Conservation Strategy for Bendire's and LeConte's Thrashers

(*Toxostoma bendirei* and *Toxostoma lecontei*)

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This document represents years of collaboration between numerous agencies and entities to address concerns over declining populations of these enigmatic desert species. This plan is the result of the collaboration by everyone that has been involved with the Desert Thrasher Working Group since its inception in 2010.

The findings and conclusions in this document are those of the author(s) collaborating as part of the Desert Thrasher Working Group and do not necessarily represent the views of any one organization.

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Cover photos:

LeConte’s Thrasher (top, photo credit: J. Tinsman), Bendire’s Thrasher (bottom, photo credit: J. Tietz)

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Introduction

Figure 1. Bendire's Thrasher (Toxostoma bendirei) Photo credit: C. McCreedy.

Bendire's Thrasher (*Toxostoma bendirei,* Figure 1) and LeConte's Thrasher (*Toxostoma lecontei,* Figure 2); hereafter collectively referred to as "Desert Thrashers", are among the fastest declining avian taxa in North America (Rosenberg et al. 2016, Sauer et al. 2020). Their populations are decreasing across their ranges according to Breeding Bird Survey (BBS) data, with annual population declines in the United States of -3.12%/year for Bendire's Thrashers and -2.77%/year for LeConte's Thrashers over the last 50 years (Sauer et al. 2020, Figure 3, Tables 1 and 2), resulting in 86% and 67% declines, respectively, over the same time period. BBS data is imperfect, and the details of the trend data are discussed below. Partners in Flight (2024) estimated worldwide population sizes for both species are already small, between 31,000 and 93,000 Bendire's Thrashers and 16,000 to 92,000 for LeConte's Thrashers, making continued declines detrimental.

The conservation concern of both species has been recognized by Federal and State agencies, as well as non-governmental organizations (Table 3). Both species are considered Species of Greatest Conservation Need (SGCN) or of Special Concern in every State Wildlife Action Plan where they occur (Wildlife Action Plan Team 2012, CDFW 2015, Utah Wildlife Action Plan Joint Team 2015, NMDGF 2016, AZGFD 2022). Both species are U.S. Fish and Wildlife Service (USFWS) Birds of Conservation Concern (USFWS 2021), and Birds of Management Concern; Bendire's Thrasher is included as a focal species (USFWS 2011), and additionally is listed as "Vulnerable" by the IUCN (IUCN 2022). Both species are rated "Red" on the Partners in Flight Watchlist (Rosenberg et al. 2016) and are included on the Department of Defense's Mission Sensitive Species list (DOD 2021). However, neither species is currently listed on Mexico's species-at-risk list, the NORMA Oficial Mexicana NOM-059-SEMARNAT (Domínguez-Sánchez 2020). Following up on widespread anecdotal evidence of Desert Thrasher declines, as well as survey data, The Desert Thrasher Working Group (DTWG) was established in 2011 to begin addressing overall downward trends.

Figure 2. LeConte's Thrasher (Toxostoma lecontei) perched on a shrub. Photo credit: J. Tinsman.

Both thrasher species occupy flat, sparse deserts, grasslands, and shrublands of the southwest United States and adjacent northwest Mexico. Both species present challenges to research and monitoring in that they nest earlier than most other land birds, they are scarce and patchily scattered across large swaths of landscape, they occur across numerous habitat types, they are cryptic in coloration and habits, and they use ephemeral food resources, often altering timing and location of breeding activities to sync with these resources.

Despite recent advancements in our understanding of the biology and ecology of the two desert thrasher species, there are still significant data gaps that need to be filled. These include comprehensive information on their breeding season and winter distributions, habitat associations, demographics, and population-limiting factors. A better understanding of Desert Thrasher's biology and ecology are needed to provide informed conservation actions for these unique desert thrasher species.

Desert Thrasher populations are threatened by numerous practices that have led to loss and degradation of vast tracts of habitat. Populations are losing habitat due to expansion of urban areas, conversion of habitat to farmland, renewable energy development, and infrastructure projects. Habitats are further degraded by unsustainable grazing practices and an influx of invasive plant species that alter fire regimes. Finally, threats from climate change play a direct role in limiting survival and productivity of Desert Thrashers, and climate change impacts exacerbate habitat degradation through impacts from prolonged droughts, increasing temperatures, and other stochastic weather events such as floods and fires. Understanding the role these factors play in population declines is critical to reversing current population trends and conservation of these species.

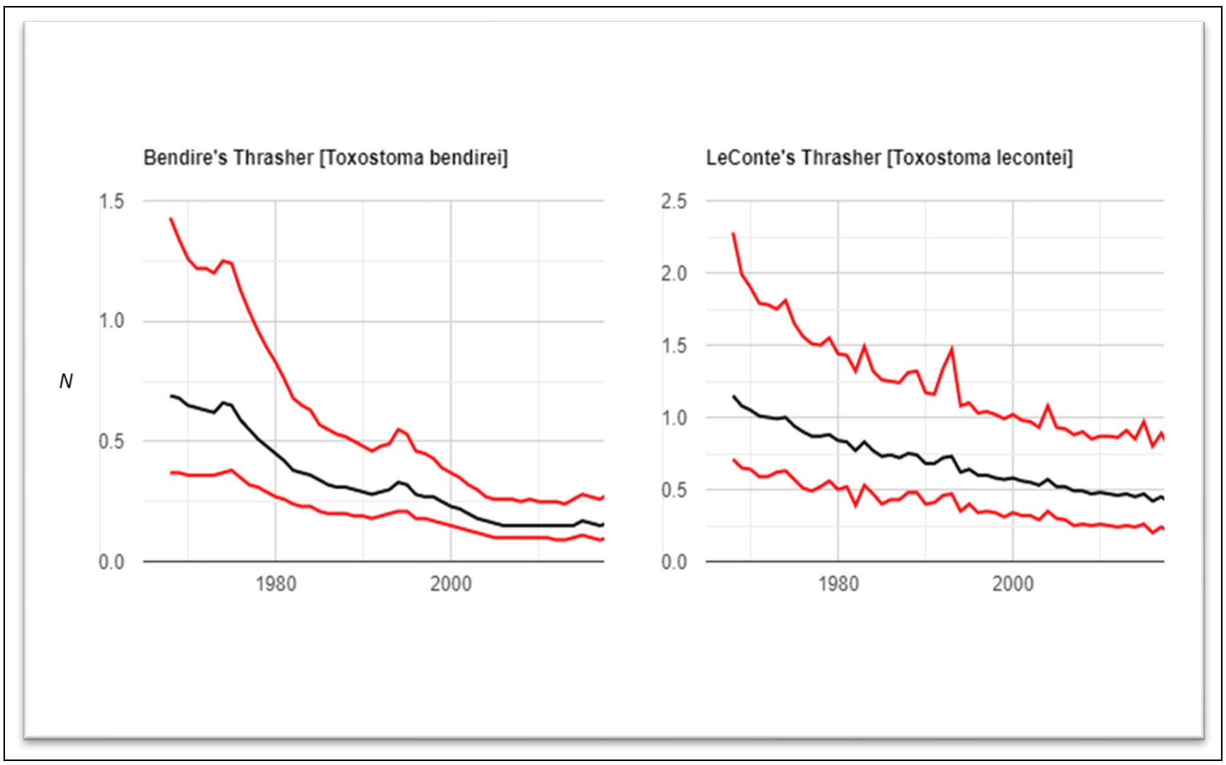


Figure 3. Population trends for Bendire's and LeConte's Thrashers from Breeding Bird Survey results 1968-2019 (Sauer et al. 2020). N = annual index of relative abundance. Solid black lines show trends in annual indices of relative abundance over the survey period; red lines indicate 95% credible intervals (2.5 and 97.5%). Bendire's Thrashers show a survey-wide trend of -2.75% annually, and LeConte's Thrashers show a survey-wide trend of -1.69% annually. See also Tables 1 and 2.

This plan summarizes the current state of knowledge of these birds, identifies data gaps that impede meaningful recovery, summarizes range-wide threats, and provides beneficial management practices that are designed to help land and wildlife managers maintain thrasher populations. It is anticipated that this plan will be updated to reflect new knowledge, changes in population trends, and other important new developments. The plan will highlight actions that can be taken to address current threats and narrow data gaps. The conservation targets of this plan are to have a 10% population increase over 10 years for both Bendire's and LeConte's Thrashers as well as to define Bendire's Thrasher habitat requirements. This plan addresses both LeConte's and Bendire's Thrashers; these species have comparable life histories and similar habitats, making the threats and conservation actions similar to each other in many cases. When there are differences, they will be treated separately.

Population Estimate, Status, and Trends

The global population of Bendire's Thrashers is currently estimated at 83,000, 95% CI [31,000, 93,000] with 56,000 of those birds estimated to be in the United States, and the remaining 27,000 in Mexico (Partners in Flight 2024). The Bendire's Thrasher population is declining with a significant negative survey-wide population trend of -3.14%/year, 95% CI [-4.3, -1.6] since BBS began in 1968 (Sauer et al. 2020). Population trends are also negative in all but one Bird Conservation Regions (BCR), with the greatest declines in the Southern Rockies BCR and New Mexico, as well as survey-wide (Table 1). Trends over the last 30 years are similar, with an overall significant negative trend of -2.8%/year, and greatest downward trends in the same regions (e.g., Southern Rockies BCR, New Mexico, and survey-wide). There are limitations to BBS data, especially for these species, both in coverage and robustness, which are discussed in more depth below, but that are especially apparent when considering subsets of the already limited data. Additionally, BBS data only reflect trends in the United States; trends in Mexico are unknown. Though BBS data are the only long-term and large-scale survey data available for estimating population trends for these species, there have been recent advances using community science data to estimate bird population abundance and trends (Fink et al. 2023). However, owing to the difficulties in detectability, stemming from their cryptic coloration and behavior, and under-visited habitats, data were not robust enough to provide trend estimates for Bendire's Thrasher. The DTWG has also developed survey methods and has conducted surveys across the range of both species to start better understanding of overall distributions, trends, and habitat associations, but these data are still being accumulated. These surveys have confirmed a low probability of detection (~20%), even when surveys are focused on Desert Thrashers (DTWG, unpublished data). Population goals outlined in the 2016 Partners in Flight Landbird Conservation Plan are to increase the population size by 75–100% between 2016 and 2046 (Rosenberg et al. 2016).

The global population of LeConte's Thrasher is currently estimated at 71,000, 95% CI [16,000, 92,000], with 46,000 of those birds estimated to be in the United States, and the remaining 25,000 in Mexico (Partners in Flight 2024). There is a significant negative BBS survey-wide trend of -2.77 %/year, 95% CI [-4.4, -1.2] since 1968, and a significant trend of -3.42 %/year, 95% CI [-5.9, -1.3] since 1993 (Sauer et al. 2020, Table 2). Trends are significantly downward in all regions except Nevada, where few routes detect the species and trends are negative but not statistically significant. BBS data only reflect trends in the United States; trends in Mexico are unknown. Unlike Bendire's Thrashers, abundance trends for LeConte's Thrasher based on community science data were robust enough to produce trend estimates. Abundance trends show a -15.3% decline between 2012 and 2022, 95% CI [-5.3, -28.5] in the United

States, and -10.4%, 95% CI [20.2, -20.6] decline in Mexico (Fink et al. 2023). These trends are much greater than trends estimated by BBS data. The 2016 Partners in Flight Landbird Conservation Plan calls to increase the population by 75–100% between 2016 and 2046 (Rosenberg et al. 2016). Other studies have shown downward trends in local LeConte's Thrasher populations which are better fit by non-linear trends (Sheppard 2018).

There are limitations in using BBS data for these species. These species have a low likelihood to be recorded with conventional point counts (Weigand and Fitton 2008). Further, the BBS survey period can be mismatched with Desert Thrasher breeding phenology, with onset of nesting typically beginning long before the beginning of the BBS survey period. In some states or BCRs there are few routes where either species may be detected (e.g., Bendire's Thrasher in BCR 9, see Table 1). Despite these sampling limitations in certain areas or timeframes, both Bendire's and LeConte's Thrashers are sampled well enough overall to provide reasonable downward trend estimates, though in some regions with fewer detections, there is greater uncertainty about the magnitude of trends.

Breeding bird surveys for both species have no greater than a "yellow" credibility score, reflecting data deficiencies. Yellow credibility scores reflect low abundance (< 1.0 bird/route), and small samples sizes (< 14 routes) where the species is detected, and in general are considered incapable of detecting trends of < 3% annually (Sauer et al. 2020). Regions with a "red" credibility score result from overall very low abundance (< 0.1 bird/route) of the target species, or very few routes (< 5) where the species is detected. For Bendire's Thrasher, this occurs in regions on the edges of the range (e.g. BCR 9) or where abundance is particularly low. Trends estimates in these regions are considered imprecise and incapable of detecting trends < 5% annually. Caution should be exercised in interpreting trends in regions especially with red trends. However, while individual regions may not have enough power to detect precise trends, survey-wide trends typically have greater power. For Desert Thrasher species, which are low density and scarce on the landscape, even survey-wide trends have a "yellow" credibility score, which should be interpreted carefully, especially if trends are less than 3%/year.

Table 1. Bendire's Thrasher population trends from 1968–2022 and the most recent analyzed 30-year BBS period (1993–2022) by Bird Conservation Region, State, and Breeding Bird Survey Route area. Note that information from Mexico is not available from these surveys. For the BBS trends, N = number of survey routes on which the species was encountered during the entire survey period. BBS trends are presented as yearly percentage changes. Numbers in parentheses are the 95% credible intervals for the trend estimate; the values represent the 2.5% and 97.5% percentiles of the posterior distribution of trend estimates (Sauer et al. 2020). Trends for which credible intervals do not include zero are considered statistically significant, and bold text represents a significant negative trend. BBS credibility scores also indicate the power of surveys to detect changes in population sizes, R = red, Y = yellow, and B = blue. Y indicates higher power, and R indicates lower power (see Sauer et al. 2020 and discussion above).

Bendire's Thrasher		**1968–2022**		**1993–2022**		
	N	**Trend (percent/ year)**	**95% CI**	**Trend (percent/ year)**	**95% CI**	**Credibility Score**
Great Basin (BCR 9)	2	-0.23	(-4.28, 3.95)	1.46	(-4.28, 7.68)	R
Southern Rockies/Colorado Plateau (BCR 16)	24	**-4.29**	**(-6.78, -1.77)**	**-5.15**	**(-9.0, -1.15)**	Y
Sonoran and Mojave Deserts (BCR 33)	28	**-2.74**	**(-4.92, -0.75)**	-1.85	(-4.85, 0.97)	Y
Sierra Madre Occidental (BCR 34)	9	0.51	(-3.14, 4.39)	-0.322.73	(-5.08, 4.5)	R
Chihuahuan Desert (BCR 35)	5	-1.36	(-4.82, 2.35)	-0.33	(-4.92, 4.8)	R
Arizona	33	**-2.64**	**(-4.71, -0.74)**	-1.68	(-4.51, 0.97)	Y
California	7	-2.74	(-5.8, -0.11)	-0.84	(-5.533.81)	R
Nevada	4	-0.37	(-3.86, 3.14)	0.03	(-4.5, 5.05)	R
New Mexico	19	**-4.59**	**(-6.78, -2.45)**	**-5.86**	**(-9.18, -2.43)**	Y
Utah	5	-2.22	(-8.24, 2.89)	-4.34	(-11.97, 1.51)	R
Survey-wide/United States	68	**-3.14**	**(-4.63, -1.6)**	**-2.8**	**(-4.91, -0.6)**	Y

Table 2. LeConte's Thrasher population trends from 1968–2022 and the most recent analyzed 30-year BBS period (1993–2022) by Bird Conservation Region, State, and Breeding Bird Survey Route area. Note that information from Mexico is not available from these surveys. For the BBS trends, N = number of survey routes on which the species was encountered during the entire survey period. BBS trends are presented as yearly percentage changes. Numbers in parentheses are the 95% credible intervals for the trend estimate; the values represent the 2.5% and 97.5% percentiles of the posterior distribution of trend estimates (Sauer et al. 2020). Trends for which credible intervals do not include zero are considered statistically significant, and bold text represents a significant negative trend. BBS credibility scores also indicate the power of surveys to detect changes in population sizes, R = red, Y = yellow, and B = blue. Y indicates higher power, and R indicates lower power (see Sauer et al. 2020 and discussion above).

