus rollandii*	Habitat occurs	S	WET
Great-spurred violet	*Viola selkirkii*	Habitat occurs	S	AS, MC, RIP

[1]For species potentially occurring within the Hayman burn, we determined whether it: Occurs = known to occur; Habitat Occurs = potential habitat occurs; No Known Populations = no known current or historic populations; Subalpine = minimal area in this cover type occurred within the Hayman burn, consequently the species is expected to have limited occurrence.

[2]Conservation Status: E: Federally listed as Endangered; T: Federally listed as Threatened; P: Federally proposed for listing; C: Federal candidate for listing; CH: Federally designated Critical Habitat; PCH: Federally proposed Critical Habitat; S: Forest Service Sensitive Species.

[3]Habitat classifications from Ryke and Marsden (2002): AL = alpine; AQ = riparian/aquatic; AS = aspen; LPP = lodgepole pine; PJ = pinyon/juniper; PP = ponderosa pine; RO = Rock, cliff, caves, canyon, mine; MC = mixed conifer; MG = mountain meadows; MS = shrublands; SF = spruce/fir; WET = riparian/wetlands.

Table 17—Species of Concern for the Pike National Forest which do not occur within the Hayman burn.

Species	Scientific name	Status[1]	Habitat[2]
Purple martin	*Progne subis*	S	AS
Mountain plover	*Charadrius montanus*	P	MG
Harlequin duck	*Histrionicus histrionicus*	S	RSS, AQ
American bittern	*Botaurus lentiginosus*	S	RSS, WET
White-faced ibis	*Plegadis chihi*	S	RSS, WET
Black tern	*Chlidonias niger*	S	RIP, WET
Whooping crane	*Grus americana*	E	RSS
Sandhill crane	*Grus canadensis*	S	WET, RSS, RIP
Western snowy plover	*Charadrius alexandrinus*	S	RSS
Black swift	*Cypseloides niger*	S	AQ,RO
Greenback cutthroat trout	*Salmo clarki macdonaldi*	T	AQ
Southern red-belly dace	*Phoxinus eos*	S	AQ
Plain's topminnow	*Fundulus sciadicus*	S	AQ
Arkansas darter	*Etheostoma cragini*	S	AQ
Uncompahgre fritillary butterfly	*Boloria acrocnema*	E	AL
Rocky Mountain capshell snail	*Acroloxus coloradensis*	S	AQ
Hog-nose skunk	*Conepatus mesoleucus*	S	MS, PJ, RO
Ringtail cat	*Bassariscus astutus*	S	MS, PJ, RO, RIP
Penland alpine fen mustard	*Eutrema penlandii*	T	AL, WET, RSS
Sea pink	*Armeria maritime* var. *siberica*	S	AL
Leadville milk-vetch	*Astragalus molybdenus*	S	AL
Smooth rockcress	*Braya glabella* ssp. *glabella*	S	AL
Hall fescue	*Festuca hallii*	S	AL, MG
Globe gilia	*Ipomopsis globularis*	S	AL
Woolly willow	*Salix lanata* ssp. *calcicola*	S	AL, RSS
Myrtle-leaf willow	*Salix myrtillifolia*	S	WET

[1]Conservation Status: E: Federally listed as Endangered; T: Federally listed as Threatened; P: Federally proposed for listing; C: Federal candidate for listing; CH: Federally designated Critical Habitat; PCH: Federally proposed Critical Habitat; S: Forest Service Sensitive Species.

[2]Habitat classifications from Ryke and Marsden (2002): AL = alpine; AQ = riparian/aquatic; AS = aspen; LPP = lodgepole pine; PJ = pinyon/juniper; PP = ponderosa pine; RO = Rock, cliff, caves, canyon, mine; MC = mixed conifer; MG = mountain meadows; MS = shrublands; SF = spruce/fir; WET = riparian/wetlands.

perimeter (table 16c). We evaluated the potential effects of the Hayman Fire for remaining 17 vertebrate species of concern (table 16a,b). We also briefly evaluate the effects on plant species of concern (table 16d).

For each species we assessed the expected numerical response immediately postfire (that is, increase, decrease, remain the same, unable to determine) based on potential postfire conditions that could result in population changes. If data on fire effects were unavailable, we used life history attributes and interviewed experts to assess potential fire effects. Specifically, we asked the following questions:

1. Are the direct or indirect effects of the fire likely to alter habitat quality or availability: (a) in short or long time frames, and (b) in mixed-severity or crown fire?
2. How important is the population at Hayman to the long-term health of the species?
3. How severe are the threats to long-term viability of the species?
4. What other factors (for example, drought, habitat fragmentation) might influence the magnitude of fire effects?

Preferred habitat types are listed for all species of concern (table 16). We grouped these into several larger categories: wetlands (including riparian and adjacent aquatic habitats), shrublands (primarily mountain mahogany), and forested (primarily ponderosa pine, Douglas-fir, aspen). For each of these cover types, we discuss the potential structural changes that may occur postfire, and discuss the implications for species inhabiting these areas. Because shrublands composed a relatively small proportion of the burn and were not a primary habitat for any species of concern, we only briefly discuss this cover type. Aquatic species are addressed elsewhere in this chapter. In addition, we provide indepth assessments for several species of concern: Mexican spotted owl, Pawnee montane skip-

per, Preble's meadow jumping mouse, three-toed woodpecker, and blanket flower/Colorado fire moth. These species were selected because they are species of high concern on the Pike National Forest and/or represent a broad spectrum of expected responses to burns.

Potential habitat maps are available for the skipper, jumping mouse, and Mexican spotted owl. We used two burn severity maps to analyze the burn severity patterns of potential habitat maps of these species: the Normalized Burn Severity (NBR) technique (Miller and Yool 2002) and the Burned Area Emergency Rehabilitation (BAER) map (fig. 30-32). We use the NBR map because it detects greater heterogeneity and was not limited to the four burn-severity classes as defined in the BAER maps. We include BAER maps for comparison because of the pervasive use elsewhere in this document.

Wetlands:

Amphibians – Three amphibian species of concern are associated with wetland habitats (table 16a). Boreal toads have no known recent or historical occurrences within the burn perimeter and are typically found at higher elevations (table 16c; Loeffler 2001). Thus, we will restrict our discussion to northern leopard frogs and tiger salamanders. No published information on the effects of fire on these amphibians in the Rocky Mountains is available, although limited information is available for other regions. Direct mortality of amphibians was probably limited because drought conditions prevalent at the time of the Hayman Fire had likely caused the amphibians to seek water or underground refuges (for example, in rodent burrows; Pilliod and others 2003). In general, such refugia are presumed to afford protection from direct morality from fire (Russell and others 1999).

