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Overwinter Ecology of Rusty Blackbirds (Euphagus carolinus) in Arkansas

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OVERWINTER ECOLOGY OF RUSTY BLACKBIRDS (*EUPHAGUS CAROLINUS*) IN ARKANSAS

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Abstract

Rusty Blackbirds are one of the most rapidly declining songbirds in North America. They have lost an estimated 85-95% of their population since the 1960s. Unfortunately, we currently do not know what is causing their decline. However, since habitat alteration and loss in their nonbreeding range has been much more severe than in their breeding range, many think the decline is associated with winter habitat loss. Consequently, knowledge of winter ecology, with a focus on habitat use and selection, may provide management insights useful for reversing the decline. My field assistants and I (hereafter we) used radio telemetry to collect data on the Rusty Blackbird's home range, habitat use, behavior, and survival during the winters of 2018-2019, and 2019-2020. Radio-tagged birds were captured and monitored in agricultural and urban landscapes. We found that home ranges were larger in the agricultural landscape, and blackbirds selected for pecan groves and riparian zones, while cattle fields and rice fields were used much less. In the urban landscape, we found that home ranges were smaller and much patchier, and selected habitats included seasonally flooded hardwood forest, residential lawns, and urban parks. Cattle fields, non-residential areas, and agricultural areas were generally avoided in the urban landscape. Home range size may have been associated with habitat patch size and fragmentation; Home ranges were larger and less patchy in unfragmented homogeneous pecan groves than in heterogeneous urban habitats. The overall high survival suggests that these largely anthropogenic habitats may be effective substitutes for more traditional bottomland hardwood habitat –much of which has been lost to human activity. The Rusty Blackbirds' use of these anthropogenic habitats presents unique opportunities and challenges in the management of this species. Urban landscapes, which are highly fragmented, can be managed at the patch level to provide a mosaic of suitable habitats in a matrix of urban development. Agricultural landscapes

can be managed at the habitat level to provide large, contiguous patches of habitat. Due to the Rusty Blackbirds' use of privately-owned land, outreach and education will need to be included in conservation efforts.

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Introduction

The Rusty Blackbird (*Euphagus carolinus)* is a migratory species that breeds in forested wetlands of Alaska, Canada, and New England, and winters in the southeastern United States. Historically, their nonbreeding habitats included shallow flooded (water < 20cm deep) bottomland hardwood forests with open understory and closed canopy, as well as riparian zones, but they can now be found in agricultural areas (e.g., pecan groves) and urban areas as well (Greenberg and Matsuoka 2010; Newell Wohner et al. 2016). In their breeding range, Rusty Blackbirds primarily feed on aquatic macroinvertebrates, as well as small frogs and fish. Nonbreeding Rusty Blackbirds have a more varied diet, and will feed on invertebrates, acorns, pine seeds, pecans, bird seed, and even other birds (Greenberg and Matsuoka 2010; Newell Wohner et al. 2016; Woodruff and Woodruff 1991).

The Rusty Blackbird is one of the most rapidly declining passerines in North America (Greenberg et al. 2011). Data from annotated checklists, regional accounts, and personal observations suggest that this species has steadily declined for over a century (Greenberg and Droege 1999). Additionally, data from the Christmas Bird Count (CBC) and the North American Breeding Bird Survey (BBS) since the 1960s indicate a total population loss of >83% and >93% in the Rusty Blackbird's winter and breeding ranges, respectively (Niven et al. 2004; Greenberg and Matsuoka 2010). As a result, the Rusty Blackbird was designated as vulnerable with decreasing populations by the IUCN (BirdLife International 2018). If the decline in Rusty Blackbird's population continues, they may soon become endangered, and numbers may be too low for effective conservation action (Greenberg and Droege 1999; Hamel et al. 2009).

Factors contributing to this long-running trend are largely unknown, primarily because the plight of the Rusty Blackbird was not widely recognized by scientists until the mid-1990s

(Greenberg and Matsuoka 2010). Further, systematic investigations to discern the causes of their decline began even more recently (Greenberg et al. 2011). Researchers have posited at least five major contributing factors to this decline: habitat loss and degradation on wintering and breeding grounds; global climate change; environmental contamination; mercury exposure; and blackbird control programs targeting species which associate with Rusty Blackbirds, such as European Starlings (*Sturnus vulgaris*) and Red-winged Blackbirds *(Agelaius phoeniceus*) (Greenberg and Matsuoka 2010; Greenberg et al. 2011). However, we currently do not know the degree to which these and other factors affect Rusty Blackbirds; consequently, we have not developed management practices for the species (Greenberg et al. 2011).

Rusty Blackbirds are difficult to study because many of their habitats are relatively inaccessible. Population and demographic data are also difficult to collect because Rusty Blackbirds are inconspicuous and exhibit unpredictable behavior, and lack distinguishing field marks between adults and juveniles. Perhaps most importantly, Rusty Blackbirds are difficult to capture in mist nets due to their extreme neophobia (Mettke-Hofmann et al. 2010; Greenberg and Matsuoka 2010; Greenberg et al. 2011). These challenges have resulted in a significant gap in our understanding of the species' ecology and decline, and we need to fill that gap before we can develop effective management (Greenberg et al. 2011).

Greenberg and Matsuoka (2010) cite the loss and degradation of nonbreeding bottomland forest habitat as the primary cause of the Rusty Blackbird's population decline. Approximately 80% of bottomland hardwood forests in the Rusty Blackbird's winter range have been converted to agriculture, and additional forests have been lost to urban development and logging. In contrast, their breeding habitat has been less affected by human disturbance (Greenberg and Matsuoka 2010). Therefore, we need to study the Rusty Blackbird's winter ecology to determine

the role habitat loss plays in their decline. For example, Greenberg et al. (2011) emphasize the need for telemetry studies of Rusty Blackbird habitat use. Moreover, Rusty Blackbird populations are declining faster than the rate of habitat loss, indicating that other factors are also contributing. Examining the species' winter ecology may reveal what those factors are (Greenberg and Droege 1999; Hamel et al. 2009). For example, conversion of habitat for agriculture, suburban and urban development, changes in hydrology, and blackbird control efforts such as spring baiting with avicide-treated rice and roost site thinning with herbicides all occur in the winter range, and could negatively affect Rusty Blackbirds (Greenberg et al. 2011; Greenberg and Matsuoka 2010; Newell Wohner et al. 2016; Blackwell et al. 2003). Also, preliminary findings suggest that nonbreeding Rusty Blackbirds are less specialized in their habitat use than are breeding birds (Luscier et al. 2010). Unfortunately, details regarding Rusty Blackbird survival, habitat use on both local and landscape scales, home range size, and responses to management activities in the winter range are unknown. In order to address the population decline we need to identify responsible factors so that we can develop a plan to stabilize or reverse that decline (Mettke-Hofmann et al. 2015; Hamel et al. 2009).

To address some of these research needs, I conducted a three-year study on the overwinter ecology of Rusty Blackbirds in Arkansas. My objectives were to:

1) Record and map Rusty Blackbird sightings

2) Determine overwinter survival

3) Describe and quantify behavior

4) Calculate individual home range sizes

5) Evaluate habitat use and selection

Methods

I conducted this study over three field seasons. The first season ran from early January through the end of March 2019 (hereafter referred to as "the 2019 season"). The second season ran from early December 2019 through the end of March 2020 (hereafter referred to as "the 2020 season"). The third season ran from early December 2020 through the end of March 2021 (hereafter referred to as "the 2021 season"). One or two technicians assisted during the first two seasons.

Locating Birds

Rusty Blackbirds were located by visiting sites reported on the eBird website (ebird.org), using reports from local birders, and surveying suitable habitat. We recorded GPS coordinates, number of birds, habitat, behavior, other species present, and any other interesting information for each individual or group of birds we sighted. I then mapped all locations by year in ArcGIS.

Mist Netting and Banding

Birds were captured only during the 2019 and 2020 seasons. We attempted to capture birds at sites where they were seen on more than one occasion (to eliminate transient individuals, and increase netting efficiency). If necessary, permission was obtained to access the sites. During the 2019 season, bait was put out in some areas to attract birds, and trail cameras were set up at bait sites to confirm consistent presence of Rusty Blackbirds and to determine times of peak activity. We made the bait from a mixture of cornmeal, boiled eggs, and cracked corn (Mettke-Hofmann et al. 2015). Mist nets (36-mm mesh) were used to capture birds. We opened nets at sunrise and closed them in the early afternoon, provided there was no rain, mist, or wind > 10mph. Bait, and blackbird decoys, were sometimes placed along mist nets to attract birds. We moved nets around regularly to avoid sensitization by the birds, and as needed in response to

localized flooding. During the 2019 season, we also attempted to capture birds by using modified quail traps. We baited the traps and set them out near the mist nets. However, although we captured other species in the traps, Rusty Blackbirds avoided them, so we abandoned this method after the first season. Rusty Blackbirds that were captured were fitted with a standard 9-digit USGS metal leg band (size 2). In the second season of the study, three plastic color bands (4.5 mm) were also placed on birds for identification. We took the following measurements for each bird: weight, wing cord, tail length, culmen length, tarsus length, body fat (5-level scale), and pectoral muscle condition (4-level scale; Table 2). All birds were sexed by plumage and aged by a combination of plumage and body condition (Mettke-Hofmann et al. 2010). All birds were captured after January 1st, so they were aged as Second Year (SY) or After Second Year (ASY). We also fit a 1.37-gram radio transmitter from Biotrack© to each bird. We used elastic polyester cord to attach the transmitters to the birds' synsacrum by following methods modified from Rappole and Tipton (1991) and Streby et al. (2015). Birds were briefly monitored post-release to ensure that their behavior was not negatively affected by the transmitter and bands.

Radio Telemetry

Radio tracking was conducted by using a 3-element Yagi antenna from Advanced Telemetry Systems© and a radio receiver from Communications Specialists, Inc. Weather conditions were recorded at the start of each session. When each bird was located, a point was taken by using a Garmin® GPSMAP® 76Cx or 64st. When the bird's exact location was accessible, we used waypoint averaging to achieve an accuracy of < 5m for each GPS point. If the bird was outside of an accessible area or was not visible, but the signal was strong enough to estimate its location, a projected or approximate waypoint was taken and labelled accordingly. When possible, we used triangulation to estimate the bird's location more accurately. During the

first year of the study, we relocated birds and monitored them continuously until they flew to another location. A single waypoint was taken for each sighting, and every time the bird moved more than 20 meters from its original location. We recorded the start and end time of each waypoint. The following year, I altered the protocol, and we began relocating birds at 10-minute intervals to avoid temporal autocorrelation of points (Powell et al. 2010). We took a new waypoint at each interval, even if the bird was at the same location. Following the change in protocol, the waypoint data from the 2019 season were separated into 10-minute increments for analysis. For each point, we recorded the time, waypoint name, waypoint accuracy (if applicable), height of the bird above the ground, behavior (resting, vocalizing, feeding/foraging, interspecific interaction, bathing/preening, unknown, other), macrohabitat, microhabitat, and any other interesting observations. Examples of macrohabitats include pecan groves, cattle fields, bottomland hardwoods, and residential areas. Examples of microhabitats within these areas include pecan trees, brush piles, lawns, flooded patches, and fence rows. Each bird was tracked at least 3 times per week until it left the area or migrated. If the bird could not be detected within the study site, we attempted relocation from high-elevation areas. We also located the roost site of each bird, and recorded the location and habitat type. Roost sites were checked on a daily basis to monitor site fidelity and occupancy.

Data Analysis

Survival

Most Rusty Blackbirds begin migrating, or preparing to migrate, by the second week of March (Newell Wohner et al. 2018); therefore, I determined overwinter survival by the presence of each bird in the study area on March 7th. If a bird disappeared from the study area after this date, it was assumed to have migrated.