LeConte's Thrasher		**1968–2022**		**1993–2022**		
	N	**Trend (percent/ year)**	**95% CI**	**Trend (percent/ year)**	**95% CI**	**Credibility Score**
Coastal California (BCR 32)	2	**-8.69**	**(-13.13, -3.40)**	**-8.86**	**(-13.94, -3.33)**	R
Sonoran and Mojave Deserts (BCR 33)	39	**-2.64**	**(-4.31, -0.97)**	**-3.38**	**(-5.83, -1.22)**	Y
Arizona	8	**-3.79**	**(-6.93, -0.30)**	**-3.59**	**(-5.83, -1.22)**	R
California	29	**-2.77**	**(-4.54, -1.12)**	**-3.59**	**(-6.31, -1.34)**	Y
Nevada	4	-0.39	(-7.6, 6.56)	-0.81	(-10.52, 6.51)	R
Survey-wide/United States	41	**-2.77**	**(-4.41, -1.16)**	**-3.42**	**(-5.85, -1.26)**	Y

Table 3. The status of Bendire's and LeConte's Thrashers on various lists of Conservation Concern held by different agencies and organizations.

	Bendire's Thrasher	**LeConte's Thrasher**
Arizona[1]	SGCN – Tier 2	SGCN – Tier 2
California[2]	Species of Special Concern	Species of Special Concern
Nevada[3]	Species of Conservation Priority G4G5S1	Species of Conservation Priority G4S2
New Mexico[4]	SGCN – Category 1 (Immediate Priority)	NA (not present)
Utah[5]	SGCN (threat impact 1)	NA (rarely occurs)
USFWS [6, 7]	Bird of Conservation Concern, Bird of Management Concern, Focal Species	Bird of Conservation Concern, Bird of Management Concern
Sonoran Joint Venture[8]	Continental Concern	Continental Concern
BLM Sensitive Species[9]	California, Nevada, New Mexico	Arizona, California, Nevada
IUCN[10]	Vulnerable	Least Concern
Partners in Flight[11]	Red List, Half-life: 18 years	Red List, Half-life: 27 years
DOD PIF[12]	Mission Sensitive Species	Tier 2 Species
Road to Recovery[13, 14]	Red Alert Tipping Point Species	Red Alert Tipping Point Species

1. Arizona Wildlife Conservation Strategy Tier 2 species are deemed vulnerable but do not match criteria for tier 1, which are generally ESA listed species or former ESA listed species (AZGFD 2023).
2. California State Wildlife Action Plan (CDFW 2015)
3. Nevada Wildlife Action Plan (Wildlife Action Plan Team 2012)
4. State Wildlife Action Plan for New Mexico (NMDGF 2016)
5. Utah State Wildlife Action Plan (Utah Wildlife Action Plan Joint Team 2015)
6. USFWS Birds of Conservation Concern (U. S. Fish and Wildlife Service 2021)
7. USFWS Birds of Management Concern (U.S. Fish and Wildlife Service 2011)
8. Sonoran Joint Venture Bird Conservation Plan (Sonoran Joint Venture Technical Committee 2006)
9. See individual state Bureau of Land Management Sensitive Species lists
10. International Union for Conservation of Nature Red List of Threatened Species (IUCN 2022)
11. Partners in Flight Landbird Conservation Plan: 2016. (Rosenberg et al. 2016)
12. Department of Defense Partners in Flight Mission Sensitive Species (DoD PIF 2021)
13. https://r2rbirds.org/tipping-point-species/
14. Partners in Flight. 2024. Avian Conservation Assessment Database, version 2024. (Partners in Flight 2024)

Natural History

Bendire's Thrasher

Bendire's Thrashers occur in Arizona, California, Nevada, New Mexico, and Utah in the United States, and Chihuahua, Sonora, and northern Sinaloa in Mexico (Map 1). They typically occupy areas of little relief and sparse vegetation across desert scrub, grassland, and savanna habitats at elevations between sea level and 1,800 meters (England and Laudenslayer Jr. 2020). This species is adaptable and can also be found in the periphery of rural agricultural land, ranches, and adjacent to low-density residential areas.

Like most thrashers, they primarily forage on the ground for insects including ants, termites, grasshoppers, beetles, various larvae and pupae (England and Laudenslayer Jr. 2020), as well as seeds and berries from small trees and shrubs such as *Lycium* spp. and desert mistletoe (*Phoradendron californicum*), though there has been little formal study on Bendire's Thrasher diet. On rural edges they have been observed feeding on livestock feed and at seed feeders.

Bendire's Thrashers usually begin to sing in early January at lower elevations and late March to early April in higher elevation habitats within their breeding range. However, singing can begin as early as December in southern portions of the breeding range, and they may continue singing through June, although singing activity declines after breeding (England and Laudenslayer Jr. 2020). This species has a complex melodic song, described by Dawson (1923) as reminding him of a Catbird, saying it "...is something of a ventriloquist, too, and on such occasions drops liquid notes like beaded custard for richness". The song was described by Herbert Brown as a continuous warble with a double quality, as if singing two songs (Phillips et al. 1983). Songs may be given at length, often from high perches, but also from less conspicuous perches.

Bendire's Thrashers construct a bowl-shaped stick nest lined with grasses, hair, fur, and other soft materials, placed in a cactus, shrub, or short tree (Figure 4). Herbert Brown (Brown 1901) found that of 200 nests studied, the nests include much finer materials and "workbirdship" than those of most thrashers; they are smaller, more compactly built and very symmetrical in their cupped shape. Finer twigs are used on the outside and are fitted closely together. The lining is variously composed of horsehair, thread, twine, pieces of cloth, grass, weeds, rootlets, fine bark, wool, and cotton from bed quilts (Bent 1948). Both sexes construct the nest (Kondrat 2019).

Eggs are 25 mm in length and laid in a clutch of three to four, and rarely five eggs (Brown 1901, England and Laudenslayer Jr. 2020, Salas 2021). Average clutch size at the Chemehuevi Wash in California was 3.2 eggs (*n* = 9 nest; Point Blue Conservation Science, unpublished data), and 3.3 eggs in southern New Mexico (*n* = 75; Salas 2021). They may attempt up to three clutches a season, but two are common (England and Laudenslayer Jr. 2020, Salas 2021). Most eggs are irregularly spotted and blotched with well-defined markings of tawny red fawn color and vinaceous buff. These markings are generally heaviest about the larger end of the egg. The female is the primary incubator. When she leaves the nest, the male, or even a young bird from a previous clutch, has been observed watching closely over the eggs or nestlings on the nest's edge (Kondrat 2019). Incubation and nestling periods are not well defined, but according to the North American Nest Record Card Program, fledglings leave the nest approximately 12 days after hatching. In southern New Mexico, incubation averaged 13 days, and the nestling period averaged 15 days (Salas 2021).

Figure 4. Bendire's Thrasher nest. Photo credit: J. Tietz.

In southern New Mexico, nests are commonly found in soaptree yucca (*Yucca elata*) or honey mesquite (*Neltuma glandulosa,* formerly *Prosopis glandulosa*)*;* Salas and Desmond 2018, Salas and Desmond 2019). In central Arizona and Sonora, nests are commonly found in honey mesquite, palo verde (*Parkinsonia* spp.), cholla cactus (*Cylindroptunia* spp.), Joshua tree (*Yucca brevifolia*), and juniper (*Juniperus spp.*). In Nevada and California, blue palo verde (*Parkinsonia florida*), *Lycium* spp., *Rhus* spp., cholla, and Joshua tree are frequently used (Ammon et al. 2020, Figure 5). In blue palo verde xeric riparian habitat on the Chemehuevi Wash in California, nine of ten nests were built in blue palo verde (Point Blue Conservation Science, unpublished data). Nests are often well concealed and placed in dense clumps of vegetation, such as limbs infected with desert mistletoe, or where Russian thistle has accumulated against shrubs, or other dense vegetation. They will also regularly nest near human dwellings or agricultural structures. Nest heights range from 0.7 meters to 4.6 meters (Bent 1948, Corman and Wise 2005, Ammon et al. 2020).

Migration and dispersal patterns, nonbreeding locations, and nonbreeding habitats are understudied or unknown, but a recent study has begun to provide insight (Borgman and Kondrat, *in prep*). The study found that individuals sampled in southern Arizona remained in their territories year-round (100%, n = 4), while individuals from northwestern Arizona, southwestern and central New Mexico were migratory (94%, n = 17); Borgman and Kondrat, *in prep*). Migratory birds primarily wintered in Sonora, with a few individuals wintering in southern Arizona; one individual remained on its breeding territory in southwestern New Mexico. The distance traveled by birds varied from 274 km to 740 km. Most birds in the nonbreeding season were found within Sonoran desertscrub (described in Brown 1994) habitats and centered around the broad area (approximately 130 km radius) surrounding Hermosillo, Sonora. A recent survey effort has also shown that Bendire's Thrashers in areas around Hermosillo are present during both breeding and nonbreeding periods (GBBO unpublished data, *in prep*).

Figure 5. Cholla with Bendire's Thrasher nest in Mojave Desert. Photo credit: J Tietz.

The study also found that birds from different sites-initiated migration at different times; birds in northwestern Arizona departed in late July (average July 24, n = 8), birds in central New Mexico departed in late August (average August 27, n = 3), and birds from southwestern New Mexico departed in late September (average September 25, n = 5). Nonbreeding site fidelity and any annual variation in departure timing are still not known. A better understanding of the migratory behavior, including factors that drive the selection of nonbreeding locations and habitats is necessary. Breeding site fidelity has been observed from a color-banding study in southern and central Arizona (Kondrat, unpublished data), and 61% of birds tagged during the migration study returned to their original trapping locations (Borgman and Kondrat, *in prep*); the factors that contribute to this behavior are not fully understood. To gain a more comprehensive understanding, further research is necessary to investigate the factors that influence nest site fidelity and nest site selection.

In general, birds at southern latitudes and low elevations breed earliest, but overall timing of breeding may vary widely and appears to be dependent on precipitation, elevation, and latitude (McCreedy and van Riper 2015). Resident birds at low elevations in central and southern Arizona and California initiate breeding in late January to mid-February, with earlier breeding dates coinciding with wet years. In Arizona, atlas data show peak nesting period in April, but nesting efforts continue through mid-June, and as late as mid-July (Corman and Wise 2005). In southwestern New Mexico, nest initiation varied by approximately one month annually, from late March to late April, with later nesting occurring in the drier year (Salas 2021); fewer nests were attempted during the drier year. Arrival and nest initiation in central New Mexico was observed from early April through May. At locations on the Colorado Plateau, breeding occurs from May into July.

Nest survival in southwestern New Mexico ranged between 40% and 69% (n = 75) during the two-year study (Salas 2021). Nest survival was modeled at various scales. Temporally, nest survival was strongly influenced by time of year, with nests initiated later in the year having reduced survival, but with a strong effect from year as well (Salas 2021). At the nest site and territory scales, no variable had a statistically significant effect, though nest concealment, distance to nearest edge, canopy gap sizes, and arthropod abundance all had positive influences on nest survival (see Salas 2021 for full discussion). Predation caused most of the nest failures; the most common predators were Chihuahuan Ravens (*Corvus cryptoleucus*) and coyotes *(Canis latrans*; Salas 2021). Apparent nest survival in Chemehuevi in California was 71%, with five of seven nests fledging young and two nests deserted during hot conditions in June. Three additional nests (n = 10 total nests monitored between 2003 and 2008) had unknown outcomes but were still active at the end of the monitoring season in June (Point Blue Conservation Science unpublished data). Nest survival in other parts of the range have not been reported. Parasitism by Brown-headed Cowbirds (*Molothrus ater*) does not appear to be common; none were observed in southwestern New Mexico, but there are a few records from Arizona (England and Laudenslayer Jr. 2020, Salas 2021).

At this same southwestern New Mexico site, post-fledging survival was estimated using radio telemetry at 38% for a 30-day period, with 10 of 25 individuals surviving. Most died within five days of fledging (Salas 2021). Transmitter effect was not considered, and transmitters may have a minimal negative effect on survival (Barron et al. 2010). Juveniles stayed on their breeding territories during this time, with early movements (first five days) within 100 m of nest sites and increasing to 300 m over time (up to 40 days). They used areas with more tall shrubs, greater shrub cover, and bare ground for foraging, but when modeled, only the effect of year was significant, and habitat characteristics did not have a significant influence on juvenile survival (Salas 2021). Suspected predators of fledglings included coyotes and raptors, but also snakes and rodents as some transmitters were recovered from burrows. Thirty-eight percent survival is low for a bird this size, but within the range of reported survival for passerines for post-fledging survival (Cox et al. 2014). However, juvenile survival below 40% may be implicated in population declines in some scenarios, so this measure is important to consider for future studies. Adult survival has not been estimated on breeding or nonbreeding grounds, but according to the Bird Banding Laboratory, there is a longevity record for Bendire's Thrasher currently aged at 10 years (Kondrat, unpublished data).

Average territory size in southwestern New Mexico was 1.7 ha over three years of study and ranged between 1.3 ha and 2.3 ha between years (Sutton 2020). Territory size did not vary across different habitat types, but it did vary between years, and precipitation drove this variation to some degree (Sutton 2020). At a territory scale, occupied territories had more bare ground, taller shrubs, and greater vegetation density than random sites. At a landscape scale, occupied territories had a higher number of small patches, and higher edge density, translating to territories that have high levels of heterogeneity, with plenty of bare ground for foraging and surrounding dense vegetation for cover. Tall shrubs may play a role in offering potential nest sites and singing perches (Figure 6). Bendire's Thrashers avoid areas of contiguous cover, such as open grasslands and dense stands of creosote (*Larrea tridentata*), mesquite, or other woody cover. They are also often associated with desert washes, which can provide structural complexity against a backdrop of homogenous upland habitats used for foraging. Thrasher's breeding territories are well-spaced, ranging from approximately 400 m of separation in densely populated clusters to a kilometer or more in apparently less suitable habitats.

Figure 6. Typical breeding habitat in the Chihuahuan Desert in southwestern New Mexico. Photo credit: A. Stein.

LeConte's Thrasher

LeConte's Thrashers were considered by early ornithologists to be among the rarest and most elusive birds. This species is a year-round resident species of the Mojave and Sonoran deserts of southeast California, including the San Joaquin Valley, the Mojave Desert in California, southern Nevada, the extreme southwest corner of Utah, and the Sonoran and Mojave deserts of western and southwestern Arizona, northeast Sonora, and Baja California (Map 2). They are residents of hot, flat, desert habitats, low on slopes in valleys, drainages, or basins, from the floor of Death Valley in California up to 1,600 m in the northern parts of its range. Maximum annual precipitation is < 20cm and the species rarely occurs where snowfall is greater than 15 cm annually (Sheppard 2018). LeConte's Thrashers require large swaths of habitat that include bare, sandy ground for foraging and some shrubs or cacti adequately sized for nesting (Sheppard 2018). Important features usually include saltbush (*Atriplex* spp.), cholla, and stands of taller shrubs and trees such as *Yucca* spp. and ocotillo (*Fouquieria splendens*; Sheppard 2020). LeConte's Thrashers forage on the ground, primarily for arthropods, as well as small vertebrates such as lizards and rodents; small amounts of seeds may also be consumed. All necessary water is obtained from prey consumption.

Singing occurs throughout the year, but typically peaks in December and January and often through February (Sheppard 2020) in the southern part of the range, and January through February in the northern part of the range. LeConte's Thrashers sing sporadically and are not known to devote large portions of their daily budget to singing (Sheppard 2020). Typically, nesting occurs between February and the middle of June (Sheppard 2018). However, in the southern portions of the range, nesting may begin in December (Sonora and Baja California) or January (southern Arizona) (summarized in Sheppard 2018). Nests are stick nests with four distinct layers: the outer layer is constructed of larger twigs, the next layer of smaller twigs, a third layer of finer materials, such as grasses and rootlets, and the definitive inner layer, which is well-padded and insulated with soft vegetation. This padded inner lining is unique to any other nest of its approximate size in the desert southwest (Sheppard 2020, Figure 7).

Figure 7. LeConte's Thrasher nest. Photo Credit: J. Tobin.

LeConte's Thrashers require a nest shrub that is adequately dense to support and protect a nest, and the presence of suitable nest substrates may be a limiting factor in defining suitable habitat (Sheppard 2018, Hargrove et al. 2019), such that nest site selection may be more driven by vegetation structure than species or diversity in sparsely vegetated habitats (Blackman et al. 2012). In a sample of about 700 nests, 82% were in cholla or saltbush, but other plant species that provide dense branching were also used. Nests are typically well concealed. Artificial structures are also used occasionally (Sheppard 2018). In California, silver cholla (*Cylindropuntia echinocarpa*) or pencil cholla (*C. ramosissima*) were most used, as well as honey mesquite afflicted with mistletoe growth (Hargrove et al. 2019, Ammon et al. 2020). In Nevada, cholla are also most commonly used, especially buckhorn (*C. acanthocarpa*) and silver cholla (Figure 8). Other favored nest substrates in Nevada include Mojave yucca (*Yucca schidigera*), *Lycium* spp., and catclaw acacia (*Senegalia greggii*) with mistletoe (Ammon et al. 2020). For 23 nests in southern Arizona, paloverde species (n = 5), teddy bear cholla (*Cylindropuntia bigeloveii*, n = 5), ironwood (*Olneya tesota*, n = 6), crucifixion thorn (*Canotia holacantha*, n = 3), and velvet mesquite (*Neltuma velutina*, formerly *Prosopis velutina*, n = 4) were used (Blackman and Diamond 2015). In saltbush associations, the favored substrate is cattle saltbush (*Atriplex polycarpa*) (Sheppard 2018). Nest heights range from 0 to 4.5 meters, and the average nest height is 0.8 m (n = 343; Sheppard 2020). Clutch sizes are generally two to five eggs, average is 3.3 eggs (n = 655, Sheppard 2018). LeConte's Thrashers typically have two to three clutches per season (Sheppard 2018). Average incubation period is 15.8 days (range 14–19 days, n = 18), and fledging occurs after 15.9 days on average (range 12–20 days, n = 51, Sheppard 2020).

