Research Article

Effect of Forest Fire Suppression on Buff-Breasted Flycatchers

COURTNEY J. CONWAY,[1] *United States Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, School of Natural Resources, 104 Biological Sciences East, University of Arizona, Tucson, AZ 85721, USA*

CHRIS KIRKPATRICK, *School of Natural Resources, 104 Biological Sciences East, University of Arizona, Tucson, AZ 85721, USA*

ABSTRACT Buff-breasted flycatchers (*Empidonax fulvifrons*) are rare in the United States due to a >90% reduction in breeding distribution. Previous authors have implicated fire suppression in montane woodlands as the underlying cause of population declines and range contraction. We examined the effect of fire suppression on population declines of buff-breasted flycatchers by comparing both presence and abundance of flycatchers in areas with and without evidence of recent fire in 9 mountain ranges in southern Arizona, USA. We also replicated previous survey efforts conducted in 1980–1983 and 1995–1996 to determine population trajectory. Twenty-two (63%) of 35 survey routes had negative trends, and the average slope of the declines was −0.105 (10.5% annual decline). The number of buff-breasted flycatchers detected at a survey point was positively associated with severity of recent fires, and flycatchers were particularly associated with areas that had evidence of high-severity surface fire. However, we failed to detect flycatchers in 5 canyons that recently burned, which suggests one or more of the following: 1) fire suppression is not the cause (or is not the main cause) of population decline and range contraction, 2) flycatchers do not colonize burned areas until >10 years postfire, 3) low- or medium-severity fires are insufficient to make fire-suppressed areas suitable for breeding flycatchers, or 4) local recruitment and immigration are insufficient to allow buff-breasted flycatchers to expand into recent fire-restored areas. Continued suppression of high-severity forest fires in the southwestern United States may eventually result in the extirpation of buff-breasted flycatchers. A landscape that includes a mosaic of recently burned and unburned forest patches appears to be most suitable for buff-breasted flycatchers. Prescribed burning is unlikely to help restore flycatcher populations unless burns are of high severity, conditions typically avoided during prescribed burns for safety reasons. (JOURNAL OF WILDLIFE MANAGEMENT 71(2):445–457; 2007)

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The distribution of buff-breasted flycatchers (*Empidonax fulvifrons*) in the United States once extended over 98,600 km^2 from the Mexico border north to Prescott and Whiteriver, Arizona, USA (Bent 1942, Phillips et al. 1964, Hubbard 1978) and the Zuni Mountains of west-central New Mexico, USA (Bailey 1928, Bowers and Dunning 1994; Fig. 1). Historical records in central Arizona and central New Mexico were not rare and evidence of breeding was repeatedly noted in appropriate habitat throughout the region (Bendire 1892, Bailey 1928, Bent 1942, Ligon 1961, Phillips et al. 1964). However, distribution and numbers of buff-breasted flycatchers declined between the late 1800s and 1970 (Phillips et al. 1964, Bowers and Dunning 1994, Martin and Morrison 1999). Indeed, Phillips et al. (1964:86) stated that buff-breasted flycatchers had "decreased markedly" in Arizona between 1920 and 1964, and buff-breasted flycatchers were formerly a Category 2 species under the Endangered Species Act (Federal Register 1994, 1996). Currently, buff-breasted flycatchers are very rare in the United States (Arizona Game and Fish Department 1995, Conway and Kirkpatrick 2001) and are known to breed only in several locations in extreme southeastern Arizona (primarily in the Huachuca and Chiricahua Mountains). The known United States breeding population consisted of 131 individuals in 1995–1996 (Martin 1997) and population status and trends in Mexico are not known. Range contraction and the small number of breeding pairs in the United States have caused concern among government agencies and conservation organizations (Arizona Game and Fish Department 1988, 1996; Hunter et al. 1993; Bowers and Dunning 1994; Latta et al. 1999). More precise estimates of current population trajectory and the extent of range contraction are needed to determine the relative priority that buff-breasted flycatchers warrant within regional and national conservation plans.

Low numbers and restricted breeding range of buff-breasted flycatchers has raised concerns regarding their risk of extirpation from the United States. Developing strategies to help restore buff-breasted flycatchers to their former breeding range in the United States requires a better understanding of the cause of past population declines and range contractions. Several authors have suggested that fire suppression in montane forests of the southwestern United States may have caused population declines by reducing the amount of suitable foraging habitat (Phillips et al. 1964; Arizona Game and Fish Department 1988, 1996; Bowers and Dunning 1994; Bowers et al. 1996; Martin and Morrison 1999). Coniferous forests in the southwestern United States were historically subjected to low-severity surface fires approximately every 2–12 years (Ganey et al. 1996, Swetnam and Baisan 1996, Covington et al. 1997). Indeed, forests in this region lead the nation in average number of lightning-ignited fires (Swetnam and Betancourt 1990). However, beginning in the early 1900s effective fire-suppression policies of federal land-management agencies greatly decreased the occurrence of fire in southwestern coniferous forests (Weaver 1951, Dieterich 1980, Allen 1989, Savage and Swetnam 1990, Swetnam 1990).

[1] *E-mail: cconway@ag.arizona.edu*

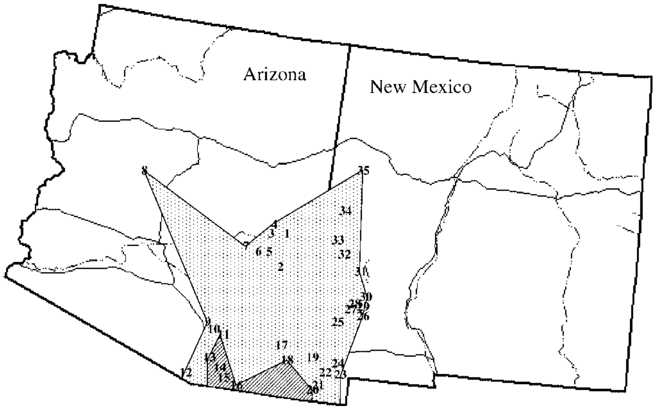

Figure 1. Historical (pre-1950; stippled area) and contemporary (2004; striped area) distribution of buff-breasted flycatchers in the United States. Numbers on the map refer to sources of historical records in Appendix B.

Elimination of periodic surface fires has allowed oak (*Quercus* spp.) saplings to colonize the understory in pine (*Pinus* spp.) forests (Covington and Moore 1994) and dense understory vegetation is thought to reduce foraging efficiency of buff-breasted flycatchers (Bowers and Dunning 1994, Martin 1997). However, the presumed negative effect of fire suppression on buff-breasted flycatchers is only conjecture. We examined whether evidence of recent fire and burn severity influenced the number of buff-breasted flycatchers detected during surveys within 9 mountain ranges in southern Arizona. We also estimated detection probability of survey efforts, estimated current population trajectory of buff-breasted flycatchers in the United States by replicating past survey efforts, and used a Geographic Information System (GIS) to estimate the proportional decrease that has occurred in the United States breeding range since the late 1800s.