Indirect effects on amphibians, such as postfire erosion and flooding, may create, alter suitability, or destroy breeding sites (Pilliod and others 2003; see part 6 of this chapter). Fire can alter temperature profiles and hydroperiods, sedimentation and nutrient loads, and availability of duff, litter, and woody debris used for refugia (Pilliod and others 2003). The effects will vary with fire conditions, such as burn severity and seasonality of fire (Russell and others 1999; Pilliod and others 2003). It has been suggested that the negative effects of fire on amphibian populations may be lower in ponds, the primary breeding sites for northern leopard frogs and tiger salamanders (Hammerson 1999), compared to streams (Pilliod and others 2003). There is limited evidence that tiger salamanders may tolerate or prefer frequent fire; in a study in Florida, tiger salamanders were captured more frequently in stands of longleaf and shortleaf pine forests that burned annually compared to unburned stands (Russell and others 1999). Because many negative effects of fire are short-term, initial postfire mortality could be offset by the creation or maintenance of required habitat conditions by fire (Russell and others 1999).

Breeding sites in the drought-prone climate of Colorado are naturally dynamic as are amphibian populations (Hammerson 1999). Indeed, the 2002 drought may have diminished breeding opportunities and may have had greater effects on amphibian populations than did the Hayman Fire. Because of the natural dynamics of amphibian populations and habitats, the potential for both positive and negative effects on these amphibians, and the limited importance of the Hayman area to the survival of these species overall, we expect that neither northern leopard frog or tiger salamander will suffer significant population declines in a result of the Hayman Fire.

Birds – Three species of concern (bald eagle, osprey, common loon) are found in association with Cheesman Reservoir. Direct effects of the fire on bald eagles are limited to the potential loss of a winter roost site, which was located in the area burned by severity. This roost has been used by approximately 20 to 40 bald eagles, a relatively small proportion of its overall population. Most of the trees in the roost were scorched but many trees retained their needles during the winter 2002 to 2003; at least 24 eagles were observed roosting in scorched trees the first winter postfire (E. Odell, personal communication). The degree to which the winter roosts offer thermal protection is unclear, and whether the eagles will continue to use the roost, switch to nearby live trees at Cheesman Reservoir, or abandon the site once the needles drop from the roost trees remains to be seen. Prior to the Hayman Fire, eagles had not been observed foraging at Cheesman Reservoir and instead appear to rely on nearby reservoirs outside the burn perimeter for fishing sites (E. Odell, personal observation). Indirect effects of fire on the other two piscivorous bird species include potential fish die-offs due to postfire erosion and degradation of water quality. In the short-term, the reduction of the prey base may cause the osprey and migrating loons to abandon the site. Whether the local populations decline or shift to another area cannot be predicted. However, this artificial lake is not critical to any of these avian species, and any local changes associated with the fire are expected to have limited effect on the overall populations, although local population changes may be observed in the short term.

Several avian species of concern are associated with riparian areas (fox sparrow, and Lewis's woodpecker, which is also associated with older burns). Often, riparian areas escape burning or have lower burn severity than adjacent uplands. Indeed, burn severity was lower in many riparian corridors within the crown

