Winter Breeding and Summer Nonbreeding Home Ranges of Bald Eagles from Louisiana

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ABSTRACT.—Home range size, location, and movements between home ranges may differ markedly within species. Some populations of Bald Eagles breed in summer and move south in winter, whereas others breed in winter and move north in summer, while even others stay in the same area all year. We studied winter breeding and summer nonbreeding home range sizes and locations for 10 Bald Eagles (five adults, three subadults, and two subadults that became adults) captured in Louisiana and tracked with GPS satellite transmitters. Individuals were tracked from 2012–2014, during which, all spent the winter breeding season in Louisiana and all migrated north to Canada for at least one summer nonbreeding season. Most held clearly defined home ranges, which varied from 19.7–2368.3 km², with no significant difference between adults and subadults, winter breeding and summer nonbreeding ranges, year, or their interactions. All nesting home ranges were less than 66 km² and, on average, nonnesting home ranges were 730.3 ± 183.4 km²; however, there was no significant difference in home range size between nesting and nonnesting adults on winter breeding grounds. Individuals exhibited a high degree of fidelity to winter breeding home ranges and relatively high fidelity to summer nonbreeding home ranges. Our baseline estimates of home range size and fidelity for adults and subadults on their winter breeding and summer nonbreeding areas provides insight into the spatial requirements of Bald Eagles, whereas locations and movements between these areas provides insight into intraspecific variation among populations.

INTRODUCTION

Understanding distributions of animals in space and time provides insight into relationships, both with their environments as well as with other animals. Where, when, and how much space an animal uses may vary considerably within a species. One way to examine these variations is to quantify an animal’s home range, defined as the “extent of area with a defined probability of occurrence of an animal during a specified time period” (Kernohan et al., 2001). Areas of high use within home ranges can be expressed as “core areas” (Hodder et al., 1998). After establishing a quantifiable definition of home range and core area, there are a variety of techniques that can be used to estimate their size (Worton, 1987; Kie et al., 2010; Fischer et al., 2013).

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Tracking technology has greatly improved over the years, wherein Global Positioning System (GPS) satellite tracking devices now provide the ability to track an animal over a large area without the contingency of a researcher relocating the animal. These tracking devices also provide large numbers of accurate locations over extended periods of time (Walter et al., 2011), which can create issues with spatial autocorrelation (Kie et al., 2010). Home range estimation techniques using minimum convex polygons, harmonic mean contours, and kernel density estimators were commonly used with locations acquired through visual observation, or by very high frequency (VHF) telemetry, but these methods generally provided few locations and therefore, were assumed not to be autocorrelated (Kernohan et al., 2001; Kie et al., 2010; Cumming and Cornélis, 2012). Introduction of the Brownian bridge movement model (BBMM) improves on previous methods by incorporating temporal information to depict the probability of occurrence between locations (Horne et al., 2007; Walter et al., 2011; Fischer et al., 2013). This depiction of an animal’s home range, using its movement path rather than individual locations, should provide a more conservative estimate of home range and core area size than methods previously used for Bald Eagles (Haliaeetus leucocephalus).

Previous estimates of home range size varied markedly for Bald Eagles depending upon breeding/nonbreeding season, age, and sampling technique. Studies of adults on their breeding areas have reported home ranges ranging from 2–47 km$^2$ using harmonic mean contours (Garrett et al., 1993; Watson, 2002). Subadult home ranges typically are larger than those of adults, ranging from 102–593 km$^2$ using VHF telemetry (Grubb et al., 1989; McClelland et al., 1994) and even larger using satellite telemetry with a kernel density estimator (Mojica, 2006). Comparisons of individual home ranges should provide a clearer understanding into the relationship that age, year, and season may have on home range and core area size.

Home range size has not been documented for Bald Eagles from Louisiana and it is also unknown where this population spends the summer nonbreeding season, as they are rarely observed in state during June, July, and August (Lowery, 1974). Many Bald Eagles from the northern United States and Canada nest in the summer and migrate south for the winter (Gerrard et al., 1978; Hodges et al., 1987; Harmata and Stahlecker, 1993; McClelland et al., 1994; Buehler, 2000; Laing et al., 2005; Mandernack et al., 2012). Bald Eagles from southern latitudes generally nest in winter, with some from Florida, Texas, Arizona, and California then migrating north in spring and returning south to their breeding areas in autumn (Broley, 1947; Hunt et al., 1992; Mabie et al., 1994; Buehler, 2000; Linthicum et al., 2007; Mojica et al., 2008; Hunt et al., 2009). Bald Eagles from Louisiana also nest in winter, laying eggs from late September to early February (Smith et al., 2016a), and therefore we hypothesized they would migrate north in the summer.