Behavior

We assigned each waypoint at least one of seven possible behavior categories: foraging/feeding, vocalizing, resting, interspecific interaction, bathing/preening, other, and unknown. I removed the waypoints where behavior was unknown since they did not represent actual behavioral observations. I then summed the remaining waypoints by year, and divided the number of points containing each behavior type by the total number of points to determine the proportion of each behavior observed. The proportions did not necessarily add up to 1 as some observations were assigned more than one behavior category (e.g., vocalizing and interspecific interaction). To compare observation frequencies between years, I conducted proportions tests for each behavior, and used the values from the 2019 season as the baseline. The analysis was done with the "prop.test" command in R version 4.0.0.

I conducted a similar calculation for the birds' height above the ground. Observations were divided into categories, each containing a single height value, or a range (e.g., 0m, 1-5m, 6-10m). The full list of height categories can be found in Table 4. The proportions of observations in each height category were calculated for both years.

Home Range

The home range of each bird was analyzed by using radio telemetry waypoints. I constructed minimum convex polygons (MCP) in ArcGIS to delineate the total area occupied by each bird. I then calculated home ranges by using kernel density estimation (KDE) in ArcGIS, Geospatial Modelling Environment Version 0.7.4, and R version 3.6.1. For the KDE, 95% and 50% isopleths were calculated to determine total range and core area sizes, respectively (Locher and Lindenberg 2016).

Habitat Use

I assessed third-order habitat selection for each bird by comparing use and availability of habitat types within the home range (Aebischer et al. 1993). Available habitat for each bird was delineated by using the MCP created for the home range analysis. A systematic point grid was placed over each MCP with the "fishnet" tool in ArcGIS, and the area was divided into habitat types by using satellite imagery. I then divided the number of systematic points in each habitat type within the MCP by the total number of points to determine the proportional availability of each habitat type (Pendleton et al. 1998). I calculated proportional habitat use for each bird by dividing the number of telemetry waypoints in each habitat type by the total number of waypoints (Aebischer et al. 1993). For birds which shared available habitat, I used compositional analysis to assess habitat selection. I performed the analysis by using the "compana" command from the "adehabitatHS" package in R version 3.6.1. When there was little to no shared habitat between birds and compositional analysis was therefore not possible, I performed a qualitative assessment of the data whereby I compared the proportions of use and availability to determine which was larger for each habitat. A habitat type was considered to be "selected for" if use was greater than availability, and it was considered to be "avoided" if use was less than availability. (Aebischer et al. 1993).

Results

Summary of Observations

Over three field seasons, we searched for Rusty Blackbirds primarily in the Arkansas River Valley, and Mississippi Alluvial Valley. We observed Rusty Blackbirds on public and private land in urban, rural, agricultural, and undeveloped landscapes. Due to time and effort constraints, some sites were surveyed only once, while others were visited multiple times in a

single season. See Tables A1, A2, and A3 for detailed descriptions of all Rusty Blackbird detections from the 2019, 2020, and 2021 seasons, respectively; maps of all sightings can be found in Figures 1, 2, and 3.

Summary of Netting Effort and Captures

2019 Season

Our first netting attempt for the 2019 season took place on Jan 31 at the Arkansas Tech University campus in Russellville (Pope County). We spent four days netting at this location; on average, we set up 1.5 nets, and kept them open for 2.9 hours each day. We did not capture any birds at Arkansas Tech. On February 9, we set up nets in a privately-owned pecan grove near Blackwell AR (Conway County; Fig. 4). After catching two birds in this area, we relocated to another pecan grove approximately three kilometers northwest of the first site (Fig. 4). Four additional birds were captured at this location. We spent nine days netting in the pecan groves; on average, we set up nine nets and kept them open for 7.4 hours each day. The last day of banding in the pecan groves was March 10. Five of the birds we captured in 2019 were fitted with radio transmitters; one bird was injured, so we decided to release it without a transmitter. We were able to relocate and track two of the radio-tagged birds, and collect sufficient data for behavior, habitat use and home range analyses.

In addition to mist nets, modified quail traps were set up at all locations, but the Rusty Blackbirds generally avoided them. Our netting effort for the 2019 season was 506 net hours; netting success was 0.01 target birds per net hour. We netted for a total of 13 days, with captures on three of those days; we caught our first Rusty Blackbird on the seventh day of netting.

2020 Season

Our first netting attempt for the 2020 season took place on December 12, 2019 at Striplin Woods Natural Area in White River NWR. Over two days, we set up seven nets, and kept them open for three hours each day; however, we were unsuccessful in capturing birds at this site. We then spent three days netting at Hindman Park in Little Rock; we set up an average of 14 nets and kept them open for 7.4 hours each day. We were likewise unsuccessful at this location. Our third netting attempt took place at Hickory Hollow Disc Golf Course in Russellville (Figs. 5 and 12), where we set up an average of nine nets, and kept them open for 4.6 hours per day. We netted for eight days at Hickory Hollow, and captured one bird. Our final attempt for the 2020 season took place at a private residence in northwestern Russellville (Fig. 5), where we netted for four days. On average, we set up six nets a day, and kept them open for 4.7 hours; we caught two birds at this location. The last day of netting in Russellville was March 15. All three birds captured in 2020 were fitted with radio transmitters, and we were able to collect sufficient behavior, habitat use and home range data on two of the birds. See Table 1 for a summary of all captures.

Our netting effort for the 2020 season was 837.43 net hours; netting success was 0.004 target birds per net hour. We netted for a total of 17 days, with captures on two of those days; we caught our first Rusty Blackbird on the 11th day of netting.

Body Condition

In the 2019 season, five birds exhibited fair pectoral muscle condition (slight concavity), and one bird had good muscle condition (flat/no concavity). Body fat values ranged from 2 (furcular cavity 25-50% full) to 4 (cavity 75-100% full; Table 2). In the 2020 season, two birds exhibited fair pectoral muscle condition, and one had good muscle condition. Body fat values

ranged from 0 (furcular cavity empty) to 1 (cavity <25% full; Table 2). Mean body weight was higher in the 2019 season (Table 2).

Survival

Of the five birds we radio-tagged in the 2019 season, four of them were present as of March 7th. Two birds remained in the study area for the duration of the season while two disappeared but were later relocated at a communal roost site, which we then monitored daily. The fifth bird was never relocated, and its fate was unknown. It is possible that the bird dispersed to another location outside the range of our transmitters, the transmitter failed, or the bird died. The earliest assumed bird migration date for this season was March 11th, while the latest was March 29th. See Table 1 for the date of last detection for each bird.

In the 2020 season, all three radio-tagged birds were present as of March 7th. Two of the birds remained in the study area after they were released. The third bird dispersed, but was briefly detected at a later date. The earliest migration date was March 20th, while the latest was March 25th (Table 1).

Behavior

Radio-tagged Birds

For the 2019 season, the most commonly observed behavior was foraging/feeding (63% of observations), followed by resting (49% of observations; Table 3). During 2020, the most common behavior was resting (47% of observations), followed by foraging/feeding (45% of observations). The differences in the proportions between years were significant for all behaviors except resting (Table 3).

During 2019 birds were most commonly observed on the ground (height category of 0m; 42% of observations), followed by 1-5m (19% of observations; Table 4). In the 2020 season,

birds were also most commonly seen on the ground (48% of observations), followed by 6-10m (19% of observations).

Preroost

We made daily observations of pre-roosting behavior. Approximately an hour before flying to their roost, Rusty Blackbirds congregated in large flocks – often mixed with Red-winged Blackbirds, Common Grackles, and European Starlings. During this time, the birds vocalized continuously and made frequent, short flights among trees, or between trees and the ground. This behavior was observed within the tagged birds' home ranges, and in a seasonally flooded hardwood forest, residential lawns, riparian zones, cattle fields, urban parks, and pecan groves. Upon ending their pre-roost, the birds flew to their respective roost sites; birds that pre-roosted together did not necessarily share a roost. In the agricultural setting, radio-tagged birds were observed pre-roosting with as few as 5, or as many as 1000 other blackbirds before flying to their roost sites – often in the company of other Rusty Blackbirds. Smaller flocks (<10) tended to be all Rusty Blackbirds, while larger flocks were mixed. On one occasion, a radio-tagged SY male which was being monitored daily, and a SY female which dispersed from the study area after capture and had not been detected for 15 days, were observed pre-roosting together in a riparian zone before flying to their roost site with about 100 blackbirds (mixed flock of Rusty Blackbirds and Red-winged Blackbirds). In the urban setting, radio-tagged birds pre-roosted with 5-200 other blackbirds; the proportion of Rusty Blackbirds to other blackbirds in these flocks, which was usually > 0.50, tended to be higher than in the agricultural setting, where it was often < 0.25. On several occasions, we observed a radio-tagged ASY female pre-roost with up to 50 other Rusty Blackbirds and then roost within 150 meters of the pre-roost site, while most or all of the other birds flew to another roost site.

Other Behavioral Observations

Overall, we observed that Rusty Blackbirds were more active in cloudy weather than in sunny weather. They seemed to spend more time foraging, flying, and vocalizing in cloudy weather, even with strong wings, mist, or light rain. On the other hand, they spent more time loafing in trees in sunny weather.

Toward the end of the 2020 season, we observed an interesting behavior in the ASY female that we monitored in Russellville. Approximately one week prior to her departure, she began leaving the Russellville area during the day, flying far outside her home range. We were unable to track her transmitter's signal during this time. However, she returned to her roost site in Russellville each night, before leaving the area permanently in late February. None of the other radio-tagged birds, from either year, displayed this behavior.

Roosts

2019 Season

In the 2019 season, four of our five birds shared a single roost site in Morrilton. The birds roosted in a small patch of mixed pine/hardwood forest adjacent to a residential area on the north shore of the Arkansas River (Fig. 6). The patch was approximately 8.69 ha in size, although the exact boundaries of the habitat were difficult to determine. The understory was mostly open, with a few shrubs and sub-canopy trees. One of the Rusty Blackbirds, a SY female, occasionally roosted in similar habitat on the opposite side of the river. This habitat patch was about 24.66 ha in size. The main roost site was approximately eight kilometers from the center of the SY male's MCP home range, and 11 kilometers from the center of the ASY male's MCP home range. The roost was shared with hundreds of Red-winged Blackbirds.

2020 Season

The ASY female roosted in two small strips of dense, shrubby mixed pine/hardwood habitat comprising about 0.99 ha. The strips were within 150 meters of each other, and were both located between private residences and non-residential areas. The roost sites were just outside the bounds of the female's MCP home range, but within the bounds of the kernel home range (Fig. 9). Other Rusty Blackbirds, American Robins, and White-throated Sparrows were seen and heard roosting at the site. The ASY male roosted in a dense patch of mixed pine/hardwood forest on the edge of a small pond behind Russellville Junior High. The patch was about 3.48 ha in size, and was approximately 650 meters from the center of the MCP home range (Fig. 10).

Home Range

In the agricultural setting (2019 season), I calculated the home ranges of two birds: an ASY female, and a SY male. The SY male had a larger home range (415.50 ha KDE, 319.28 ha MCP, n = 49) and core area (85.23 ha KDE), with waypoints concentrated in two general areas (Fig. 7). The ASY male had a smaller home range (48.70 ha KDE, 33.52 ha MCP, n = 104) and core area (10.82 ha KDE), with a more even spread of waypoints (Fig. 8).

In the urban setting (2020 season), I calculated the home ranges of two birds: an ASY female, and an ASY male. The ASY female had a much larger home range (176.66 ha KDE, 604.37 ha MCP, n = 457) and core area (19.83 ha KDE), with a very patchy distribution of waypoints (Fig. 9). The ASY male had a very small home range (19.86 ha KDE, 27.05 ha MCP, n = 86) and core area (3.92 ha KDE), though this may be due to the fact that this bird was only monitored for a few days before it migrated (Fig. 10).

