Mountain Bluebird (*Sialia currucoides*): A Technical Conservation Assessment

Prepared for the USDA Forest Service,
Rocky Mountain Region,
Species Conservation Project

March 17, 2006

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Peer Review Administered by
Society for Conservation Biology

Wiggins, D. (2006, March 17). Mountain Bluebird (*Sialia currucoides*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/mountainbluebird.pdf [date of access].

ACKNOWLEDGMENTS

I thank L. Scott Johnson for information on the breeding habitat of mountain bluebirds in the Bighorn Mountains. Gary Patton, Harry Power, and Steve Sheffield provided thorough reviews and many suggestions that greatly improved the quality of the assessment.

AUTHOR'S BIOGRAPHY

David Wiggins developed an early interest in Ornithology. During his high school years, he worked as a museum assistant under Gary Schnell and George Sutton at the University of Oklahoma. He later earned degrees from the University of Oklahoma (B.Sc. in Zoology), Brock University (M.Sc. – Parental care in Common Terns, under the supervision of Ralph Morris), and Simon Fraser University (Ph.D. – Selection on life history traits in Tree Swallows, under the supervision of Nico Verbeek). This was followed by a National Science Foundation Post-doctoral fellowship at Uppsala University in Sweden, where he studied life history evolution in Collared Flycatchers, and later a Fulbright Fellowship working on the reproductive ecology of tits (Paridae) in Namibia and Zimbabwe. He currently splits time between ecological research programs in Sweden and North America..

COVER PHOTO CREDIT

Female (left) and male (right) mountain bluebirds (*Sialia currucoides*). Copyrighted photos courtesy of Don Getty (www.dongettyphoto.com).

Summary of Key Components for Conservation of the Mountain Bluebird

Mountain bluebird (*Sialia currucoides*) populations have been relatively stable across their range over the past 40 years. However, local declines have apparently occurred in some areas along the eastern foothills of the Rocky Mountains, as well as in the Black Hills of South Dakota and Wyoming. Mountain bluebirds breed in a variety of habitats characterized by open ground or short grass with nearby tree cavities for nesting. Consequently, the primary conservation consideration for mountain bluebirds is the availability of mature trees in proximity to open habitat.

A large number of studies have now shown that mountain bluebirds show relatively strong affinities to habitats impacted by fire and logging; their abundance typically increases significantly in such habitats. It is likely then that widespread fire suppression in western forests has negatively impacted the abundance of mountain bluebirds. While logging may create nesting habitat for mountain bluebirds, there are limited data suggesting that nesting success may be low in logged areas. A better understanding of the relative quality of mountain bluebird breeding habitat would simplify habitat management efforts for this species. For example, studies of bluebird breeding success in natural cavities in recently burned forest, on logged sites, and in undisturbed situations would help to clarify the role of these habitats in determining population viability.

It is important to note that the vast majority of published reports of mountain bluebird reproductive ecology have come from studies utilizing nest boxes. The available evidence, although limited, suggests that there may be important differences (e.g., in fledging success) between pairs breeding in natural cavities and those breeding in nest boxes. Consequently, there is a clear need for more information on the ecology (e.g., density in different habitats, clutch size, fledging success) of mountain bluebirds breeding in natural cavities.

Land management policies that would likely have the largest positive impact on habitat conditions for mountain bluebirds are 1) relaxing fire suppression policy to allow occasional fires to burn, especially those in areas adjacent to open habitats such as grasslands; 2) reducing livestock grazing within riparian woodlands and along forest edge habitats above 7,500 ft. (2,275 m) elevation to allow for regeneration of aspen; 3) further investigating the role of primary cavity nesting species (e.g., northern flickers, hairy woodpeckers, sapsuckers) in providing nest sites of varying quality for mountain bluebirds.

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INTRODUCTION

This conservation assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2) (**Figure 1**). The mountain bluebird (*Sialia currucoides*) is the focus of an assessment because it is a Management Indicator Species (MIS) on several national forests within Region 2. Within the National Forest System, a MIS serves as a barometer for species viability at the forest level. By monitoring a MIS, managers can 1) estimate the effects of planning alternatives on fish and wildlife populations [36 CFR 219.19 (a) (1)]; and 2) monitor the effects of management activities on species via changes in population trends [36 CFR 219.19 (a) (6)].

This assessment addresses the biology, ecology, conservation, and management of the mountain bluebird throughout its range, with an emphasis on Region 2. The broad nature of the assessment leads to some constraints on the specificity of information for particular locales. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide land managers, biologists, and the public with a thorough discussion of the biology, ecology, conservation, and management of certain species based on current scientific knowledge. Assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of implications of that knowledge, and outlines of information needs. The assessment does not seek to develop prescriptive management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management

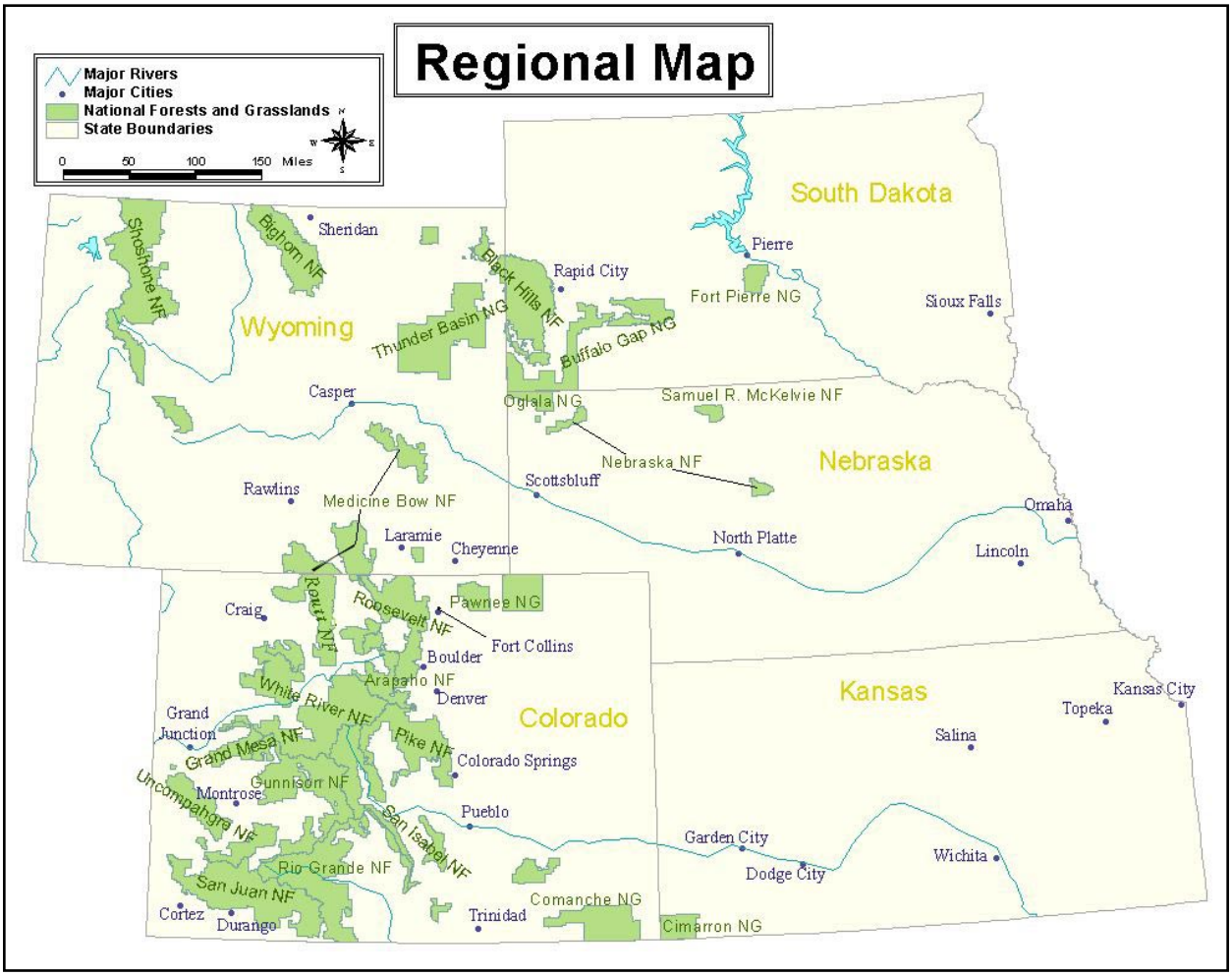

Figure 1. Map of national forests and grasslands within USDA Forest Service Region 2.

(i.e., management implications). Furthermore, this assessment cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope and Limitations of Assessment

The mountain bluebird conservation assessment examines the biology, ecology, conservation, and management of this species with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region (**Figure 1**). Although a majority of the literature on this species originated from field investigations outside the region, to the extent possible, this document places that literature in the ecological and social context of the central and southern Rocky Mountains. Similarly, this assessment is concerned with characteristics of mountain bluebirds in the context of the current environment. The evolutionary environment of the species is considered in conducting the synthesis, but placed in current context.

In producing the assessment, I reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on mountain bluebirds are referenced in the assessment, nor were all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were regarded with greater skepticism, but some of these were used when refereed information was otherwise unavailable, or when recent research results were not yet in published form.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. The geologist T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). Ecology is similar to geology in the difficulty in conducting critical experiments and the reliance on observation, inference, and models to guide understanding of the world (Hillborn and Mangel 1997). Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and when appropriate, alternative explanations are described.

Publication of Assessment on the World Wide Web

To facilitate their use, species conservation assessments are being published on the Region 2 Web site. Placing the documents on the Web makes them available to land managers, agency biologists, and the public more rapidly than publishing them as reports. More importantly, Web publication facilitates the revision of the assessments, which will be accomplished based on guidelines established by Region 2.

Peer Review

Conservation assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the Society for Conservation Biology, employing two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Mountain bluebirds are not currently listed as a threatened species in the United States (U.S. Fish and Wildlife Service 2002) or in Canada (Committee on the Status of Endangered Wildlife in Canada 2004). However, due to its perceived sensitivity to land management practices, the mountain bluebird is listed by the USFS as a MIS on several units in Region 2 (i.e., Arapaho, Pike-San Isabel, San Juan national forests). Mountain bluebirds are not listed as a Priority Species in Region 2 or adjoining states that have published Partners in Flight (PIF) bird conservation plans. However, within the North American Bird Conservation Initiative planning units, mountain bluebirds have been listed (using PIF criteria) as a high priority species within Bird Conservation Region 17 (Badlands and Prairies; including western South Dakota). All of the Region 2 state Natural Heritage Programs that rank

the mountain bluebird list it as secure or apparently secure (**Figure 2**), a pattern generally echoed across the species' range in the western United States and Canada. The only states that list the species as vulnerable are Alaska and Texas, both of which are on the fringe of the species' breeding range.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

The only federal regulatory mechanism covering mountain bluebirds is the Migratory Bird Treaty Act (16 U.S.C. 703-712), which prohibits "take" of listed migratory birds, including mountain bluebirds. Aside from volunteer efforts by amateurs, there are currently no conservation strategies or management plans in place for mountain bluebirds. Western state PIF bird conservation plans have not developed management recommendations for mountain bluebirds since the species generally is seen as being stable in most areas of its range (but see the Population trend section). There is considerable interest from amateurs in increasing the abundance and reproductive success of mountain bluebirds, but that interest typically is limited to initiating local bluebird "trails" of nest boxes and generally does not extend to developing habitat management plans on a larger scale.

Biology and Ecology

Systematics

There are no recognized subspecies of the mountain bluebird (American Ornithologists' Union 1957, Power and Lombardo 1996). Mountain bluebirds occasionally hybridize with eastern bluebirds (*Sialia sialis*; Lane 1969, Rounds and Munro 1982, Steblay 1986) and western bluebirds (*S. mexicana*; Aylesworth 1987) in areas of sympatry.

Nominate race: *Sialia currucoides* Bechstein.