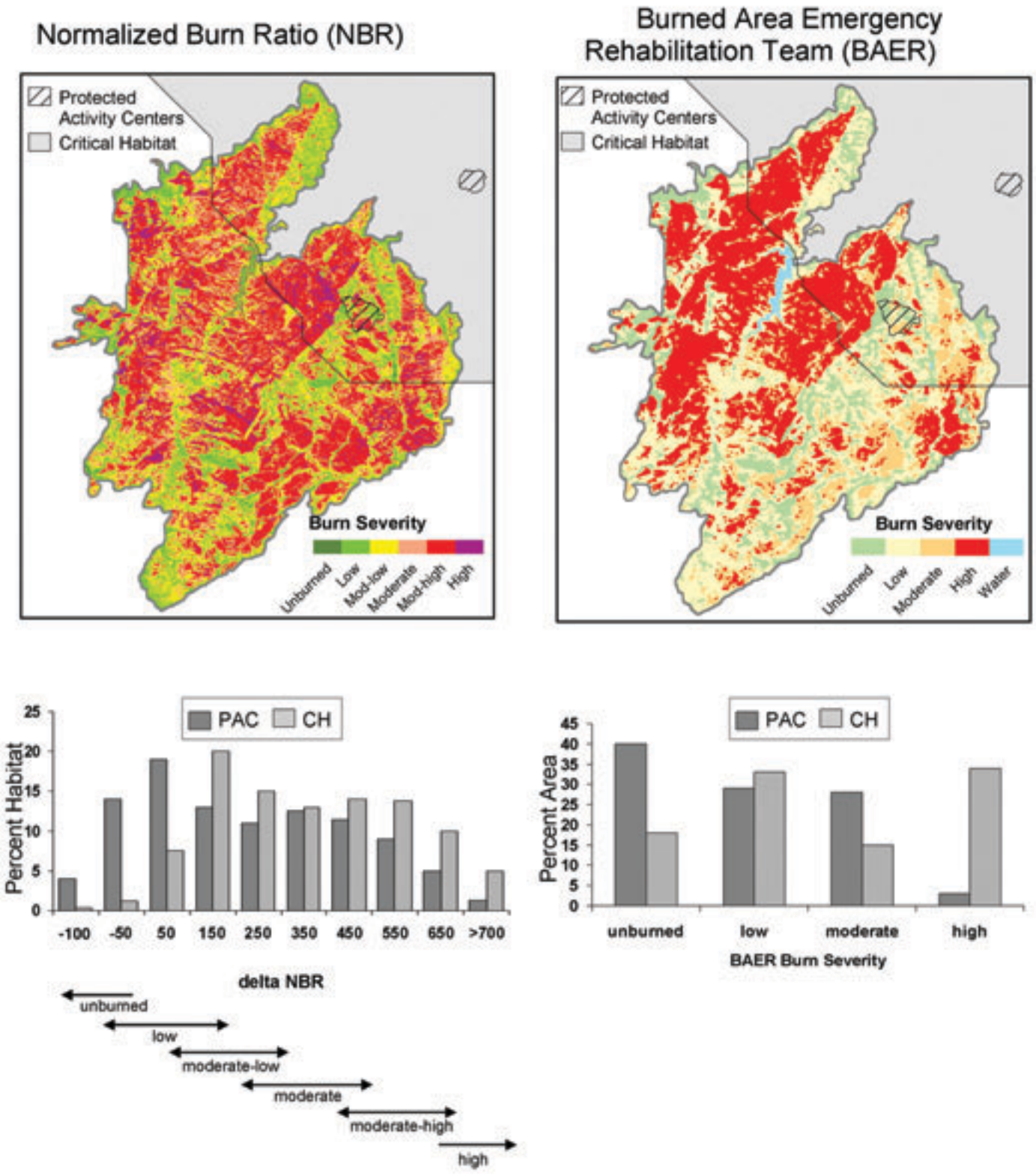

Figure 30—Burn severity patterns in Mexican Spotted Owl Protected Activity Centers (PAC) and Critical Habitat (CH). Normalized Burn Ratio (NBR) is an index of burn severity; low delta NBR scores indicate lower severity than high delta NBR scores.

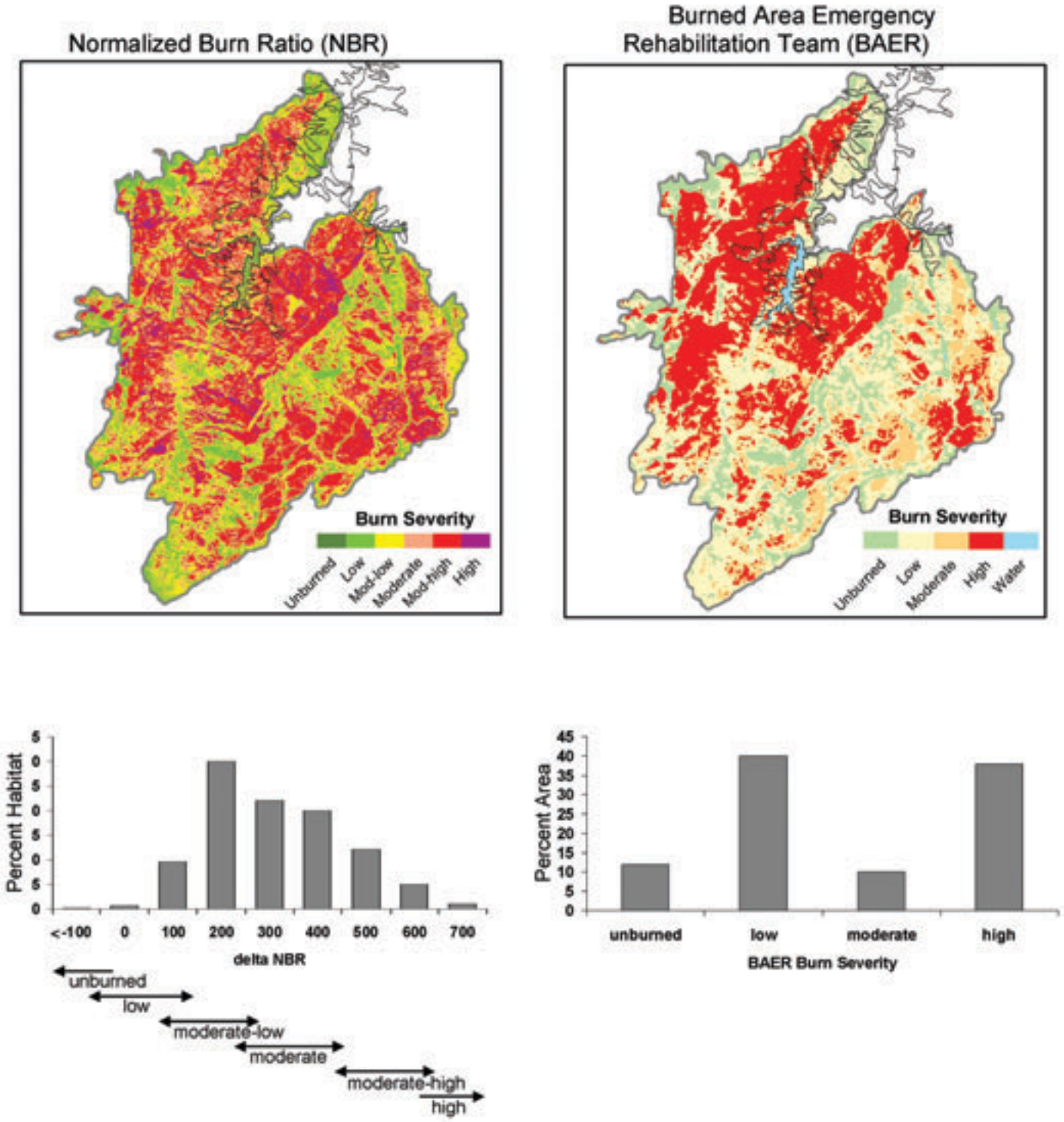

Figure 31—Burn severity patterns in Pawnee Montane Skipper Potential Critical Habitat. Normalized Burn Ratio (NBR) is an index of burn severity; low delta NBR scores indicate lower severity than high delta NBR scores.