Overall, area use was much patchier in the urban area, with distinct clusters of waypoints in a matrix of unused habitat. The MCPs for both birds in the urban area greatly overestimated home range size, and did not accurately represent the distribution of waypoints or the area that

was actually used. Area use in the agricultural area was much less patchy; waypoints were distributed more evenly within the isopleth polygons. However, the MCPs for both birds underestimated home range size, and once again did not accurately represent the area used by Rusty Blackbirds because waypoints were not evenly distributed within the MCPs (Figs. 7 and 8).

Habitat Use

Radio-tagged Birds

A detailed description of each habitat type in the agricultural and urban areas can be found in Table 5. Habitat selection in the agricultural landscape was assessed within the home ranges of the birds we followed. Microhabitats utilized by birds in the agricultural landscape included pecan trees (*Carya illinoinensis*), wet patches of short grass (< 15cm in height) and medium grass (< 30cm in height), shallow grassy ditches, brush piles, shrubby fence rows, mature riparian hardwoods, and vegetation (including shrubs < 5m in height, and mature hardwoods) bordering small cattle field ponds. The sample size was insufficient for compositional analysis, so I performed a qualitative assessment of habitat selection in order to determine habitat selection. Of the habitat types shared by the two birds, pecan groves were the most strongly selected for (proportional use was much higher than availability) while agricultural areas other than pecan groves and rice fields were most strongly avoided (Table 6). For the SY bird, there was also moderate selection for a riparian zone and cattle pasture. Rice fields were generally avoided.

Habitat selection in the urban landscape was also assessed for the two birds mentioned in the home range analysis. Microhabitats utilized by birds in the urban setting included pecan trees, willow oaks (*Quercus phellos*), sweetgums (*Liquidambar styraciflua*), other hardwoods,

residential lawns and other grassy fields, and wet patches of leaf litter. Four habitat types were common to both bird's home ranges, and I used compositional analysis to evaluate habitat selection among those habitats. The resulting ranking matrix (Table 8) provides a pairwise comparison of use for these habitat types. Overall, the habitat within both home ranges that was most strongly selected for by both birds was a patch of seasonally flooded hardwood forest with an open understory (Fig. 11). I also found moderate selection for residential areas. Both birds avoided non-residential areas (schools and businesses) and seasonally flooded mixed forests that had dense understories. Four additional habitats were unique to the ASY female, and I performed a qualitative assessment of these habitats. Within her MCP she selected for urban parks – including a cemetery (proportional use was 0.05; proportional availability was 0.02; Table 7), and avoided cattle fields, other agricultural areas, and a mature old field (Table 7).

Visual Observations of Other Birds

During our surveys of the Arkansas River Valley and Mississippi Alluvial Valley, we located Rusty Blackbirds in seven habitat types: shallow flooded hardwood forests – including bottomland hardwood forests; riparian zones – particularly along small creeks; pecan groves; cattle fields; shallow flooded agricultural fields – including rice fields; urban parks – including disc golf courses and cemeteries; and mowed lawns – including lawns with oak trees - in residential and non-residential areas. We observed Rusty Blackbirds utilizing many different microhabitats, including wet and dry patches of short mowed grass and leaf litter; wet, muddy patches of cattle fields and agricultural fields; paved patches of asphalt or cement, hardwood trees – including mature pecan trees –and shrubs; and streams and vegetated drainage ditches less than 15cm deep.

We documented annual variation in the presence of Rusty Blackbirds among habitats. Specifically, Rusty Blackbirds were consistently present on lawns that had a very open oak overstory at the Arkansas Tech University campus (Russellville) during the latter half of the 2019 and 2021 seasons, but were absent from this habitat in the 2020 season. We observed as few as two, and as many as 350, Rusty Blackbirds in the 2019 and 2021 seasons, with a mean count of 100. Similarly, we observed small (n = 8 blackbirds) to medium-sized (n = 30-60 blackbirds) flocks of Rusty Blackbirds in the pecan groves in the Atkins/Blackwell area during the 2019 and 2021 seasons; however, Rusty Blackbirds were either absent, or present in very small numbers (n < 3 blackbirds) in this habitat during the 2020 season.

Foraging

Birds in the agricultural area were primarily observed feeding on pecans and terrestrial non-native earthworms (*Lumbricus* spp.). Birds in the urban area were observed feeding on acorns and earthworms. However, most food items could not be identified in the field, so our observations were far from exhaustive.

Discussion

During our surveys of the Arkansas River Valley and Mississippi Alluvial Valley, Rusty Blackbirds were found in anthropogenic habitats within agricultural and urban landscapes. Radio-tagged birds often selected habitats that were converted for agriculture, or in heavily populated and developed areas. These included pecan groves, cattle fields, residential areas, and urban parks. The tremendous loss of bottomland hardwood habitat and the resources it provides in the Rusty Blackbird's winter range has led to use by Rusty Blackbirds of new habitats to substitute or supplement those lost resources (Newell Wohner et al. 2016). Rusty Blackbirds may also use anthropogenic habitats that are structurally similar to bottomland hardwood habitat. For

example, an urban park (Fig. 12) which provides acorn mast or invertebrates may serve as a substitute for a bottomland hardwood stand. Similarly, pecans serve as a high-lipid substitute for acorns in agricultural areas – where acorns are scarce or absent (Newell Wohner et al. 2016). On the other hand, selection of a riparian zone by Rusty Blackbirds in the 2019 season, and a seasonally flooded hardwood forest in the 2020 season, suggests that Rusty Blackbirds will still use more "traditional" habitats when they are available. Further, the apparent high survival rate of the radio-tagged birds in the agricultural and urban landscapes, and the presence of other Rusty Blackbirds in these habitats through late March (personal observation), suggests that the combination of undeveloped and anthropogenic habitats may provide the resources Rusty Blackbirds need to survive the winter.

The anthropogenic habitats mentioned above are also used by Rusty Blackbirds in the weeks leading up to migration. Wright et al. (2018) found that Rusty Blackbirds exhibited longer stopovers than many passerines during spring migration – likely due to high energetic requirements of migration, as well as to fuel their partial prealternate molt. Therefore, I suspect that habitats used by Rusty Blackbirds in the winter also provide sufficient food resources needed to build up energy stores prior to migration (Metcalfe and Furness 1984). Consequently, resource availability in these habitats will impact both overwinter and migratory survival of the Rusty Blackbirds. In the 2020 season, we noted the ASY female leaving the Russellville area during the day, and returning to her roost site at night; she exhibited this behavior for a week before we permanently lost signal on her. Some bird species are known to explore new habitats prior to migration when seeking food to build up fat reserves. Given that body fat was lower in the birds we captured in the 2020 season (Table 2), it may be that she was unable to find sufficient resources in the Russellville area to build her fat reserves, and was therefore exhibiting

similar exploratory behavior. Further research is needed to assess the suitability of the anthropogenic habitats as substitutes for traditional habitats, and to determine their impact on the overwinter and migratory survival of the Rusty Blackbirds.

In a study of Rusty Blackbird occupancy in the Mississippi Alluvial Valley, Luscier et al. (2010) found that Rusty Blackbirds were less specialized in their habitat use than previous observations had suggested. They also could not reliably predict Rusty Blackbird occupancy from canopy cover, tree density, or water cover. The Rusty Blackbirds' apparent flexibility in winter habitat use suggests that our observations in this regard may have been season-specific, and do not necessarily represent the birds' habitat use across all seasons. For example, while radio-tagged birds were absent from cattle fields in the urban setting during the 2020 season, I observed up to 300 Rusty Blackbirds in this habitat during the 2021 season. Multi-year studies of habitat use are needed to better understand the lack of habitat specialization in Rusty Blackbirds.

The differences that we observed in the Rusty Blackbirds' habitat use among years may also be due to an interaction between weather and food availability. Newell Wohner et al. (2016) found that the diet composition of wintering Rusty Blackbirds was impacted by temperature and precipitation patterns. Rusty Blackbirds increased their consumption of protein-rich earthworms prior to precipitation events and higher daily max temperatures, whereas when colder temperatures were expected, the blackbirds increased their consumption of lipid-rich acorn mast and pecans. In the Arkansas River Valley, mean temperatures in December and January were higher in the 2020 season than either the 2019 or 2021 seasons (NOAA), which may explain the presence of Rusty Blackbirds in pecan groves in the latter seasons, and their absence in the former. It may also explain the pattern of Rusty Blackbird occupancy on the Arkansas Tech campus in Russellville, where they were seen feeding on acorn mast in the 2019 and 2021

seasons, but from which they were absent in the 2020 season. The differences in habitat use among our radio-tagged birds may be due to weather patterns as well. The annual variation in Rusty Blackbird habitat occupancy indicates the need for multi-year studies on their winter ecology to better understand patterns of habitat use. Moreover, it indicates that we need to manage for both mast and invertebrates, to fulfill the Rusty Blackbird's foraging needs across years that have different weather patterns. An understanding of Rusty Blackbird habitat use patterns can help us prioritize management needs when resources are limited (Newell Wohner et al. 2016).

Due to our extremely small and uneven sample sizes, I cannot make robust comparisons of home ranges among birds, or between seasons. However, some general patterns in the data are worth mentioning. Overall, the kernel home ranges of the radio-tagged birds were much patchier in the urban landscape than the agricultural landscape. Waypoints were clustered in specific areas (e.g., a particular lawn, park, or patch of forest), and the habitat matrix outside these clusters (but within the MCPs) was practically unused. In contrast, the birds in the agricultural setting had more contiguous kernel home ranges, with proportionately less unused habitat matrix within the MCPs. These patterns may be due to the patchy distribution of appropriate habitat in the urban landscape. The distribution of appropriate habitat in urban landscapes may result in Rusty Blackbirds spending more time in each patch before making a long flight to another patch. In contrast, the agricultural landscape comprises large, contiguous swaths of habitat, in which the food is more evenly distributed. Consequently, the birds can make frequent, short flights to different locations within a single habitat type in search of food.

In birds and mammals, home range size often increases with greater habitat fragmentation and heterogeneity, and decreases with greater habitat quality and prey abundance

(Evens et al. 2018; Kouba et al. 2017; Mayer et al. 2019; Siffczyk et al. 2003). Mettke-Hofmann et al. (2015) found that Rusty Blackbird body condition was higher in pecan groves than forests and riparian zones; additionally, nut biomass availability was less variable in the pecan groves than was invertebrate availability in other habitats. These findings led to the conclusion that, despite having the lowest invertebrate biomass, pecan groves were the preferred habitat type. In urban areas, where Rusty Blackbirds feed on both invertebrates and acorn mast, food availability may be more variable than in the pecan groves (Newell Wohner et al. 2016). The birds we captured in the pecan groves had more body fat, and weighed more on average, than the birds in the urban setting (Table 2). The differences in habitat quality between the agricultural and urban landscapes, as well as the greater habitat fragmentation and heterogeneity in the urban setting, may explain why the MCP of the ASY female in the urban landscape (604.37 ha) was larger than the MCPs of the SY and ASY males in the agricultural landscape (319.28 ha and 33.52 ha, respectively; the MCP of the ASY male in the urban landscape was the smallest [27.05 ha], but this may be because we only monitored the male for a few days prior to migration). Despite the patterns in MCP size between landscapes, mean kernel home range size was lower in the 2020 season. A comparative study of habitat quality and body condition between agricultural and urban landscapes is needed to clarify these patterns.