Accordingly, we deployed satellite GPS transmitters on Bald Eagles in Louisiana to document the location of their summer nonbreeding areas and estimate their winter breeding and summer nonbreeding home ranges using BBMM. Our objectives were to estimate and compare winter breeding and summer nonbreeding home range sizes as well as document the seasonal and annual repeatability of home range use for subadults and adults.

**METHODS**

**TRAPPING AND MARKING**

We captured Bald Eagles using rocket nets at sites baited with carrion during January through May in 2012 and 2013 (Smith et al., 2016b; Louisiana State University Agricultural...
Center Institutional Animal Care and Use Protocol #A2011-22 and Louisiana Department of Wildlife and Fisheries Federal Banding Permit #06669). The rocket net system used was a modification of Grubb’s portable rocket net capture system (Grubb, 1988; 1991). Rather than the net being deployed from a portable box, the 3-rocket net (9.1 × 15.2 m) was folded like an accordion to approximately 0.3 × 9.1 m extending along the trailing edge. The trailing edge was staked to the ground while the leading edge of the net was attached to three rockets, each elevated above the ground approximately 1 m using metal posts positioned directly behind the net. All trapping was done within 80 km of Mandalay National Wildlife Refuge headquarters in Houma, Louisiana (29°33.638′ N, 90°46.714′ W; Fig. 1). This area contained the largest concentration of Bald Eagles in Louisiana, containing 82% of known active nests in the winter of 2007–2008 (Smith et al., 2016a).

Plumage, beak, and iris characteristics were used to estimate age and categorize each bird as either adult (≥5½ y of age or having definitive plumage: white head, tail, and upper and lower tail coverts) or subadult (≥1½ y of age but lacking definitive plumage; McCollough, 1989). A few drops of blood were collected from the wing vein, placed on a card, and sent to Zoogen DNA Services (Davis, California) for sex determination (Norris-Ceneda and Elliot, 1998). Individuals were fitted with 70-gram ARGOS/GPS solar powered satellite telemetry platform terminal transmitters (PTTs; Microwave Telemetry Inc., Columbia, Maryland). We insured that transmitter weight did not exceed 3% of the birds’ body mass (max = 2.2% in our sample). Each PTT was attached with a backpack style harness using Teflon ribbon (Bally Ribbon Mills, Bally, Pennsylvania; Buehler et al., 1995). Transmitters were programmed to acquire a GPS location every hour and transmit those locations via satellite every other day. A total of 10 individuals were tracked in our analysis of home ranges. We never marked both members of mated pairs, and although genealogy was not known, based on trapping date and age, we assumed that none of the marked individuals were related to each other.

**HOME RANGE**

We estimated home ranges of Bald Eagles captured in Louisiana while on their winter breeding and summer nonbreeding areas. Home ranges were calculated using GPS location data acquired at the northernmost (summer nonbreeding) or southernmost (winter breeding) area where an eagle made omnidirectional movements (<100 km radius) for at least 31 consecutive days. We used the software package BBMM in Program R (version 3.0.1) to calculate overall home range size using a 95% BBMM and a 50% BBMM to represent the core area of use (Horne et al., 2007). Locations were stratified into diurnal and nocturnal movements in order to account for differing movement patterns and provide a more conservative estimate of BBMM variance. Sunrise and sunset times were calculated for each point given its geographical location and date. Horizontal spatial accuracy of GPS locations was assumed to be ±18 m based on the manufacturer’s technical specifications. Cell size was set to 90 m and was later resampled to 30 m in ArcGIS 10.0 (ESRI, 2011, Redlands, California) using a bilinear interpolation. Extents for each home range were set to be the same size (300 × 300 km) and were centered over the locations by calculating the midpoint between the maximum and minimum northing and easting. We did this to allow comparison between BBMMs, since the probability of an individual being within a given cell is calculated as a fraction of the probability of that individual being within the extent, which is set at one (Horne et al., 2007). Therefore, the size of the extent would affect home range size, if it was not standardized across all individuals.
Fig. 1.—Trapping area and subsequent winter breeding area for ten satellite tracked Bald Eagles from Louisiana along with the distribution of their summer nonbreeding home ranges labeled with Eagle ID and the year(s) in which each location was used