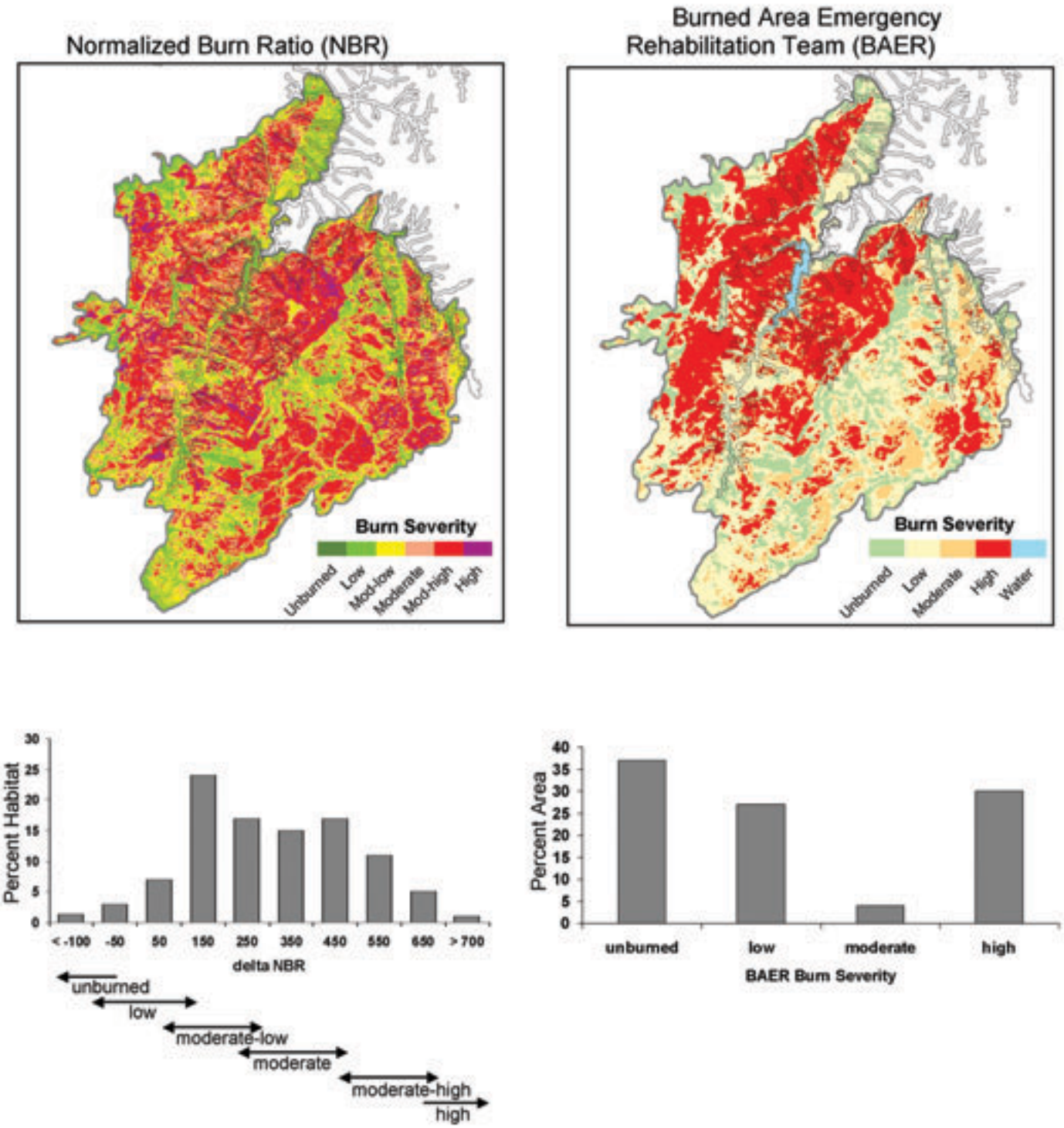

Figure 32—Burn severity patterns in Preble's Meadow Jumping Mouse Potential Critical Habitat. Normalized Burn Ratio (NBR) is an index of burn severity; low delta NBR scores indicate lower severity than high delta NBR scores.

compared to adjacent uplands. Although during severe drought, wetlands may burn (often severely) if moisture levels are reduced, riparian vegetation (for example, willows, aspen) resprouts readily after fire or following siltation from postfire erosion. Fire can also have positive effects on these species of concern. By decreasing canopy closure, severe fires may have increased habitat suitability for fox sparrows, which prefer open shrublands. Lewis's woodpeckers are associated with forested riparian areas but also use older burns (Kotliar and others 2002); fire may have diminished habitat availability in the short term, but as snags fall and the forest opens up, and as riparian forests resprout, potential habitat availability will increase. Because fox sparrows and Lewis's woodpeckers are fairly common and widespread, populations of both species should be able to withstand, and will likely benefit, from such habitat dynamics.

Mammals – Only one mammalian species of concern, the Preble's meadow jumping mouse, is associated with wetland (riparian) systems. This species is discussed below.

Plants – The majority of plant species of concern that are present or potentially occuring within the Hayman and Schoonover Fires, occur in conjunction with wet or riparian areas (table 16d). Because nonnative plant species are likely to respond favorably to the postfire environment (Grace and others 2001), especially in more mesic habitats (Stohlgren and others 1998, 1999, 2002), nonnative plant species over the short and long term may be expected to have negative effects on the native plant species of concern. Initial inventory and subsequent monitoring of vegetation in areas at high risk for nonnative plant species invasion and resulting negative impacts on species of concern, are needed to provide information for control of nonnatives.

Shrublands:

The primary shrublands that burned in the Hayman Fire were generally small pockets of mountain shrub communities that frequently occur in small forest openings or on south-facing slopes. The dominant species is typically mountain mahogany, but wax current and gambel oak are also present. Most of these shrub species are expected to resprout following fire. In addition, aspen sprouts (when small) are often used by many vertebrate species common to shrub systems. Because mule deer use shrublands for forage, there are some concerns about how the decrease in forage availability may affect the local populations, and how changes in forage may interact with wildlife diseases (for example, chronic wasting disease). However, resprouting shrubs and aspen, which are not protected by older woody growth (burned by fire), may potentially increase forage availability. Although the mule deer is a game species and is not listed as a species of concern, biologists on the Pike National Forest expressed concern about their status (D. Bohon, personal communication). Even in high-severity burns, we expect that the shrubland community will recover to prefire conditions relatively rapidly and may even be enhanced in some areas due to removal of the overstory.

Forests:

The dominant tree species burned in the Hayman Fire are ponderosa pine and Douglas-fir. Aspen and small areas of subalpine forests (lodgepole pine, spruce/fir) also burned. Two of the threatened species we are considering as part of this review, Mexican spotted owl and Pawnee montane skipper (see below), occur in forested habitats.

Birds – Several avian species of concern (northern goshawk, flammulated owl, and pygmy nuthatch) prefer mature or old-growth forests. Large crown fires may reduce habitat quality and availability for these species in the short term but enhance habitat quality in the long term by increasing landscape heterogeneity in the Pike. Goshawks have been observed in severe burns, and their prey includes woodpeckers, which are common in early postfire forests (N. Kotliar, P. Kennedy, personal observation). However, it is unclear how readily goshawks will use severely burned forest compared to old-growth forests (Kennedy, personal communication). Goshawk habitat quality may be enhanced, both short-term and long-term, by mixed-severity burns that can increase forest heterogeneity (Reynolds and others 1992). Flammulated owls prefer open montane forests, often with a dense understory, and require snags or dead limbs for nesting (McCallum 1994). Mixed-severity burns may enhance flammulated owl habitat by creating forest openings and snags, whereas large severe fires may diminish habitat quality in the short term, except, perhaps, along burn edges. Pygmy nuthatches are largely restricted to ponderosa pine forests across much of their range (Andrews and Righter 1992). They usually avoid severely burned forests but are common in understory burns (Kotliar and others 2002). Thus, habitat availability and quality may decrease locally for the nuthatches in severely burned areas, but such dynamics are not expected to have long-term negative effects given this species' dependency on forest types that burn regularly. Because all three species are fairly common and widespread, we do not expect any short-term declines in populations that may occur as a result of the Hayman Fire to negatively impact these species in the long term.