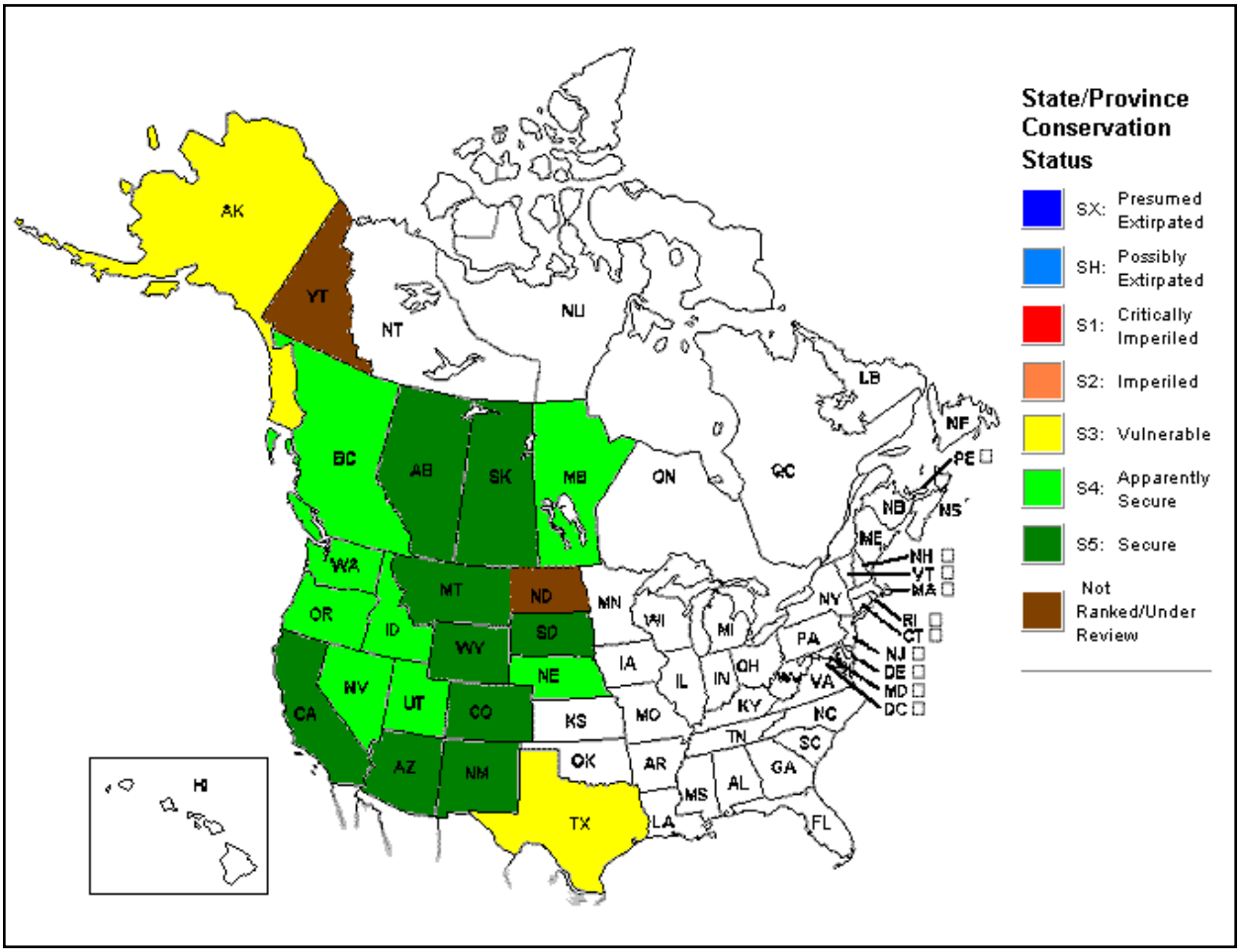

Figure 2. Status of mountain bluebirds in North America based on state and provincial Natural Heritage Program rankings (NatureServe Explorer 2003).

Distribution and abundance

Global distribution

Mountain bluebirds breed over a large portion of western North America, including Alaska, western and south-central portions of Canada, and most of the western United States (**Figure 3**). They are a relatively common species throughout most of their range, becoming rare only in areas that lack open habitats with suitable nest sites (i.e., tree cavities). Although largely restricted to mid- and high-elevation mountainous areas, they will breed in low-elevation foothills and have spread onto the northern Great Plains during the early 1900's (Bent 1949). Mountain bluebirds winter at lower altitudes and latitudes in the western and southwestern United States, the southern Great Plains, as well as portions of northern and central Mexico.

Regional distribution and abundance

Mountain bluebirds have always been relatively common breeding birds within and near Region 2. In the 1800's, they were considered common to abundant in the Black Hills of South Dakota and in the mountainous regions of eastern Wyoming (Ducey 2000), and Goss (1886) considered the species a common summer resident in Kansas. In Colorado, Sclater (1912) described mountain bluebirds as a common to abundant breeding species from the plains to the mountains, with wintering populations at lower elevations in the southern part of the state.

Currently, mountain bluebirds are common breeding birds in the mountain and foothill areas of Region 2, with breeding largely restricted to areas above about 5,000 ft. (1,515 m) elevation. **Figure 4** shows a map of the breeding density of mountain bluebirds in North American, based on Breeding Bird Survey abundance analyses (Sauer et al. 2005). During the winter, mountain bluebirds are residents on the southeastern plains and in the valleys in the southern portion of Region 2 (**Figure 5**).

The historical and current distribution and abundance of mountain bluebirds in Region 2 are as follows:

South Dakota: Ludlow (1875, cited in Ducey 2000) found mountain bluebirds breeding abundantly throughout the Black Hills area with "each little opening in the woods occupied by a family". Over and Thoms (1921) noted that mountain bluebirds were summer residents in the Black Hills and Badlands areas, but they provided no specifics on the species' abundance. Pettingill and Whitney (1965) described this species as a very common summer resident at all elevations in the Black Hills. Recent studies suggest that mountain bluebirds are largely restricted to the western quarter of the state, being relatively common breeders in the Black Hills area, but uncommon to rare breeders further north (Peterson 1995, Tallman et al. 2002). Recent surveys of the Black Hills have found mountain bluebirds distributed locally and at relatively low abundance (Panjabi 2001, 2003, 2004). Thus, the current vs. historical information suggests little change in distribution, but a decrease in abundance in the Black Hills.

Wyoming: The status of mountain bluebirds in Wyoming does not appear to have changed substantially over time. Knight (1902) described the species as abundant throughout the state. Scott (1993) suggested that mountain bluebirds were one of the most common bird species in Wyoming. More recently, Dorn and Dorn (1999) also considered mountain bluebirds a common breeding species throughout the state.

Nebraska: Hayden (cited in Coues 1874) described mountain bluebirds as abundant in the northwestern corner of Nebraska. Recent (1984-1989) breeding bird atlas work in Nebraska found mountain bluebirds breeding in the Scotts Bluff and Pine Ridge areas of the panhandle (Molhoff 2001). Sharpe et al. (2001) note that the species breeds regularly only in areas with ponderosa pine (*Pinus ponderosa*) forest in Sioux, Dawes, and Scotts Bluff counties, but it may also occur in similar habitat in Sheridan County.

Colorado: In Colorado, mountain bluebirds have always been considered common breeding birds. Sclater (1912) noted them breeding commonly throughout the state, with wintering populations in the south. Recent Colorado breeding bird atlas surveys found mountain bluebirds breeding widely throughout western Colorado and east to the Front Range and the southeastern foothills (Barrett 1998). There are a few breeding records for the eastern plains (Andrews and Righter 1992, Barrett 1998). During winter, they are largely restricted to low elevation areas in western Colorado and the plains and foothills of the southeastern quarter of the state (Andrews and Righter 1992).

Kansas: Early authors considered mountain bluebirds a winter resident in western and central Kansas (Goss 1886, Johnston 1965). The species has twice been recorded breeding in the state, on both occasions along the Colorado border (Thompson and

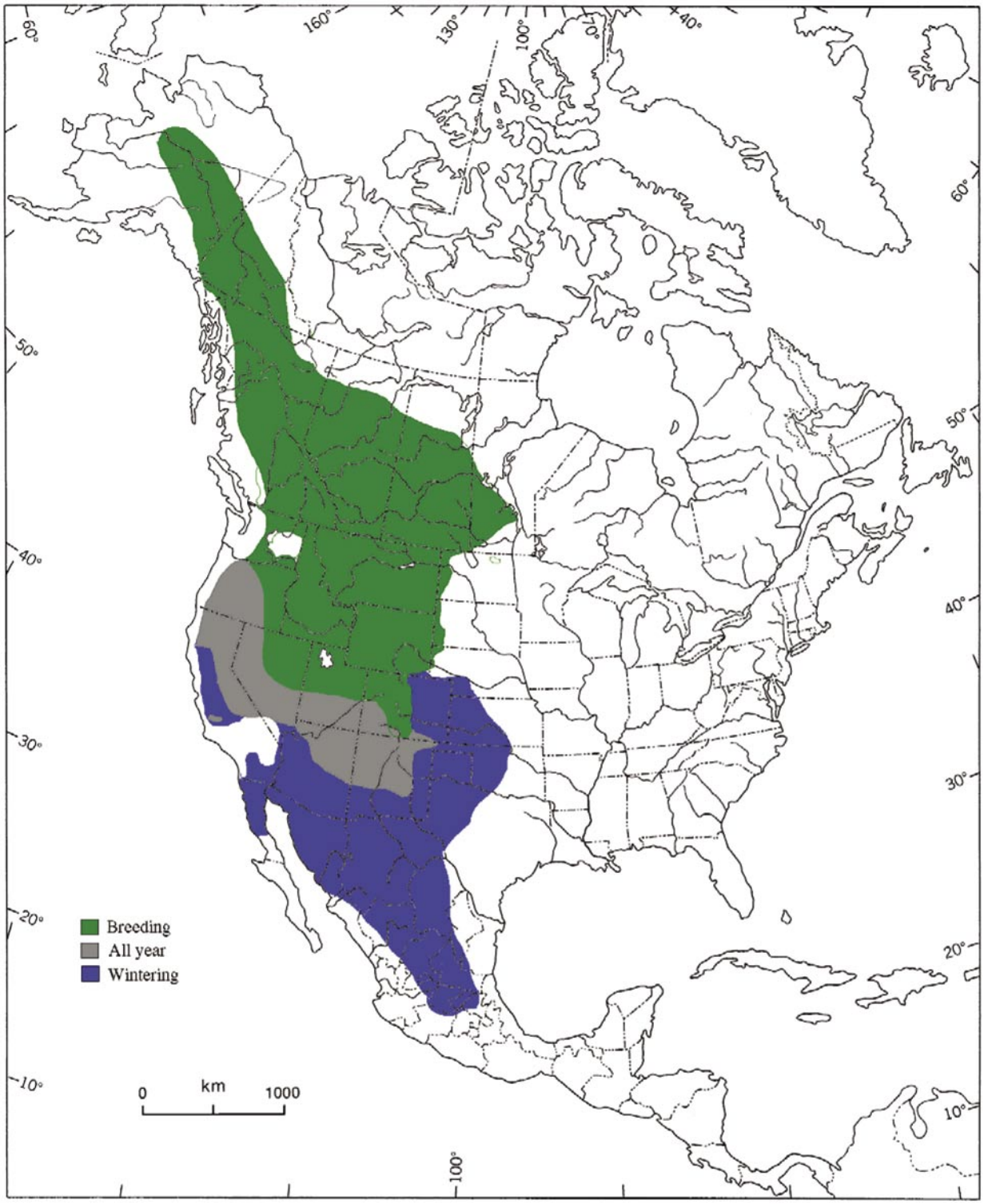

Figure 3. Breeding range of mountain bluebirds in North America. The figure is modified from information provided in Power and Lombardo (1996).

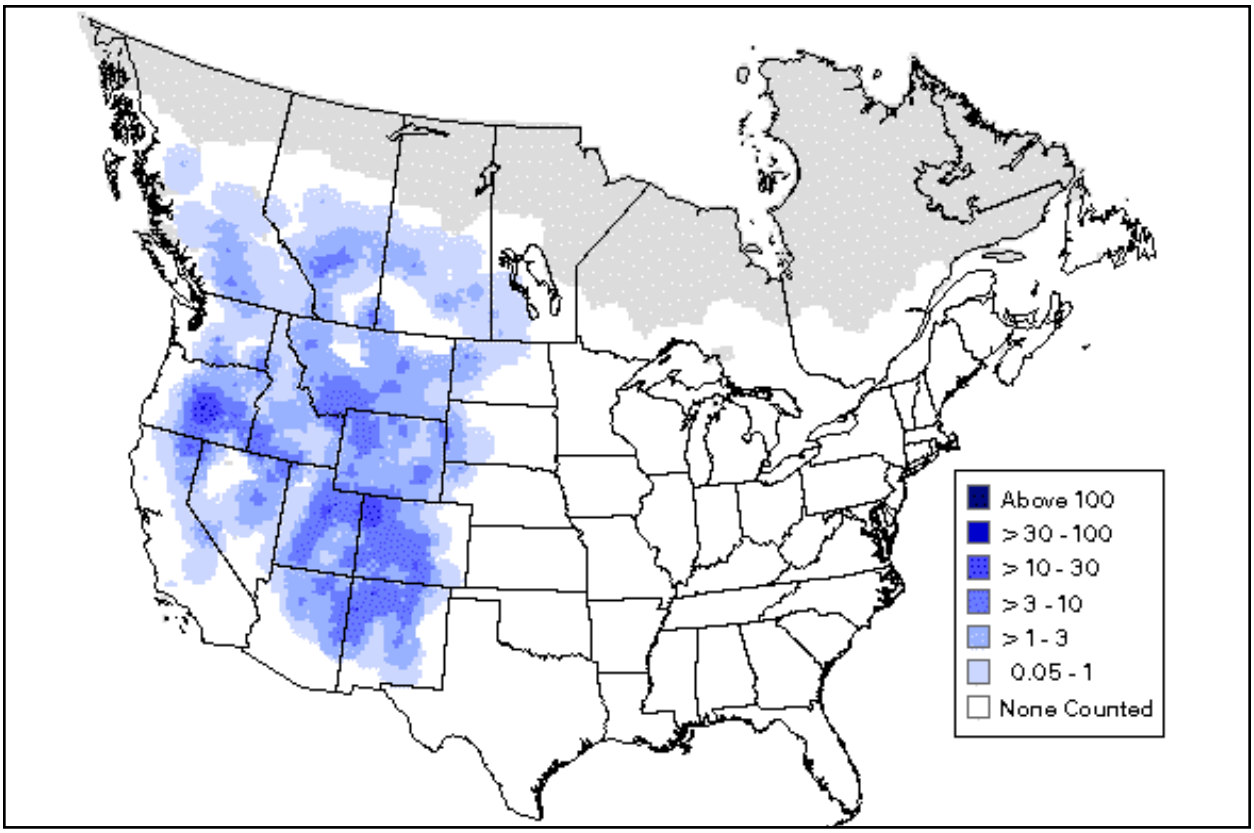

Figure 4. The mean number of mountain bluebirds observed on Breeding Bird Surveys during the years 1982-2003 (Sauer et al. 2005).