STUDY AREA

We conducted field work in the 9 highest mountain ranges in southern Arizona: Chiricahua, Galiuro, Huachuca, Pinaleno, Rincon, Santa Catalina, Santa Rita, Santa Teresa, and Whetstone (Pinal, Pima, Santa Cruz, Graham, and Cochise Counties). These mountain ranges are often referred to as the Sky Islands because they are high-elevation (2,300–3,300 m) mountain ranges separated by broad, low-elevation (760–1,400 m) desert basins. The areas where we conducted surveys encompassed primarily pine–oak woodland but also ponderosa pine (*Pinus ponderosa*) and mixed-conifer forests between 1,585-m and 2,900-m elevation. Other common trees at this elevation included Apache pine (*P. englemannii*), Chihuahua pine (*P. leiophylla*), southwestern white pine (*P. strobiformis*), white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), Arizona sycamore (*Platanus wrightii*), alligator juniper (*Juniperus deppeana*), and several species of oak. Most of the areas were on public lands managed by the United States Forest Service and to a lesser extent by the United States National Park Service and United States Department of Defense. The climate ranged from arid to semi-arid. Average annual precipitation varied greatly among mountain ranges and even within mountain ranges, but most precipitation fell during 2 distinct periods: monsoon rains between July and September and mild winter rains between December and March (Sellers et al. 1985).

METHODS

Breeding Distribution

We estimated the total land area contained within both the historical and contemporary buff-breasted flycatcher breeding range by creating a polygon for each range delineated by records for buff-breasted flycatchers in the late 1800s–1950 (historical) and 2000–2004 (contemporary). We consulted historical ornithological reports for the region and more recent publications that included summaries of historical records (Henshaw 1875; Bailey 1928; Marshall 1956; Phillips et al. 1964; Phillips 1968; Hubbard 1978, 1987; Fischer 2001) and we solicited records of breeding flycatcher skins, skeletons, nests, and eggs located in 60 major ornithological museum collections in North America to identify historical breeding distribution in the United States. Estimating sizes of contemporary and historical breeding ranges based on records from the historical literature and museum collections is potentially biased because survey efforts were not standard or equal among time periods. Moreover, the precision of this approach includes some unknown level of error in the spatial extent of the historical breeding range due to the angular nature of the resulting polygon. However, this approach is the only one currently available for estimating the magnitude of range contraction in breeding distribution of a small-bodied bird over the past century. We used Arcview GIS software to calculate the total area within both the historical and contemporary ranges of the species in the United States. We estimated percent reduction in buff-breasted flycatcher breeding distribution as: $[1 - (\text{size of contemporary breeding range/size of historical breeding range})] \times 100$.

Within both the historical and contemporary breeding range, we also calculated the amount of potential buff-breasted flycatcher breeding habitat. To compare the amount of potential breeding habitat within each range, we calculated the area covered by the following 5 vegetative communities using Southwestern Regional Gap Analysis Project (ReGAP) vegetation data: Madrean Pine–Oak Forest and Woodland, Madrean Upper Montane Conifer–Oak Forest and Woodland, Rocky Mountain Montane Dry–Mesic Mixed Conifer Forest and Woodland, Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland, and Rocky Mountain Ponderosa Pine Woodland. The available data layers do not differentiate seral stages of each vegetative association (which may influence suitability for flycatchers), but this approach provided the best available way to account for the fact that not all of the land area within either the contemporary or historical range limits was occupied (or even suitable) flycatcher habitat. This approach assumes that the ReGAP veg data layers provide good estimates of the amount of suitable flycatcher habitat within both the contemporary and historical breeding

Table 1. Number of buff-breasted flycatchers (BBFL) detected in April–July 2000 and percent of 2,021 survey points that had no evidence of recent fire (burn severity index 0), evidence of low-severity surface fire (burn severity index 1), medium-severity surface fire (burn severity index 2), severe surface fire (burn severity index 3), and severe crown fire (burn severity index 4) within each of 9 mountain ranges in southeastern Arizona, USA. Numbers within a column can sum to >100% because some survey points had evidence of 2 different burn severities (one on either side of the survey route).

Burn severity index	Mountain range								
	Rincon $n = 225$	Huachuca $n = 472$	Chiricahua $n = 843$	Santa Catalina $n = 238$	Pinaleno $n = 104$	Santa Rita $n = 93$	Galiuro $n = 71$	Santa Teresa $n = 31$	Whetstone $n = 7$
0	29	78	84	74	85	97	99	100	100
1	25	7	12	13	14	1	7	3	0
2	41	12	10	9	9	0	0	0	0
3	30	13	5	7	2	2	0	0	0
4	3	4	1	2	0	0	0	0	0
No. of BBFL	2[a]	38	34	0	0	0[b]	0	0	0

[a] Five birds detected in 2004 and 2005 (Kirkpatrick et al. 2007).
[b] Three birds detected in 2004.

distribution (i.e., that the total area of any vegetative communities that are particularly suitable for flycatchers has not changed appreciably over the last century).

Population Trend

We conducted point-count surveys for buff-breasted flycatchers along 114 survey routes from 14 April through 11 July 2000 in pine–oak and mixed-conifer woodland above 1,585 m (4,800 ft) elevation in 9 mountain ranges (Table 1) in southeastern Arizona. We used 1,585 m as a cutoff because Martin (1997) used this cutoff and because flycatchers have never been reported nesting lower than 1,640 m (Bowers et al. 1996, Conway and Kirkpatrick 2001). We replicated 47 buff-breasted flycatcher survey routes that were originally surveyed in 1995–1996 (Martin 1997, Martin and Morrison 1999) to determine whether populations have increased, decreased, or remained stable. We also surveyed an additional 67 survey routes that were not included in the 1995–1996 surveys. We included 7 of these new routes because they were in areas with past reports of buff-breasted flycatchers, we selected 33 routes because the habitat appeared suitable for breeding flycatchers, and we selected 27 routes randomly. We used stratified random sampling (based on the no. of potential survey routes in each of the 9 mountain ranges) to select these 27 random survey routes from 53 possible survey routes located in areas that were >1,585 m elevation and included potential breeding habitat for buff-breasted flycatchers. In 2004, we replicated our 2000 survey effort and surveyed each route on which we detected flycatchers on approximately the same date (±5 d) that we surveyed the route in 2000. In 2004, we also surveyed a subset of 29 survey routes on which we detected no flycatchers in 2000.