a Died of unknown causes prior to establishing 2013 summer nonbreeding home range
b Transmitter not deployed until winter 2012–2013
c Died after capture in a foothold trap and prior to establishing 2014 summer nonbreeding home range
d No summer 2013 nonbreeding home range established, but northernmost location in same general area
e No summer 2012 nonbreeding home range established, but northernmost location in same general area
f Died of unknown causes prior to establishing 2014 summer nonbreeding home range
Nesting status was classified as nesting or nonnesting. A Bald Eagle was presumed to be nesting if it used the same location (presumed nest) every day for at least 35 d, as determined by GPS locations. Presumed nest sites were visually confirmed later from the ground. We chose a 35 d minimum to reflect the incubation period, since both sexes participate in incubation, consistently returning to the nest for the entire period (Buehler, 2000). This also helped distinguish nonnesting birds that may use the same roost or perch site, as these sites were not consistently used for multiple consecutive days.

We compared winter breeding and summer nonbreeding home range sizes by year, sex, age group, and nesting status. Home range fidelity was examined for both winter breeding and summer nonbreeding home ranges. We quantified fidelity as the proportional overlap of an individual’s 95% home range among all years.

**Statistical Analysis**

We used a repeated measures three-way analysis of variance (ANOVA, PROC GLIMMIX; SAS Institute Inc., 2011) to test whether home range size differed (P < 0.05) between age groups (subadult and adult), years, seasons (winter breeding and summer nonbreeding), and their two and three-way interactions. We used a repeated measures one-way ANOVA (PROC GLIMMIX; SAS Institute Inc., 2011) to test whether home range size differed (P < 0.05) between nest status (nesting and nonnesting) for adults during the winter breeding season. We used a repeated measures three-way ANOVA (PROC GLIMMIX; SAS Institute Inc., 2011) to test whether home range size differed (P < 0.05) between sexes (adults only due to the lack of subadult females in our sample), years, seasons, and their two and three-way interactions. Individual birds were used as repeated measures and all explanatory variables were treated as fixed effects.

**Results**

All ten Bald Eagles captured in Louisiana established winter breeding home ranges in Louisiana and migrated north to Canada for at least one summer nonbreeding season where most held clearly defined home ranges (Table 1, Fig. 1, figures for all ten satellite tracked Bald Eagles are available at https://doi.org/10.6084/m9.figshare.4876835). In 2012, nine of ten Bald Eagles established summer nonbreeding home ranges in Canada. Adult male Bald Eagle 201 was the single exception: he flew to British Columbia, Canada, but stayed only 5 d at his northernmost stopover site before starting his southbound migration. In 2013 adult female Bald Eagle 200 stayed at a stopover site for 34 d but then traveled approximately another 500 km north to the area where she established a home range the previous year. That area was again her northernmost stopover site, but she only stayed there for 17 d. Therefore, both Bald Eagle 201’s and 200’s northernmost stopover sites were not considered in the home range analysis for those years (Table 1). However, when tracked birds did establish summer nonbreeding home ranges, they stayed for about 2 mo (n = 23, x = 64.1 ± 4.8, range = 32.8–120.8 d).

Winter breeding and summer nonbreeding home range sizes were x = 723.4 ± 112.0 km² (range = 19.7–2368.3 km²) and x = 281.1 ± 55.1 km² (range 8.8–909.8 km²), respectively, and core area sizes were x = 55.3 ± 8.3 km² (range = 0.6–179.2 km²) and x = 20.5 ± 3.6 km² (range = 1.0–58.7 km²), respectively (Table 1 and 2). Home range size did not differ between male and female adults (F1,15 = 0.45, P = 0.51) when controlling for season (winter breeding/summer nonbreeding), year, and their interactions. Likewise, home range size did not differ between adults and subadults, season, year, or their
interactions (all P’s > 0.06). All nesting home ranges were less than 66 km² (Table 1 and 2) and, on average, nonnesting home ranges were 730.3 ± 183.4 km² (Table 2); however, there was no significant difference in home range size between nesting and nonnesting adults on winter breeding grounds ($F_{1,8} = 2.60, P = 0.14$). Nesting adults spent most of their time at or near the nest site, whereas most nonnesting birds moved between several different core

### Table 1.—Individual winter breeding and summer nonbreeding home ranges, core areas, and percent overlap of home ranges for satellite tracked Bald Eagles from Louisiana. A 95% and 50% Brownian bridge movement model were used to estimate home range and core area size (km²)