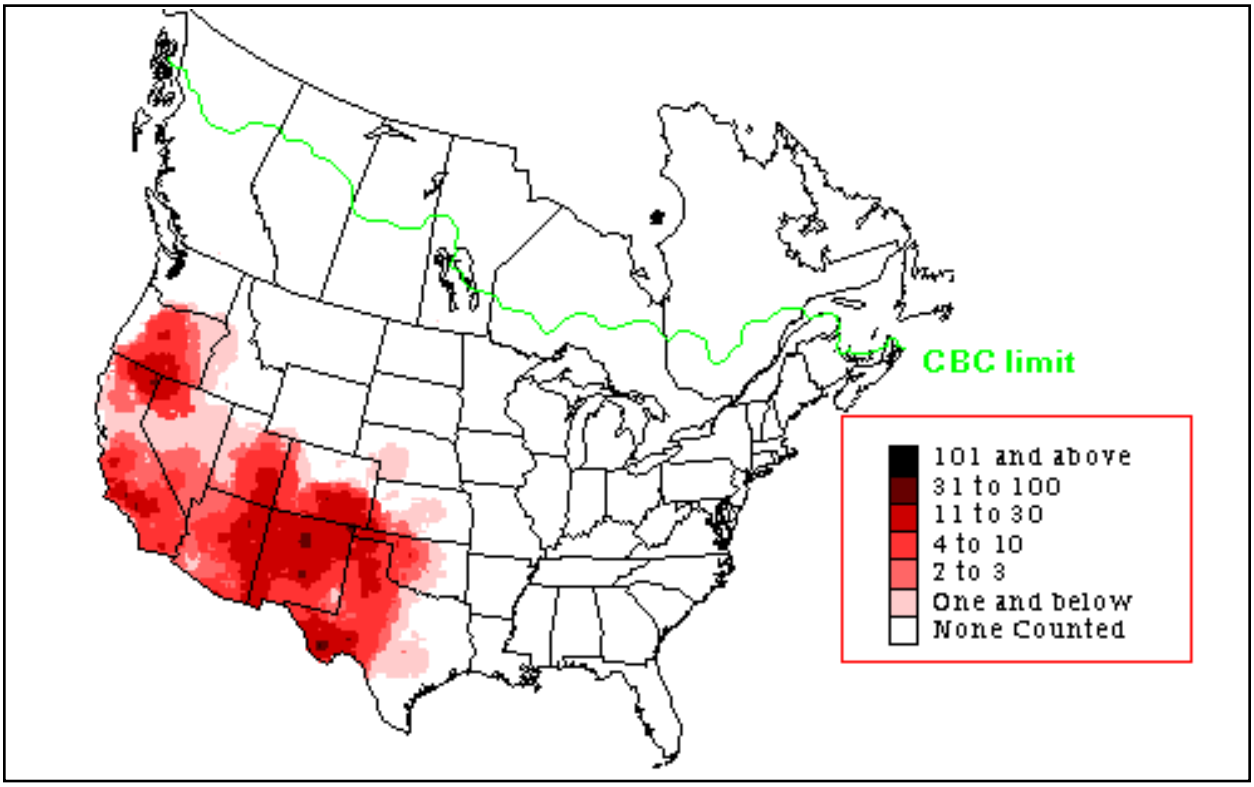

Figure 5. The distribution and abundance of mountain bluebirds based on historical Christmas Bird Count data. Note that data are not collected in the Mexican portion of the bluebird's winter range.

Ely 1992). The recently completed Kansas breeding bird atlas project (Busby and Zimmerman 2001) found no evidence of breeding in the state during the 5-year atlas period.

Within Region 2, the distribution and abundance of mountain bluebirds do not appear to have changed significantly since the 1800's. The only exception is perhaps in the Black Hills of South Dakota, where the species was once described as abundant, but now appears to be declining (**Table 1**).

Regional discontinuities in distribution and abundance

Mountain bluebirds have a wide distribution within mountainous areas of Region 2, breeding at elevations from about 4,500 ft. (1.365 m) to well above timberline and in a variety of open, woodland fringe habitats. They are most commonly found breeding at elevations of 7,000-9,000 ft. (2,120 to 2730 m). Thus, aside from the absence of mountain bluebirds on much of the Great Plains grasslands, there are no real discontinuities in distribution within Region 2. Breeding Bird Surveys (BBS) suggest that mountain bluebirds reach their highest abundance in northwestern Colorado, but they are also relatively common throughout western Colorado and western Wyoming (**Figure 4**).

Population trend

Population trend data from the North American BBS (Sauer et al. 2005) are summarized in **Table 1**. Range-wide, the general picture from BBS analyses is that the abundance of mountain bluebirds has remained relatively stable in the western United States. The available data suggest that mountain bluebirds have declined in abundance in Region 2 since 1980, but at the state level, the decline is statistically significant only in South Dakota (**Table 1**). **Figure 6** portrays the trends in BBS data from 1982 to 2003, with local declines apparent in South Dakota, Nebraska, eastern Colorado, and eastern Wyoming. Thus, the BBS data suggest that within Region 2, populations of mountain bluebirds may be declining along the eastern portion of the species' range, but they appear to be relatively stable in central and western Wyoming, as well as western Colorado. However, as is often the case with BBS data, some caution must be used when interpreting the trends as the surveys are not species-specific, are typically carried out along roads, and may not be able to detect subtle changes in abundance.

Data from Christmas Bird Counts (CBC) show high annual fluctuations in the abundance of mountain bluebirds in Colorado, New Mexico, and Kansas, but they give no indication of a long-term decrease in

Table 1. Mountain bluebird population trend results from North American Breeding Bird Surveys. Data were taken from Sauer et al. (2005) and focus on USDA Forest Service Region 2 and surrounding areas. Trend indicates the percentage change per year. Region 2 states are in bold font, and statistically significant ($P < 0.05$) trends are underlined.

	1966-1979			1980-2003			1966-2003		
Region	***N***	**Trend**	***P***	***N***	**Trend**	***P***	***N***	**Trend**	***P***
Wyoming	17	- 0.5	0.92	79	- 0.3	0.89	79	- 0.7	0.70
Colorado	10	9.2	0.06	87	- 1.3	0.21	88	- 0.1	0.94
South Dakota	4	3.9	0.26	16	- 7.2	0.00	17	- 4.2	0.00
Montana	14	- 3.5	0.58	31	1.9	0.12	35	2.5	0.01
North Dakota	—	—	—	7	6.5	0.30	7	2.3	0.47
Idaho	5	- 1.5	0.87	26	3.5	0.00	27	3.5	0.00
Utah	—	—	—	55	- 0.1	0.92	54	0.5	0.78
Arizona	5	- 4.6	0.53	18	- 3.4	0.42	22	- 3.4	0.22
New Mexico	12	- 19.0	0.42	34	- 5.5	0.00	34	- 5.4	0.00
Black Hills (SD)	3	3.5	0.12	17	- 4.2	0.09	17	- 2.8	0.03
Southern Rocky Mountains	7	4.7	0.34	68	- 1.3	0.15	69	0.0	0.98
United States	112	- 5.4	0.37	457	0.2	0.71	479	0.8	0.14
Survey-wide	148	- 4.4	0.31	568	0.6	0.31	599	1.6	0.00

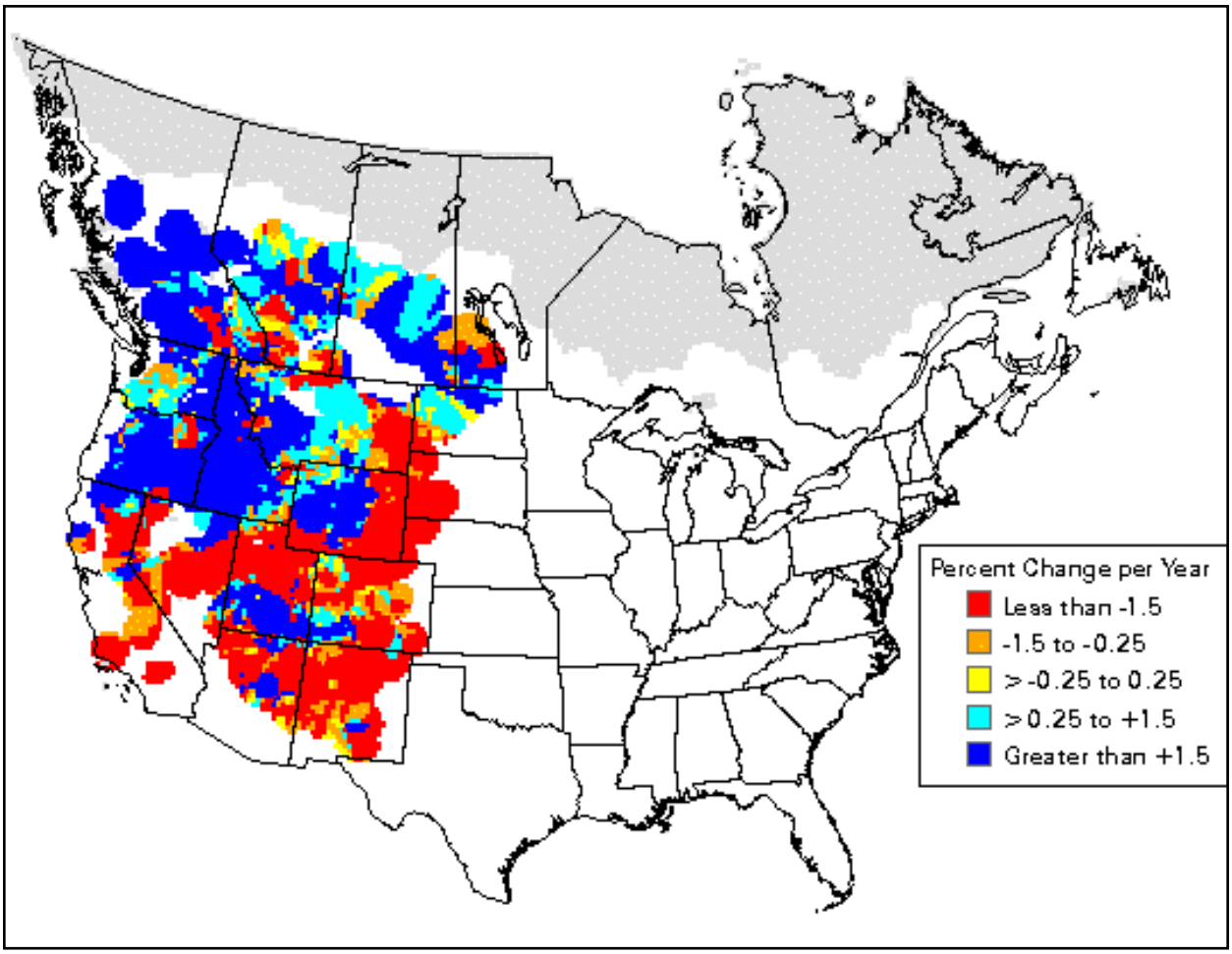

Figure 6. Changes in the mean number of mountain bluebirds counted on Breeding Bird Surveys. Changes are expressed in percentage change per year over the period 1982-2003 (Sauer et al. 2005).

abundance (**Figure 7**). It should be noted, however, that the origin of mountain bluebirds wintering in these states is uncertain; they may derive from areas to the north and northwest of Region 2. Thus, without better knowledge of the wintering range of Region 2 breeding birds, it is difficult to interpret trends in the abundance of wintering mountain bluebirds.

In summary, despite inherent shortcomings in the data derived from general, broad-based surveys such as the BBS and CBC, the available data suggest that mountain bluebird abundance has not changed significantly in Region 2 since 1960, with the possible exception of South Dakota, where the species appears to have declined as a breeding species.