We established routes by pacing 200 m between survey points along canyon bottoms, ridges, or dirt roadsides. We used a Garmin Emap handheld Global Positioning System receiver to record the location of each survey point. At each survey point, we passively listened for vocalizations for the first 3 minutes, and then we broadcasted buff-breasted flycatchers vocalizations (*pit* and *chee-lick-chou*) for 3 minutes. The 3-minute call-broadcast segment consisted of 30 seconds of calls followed by 30 seconds of silence, with this sequence repeated 3 times. Each 30-second calling period consisted of the 2 primary songs (7 repetitions of *chee-lick-chou* and 3 repetitions of *chee-lick*; Bowers and Dunning 1994) and 9 repetitions of the most common call (*pit*) of buff-breasted flycatchers. We broadcasted buff-breasted flycatcher songs and calls at 90 decibels (measured at 1 m from broadcast source) using a tape cassette player (Optimus Model SCP-88, Fort Worth, TX) and an amplified speaker (Radio Shack Cat. No. 32-2040, Fort Worth, TX). We scanned the surrounding area in a 360° arc around the survey point looking and listening for flycatchers during the 6-minute survey period. We recorded whether or not we detected any flycatchers visually or aurally during each 1-minute segment of the survey. We recorded whether each flycatcher detected was a bird already recorded at a previous survey point (i.e., a repeat), a possible repeat, or a new bird. We classified a bird as a possible repeat if the surveyor detected the bird flying toward the survey point from the direction of the previous survey point and ≥1 flycatchers had already been detected at the previous point. We conducted all surveys between sunrise and 4–5 hours after sunrise.

Detection Probability

Using survey counts to monitor trends in actual population size is potentially biased because not all birds in the population are counted, and the proportion of birds responding may differ temporally and spatially (Burnham 1981, Skalski and Robson 1992, Link and Nichols 1994). One way to avoid this bias is to estimate the probability of detection during each survey. Few survey efforts measure detection probability, but estimates of detection probability are essential for estimating actual population size and estimating population trends from survey data (especially when survey methods or observers vary over time). We wanted to estimate the proportion of the birds present in an area that we were likely to detect using our survey methods with the hope that doing so would facilitate comparison with both past and future survey efforts. We estimated detection probability associated with our surveys using 3 approaches: focal-bird detection trials, nest detection trials, and double-sampling.

Focal-bird detection trials.—After we detected a flycatcher on one of our standardized surveys, 2 observers returned to the area where the bird was detected on a subsequent day. Buff-breasted flycatchers have small territories (Bowers and Dunning 1994) and relocating a territorial pair was relatively easy for observers. The 2 observers separated themselves by 50–100 m and walked through the area looking and listening for flycatchers. Once one of the observers located a flycatcher, the other observer initiated a detection trial. The observer who originally located the flycatcher became the follower and the other observer became the surveyor for the detection trial. The surveyor conducted a 6-minute survey (3-min passive period followed by 3 min of call-broadcast as described above) initially facing a random direction to reduce bias associated with presence of the follower. The follower watched the focal bird throughout the 6-minute detection trial and noted if and when the focal bird vocalized. The surveyor independently recorded whether he saw or heard the focal bird during each segment of the 6-minute detection trial. We conducted focal-bird detection trials between 0500 hours and 1900 hours, 13 April through 26 July 2000 and we recorded the ambient temperature (° C) at the start of each trial.

Detection trials directed at nests.—In an effort to estimate detection probability of flycatchers with active nests, we presented nests with the 6-minute survey protocol and recorded whether we detected flycatchers. We conducted each nest detection trial in 1 of 2 random directions from the nest (up- or down-drainage). We started each nest detection trial 200 m from the nest and conducted our 3-minute passive and 3-minute call-broadcast survey. We recorded whether or not we detected any flycatchers visually or aurally during each 1-minute segment of the nest detection trial. If we did not detect any flycatchers during the 6-minute trial, we moved 50 m closer to the nest and conducted another 6-minute nest detection trial. We continued moving closer to the nest in 50-m increments until we detected a flycatcher. This approach allowed us to determine the distance at which flycatchers with active nests typically respond to our call-broadcast survey protocol (or distance at which observers can detect a calling flycatcher). We checked the nest after the final 6-minute nest detection trial to verify that the nest was still active. We conducted nest detection trials between 0600 hours and 1330 hours, 16 May through 27 June 2000.

Double-sampling.—We revisited the areas where we detected flycatchers repeatedly throughout the summer to search for nests, monitor nests, and conduct focal-bird and nest detection trials. We located additional flycatchers during these repeat visits and we were able to better determine the true number of flycatchers in each of these areas. We estimated detection probability as (no. of flycatchers detected during standardized survey)/(total no. of flycatchers detected during repeated visits to these areas throughout the breeding season).

Effects of Fire Suppression

We took 2 approaches for examining the effects of fire suppression on buff-breasted flycatchers. One approach involved choosing paired canyons (one which had, and one which had not, been burned in the last 10 yr) in areas <6 km from known buff-breasted flycatcher breeding locations. We chose these paired canyons prior to the field season by examining maps of recent burns obtained from the United States Forest Service. For this paired analysis, we only included canyons that were not part of the 1995–1996 survey effort or had no birds in 1995–1996 because we were interested in examining whether flycatchers were colonizing previously unoccupied areas following fire. We surveyed paired canyons on the same morning using the survey methods described above; 2 observers alternated surveying a burn route and the paired control route.

As a second approach to examining the effects of fire suppression on buff-breasted flycatchers, we scanned roughly 100 m on either side of the transect during standardized surveys and used the following index of burn severity (Kirkpatrick et al. 2006) to quantify visual evidence of the effects of recent (median time since fire = 6 yr) fire at each survey point:

(0) no evidence of recent fire;
(1) evidence of low-severity surface fire (e.g., fire-charring roughly 0–0.3 m above ground on a few trees);
(2) evidence of moderate-severity surface fire (fire-charring roughly 0.3–1.5 m above ground on most trees; a few small oaks or pines killed in understory);
(3) evidence of severe surface fire (e.g., fire charring often >1.5 m above ground on trees; almost all understory oaks or pines killed [some oaks re-sprouting]; a few large trees killed [burned snags or fallen trunks]);
(4) evidence of severe crown fire (e.g., all above-ground vegetation killed with some re-growth from roots or seeds).

This visual assessment of burn severity (Kirkpatrick et al. 2006) is similar to the system used by the National Park Service (U.S. Department of Interior 2003) to estimate burn severity in forests immediately following fire. For instance, both systems measure height of charring on tree boles and the proportion of forest plants consumed by fire as indices of burn severity. For our index, we concentrated on height of charring and gross changes in forest structure resulting from fire because these visual assessments of burn severity persist after a fire has passed through a forest (E. Margolis, Tree Ring Laboratory, University of Arizona, personal communication).