In Maricopa, California, 64% of nests fledged at least one young (*n* = 139), and successful nests fledged an average of 2.98 per nest (Sheppard 2018). Apparent nest success of 42% was recorded in California in 2019 (*n* = 26, Hargrove et al. 2019), though estimating nest survival was not the goal of the study. No nest survival estimates have been made that account for sources of detection bias (e.g., Mayfield (1975) or Program Mark (Dinsmore et al. 2002)); estimates derived from these measures are typically lower than apparent success, and factors influencing nest success have not been investigated. Individual nests were most commonly lost to predation, however, failure of eggs to hatch, nestling starvation, and weather events were also significant factors in nest loss (Sheppard 2018).

Figure 8. LeConte's nest site in cholla (center) in typical LeConte's habitat in Avi Kwa Ame National Monument in Nevada. Photo credit: L. Harter.

A radio-telemetry study conducted at Barry M. Goldwater Range in southern Arizona revealed large post-fledging dispersal distances and large home-ranges of contiguous habitat for a bird of this size (Blackman and Diamond 2015). Juvenile home ranges were on average 364.6 ha (*n* = 7, range 222.4–747.5 ha), and core areas covered 87.3 ha. Movements were on average 678.9 m (range 441.9–825.2 m) from their nests within 50 days of fledging. Home ranges of birds from adjacent territories all overlapped to some degree (Blackman and Diamond 2015). In another study area, with significant differences in study area, study design, and study goals, average breeding territory size for adults was 7.34 ha, ranging from 4-12 ha in Maricopa, California (Sheppard 2018). Total cumulative habitat utilized by the same marked pairs over several years ranged from about 10-40 ha, averaging 27 ha in optimum habitat. These are considered minimal territory sizes. In less optimal habitats cumulative home ranges may cover significantly larger areas. The measures from these two studies vary drastically, but also investigated different measures (e.g., home range versus territory size). More study is needed to understand the true home range or territory size requirements for this species.

Juvenile survival was estimated at 46.13% (SE +/-7.69, *n* = 7) during the first 58 days of the post-fledging period, and survival probability was inversely related to fledgling age, as survivorship decreased with greater time spent out of the nest (Blackman and Diamond 2015). Blackman and Diamond evaluated a fairly small sample (*n* = 7) of post-fledging juveniles using radio telemetry. Transmitter impacts were not assessed. However, Sheppard (2018) also estimated a low apparent juvenile survival of 20% for the first 90-days post-fledge (*n* = 242) by resighting color bands. Approximately 20% of the young survive to the following year. More investigation is needed into juvenile survival as a potentially limiting factor in population growth. Like Bendire's Thrashers, these juvenile survival rates are low compared to other species (Cox et al. 2014) and could be implicated in population declines. Annual survival rate for adults was approximately 60%, and maximum life expectancy for adults is seven to eight years (Sheppard 2018).

Taxonomy

Bendire's Thrasher

Since its first description by Western ornithologists, Bendire's Thrasher (Figure 9) has been shrouded in uncertainty. Major Charles E. Bendire collected the first specimen of this species in 1872 near Camp Lowell, in current-day Tucson, Arizona. The specimen was examined by Robert Ridgway and Elliott Coues. It was eventually determined to be a new species, distinct from the similar Curve-billed Thrasher (*Toxostoma curvirostre*, Coues 1873, Brandt 1951, American Ornithologists' Union 1957).

There are three subspecies currently recognized by the AOU (1957): *T. b. bendirei* is found from southeastern California, southern Nevada, southern Utah and southern Colorado southward to N. Sonora. *T. b. candidum* is confined to west-central Sonora, and *T. b. rubricatum* is confined to interior southern Sonora. Among the *Toxostoma* thrashers, Bendire's Thrashers are most closely related to Gray Thrasher of Baja California (*T. cinereum*), according to genetic studies, and separate from Curve-billed Thrashers, a widespread and very similar species in appearance (Zink et al. 1999).

Figure 9. Bendire's Thrasher. Photo Credit: C. Kondrat..

Bendire's Thrasher's overall appearance of plumage is of a light sand color with triangular marks on the breast. The bill of an adult Bendire's Thrasher is mostly grayish brown. The maxilla is slightly curved, and the mandible is straight with a pale patch at the base (Figure 9). This pale patch is present in all life stages of the bird (hatchlings, recently fledged young, and adults). In contrast, the similar Curve-billed Thrasher's bill is a dark grayish brown, with distinct long curves to both the maxilla and mandible, there is no pale patch at the base of the mandible (Kondrat 2022), and markings on the breast are rounded rather than triangular.

LeConte's Thrasher

The LeConte's Thrasher (Figure 10) was first collected by Dr. John LeConte near Fort Yuma, Arizona in 1851. As with the Bendire's Thrasher, it is rare and elusive, and one of the last North American bird species to be formally described. Only five specimens of this species were collected in the 30 years following its "discovery" by modern ornithology (Bent 1948). Currently, there are three recognized subspecies (Dickinson and Christidis 2014): *Toxostoma lecontei lecontei,* the most widespread subspecies, is resident across the Mojave and Sonoran Deserts of Arizona, Nevada, and California; *Toxostoma lecontei arenicola*, a resident of the Vizcaino Desert of Baja California; and *Toxostoma lecontei macmillanorum,* found in the southern San Joaquin Valley of California. However, evidence for subspecies status of *T. l. macmillanorum* is weak, with multiple authors providing evidence against including it as a separate subspecies (Zink et al. 1999, Sheppard 2018). Genetic studies show the LeConte's Thrasher is most closely grouped with Crissal Thrashers (*T. crissale*, Zink et al. 1999).

Figure 10. LeConte's Thrashers. Photo Credit: M. Brady.

LeConte's Thrashers are similar in size to other thrashers, with a distinctly unmarked breast, dark iris, strongly decurved bill, buff-colored vent, and contrasting dark tail. LeConte's Thrashers are unique in that they occupy especially harsh environments, exhibit a preference for running over flying, and are extremely reclusive (DTWG 2018).

Appearance and Identification

It can be difficult for untrained observers to differentiate between similar Thrasher species. For instance, Bendire's and Curve-billed Thrashers can be difficult to identify, especially during parts of the year where juvenile Curve-billed Thrashers may appear short-billed. To bring awareness of and aid in identification of similar Thrashers, The Desert Thrasher Working Group (DTWG) has provided reference Desert Thrasher (Figure 11) identification materials.

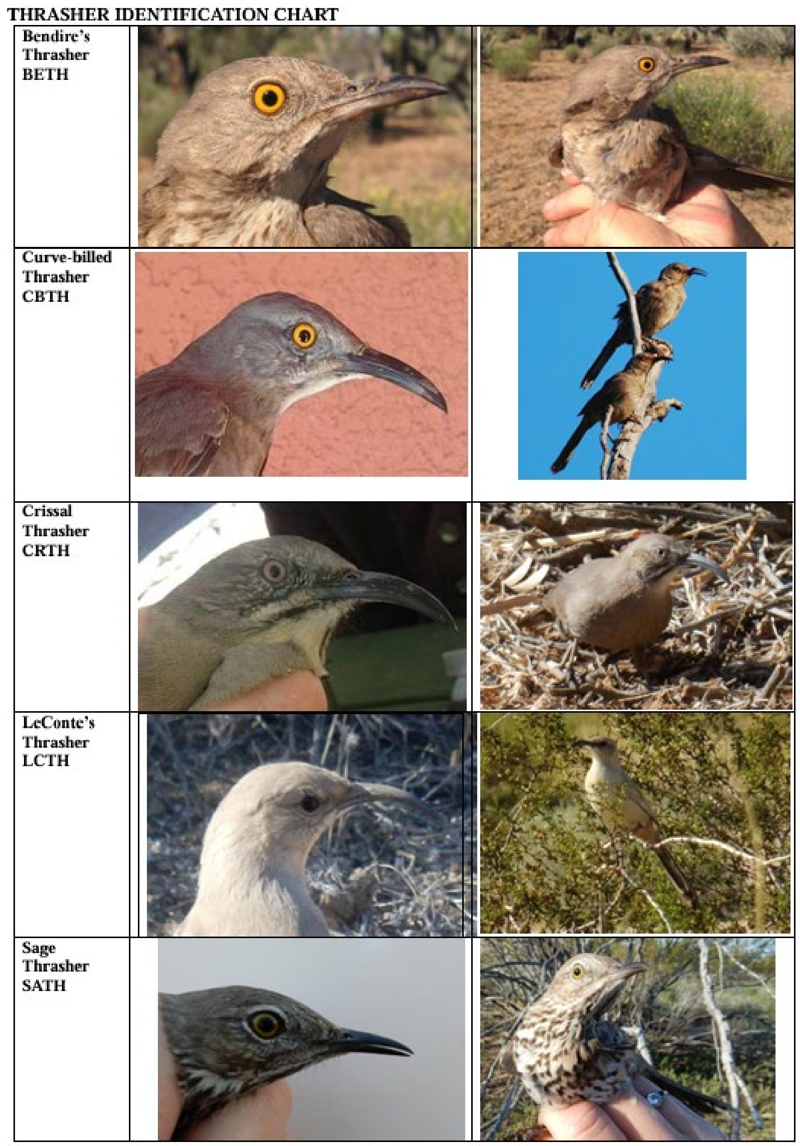


Figure 11. Example of Thrasher identification materials available from DTWG.

Range and Distribution

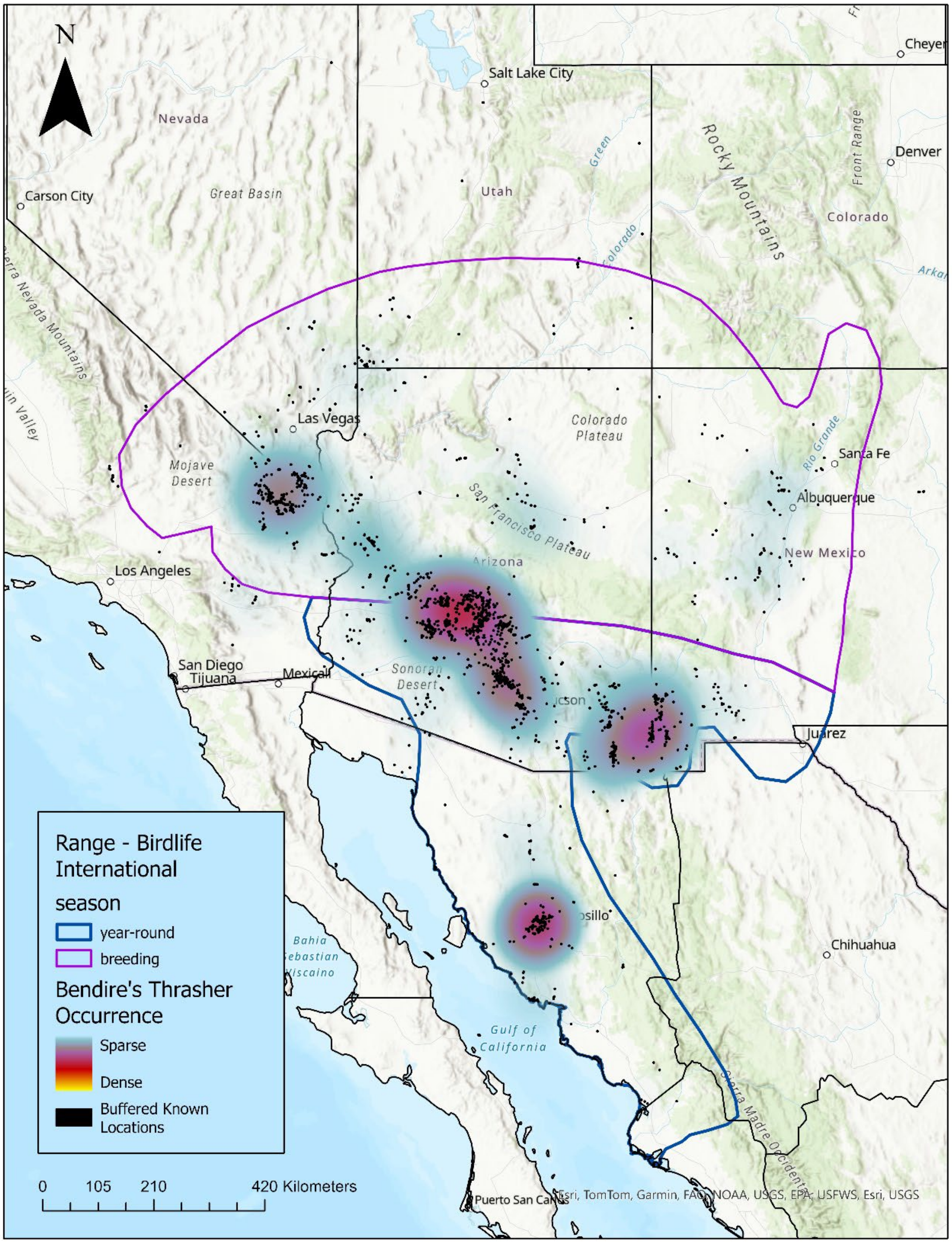
Bendire's Thrasher

Bendire's Thrashers are limited to the southwestern United States and northwestern Mexico (Map 1). They range from approximately the Rio Grande in New Mexico westward through the Mojave Desert in Southern California and Nevada. They occur from sea level near Guaymas, Sonora, Mexico (mostly in the winter) to approximately 1,800 m near Escalante, Utah, with some occurring at over 2,000 m in New Mexico (Gilman 1909, England and Laudenslayer Jr. 2020, Sutton 2020). They extend from southern Sonora to northern New Mexico, northern Arizona, and southern Utah, with a few historical detections in southwestern Colorado. The core of their range occurs in southwestern New Mexico, through Arizona and into parts of Southern California, Nevada, and Sonora. The species occurs rarely in locations outside of its normal range, with extralimital detections in southwestern Colorado, east-central Utah, the greater Los Angeles area, the Farallon islands, and the mountains outside of Bakersfield, California (DeSante and Ainley 1980).

Some changes to the distribution of the species have occurred. In New Mexico, numerous historic locations in the eastern part of the state have not had follow-up detections despite survey efforts (Baumann 2015), and detections are rare east of the Rio Grande. There is some indication of northward range expansion in Nevada with confirmed breeding near Wendover, Nevada. (eBird 2024, Great Basin Bird Observatory unpublished data). In California, the species has undergone some range contractions as habitats have disappeared and shifted.

Bendire's Thrashers are distributed primarily across six Bird Conservation Regions. These include the Great Basin (9), Southern Rocky Mountains (16), Coastal California (32), Sonoran and Mojave Deserts (33), Sierra Madre Occidental (34), and the Chihuahuan Desert (35). Additionally, because there is significant planning focused at an ecoregional scale, we also consider here the breadth of occurrence across North American Level III ecoregions (Wiken 2011) (See habitat section below for complete list).

Map 1. Bendire's Thrasher range map. Known Bendire's Thasher presence from various data sources including eBird (eBird Basic Dataset), Desert Thrasher Working Group surveys, and other research and monitoring efforts. Presence is depicted as a density heat map, with buffered detection points (black polygons). The Birdlife International range map is also included for reference. Note that the presence points included herein represent known locations, but are not comprehensive, and due to use of eBird data, detections are likely skewed toward higher densities in populated areas (e.g., Phoenix, Arizona).