Three-toed woodpeckers (see expanded discussion below), olive-sided flycatchers, and Lewis's woodpeckers all readily use postfire forests (Kotliar and others 2002). Olive-sided flycatchers are common in burned forests, particularly at the interface between live trees and snags (Kotliar and others 2002). Thus, we expect their greatest use will be in the mixed-severity burns and along burn edges and unburned remnants of large severely burned areas. Lewis's woodpecker is an aerial forager, and appears to prefer older (for example, 10 years postfire) burns that still have high densities of snags but also include forest openings used for foraging (Kotliar and others 2002). Thus, we predict short-term local increases in habitat availability for these species as a result of the Hayman Fire.

Mammals – Two sensitive bat species may have been affected by fire. Maternal colonies of Townsend's big-eared bat are located in caves and abandoned mines, which may also function as a refuge during the fire. The fringed-tailed bat uses snags for maternal colonies, and thus, there may have been direct mortality to young if the mothers were unable to move their young (T. O'Shea, personal communication). Other than direct mortality, it is unclear whether the fire will enhance or degrade habitat quality and likely will depend primarily on the response of aerial insects to postfire changes. In addition, the availability of numerous snags for maternal colonies may benefit the fringed-tailed bat.

Focal Species of Concern

Mexican Spotted Owl – One known nest location for the Mexican spotted owl was located within the mixed-severity portion of the Hayman burn (fig. 30). Mexican spotted owls have been detected at approximately 20 sites in Colorado, including one other known nesting pair on the Pike National Forest. This represents a small proportion of the estimated 1,000 to 3,000 birds occurring in the United States (S. Hedwall, personal communication). However, spotted owl surveys in Colorado have been limited, and both the Colorado and U.S. population of Mexican spotted owls are deemed unreliable (S. Hedwall, personal communication). The short-term effects of fire on Mexican spotted owls are unclear (Jenness 2002), but mixed-severity fire is expected to enhance habitat quality by creating forest openings, snags for roost sites, and coarse woody debris that can enhance prey habitat (Bond and others 2002; Jenness 2002). Furthermore, low- or moderate-severity fires can decrease the threat of subsequent crown fires (Jenness 2002), which could potentially have negative effects on spotted owls.

Because of the minimal number of owls known to occur on the Pike and the potential for positive effects of mixed-severity burns on habitat quality, we do not expect the Hayman burn to have significant negative effects on this species. However, the cumulative effects of recent large crown fires across the range of the Mexican spotted owl need to be evaluated.

Pawnee Montane Skipper – A member of the *Hesperidae* butterfly family, the Pawnee montane skipper is Federally listed as a threatened species. The skipper is restricted to approximately 9,000 ha within a 38 mi^2 portion of the South Platte River Drainage on the Pike (Keenan and others 1986; Earth Resources Technology 1986). Mixed-severity fires from the Hayman and Schoonover Fires covered approximately 4,000 ha of skipper habitat, which constitutes 40 percent of the skipper's entire range (Ryke and Madsen 2002). Another 10 percent of the skipper's range was burned recently by the Buffalo Creek and Hi Meadow Fires. Because approximately 50 percent of the skipper's habitat burned in recent years, and because of the skipper's limited distribution, the status of the skipper population is of particular concern.

Burn-severity patterns of skipper habitat within the Hayman burn perimeter differed among NBR and BAER maps. NBR burn severity maps indicated that 76 percent of skipper habitat occurred in low- to moderate-severity burn patches. The remaining habitat was located along the perimeter of high severity burns area (fig. 31a). BAER burn severity maps indicated greater burn severity in potential skipper habitat; 48 percent of the potential habitat within the burn perimeter burned sufficiently to cause high tree mortality, whereas the remaining 51 percent was classified as either low-severity or unburned remnant patches (fig. 31b).

Because much of the skipper population was either in the larval or pupal stages during the Hayman Fire, direct mortality from the fire may have been high due to limited mobility. However, skipper populations are characterized by extreme fluctuation, in part because of the current drought. Thus, the low numbers of skippers observed in 2002 surveys may also reflect drought conditions, presumably due to limited availability of adult host plants (L. Ellwood, personal communication). Recovery of populations postfire depends on the species' ability to gain access to suitable postfire habitats and rebuild numbers from survivors or colonizers (Swengel 2001). Past studies suggest that skippers may take several years to recolonize an area following fire, severe disturbance, and regeneration (Ryke and Madsen 2002).

The effects of the Hayman Fire on skipper habitat quality and availability are expected to vary based on the severity of fire, the response of hosts plants to burn severity, and suitability of postfire vegetation. The Pawnee montane skipper occurs in open ponderosa

pine woodlands on moderately steep slopes. Blue grama grass (*Buteloua gracillis*), the larval food plant, and *Liatris punctata*, the primary nectar plant, are critical components of skipper habitat. Blue grama typically resprouts from rhizomes across a range of burn severities, provided moisture is available and nonnative plant species invasions do not interfere with recovery (see Wasser 1982; see also http://www.fs.fed.us/database/feis/plants/graminoid/bougra/fire_effects.html). *Liatris* appears to require openings created by disturbances such as fire but apparently does not tolerate continuous disturbance (USFWS 1998) and may make take several years to recolonize high-severity burns. Based on fire research in mixed-grass prairies, postfire soil moisture is a major factor in determining the effects of fire; drought can slow or alter *Liatris* response to a fire (see http://www.fs.fed.us/database/feis/plants/forb/liapun/fire_effects.html). Thus, if there were higher than average precipitation received in 2003, it would have facilitated host plant recovery; however, Colorado continued its drought into that year.