Data Analysis

For the 35 routes surveyed during ≥ 2 of the 4 survey periods (1980–1983, 1995–1996, 2000, and 2004), we conducted a linear regression analysis with number of flycatchers detected versus year of survey to obtain an estimate of the rate of change in numbers of flycatchers for each route (i.e., slopes of the regression lines for each of the 35 survey routes). Using the 35 slope estimates, we conducted a one-sample t-test to evaluate whether the overall rate of population change differed from zero. This approach allowed us to estimate the mean annual rate of population change for buff-breasted flycatchers and to determine whether that change was significant across all known United States breeding locations. We used a *t*-test to examine whether ambient temperature differed between focal-bird detection trials on which the surveyor did and did not detect the focal bird. We used a contingency table analysis to evaluate whether survey points with evidence of each type of burn severity were more likely to have buff-breasted flycatchers compared to survey points lacking that evidence. To examine whether burn severity was associated with the number of buff-breasted flycatchers detected at a survey point, we used analysis of variance with the number of flycatchers detected on a point as the dependent variable and the burn severity index as the independent variable. The University of Arizona Institutional Animal Care and Use Committee (protocol no. 03-122) approved all work.

RESULTS

Breeding Distribution

Since the late 1800s, the total area within the buff-breasted flycatcher's breeding distribution in the United States has been reduced by 91% to only 8,500 km^2 (Fig. 1). We estimated the amount of potential buff-breasted flycatcher breeding habitat as 13,300 km^2 within the historical range and 119 km^2 within the contemporary range. Hence, the buff-breasted flycatcher's breeding distribution in the United States has been reduced by 99% after we restrict the analysis to appropriate breeding habitat within the historical and contemporary United States breeding ranges.

Population Trend

In 2000, we conducted surveys at 2,021 points and detected 55 buff-breasted flycatchers at 76 of our 2,021 points (we detected some individuals at >1 point). We detected an additional 17 flycatchers during nest-searching efforts and detection trials in our surveyed areas, plus 2 additional flycatchers in areas not included in our survey effort (total of 74 flycatchers detected; Appendix A). We detected flycatchers in 3 of the 9 mountain ranges in 2000 and 4 of the 9 mountain ranges in 2004 (Table 1). Assuming our survey effectively detected flycatchers within a 100-m radius of our survey point (see *Detection trials directed at nests*), we surveyed 6,350 ha [$\pi \times (100\ m)^2 \times 2,021$ points] of pine–oak, mixed-conifer, and riparian woodland.

The number of buff-breasted flycatchers breeding in the United States appears to have declined over the past 10–20 years ($t = -1.94$, df = 34, $P = 0.061$). The mean rate of change (average slope across the 35 survey routes) was –0.105, which suggests a 10.5% population decline per year. Twenty-two (63%) of the 35 survey routes had a negative trend. The number of flycatchers detected on the 47 routes surveyed in 1995–1996 was lower in 2000 (42 flycatchers) and 2004 (66 flycatchers) compared to 1995–1996 (86 flycatchers; Appendix A). However, the rate of change appears to differ between the 2 mountain ranges that support most of the remaining flycatchers. The number of flycatchers has declined in the Chiricahua Mountains ($t = -2.59$, df = 14, $P = 0.022$), remained relatively constant in the Huachuca Mountains ($t = -0.62$, df = 13, $P = 0.548$), and slightly increased in the Rincon Mountains ($t = 4.23$, df = 2, $P = 0.052$). Buff-breasted flycatchers are very patchily distributed within their remaining United States range (e.g., Carr, Sunnyside, and Sawmill Canyons in the Huachuca Mountains currently support 49% of the known breeding population in the United States) and the number of birds detected in these 3 canyons has varied greatly among years (Appendix A).

Detection Probability

Focal-bird detection trials.—We conducted 93 focal-bird detection trials. We conducted focal-bird detection trials on 54 different birds and the number of replicate trials varied among flycatchers ($\bar{x} = 1.7$, range = 1–5). Observer detection probability for the surveyor was 92.5% (focal bird detected on 86 of 93 trials). All 7 undetected focal birds vocalized during the trial (recorded by the follower), but the surveyor failed to record the vocalizations because the calls were not very loud. Ambient temperature was associated with detection probability; temperature on the 7 trials during which the surveyor failed to detect the focal bird (27.3 ± 1.5° C) was over 4° C higher ($t = 1.8$, df = 91, $P = 0.068$) than temperature on the 86 trials during which the surveyor detected the focal bird (23.1 ± 0.6° C).

Detection trials directed at nests.—We conducted nest detection trials at 8 active buff-breasted flycatcher nests. We did not detect flycatchers during any of our 8 trials at 200 m from the nest. We first detected a flycatcher at 150 m from the nest on 2 trials, at 100 m from the nest on 4 trials, and at 50 m from the nest on 2 trials. Hence, detection probability for birds at their nests was 0% at 200 m and 100% at 50 m (assuming that the surveyor would have detected flycatchers at 50 m at those nests for which he detected birds at greater distances).

Double-sampling.—We detected 55 flycatchers during standardized surveys and an additional 17 flycatchers during repeated visits to areas with breeding birds. Hence, detection probability associated with our 6-minute survey was 76%.

Effects of Fire Suppression

Thirty percent of our 2,021 survey points had visible signs of recent fire. Proportion of pine–oak woodland and mixed-conifer forest with visible signs of recent fire varied among the 9 mountain ranges and forests in many of the mountain ranges had few visible signs of recent fire (Table 1). Thirty-six percent of the 76 survey points at which we detected buff-breasted flycatchers had visible signs of fire. Buff-breasted flycatchers were particularly associated with severe surface fire (burn severity index 3); 24% of the 76 survey points at which we detected buff-breasted flycatchers were in areas with evidence of severe surface fire. However, evidence of severe surface fires was rare; only 9% of the 2,021 survey points were in areas with evidence of a high-severity surface fire ($\chi^2 = 19.9$, df = 1, $P < 0.001$). Our results were similar when we restricted our analysis to the 2 mountain ranges (Huachuca and Chiricahua Mountains) that had the most flycatchers.