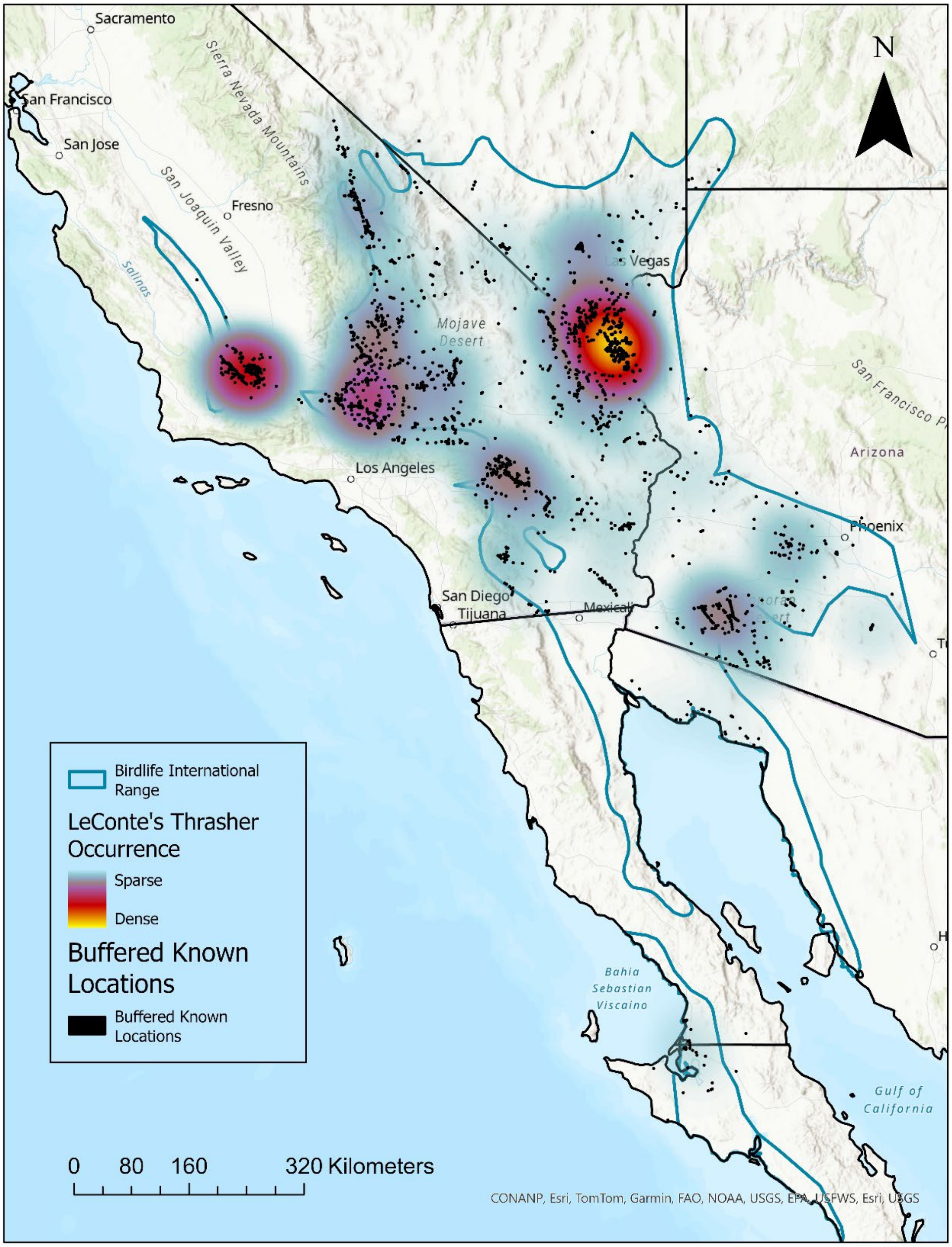
LeConte’s Thrasher

LeConte’s Thrashers (Figure 12) are found in some of the driest portions of the Mojave and Sonoran Deserts of Southern California, southern Nevada, southward around the Gulf of California to about central coastal Sonora and eastern Baja California, and throughout Arizona eastward to Phoenix (Map 2). The *T. l. arenicola* subspecies occurs as an isolated subpopulation on the west coast of the Baja California peninsula.

Local changes to the overall distribution have occurred in many parts of the range. The population in the San Joaquin Valley of California has retracted due to habitat loss and fragmentation (Shuford and Gardali 2008), and the population in the Coachella Valley, California has likely been extirpated (Hargrove et al. 2019) due to land use changes and habitat loss and degradation. LeConte’s Thrashers are primarily found in two Bird Conservation Regions: Sonoran and Mojave Deserts (33), and Desierto de Baja California (40). Researchers from the Comision de Ecologia y Desarollo Sustentable de Estado de Sonora (CEDES), conducted surveys in 2021 to investigate the distribution of Bendire’s and LeConte’s Thrashers with the Comcaac community in areas near Puerto Libertad and Puerto Lobos, Sonora and found that previous populations of LeConte’s Thrashers were no longer observed (CEDES personal communication).

Figure 12. LeConte's Thrasher Photo Credit: J Tinsman.

Map 2. LeConte's Thrasher range map. Known LeConte's Thrasher presence from various data sources including eBird (eBird Basic Dataset), Desert Thrasher Working Group surveys, and other research and monitoring efforts. Presence is depicted as a density heat map, with buffered detection points (black polygons). The Birdlife International range map is also included for reference. Note that the presence points included herein represent known locations, but are not comprehensive, and densities may be skewed toward areas with more survey effort or populated areas.



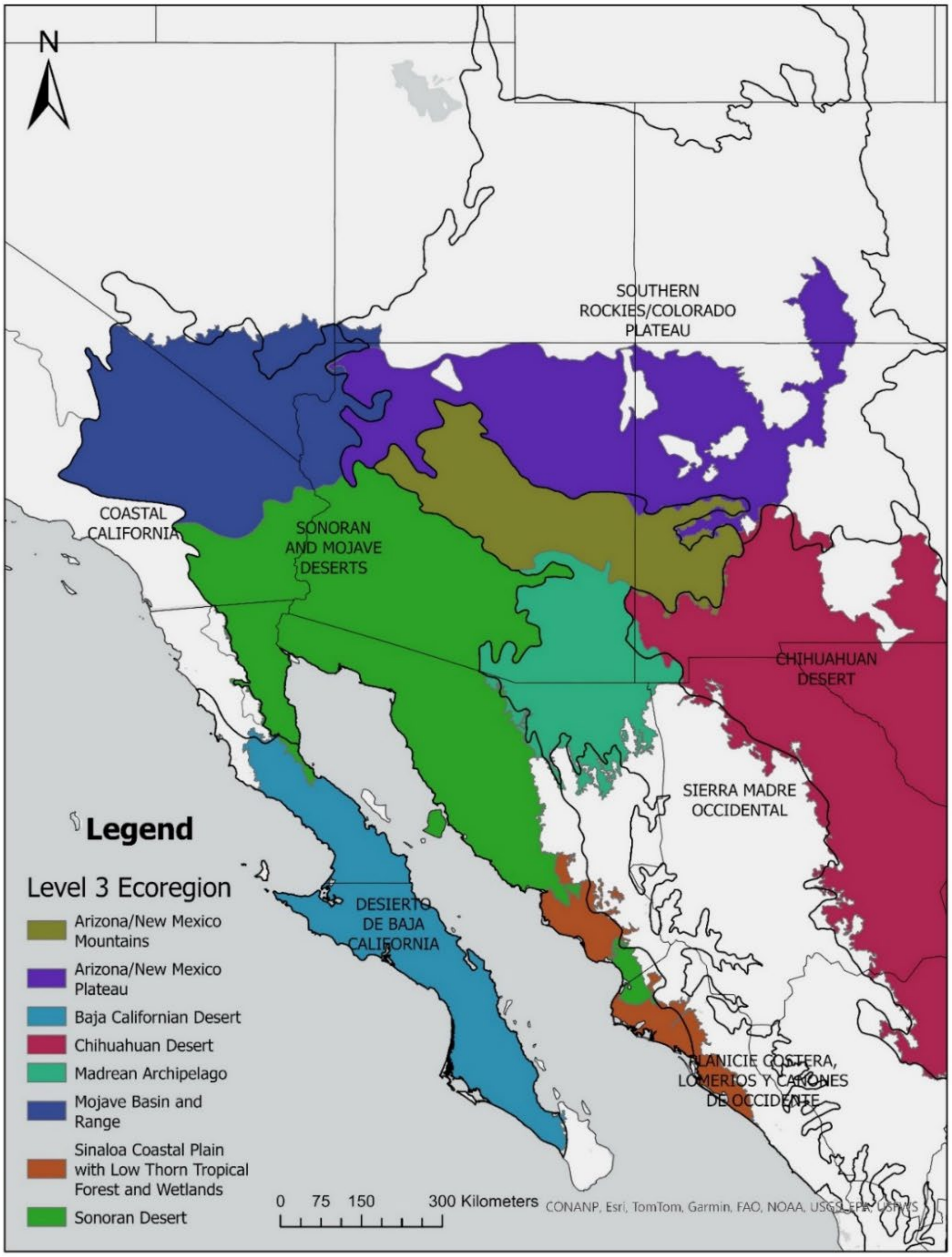
Habitat – Breeding and Nonbreeding

Ecoregional Habitat Descriptions

Specific plant associations and habitat characteristics for these two species vary regionally. We use the Commission for Environmental Cooperation (CEC) Level III Ecoregions (Wiken et al. 2011) as logical cut-points for habitats and include a discussion by Bird Conservation Region (BCR; Bird Studies Canada and NABCI 2014). Habitat descriptions are included below for each of the ecoregions where Bendire's and LeConte's Thrashers occur. We chose to evaluate habitat based on ecoregions because they closely match Bird Conservation Regions, and because some land managers, such as the Bureau of Land Management (BLM), manage many of the key areas where both LeConte's and Bendire's Thrashers (Figure 13) occur, and use these designations for planning.

Figure 13. Bendire's Thrasher Photo Credit: C. McCreedy.

Map 3. Bird Conservation Regions (BCR; Bird Studies Canada and NABCI 2014) and Level III Ecoregions (US EPA 2013) across range of Bendire's and LeConte's Thrashers. BCRs are shown in black outlines, ecoregions are colored according to the legend.



Bendire’s Thrasher

Breeding

Bendire’s Thrashers prefer desert habitats with open ground, including short grasslands with a significant shrub component, open shrublands, or shrubby woodlands with scattered shrubs and trees (Figure 14). Vegetated desert washes are important habitat features across the many different habitat types. Bendire’s Thrashers are found in flat areas with less than six percent slope (Sutton 2020) from near sea level to 2,000 m and prefer firmly packed soils (Shuford and Gardali 2008). Bendire’s Thrashers are not found in large blocks of dense vegetative cover such as riparian woodlands nor monotypic shrub or grassland communities, but they have been recorded using the edge habitat of broken woodlands adjacent to large tracts of open brush and shrublands (Phillips et al. 1983, Corman and Wise 2005, England and Laudenslayer Jr. 2020). In lower elevation desert grasslands and shrublands, representative vegetative species are a variety of cacti such as cholla, Joshua tree, and other yuccas, mesquite, palo verde, acacias (*Senegalia* spp.), agaves (*Agave* spp.), ironwood, *Lycium* spp., and netleaf hackberry (*Celtis reticulata*). At higher elevations, the preferred dominant vegetative cover can include a variety of sagebrush species (*Artemisia* spp.) and junipers within a broken mosaic of cholla cacti or shrubland and grassland (Corman and Wise 2005, England and Laudenslayer Jr. 2020). England (1998) found that in the Mojave Desert of southeastern California, the species is found in the highest densities in habitats which had a higher incidence of Mojave yucca, Joshua tree, and cholla cactus. Bendire’s Thrashers appear to prefer large heterogeneous landscapes with varying degrees of past disturbance and found on floodplains, such as the Gila River in Arizona (Rea 1983).

Figure 14. Sonoran Desert Bendire's Thrasher habitat. La Paz Co., Arizona. Photo Credit: L. Harter.

Nonbreeding

Vegetative characteristics of suitable nonbreeding habitat are poorly known and are conspicuously lacking in the literature (England and Laudenslayer Jr. 2020). It is believed that they are attracted to similar vegetative structure and species composition in the nonbreeding season as on the breeding grounds for the resident or short-distance migrants (AOU 1983, England and Laudenslayer Jr. 1998, Russell and Monson 1998). Howell and Webb (1995) described the thrasher’s habitat preferences as arid to semiarid open or semi-open country, sometimes with a broken grassland component, with scattered bushes, cacti, and shrublands present. Birds tagged during a migration study spent the nonbreeding season primarily in Sonora and used Sonoran desertscrub habitats (Borgman and Kondrat, *in prep*). Plant composition was similar to breeding habitat in the Sonoran Desert, and included mesquite species, ironwood, and palo verde, as well as jumping cholla (*Cylindropuntia fulgida*) and organ pipe cactus (*Stenocereus thurberi*). Year-round residents tagged during this study stayed on their breeding sites throughout the winter.

Bendire's Thrasher Habitat by Ecoregion

Arizona/New Mexico Plateaus and Mountains

Figure 15. Juniper savanna habitat in central New Mexico. Photo credit: C. Borgman.

Arizona/New Mexico Plateaus (10.1.7) are within the Southern Rockies/Colorado Plateau BCR (16), and Arizona/New Mexico Mountains (13.1.1) are within the Sierra Madre Occidental BCR (34) and Southern Rockies/Colorado Plateau BCR (16). Bendire's Thrashers are known from Arizona, New Mexico, and Utah in this ecoregion. Within these two ecoregions, Bendire's Thrashers use similar habitat types. While high-elevation pine and mixed-conifer forests are present, these forest types are not used; Bendire's Thrashers sparsely inhabit lower elevations in pinyon and/or juniper savannas (Figure 15) during the breeding season, often with a dominant cholla cactus component or with other shrub species including four-wing saltbush (*Atriplex canescens*), barberry (*Berberis* spp.), *Lycium* spp., as well as grama grasses (*Bouteloua* spp.). Invasive annuals such as Russian thistle (*Salsola* spp.) are also common.

Figure 16. Vegetated desert wash habitat in central New Mexico. Photo credit: C. Borgman.

Vegetated desert washes are a common and important habitat feature in these ecoregions (Figure 16). Bendire's Thrashers occur at the highest elevations in these ecoregions (up to 2,000 m). Bendire's Thrashers in these ecoregions are primarily migratory.

Mojave Basin and Range

This ecoregion (10.2.1) is included within the larger Sonoran and Mojave Desert BCR (33). Bendire's Thrashers in this ecoregion are found in Arizona, California, Utah, and Nevada. In the Mojave Desert, the Bendire's Thrasher is most often found in areas containing a moderate density of Joshua tree, as well as big galleta (*Hilaria rigida*) or other bunchgrass species. Smaller shrubs are typically present in moderate to high density and include a diversity of species such as Mojave buckwheat (*Eriogonum fasciculatum*), blackbrush (*Coleogyne ramosissima*), white bursage (*Ambrosia dumosa*), ephedra (*Ephedra* spp.), and winterfat (*Krascheninnikovia lanata*). Mojave yucca and banana yucca (*Yucca baccata*) and large to medium size chollas (*Cylindropuntia acanthocarpa* and *C. echinocarpa*) are usually present in medium to high densities (Figure 17). Occasionally, the Bendire's Thrasher is found in areas lacking Joshua tree when large Mojave yuccas are present. Bendire's Thrashers in this ecoregion are primarily migratory.

Figure 17. Bendire's Thrasher habitat in Mojave Basin and Range ecoregion. A nest is present in the cholla in the foreground. Photo credit: J. Tietz.

Sonoran Basin and Range

Figure 18. Sonoran Basin and Range. Pima Co., Arizona. Photo Credit: A. Hannuksela.

This ecoregion (10.2.2) is in Arizona, California, Baja California, and Sonora and is included within the larger Sonoran and Mojave Desert BCR (33). Bendire's Thrashers in this ecoregion are primarily year-round residents. Breeding and nonbreeding populations (both migratory and resident) occur throughout the floodplains and valleys. The vegetation community in the Sonoran ecoregion where Bendire's Thrashers regularly occur is commonly composed of creosote, *Lycium* spp., graythorn (*Ziziphus obtusifolia*), desert tree species such as mesquite, palo verde, and ironwood, as well as large yucca and cholla (Figure 18). In altered habitats, Bendire's Thrashers can be commonly found utilizing mesquite tree and shrub-lined edges of agricultural fields and large livestock operations within the Sonoran ecoregion, as well as small rural farm and ranch communities (Figure 19).

Figure 19. Bendire's Thrasher habitat in Sonoran Basin and Range adjacent to housing in Avra Valley, Arizona. Photo credit: C. Borgman.