The differences we observed in the Rusty Blackbirds' home ranges may also be due to the weather patterns discussed earlier. Lower temperatures in the 2019 season would have increased the Rusty Blackbirds' need for a high-lipid mast diet, and possibly necessitated a larger foraging area to fulfill that need. Conversely, warmer temperatures in the 2020 season would have reduced the caloric needs of the Rusty Blackbirds; consequently, these birds would not need extensive foraging areas to fulfill their energy requirements. The need for a larger foraging

area may explain why the kernel home range of the SY male in the agricultural landscape (415.50 ha) was larger than the kernel home ranges of the ASY female and ASY male in the urban landscape (179.66 ha and 19.86 ha, respectively). The relationship between weather and energy requirements may also explain why we had a significantly higher proportion of feeding observations in the 2019 season (Table 3). However, weather can have either a positive of negative effect on home range size (Kouba et al. 2017; Perkins et al. 1997). The differences we observed in home range sizes, among individuals and between seasons, were probably caused by interactions among several factors, including landscape features, habitat quality, prey abundance, weather, and demographics.

The Rusty Blackbird's use of anthropogenic habitats presents unique opportunities and challenges in managing for this species. Because much of the land in the historic range of the Rusty Blackbird has been converted into agricultural and urban landscapes, the establishing of new habitat for Rusty Blackbirds will be extremely difficult and expensive. As a result, management efforts will need to focus on making the existing habitat suitable for Rusty Blackbirds. In the urban setting, the fragmented nature of the landscape will necessitate managing a network of habitat patches for Rusty Blackbirds. The most viable course of action will be to maintain a mosaic of attractive habitat patches (e.g., lawns, small urban parks, grassy fields) in a matrix of undesirable habitat. These patches could serve many uses; for example, Rusty Blackbirds utilized disc golf parks in Russellville and Little Rock, which also provided recreational opportunities for residents. Potential management actions to increase the suitability of urban habitat include maintaining shallow flooded wetlands (Newell Wohner et al. 2016); establishing vegetated ditches in urban parks and lawns; planting oak trees that have small acorns or pecan trees to provide food for the birds in parks and residential areas, as well as planting

other hardwoods to provide leaf litter and perching habitat for the birds; maintaining appropriate soil conditions for earthworms and other invertebrates; and planting shrubs or placing brush piles in parks and lawns to provide cover. In the agricultural setting, management can be conducted at the habitat level to provide large, contiguous patches of suitable habitat. Potential management actions are more limited in the agricultural setting, but improvements are possible. For example, discarded pecans may be left on the ground – or even distributed throughout the grove – to provide forage for the Rusty Blackbirds. Similarly, water levels in vegetated drainage ditches and wet patches in the pecan groves can be maintained at depths which are suitable for the Rusty Blackbirds; generally, we observed birds foraging in and around patches that were less than 15cm deep. In both the agricultural and urban settings, reducing the use of pesticides or herbicides will also benefit the Rusty Blackbirds by increasing invertebrate prey abundance, and reducing bird mortality and possible bioaccumulation of toxins (Blanchfield 2011; Minh et al. 2002).

In the states occupied by nonbreeding Rusty Blackbirds, private land comprises anywhere from 71% to 97% of the total area (Summitpost n.d.). Much of the land used by Rusty Blackbirds in this study was privately owned as well. Consequently, education and outreach will need to be key components of conservation measures for this species. In agricultural areas, where many farmers still think of blackbirds as crop pests, we should speak to land owners – especially pecan grove owners – about the plight of the Rusty Blackbird, and provide resources to aide in their identification, in order to facilitate coexistence with this species. In residential areas, where Rusty Blackbirds utilize private lawns, we should familiarize homeowners with some of the management practices mentioned above. Similarly, collaboration with local and regional officials

will be necessary to move forward with habitat management in urban parks and other public lands.

The need for further research on all aspects of Rusty Blackbird ecology is still great, and will likely increase in the face of climate change and continued habitat loss. There are many components of the Rusty Blackbird's winter ecology that are poorly studied, such as site fidelity, or sex-, age-, and habitat-specific survival. Additionally, flooding and the resulting inaccessibility hinder studies in the remnant bottomland hardwood forests of the Southeast. Large populations of Rusty Blackbirds still utilize this habitat, but little is known about their movements or ecology. Remote telemetry or the use of geolocators may aide the study of Rusty Blackbirds in these areas. There is also a need for comparative studies of Rusty Blackbird winter ecology among regions or states. For example, in an analysis of Christmas Bird Count data on Rusty Blackbirds in Arkansas, we found a positive trend in bird counts over the past two decades (Fig. 13; National Audubon Society 2020). In contrast, neighboring states such as Louisiana, Mississippi, and Texas have shown negative population trends over the same time period (Meehan et al. 2020). Comparative analyses of habitat quality, availability and use, as well as other aspects of the birds' winter ecology, among these states may provide useful insights for managers in establishing and maintaining suitable habitat for wintering Rusty Blackbirds. With increased effort toward the study, management, and conservation of this species, it may still be possible to curtail their population loss and prevent extinction.

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Tables and Figures

Table 1. Summary of all Rusty Blackbird captures. See Table 5 for habitat descriptions of the capture sites.

Date Captured	Site	City/County	Age	Sex	BBL Band Number	Date last detected	Total days with active transmitter
2/15/2019	Pecan grove 1	Blackwell/Conway	SY	M	1342-45812	3/17/2019	31
2/18/2019	Pecan grove 1	Blackwell/Conway	SY	F	1342-45813	3/20/2019	30
2/21/2019	Pecan grove 2	Blackwell/Conway	SY	M	1342-45814	3/29/2019	36
2/21/2019	Pecan grove 2	Blackwell/Conway	ASY	M	1342-45815	3/11/2019	19
2/21/2019	Pecan grove 2	Blackwell/Conway	SY	M	1342-45816	2/26/2019	5
2/22/2019	Pecan grove 2	Blackwell/Conway	AHY	M	1342-45817	n/a	n/a
2/7/2020	Hickory Hollow Disc Golf Course	Russellville/Pope	ASY	F	1342-45818	3/25/2020	48
3/15/2020	Private residence	Russellville/Pope	ASY	F	1342-45819	3/20/2020	19
3/15/2020	Private residence	Russellville/Pope	ASY	M	1342-45820	3/21/2020	7

Table 2. Body condition of birds captured in the 2019 and 2020 seasons. Body fat values were assigned on a scale of 0 to 5. Descriptions of the numeric categories are as follows: 0 - furcular cavity is empty; 1 - cavity is < 25% full; 2 - 25-50% full; 3 - 50-75% full; 4 - 75-100% full; 5 - >100% full (overflowing). Pectoral muscle values were assigned on a scale of 1 to 4. Descriptions are as follows: 1 - poor (pronounced concavity); 2 - fair (slight concavity); 3 - good (flat/no concavity or bulging); 4 - very good (bulging).

Season	**Age**	**Sex**	**Mass (g)**	**Body Fat**	**Pectoral Muscle**
2019	SY	M	79	2	3
2019	SY	F	68	2	2
2019	SY	M	84	3	2
2019	ASY	M	78	3	2
2019	SY	M	80	4	2
2019	AHY	M	83.5	2	2
2020	ASY	F	55	1	2
2020	ASY	F	53	0	2
2020	ASY	M	60	1	3

Table 3. Summary of behaviors recorded for all radio-tagged birds. Numeric values represent the proportion of telemetry points (observations) that contained the corresponding behavior. For the 2019 season, behavior was unknown for 21% of observations; values in the table represent the proportions of the remaining 79% of waypoints. In the 2020 season, behavior was unknown for 49% for observations; values in the table represent the proportions of the remaining 51% of waypoints. Note: proportions do not add up to 1 as some observations had more than one behavior associated with them. The results of the pairwise proportions tests are included in the last column.

Behavior	**Proportion of Observations - 2019 Season**	**Proportion of Observations - 2020 Season**	**Proportions Test Results**
Foraging/Feeding	0.63	0.45	$\chi^2 = 38.73$; $p << 0.001$
Vocalizing	0.10	0.01	$\chi^2 = 23.49$; $p << 0.001$
Resting	0.49	0.47	$\chi^2 = 0.56$; $p = 0.45$
Interspecific Interaction	0.00	0.01	$\chi^2 = 17.86$; $p << 0.001$
Bathing/Preening	0.06	0.17	$\chi^2 = 61.04$; $p << 0.001$

Table 4. Summary of height observations for all radio-tagged birds. Numeric values represent the proportion of total observations in which the bird was seen at the corresponding height interval. For the 2019 season, height was unknown for 2% of observations. Values in the table represent the proportions of the remaining 98% of waypoints. In the 2020 season, height was unknown for 48% for observations; values in the table represent the proportions of the remaining 52% of waypoints. "< 0m" refers to birds that were seen on partially submerged vegetation in a creek below ground level. "Unknown (< 5m)" refers to birds that were hidden from view in a shrub or brush pile less than 5m tall.

Height (m)	**Proportion of Observations - 2019 Season**	**Proportion of Observations - 2020 Season**
< 0	0.01	0.00
0	0.42	0.48
1-5	0.19	0.13
6-10	0.12	0.19
11-15	0.10	0.15
16-20	0.04	0.05
21-25	0.01	0.00
Unknown (< 5m)	0.11	0.00

Table 5. Descriptions of habitats associated with radio-tagged birds, as well as some additional habitats where netting was attempted.

Habitat	Description
Pecan grove 1	Approximately 65.34 ha in size, with an average DBH of 48.40cm, and a density of 28.67 trees/ha. Substrate was a mix of bare ground (sandy soil), mossy patches, and short grass (< 15cm). Grove contained a few shallow grassy ditches.
Pecan grove 2	Mature grove was approximately 58.21 ha in size, with an additional patch of saplings about 13.59 ha in size. Average DBH of mature trees was 25.56cm; density was 64.85 mature trees/ha. Substrate was a mix of bare ground (sandy soil), mossy patches, short grass (< 15cm), and medium grass (< 30cm). A small, shallow drainage ditch ran diagonally across the northern portion of the grove.
Rice field	Rice fields ranged from mostly dry with a few shallow flooded patches, to completely inundated.
Cattle field	Cattle fields in the agricultural area (2019) comprised mostly very short grass, with a few small ponds edged with shrubby vegetation or mature hardwoods. Cattle fields in the urban area (2020) comprised mostly very short grass; one field contained a single patch of oak trees about 0.39 ha in size.
Riparian zone	Riparian zones bordered small streams and creeks ranging in width from 4 m (Prairie Creek) to 30 m (Point Remove Creek). Riparian vegetation ranged from small shrubs to large, mature hardwoods. Riparian habitat sometimes included partially submerged vegetation.
Hardwood forest	Single patch of privately-owned seasonally flooded hardwood forest in Russellville approximately 3.61 ha in size. The closed-canopy forest had a completely open understory, and contained many small pools of water, ranging in depth from a few centimeters to about 0.5 m. Canopy tree density was approximately 130.94 trees/ha, while sub-canopy tree density was about 74.82 trees/ha. Basal area was 27.53 m^2/ha, and average canopy cover was 94.07%. Tree species present included southern red oak (*Quercus falcata*), willow oak (*Quercus phellos*), water oak (*Quercus nigra*), shagbark hickory (*Carya ovata*), elm (*Ulmus* spp.), and red maple (*Acer rubrum*).

Table 5 (Continued). Descriptions of habitats associated with radio-tagged birds, as well as some additional habitats where netting was attempted.