The average number of buff-breasted flycatchers detected at a survey point was approximately 3 times higher in areas with evidence of high-severity burns (burn severity index 3

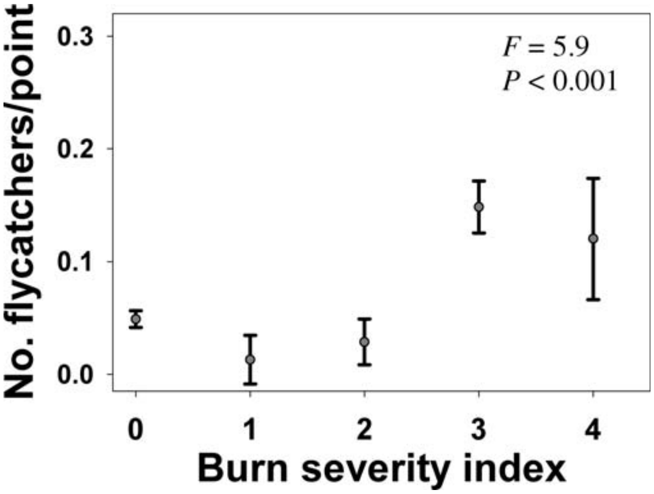

Figure 2. Mean (±1 SE) number of buff-breasted flycatchers detected in April–July 2000 at survey points within 9 mountain ranges in southern Arizona, USA, differed depending on the severity of recent fires (0 = no evidence of recent fire; 1 = low-severity surface fire; 2 = moderate-severity surface fire; 3 = severe surface fire; and 4 = severe crown fire; see text for more details on burn severity index).

and 4) compared to areas with evidence of less-severe burns (burn severity index 1 and 2) or no evidence of recent fire (burn severity index 0; $F = 5.9$, $P < 0.001$; Fig. 2). However, buff-breasted flycatchers were not common (and not even always present) in areas that had recently burned (median time since fire = 6 yr; Kirkpatrick et al. 2006); only 9% of areas with evidence of high-severity burns (burn severity index 3 and 4) had buff-breasted flycatchers (Fig. 2). The 3 mountain ranges in which we detected buff-breasted flycatchers in 2000 (Rincon, Huachuca, and Chiricahua) had the highest proportion of points with burn severity indices ≥ 2, whereas 5 of the 6 mountain ranges lacking buff-breasted flycatchers had few or no points with burn severity indices ≥ 2 (Table 1).

In our paired burned versus nonburned area comparisons, we failed to detect buff-breasted flycatchers in any of the recently burned canyons, but we did detect a pair of flycatchers on one of the nonburned survey routes. Canyons chosen as burned plots had evidence of recent fire and our burn severity indices suggested that these canyons had more evidence of low-severity fire (but not high-severity fire) than the nonburned canyons (nonburned canyons had, no doubt, burned in past fires, but had not burned recently).

DISCUSSION

Breeding Distribution

Our results suggest that the size of the breeding distribution of buff-breasted flycatchers in the United States has declined by >90% since the late 1800s. Our estimate is conservative because we included the Rincon Mountains in Arizona and the Peloncillo and Animas Mountains in New Mexico within the contemporary breeding distribution, despite the fact that breeding has not been confirmed in the Peloncillo or Animas Mountains (9 records, but nests or nesting activity has not been documented; Williams 1995) and only one pair has been detected in the Rincons (Kirkpatrick et al. 2007). Moreover, the breeding range of the buff-breasted flycatcher has declined significantly even if our approach substantially overestimates the historical range (although we do not believe this to be the case). The historical records available suggest that buff-breasted flycatchers were once regular if not fairly common in many mountainous areas throughout central and southern Arizona and New Mexico and their breeding range in the United States has undoubtedly been greatly reduced. Indeed, buff-breasted flycatchers have one of the most restricted breeding ranges of any bird that breeds in the United States (Bowers et al. 1996).

Coniferous forests in the southwestern United States represent the northern extent of buff-breasted flycatcher breeding distribution and areas on the periphery of any species' range are typically thought to go through repeated periods of extirpation and recolonization (Lawton 1993, Hoffmann and Blows 1994, Doherty et al. 2003). However, prior to the recent records in the Rincon Mountains (Kirkpatrick et al. 2007), we have no evidence to suggest that buff-breasted flycatchers have recolonized any of their former breeding range in the United States during the past 50 years (i.e., no confirmed AZ breeding records north of the Santa Rita Mountains since 1951) and we failed to detect flycatchers in 7 canyons in 2004 that were occupied in 1995–1996; Appendix A). We detected only 13 flycatchers in areas not previously surveyed by Bowers and Dunning (1994) or Martin (1997), and only 9 of our 67 new survey routes had flycatchers (only 1–2 flycatchers detected on each). The United States population is breeding primarily in 2 relatively small areas within the Huachuca and Chiricahua Mountains. Buff-breasted flycatchers are vulnerable to extirpation in the United States because low overall numbers of flycatchers are distributed primarily among only 2 isolated mountain ranges located <100 km from the United States border with Mexico.

Approximately 16% of the overall historical breeding range of the buff-breasted flycatcher was in the United States. If we assume that populations in Mexico have remained stable over the past 100 years, a 91% reduction in the United States breeding range represents a 15% reduction in the breeding range for the species as a whole. Although estimates of the extent of annual range contraction or expansion at the periphery of species' ranges due to stochastic events are not available, a 15% contraction at the northern end of a species' breeding range is higher than we would expect from annual stochasticity at a species' range boundary. We currently know little about the status of buff-breasted flycatcher populations in Mexico. Even if buff-breasted flycatcher populations in Mexico are stable, extirpation of this once-common species from the United States would represent the loss of a species indigenous to the mountain ranges of the southwestern United States and a considerable reduction in breeding distribution for the species as a whole.

Population Trend

We detected fewer flycatchers compared to the number detected on the 47 routes surveyed in 1995–1996 and average rate of decline was 10.5% per year across all 35 survey routes. Martin (1997) used only a 2-minute call-broadcast survey at each point and ceased the call broadcast at each point upon response by a flycatcher. We used 6-minute surveys (with 3 min of call-broadcast) at each point and continued the survey regardless of whether we detected a bird immediately. However, estimates of detection probability were similar among the 2 studies (see below) despite the difference in survey protocol.

In contrast, our survey results do not suggest a population decline if we only compare our numbers to those of Bowers (1983) based on the 10 canyons he surveyed in 1980–1983 (Appendix A). Interpretation of the change in number of buff-breasted flycatchers since 1980–1983 and 1995–1996 must take into account survey methods. Bowers visited some canyons every 2–14 days during the breeding season and attempted to individually mark all flycatchers, but search effort in other canyons was limited to a single visit (Bowers 1983). Our survey effort was similar to Martin's (1997) survey methods; we did not individually mark flycatchers, but we both sought to include only flycatchers that we did not count at previous survey points. Similar to Martin (1997), we were conservative in estimating numbers of individual flycatchers (see the methods section regarding whether we recorded a detection as a repeat or a new individual). However, the fact that surveys in 2004 failed to detect any buff-breasted flycatchers on 7 routes on which Martin (1997) detected birds and in 3 areas at which Bowers and Dunning (1994) detected birds suggests that we need annual surveys using a standardized survey methodology to obtain better information on population trajectory of this rare bird. In 2004, we re-surveyed only a subsample of routes at which zero flycatchers were detected in all previous years. Hence, we may have missed some flycatchers that had colonized previously unoccupied areas between 2000 and 2004.