Chihuahuan Desert

Found in New Mexico and Chihuahua, the Chihuahuan Desert ecoregion (10.2.4) includes the Chihuahuan Desert BCR (35). Bendire's Thrashers are known in this ecoregion in New Mexico, with expected but unconfirmed occupancy in parts of Chihuahua. In the Chihuahuan Desert, Bendire's Thrashers can be found in desert scrub and desert grassland habitat types (Figure 20), on generally flat slopes and elevations below 1,200 m. They are often found toward the bottom of bajada slopes, and in closed basins. Regardless of plant associations, the amount of bare ground and average shrub height were positive drivers of Bendire's Thrasher occurrence within the Chihuahuan Desert (Sutton 2020). Areas with greater proportion of bare ground and taller than average shrubs were more likely to be occupied by Bendire's Thrashers. They are associated with shrubs such as soaptree yucca, honey mesquite, little-leaf sumac (*Rhus microphylla*), catclaw acacia, and creosote. However, Bendire's Thrashers are not found in homogeneous patches of dense creosote or mesquite. Desert washes are an important feature for Thrashers in this ecoregion. Bendire's in this ecoregion may be resident or migratory.

Figure 20. Bendire's Thrasher habitat in the Chihuahuan Desert in southwestern New Mexico. Photo credit: C. Borgman.

Madrean Archipelago

This ecoregion (12.1.1) includes parts of the Sierra Madre Occidental BCR (34). Bendire's Thrashers in this ecoregion are found in New Mexico, Arizona, Sonora, and Chihuahua. The Madrean Archipelago, often referred to as the "Sky Islands", are made up of basin and range topography. Within this region, Bendire's Thrashers are found within the low-lying basins and low hills. These broad, low-lying valleys are dominated by deserts and desert grasslands, with tobosa grass (*Pleuraphis mutica*) and grama grasses, mesquite, yucca, and creosote (Figure 21). Bound by the Chihuahuan Desert to the east and the Sonoran Desert to the west, this ecoregion shares plant associations with both adjacent ecoregions. Bendire's Thrashers in this ecoregion may be resident or migratory.

Figure 21. Bendire's Thrasher habitat in Madrean Archipelago ecoregion. Photo credit: C. Rubke.

Sinaloa Coastal Plain with Low Thorn Tropical Forest and Wetlands

Figure 22. Bendire's Thrasher habitat in Sinaloa Coastal Plain, Sonora. Photo Credit: A. Hannuksela.

This ecoregion (14.3.1) is within Sonoran and Mojave Desert BCR (33) in Sinaloa and Sonora. Bendire's Thrashers seem to prefer disturbed areas in this ecoregion (Figure 22). At low elevations, this ecoregion has dense thornscrub and high abundance of columnar cactus (*Stenocereus* spp. and *Pachycereus* spp.) and dense shrubs. Higher elevations have taller trees and thorn forest, though Bendire's do not occur in these habitat types. The low elevations have some of the most expansive agricultural development in Mexico. Birds in this ecoregion are known with few records from Sonora and Sinaloa during the winter in disturbed areas.

LeConte's Thrasher

Breeding and Nonbreeding

Year-round residents of the driest deserts, LeConte's Thrasher habitat is the same throughout the year. Habitat is typically distributed within alluvial fans, desert flats, dunes, or the margins of river drainages or dry lakes (Sheppard 2018). They prefer habitats with scattered cholla and saltbush plant associations (Grinnell 1933, Zeiner et al. 1990, Sheppard 2018). In general, the species occupies desert scrub habitat (Zeiner et al. 1990, Sheppard 2018), and Mojave yucca and Joshua tree dominated woodlands (Garrett and Dunn 1981, Zeiner et al. 1990). They can occur in areas of nearly pure creosote and bursage (*Ambrosia* spp.) if there is a minimal amount of cholla or other dense shrubs present to serve as nesting substrate habitats. Areas of ample soil, sand, or leaf litter are necessary for vegetation and shelter for their prey. They are often associated with dunes, and rarely with locations where bedrock is close to the surface. Shrubs, including cholla, rarely exceed two meters in height, with scattered larger trees and yucca often present. Surface water is almost never present. LeConte's thrashers are often found in heterogeneous shrub cover; they can often be found near desert washes or arroyos that typically offer a wider variety of shrubs and at slightly greater sizes and densities than their surrounding flats (Figure 23, and where larger shrubs can support nests (Grinnell 1933, Engels 1940, Sheppard 2018). Roadways across washes and lower depressions often have increased shrub sizes due to increased runoff, and therefore can be important features for this thrasher as well.

Figure 23. LeConte's Thrasher habitat in a vegetated desert wash on the Carrizo Plain of California. Photo credit: J. Tietz.

They are found in flat areas of less than five percent slope (Fletcher 2009). They can be found in higher relief areas with smaller, flat valleys and low rolling hills (Sheppard 2018). A nest was recently found in a juniper, indicating thrashers may be moving up in elevation as result of drought or climate change (Sheppard 2018). This species tends to occur in substrates that thrive in alkaline soils (Grinnell and Miller 1944, Sheppard 1970, 1973).

Ecoregional Habitat Descriptions

Mojave Basin and Range

This ecoregion (10.2.1) is included within the larger Sonoran and Mojave Desert BCR (33). LeConte's Thrashers in this ecoregion are found in Arizona, California, and Nevada. In the Mojave Desert, the LeConte's Thrasher is most often found in areas of little topographic relief. This species is often associated with the creosote and white bursage cover types which make up the majority of the Mojave Desert, but only when occurring in conjunction with larger plants that offer appropriate structure for nesting. Within this habitat type, LeConte's Thrashers are typically found in areas containing at least one of the following species: Mojave yucca, silver cholla, or buckhorn cholla (Fletcher 2009, Figure 24). Other important species include desert willow (*Chilopsis linearis*), desert almond (*Prunus fasciculata*), and catclaw acacia, which are often associated with desert washes or arroyos. Additionally, the LeConte's Thrasher can be found nesting in saltbush-dominated cover types, specifically in cattle saltbush (Fletcher 2009, Sheppard 2018).

Figure 24. LeConte's Thrasher habitat in Mojave Basin and Range ecoregion. Photo credit: D. Fletcher.

Sonoran Desert

This ecoregion (10.2.2) is in Arizona, California, Baja California, and Sonora. This ecoregion is included within the larger Sonoran and Mojave Desert BCR (33). It is a dry subtropical climate marked by hot summers and mild winters. Most of the precipitation occurs during summer monsoons, and light winter rains. Common vegetation includes small-leaved trees such as palo verde, mesquite, and ironwood. Shrubs

Figure 25. Typical LeConte's Thrasher habitat in Sonoran Desert ecoregion. Photo credit: C. Kondrat.

and cactus, such as creosote, brittlebush *(Encelia farinosa*), and cholla are common (Figure 25).

The ecoregion contains alluvial valleys and fans, fault block mountains, and lower mountains/hills. Sand dunes, large open dry washes, and arroyos are important for this thrasher and other wildlife. LeConte's Thrashers commonly occur in such areas with sparse vegetation. Typical desert habitat consists of open, flat to gently rolling hills and shallow braided washes (Figure 26). Saguaros are typically absent where LeConte's can be found. The vegetation community is commonly composed of saltbush, bursage, and *Lycium* spp. Trees and larger desert shrubs are very sparse (Corman and Wise 2005).

Figure 26. Aerial photograph of LeConte's Thrasher habitat in the Sonoran Desert. Photo credit: M. Reigner.

10.2.3 Baja California Desert/Desierto de Baja California (40)

The ecoregion includes southern two-thirds of the Baja California peninsula. It contains the coastal plains and mountain ranges of the peninsula. Desert vegetation is the dominant type, gaining significant moisture from ocean fog on the west coast. Xeric shrubs, including several endemics, make up the majority of the ecoregion, which is superficially similar to Sonoran Desert vegetation. Common species include: Vizcaíno agave (*Agave vizcainoensis*), cirio (*Fouqueria columnaris*), creeping devil cactus (*Stenocereus eruca*), sour pitaya (*Stenocereus gummosus*) and red barrel cactus (*Ferocactus peninsulae*). Large areas have been converted to vineyards and other agriculture. High elevation mountain ranges host communities of oak and tropical deciduous forests but no LeConte's Thrashers, which inhabit the lowlands.

Causes of Decline

Both Bendire's and LeConte's Thrashers have experienced significant population declines over the last 50 years (Sauer et al. 2020, Rosenberg et al. 2019, Rosenberg et al. 2016). We assessed current threats to thrasher populations and include a detailed discussion of those threats. Historically, land use practices have reduced habitat availability and quality. Both thrasher species prefer flat, sparsely vegetated habitats and desert washes. The physical features of these habitats make these areas desirable for land conversion and recreational uses that include urban, agricultural, infrastructural, energy development, and off-highway vehicle (OHV) travel. The intersection between thrasher habitat needs and competing land uses such as urban development has resulted in habitat loss, range reduction, and overall population decline over the last 50 years.

Both species have small overall population sizes and patchy distributions, increasing their vulnerability to extirpation, local and otherwise, and the suite of threats to these species are often interrelated. Land uses such as grazing practices and OHV use, may result in degradation of habitat or disturbances that may result in decreased survival or productivity. Overstocking of cattle, especially during drought, may lead to the proliferation of invasive annuals, woody plant encroachment (in some regions), reduced cover, compacted soils, and other landscape impacts that reduce the viability of habitat and increase fire risk. Finally, impacts from climate change are compounding and can negatively impact survival and productivity for thrashers as well. Prolonged droughts reduce primary productivity, impacting food availability, and can exacerbate threats from agricultural practices, invasive plants, and fires, thus leading to reduced breeding attempts or reduced nest survival, plant mortality, as well as direct mortality of thrashers. Increasing high temperatures exacerbate drought conditions by increasing water deficits through increased evapotranspiration, and place additional physiological demands on both thrashers and their food resources. Extreme and unpredictable weather events may also cause rare but significant impacts to thrashers resulting from floods and erosion, early or severe low temperatures, droughts, and prolonged heat waves.

Threats Assessment

Threats to both Bendire's and LeConte's Thrashers were assessed across the range of each species by experts in each region. Threat rankings were conducted according to the methods outlined in Salafasky et al. (2008). Threats were assessed individually for each species in every state and Bird Conservation Region where they occur, then overall rankings were combined across the range of the species for an overall threat ranking. Because both Bendire's and LeConte's Thrasher distributions overlap in many areas, and because they share similar habitat types undergoing similar threats, we present the results of the threats assessment for both species within Table 4 (below).

Threats are ranked according to three criteria: scope, severity, and irreversibility (Salafsky et al. 2008). In summary, this ranks threats based on the proportion of thrasher populations affected by each direct threat, the level of damage caused by each direct threat, and the degree to which effects from a threat can be reversed. Direct threats as assessed through this process are anthropogenic by nature and have negative effects on bird populations. For full discussion and definitions about the process of ranking threats, see Salafsky et al. (2008). The Desert Thrasher Working Group broke level two threats into more specific "level three" threats that impact thrashers. Below, threats are discussed according to level two and three threats as defined within. Numbers correspond to definitions from Salafsky.

Table 4. Direct threat rankings for both Bendire's and LeConte's Thrashers as ranked by members of the Desert Thrasher Working Group. Seventeen direct threats were identified and ranked as Medium (M), High (H), or Very High (VH). Threats that were ranked Low for both species are not included. Table is broken up and used as headings for threats descriptions discussed below.

Salafsky Level Two Threat	**Level Three Threat**	**Bendire's Thrasher**	**LeConte's Thrasher**
1: Residential and commercial development	1.1: Urban sprawl	H	H
	1.2: Ranchettes	M	L
	1.3: non-housing related development	M	M
2: Agriculture and aquaculture	2.1: Conversion of habitat to cropland	M	M
	2.2: Conversion of habitat to orchards, vineyards, cannabis farms	M	M
	Improper grazing - current	M	M
	Improper grazing - historic	H	H
3: Energy production and mining	Solar power facilities	M	H
	Wind power facilities	M	M
4: Transportation and service corridors	roads and railways	M	M
6: Human Intrusions and disturbance	Legal OHV use	M	M
	Illegal OHV use	M	M
7: Natural systems modifications	7.1: Fire and fire suppression	H	H
8: Invasive plant species	8.1 Invasive non-native/alien species	M	H
11: Climate change and severe weather	11.1: Habitat shifting and alteration	VH	VH
	11.2: Droughts	H	H
	11.3: Temperature extremes	H	H
12: Other	12.1: Data gaps	H	H

Discussion of Direct Threats:

1: Residential and Commercial Development

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
1: Residential and commercial development	1.1: Urban sprawl	H	H
	1.2: Ranchettes	M	L
	1.3: non-housing related development	M	M

Both Bendire’s and LeConte’s Thrashers occupy flat desert and semi-desert habitats that continue to be targeted for urban and suburban development. The southwestern United States (Arizona, California, Colorado, Nevada, New Mexico, Utah) is the fastest-growing region of the country and is expected to continue along a similar trend (Theobold et al. 2013, Beavers et al. 2022). Phoenix is the fifth largest city in the U.S., and five of the 15 fastest-growing U.S. cities (> 50,000) are in the greater Phoenix area (U.S. Census Bureau 2020). The human population of Maricopa County (Phoenix) has increased from 971,000 in 1970 when Breeding Bird Survey efforts began to 4.4 million in 2020 (U.S. Census Bureau 2020). While Maricopa County is one of the greatest and largest urban centers in the habitats of desert thrashers, Pima County, Arizona, Clark County, Nevada, and Riverside County, California have also experienced rapid urbanization. As the populations have grown, urban land cover in the southwest has also increased by 45% since 1973, with a projected doubling of urban cover from 4.1 million acres in 2010 to 9.3 million acres by 2050, and the footprint of exurban development is expected to increase from 13.6 million acres in 2010 to 19.1 million acres by 2050 (Theobold et al. 2013). Land type conversion has primarily been from grass or shrublands to urban (Theobold et al. 2013). There is significant overlap between the fastest-growing urban centers and historical Thrasher distributions, in the Sonoran and Mojave deserts (e.g., Phoenix and Tucson, Arizona, Las Vegas, Nevada, Coachella Valley and Apple Valley, California). Loss of habitat due to urban expansion has very likely caused declines in Thrasher populations, and in the case of Coachella Valley, historic LeConte’s Thrasher populations have largely been extirpated (Hargrove et al. 2019). Direct threats to thrashers from urban expansion also include increased predation risk from outdoor cats, increased collision risk (e.g., vehicles, buildings, roadways, powerlines) and reduced food resources in many cases.

Much the same to urban expansion in nature, the expansion of the anthropogenic footprint related to the development of commercial properties similarly impacts thrasher habitat targets. Development of data centers, factories, shopping centers, indoor cannabis farms, etc. contribute to the expansion of building footprints and habitat loss and fragmentation. Included under agricultural threats, the proliferation of cannabis farms can be locally problematic, especially in BCR 33 in California where large indoor farms require an expansion of building footprints. This also creates a large water demand that impacts groundwater.

However, not all development necessarily excludes these thrasher species. Bendire's Thrashers in particular will occupy low-density exurban housing and rural edges around "ranchettes" where suitable habitat is adjacent or where landscaped or other woody vegetation provides structure and cover for nesting. Both thrashers commonly nest near houses or other development such as corrals and farmhouses in these scenarios (Dawson 1923, Kondrat pers. comm., England and Laudenslayer Jr. 2020, Sheppard, pers. comm.). Bendire's Thrashers may be attracted to taller and more dense vegetation that benefits from irrigation and resultant increased food resources. Threats from increased predation and collision risks, and how nesting in proximity to housing impacts demographics such as nest survival, productivity, or adult and juvenile survival are unknown. The density of development tolerated by thrashers is also unknown, though thrashers do not occupy urban or suburban areas where adjacent native or other suitable habitat is not present. The extent of suitable habitat (minimum patch size) required for Bendire's Thrasher occupancy is also unknown. The trend of subdividing larger rural parcels into smaller "ranchettes" may create some habitat suitable for Bendire's Thrashers but may also eventually result in development at a density that is unsuitable for thrashers; more research is required on patch size requirements, fecundity, and survival for thrashers in these habitats.

A big difference between these two thrashers is their general mobility. Bendire's Thrashers are migratory over much of their U.S. range, while LeConte's Thrashers might not move more than 5-8 km in a lifetime. Dispersal into isolated patches of suitable habitats is greatly restricted for the latter, while the former has a greater likelihood of finding other suitable nesting habitats with changing habitat conditions.

LeConte's Thrashers are generally more sensitive to disturbance and are less likely to tolerate urban development, though as stated above, will make use of man-made structures for nesting or will nest near low density development in certain scenarios (Sheppard 2018). They have large minimum patch size requirements. In the San Joaquin Valley of California, patches of habitat less than 160 ha in size were not occupied despite typical use of 10–30 ha per pair (Sheppard 2018). Post-fledging juveniles in southern Arizona also used very large swaths of habitat (average 365 ha; Blackman and Diamond 2015). In addition, they have weak dispersal capabilities and patchy distributions that make it difficult for them to adapt to urbanization (Fletcher 2009, Sheppard 2018). In the Coachella Valley of southern California, which has changed from open desert scrubland to housing and agriculture since the 1950s (Figure 27), LeConte's Thrashers were relatively abundant according to historic records (pre-1940). However, during surveys in 2004 and 2005, few LeConte's Thrashers were noted (Hutchinson 2005), and in 2019 no LeConte's Thrashers (Hargrove et al. 2019) were detected, despite detections occurring in the surrounding areas, representing extirpation or near extirpation of LeConte's Thrashers in this former stronghold.