Skipper habitat quality may either be enhanced or diminished depending on the effects of burn severity on forest structure. Skippers appear to prefer small forest openings and avoid large openings (USFWS 1998). Much of the skipper habitat within the Hayman burn was characterized as moderate severity, which can enhance skipper habitat by creating forest openings. In contrast, large treeless areas created by severe fires may diminish habitat quality in the short term. The size of forest openings may also be increased by postfire tree mortality resulting from outbreaks of bark and woodboring beetles. The effects of fire on the understory structure may likewise affect habitat suitability. Skippers are uncommon in pine woodlands where tall shrubs or young conifers dominate the understory (Keenan and others 1986; Earth Resources Technology 1986). They also avoid north-facing Douglas-fir stands where neither *Liatris* or blue grama are uncommon (USFWS 1998). Thus, fire exclusion, which can lead to greater density of understory trees and shrubs, can thereby diminish habitat quality and availability (USFWS 1998). In contrast, moderate-severity burns that kill understory but not overstory trees can enhance skipper habitat suitability. By contributing to landscape heterogeneity and dynamics as well as reducing future risk of severe crown fire, the Hayman burn may have many positive effects on skipper habitat in the long term.

Postfire management and resulting vegetation characteristics also influence habitat quality. During seeding and/or mulching of burned areas, efforts were made to minimize disturbance or unintentional introduction of nonnative plants that could affect recolonization/resprouting of host plants (D. Bohon, personal communication). However, research and monitoring are needed to determine the effects of postfire treatments on natural regeneration in skipper habitats.

It is unclear whether the potential long-term effects of drought and fire will compound other threats to the population. Human activities and development (for example, livestock grazing, logging, housing, roads, reservoirs, recreational access) in the Platte River Canyon have decreased former skipper range and modified its habitat. Invasion of noxious weeds that may compete with blue grama and *Liatris*, are a serious threat to the skipper (USFWS 1998). Long-term monitoring of the skipper populations is necessary to determine if any mitigation of postfire effects is warranted.

Preble's Meadow Jumping Mouse – Montane populations of the Preble's meadow jumping mouse are poorly studied (Meany 2000), but recent surveys located the mouse along the South Platte River and its tributaries (Schorr 1999; Meany 2001). Preble's meadow jumping mouse habitat has been characterized as "well-developed plains riparian vegetation with relatively undisturbed grassland and a water source in close proximity" (Armstrong and others 1997). Almost 6,000 ha of stream segments identified as potential critical habitat occurred within the perimeter of the Hayman Fire (fig. 32). Both NBR and BAER maps indicated that 66 percent of the habitat burned under low to moderate severity, with the remaining 34 percent burned with high severity (fig. 32).

In riparian areas, higher fuel moisture and the ability of dominant riparian species to resprout, can moderate fire effects compared to upland areas. For much of the potential critical habitat this appears to be the case. However, under severe drought, riparian areas can burn severely, as occurred along several portions of the habitat; in many high-severity patches, riparian vegetation apparently burned in continuous blocks along with surrounding trees and upland areas; thus, direct fire mortality may have been high in these areas if the mouse was unable to find refuge underground. However, most of the potential critical habitat that burned under high severity is in proximity to low- or moderate-severity patches that may serve as potential recolonization sources (fig. 32). There are some concerns that postfire erosion could alter mouse habitat further (L. Ellwood, personal communication), but it is difficult to predict the short- and long-term effects of erosion on Preble's meadow jumping mouse populations. Additional information is needed to assess the effects of fire, climate variability, and invasive plant species on these montane populations. Given the limited amount of potential mouse habitat that burned, the heterogeneity of the burn within its habitat, and the ability of riparian vegetation to resprout following

disturbance, the effects of the Hayman Fire on these populations will likely be relatively short lived.

Three-Toed Woodpecker – Three-toed woodpeckers are uncommon and difficult to monitor, so population levels and trends are poorly quantified (Leonard 2001). Three-toed woodpeckers rapidly colonize severely burned forests in response to outbreaks of bark and woodboring beetles that feed on dead and dying trees (Kotliar and others 2002). Postfire insect outbreaks are short lived, and three-toed woodpeckers are usually rare in burns older than 5 years. Because the woodpeckers are generally uncommon outside areas of insect outbreaks, the availability of mixed-severity and severe burns may represent critical habitat needs; it has been suggested that three-toed woodpecker populations fluctuate with fluctuating availability of burns and other extensive insect outbreaks (Crist 2000). Thus, severe burns represent potentially critical, but ephemeral, habitat for this species (Kotliar and others 2002). Recent nearby fires (Hi Meadow, Buffalo Creek) may have increased the local woodpecker populations available to colonize the Hayman burn; at least 30 adult three-toed woodpeckers were observed in 2003 (Kotliar, personal observation). In turn, the Hayman Fire will likely result in an increase in local populations of three-toed woodpeckers.

Blanketflower and Colorado Fire Moth – The blanketflower (*Gaillardia aristata* Pursh) is found in open, sunny areas, such as hillsides, meadows, and clearings in woods from mesas into the foothills (Guennel 1995; Weber 1976). Research indicates that blanketflower may respond favorably to fire, thereby creating habitat patches for *Schinia masoni* (referred to as Colorado Firemoth; B. Byers, personal communication). Both larvae and adults of *Schinia masoni* depend on blanketflower for food. The reliance of the moth on blanketflower is manifest in the adult moth's cryptic coloring; their head and thorax blend with the yellow ray flowers and their crimson wings match the color of disc flowers (Ferner 1981).

Blanket flower is often a pioneer species that can become established following disturbances such as fire (Cox and Klett 1984). Seeds remain viable in the soil for 2 years (Hotes 1918) and may germinate after burning (Cox and Klett 1984). It also quickly resprouts from rhizomes if the stem is removed (Iles and Agnew 1993). Blanketflower competes well under moisture stress but not under low light conditions present in closed-canopy forests (Hotes 1918; Coupland and Brayshaw 1953; Budd 1979). Thus, blanketflower life history facilitates a positive response to mixed-severity burns and crown fire as long as seed sources or rhizomes are present. Consequently, increased habitat for the Colorado fire moth may occur following the Hayman Fire, provided the moth is able to recolonize burned areas from the surrounding landscape. Burns and other disturbances that cause increases in blanketflower may be essential for the long-term survival of the moth.

Postfire Management

A number of management activities designed to mitigate fire effects and remove dead trees are under way or proposed. The potential ecological effects of such activities have been addressed elsewhere (Robichaud and others, this volume). Here, we briefly discuss the potential implications of postfire management for species of concern.