Other anecdotal information suggests that numbers of buff-breasted flycatchers have declined within their contemporary breeding range. In May 1903, Swarth (1904) found 7 or 8 pairs breeding within a 50-ha area at the head of Garden Canyon (Huachuca Mountains). Yet, surveys over the past 20 years detected only 1–3 birds along the entire length of Garden Canyon (Appendix A). Willard (1923) visited the Huachuca Mountains repeatedly between 1897 and 1922 and reported seeing fewer flycatchers in 1922 compared to 1897–1910. Brandt (1951) reported seeing multiple flycatchers (and nests) in most of the canyons in the Huachucas throughout the 1940s, some of which have not had recent records (i.e., Huachuca Canyon, lower Carr Canyon, Ramsey Canyon) and recent surveys in other canyons have detected only 2 birds (upper Garden Canyon; Appendix A).

An annual population decline of 10.5% does not bode well for the future of buff-breasted flycatchers in the United States. For the 1,029 species of birds in the world considered to be threatened with extinction (Collar and Andrew 1988), only 7% have estimates of population change available (Green and Hirons 1991). Of the estimates of population change available for threatened birds, only 24% were rates of decline in excess of 10% per year and only 16% were rates of decline in excess of 15% per year (Green and Hirons 1991). If the number of buff-breasted flycatchers breeding in the United States continues to decline by 10.5% annually, the species would be extirpated from the United States within 45 years.

Detection Probability

Our estimate of detection probability was very high for focal-bird (92.5%) and nest (100%) detection trials, but our estimate from double-sampling was lower (76%). Martin and Morrison (1999) reported similar discrepancy between estimates based on detection trials of focal pairs (100% detection probability) and double-sampling (72.5% detection probability). The similarity in estimates of detection probability between the 2 survey efforts suggests that observed declines in numbers counted do not reflect differences in detection probability among survey efforts. Estimates of detection probability from focal-bird detection trials probably represent overestimates because observers are only able to conduct trials on birds that they are able to locate. Observers typically locate focal birds by hearing flycatcher vocalizations or detecting movement, activities that probably increased the probability that the bird would be detected once the trial began. We detected flycatchers during our 6-minute trials when we were within 100 m of an active nest, but we rarely detected flycatchers during trials when we were >150 m from an active nest. Hence, our estimate of 76% detection probability based on double-sampling is probably more reliable than our estimate based on focal-bird detection trials. Point-count surveys that include call-broadcast appear to effectively survey buff-breasted flycatchers with high detection probability within 100 m of the broadcast source, and researchers should use them on future survey efforts to maximize detection probability. Researchers should conduct surveys in the early morning when temperatures are cooler and detection probability higher.

Effects of Fire Suppression

Our correlative data support the hypothesis that buff-breasted flycatchers have declined in the United States due to fire suppression. Areas at which we detected buff-breasted flycatchers had more evidence of recent fire compared to areas at which we failed to detect flycatchers. Isolated mountain ranges with substantial evidence of recent fire still have breeding flycatchers, whereas mountain ranges with little or no evidence of recent fire have no breeding flycatchers. However, we failed to detect flycatchers in any of the recently burned canyons used in our paired burned versus nonburned comparison. All burned canyons were within 6 km of known buff-breasted flycatcher breeding territories and individuals have been documented moving distances >6 km (Dunning and Bowers 1984). If fire suppression is the cause of flycatcher declines and range contraction in the United States, we would have expected flycatchers to colonize at least some of these recently burned canyons.

The lack of flycatchers in these recently burned areas suggests one or more of the following, 1) fire suppression is not the cause (or not the main cause) of population decline and range contraction, 2) flycatchers do not colonize burned areas until >10 years postfire, 3) one incident of low- or medium-severity surface fire is insufficient to make fire-suppressed areas suitable for breeding flycatchers, or 4) local recruitment and immigration are insufficient to allow buff-breasted flycatchers to expand into recent fire-restored areas. We need to test these alternatives if we want to prevent extirpation of this species from the United States. For example, prescribed understory fires may only be helpful if 1) understory fires are of high severity and burn most or all of the understory (an outcome that is not common in most prescribed fires), or 2) areas receive moderate-severity understory fires repeatedly over long periods such that little understory vegetation remains. Alternatively, low reproductive success may be causing declines and perhaps even preventing populations from responding to changes in habitat quality. Hence, in addition to annual population surveys, we recommend demographic studies to determine whether constraints on local recruitment limit the ability of the current population to expand into newly restored habitat.

Perhaps a more direct way to evaluate the effects of fire suppression on buff-breasted flycatchers would be to burn areas (with high-severity surface fires) which, until recently, attracted higher numbers of breeding flycatchers (e.g., South Fork Cave Creek, Turkey Creek, Red Rock Canyon, and Bear Canyon in the Chiricahua Mountains; Rose Canyon Lake and Sycamore Canyon in the Santa Catalina Mountains; and Sunnyside Canyon in the Huachuca Mountains). We would expect flycatchers to re-occupy these canyons after burning if fire limits population growth. The buff-breasted flycatchers that we detected in the Rincon Mountains in 2000 and 2004 represent the first records for this range in 89 years (Kirkpatrick et al. 2007). The Rincon Mountains have limited accessibility (and hence little birding and survey effort), but the recent records of buff-breasted flycatchers in this range (which has been actively managed with repeated prescribed fire in recent years and has had higher-severity wildfires than surrounding ranges) suggest that repeated applications of moderate-severity prescribed fire may have the potential to increase habitat suitability and to restore buff-breasted flycatchers to portions of their former breeding range in the United States. Finally, the high-severity fires that occurred between 2002–2004 in the Santa Catalina Mountains and in other mountain ranges in the southwestern United States have created conditions that may benefit buff-breasted flycatchers, conditions that are typically not created with most prescribed fires.

MANAGEMENT IMPLICATIONS

Our results suggest that high-severity fire (or repeated application of moderate-severity fire) may create habitat conditions that are suitable for buff-breasted flycatchers, but that infrequent or low-severity fire may not restore populations to historical levels in the United States. Prescribed burning as a management tool is often limited to low- and moderate-severity fire in order to maintain control of the fire, prevent breach of fire lines, and prevent property loss. Hence, prescribed burning may only be useful for restoring habitat quality for buff-breasted flycatchers if moderate-severity burns are repeated over time such that most understory vegetation is removed. A landscape that includes a mosaic of recently burned and unburned forest patches appears to be most suitable for buff-breasted flycatchers. Severe natural fires may provide the best hope for improving habitat conditions for buff-breasted flycatchers in the United States in the near future. A let-burn policy in mountain ranges with few or no structures may be one option to attain optimal habitat conditions for buff-breasted flycatchers. Restoring the natural fire regime in these mountain ranges, either through a let-burn policy or active fire management (frequent moderate-severity surface burns and infrequent high-severity crown fires in some areas), appears to be necessary before buff-breasted flycatchers recolonize their former breeding range in the United States.