Habitat	Description
Mixed forest	Seasonally flooded mixed forest with a very dense understory. Closed canopy forest comprised mainly hardwood trees and shrubs, with a few pine trees along the edges.
Residential	Consisted primarily of individual homes and apartment buildings, with associated manicured lawns. Residential lawns consisted of very short, regularly mowed grass with occasional shrubs, brush piles, drainage ditches, and hardwood trees [including oak trees (*Quercus* spp.), pecan trees (*Carya illinoinensis*), and sweetgum (*Liquidambar styraciflua*)]. Lawns ranged in size from about 0.01 ha to 3.22 ha in size. The latter refers to a private residence where birds were captured in the 2020 season; this lawn contained about 30-35 hardwood trees, as well as small, shallow pools.
Non-residential	Includes schools, businesses, industrial areas, large roads, and railroads.
Urban parks	Includes a cemetery. Most parks comprised short grass fields with sparse pines and hardwoods. Hickory Hollow Disc Golf Course, where birds were captured in the 2020 season, was approximately 5.90 ha in size, with a canopy tree density of 99.76 trees/ha, subcanopy tree density of 12.47 trees/ha, basal area of about 10.84 m^2/ha, and an average canopy cover of 60.48 %. Trees present at Hickory Hollow included American sycamore (*Platanus occidentalis*), post oak (*Quercus stellata*), southern red oak, willow oak, shortleaf pine (*Pinus echinata*), and ash (*Fraxinus* spp.). Pecan trees were found at some urban parks.
Shrubby second-growth field	Single patch of shrubby field approximately 14.86 ha in size, bordered by Prairie Creek in the north, the hardwood forest in the south, and agricultural area on the west, and a road on the east.

Table 6. Proportions of habitat availability and use for two radio-tagged birds from the 2019 season. "Proportion availability" refers to the proportion of each habitat type within the MCP home range, and "proportion use" refers to the proportion of telemetry waypoints in each habitat type within the MCP home range. "Other Ag" refers to all agricultural areas that are not cattle fields, rice fields, or pecan groves. Detailed descriptions of each habitat type can be found in Table 5.

Bird	Habitat Type	Proportion availability	Proportion use
SY Male	Pecan Grove 1	0.18	0.63
	Cattle Field	0.11	0.16
	Rice Field	0.21	0.04
	Riparian Strip	0.07	0.16
	Other Ag	0.43	0.00
ASY Male	Pecan Grove 2	1.00	0.99
	Other Ag	0.00	0.01

Table 7. Proportions of habitat availability and use for two radio-tagged birds from the 2020 season. The first four habitat types were found in the MCP home ranges of both birds, while the latter four were present only in the home range of the ASY female. Detailed descriptions of each habitat type can be found in Table 5.

	ASY Female		**ASY Male**	
Habitat Type	**Proportion availability**	**Proportion use**	**Proportion availability**	**Proportion use**
Residential	0.28	0.55	0.28	0.08
Non-residential	0.44	0.28	0.44	0.20
Seasonally flooded hardwood forest (open understory)	0.01	0.10	0.20	0.57
Seasonally flooded mixed forest (dense understory)	0.06	0.00	0.07	0.15
Other ag	0.09	0.00	n/a	n/a
Urban park/cemetery	0.02	0.05	n/a	n/a
Riparian	0.01	0.00	n/a	n/a
Mature old field	0.03	0.00	n/a	n/a

Table 8. Ranking matrix for habitat use of an After Second Year female and an After Second Year male in the 2020 season. “Hardwood” refers to seasonally flooded hardwood forest, and “mixed” refers to seasonally flooded mixed forest. Detailed descriptions of each habitat type can be found in Table 5.

Habitat type	**Habitat type**			
	Residential	**Non-residential**	**Hardwood**	**Mixed**
Residential		+	- - -	+
Non-residential	-		- - -	+
Hardwood	+ + +	+ + +		+ + +
Mixed	-	-	- - -	0

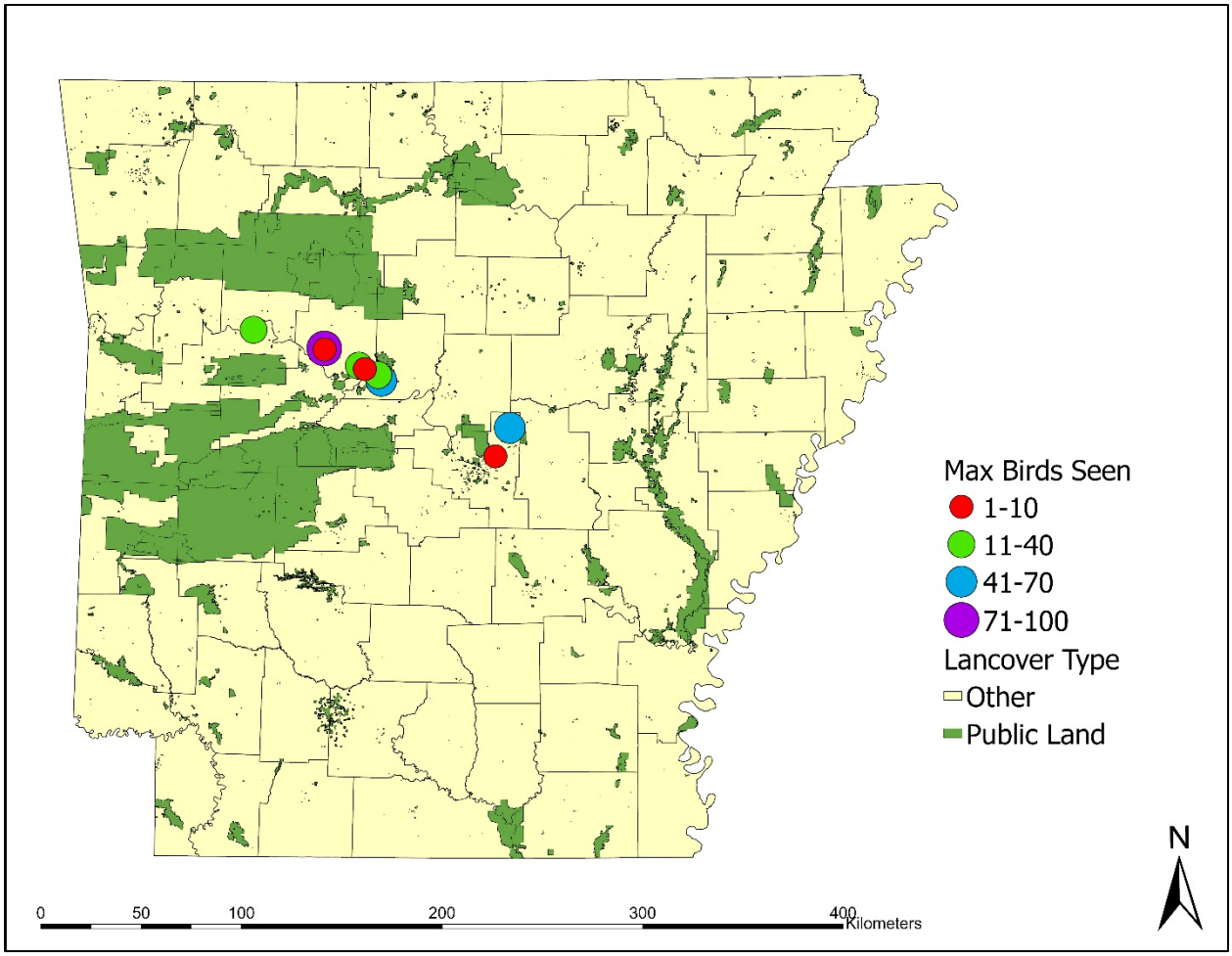

Figure 1. Map of Rusty Blackbird sightings from January through March 2019. Values represent the maximum number of birds seen for sites which were visited more than once. “Other” refers to non-public land, i.e., private, commercial, and residential.

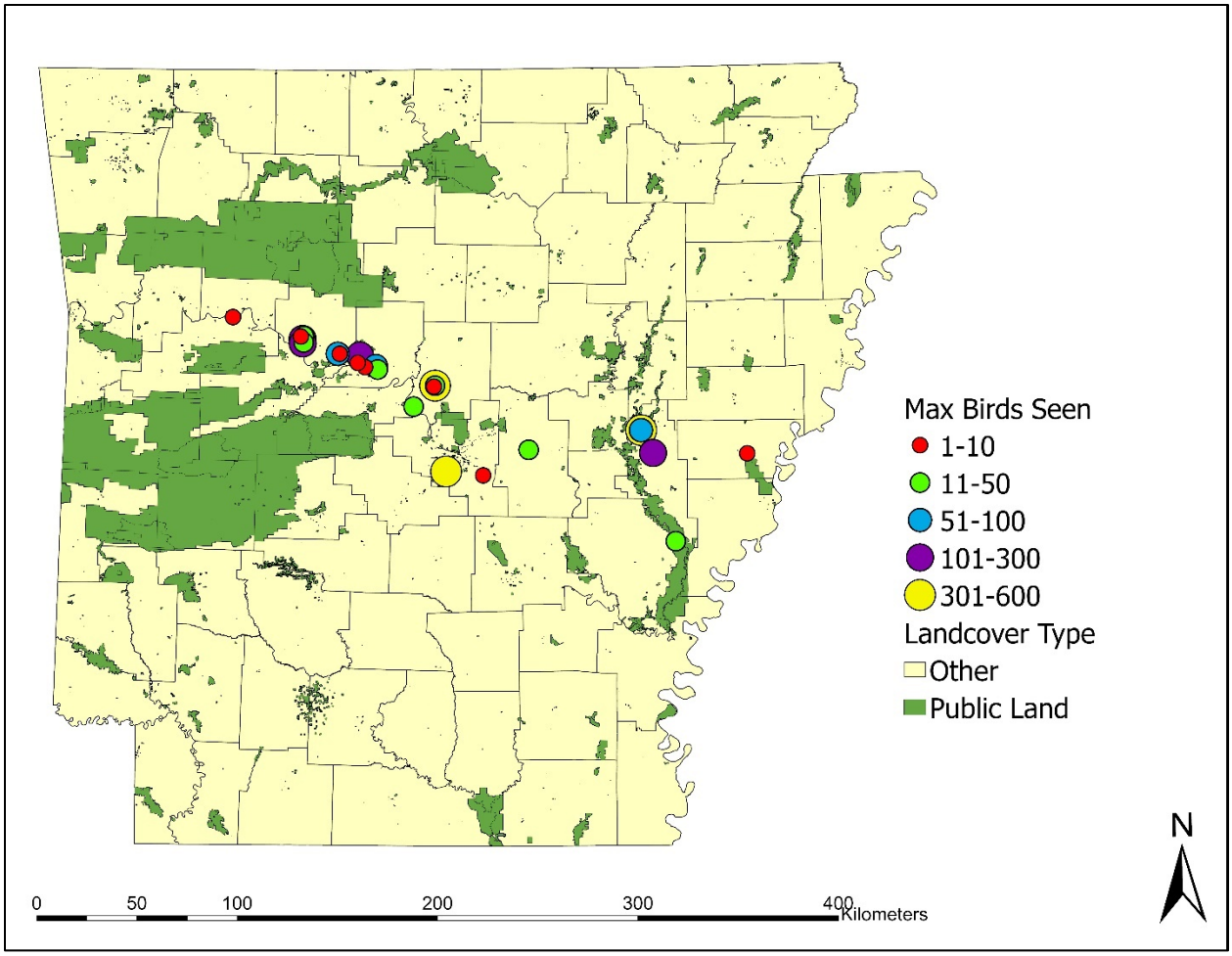

Figure 2. Map of Rusty Blackbird sightings from December 2019 through March 2020. Values represent the maximum number of birds seen for sites which were visited more than once. “Other” refers to non-public land, i.e., private, commercial, and residential.