Rehabilitation activities are primarily designed to reduce erosion in high severity-burn areas; however, the effectiveness or ecological effects have been poorly studied (Robichaud and others, this volume). Species of concern associated with wetland habitats may be negatively affected by erosion-control materials. Soil scarification, used to break up hydrophobic soils, could potentially increase rather than decrease erosion if assumptions about the prevalence and persistence of hydrophobicity are incorrect (D. Martin, personal communication). Materials used to control erosion (straw mulch, hydromulch, seeds) may collect in riparian and wetland areas following rain events. Such negative effects can be magnified by the undetected presence of invasive exotics within seed mixes. Once established, invasive exotics are difficult to eradicate and may compete with native plants, such as host plats for lepidopteran species of concern. Likewise, competition from seeing may inhibit ponderosa pine regeneration because seedlings require bare mineral soil for germination. Consequently, rehabilitation activities could alter the timing or direction of postfire successional trajectories and increase the time necessary for populations to return to prefire levels; this could diminish the ability of a local population to rebound after fire and may especially pose problems for species with restricted or limited populations.

Salvage logging can have serious implications for three-toed woodpeckers, which rarely use burned forests that are partially logged (Kotliar and others 2002). Salvage logging can reduce inputs of coarse woody debris that can provide important refugia for prey species for several species of concern. Disturbance from salvage logging operations may damage resprouting plants and potentially delay or alter postfire recovery. Likewise, disturbance from hazard tree removal along roads may have the greatest effects on riparian areas by potentially increasing erosion. Hazard tree removal includes live trees (75 percent crown scorch) that either may survive or may persist long enough to provide seed sources or refugia, which

becomes increasingly important as tree mortality and distance to live trees increases. The potential negative ecological effects of rehabilitation and salvage logging have been poorly studied and thus not adequately considered when evaluating postfire management activities.

Critical Ecological Elements

There are a number of important elements created by fire that can be harmed by postfire management activities. High densities of dead and dying trees are critical resources for insects and woodpeckers. Isolated live trees are important seed sources and refugia. Likewise, remnant patches of unburned or lightly burned areas supporting a diverse understory of native plants may be important habitat refugia for species of special concern and may provide critical seed sources for recovery of burned and or disturbed areas. Bare mineral soil is necessary for germination of ponderosa pine seedlings, and blanketflower may respond favorably to the disturbance caused by fire. Only the full spectrum of burn-severity patterns present in mixed-severity burns can provide all these essential ecological elements.

In addition, dynamic landscapes are important to the health of ponderosa pine systems. Native vegetation in heterogeneous arrangements, as would have been present during pre-European settlement fire regimes, is essential to the natural recovery of wildlife populations. Nonnative plant species are a serious threat to the recovery of native vegetation, especially in mesic and riparian areas, which also tend to support the greatest variety of native species and species of concern. In particular, native host plants required by moths and butterflies may be displaced by seeding and via competition from invasive exotics. Thus, rehabilitation and other human activities that alter species composition and natural postfire recovery processes, can diminish the positive effects of fire and magnify the negative effects.

Conclusions

The effects of the Hayman Fire are expected to vary based on the patterns of fire severity. In general, the mixed-severity burn in the Hayman Fire will enhance habitat availability for several species of concern in the short term. Although it is possible that several species of concern may decline initially postfire, our review suggests that few, if any, species of concern will suffer long-term negative effects from the mixed-severity burn. Because of the lack of specific information on population changes resulting from fire, and the variation in fire effects (for example, burn severity), such a conclusion must be considered preliminary for many species. Postfire monitoring is necessary to test this prediction, and further research is desperately needed to improve our understanding of the effects of fire on many species of concern. However, given the importance of a mixed-severity fire regime to the health of ponderosa pine and Douglas-fir forests, it is unlikely that many of the 59 species listed as sensitive on the Pike will suffer long-lasting negative impacts of the fire, whereas several species of concern will benefit from the fire.

Concern remains for the Pawnee montane skipper because it is restricted to specialized habitat within a limited area. Further research is needed to quantify burn-severity patterns in the 40 percent of the skipper habitat that burned, and to determine how the species responds (positively and negatively) to burn-severity patterns in conjunction with drought conditions. Although drought is a common occurrence along the Colorado Front Range, rangewide monitoring is necessary to fully quantify the effects of the fire and drought in the context of changing land use and other threats to skipper habitat.

Although we expect that the mixed-severity burn will generally have positive long-term effects for most species, and forest health overall, the Hayman Fire occurred across a landscape that has been altered in numerous ways by human activities. The removal of beaver, roads, fire suppression, postfire rehabilitation, grazing, and habitat fragmentation can alter the structure and functioning of systems. Consequently, there may be interactions between the Hayman Fire and the altered landscape that could lead to greater effects on species of concern than that caused by historic fires. On the other hand, the Hayman Fire may help restore system structure and function by increasing landscape heterogeneity and contributing to system dynamics.

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References

Andrews, R. and R. Righter. 1992. Colorado birds. Denver Museum of Natural History. Denver, CO, 442 pp.

Armstrong, D., M. Bakeman, N. Clippinger, A. Deans, M. Margulies, C. Meany, C. Miller, M. O'Shea-Stone, T. Ryon, and M. Sanders. 1997. Edited by Mark Bakeman. Report on habitat findings of the Preble's meadow jumping mouse. For the U.S. Fish and Wildlife Service and Colorado Division of Wildlife. 91pp.

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

Brown, P.M., M.R. Kaufman, and W.D. Sheppard. 1999. Long-term, landscape patterns of past-fire events in a montane ponderosa pine forest of central Colorado. Landscape Ecology 14: 513-532.

Budd, A.C. 1979. Budd's Flora of the Canadian Prairie Provinces. Revised and enlarged by J. Looman. 1987. Agric. Canada Pub. Ottawa, ON.

Coupland, R.T. and T.C. Brayshaw. 1953. The fescue grassland in Saskatchewan. Ecology 34:386-405.

Cox, R.A. and J.E. Klett. 1984. Seed germination requirements of native Colorado plants for use in the landscape. Plant Prop. 30:6-10.

Cryan, P.M., M.A. Bogan, and G.M. Yanega. 2001. Roosting habits of four bat species in the Black Hills of South Dakota. Acta Chiropterologica 3: 43-52.

Earth Resources and Technology (ERT Company). 1986. Pawnee montane skipper field studies. Unpublished report to the Denver Water Department, Denver, Colorado. 40pp.

Ferner, J.W. 1981. A cryptic moth, Schinia masoni, on Gaillardia aristata in Colorado. Southwest Natur. 26:88-90.