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Appendix A. Number of buff-breasted flycatchers detected on surveys in southeastern Arizona, USA, in 1980–1983, 1995–1996, 2000, and 2004. Number of birds detected in 1995–1996 and in 2000 are reported as number of adult birds detected on point-count surveys (with call-broadcast) and total number of adults based on surveys, incidental detections, and repeated visits to areas for nest searching and other activities.

		No. of buff-breasted flycatchers detected					
Survey route	**No. points**	**1980–1983[a]**	**1995–1996[b]**	**1995–1996[c]**	**2000[d]**	**2000[c]**	**2004[d]**
Huachuca Mountains							
Scotia Canyon	23	3.3	1	4	4	4	5
Sunnyside Canyon	15	1.3	4	12	1	1	8
Carr Canyon	28	6	13	17	4	9	23
Comfort Spring	1	2			0		
Sawmill Canyon	22	8	24	24	7	9	7
Rock Spring Canyon	12	2	0		1	2	3
Lower Garden Canyon	22	2			1	2	1
Garden Pond	5				2	2	0
Scheelite Canyon	21				1	1	3
Carr–Miller Ridge	19				2	2	1
Crest Trail	19				2	2	0
Miller Canyon	22				1	1	0
Old Sawmill Spring[e]						1	
Carr Peak Trail[e]						1	
Upper Sunnyside Canyon	16				1	1	0[f]
Blacktail Canyon	10		0		0		
Huachuca Canyon	17	0	0		0		
Upper Garden Canyon	16		0		0		2
Lyle Canyon	24		0		0		
Parker Canyon Lake	29		0		0		
Oversite Canyon	11		0		0		0
Ramsey Canyon	14		0		0		0
Upper Sawmill Canyon	6		0		0		
Collin's Canyon	19				0		
Eureka Canyon	19				0		
Lower Oversite Canyon	5				0		0
Lower Ramsey Canyon	21				0		0
North Huachuca Canyon	5				0		
Chiricahua Mountains							
Ward Canyon	12	4	1	6	3	5	0
Upper Rucker Canyon	25	[g]	6	8	2	2	2
Saulsbury Canyon	12	3[h]	3	4	2	2	0
South Fork Cave Creek	30	[g]	0		0		0

Appendix A. Continued.

Survey route	No. points	No. of buff-breasted flycatchers detected					
		1980–1983[a]	1995–1996[b]	1995–1996[c]	2000[d]	2000[c]	2004[d]
Middle Fork Cave Creek	22	[g]	4	6	2	3	3
Whitetail Canyon	27	0.3[i]	0		0		0
Lower Rucker Canyon	23		7	7	5	6	6
Upper Pinery Canyon	32		1	10	4	6	2
Pine Canyon	41		1	1	2	2	0
Lower Pinery Canyon	20		3	10	3	4	1
Horsefall Canyon	14		0		2	2	0
West Turkey Creek	21	0	2	6	0		3
Bear Canyon	17		3	3	0		0
East Turkey Creek	25		1	1	0		0
Red Rock Canyon	32		10	10	0		0
Polebridge Canyon	15				2	2	0
Barfoot–Rustler–Long's Park	35		0		0		
John Long Canyon	29		0		0		
Price Canyon	25		0		0		
Sulphur Draw	21		0		0		0
Horseshoe Canyon	38		0		0		
Mormon Ridge Trail	15		0		0		
Hoovey Canyon	25				0		
Rattlesnake Canyon	16				0		
Ryolite Canyon	30				0		
Sarah Deming Canyon	9				0		
Bonita Canyon	15				0		
Upper Rucker Canyon Ext.	10				0		
North Fork Rucker Canyon	22				0		
Lower West Turkey Creek	17				0		
Mormon Canyon	8				0		
Upper Pine Canyon	10				0		
Barfoot Canyon	10				0		
Lower Horsefall Canyon	12				0		
Basin Trail	10				0		
Upper Booger Canyon	12				0		
Lower East Turkey Creek	24				0		
Lower Booger Canyon	10				0		
Brushy Creek	10				0		
Middle Rucker Canyon	10				0		
Herb Martyr	10				0		
Research Station Canyon	10				0		
Lower Price Canyon	9				0		
Lower Horseshoe Canyon	9				0		
Upper South Fork Cave Creek	14				0		
Santa Catalina Mountains							
Sycamore Canyon	16		2	2	0		0
Rose Canyon Lake	15	1	0		0		0[j]
Bear Canyon	9		0		0		0
Organization Ridge	14		0		0		0
Marshall Gulch	17		0		0		0
Butterfly Trail	19		0		0		0
Sabino Canyon	19		0		0		0
Forest Road no. 38	15		0		0		0
Spencer Canyon	15		0		0		0
Willow Canyon	20				0		0
Box Camp Trail	19				0		0
Wilderness of Rocks	18				0		0
Canada del Oro	14				0		0
Samaniego Ridge	17				0		0
Santa Rita Mountains							
Temporal Gulch	13						3
Cave Creek	20		0		0		
Madera–JS–Sprung Spring	19		0		0		
Gardner Canyon	12				0		
Florida Canyon	16				0		
Sawmill Canyon	11				0		
Walker Basin	15				0		

Appendix A. Continued.

Survey route	No. points	No. of buff-breasted flycatchers detected					
		1980–1983[a]	1995–1996[b]	1995–1996[c]	2000[d]	2000[c]	2004[d]
Whetstone Mountains							
French Joe Canyon	7		0		0		
Rincon Mountains							
Spud Rock	21				0	1	0
Cowhead Saddle	29				1	1	1
Manning Camp	12		0		0		1
Mica Meadow	14				0		1
Italian Springs	16				0		
Heart Break Ridge	29				0		0
Miller Creek–Happy Valley Saddle	12				0		
West Manning Camp	15				0[f]		1
Mica Mountain	6				0		0
Deerspring Trail	26				0		
Rincon Peak	12				0		
Devil's Bathtub	13				0		0
Chiminea Canyon	20				0		
Pinaleno Mountains							
Ash Creek	22				0		
Oak Flat	12				0		
Rigg's Lake	40				0		
Arcadia–Wet Creek	18				0		
Noon Creek	12				0		
Galiuro Mountains							
Rattlesnake Canyon	15				0		
Paddy's River	21				0		
High Creek	14				0		
Ash Creek	21				0		
Santa Teresa Mountains							
Upper Holdout Canyon	9				0		
South Fork Goodwin Canyon	22				0		
Total	2,035	32.9	86	131	55	74	77