Activity pattern and movements

Mountain bluebirds typically leave their breeding areas in September or October and move to lower altitudes and more southerly locations for the winter. They usually arrive on the Great Plains in October and stay until late March or early April, with large annual variation in numbers being typical (Andrews and Righter 1992, Thompson and Ely 1992). In western Colorado, the main migratory movements occur in March and early April, then again in September and October (Righter et al. 2004). Although mountain bluebirds generally abandon their breeding sites, on occasion they will winter at elevations of up to 8,000 ft. (2,425 m) in western Colorado (Righter et al. 2004); this raises the possibility that some individuals may stay on or very near their breeding sites. However, there are no confirmed cases of such year-round site fidelity.

Mountain bluebirds wintering in Region 2 may undergo large-scale movements during periods of alternating weather conditions. During mild weather, they may move northward, only to move south again when cold weather returns (e.g., Sclater 1912). Such

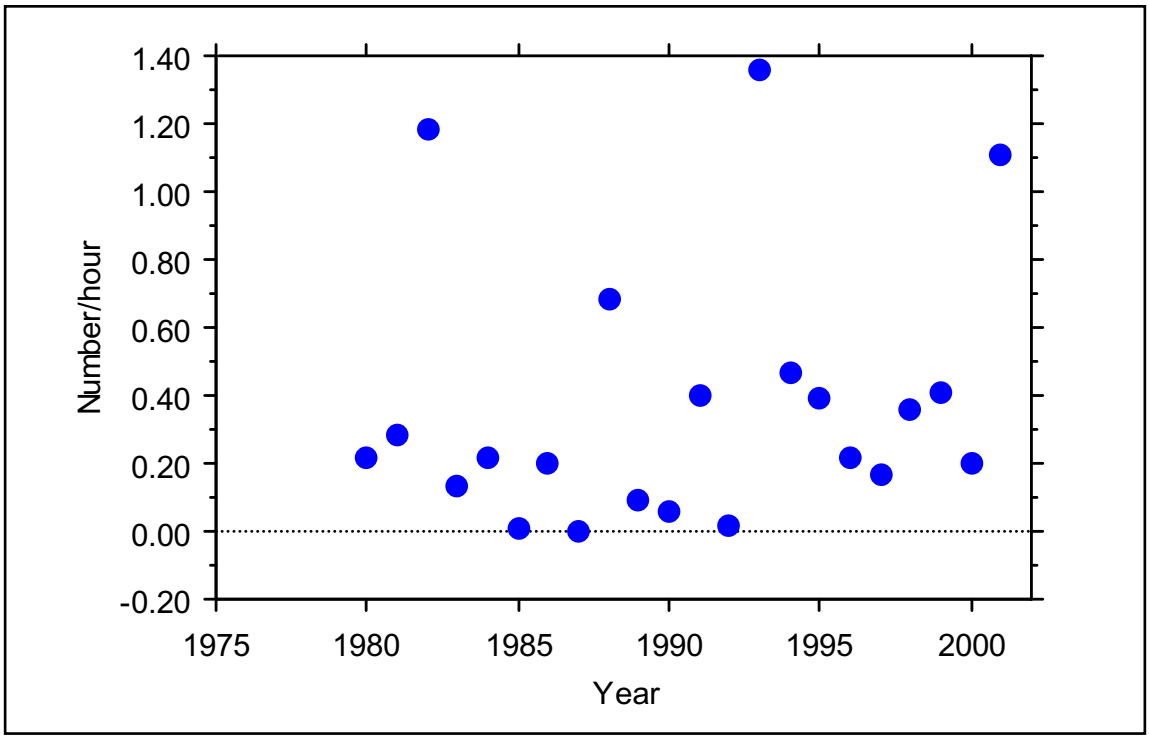

Figure 7. The mean number of mountain bluebirds seen per hour on Christmas Bird Counts (CBC) in Colorado and Kansas. Data are from the CBC website (www.audubon.org/bird/cbc/hour/index.html) and are from 1980 to 2003.

movements may explain the strong fluctuations seen on annual Christmas Bird Counts in Colorado and Kansas (**Figure 7**). During the winter, mountain bluebirds typically reach their highest regional densities in southeastern Colorado (**Figure 5**).

Despite widespread banding of mountain bluebirds in western North America, there is surprisingly little information on adult and (especially) juvenile dispersal. Adults that breed successfully typically return to their previous nest site or the local area (Power 1966, 1974), but unsuccessful breeders appear to disperse (Power and Lombardo 1996). Dispersal is apparently more common in males than in females; Herlugson (1981) reported a 25 percent (24 of 95) return rate for females banded as adults in Washington while none of the 11 males returned. Although his sample sizes were small, Power (1966) reported that some adult males returned to their previous year's nest sites in Montana. Scott and Lane (1974) documented a female mountain bluebird (and possibly her mate) moving 210 km (130 mi.) to renest after the first nesting attempt failed.

First-year mountain bluebirds apparently show limited natal site fidelity; Herlugson (1981) reported a return rate of only 4 percent (8 males and 12 females out of 481 banded nestlings in Washington). Thus, juvenile dispersal appears to be relatively strong in mountain bluebirds. There is no information on site fidelity by wintering mountain bluebirds (Power and Lombardo 1996).

Habitat

Nesting habitat

Mountain bluebirds prefer to nest in habitats characterized by open or scattered woodlands, with intervening areas of grassland, small shrubs, or sagebrush. They are attracted to woodland openings created by fire (Taylor 1973), as well as logged areas where snags (and thus nest sites) are present. In Region 2, they nest from elevations of about 4,500 ft. (1,365 m) to well above timberline. During the recent Colorado breeding bird atlas study (Barrett 1998), mountain bluebirds were found most commonly in pinyon-juniper (*Pinus edulis*) (30 percent of sightings) and aspen (*Populus* spp.; 18 percent) woodlands. In the Black Hills of South Dakota and Wyoming, Panjabi (2004) found that breeding mountain bluebirds reached their highest densities in areas where forests had undergone recent burns, and along pine forest (*Pinus*)-grassland ecotones. In Nebraska, breeding mountain bluebirds are apparently only found in open ponderosa pine woodlands (Ducey 1988, Sharpe et al. 2001).

Bluebird nests normally are placed in tree cavities, such as old woodpecker holes. However, they will also utilize a wide assortment of niches and holes including crevices in cliffs and buildings, old cliff swallow (*Petrochelidon pyrrhonata*) nests, and holes in pipes and railings (Oberholser 1974, Barrett 1998). A recent study in British Columbia (Aitken and Martin 2004) showed that mountain bluebirds had no preference for nesting in cavities in live vs. dead trees. Rather, live/dead nest trees were used in proportion to their availability in the local landscape. In aspen woodlands in eastern Oregon, Dobkin et al. (1995) measured characteristics of mountain bluebird nest cavities and nest trees and reported the following (mean) characteristics:

- horizontal nest hole entrance diameter of 6.3 cm
- nest height of 3.1 m
- tree height of 12.2 m
- canopy cover of 70 percent
- distance to forest edge of 14.7 m.

In Wyoming, mountain bluebirds generally are restricted to elevations above 4,500 ft. (1,365 m) in the Bighorn Mountains (S. Johnson personal communication 2005). They range into the relatively low-elevation Badlands area of South Dakota, where they typically nest in niches in rock formations (Peterson 1995). In Colorado, prime nesting habitat (aspen forest edges) is typically above 7,500 ft. (2,500 m; Righter et al. 2004), but mountain bluebirds will nest sparsely at elevations as low as 4,500 ft. (1,365 meters) in southeastern Colorado (D. Wiggins personal observation).

Foraging habitat and behavior

Mountain bluebirds forage in open areas including grasslands, sagebrush, open woodlands, and pastures. In most situations, they forage over open ground or areas where grasses are shorter. However, they may forage in taller grasslands during periods of food stress, for example when feeding young or when weather conditions are poor (Power and Lombardo 1996).

Mountain bluebirds typically forage from elevated perches, either flying down to capture insects in low vegetation or on the ground, or performing flycatching flights. They may also perform hovering flights, searching for prey while temporarily hovering over open ground or vegetation. At least during the breeding season, foraging activity peaks in the early morning and late afternoon (Power 1974).

Food habits

Mountain bluebirds feed primarily on insects, including Coleopterans (beetles), Orthopterans (grasshoppers, crickets, katydids), Arachnids (spiders), and Lepidopterans (primarily caterpillars). Beal (1915) analyzed stomach contents of 66 adult mountain bluebirds and found that the primary insect prey was composed of Coleoptera (30 percent), Orthoptera (23 percent), Formicidae (13 percent), and Lepidoptera (primarily larvae; 14 percent). In Utah, mountain bluebird stomach contents (194 adults, from April to October) consisted of Coleoptera (34 percent), Hymenoptera (30 percent), Orthoptera (9 percent), Lepidoptera (8 percent), Hemiptera (5 percent), and small percentages of other insects (Knowlton and Harmston 1946). Herlugson (1982) studied the diet of adult and nestling mountain bluebirds in Washington and found that prior to the nesting stage, adults fed extensively on spiders, switching to Coleoptera and Orthoptera as the season progressed. Nestlings (155 at 27 nests) were fed Orthoptera (58 percent), Homoptera (23 percent), Coleoptera (10 percent), Arachnida (5 percent), and Lepidoptera (4 percent). In Montana, the food delivered to four mountain bluebird nests included Orthoptera (33 percent), Lepidoptera larvae (27 percent), and a smaller proportion of spiders (Power 1980a).

During the winter, mountain bluebirds continue to take insects when available, but berries become an important component of their diet. Beal (1915) documented the following vegetable matter in the diet of mountain bluebirds: grapes (*Vitis*), currants (*Ribes*), elderberries (*Sambucus*), sumac (*Rhus*) seeds, mistletoe (*Viscacae*) berries, hackberry (*Celtis*) seeds, and cedar (*Cedus*) berries.

There have been no published studies of mountain bluebird food habits within Region 2, but wintering birds on the southern Great Plains tend to concentrate in areas with abundant juniper (*Juniperus*) trees (D. Wiggins personal observation).

Breeding biology

Although the breeding biology of mountain bluebirds has been relatively well-studied, most of the studies must be interpreted cautiously as they typically were carried out on pairs utilizing nest boxes, rather

than those breeding in natural cavities. Although they provide a wealth of easily-collected demographic information, nest box studies are rife with potential bias (see discussions in Møller 1989, Purcell et al. 1997), including altered rates of nest predation, unnaturally high, local breeding densities (and consequent effects on social behavior), and the elimination of natural variation in nest-site quality. For example, Purcell et al. (1997) found that western bluebirds that nested in boxes bred earlier, were less often depredated, and raised more young than bluebirds breeding in natural cavities. The general lack of studies on mountain bluebird breeding biology in natural cavities is the most important information need for the conservation of the species in Region 2 (see Information Needs section).

Courtship, pair formation, and nest building

In most areas of their range, male mountain bluebirds arrive on the breeding grounds in early spring (early March-April in Region 2), about one week prior to females. Males quickly establish territories around potential nest sites and are then visited by prospecting females. Once a pair-bond has formed, males spend a large proportion of their time mate-guarding, presumably in an attempt to ensure paternity (Power 1979, Power and Doner 1980). Mountain bluebirds are socially monogamous, but both sexes will engage in extra-pair copulations. Power and Doner (1980) showed that both sexes readily attack same-sex intruders but not intruders of the opposite-sex. In addition, when males are experimentally prevented from guarding their mates, females offer no resistance to extra-pair copulation attempts (Power and Lombardo 1996).

Mountain bluebirds are cavity-nesters, and pairs may explore a number of nest sites on their territory before the female chooses the site and begins nest building (Power 1966, Power and Lombardo 1996). They line the chosen cavity with grasses and fine plant materials (Power and Lombardo 1996); in southwestern Wyoming, mountain bluebirds were observed lining nests solely with sagebrush (*Artemisia* spp.) bark, with a few feathers as a final lining in the nest cup (Haecker 1948). Nest building typically occurs intermittently and usually is complete within a week (Haecker 1948, Power and Lombardo 1996).

Clutch and brood size

Female bluebirds lay one egg per day, typically in the morning, until clutch completion (Power and Lombardo 1996). Clutch size varies from four to eight eggs (mean five to six) and surprisingly shows no latitudinal or altitudinal variation (Power and Lombardo 1996). Pairs will often attempt a second brood after successfully raising their first, with reported double-brooding rates of 50 percent in both Montana (Power 1966) and Manitoba (Randall and Lane 1969). Due to the presence of second broods, detecting seasonal declines in clutch size of first broods is difficult. Power and Lombardo (1996) reported a significant difference in clutch size between first (5.5 eggs) and second (4.4 eggs) clutches in Montana; Rounds and Munro (1983) found that second broods in Manitoba averaged 0.6 fewer young than first broods.

Parental care and offspring behavior

Only female mountain bluebirds develop a brood patch and incubate the eggs. The incubation period is approximately 13 days (Power 1966). During this time, the male provides the female with considerable amounts of food, allowing the female to spend longer periods incubating the eggs (Power and Lombardo 1996). Typically all of the young hatch on the same day, but occasionally one young will hatch a day later. This suggests that females begin incubating either when the clutch is complete, or after laying the penultimate egg.