Grace, J.B., M. Smith, S.L. Grace, S. Collins, and T.J. Stohlgren. 2001. Interactions between fire and invasive plants in temperate grasslands in North America. Pages 40-65. In K. Galley and T. Wilson (Eds.), Fire Conference 2000: The First National Congress on Fire, Ecology, Prevention and Management. Invasive Species Workshop: The Role of Fire in the Control and Spread of Invasive Species. Tall Timbers Research Station, Miscellaneous Publication No. 11.

Guennel, G.K. 1995. Guide to Colorado Wildflowers: Mountains. Westcliffe Publishers, Inc., Engelwood, CO.

Hammerson, G.A. 1999. Amphibians and reptiles in Colorado. 2nd edition. University Press of Colorado, Niwot, CO.

Hotes, A.C. 1918. Commercial plant propagation. A.T. Delamare Co., Inc. New York, NY.

Iles, J.K. and N.H. Agnew. 1993. Response of five container grown herbaceous perennial species to laboratory freezing. HortTechnol. 3:192-194.

Jenness, J. 2002. The effects of fire on Mexican Spotted Owls in Arizona and New Mexico. Unpublished Ph.D. Dissertation. Northern Arizona University, Flagstaff, AZ.

Keenan, L.C., R.E. Stanford, S.L. Ellis, and B. Drummond. 1986. Status report on: Pawnee montane skipper. Report to the Denver Water Department, Denver, Colorado. 49pp.

Kotliar, N.B., S. Hejl, R.L. Hutto, V.A. Saab, C.P. Melcher, and M.E. McFadzen. 2002. Effects of fire and postfire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology 25:49-64.

Leonard, D.L., Jr. 2001. Three-toed Woodpecker (Picoides tridactylus). *In* The Birds of North America, No. 93 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences,: Washington, D.C.: The American Ornithologists' Union.

Loeffler, C. 2001. Report on the status and conservation of the boreal toad (Bufo boreas boreas) in the southern Rocky Mountains. Colorado Division of Wildlife, Denver, CO.

McCallum, D.A. 1994. Flammulated Owl (Otus flammeolus). *In* The Birds of North America, No. 93 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences, Washington, D.C.: The American Ornithologists' Union.

Meany, C. 2000. Survey for Preble's Meadow jumping mice, Wigwam Campground, Jefferson County. For the Pike National Forest, South Platte Ranger District, Morrison, Colorado.

Meany, C. 2001. Survey for Preble's Meadow jumping mice, Trout Creek, Jefferson County. For the Pike National Forest, South Platte Ranger District, Morrison, Colorado.

Miller, J. D .and S. R. Yool. 2002. Mapping forest postfire canopy consumption in several overstory types using multi-temporal Landsat TM and ETM data. Remote Sensing of Environment 82:481-496.

Philliod, D. S., R. B. Bury, E. J. Hyde, C. A. Pearl, and P. S. Corn. 2003. Fire and amphibians in North America. Forest Ecology and Management 178: 163-181.

Pierson, E.., M.C.Wackenhut, J.. Altenbach, P. Bradley, P.all, D.. Genter, C.. Harris, B.L. Keller, B. Lengus, L. Lewis, B. Luce, K.. Navo, J. M. Perkins, S. Smith, and L. Welch. 1999. Species conservation assessment and strategy for Townsend's big-eared bat (Corynorhinus townsednii townsendii and Corynorhinus townsendii pallescens). Idaho Conservation Effort, Idaho Department of Fish and Game, Boise, ID.

Reynolds, R.T., R. T. Graham, M.H. Reiser, R.L. Bassett, P.L. Kennedy, D.A. Boyce, Jr., G. Goodwin, R. Smith, and E.L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service, GTR Rm-217.

Russell, K. R., D. H. Van Lear, and D. C. Guynn, Jr. 1999. Prescribed fire effects on herpetofauna: review and management implications. Wildlife Society Bulletin 27:374-384.

Ryke, N., and B. Madsen. 2002. Biological Evaluation/Assessment For Threatened, Endangered and Sensitive Species: Hayman and Schoonover Fires - Hazard Tree Removal. Pike National Forest: South Park, Pikes Peak and South Platte Ranger Districts

Ryke, N. D. Winters, L. McMartin, S. Vest, B. Masinton. 1994. Threatened, endangered, and sensitive species of the Pike and San Isabel National Forests and Comanchi and Cimmarron National Grasslands.

Schorr, R. 1999. Small mammal surveys on Pike National Forest. Douglas County, Colorado. Trout Creek, South Platte River and Indian Creek. For the Pike National Forest, South Platte Ranger District, Morrison, Colorado.

Stohlgren, T.J., D. Binkley, G.W. Chong, M.A. Kalkhan, L.D. Schell, K.A. Bull, Y. Otsuki, G. Newman, M. Bashkin, and Y. Son. 1999. Exotic plant species invade hot spots of native plant diversity. Ecological Monographs 69: 25-46.

Stohlgren, T.J., K.A. Bull, Y. Otsuki, C.A. Villa, and M. Lee. 1998. Riparian zones as havens for exotic plant species in the central grasslands. Plant Ecology 138:113-125.

Stohlgren, T.J., G. W. Chong, L.D. Schell, K.A. Rimar, Y. Otsuki, M. Lee, M.A. Kalkhan, and C.A. Villa. 2002. Assessing vulnerability to invasion by nonnative plant species at multiple scales. Environmental Management 29:566-577.

Swengel, A.B. 2001. A literature review of insect responses to fire, compared to other conservation managements of open habitat. Biodiversity and Conservation 10 (7): 1141-1169.

U.S. Fish and Wildlife Service (USFWS) 1998. Pawnee montane skipper butterfly (Hesperia leonardus montana) recovery plan. Denver, Colorado. 16 pages http://ecos.fws.gov/recovery_plan/pdf_files/1998/980921.pdf

Veblen, T. T., T. Kitzberger, and J. Donnegan. 2000. Climatic and human influences on fire regimes in ponderosa pine forests in the Colorado front range. Ecological Applications 10: 1178-1195.

Wasser, C. H. 1982. Ecology and culture of selected species useful in revegetating disturbed lands in the West. FWS/OBS-82/56. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services, Western Energy and Land Use Team. 347 p. Available from NTIS, Springfield, VA 22161; PB-83-167023.

Weber, W.A. 1976. Rocky Mountain Flora. Colorado Associated University Press, Boulder, CO.