[a] Average across 4 yr (Bowers 1983; Bowers and Dunning 1994; R. Bowers, personal communication).
[b] No. detected during 2-min call-broadcast surveys only (Martin 1997).
[c] Total no. detected during point-count surveys, nest-searching efforts, and detection trials.
[d] No. detected during 6-min point-count surveys only.
[e] Incidental detection—no surveys conducted in this area.
[f] One bird detected incidentally (not during survey effort).
[g] Bowers (1983) lists anecdotal reports of birds in these canyons, but he didn't survey these areas (R. Bowers, personal communication).
[h] Three birds detected during one 3-hr visit in 1983 (R. Bowers, personal communication).
[i] One bird detected on 6 Sep 1981 was probably a migrant (Bowers 1983).
[j] Not formally surveyed in 2004, but this area is visited regularly by amateur birders and no records were reported.

Appendix B. Historical records (1865–1995) of buff-breasted flycatchers in the United States from published papers and museum collections. Numbers in first column refer to location in United States (see Fig. 1).

	Location	Date	Material	Source[a]
1	Seven-mile hill	Jul–Sep 1876	2 M and 1 F collected; departs for autumn migration	Aiken 1937; Bent 1942; Phillips et al. 1964; UCM
2	Natane's Plateau	12 May 1916	2 M collected	NMNH
3	Fort Apache	1873, 1876	1 M and 1 juv collected	Henshaw 1874, 1875; UCM
4	4 miles north of Whiteriver	15 Aug 1936	1 ad collected	DMNH
5	Black River	27 Aug 1876	at least 1 ad observed	Aiken 1937
6	4 miles east of Saw Mill, San Carlos Indian Res.	21 Aug 1936	1 ad collected	DMNH
7	27 miles northeast of Globe	23–25 Apr 1949–51	4 M and 1 F collected	MVZ
8	Fort Whipple	9 May 1865	1 M and 1 F collected	Coues 1866; NMNH
9	Catalina Mountains	1906–1909	9 ad collected, 3 nests found, other records	Visher 1910; Phillips et al. 1964; AMNH; FMNH; MCZ
10	Tucson	7 Jun 1923	1 M collected	UCLA
11	Rincon Mountains	18 Aug 1911	1 juv collected; other records	Marshall 1956; Phillips et al. 1964; UA
12	Pajarito Mountains	13 Apr 1947	1 ad collected	Phillips et al. 1964; DMNH
13	Santa Rita Mountains	1876–1921	>2 ad collected, >4 birds observed, other records	Bendire 1892; Lusk 1901; Swarth 1905; Bailey 1923; Phillips et al. 1964
14	Patagonia, Sonoita Creek	30 Mar 1927	1 F collected	Phillips et al. 1964; UA
15	Patagonia Mountains	no date given	old records	Phillips et al. 1964
16	Huachuca Mountains	1895–1950	27 ad collected, 28 nests collected; many records	Howard 1899; Swarth 1904; Willard 1923; AMNH; CAS; CM; SMNH; LSU; MCZ; MSU; MVZ; SBCM; UA; WFVZ
17	Apache Pass	1873, 1876	1 ad and 1 juv collected	MCZ; NMNH
18	Chiricahua Mountains	1874–1925, 1959	>41 ad and 3 juv collected, 24 clutches collected	Henshaw 1875; Bendire 1892; Lusk 1901; AMNH; ANS; CU; DMNH; DMNS; MCZ; MVZ; NMNH; ROM; UA; UCLA; WFVZ; WNMU; YUPM
19	Peloncillo Mountains	20 May 1995	1 bird observed	Williams 1996
20	Animas Mountains	10 Jul and 19 Aug 1976	several probable records	Witzeman et al. 1976; Hubbard 1978; Black 1997
21	Apache Hills	16 Aug 1886	>1 bird observed, 1 M collected; autumn arrival	Anthony 1892; Bailey 1928; Hubbard 1978; CM
22	Burro Mountains	18 Jun 1876	1 M collected	UCM
23	Lone Mountain	22 Apr 1885	1 M collected	MCZ
24	Silver City	26 Apr 1884	spring arrival	Marsh in Bailey 1928
25	Walnut Ranch[b]	May 1885	2 F, 3 M, 2 unknown collected	AMNH; BMNH; MCZ
26	Fort Bayard	1875–1876	4 F and 4 M collected	Bendire 1892; Bailey 1928; ANS[c]; MSB; SDMNH; UCM
27	near Fort Bayard	22 Apr 1876	1 F collected	CAS
28	west slope Black Range	1916–1918	often observed	Bailey 1928; Ligon 1961
29	Mogollon Mountains	1916–1918	visual records	Ligon 1961
30	Reserve area	9 May–28 Jun 1926–1929	5 M and 1 F collected	Hubbard 1978; FMNH; MSB; UM
31	Saliz Canyon	12 May 1926	1 F collected	FMNH
32	Apache Canyon, 12 miles west of Aragon	Apr–May 1915	2 breeding birds collected	Bailey 1928; Bent 1942; Ligon 1961; MSB
33	El Morro–Inscription Rock	24 Jul 1873	1 pair and 3 juv collected	Henshaw 1874, 1875; AMNH; NMNH
	Near Colorado, TX[d]	10 Jun 1884	1 bird collected	MCZ

[a] UCM = University of Colorado Museum of Natural History; NMNH = National Museum of Natural History; DMNH = Delaware Museum of Natural History; MVZ = Museum of Vertebrate Zoology; AMNH = American Museum of Natural History; FMNH = Field Museum of Natural History; MCZ = Museum of Comparative Zoology; UCLA = University of California at Los Angeles; UA = University of Arizona Museum; CAS = California Academy of Sciences; CM = Carnegie Museum of Natural History; SMNH = Slater Museum of Natural History; LSU = Louisiana State University; MSU = Michigan State University Museum; SBCM = San Bernardino County Museum; WFVZ = Western Foundation of Vertebrate Zoology; ANS = Academy of Natural Sciences; CU = Cornell University Museum of Vertebrates; DMNS = Denver Museum of Nature and Science; ROM = Royal Ontario Museum; WNMU = Western New Mexico University; YUPM = Yale University Peabody Museum; BMNH = British Museum of Natural History; MSB = Museum of Southwestern Biology at the University of New Mexico; SDMNH = San Diego Museum of Natural History; UM = University of Michigan Museum of Zoology.

[b] Exact locality is not known, but birds were collected by C. H. Marsh who lived near Silver City.

[c] Sierra Madre = Fort Bayard.

[d] Exact locality is not known.