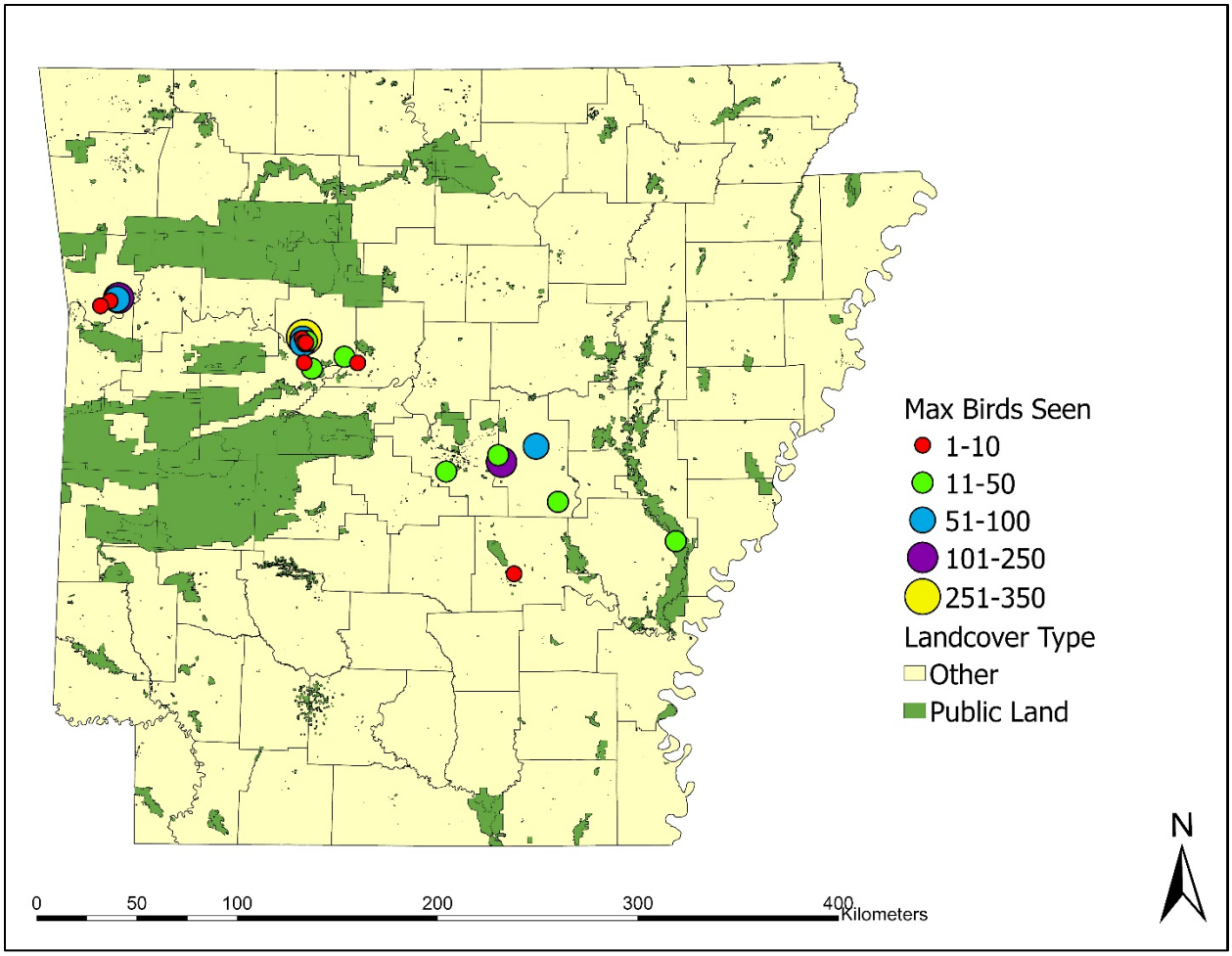

Figure 3. Map of Rusty Blackbird sightings from December 2020 through March 2021. Values represent the maximum number of birds seen for sites which were visited more than once. “Other” refers to non-public land, i.e., private, commercial, and residential.

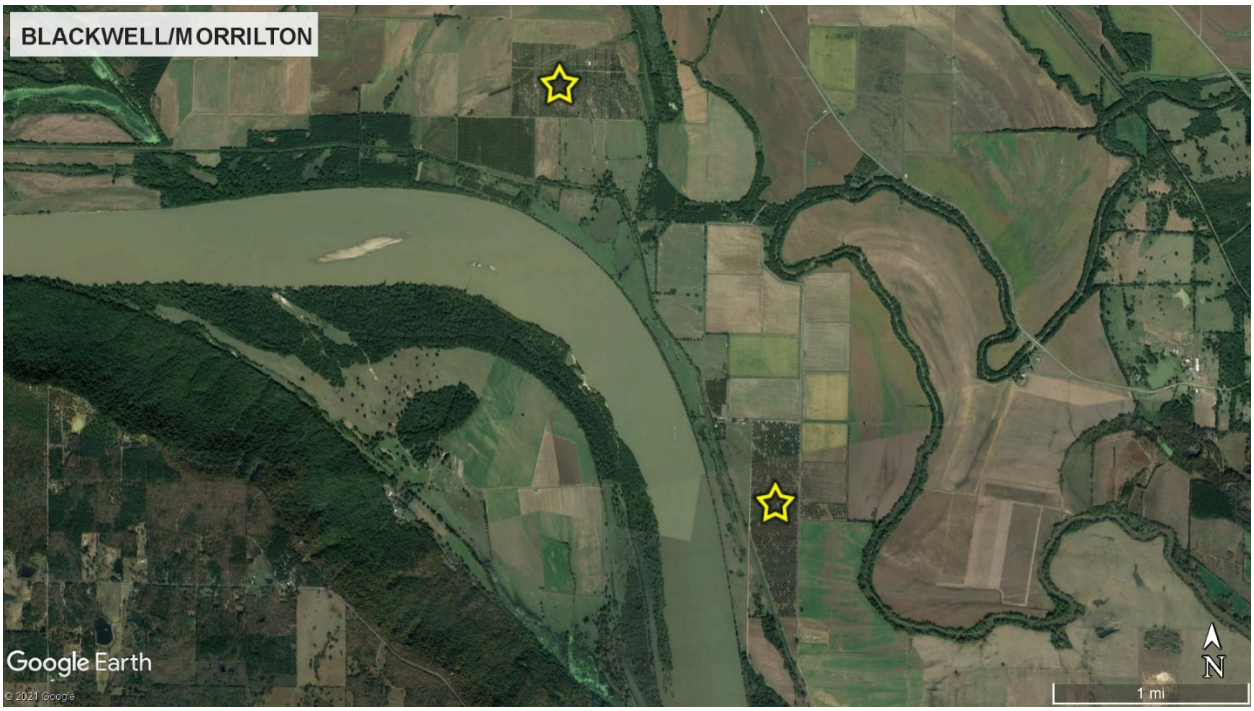

Figure 4. Rusty Blackbird capture sites from the 2019 season. Birds were captured at two privately owned pecan groves near the Arkansas River: a larger, more mature grove to the south (Pecan Grove 1) and a smaller, younger grove to the north (Pecan Grove 2). Sites are marked with yellow stars.

Figure 5. Rusty Blackbird capture sites from the 2020 season. Birds were captured at Hickory Hollow Disc Golf Course (southern marker) and a private residence (northern marker).

Figure 6. Communal Rusty Blackbird roost site from the 2019 season. The site was located between the Lewisburg Bay RV park in the north, and a private residence in the south. Site is marked with a red star.

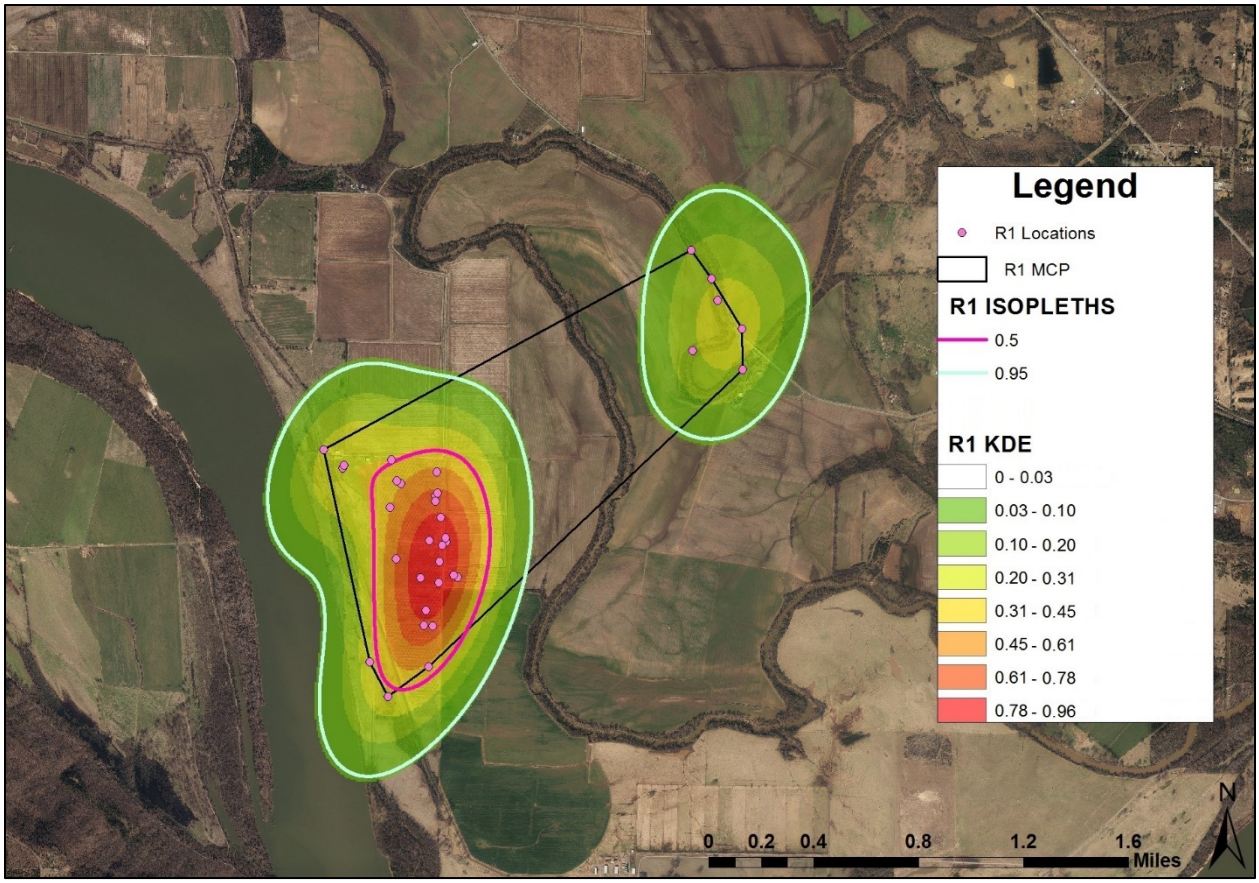

Figure 7. Minimum Convex Polygon home range, and 50% and 95% kernel home ranges, of a Second Year male (Rusty 1) from the 2019 season.