Threats from urban expansion were most relevant in the Mojave Desert regions (BCR 33) of California and Nevada including Riverside, Coachella Valley, Victorville, California and Clark County, Nevada.

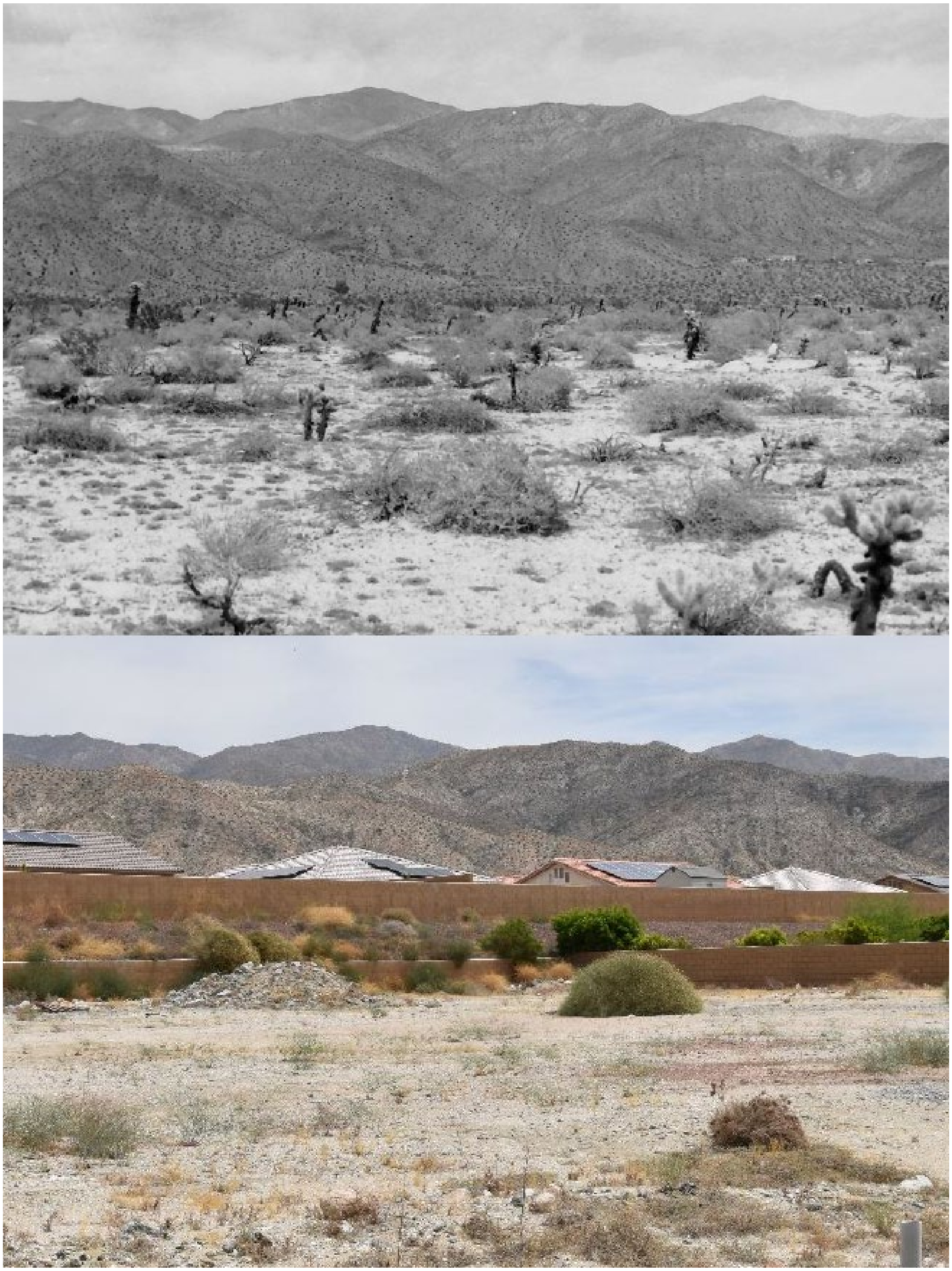


Figure 27. LeConte's Thrasher habitat (top) in Desert Hot Springs, California taken in 1970 (Photo credit: J. Sheppard), versus cleared habitat and housing at the same location taken in 2015 (bottom, photo credit: L. Hargrove).

2: Agriculture and Aquaculture

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
2: Agriculture and aquaculture	Conversion of habitat to cropland	M	M
	Conversion of habitat to orchards, vineyards, cannabis farms	M	M
	Improper grazing - current	M	M
	Improper grazing - historic	H	H

Agricultural conversion

Agricultural conversion from rangelands and desert scrub to irrigated crop land also results in habitat loss for thrashers and can contribute to threats by reducing foraging resources (Figure 28). Agriculture is not as prevalent in the southwestern United States as in other parts of the county (e.g., the plains states or south) due primarily to aridity and water scarcity. However, there is still significant agricultural conversion in areas that can be irrigated. Cropland in the arid southwest and Mexico is mostly situated along river valleys and the coast https://www.croplands.org/app/map. Cropland as a land cover type has marginally increased in Arizona, Nevada, and California since 1973, while it has decreased significantly in New Mexico (Theobold et al. 2013). Agricultural conversion has also been significant in Sonora and parts of Baja California. Locally, agricultural conversion may conflict with available habitat for thrashers. Again, because thrashers are often found in sparsely vegetated and flat slopes, often in valleys, agricultural conversion occurs in areas likely to hold suitable Thrasher habitat. Conversion occurs for orchard crops such as pecan and almond, vineyards, and corn, cotton, alfalfa, wheat, and vegetable crops (primarily vegetable crops in the lower Colorado River Valley in Arizona, California, Sonora, and Baja California). Southern Sonora has large areas of irrigated wheat, but Bendire’s Thrasher occurrence is generally sparse and during the winter.

Figure 28. Agricultural expansion in Sonora. Photo Credit: A. Hannuksela.

LeConte's Thrashers in the Coachella, San Joaquin, and Imperial Valleys in California, as well as the Gila Valley in Arizona, have lost large swaths of habitat to agricultural expansion since the 1960s (Sheppard 2018). LeConte's Thrashers do not occur in farmed habitats, nor are they observed in areas immediately adjacent to heavy agricultural use (Sheppard 2018). These areas that had previously been strongholds for LeConte's Thrashers have seen declines or extirpations (San Joaquin Valley). Agricultural expansion in Sonora, Mexico has been prevalent for many years and continues to grow. In some areas, such as between Hermosillo and the Pacific coast, some fields have been abandoned, but expansion is still occurring in other parts of the state. Although aquaculture ranked as a low threat overall for both species, it was identified as a significant threat locally in parts of Sonora and Baja California where shrimp farms cover large footprints of upland habitat conflicting with suitable thrasher habitat. Other threats from agriculture and aquaculture aside from habitat loss and fragmentation include potentially reduced food resources for thrashers, and the introduction of pollutants from herbicides, pesticides, and effluents.

In some areas of the southwest, sites previously converted to irrigated crops are being abandoned as water availability becomes less reliable. Along the Gila River, Bendire's Thrashers were once abundant among indigenous farmland and in floodplains (Rea 1983). In Avra Valley and other areas, abandoned farmland presents opportunities for mitigation and restoration planning.

Grazing Impacts from current and historic practices

Bendire's and LeConte's Thrashers occur across grasslands and shrublands on private, tribal, and public lands that are frequently used for grazing cattle and other livestock. The arid southwestern United States and northwestern Mexico are often characterized by variable and frequently low annual precipitation, and stocking rates for cattle are often inappropriately high for environmental conditions. Additionally, arid grasslands have not evolved in the presence of large grazing mammals, and plants lack adaptations to livestock grazing. Overstocked range lands can result in several habitat degradations including increased soil compaction and run-off, proliferation of invasive annual plant species and dense, monotypic stands of native shrub species (e.g., mesquite and/or creosote), loss of plant cover, and occasional direct mortality of bird nests from livestock (Nack and Ribic 2005).

Grazing can be more prevalent in Bendire's Thrasher habitat than LeConte's, although occasional rotation of cattle, usually at low densities, does occur in LeConte's Thrasher habitat. Historic grazing practices were identified as a high threat whereas current grazing was ranked as a medium threat for both species. Historic grazing practices (overstocking) resulted in landscape changes including changed hydrology, increased shrub and tree cover, and increased invasive plant species. Bendire's Thrashers do not occur in areas of dense monotypic shrub cover such as creosote or mesquite. Invasive annuals are evident on most plots occupied by Bendire's (77%) and LeConte's Thrashers (93%) in range-wide surveys (Ammon et al. 2020), so presence of invasives does not result in avoidance by either thrasher species, though the impacts on foraging suitability and overall productivity or survival are unknown. Increases in invasive annuals can contribute to increased fire risk, changing fire frequency and resulting in permanent conversion of preferred shrub/woody habitat to annual grasses (discussed below in section 8 and 9). Bufflegrass (*Cenchrus ciliaris*) is used as livestock forage in Sonora, where native vegetation is cleared for bufflegrass pasture. It is an invasive species throughout southern Arizona. Because both species require bare ground for foraging, increased ground cover from invasive annuals likely has an additional negative impact.

However, livestock grazing is a common land use where thrashers, and especially Bendire's Thrashers, occur and can be compatible with thrasher presence. Evidence of livestock use was present on 53% of occupied plots, range wide, and had a minor but positive statistically significant effect on occupancy; evidence of livestock was only present on eight percent of occupied LeConte's Thrasher plots (Ammon et al. 2020). At nest sites in California, occupied sites had less soil compaction than unoccupied sites (Hargrove et al. 2019). In some cases, limited grazing can have a positive impact on foraging by LeConte's and Bendire's Thrashers. Thick grasses can impede thrasher access to their prey, a minor reduction by grazing in non-native grasses allowed the thrashers more access to substrate preferred by arthropod prey (Sheppard 2018). Bendire's Thrashers are commonly detected at infrastructure related to grazing such as stock tanks, windmills, and corrals, and may be attracted to the increased structure, larger trees and shrubs associated with these sites, as well as increased foraging opportunities related to increased water availability and cow manure. The impacts of grazing on nest survival, productivity, or other measures are largely unknown, but there is some evidence of negative associations.

3: Energy Production and Mining

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
3: Energy production and mining	Solar power facilities	**M**	H
	Wind power facilities	**M**	**M**

As alternative sources of energy to fossil fuels are sought to slow the impacts of climate change, renewable energy production will continue to grow. In the southwestern United States and northwestern Mexico, renewable energy development occurs primarily as wind and solar energy. Within the ranges of these thrasher species, oil and gas extraction is rare, but renewable energy development is becoming more common. Direct threats to thrashers from renewable energy development include mortality from collision or singeing in the case of concentrating solar-thermal power (CSP) facilities. Collision may occur from wind turbines, solar panels, as well as gen-tie lines, fencing, and other infrastructure. Because Desert Thrashers spend most of their time on the ground, collision risk from wind turbines is expected to be relatively low. Collision risk with solar panels is less well understood but is also probably low, though neither of these risks have been formally studied. However, the loss and fragmentation of thrasher habitat has the potential to occur at large scales and pose a significant threat to Thrasher populations. Areas cleared of vegetation for development will result in habitat loss for Thrashers, and whether Thrashers will use habitat adjacent to disturbance, how close, and what minimum size of retained habitat is needed for occupancy are unknown. Fragmentation and infrastructure development often result in increased predation risk and may also affect food and water resources. Both solar and wind facilities require development of infrastructure such as gen-tie lines, fencing around electrified components, and construction of roads and pads that also increase risks from habitat fragmentation and degradation, and risk of collision, entrapment, and predation increase. In particular, Common Ravens (*Corvus corax*) can have significant negative impacts on numerous bird species as predators of nests and young, and their predicted occurrence was positively influenced by transmission lines, roads, and edge habitats (Coates et al. 2014). Specific impacts from increased predation, decreased productivity, and survival (nest, juvenile, and adult) related to habitat loss and fragmentation are all data gaps.

Solar

In the United States, the greatest solar energy resource potential coincides with the southwestern states (Arizona, California, Colorado, New Mexico, Nevada, and Utah; NREL http://www.nrel.gov/gis/data_solar.html), and indeed, most operational solar facilities are found in this region (in Walston et al 2016). Photovoltaic (PV) solar has increased by 41% from 2009-2020 and is expected to increase tenfold again by 2040 (Kruitwagen et al. 2021). Both Bendire's and LeConte's Thrashers will be impacted by these increases in solar energy build-out. Solar facilities are in areas of low relief and sparse vegetation where solar resources are highest and where costs are lowest to prepare sites for installation (Figure 29). Utility-scale solar requires large footprints ranging from 1.4–6.2 ha/MW. As solar development continues to grow, it is projected that 370,000 to 1,400,000 ha will be needed to meet projected needs (Hernandez et al. 2015a, Walston et al. 2016). In the United States and Mexico, targeted land cover types are primarily

Figure 29. Google Earth image of solar facilities near Desert Center, California, outside of Joshua Tree National Park. Red line is 1 km for scale.

aridlands (Figure 30), followed by agricultural areas and grasslands (Kruitwagen et al. 2021).

Solar development occurs on private lands and public lands. On BLM lands, areas have been specifically designated for solar development (Solar Energy Zones; SEZ). In 2012, 13 SEZ were established across six states, totaling 285,000 acres (Bureau of Land Management and U.S. Department of Energy 2012). In 2023, the BLM proposed to expand the existing SEZ from six states to 11 states. The final proposed plan makes 31 million acres available for solar development across 11 states (Bureau of Land Management 2024), illustrating the scale of the potential conflict. Development will be focused within 15 miles of existing or proposed transmission lines or existing energy corridors and may extend beyond this 15 mile footprint when occurring on previously disturbed lands. Development may be proposed on sites up to 10% slope, with Desert Thrashers occupying slopes of less than 5-6%.

Figure 30. Image of Aqua Caliente Solar Project near Gila Bend, Arizona. Photo Credit: https://clui.org/ludb/site/agua-caliente-solar-project

In the final 2012 designation for SEZ, lands were excluded for various reasons, including sensitive habitats, cultural resources, as well as land with greater than five percent slope (Bureau of Land Management and U.S. Department of Energy 2012). LeConte's and Bendire's Thrashers probability of occurrence declines at slopes greater than five to six percent (Fletcher 2009, Sutton 2020), highlighting the overlap between developable areas for solar and suitable thrasher habitat. The Environmental Impact Statement (EIS) for these SEZ does include consideration of LeConte's and Bendire's Thrashers, including pre-construction surveys in some cases (Bureau of Land Management and U.S. Department of Energy 2012). However, as analyzed within the EIS, effects are generally considered to be low, citing the extent of potentially suitable habitat available elsewhere. Unfortunately, specific habitat characteristics that define Thrasher occupancy, including structural characteristics, soil properties, plant species, and disturbance are not well understood, and are not captured by habitat layers. The EIS considers that all desert or desert scrub habitat types are suitable for Thrashers and does not consider the actual occupancy of Thrashers at individual sites. Based on evaluation of publicly available data such as eBird and DTWG survey data, of the current 13 SEZs (as of 2024), four are outside of either Thrashers' expected range, four have had previous Thrasher occupancy, and five have had nearby Thrasher occupancy (eBird 2024, DTWG unpublished data). No formal surveys were conducted to evaluate Thrasher occupancy or density. Solar development is expected to have a greater impact on LeConte's Thrashers than Bendire's Thrashers based on the location of current and expected solar build-out, as well as LeConte's Thrasher's need for large swaths of undisturbed habitat. However, any utility-scale solar within occupied Thrasher range could have potential negative impacts.

Solar expansion is also increasing in Sonora and is expected to grow exponentially in the coming years. In 2023, the Mexican government introduced the "Plan Sonora de Energias Sostenibles" that aims to invest seven billion U.S. dollars into renewable energy growth, including developing photovoltaic facilities and transmission infrastructure, as well as lithium exploitation. This plan has the state of

Sonora leading Mexico in developing renewables. Some areas proposed for development include areas known to be occupied by Desert Thrashers. Meanwhile, construction has started on the first phase of a one-gigawatt solar development near Puerto Peñasco in northwest Sonora (Cabanillas 2022) on a site that contained habitat occupied by LeConte's Thrashers (eBird 2024).