Only the female broods the young, but the male provides almost all of the food to the newly hatched young (Power 1980a). Once the young have reached a few days of age, brooding declines as the female takes up an increasing role in providing food for the young. Over the course of the nestling stage, the male and female provide similar amounts of food to the brood.

In Montana, Power (1966) found an average of 14 feeding trips to the nest per hour, or 2.2 feeds per chick per hour. Both parents continue to provide food to the fledged young, but if a second clutch is laid, females cease feeding the fledglings. There has been one report of a first-brood juvenile assisting with feeding young of the second brood (Mills 1931).

Nestling growth

Nestlings weigh 3 grams at hatching and reach an asymptotic mass of about 31 grams, slightly above the average mass (30 grams) of adults (Herlugson 1983). Surprisingly, Herlugson's (1983) study found no significant variation in nestling growth rates associated with brood size, year, or timing of breeding.

Timing of breeding and breeding success

Table 2 provides a summary of the timing of major reproductive events for mountain bluebirds in Region 2. Arrival on the breeding grounds and initiation of clutches occur earliest at low-elevation, southerly sites. In most areas, there is a long period (at least 1 month) between arrival at the breeding site and clutch initiation. Most first clutches are laid in May, and second clutches, if attempted, are laid in late June or early July (Barrett 1998).

Breeding success varies with spring/summer climatic conditions, being higher in dry, warm conditions and lower when conditions are wet and cold (Power 1974, Power and Lombardo 1996). When late freezes or prolonged periods of cold, wet weather occur, considerable mortality may occur among eggs, nestlings, fledglings, and even adults (Haecker 1948, Lane 1971, Scott and Lane 1974, Houston 1982, Power and Lombardo 1996). Power (1974) documented high reproductive success during years with good weather conditions in Montana. In such years, 87 percent of first-clutch eggs and 93 percent of second-clutch eggs hatched, and 76 percent of first-brood and 87 percent of second-brood nestlings fledged.

On the Canadian prairies (Criddle 1927, Scott 1967, Randall and Lane 1969, Pinel 1980, Rounds and Munro 1983) and in Montana (Power 1966), approximately 50 percent of mountain bluebird pairs nesting in nest boxes raise two broods during a single breeding season. In a nest box study in British Columbia, the presumed percentage of pairs that raise a second brood averaged 30 percent (H. Pollock, cited in Campbell et al. 1997). Holt and Martin (1997) found contrasting results in two years in eastern British Columbia, with 32 percent of 13 pairs laying second clutches in one year, and none of 14 pairs attempting second clutches the following year. In some cases, a third clutch may be laid, but this apparently only occurs when either the first or second clutch has failed (Power and Lombardo 1996).

As mentioned elsewhere in this assessment, analysis of mountain bluebird ecology and conservation is complicated due to the prevalence of data originating from nest box studies. One of the primary concerns when interpreting data from such studies is the potential for unnaturally high reproductive success of pairs breeding in boxes (Purcell et al. 1997). Studies of mountain bluebirds nesting in British Columbia support this notion; overall nest success rates (the percent of nests where at least one young fledged) averaged 71 percent (884 of 1233) in nest boxes and 62 percent (36 of 58) in natural cavities (Campbell et al. 1997). In addition, Campbell et al. (1997) report an unpublished study in British Columbia by R. F. Holt showing that of 40 mountain bluebird nests in natural cavities (primarily old northern flicker [*Colaptes auratus*] nests) in a clearcut area, 45 percent were depredated. Finally, Purcell et al. (1997) found that the predation rate at western bluebird nests in natural cavities was more than double that of pairs nesting in boxes. Thus, some caution needs to be used when interpreting regional patterns of reproductive success in mountain bluebirds. For example, if we assume that the observed pattern of lower reproductive success of pairs nesting in natural (i.e., non-nest box) situations holds across the species' range, then it is likely that the percentage of pairs successfully raising two broods is also lower in such situations. As noted by Power and Lombardo (1996),

Table 2. Approximate timing of major breeding events for mountain bluebirds in USDA Forest Service Region 2. In all areas, mountain bluebirds breed earlier at lower elevations; therefore, individual breeding events occur over relatively broad time frames.

State	Spring arrival date	1st clutch date	Fledge date	Citation
Wyoming	March to April	May to June[1]	June to July[1]	Dorn and Dorn 1999
Colorado	late February to March[2]	mid April to mid June	mid May to mid August	Andrews and Righter 1992, Barrett 1998
South Dakota	March to April	May to July	June to July	Peterson 1995, Tallman et al. 2002
Nebraska	late February to March	April to June	May to July	Molhoff 2001, Sharpe et al. 2001

[1]In Wyoming, the timing of clutch initiaition and fledging are extrapolations from known spring arrival dates.

[2]In Colorado, some birds regularly winter in the southern and western portions of the state, making arrival times difficult to determine in these areas.

the time lost during failed nesting attempts reduces the probability that a pair would have sufficient time to successfully raise more than one brood in a season. This is an important consideration given that across the species' range, a large proportion of mountain bluebirds nest in natural cavities, and the demographic data derived from nest box studies may not accurately reflect the situation for birds nesting in natural cavities.

The success of first and second broods has been studied in some areas. However, such studies are often *assumed* first and second broods as researchers typically divide nesting attempts into early and late phases, under the assumption that early attempts are first broods and late attempts are second broods (Rounds and Munro 1983). The available data suggest that fledging success (the percentage of eggs laid that result in fledged young) is similar among first and second broods (**Table 3**). The major cause of the difference in reproductive success between first and second broods is clutch size, with first clutches averaging about one more egg than second clutches (Power 1974).

Long-term data from a nest box study of mountain bluebirds in Manitoba suggest that first broods are subject to greater total nest loss, due to poor weather, interspecific competition, and the effects of nestling parasites, than are second broods (Rounds and Munro 1983). Thus, because they nest relatively early in the spring, mountain bluebirds are subject to relatively frequent nest failure during their initial breeding attempt. However, Houston and Houston (1998) summarized almost 30 years of data from mountain bluebirds nesting in nest boxes on the Canadian prairies and found that fledging success (the percent of nests where at least one young fledged) ranging from 61 to 88 percent, with a mean of 77 percent.

Demography

Genetic characteristics and concerns

Mountain bluebirds are widely distributed and common in Region 2, breeding in many open habitats above 4,500 ft. (1,365 m) elevation. Populations are not fragmented, and dispersal from breeding sites (especially among juvenile bluebirds) is relatively high. As a consequence, there is no reason to suspect that the species may be affected by a lack of gene flow among populations. The construction of nest boxes and the availability of nest sites in and around man-made structures have no doubt led to an increase in the abundance of mountain bluebirds in some areas.

Life history characteristics

Mountain bluebirds lay large clutches and often successfully raise two broods per season. Reproductive potential is, therefore, relatively high. However, since this observed productivity invariably comes from nest box studies, further research is needed to assess whether high reproductive output is typical of pairs breeding in natural cavities. Studies of marked individuals in Montana suggest that both sexes first breed when they are one year old (Power and Lombardo 1996). Due to the relatively strong dispersal tendencies in this species, post-fledging and adult survival rates have not been accurately determined (Power and Lombardo 1996). Given the lack of survival data, as well as a scarcity of any demographic data from pairs breeding in natural cavities, I chose not to carry out an analysis of life cycle diagrams and associated demographic matrices (Caswell 1989, McDonald and Caswell 1993) in this review. While such analyses can provide valuable insights into which life-history stages may be most

Table 3. Clutch size and fledging success for mountain bluebirds in North America. Data from first and second clutches are reported separately. In some studies (e.g., Rounds and Munro 1983), the first and second broods reported below represent "early" and "late" clutches during the breeding season (i.e., presumed first and second broods).

	First clutch/brood		Second cluth/brood		
State/Province	**Cluth size (n)**	**Brood size at fledging (n)**	**Cluth size (n)**	**Brood size at fledging (n)**	**Citation**
Manitoba	—	4.83 (815)	—	4.23 (880)	Rounds and Munro 1983
British Columbia	5.2 (870)	—	4.9 (507)	—	Campbell et al. 1997
British Columbia	4.9 (14) to 5.5 (13)	4.6 (8) to 4.8 (7)	—	—	Holt and Martin 1997
Montana	5.53 (85)	4.81	4.39 (22)	4.09	Power 1974

critical to population growth, constructing models based on incomplete and/or poor quality data may have little relevance (Reed et al. 2002).

Social patterns and spacing

Mountain bluebirds nest solitarily in most situations, but where nest sites are abundant (e.g., recently burned forests, nest box trails), they may breed in loose aggregations (Holt and Martin 1997). Typically, adjacent nest sites are at least 100 meters apart. Territory size averaged 5 hectares in Montana, but the effective territory shrinks as the breeding season progresses and the pair concentrate their activities around the nest site (Power 1980b). In addition to conspecifics, breeding mountain bluebirds aggressively exclude western bluebirds (Herlugson 1982) and eastern bluebirds (Lane 1973) from their territories.

Groups of more than 30 birds may form temporary post-breeding flocks that may remain together until migration occurs (Power 1974, 1980a). During migration and on the wintering grounds, mountain bluebirds typically occur in groups, ranging from a few individuals to several hundred. The composition and movement of winter flocks have not been studied.

Factors limiting population growth

Within Region 2, the factors regulating mountain bluebird population growth are largely unknown. Mountain bluebirds typically nest in mature trees (e.g., aspen, pinyon-juniper, ponderosa pine) that are situated in or near forest clearings or forest/grassland edge habitats. A lack of suitable nest sites is considered to be the principal factor thought to limit population growth (Erskine 1964, Power 1966, Miller 1970, Houston and Houston 1998). Holt and Martin (1997) added nest boxes relatively late in the breeding season and found most quickly occupied by mountain bluebirds. The lack of suitable nesting sites can arise either from a lack of breeding habitat in general (i.e., open woodland and forest/grassland edge habitat) or a lack of available nest cavities per se. Forest fires produce open habitats and dead/damaged trees and are thus generally beneficial to mountain bluebirds. Consequently, fire suppression policies have probably led to local declines of mountain bluebirds.

In some areas, competition over access to nest sites may limit the local abundance of mountain bluebirds. In areas where nest boxes are set up for bluebirds, the boxes are often placed far from wooded habitats so that bluebirds face less competition from chickadees (*Poecile* spp.) and house wrens (*Troglodytes aedon*). At natural cavities, mountain bluebirds may face intense competition from western bluebirds, European starlings (*Sturnus vulgaris*), house wrens, tree swallows (*Tachycineta bicolor*), violet-green swallows (*T. thalassina*), and several other cavity-nesting species (e.g., Power 1966, Herlugson 1982).

Community ecology

Interactions between mountain bluebirds and their predators, and how these factors interact with habitat use, are presented in **Figure 8**. The primary factor influencing the local abundance of mountain bluebirds is the availability of nest sites near open habitat, and consequently, the primary threats are those that lead to a reduction in suitable breeding habitat. These threats include fire suppression; overgrazing, which may have beneficial and/or detrimental effects (see Threats section); and logging techniques that fail to leave a sufficient numbers of snags and other potential nesting trees. In addition, interspecific competition for nest sites and nest depredation may severely affect reproductive success.

Predation of eggs and young, and possibly adults, at nests is relatively common; one study reported a 45 percent depredation rate of cavity nests in British Columbia (R. F. Holt, cited in Campbell et al. 1997). Predators known to take bluebird eggs and nestlings include deer mice (*Peromyscus* spp.; Swenson 1968) and eastern chipmunks (*Tamias striatus*; Lane 1971, Rounds and Munro 1983). Eggs and nestlings may also be killed by various species of ants (Lane 1971, Rounds and Munro 1983). House wrens are known to puncture eggs (Power and Lombardo 1996). Sharp-shinned hawks (*Accipiter striatus*), Cooper's hawks (*A. cooperi*), northern harriers (*Circus cyaneus*), merlins (*Falco columbarius*), American kestrels (*Falco sparvarius*), and American crows (*Corvus brachyrhynchos*) are known predators of adults and fledged young (Bent 1949, Power 1966, Lane 1971).