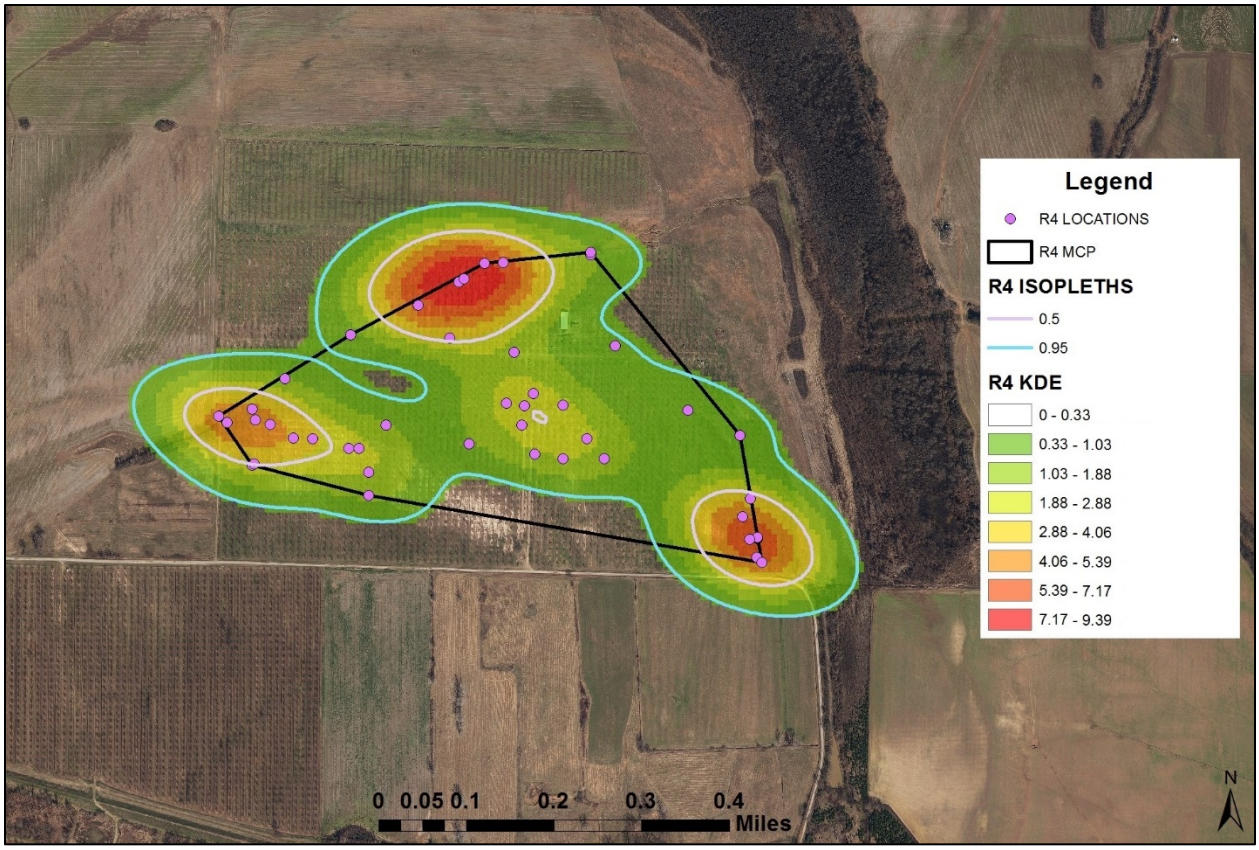

Figure 8. Minimum Convex Polygon home range, and 50% and 95% kernel home ranges, of an After Second Year male (Rusty 4) from the 2019 season.

Figure 9. Minimum Convex Polygon home range, and 50% and 95% kernel home ranges, of an After Second Year female (Rusty 6) from the 2020 season. The roost site is marked with a red star.

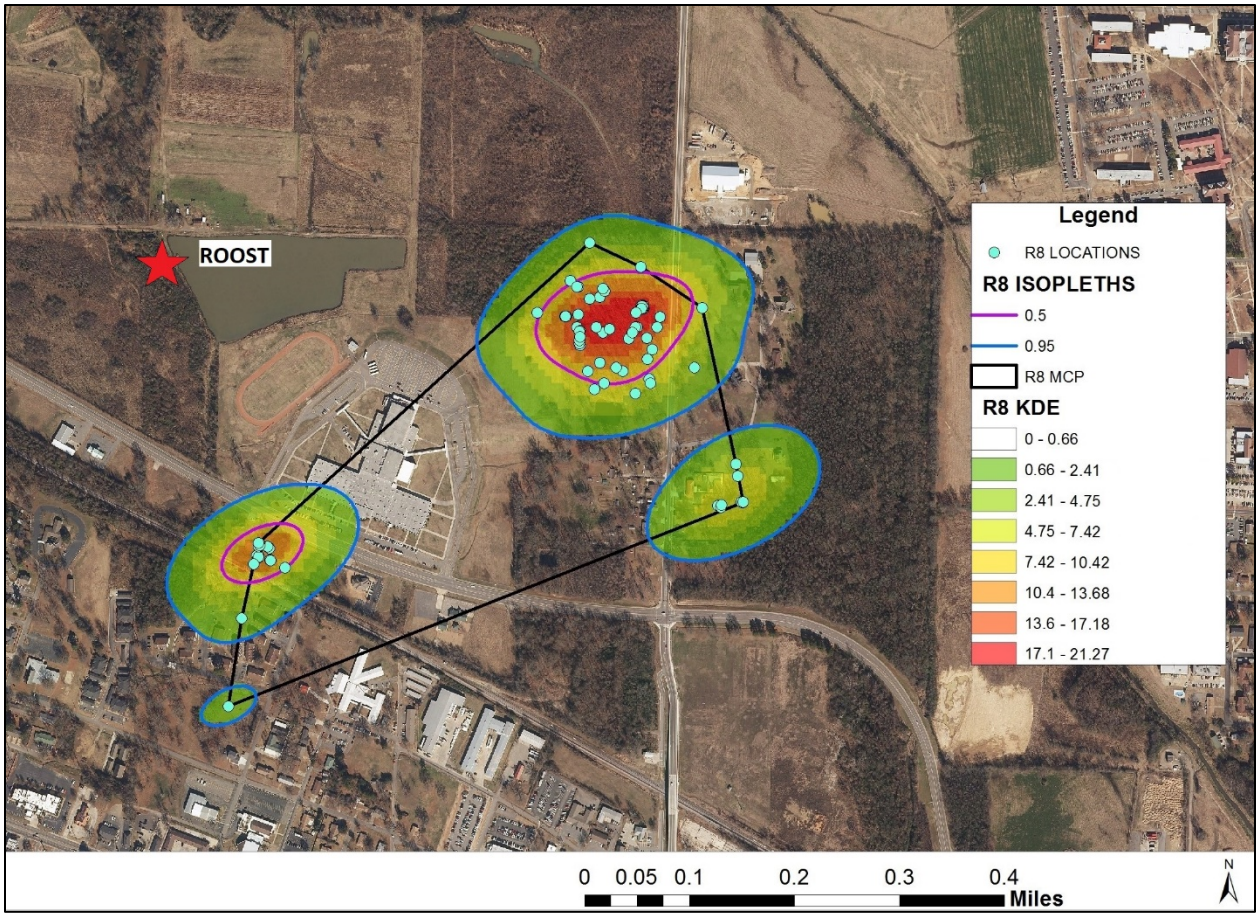

Figure 10. Minimum Convex Polygon home range, and 50% and 95% kernel home ranges, of an After Second Year male (Rusty 8) from the 2020 season. The roost site is marked with a red star.

Figure 11. Seasonally flooded hardwood forest used by birds in the 2020 season (Russellville, Pope County). A detailed description of the habitat can be found in Table 5.

Figure 12. Hickory Hollow Disc Golf Course – an urban park in Russellville, Pope County. A detailed description of the habitat can be found in Table 5.

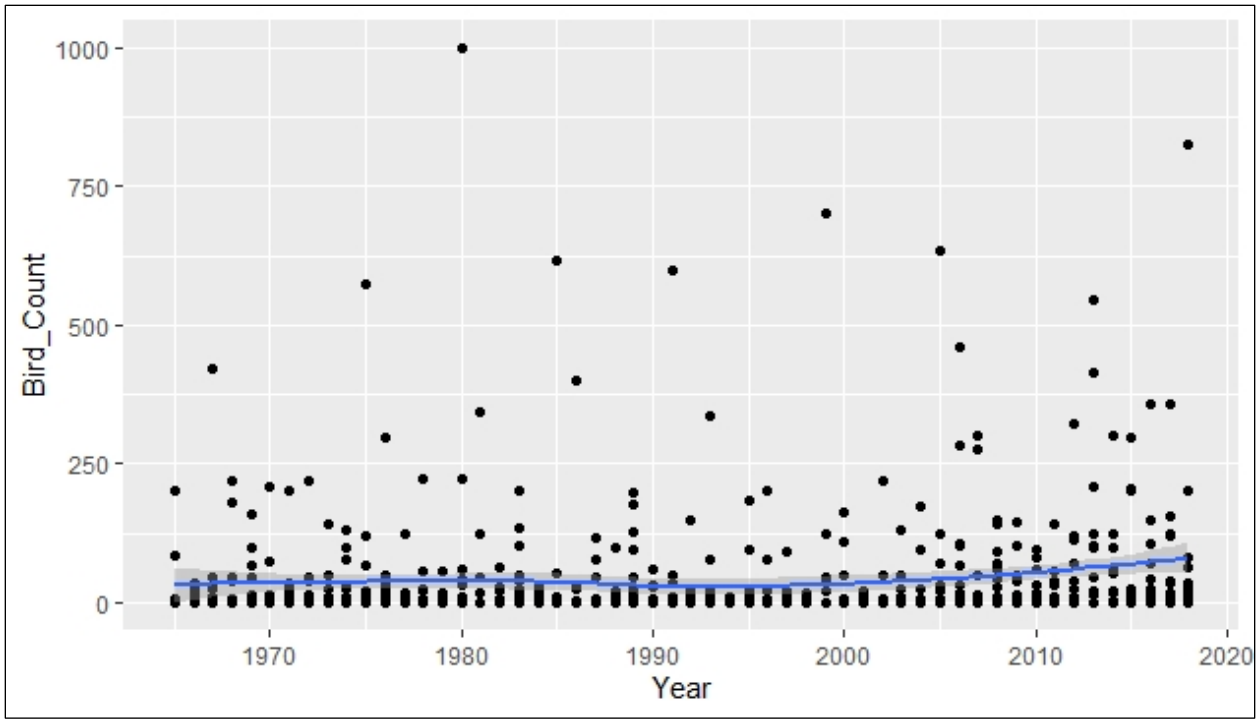

Figure 13. Rusty Blackbird counts in Arkansas from Christmas Bird Count data, 1965 to 2019. The trendline is shown in blue, with the shaded gray area representing standard error. Counts of over 1000 have been excluded to improve the resolution of the data. All data are adapted from the National Audubon Society (2020).

Appendix

Table A1. Detailed descriptions of all Rusty Blackbird sightings from the 2019 season (Jan March 2019). Habitat descriptions for sites marked with a * can be found in Table 5.

Site	City/ County	Date of First Sighting	No. of Visits to Site	Proportion of Visits with RUBL Sightings	Min No. Seen	Max No. Seen	Habitat/Details
Pecan Grove 1*	Blackwell/ Conway	1/10/2019	n/a	n/a	10	50	Site visited several times a week. RUBL seen here regularly through end of March. Captured two birds at this site.
Pecan Grove 2*	Blackwell/ Conway	1/10/2019	n/a	n/a	10	60	Site visited several times a week. RUBL seen here regularly through end of March. Captured four birds at this site.
Atkins Bottom Rd/ McLaren Loop	Atkins/ Pope	1/13/2019	2	1.00	5	20	Birds seen in pecan grove.