It is recommended that new solar energy be focused on local distributed power production. Additionally, it is recommended that development is directed to already compromised areas such as former landfills, parking lots, rooftops, over canals, and roadway/interstate rights-of-way, or other previously degraded landscapes rather than through land-use changes of native or intact desert habitats. In California, for example, developed areas offer ample opportunity to achieve significantly more energy production than energy demands (Hernandez et al. 2015b).

When development of utility-scale solar occurs within native or intact habitats, design features can also help minimize damage to landscapes by leaving vegetation and soils intact between panel rows and around development. Because of the potential conflicts between solar development and thrasher habitat, the Desert Thrasher Working Group has developed "Recommendations for Conserving Bendire's and LeConte's Thrashers at Utility-Scale Solar Sites", to outline beneficial practices and to minimize impacts from development and operations to Thrashers. Additional research is necessary to pinpoint Thrasher response to the habitat loss, fragmentation, and disturbance caused by solar installations and to identify and recommend effective minimization measures that can be taken to reduce the adverse effects on these species.

Wind

Current wind build-out within either Thrasher's range is relatively minimal as of 2024, though locally some facilities do occur within the Imperial and Coachella Valleys in California, the northwestern corner of Arizona, and scattered sites north of the Mogollon Rim in Arizona, equaling approximately 1,850 MW (Hoen et al. 2018). However, an increase in wind development is expected, though wind resources are only marginal for development across most of these thrashers' ranges (NREL 2017, Boggie et al. 2023). The best potential for wind build-out is localized along the northern interior of the Baja Peninsula, and at scattered locations throughout their range (NREL 2017, considered wind resource at 80 m), though improvements in technology should allow expansion into lower wind resource areas in the future. Development is being investigated in more areas within thrasher range, primarily in Arizona north of the Mogollon Rim, but also some locations in southern Arizona and California (FAA database, https://www.fws.gov/library/collections/federal-aviation-administration-faa-wind-turbine-location-data).

Mining

Mining for gold and rare earth minerals was ranked low overall but may have impacts locally. There are several large-scale mines planned for eastern Sonora. Lithium and other minerals may be targeted in Imperial County, California near the Salton Sea, Willcox Playa in Cochise County, Arizona, and casual prospecting in thrasher hotspots such as the Coolgardie Mining District may also negatively impact habitat occupied by LeConte's and Bendire's thrashers.

4.1: Transportation and Service Corridors

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
4: Transportation and service corridors	Roads and railways	**M**	**M**

Expansion of roadways within thrasher habitat is another source of habitat loss and fragmentation. The level of impacts from expansion will be dependent upon selected routes. Residential road expansion can increase risks from collision with vehicles and further fragment habitat but can be compatible to some degree with thrasher presence, especially in the case of Bendire's Thrasher that are more tolerant of low-density development. LeConte's Thrashers would be more heavily impacted by this type of development.

Other expansion could be more detrimental, as in the case of the proposed expansion of Interstate 11 (I-11) to connect Nogales to Phoenix and Las Vegas. Some segments would include construction of new interstate facilities through known areas of significant Bendire's Thrasher occupancy within the Hassayampa Plains near Wickenburg, Arizona, and Avra Valley, outside of Tucson, Arizona. The corridor that was approved in the Arizona Department of Transportation's (ADOT's) Tier One programmatic EIS can be found on page five of the Final Tier 1 EIS. An interactive map of the route is also available. Arizona Department of Transportation will proceed with a Tier 2 NEPA analysis (i.e., project level analysis) for the northern section of I-11 (Wickenburg to Interstate 10); NEPA analysis is expected to begin in 2024. The other segments of I-11 will proceed with Tier 2 NEPA analysis as funding becomes available.

Additionally, impacts from low-use gravel roads, especially those with undersized culverts in wilderness areas and other protected areas include significant erosion impacts that remove woody vegetation. Removal and decommissioning of these existing features would likely reduce the negative impact of flood events and erosion on washes and surrounding woody vegetation (e.g. saltbush) used by thrashers. It would also reduce access and use of illegal OHVs in protected areas (see section 6 below).

4.2 Utility lines and service lines

At the time of ranking, threats in this category did not rank medium or high for either species overall but have the potential for significant local impacts where developments are planned in areas known or likely to have significant numbers of Thrashers. Numerous transmission lines are planned or are under construction currently (2024), and to meet current renewable energy goals, at least a doubling of capacity is needed. Renewable energy development will preferentially occur in proximity to transmission lines. For example, the final EIS for solar development includes lands only within 15 miles of transmission lines (Bureau of Land Management 2024). There is no understanding of how this fragmentation or collision risk will impact either thrasher species.

6.1: Recreational Activities

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
6: Human Intrusions and disturbance	Legal OHV use	**M**	**M**
	Illegal OHV use	**M**	**M**

Off-highway vehicles (OHV) have the potential to cause direct and indirect issues for Thrashers through habitat destruction and disturbance. The distinction between illegal and legal OHV use is difficult to draw, as in most areas law enforcement is minimal even if use is largely illegal, and in other areas, a lack of regulation for OHV users exists. Management of OHV-established areas varies by state and land managers.

Regulation is variable but most OHV use is legal, and off-trail use can be common in some areas. On BLM land in Nevada, only off-road use within Areas of Critical Environmental Concern (ACEC) is illegal. In California, there are minimal plans for additional OHV use areas to be added, but existing footprints are sufficiently large. Impacts are expected to be most pronounced in areas where thrashers are known to occur, such as Sloan Canyon, Ivanpah Valley, and Hidden Valley, Nevada, and Apple Valley and Barstow, California, or in areas where illegal OHV use is prevalent, such as at the Naval Petroleum Reserve #2 near Taft, CA.

In Mexico on the Baja peninsula, many formal off-road races are hosted each year (e.g., Baja 1000, but also numerous shorter races each year). Races are held throughout the year, and courses change annually. The level of impacts will be dependent on whether races coincide with LeConte's Thrasher breeding season and overlap with occupied habitat.

Illegal activities occurring along the international border between the United States and Mexico (e.g., drug trafficking, undocumented migrants) and associated law enforcement activities can disturb wildlife and create illicit trails and roads which can lead to damage to vegetation and erosion. Use of OHV by Border Patrol is unregulated. Threats may be higher locally, especially in areas proximate to the border and particularly south of Interstate 10.

7.1: Fire and Fire Suppression

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
7: Natural systems modifications	7.1: Fire and fire suppression	H	H

Arid regions historically have had a low propensity to burn in wildfires due to their relatively sparse vegetation which prevents fire from spreading. The lack of wildfire in this environment has caused the native vegetation to evolve mostly without fire adaptations. However, the introduction of exotic vegetation, especially annual grasses, has made the landscape more fire prone by creating a more continuous layer of vegetation. Climate change is exacerbating the situation by thoroughly drying out fuels during the summer, so when fires ignite, they are difficult to control and consume nearly all vegetation in their paths.

In August of 2020, the lightning-caused Dome Fire burned 43,273 acres of Joshua tree habitat on Cima Dome within the Mojave National Preserve. From 2021–2023, a study was conducted to determine the effect of the fire on Bendire's Thrasher occupancy. At study sites within the fire footprint, 93% of the Joshua trees were killed and 98% of the shrub/annual vegetation was burned. Bendire's Thrasher occupancy averaged across years and sites equaled 29% at sites outside the fire perimeter, 26% at sites straddling the fire perimeter, and two percent at sites entirely within the fire perimeter (Tietz and Geupel 2023). The fire left very few patches of unburned vegetation within its perimeter. The natural recruitment of Joshua trees into large areas of denuded vegetation is a slow process. Even if Joshua tree recruitment is augmented through the planting of seedlings, it will take several decades for the trees to grow tall enough to become suitable nesting habitat for Bendire's Thrashers.

Fire risk is elevated following wet periods with above average precipitation that spurs proliferation of non-native vegetation at sites that support Thrashers. For example, following a relatively wet winter and spring, the York fire burned 93,078 acres in the eastern Mojave National Preserve in July and August of 2023 (Figure 31). Like the Dome Fire, the York Fire footprint consisted largely of Joshua tree habitat and left few unburned patches. Considering the threat posed by wildfires to Desert Thrashers and their habitats, it may be necessary to consider various methods of reducing the risk, such as installing fire breaks and managing the non-native vegetation, especially after wet years, with mechanical or biological means. Fire management planning should also consider important Desert Thrasher habitats and elevate protections or actions in these areas to benefit Desert Thrashers and preserve their habitats.

Figure 31. Burned Joshua Trees from York Fire. Photo credit: S. Giesemann.

8.1: Invasive plant species

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
8: Invasive plant species	8.1 Invasive non-native/alien species	M	H

The threats to Bendire's and LeConte's Thrashers from invasive plant species are largely tied to the increased risk of catastrophic fire (discussed above in Section 7), reduced foraging opportunities, and in some cases, conversion of habitat to types incompatible with thrasher presence. Invasive annual plant species are common on occupied thrasher plots for both species (73% of Bendire's Thrasher plots and 93% of LeConte's Thrasher plots, Ammon et al. 2020, Figure 32). Despite thrashers occurring where invasive annuals are common, which likely reflects the prevalence of, rather than the selection for invasive annuals, the impacts of how invasive annuals impact foraging opportunities and food resources are unknown. Typically, invasive annuals, particularly grasses such as red brome (*Bromus rubens*), and cheatgrass (*Bromus tectorum*), offer few food resources to wildlife and otherwise outcompete native vegetation that have higher food resource value. Buffelgrass (*Pennisetum ciliare*) is valued as a forage species for cattle and sheep, but easily colonizes and invades surrounding areas, outcompeting native vegetation. It is prevalent across Arizona and Sonora and is still actively planted in Sonora where it is estimated to occur on over 400,000 ha, and where its expansion has been accompanied with woody plant removal to provide cattle forage (Marshall et al. 2012, Lyons et al. 2013). While Bendire's Thrashers occupy desert grasslands, they still require a shrub component for

Figure 32. Former LeConte's Thrasher habitat (top photo, taken 1970, photo credit: J. Sheppard), versus current state in 2015 (bottom photo, photo credit: L. Hargrove). Note plant community changes with increased invasive annuals and creosote.

nesting and cover. Additionally, both thrasher species require extensive bare ground or leaf litter for foraging; an abundance of ground cover comprised of invasive grasses such as those mentioned above, or other invasives such as stinknet (*Oncosiphon piluliferum*) may also hinder foraging opportunities.

This threat received locally higher risks for Bendire's Thrasher in BCR 33 in Nevada, as well as in Sonora.

11: Climate Change and Severe Weather

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
11: Climate change and severe weather	11.1: Habitat shifting and alteration	VH	VH
	11.2: Droughts	H	H
	11.3: Temperature extremes	H	H

Impacts on thrashers from climate change are expected to be significant and are already occurring (Iknayan and Beissinger 2018). Aridland vegetation communities are predicted to shift northward, or, in some instances, disappear entirely from large portions of LeConte's and Bendire's thrashers' current ranges (Cole et al. 2011). LeConte's and Bendire's thrasher distributions are in turn predicted to shift northward (Wilsey et al. 2019, National Audubon Society 2023 a, b), yet vegetation communities' capacity to keep pace with changes in climatic conditions may be untenable (McLachlan et al. 2005, Loarie et al. 2009, Cunze et al. 2014). Impacts to LeConte's Thrashers might be even more dramatic due to their overall low dispersal capabilities.

Increased drought frequency and severity will produce immediate effects on thrasher populations (McCreedy and Van Riper 2015, Albright et al. 2017). LeConte's Thrashers rely on their prey for water (Sheppard 1996) and reduced secondary production can constrain individuals' ability to thermoregulate during extreme temperatures (McKechnie et al. 2021). Reduced secondary production can also delay nesting phenology (McCreedy and van Riper 2015) and shorten the length of the breeding season (Seavy et al. 2018). Thrashers have been found to have reduced fecundity in years of low precipitation, occasionally foregoing breeding altogether (McCreedy 2012a, 2012b, Sheppard 2018, Salas 2021). In turn, low rates of fecundity will burden any conservation efforts to restore populations.

In addition to other climate change impacts, Radchuk et al. (2019) found that "incomplete adaptive responses to ongoing changing climate may already be threatening the persistence of species". To this point, Youngflesh et al. (2022) observed that from just 1989 through 2018 many bird species are reducing body size to adapt to warming temperatures. Birds with smaller body sizes are better equipped to meet water demands associated with thermal homeostasis (Riddell et al. 2019). Larger bodied birds, and those that obtain water through prey, such as Desert Thrashers, are least capable of meeting water needs (Riddell et al. 2019) and risk lethal dehydration and hyperthermia associated with a hotter and drier climate. Cooling costs have increased nearly 20% relative to historic, and these increased water demands for desert species were linked to overall declines in occupancy for numerous species in the

Mojave Desert (Riddell et al. 2019). Species that live in arid habitats are already at the limits of endurable temperatures and will not be able to adapt in sufficient time.

12: Data Gaps/Research Needs.

Salafsky Level Two Threat	Level Three Threat	Bendire's Thrasher	LeConte's Thrasher
12: Other	12.1: Data Gaps	H	H

There are numerous data gaps that exist for both Thrasher species that hinder our ability to enact meaningful conservation actions. For both species, we have incomplete knowledge of full distributions, breeding and nonbreeding season habitat requirements, factors influencing demographic parameters across their range, impacts from development and disturbance. Using a list of potential data gaps adopted from the Utah State Wildlife Action Plan (Utah Wildlife Action Plan Joint Team 2015), members of the DTWG ranked the top five most crucial data needs to enact conservation for these thrasher species. Level three data gaps were ranked, and Salafsky level two data gaps are included for context. These top five broad data gaps are outlined below (Table 5), while many other data needs exist or have been identified since these gaps were ranked. See also Suggested Conservation Actions/Strategies below for additional discussion and needs.

Table 5. Top five most crucial data gaps as identified and ranked by the Desert Thrasher Working Group. The specificity of threats increases from Level Two to Level Three threats, and rankings were conducted at the most specific level (Level Three Threats).

Rank	Crucial Data Gaps	
	Salafsky Level Two Threats	**DTWG Level Three Threats**
# 1	12.1: Inadequate understanding of ecology and life history - poor knowledge of target species and their relationship to their environment complicates or retards effective conservation	**12.1.1: Lack of clarity regarding habitat components at territory and nest scale, as well as nonbreeding season habitat requirements**
# 4	12.2: Imperfect understanding of distribution or range - poor knowledge of location, extent, timing, and/or seasonal variation of occurrence complicates or retards effective conservation	**12.2.2: Lack of knowledge about breeding season distribution**
# 2	12.3: Inadequate inventory and monitoring methods - inability to sample or characterize condition of individuals or population complicates or retards effective conservation	**12.3.1: Sampling efforts are hindered by low density and detectability**
# 3	12.7: Inadequate restoration tools - lack of adequate restoration materials or methods complicates or retards effective conservation	**12.7.1: Difficulties with implementing or designing successful habitat improvement or restoration projects**
# 5	12.8: Lack of awareness by public or agencies - target is relatively unknown by members or the public or agencies and may not receive attention or funds needed to achieve effective conservation	**12.8.2: Lack of awareness or planning for species in development planning (urban, roads, energy, agricultural, etc.)**

Suggested Conservation Actions and Strategies

We present the following conservation strategies and actions needed to conserve Desert Thrashers. These strategies and actions are outlined so that stakeholders and interested parties can consider prioritizing their actions to support meaningful conservation for Desert Thrashers. Much of the current or ongoing research, monitoring, and conservation has been conducted or coordinated through the DTWG, but all efforts to address these strategies and actions by any party are encouraged. The DTWG is available to provide insight, advice, or coordination with interested parties to engage in Desert Thrasher conservation. The DTWG consists of species experts for Bendire's and LeConte's Thrashers and can identify targets. The main targets are arresting population declines and increasing Desert Thrasher populations. We used the Open Standards for the Practice of Conservation to create a conceptual model and identify and rank threats. The group used the conceptual model, results chains, and expert opinion to develop actions and strategies to increase populations, address threats, and address the gaps in knowledge of these enigmatic species. In contrast to species that are better studied, there are actions we have chosen that will fill in our knowledge of the habitats and biology of LeConte's and Bendire's Thrasher.

The following 9 conservation actions were identified to benefit Desert Thrasher populations:

1. Compile habitat requirements.
2. Enhance monitoring methods.
3. Identify and prioritize research and monitoring to address key knowledge gaps.
4. Increase funding for research and monitoring.
5. Identify areas of climate resiliency
6. Develop Beneficial Management Practices (BMPs) for thrasher habitat.
7. Restore abandoned farmland
8. Encourage stakeholders to consider thrashers in planning and increase awareness.
9. Increase regulation/enforcement of OHV use.