Competition for limited nest cavities can be intense, and mountain bluebirds have been usurped from nest cavities by red squirrels (*Tamiasciurus hudsonicus*), deer mice, and bushy-tailed woodrats (*Neotoma cinerea*; Power and Lombardo 1996). Competition for access to cavity nest sites occurs with a number of other bird species including bufflehead (*Bucephala albeola*), northern flicker, tree swallow, violet-green swallow, black-capped chickadee (*Poecile atricapillus*), boreal chickadee (*P. hudsonica*), eastern and western bluebirds, European starling, house wren,

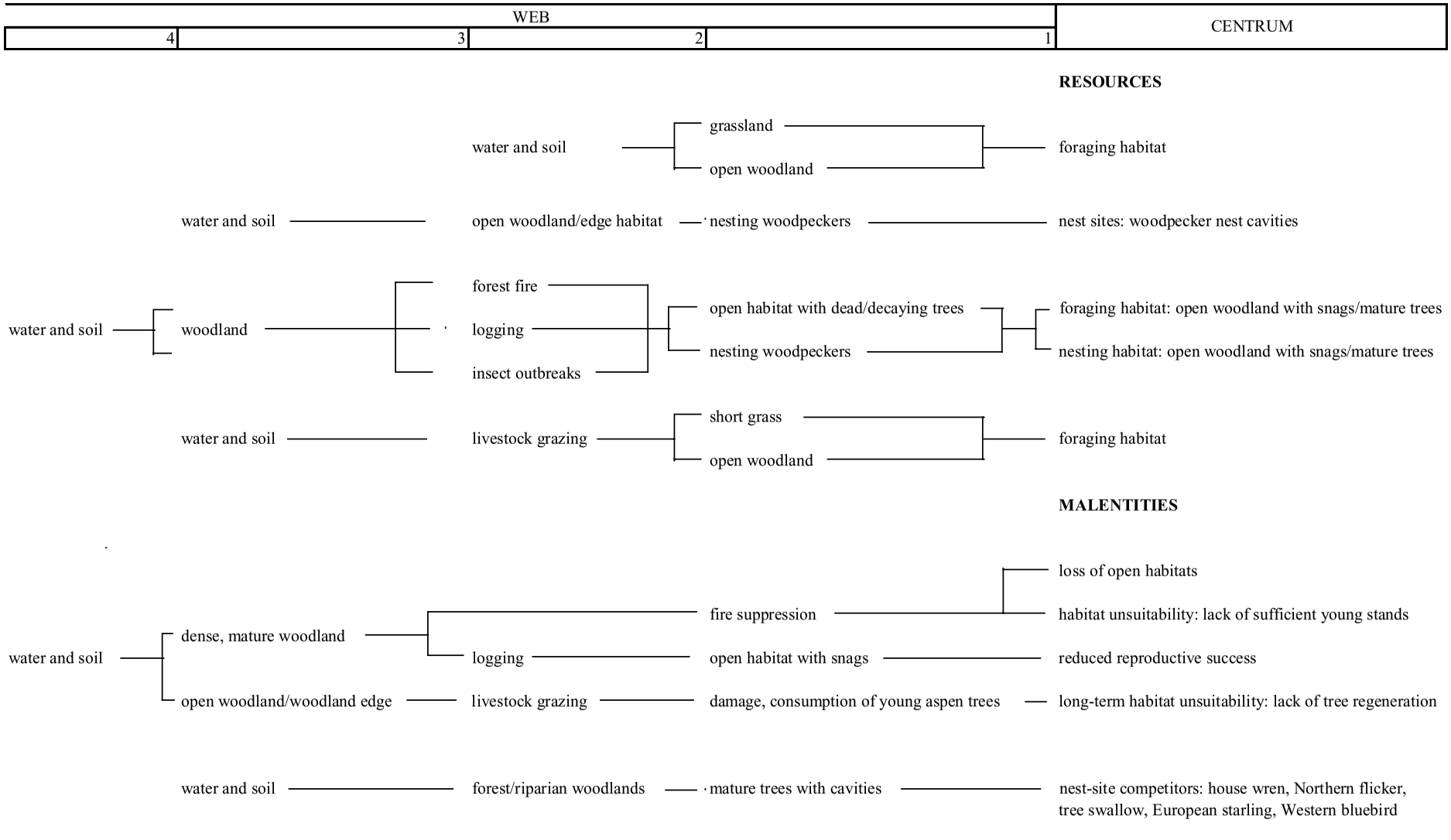

Figure 8. Envirogram representing the web of linkages between mountain bluebirds and the ecosystem in which they occur.

and house sparrow (*Passer domesticus*). As with most other aspects of the mountain bluebird's biology, most of the interspecific interactions noted above have come from studies of bluebirds utilizing nest boxes (see Power and Lombardo 1996). The extent to which such predation and competition occur at natural cavity nest sites is less well-known, but it is an important consideration given that bluebird boxes are often erected at sites (e.g., along fencerows) that are not natural nesting environments (see discussion in Power and Lombardo 1996).

Mountain bluebirds are very rarely hosts to the brood-parasitic brown-headed cowbird (*Molothrus ater*); only four instances of parasitization have been documented (Power and Lombardo 1996). Given the large number of mountain bluebird nests monitored across the species' range, the rarity of parasitization events suggests that cowbirds are not a threat to mountain bluebird viability.

Blowflies (*Protocalliphora sialis*), whose larvae feed on the blood of nestlings, are relatively common in mountain bluebird nests (Sabrosky et al. 1989). Although there are no studies of the effects of blowflies on mountain bluebird nestlings, Roby et al. (1992) found no significant effects of blowflies on the survival of nestling eastern bluebirds. Rounds and Munro (1983) correlated poor reproductive success of mountain bluebirds with high numbers of black flies (*Simulium* spp.), which are assumed to feed on nestlings.

CONSERVATION

Threats

Given the widespread occurrence and general abundance of the mountain bluebird in western landscapes, there has been surprisingly little study of its ecology. Under natural conditions (i.e., in areas where nest boxes are not available), mountain bluebirds are secondary cavity nesters, and their local abundance varies directly with nest-site availability. Studies throughout the western United States and Canada suggest that in areas of suitable habitat, the availability of old woodpecker cavities is the key to the local abundance of mountain bluebirds (Erskine and McLaren 1976, Dobkin et al 1995, Campbell et al. 1997). Recent breeding bird atlas work in Colorado found a large number of mountain bluebird nests in old woodpecker holes (Barrett 1998). Suitable foraging habitat is also a critical factor determining mountain bluebird abundance. Mountain bluebirds forage in open grasslands, sagebrush pastures, and clearings in woodlands. Thus, optimal breeding habitat for this species is open woodland and areas where open habitats are fringed with trees, including open areas created by woodland fires. The most important threats to mountain bluebird population viability appear to be 1) the loss of breeding habitat and 2) a lack of suitable nest sites.

Fire suppression

There is considerable evidence that fire suppression policy has led to a decrease in the *extent* and severity of forest fires in the United States. **Figure 9** summarizes the total number of reported fires as well as the number of acres burned from 1919 to 1999. Especially notable is the large decrease in the extent of fires, and thus the loss of burned woodland that would represent potential breeding habitat for mountain bluebirds in western North America. Recent data from the USFS show no significant change in the number of acres burned on National Forest System lands in Region 2 over the past 35 years (**Figure 10**). However, analysis of tree ring data over several centuries shows a strong cessation of large-scale fire activity, at least within federally protected sites within the Black Hills (e.g., Jewel Cave National Monument and Wind Cave National Park; Brown and Sieg 1996, 1999). Brown and Sieg (1996, 1999) demonstrated that for the period between 1388 and 1900, the mean Black Hills fire interval was 16 years. From the time the area was settled by non-natives, however, there were few recorded large-scale fires until the Jasper fire (83,000 acres) in 2000. This fire-free period is longer than any fire-free period recorded prior to non-native settlement. A similar pattern of fire cessation following non-native settlement has been noted in a number of previous studies from throughout the western United States (Fisher et al. 1987, Baisan and Swetnam 1990, Savage 1991, Swetnam 1993, Brown and Swetnam 1994, Brown et al. 1999).

Since forest fires produce open habitats and dead/damaged trees, they are generally beneficial to mountain bluebirds. Recent fire suppression policies have probably led to local declines of this species. Habitat loss due to fire suppression may be offset somewhat by logging practices in western forests with active timber production programs. Hejl et al. (1995) found that, among over 50 species of forest-dwelling birds, mountain bluebirds exhibited the strongest positive response (i.e., increase in abundance) to various silvicultural treatments including clearcuts and partial-cuts. While these results do not argue for an increase in the frequency of logging, they may help to explain why mountain bluebirds have not decreased over large

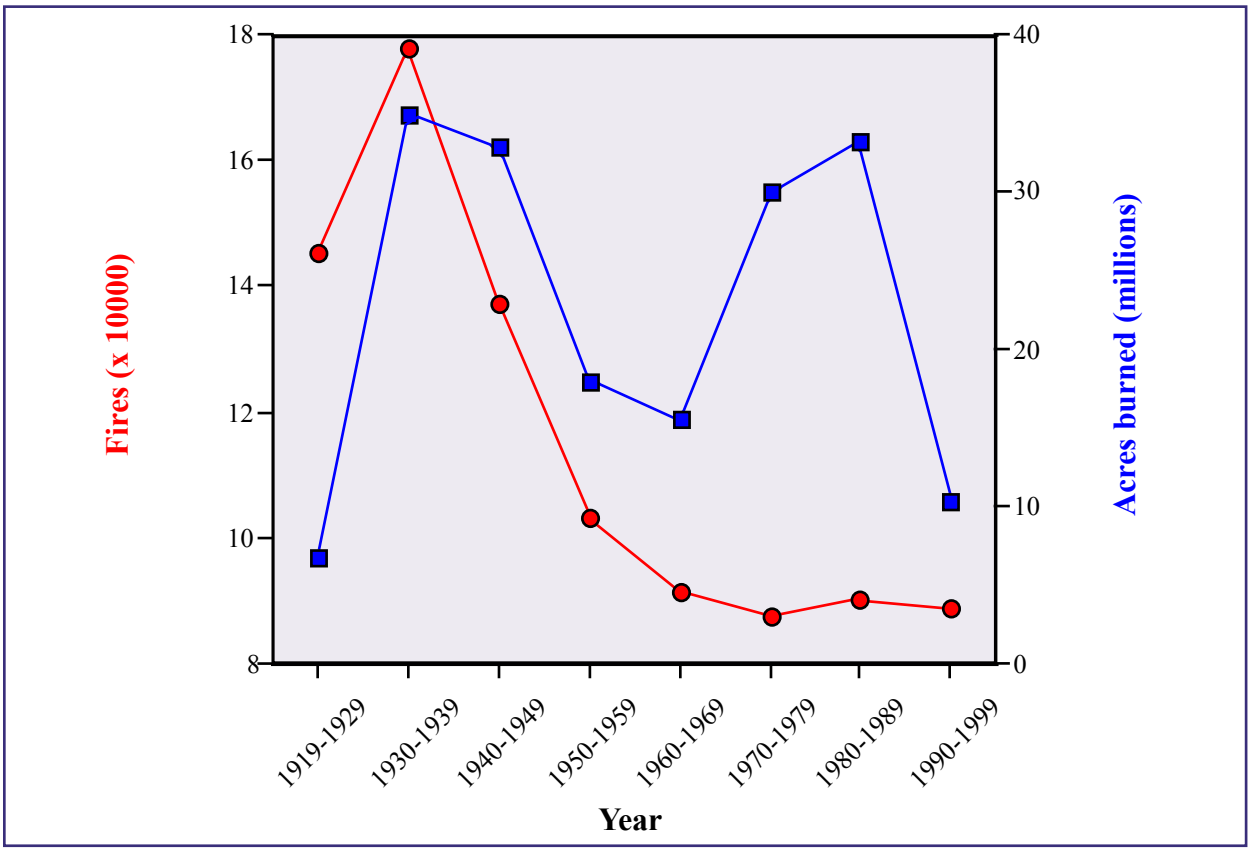

Figure 9. Changes in the total number of forest fires (left Y-axis, open squares) and total acres burned (right Y-axis, closed circles) by decade. Data are for the continental United States and Alaska and were derived from the National Interagency Fire Center (http://www.nifc.gov/stats/wildlandfirestats.html).