SW 12th St.	Atkins/ Pope	1/13/2019	1	1.00	40	40	Rural area. Single group on mowed residential lawn.
Arkansas Tech University Campus	Russellville/ Pope	1/19/2019	8+	1.00	2	8	Birds mainly seen in oak lawns and grassy fields near parking lot. Attempted to net birds at this location on 2/1, 2/4, and 2/24. Birds seen in this area through at least late February.
Mercury Dr.	Jacksonville/ Pulaski	1/21/2019	1	1.00	60	60	Residential area. Moving through a patch of closed-canopy hardwood forest in a residential area. In mixed flock of COGR, and BRBL.
Hwy 109/River Port Rd.	Morrison Bluff/ Logan	1/23/2019	2	1.00	4	16	Birds seen in short grass lawns and fields

Heritage Dr.	North Little Rock/ Pulaski	1/28/2019	1	1.00	10	10	Urban area. Birds were seen foraging with AMRO in an oak lawn between Medical Center parking lot and Post Office.
Red Hill Ln.	Russellville/ Pope	2/23/2019	1	1.00	100	100	Pre-roosting with EUST in hardwood trees between residential and non-residential areas.

Table A2. Detailed descriptions of all Rusty Blackbird sightings from the 2020 season (December 2019 - March 2020). Habitat descriptions for sites marked with a * can be found in Table 5.

Site	City/ County	Date of First Sighting	No. of Visits to Site	Proportion of Visits with RUBL Sightings	Min No. Seen	Max No. Seen	Habitat/Details
Hwy 241/Hwy 17	Keevil/ Monroe	12/6/2019	3	1.00	40	140	Rice fields and other agricultural fields; birds were first seen in a massive mixed flock with RWBL, COGR, and BHCO
White River NWR - Bottomland Hardwoods Trail/Striplin Woods Natural Area	St. Charles/ Arkansas	12/8/2019	9	0.89	6	26	Seasonally flooded bottomland hardwood forest with closed canopy and open understory. Birds were seen in trees, and occasionally foraging on the ground with COGR. We attempted to net at this location on 12/12 and 12/13

Dagmar WMA - Mud Slough Birding Trail	Brinkley/ Monroe	12/18/2019	4	0.75	65	345	Site consists of closed-canopy bottomland hardwood forest. Birds were seen in treetops above birding trail.
Acxiom Building	Conway/ Faulkner	12/18/2019	2	1.00	28	350	Birds pre-roosting with COGR, RWBL, and EUST in small strip of mixed hardwood/pine forest bordering a parking lot in a non-residential area.
E. Robins St.	Conway/ Faulkner	12/18/2019	9	1.00	20	20	Seen in hardwood trees bordering a non-residential area. Birds were pre-roosting, or en route to pre-roost area.

Mississippi River State Park - Visitor's Center	Marianna/ Lee	12/21/2019	1	1.00	2	2	Flyover
Bona Dea Trails & Sanctuary	Russellville/ Pope	12/22/2019	9	0.11	10	10	Foraging by shallow creek in closed-canopy hardwood forest off Prairie Creek Trail
Lonoke Cemetery	Lonoke/ Lonoke	12/30/2019	1	1.00	11	11	Feeding in grassy ditch

Hwy 109 near River Port Rd.	Morrison Bluff/ Logan	1/13/2020	1	1.00	2	2	2 males seen in hardwood treetop
David D. Terry Park	Little Rock/ Pulaski	1/14/2020	1	1.00	2	2	One male and one female seen briefly with COGR in hardwood trees bordering a parking lot. Park is adjacent to an agricultural area outside Little Rock.
Hindman Park	Little Rock/ Pulaski	1/14/2020	7	1.00	40	600	Urban park. Seen in Disc Golf Course area, foraging in wet patches of short grass, and in mixed pine/hardwood forest with open understory. Attempted to net birds here on 1/20, 1/21, and 1/25.

Pecan Grove 2*	Blackwell/ Conway	1/16/2020	6	0.33	2	2	Birds seen briefly in trees, and with a small flock of EUST.
Red Hill Lane	Russellville/ Pope	1/16/2020	n/a	n/a	5	200	Birds were seen pre-roosting in hardwood trees between residential and non-residential areas, and foraging on the ground in a small portion of a cattle field containing a grove of hardwood trees. A radio-tagged ASY female regularly pre-roosted and roosted in this area through the end of March

Hickory Hollow Disc Golf Course*/ Russellville Middle School Fields	Russellville/ Pope	1/28/2020	10	1.00	4	111	Urban park. Birds were often seen feeding in open grassy areas, and in open-canopy patches of mixed pine/hardwood. Birds were also seen vocalizing in trees, and would occasionally fly across the street to forage in a large mowed lawn at Russellville Middle School. We netted this location 1/30, 1/31, 2/1, 2/2, 2/6, 2/7 (caught one ASY female), 2/11, and 2/16.
James Park	Russellville/ Pope	1/28/2020	5	0.80	2	15	Urban park. Birds seen foraging in short grass, and perched in pecan trees, often accompanied by RWBL, COGR, and EUST. A radio-tagged ASY female was seen here on at least two occasions.

Blackwell Liquor Store	Blackwell/ Conway	2/6/2020	3	0.33	180	180	Rural area adjacent to interstate. Birds were vocalizing in mowed lawn and hardwood trees behind Liquor Store parking lot.
Point Remove Creek	Blackwell/ Conway	2/6/2020	2	0.50	4	4	Rural area. Birds were seen in a riparian zone with mature hardwoods near Old Point Remove Creek Bridge. Two radio-tagged birds were seen in this area last season.
SW 12th St.	Atkins/ Pope	2/16/2020	2	1.00	2	70	Birds detected in two different residential lawns, foraging on the ground with EUST, RWBL, COGR, and BHCO; also heard vocalizing in residential hardwoods.

Phoenix Ave/W L St	Russellville/ Pope	2/17/2020	n/a	n/a	4	120	Foraging on ground with COGR, RWBL, and EUST in small patch of seasonally flooded hardwood forest on west side of Phoenix. Birds seen regularly in this area and on large residential lawn on east side of Phoenix through 3/23. We netted in the residential lawn on 2/25, 3/1, 3/3, 3/12, and 3/15 (caught two birds).
Harris Funeral Home	Morrilton/ Conway	3/8/2020	2	1.00	8	65	Residential area. Birds were seen with RWBL, EUST, and COGR, foraging on mowed lawn, and vocalizing in hardwood trees by funeral home.

Table A3. Detailed descriptions of all Rusty Blackbird sightings from the 2021 season (December 2020 - March 2021). Habitat descriptions for sites marked with a * can be found in Table 5.

Site	City/ County	Date of First Sighting	No. of Visits to Site	Proportion of Visits with RUBL Sightings	Min No. Seen	Max No. Seen	Habitat/Details
Pecan Grove 2*	Blackwell/ Conway	12/5/2020	4	0.25	8	8	Foraging on ground with COGR and EUST
Arkansas Tech University	Russellville/ Pope	12/10/2020	20	0.75	2	350	Habitats used by birds included open mowed grass fields, oak lawns, cattle fields, vegetated ditches, and paved parking areas. Birds were often in mixed flocks with COGR, RWBL, BHCO, EUST, and AMRO. Birds were seen foraging on the ground and vocalizing in hardwood trees; pre-roosting behavior was also observed in trees along El Paso Ave.

Water Plant Rd.	Dardanelle/ Yell	12/30/2020	1	1.00	1	1	Rural area. Single female perched in hardwood tree bordering agricultural area.
Hwy 155	Dardanelle/ Yell	12/30/2020	5	0.40	5	30	Rural area. Birds seen foraging in wet cattle field with other blackbirds, and vocalizing in hardwoods bordering cattle field, in mixed flock with RWBL.
Lake Saracen	Pine Bluff/ Jefferson	1/4/2021	3	0.33	8	8	Large urban park. Birds were foraging on the ground in a small patch of shallow flooded hardwood forest on the east side of the lake.
White River NWR - Bottomland Hardwoods Trail/ Striplin Woods Natural Area	St. Charles/ Arkansas	1/8/2021	1	1.00	20	20	Perched in snags at end of boardwalk. At least one vocalizing. Habitat is seasonally flooded bottomland hardwood forest with closed canopy and open understory.

Hwy 13 near Co Rd 990	Humnoke/ Lonoke	1/10/2021	1	1.00	50	50	Rural area. Foraging on residential lawn, in shallow ditch next to highway, and in wet agricultural field. One piebald individual in group.
Frontage Rd east of S Watson Rd	Lonoke/ Lonoke	1/10/2021	1	1.00	60	60	Rural area. Foraging in wet agricultural field with COGR and RWBL, just south of I-40.
S Kerr Rd south of I-40	Kerr/ Lonoke	1/10/2021	1	1.00	220	220	Rural area. Foraging in large residential lawn with RWBL.
Hwy 70 west of George Dr	Kerr/ Pulaski	1/10/2021	1	1.00	15	15	Rural area. Foraging in wet, muddy patch of an agricultural field with RWBL.

Hindman Park	Little Rock/ Pulaski	1/23/2021	1	1.00	50	50	Urban park. Birds seen flying over disc golf course, and later foraging in wet leaf litter in forested portion of disc golf course (mixed pine/hardwood)
Phoenix Ave/W L St*	Russellville/ Pope	1/26/2021	3	1.00	15	100	Birds seen foraging in seasonally flooded hardwood forest, and residential lawn across the street. Often mixed with AMRO, COGR, EUST, and RWBL.
Russellville Junior High School	Russellville/ Pope	1/31/2021	6	0.40	10	10	Birds seen foraging in football field, and grassy field between parking lot and flooded forest; usually with large numbers of AMRO, COGR, BHCO, RUWBL, and EUST.

Hickory Hollow Disc Golf Course*/ Russellville Middle School Fields	Russellville/ Pope	2/9/2021	4	0.50	2	60	Urban park. Birds were heard vocalizing in hardwood trees, foraging in grass/leaf litter in forested portion of park with COGR, and foraging in Middle School fields (mowed) with RWBL, BHCO, EUST, and AMRO.
Atkins Bottom Rd/ McLaren Loop	Atkins/Pope	2/13/2021	4	0.25	25	25	Birds were vocalizing and foraging with EUST and AMCR in pecan grove
James Park	Russellville/ Pope	2/25/2021	3	0.33	4	4	Urban park. Female foraging alone in short grass on west side of park - was eventually chased off by AMRO. One male vocalizing in pecan tree - later joined two males foraging in grass.

S Erie Ave/ E Fifth St	Russellville/ Pope	2/25/2021	1	1.00	1	1	Residential area. Single female foraging in small residential lawn.
S Arkansas Ave near E 11th St	Russellville/ Pope	2/26/2021	2	0.50	6	6	Urban area. Three males and three females were foraging in a grassy field just south of Adult Education Center; mixed with ROPI, KILL, EUST, and AMRO.
E Parkway Dr/ Russellville City Park	Russellville/ Pope	2/27/2021	4	0.50	7	40	Residential/urban area. Birds seen foraging in two different residential lawns with EUST, RWBL, COGR, and BHCO; also heard vocalizing in residential hardwoods. Later seen about 1/2 block south in City Park, foraging in wet grass and vocalizing in hardwood trees.

CR-51/Twelve Corners Ln	Alma/ Crawford	3/14/2021	1	1.00	150	150	Rural residential area. Birds were vocalizing in hardwoods above abandoned lawn and field; also foraging in residential lawns and flooded field along Hwy 51 with RWBL and COGR.
Sharp Chapel Rd	Alma/ Crawford	3/14/2021	1	1.00	75	75	Rural area. Birds were foraging in short grass field with COGR, AMRO, EUST, and RWBL. Field is adjacent to flooded hardwood forest.
Hamer Rd/Old Macedonia Rd	Alma/ Crawford	3/14/2021	1	1.00	1	1	Rural area. Female foraging in short grass by the side of the road with AMRO. Flew across road. Vocalizations heard. Habitat consisted of residential lawns, hardwood forest, and agricultural fields.

Westville Rd/Hwy 162	Van Buren/ Crawford	3/14/2021	1	1.00	1	1	Single male foraging in short grass with EUST. Habitat consisted of sparse hardwood grove.