Strategy 1: Compile habitat requirements

Without a clear understanding of the components that define breeding and nonbreeding season habitat, we are unable to predict where Desert Thrashers are likely to occur on the landscape, nor provide land managers with the tools they need to manage habitat for Bendire's or LeConte's Thrashers. This information is also needed to incorporate thrashers into planning for infrastructure and energy projects, and to develop habitat restoration projects. Some pre-existing data are already available for analysis (e.g., habitat data collected during area search monitoring by the DTWG from survey locations) and offer a logical starting point for evaluating habitat requirements and outlining common habitat characteristics. Initially analyzed data from 2017 and 2018 (Ammon et al. 2020), showed some commonalities, but also some important differences between ecoregions. Analysis should be completed again with the full set of data, which includes numerous additional years. Nonbreeding habitat characteristics are even less understood, with initial qualitative habitat assessments being conducted in Sonora currently (2024). Compiling habitat requirements is a critical first step for other strategies listed here (e.g., Strategy 3: Data gaps, Strategy 6: Develop beneficial management practices, Strategy 7: Restore abandoned farmland).

Actions:

1) Compile habitat requirements.
   a) Use existing data to summarize current knowledge of habitat.
      i) Analyze full suite of habitat data collected during area search monitoring from all years.
         (1) Outline important habitat features associated with Thrasher presence.
         (2) Include analysis by ecoregion whenever possible.
   b) Create vegetation protocol for assessing nonbreeding habitat.
2) Assess whether existing data provide sufficient power to describe Thrasher habitat.
   a) If no, evaluate what next steps are needed to adequately describe habitat requirements for Thrashers.

Strategy 2: Enhance monitoring efforts.

Desert Thrashers have challenges to monitoring related to their low detectability, early and variable phenology, and overall limited baseline data regarding their distribution. To address these challenges, the DTWG has developed monitoring protocols that satisfy several different monitoring goals. These include 1) the area search survey protocol, 2) discovery survey protocol, and 3) clearance survey protocol (summarized in Table 6). Use of these protocols is encouraged for current and future research and monitoring. This portion of the strategy has received significant attention and the monitoring protocols in place are adequate but can be adapted as additional information is obtained or as different goals are identified.

Figure 33. Thrasher Surveyors. Photo Credit D. Fletcher

The three protocols were created to address different issues for different objectives and regions. The area search protocol includes plot-based surveys that are sampled multiple times over the breeding season to help identify occupancy and include vegetation sampling at plot centers to identify important habitat features. Species distribution models have been used in the past for site selection, but strata for selection can be modified to fit various objectives. These surveys require more resources to conduct than the other two methods but also garner the most rigorous data for analysis. The discovery survey protocol was developed to allow for greater coverage of potential Desert Thrasher distribution, especially for areas with little or no previous location data, such as much of Mexico and remote regions. Though these surveys typically provide a greater volume of data at lower costs, they are less rigorous due to the inherent biases. Still, they provide valuable baseline information about the distribution of the species and their occurrence in a specific area. The clearance survey protocol was developed from the discovery protocol to address the growing need for partners to conduct pre-construction surveys in areas planned for significant habitat modification (e.g., solar site development).

Data collected according to area search methods are supported through the Avian Knowledge Network (AKN) and AKN protocols designed to accommodate data collected using our standard field methods. The AKN integrates data, coordinating field methods and data entry into a secure and centralized database, and allows our data to be easily managed and summarized, as well as readily shared through numerous portals, including the Borderlands Avian Data Center (BADC). The AKN also provides data for use through tools such as the Rapid Avian Location (RAIL) tool, which can be used to inform management activities, as well as other visualizations. Additionally, the DTWG webpage is hosted through BADC.

Through cooperation of multiple partners and agencies, area search protocol-based monitoring was conducted throughout the United States portion of the range in 2017 and 2018. Area search monitoring occurred in Arizona, California, Nevada, New Mexico, and Utah (summarized in Ammon et al. 2020). Since 2019, additional surveys have been conducted in all U.S. states at varying intervals. Surveys based on the discovery protocol have been conducted in Sonora in 2021 and 2024, and in Nevada in 2023. In Sonora, there are very few data points for either Thrasher species, land access can be difficult due to the high prevalence of private lands and safety concerns, and discovery surveys are a cost-effective way to gather baseline data.

A range-wide monitoring plan should be established to determine overall monitoring goals, extent, and implementation schedule, as well as identifying potential funding sources and partners. Evaluation of existing data is needed to determine population trends or other metrics as determined through a range-wide monitoring plan. Area search monitoring also includes evaluation of vegetation metrics, which need to be evaluated and integrated into Strategy 1: Compile habitat requirements.

Actions:

1) Improve/refine monitoring methods.
    a) Update protocols as new information becomes available.
2) Develop a range-wide monitoring plan.
    a) Establish monitoring goals and schedule.
    b) Increase capacity, funding, and implementation of surveys across the range, but especially in Sonora and Baja California in breeding and nonbreeding seasons.
        i) Identify Mexican partners to conduct surveys.
        ii) Provide training opportunities to increase capacity.
    c) Develop and maintain database of Desert Thrasher locations.
        i) Develop AKN entry protocol for incidental locations, and data from clearance and discovery protocols.
    d) Implementation of monitoring
        i) Identify funding sources.
    e) Evaluate monitoring data.
    f) Disseminate results of monitoring data

Table 6. Comparison of different survey protocols developed by the Desert Thrasher Working Group. Protocols, training materials, mp3 files, and datasheets are available at https://borderlandsbirds.org/projects/desert-thrasher/

Protocol	General Description	Objective	Intended User
Area Search Survey Protocol	▪ Statistically rigorous survey method for both population monitoring and fine scale modeling assessments. ▪ Provides quantitative measurements. ▪ Standardized survey method that can be applied range-wide for Desert Thrashers. ▪ Survey plots are stratified and surveyed 3 times throughout the breeding season.	Estimate distribution, determine occupancy, determine population trends, account explicitly for detectability, identify habitat preferences	Researchers or partners conducting monitoring work Data entry and storage within Avian Knowledge Network
Discovery Survey Protocol	▪ Establish presence of the species in each area ▪ Provide qualitative estimates of abundance in that area.	Gain a better understanding of thrasher distribution through a non-random survey method covering a large area at relatively low costs.	Researchers or partners conducting monitoring work
Clearance Survey Protocol	▪ Recommended by the DTWG to use for pre-clearance survey purposes.	Determine presence of LeConte's and/or Bendire's thrashers within a given area prior to construction or other landscape alterations.	Pre-construction monitors for solar, wind, transmission line, pipeline, or other construction projects

Strategy 3: Identify and prioritize research and monitoring to address key data gaps.

As both Desert Thrasher species are relatively under-studied there remain significant gaps in our knowledge of several key aspects of the annual life cycle and habitat relationships. The DTWG identified and prioritized five knowledge gaps and steps to address each (see Threats: Data Gaps/Research Needs). Additional research needs have been added to reflect current needs by the DTWG. Though other research needs exist, addressing these prioritized needs first should have the greatest conservation benefit for Desert Thrashers.

Actions:

1) Improve clarity regarding habitat components at territory and nest scale.
   a) See Strategy 1: Compile habitat requirements.

2) Design or enhance sampling efforts to account for target occurring in low densities, and with low detectability.
   i) Monitoring efforts need to be designed to explicitly address low detectability and sufficient in scale to address low density.
   ii) Include explicit measures of detectability in monitoring designs when appropriate.
   iii) See Strategy 2: Enhance monitoring efforts.

3) Identify, design, and implement successful habitat improvement or restoration projects.
   a) See Strategy 1: Compile habitat requirements and Strategy 7: Restore abandoned farmland.
   b) Identify farmland to be abandoned and consult with restoration experts to create restoration protocols.
   c) Investigate enhancement of nesting substrates (primarily cholla) where they have become a limiting factor, such as in areas impacted by former farming, grazing, or OHV practices, or where fires have occurred.
   d) Study arthropod food availability in native and non-native dominated habitats.

4) Increase knowledge about breeding season distribution
   a) Further implement discovery surveys to provide baseline information about Desert Thrasher presence where few or no previous data are available.
   b) See Strategy 2: Enhance monitoring efforts.
   c) Refine distribution models.

5) Advance awareness of species in development planning (urban, roads, energy, agricultural, etc.)
   a) See Strategy 8: Encourage stakeholders to consider thrashers in planning/increase awareness.

6) Gain knowledge about nonbreeding season movements
   a) Create a plan that uses Motus, the Bird Genoscape Project, satellite tags, data loggers, nonbreeding surveys, and other methods to expand nonbreeding range knowledge base.
   b) Identify important areas, landforms, or habitat characteristics that are used by Thrashers on migratory or nonbreeding grounds.

7) Characterize impacts of various disturbance regimes on Thrashers
    a) Evaluate responses of Thrashers to solar development
        i) Using Satellite tags, Motus, and/or pre- and post-construction surveys to determine whether Thrashers:
            (1) use habitat adjacent to or within solar developments,
            (2) determine minimum patch sizes, address changes in survival and productivity, assess collision risk, or other metrics.
            (3) evaluate Thrasher use within different solar facilities that employ different design features.
    b) Evaluate responses of Thrashers to wind, transmission lines, or other infrastructure.
    c) Design and implement a study to evaluate impacts to Thrashers from different grazing methods and comparing to ungrazed habitat.
    d) Evaluate responses of Thrasher to disturbance from OHV use
    e) Evaluate specific impacts of invasive annuals on factors influencing survival, such as food availability.

Strategy 4: Increase funding for research and monitoring.

The need for more funding and associated research and monitoring is perhaps the most common need in conservation planning and species recovery. Most previous conservation accomplishments are the direct result of increased funding, along with legislation. This strategy is tied to and necessary for all other strategies, see Strategy 3 in particular. Desert Thrashers are no exception, and these little-understood species still require more research and monitoring to complete our understanding of population distributions, habitat needs, and other knowledge gaps, which were identified as a "high" threat, and are prioritized above in crucial data gaps. This will require new and previously used funding sources to address these needs. Though we encourage all interested parties to engage in increasing funding to address Desert Thrasher conservation, the DTWG can serve an important role in defining research needs, matching funding with researchers, facilitating opportunities for collaboration, and directing conservation actions.

Figure 34. Researcher examining a Bendire's Thrasher wing for aging. Photo credit: A. Stein.

Action:

1. Identify potential funding sources.
2. Maintain an active list of funding needs.
    a. Match needs to different funding opportunities.
    b. Encourage stakeholders to pursue funding.

Strategy 5: Identify areas of climate resiliency.

Climate change impacts were rated as "very-high" threats to both Bendire's and LeConte's Thrashers. Range shifts may be expected to occur over time for both species, as indicated by numerous climate models; both species may be expected to occur in areas further north than their ranges currently extend. Some extralimital records for both species indicate this may be starting to occur already. However, most climate models predict range shifts based on climatic conditions (temperature and precipitation), leaving uncertainty to how and if vegetation shifts will follow. Identifying areas of resiliency where vegetation species, structure, and food resources required by Thrashers are likely to persist through predicted climatic changes can prioritize locations for Desert Thrasher conservation efforts.

Actions:

1) Use existing models and maps to identify, map, and protect the most likely areas of resiliency for vegetation, food species, and thrashers.
2) Observe and track both elevational and latitudinal range shifts in real time while studying local habitat conditions, which will allow adaptable alterations to fluctuating thrasher ranges.

Strategy 6: Develop "Beneficial Management Practices" (BMPs) for Thrasher habitat.

It is necessary to draft BMPs using increased understanding of Thrashers' biology and ecology accomplished through other strategies (such as Strategy 1: Compile habitat requirements, as well as how disturbance regimes impact Thrasher occupancy, productivity, and survival and Strategy 3: particularly Actions 4, 6, and 7). Land managers, industry partners, and other stakeholders are encouraged to incorporate BMPs when planning and working within occupied or suitable thrasher habitat to minimize negative impacts and provide benefits to thrashers and their habitats.

Actions:

1) Apply established Beneficial Management Practices for solar and renewable energy development and use this as a starting point for other applications and additional BMPs.
2) Crosswalk knowledge of known habitat requirements (Strategy 1) and thrasher distributions (Strategies 2 and 3) to common management practices.
3) Work with agencies, landowners, and other land stewards to assess needs and ways to complement existing stewardship activities.
4) Disseminate BMPs to partners.
5) Share recommendations for development of solar sites: Conservation of Bendire's and LeConte's Thrashers at Solar Development Sites: Site Evaluation, Selection, and Design Considerations to Benefit Desert Thrashers

    a) The DTWG developed recommendations to address issues that arise between Desert Thrasher habitat and sites being evaluated for development of utility-scale solar. The threat of renewable energy development, and particularly solar, was ranked "very high" for LeConte's Thrashers and "high" for Bendire's Thrashers as discussed above in the threats section. Because of the likely overlap between Desert Thrasher habitat and sites desirable for solar development, the DTWG established a process to evaluate sites for Desert Thrasher presence, identify priority areas known to be used by thrashers, presents measures to avoid impacts to Desert Thrashers, and provides some design features that can be employed to minimize impacts to Desert Thrashers if construction does occur in areas where these species are present. Additionally, it gives some examples of conservation opportunities for those partners wishing to provide benefit to Desert Thrashers.

Strategy 7: Restore abandoned farmland.

The key to recovering Desert Thrashers is the recovery and conservation of habitat. The first step in recovery of species is to preserve intact desert habitat. Desert habitat can be more difficult to restore than other habitats due to limited water resources, slow-growing species, and increased risk of invasive plants. With the reduction in the Colorado River and other water sources in the American southwest, agriculture will likely be one of the first areas to experience significant cuts to water allotment. This may result in abandonment of farmland, with lower quality and more remote farmland likely the first to be abandoned. Abandoned sites present an opportunity to reclaim previously converted native desert habitat.

Actions:

1) Use results of Strategy 1: Habitat requirements, and Strategy 6: Develop beneficial management practices for thrasher habitat inform restoration goals.
2) Evaluate changes in land use and Bendire's Thrasher occupancy in Avra Valley, Arizona as an example of abandoned farmland reverting to Bendire's Thrasher habitat.
   a) Evaluate history of the site to understand which practices were used to restore habitat, or if restoration was passive.
3) Identify potential sites for restoration.
   a) Restore selected sites.
   b) Evaluate success of restoration efforts

Strategy 8: Encourage stakeholders to consider Thrashers in planning and increase awareness.

Awareness is an important step for conservation and recovery; as habitat associations and requirements are better understood and BMPs are developed, the DTWG will be able to provide better information to partners to minimize negative impacts and promote beneficial practices.

Actions:

1) Associate Desert Thrashers with other species of concern in the planning process.
2) Prepare a plan for strategic communications and outreach.
3) Implement clearance survey protocol prior to activities that may negatively impact occupied Desert Thrasher habitat.
4) See Strategy 6: Develop beneficial management practices.
   a) See: Conservation of Bendire's and LeConte's Thrashers at Solar Development Sites: Site Evaluation, Selection, and Design Considerations to Benefit Desert Thrashers

b) Develop and disseminate BMPS for solar facilities and other applications (completed 2024)

5) Work towards inclusion of Bendire's and LeConte's Thrashers on the NOM-059 in Mexico to raise awareness and protection within Mexico.

Strategy 9: Increase regulation/enforcement of off-highway vehicle (OHV) use.

With the increased prevalence of off-highway vehicles by the public and Customs and Border Patrol, and the impacts of unregulated or poorly enforced regulations, the effects of OHV use can have negative impacts to thrashers and their habitat. By strengthening regulations and enforcement of regulations on OHV use, Thrashers and other wildlife will benefit from decreased fragmentation and disturbance.

Actions:

1. Identify areas where OHV use has significant overlap with Desert Thrasher presence.
    a. Focus efforts to increase regulation in these areas.

Summary and Next Steps

This conservation plan has accumulated much of the known information regarding Desert Thrashers biology and ecology and has identified many of the key unknowns for these species. Threats are identified and discussed, and conservation strategies and actions are identified as well. The intent of this plan is that actions will be taken within the conservation strategies, so by nature this plan is intended to be fluid. Threats may change through time in scope or location, and novel threats may emerge. Knowledge gaps are intended to be filled. A such, this plan should be revisited or amended at points in the future to ensure that actions taken by stakeholders to address Desert Thrasher conservation are novel or consistent with other completed or ongoing actions.

As a group of individuals and entities dedicated to the conservation, research, and monitoring of Desert Thrashers, the DTWG is likely to play an important role in coordination of actions outlined in this plan. However, this plan is intended for all entities with stake in maintaining Desert Thrasher populations and their habitats. Additionally, the DTWG is open to addition of new interested parties, see https://borderlandsbirds.org/projects/desert-thrasher for current contact information.

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