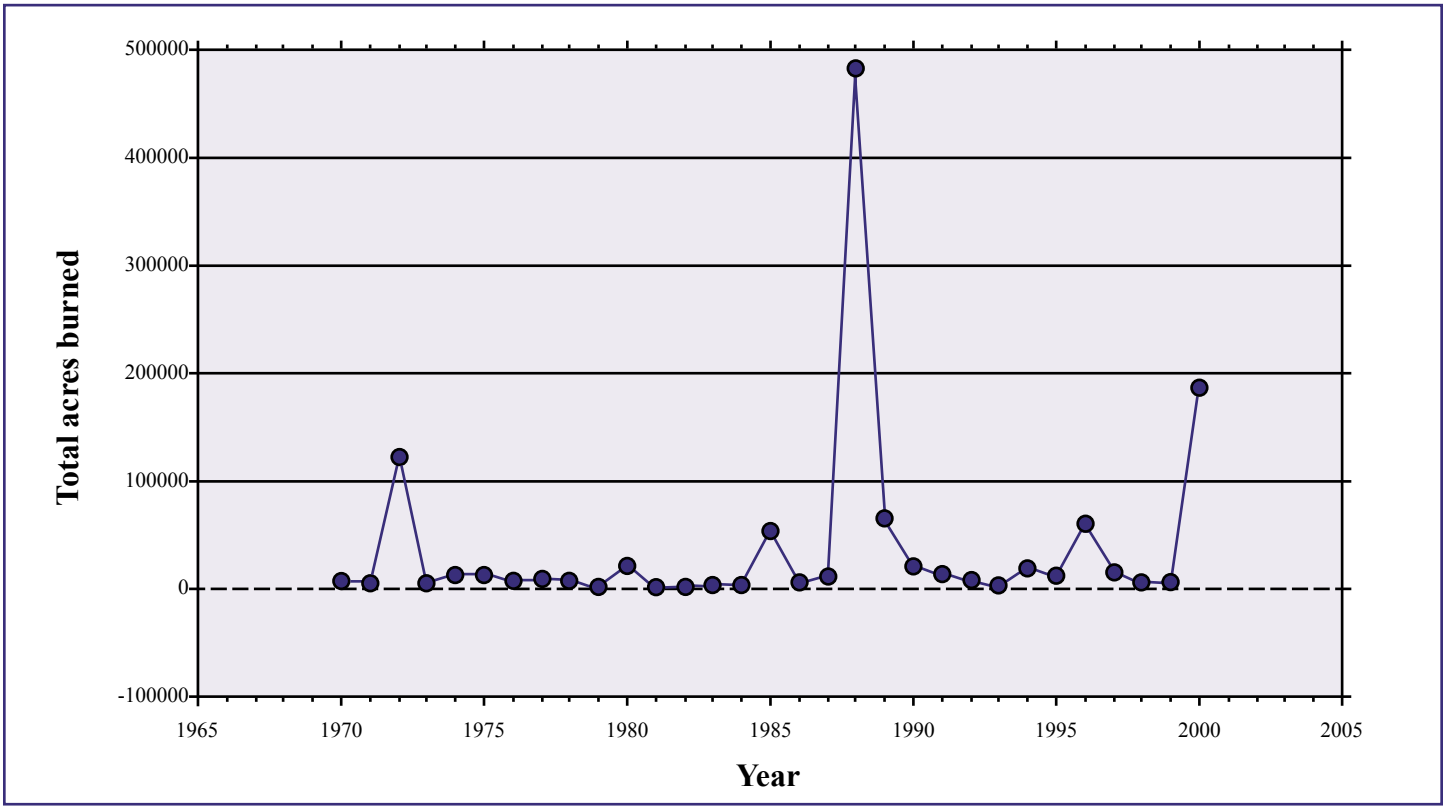

Figure 10. The total number of acres burned during wildfires within USDA Forest Service Region 2 from 1970 to 2000. There was no significant change in acres burned during the period (r_s = 0.17, P = 0.35, n = 31). Data were provided by the USDA Forest Service, Lakewood, Colorado.

areas of the West where strict fire suppression policy has generally been the rule.

Grazing effects

Livestock grazing may have both positive and negative effects on mountain bluebirds. Grazing may keep woodlands open and grasses short, both of which improve foraging conditions for mountain bluebirds (Page et al. 1978, Power 1980a, Schulz and Leininger 1991). However, heavy livestock grazing inhibits the regeneration of woodlands (Bock et al. 1993, Fleischner 1994, Saab et al. 1995). This may lead to a lack of suitable nest trees over time since primary cavity nesters, which create nest sites eventually used by mountain bluebirds, prefer mature trees for nesting. In Region 2 and much of the western United States, aspen is commonly found at the transition from open to wooded habitats, as well as in recently disturbed (e.g., fire, clearcut) habitats. Dobkin et al. (1995) found that riparian aspen represented an important breeding habitat for mountain bluebirds in the Great Basin, and that such habitats were threatened by a lack of regeneration, largely due to overgrazing by livestock. Similar concerns have been expressed in Colorado (Gillihan and Levad 2002), where mountain bluebirds commonly nest in open aspen forest and where aspen appears to be declining as a result of poor regeneration (due to fire suppression and livestock overgrazing; see Romme et al. 1992). Thus, there is conflicting evidence concerning the effects of livestock grazing on mountain bluebird habitat; grazing maintains short, open habitats that are preferred foraging areas, but it may also seriously reduce the recruitment of aspen and other edge tree species.

Interspecific competition for nest sites

Several authors have noted intensive competition for cavity nest sites in western forests (Brawn and Balda 1988, Dobkin et al. 1995). Such competition often involves secondary cavity nesters (e.g., mountain bluebirds, tree swallows, violet-green swallows, and house wrens). Finch (1990) and Dobkin et al. (1995) suggested that in riparian aspen woodlands, house wrens may exert a negative influence on nearby cavity nesters by filling cavities with sticks and/or by destroying eggs.

Competition with introduced European starlings may present a more serious threat to mountain bluebirds. Erskine and McLaren (1976) suggested that the arrival of European starlings in central British Columbia was followed shortly thereafter by a decline in the abundance of mountain bluebirds. Their data suggest that starlings and bluebirds competed for the same nest sites, old flicker holes in aspen trees along forest edges. Although his data set was small, Weitzl (1988) documented the complete displacement of nesting native bird species (including mountain bluebirds) from a small woodlot in Nevada following the establishment of breeding European starlings. Following the removal of starlings from the site, native species (including two pairs of mountain bluebirds) immediately resumed breeding there. Clearly, European starlings represent a serious threat to cavity-nesting birds, but the extent to which this is a problem away from cities and human habitations is unclear.

Pesticides

The prevalence of insects in the diet of mountain bluebirds makes the species susceptible to the effects of insecticides like DDT. Lane and Bauman (1970) reported direct mortality of nestling mountain bluebirds in Manitoba as a result of pesticide applications. Aerial application of DDT in the nesting areas of mountain bluebirds in Oregon had no apparent effects on mountain bluebird reproductive success (Thomas and McCluskey 1974, McCluskey et al. 1977), but it did result in high levels of DDT residues in eggs one year after spraying (Henny et al. 1977). In Region 2, Den (1985) analyzed a total of 15 mountain bluebird eggs for organochlorine residues and found DDE in small amounts (0.06 ppm). This low level of residue suggests little exposure to DDT residues on the breeding and wintering grounds. Den (1985) also reported an unpublished study showing DDE residues of 0.18 ppm in the body tissues of adult mountain bluebirds in the Black Hills. Such levels are minimal compared to the 7.83 ppm reported for mountain bluebirds in northeastern Oregon, three years after a local application of DDT (L.R. DeWeese, cited in Den 1985). Thus, while the limited data available from two areas within Region 2 suggest that pesticides may not currently pose a serious threat to mountain bluebirds, given the potentially severe effects of organochlorine contamination, further studies are needed.

Conservation Status of the Mountain Bluebird in Region 2

Within Region 2, mountain bluebirds appear to have declined in abundance as a breeding species in the Black Hills and possibly in Colorado and Wyoming. The declines in Colorado and Wyoming have been approximately 2 percent per year, but in neither case are they statistically significant (**Table 1**). In the Black Hills, mountain bluebirds were considered common in

the late 1800's but are now uncommon breeders. Thus, although the species remains relatively common in most areas of Region 2, there is reason for concern over the status of some local populations.

While there has been no research directed at the potential causes of local declines in mountain bluebirds, studies from outside Region 2 suggest that a lack of forest disturbance (e.g., fires) is the major factor affecting local abundance. Long-term data show a decrease in the frequency and extent of forest fires, but recent (2000 onwards) drought conditions and relatively widespread fire activity on National Forest Service land probably have acted to increase breeding habitat for mountain bluebirds. Since 2000, several large wildfires have burned significant areas of the San Juan, Pike, and Black Hills national forests. In addition, outbreaks of various bark and wood-boring beetles (e.g., *Ips* spp., *Dendroctonus* spp., Cerambycid and Bupresitid beetles) may also benefit mountain bluebirds by creating snags and openings in forested areas. However, it is unclear how the recent large-scale outbreak of the pinyon engraver beetle (*I. confuses*) may affect mountain bluebirds. Pinyon-juniper woodland represents an important breeding habitat for mountain bluebirds in southern and western Colorado, and the widespread death of pinyon trees in southern Colorado may have long-term negative impacts on nest-site availability.

Management of the Mountain Bluebird in Region 2

Implications and potential conservation elements

The primary consideration for the conservation of mountain bluebirds in Region 2 is a restoration of natural forest disturbance patterns, particularly with respect to forest fire. The mountain bluebird is one of several species (including olive-sided flycatcher [*Contopus cooperi*], black-backed woodpecker [*Picoides arcticus*] and American three-toed woodpecker [*P. tridactylus*]) that typically increases in density in forested areas affected by fire. Given that fire creates both open habitats and suitable nesting trees (i.e., snags), the effects of fire may provide relatively long-lasting habitat benefits for mountain bluebirds (Taylor 1973, Hutto et al. 1993).

There is an increasing body of evidence that widespread, strict fire suppression policy has greatly altered ecosystem structure in the western United States (Gruell 1985, Saab and Dudley 1998, Kotliar et al 2002). The frequency and extent of forest fires on federal land decreased greatly during the 20th century (**Figure 9**). As fires act to regenerate woodlands and grasslands, the suppression of fire has almost certainly led to more homogenous forest stands and increased forest coverage. Aspen has likely undergone particularly strong declines relative to its abundance in pre-settlement times, as this species typically colonizes newly opened habitat such as recent burns (Romme et al. 2002). In many Region 2 forests, particularly the Shoshone, Bighorn, and Black Hills national forests, aspen coverage is low relative to presumed historical levels (**Table 4**; Romme et al. 1992). Although the extent to which this is the case on non-federal lands is unknown, it is likely that similar fire suppression attitudes have prevailed there as well. In Region 2, there is concern over a lack of regeneration of aspen stands on federal (Romme et al. 1992) and private (Gillihan and Levad 2002) lands. As aspen represents one of the primary nest-site habitats for mountain bluebirds (Barrett 1998), the loss of mature aspen coverage will have negative consequences for mountain bluebirds.

While it is difficult to firmly link fire suppression policy to declines in mountain bluebird abundance, the available evidence suggests that the two are correlated. The best data available in Region 2 are from the Black Hills, where there has been a strong decrease in the frequency and coverage of forest fires (Brown and Sieg 1996, 1999) and an apparent long-term decrease in the abundance of mountain bluebirds (**Table 1**). In addition, recent point-count data (2002-2004) from the Black Hills show that breeding mountain bluebirds are most commonly found near burns (Panjabi 2001, 2003, 2004). In northern New Mexico, just south of the southern limit of Region 2, mountain bluebirds showed significant increases after fires in a ponderosa pine forest (Johnson and Wauer 1996). Thus, at both local and landscape scales, land management strategies that incorporate a relaxation of strict fire suppression policy (i.e., allowing some fires to burn and/or using prescribed burning techniques) may help to maintain suitable habitat for mountain bluebirds.

Another form of habitat creation for mountain bluebirds is logging. As with forest fires, open habitat is created in wooded areas following logging, and mountain bluebirds have shown pronounced increases in abundance in logged areas (Hutto et al. 1993, Hejl et al. 1995). In the northern Rocky Mountains (Idaho and Montana), mountain bluebirds increased significantly in forests following logging (Hejl et al. 1995). Hutto et al. (1993) showed that the positive response of mountain bluebirds to logging was most pronounced in the first 10 years after logging, but that abundance was also relatively high even 10 to 20 years after logging activity.

Table 4. The extent of aspen cover within USDA Forest Service Region 2 forests, as well as the number of acres of aspen logged in 1999 and 2000.

			Acres logged	
National Forest (State)	**Acres of aspen**	**% aspen cover**	**1999**	**2000**
Bighorn (WY)	10,289	<1%	0	0
Black Hills (WY, SD)	48,683	3%	210	24
Shoshone (WY)	5,977	<1%	0	0
Grand Mesa (CO)	690,058	22%	25	130
Medicine Bow (WY)	83,168	6%	19	0
Routt (CO, WY)	279,422	21%	61	89
Rio Grande (CO)	277,881	14%	18	49
Arapaho/Roosevelt (CO)	51,215	3%	0	0
Pike/San Isabel (CO)	180,796	7%	0	0
San Juan (CO)	307,144	15%	103	449
White River (CO)	422,957	17%	424	7

The same study differentiated between clear-cuts and partial-cuts and showed that mountain bluebirds responded positively to both, but more strongly to clear-cuts. Logging of aspen, however, may negatively affect local mountain bluebird abundance since aspen is one of the most preferred nest tree species in Region 2. The available data suggest that, at least on Region 2 federal land, logging of aspen has decreased significantly in recent years to levels that do not appear to pose a threat to aspen-dependent species (**Figure 11**).

It is important to consider that while the vast majority of studies on the effects of logging and fire on mountain bluebirds (and other species) typically show increases in bluebird abundance, these results must be viewed with caution. Variance in abundance per se across habitats does not necessarily correlate positively with improved population viability. The notion of ecological "sink" habitats must always be considered (Pulliam 1988, Pulliam and Danielson 1991). As an example, in British Columbia, mountain bluebirds nesting in natural cavities in a clear-cut area suffered high (45 percent) losses due to nest depredation (R.F. Holt, cited in Campbell et al. 1997). Although there were no comparative data from bluebirds nesting in natural cavities outside the clear-cut area, Holt's results suggest that, at least under certain conditions, clear-cut areas may not provide optimal nesting conditions for mountain bluebirds. The extent to which logged forests constitute suitable breeding habitat for mountain bluebirds clearly is a research priority for the species in Region 2 (see Information Needs section).

In most areas of Region 2, livestock grazing is a common feature on public and private land. As mentioned in the Threats section, grazing may have short-term, positive effects (i.e., creating suitable foraging habitat) but long-term, negative effects (i.e., reducing regeneration of mature trees) on mountain bluebird habitat. Thus, although the majority of studies cite mountain bluebirds as one of the primary beneficiaries of livestock grazing (e.g., see **Table 2** in Bock et al. 1993), those studies may be over-emphasizing the short-term, positive effects and ignoring the long-term, negative effects. A grazing scheme that allows livestock in open areas, but seasonally excludes them from wooded fringes (e.g., where saplings grow), may be the optimal strategy for maintaining breeding habitat for mountain bluebirds.

Tools and practices

Habitat management

The fact that mountain bluebirds adapt readily to nesting in nest boxes suggests that a lack of nest sites may be limiting population density in some areas. Power (1966) suggested that a lack of suitable nest sites has been the principal cause of local declines of mountain bluebirds, but he provided no clarification of where or to what extent declines had occurred. Management activities that improve nest-site availability may be the most effective form of habitat management for mountain bluebirds. Although there are no published habitat management plans focusing on mountain bluebirds, at least two studies (Dobkin et al. 1995, Saab et al. 1995) have suggested habitat management strategies that will improve breeding habitat conditions for mountain bluebirds: 1) creating new habitat by relaxing strict fire suppression policies and 2) improving the regeneration of aspen forest by reducing overgrazing by livestock.

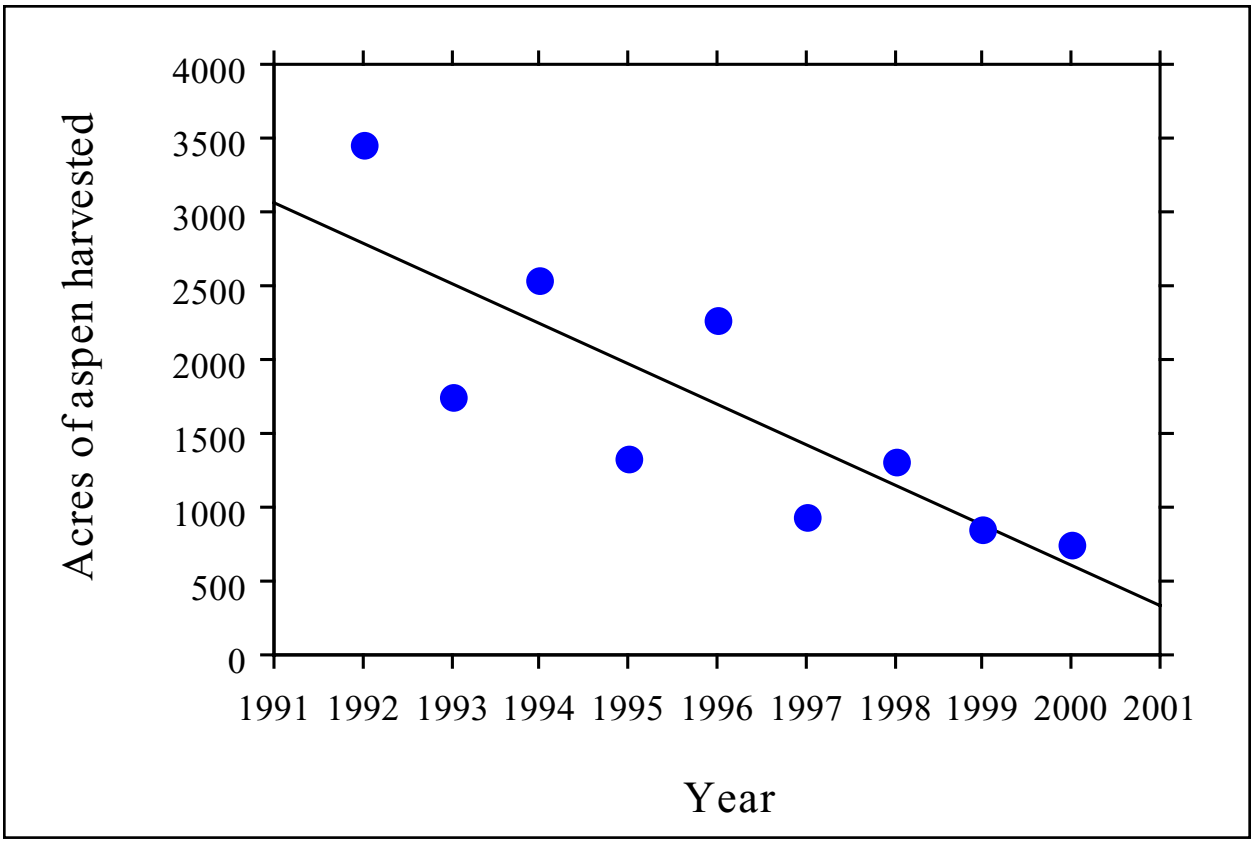

Figure 11. The number of acres of aspen harvested on USDA Forest Service Region 2 forests from 1992 to 2000. The negative trend is statistically significant (R_s = - 0.90, P = 0.011, n= 9).

Allowing some natural fires to burn, as well as using prescribed burns along woodland/grassland edges, may help to improve conditions by creating new, open habitat and by increasing the establishment and recruitment of aspen in edge habitats. In areas affected by fire or logging, retaining old snags (≤ 15 inches dbh) that still have their bark will provide the optimal conditions for mountain bluebird nest sites (Scott 1978, Pinkowski 1979).

Livestock grazing appears to benefit mountain bluebirds by creating optimal foraging habitat, but it may also cause long-term problems by suppressing the regeneration of aspen woodlands. Consequently, restricting livestock grazing to open areas, away from edge habitats, may eliminate the negative effects of grazing on bluebird habitat.

In Colorado, limiting the collection of firewood within pinyon-juniper woodlands may help to increase the availability of nesting sites, as older trees and snags (that harbor the most suitable nesting sites) typically are chosen by firewood collectors.

At the landscape scale, then, a habitat management plan that would benefit mountain bluebirds would ideally include:

- ❖ relaxing fire suppression policies to restore more natural forest disturbance patterns
- ❖ restricting livestock grazing in edge habitats to improve regeneration of aspen and other suitable nesting trees
- ❖ reducing the elimination and degradation of pinyon-juniper woodlands that are an important breeding and wintering habitats in southern portions of the species' range in Region 2.

In step with any of these measures, attempts should be made to assess the reproductive success of mountain bluebirds in managed habitats. As mentioned earlier, simple increases in the density of breeding birds are not always linked to improved population viability. Data on reproductive success of mountain bluebirds in

burns, on logged sites, and in more undisturbed areas would help to clarify the potential effectiveness of habitat management techniques (see the Information Needs section).

Given that mountain bluebirds are secondary cavity nesters and thus depend on healthy local populations of woodpeckers, land management strategies that benefit woodpeckers will have positive benefits (i.e., more potential nest cavities) for mountain bluebirds. Consequently, such measures should be seen as necessary components of any effort to conserve mountain bluebirds. At the landscape level, strategies that aid local woodpecker populations might include the following:

- ❖ increasing the abundance of old-growth aspen forest
- ❖ relaxing forest fire suppression policies
- ❖ decreasing harvest levels of old-growth trees along forest edges
- ❖ reducing salvage logging in burns, insect-infested forests, and blowdowns
- ❖ retaining snags and large, mature trees in heavily logged areas

Inventory and monitoring

Because the mountain bluebird has not been widely considered a species of conservation concern, there has been little interest in developing inventory and monitoring techniques for the species. The exception to this are local volunteer efforts along bluebird trails, where volunteers maintain and monitor nest boxes for bluebirds (e.g., www.mountainbluebirdtrails.com).

Although they are most common in pinyon-juniper and relatively open aspen forest in Region 2, mountain bluebirds will also nest in a wide variety of other open, wooded habitats including ponderosa pine, recent burns, and alpine areas (Barrett 1998, Panjabi 2004). It is likely that habitat affinities of mountain bluebirds will vary across Region 2 forests, with strong affinities for pinyon-juniper in southwestern Colorado, aspen in central Colorado and Wyoming, and ponderosa pine in northeastern Wyoming and South Dakota (see Habitat section). Consequently, a good starting point for inventory efforts at the landscape level would be to perform presence/absence surveys along transects in a variety of habitats.

A survey protocol for mountain bluebirds has not been published, but given that they utilize exposed perches in open habitats, mountain bluebirds could be adequately surveyed with the following techniques:

- ❖ select transects along roadsides or along forest edge/riparian habitats
- ❖ adapt transect length to local conditions; for example, 1 km along edge habitats or 10 km along roadways
- ❖ establish stops every 100 to 200 m along transect routes
- ❖ conduct observation for 2 to 3 minute periods at each stop
- ❖ during the breeding season, take notes on food-carrying behavior or any other signs of local nesting

Bluebirds are generally active throughout the day during the breeding season (Herlugson 1978), so the results of inventory work are probably not dependent on the time of day.

During the winter, mountain bluebirds inhabit low-elevation, open country with scattered trees. In western and southern Colorado, this includes pinyon-juniper woodland, which is also breeding habitat. In eastern Colorado and western Kansas, wintering mountain bluebirds are typically found in open country with scattered clumps of juniper and eastern red cedar. In such areas they probably are relatively well-sampled during the annual Christmas Bird Count, but dedicated surveys in areas where natural fruits (e.g., juniper berries) are available would increase the sample sizes and statistical accuracy of long-term winter counts.

Assessing reproductive success is relatively simple in areas where mountain bluebirds use nest boxes. However, monitoring bluebirds that nest in tree cavities present a difficult problem since nests may be located high in snags. The behavior of parents (e.g., carrying food to the nest hole) late in the nesting stage can be used to assess whether nests were successful or not, but exact counts of fledged young are probably only feasible by using some form of optical fiber camera (e.g., www.peeperpeople.com). This technique may require substantially more time than is available in most research situations. If so, then monitoring the behavior of parents and fledglings around the presumed fledging date would provide a measure of whether or

not the nesting attempt was successful (i.e., produced fledged young).

Information Needs

Research on the ecology of mountain bluebirds has centered almost exclusively on birds breeding in nest boxes. As a result, we have very little information on the species' breeding ecology in natural cavities, and this is especially true for Region 2. Data from natural nest sites that would be particularly useful include the density of nesting pairs, timing of breeding, reproductive success, the frequency of second clutches, and interspecific competition for access to nest cavities. In addition, data on nest-site selection from within Region 2 would also help to provide a stronger basis for land management options for mountain bluebirds.

Another critical information need is to determine which species of primary cavity nesters provide the highest quality nest holes for mountain bluebirds. Although bluebirds often use abandoned northern flicker nest holes, the quality of such sites may not be as high as for smaller species such as hairy woodpeckers (*Picoides villosus*) or red-naped sapuckers (*Sphyrapicus nuchalis*). Power (personal communication 2005) has suggested that although they are often the most common nest hole in some areas, flicker holes are relatively large and therefore may allow higher predation rates as well as greater exposure to poor weather (e.g., rain, snow). Aside from the direct influence that nest-site quality likely has for mountain bluebirds, it is also important to determine the quality of northern flicker nests as flickers are undergoing a long-term, large-scale decline in abundance, including all Region 2 states except South Dakota (BBS website: www.mbr-pwrc.usgs.gov). If flicker nests are a critical resource for mountain bluebirds, then management activities for mountain bluebirds may have to be modified to include activities that also help northern flickers.

Another important information gap for Region 2 (as well as range-wide) is the relative reproductive success of mountain bluebirds breeding in different habitats. The factors responsible for variance in mountain bluebird reproductive success are poorly known. Formulating management plans for mountain bluebirds would be much easier if we knew how reproductive success was affected by factors such as habitat degradation and disturbance, and livestock grazing. Examining the breeding success (as well as the density of nesting pairs) in recent burns, in logged areas, and in undisturbed, open forests would help to clarify whether open areas created by disturbance are equivalent to undisturbed areas. There are scant data on the reproductive success of mountain bluebirds nesting in natural cavities, and it is important that breeding success data be collected at natural nest sites and not nest boxes, which can bias the results. Although there are clear difficulties in tracking reproductive success of bluebirds nesting in natural cavities, such data would be extremely useful to land managers seeking strategies to increase bluebird population viability.

There is very little information available on mountain bluebird dispersal or survival, both of which are key data points when assessing population viability. Capturing and banding adults and young in natural cavities would require a relatively large commitment of time and effort. Ideally, demographic data would be collected in areas where mountain bluebirds are relatively isolated (e.g., the northern unit of the Medicine Bow National Forest in Wyoming) as this may increase the likelihood of resighting or recapturing banded birds. Furthermore, for the purposes of collecting information on survival and dispersal, the use of nest boxes would greatly simplify data collection. Whether adults are captured in nest boxes or at natural nest sites, care should be taken to band the adults.

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