<table>
<thead>
<tr>
<th>Eagle ID, sex</th>
<th>Nesting status, age</th>
<th>Winter breeding</th>
<th>Summer nonbreeding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nesting status, age</td>
<td>Home range</td>
<td>Core area</td>
</tr>
<tr>
<td>200, F</td>
<td>Yes, A</td>
<td>27.8</td>
<td>0.6</td>
</tr>
<tr>
<td>201, M</td>
<td>Yes, A</td>
<td>43.9</td>
<td>3.0</td>
</tr>
<tr>
<td>202, F</td>
<td>No, S</td>
<td>911.1</td>
<td>52.8</td>
</tr>
<tr>
<td>203, F</td>
<td>Yes, S</td>
<td>1148.2</td>
<td>81.6</td>
</tr>
<tr>
<td>204, F</td>
<td>No, S</td>
<td>777.6</td>
<td>53.2</td>
</tr>
<tr>
<td>205, M</td>
<td>No, A</td>
<td>62.7</td>
<td>8.8</td>
</tr>
<tr>
<td>206, F</td>
<td>No, A</td>
<td>256.3</td>
<td>16.4</td>
</tr>
<tr>
<td>207, F</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>208, M</td>
<td>No, A</td>
<td>19.7</td>
<td>2.5</td>
</tr>
<tr>
<td>209, M</td>
<td>No, A</td>
<td>294.6</td>
<td>42.7</td>
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</table>

Winter breeding

<table>
<thead>
<tr>
<th>Eagle ID, sex</th>
<th>Nesting status, age</th>
<th>Winter breeding</th>
<th>Summer nonbreeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eagle ID, sex</td>
<td>Nesting status, age</td>
<td>Home range</td>
<td>Core area</td>
</tr>
<tr>
<td>Eagle ID, sex</td>
<td>Nesting status, age</td>
<td>Home range</td>
<td>Core area</td>
</tr>
<tr>
<td>200, F</td>
<td>Yes, A</td>
<td>97.3</td>
<td>12.5</td>
</tr>
<tr>
<td>201, M</td>
<td>Yes, A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>202, F</td>
<td>ON, S</td>
<td>277.2</td>
<td>19.9</td>
</tr>
<tr>
<td>203, F</td>
<td>MB, S</td>
<td>164.1</td>
<td>16.0</td>
</tr>
<tr>
<td>204, F</td>
<td>ON, S</td>
<td>120.5</td>
<td>10.7</td>
</tr>
<tr>
<td>205, M</td>
<td>SK, A</td>
<td>909.8</td>
<td>55.8</td>
</tr>
<tr>
<td>206, F</td>
<td>MB, S</td>
<td>178.0</td>
<td>15.4</td>
</tr>
<tr>
<td>207, F</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>208, M</td>
<td>NT, A</td>
<td>60.8</td>
<td>5.0</td>
</tr>
<tr>
<td>209, M</td>
<td>ON, A</td>
<td>602.1</td>
<td>58.7</td>
</tr>
</tbody>
</table>

Summer nonbreeding

### Notes:

a F = female, M = male  
b Yes = nesting, No = nonnesting, A = adult, S = subadult  
c Transmitter not deployed until winter 2012–2013  
d Died of unknown causes prior to establishing 2012–2013 winter breeding home range  
e BC = British Columbia, Canada, IL = Illinois, USA, MB = Manitoba, Canada, NW = Northwest Territories, Canada, ON = Ontario, Canada, SK = Saskatchewan, Canada  
f No summer nonbreeding home range established  
g Died of unknown causes prior to establishing 2014 summer nonbreeding home range  
h Died after capture in a foothold trap and prior to establishing 2014 summer nonbreeding home range  

interactions (all P’s > 0.06). All nesting home ranges were less than 66 km² (Table 1 and 2) and, on average, nonnesting home ranges were 730.3 ± 183.4 km² (Table 2); however, there was no significant difference in home range size between nesting and nonnesting adults on winter breeding grounds ($F_{1,8} = 2.60, P = 0.14$). Nesting adults spent most of their time at or near the nest site, whereas most nonnesting birds moved between several different core
areas (Figs. 2, 3). For example, in winter 2011–2012 adult female 200 was confirmed nesting and had a home range size of 27.8 km², but in 2012–2013 and 2013–2014 she did not nest and moved between several core areas within a home range of 996.2 km² and 1127.7 km² (Table 1). Similarly, during the summer nonbreeding season, most birds moved between several different core areas and individuals with large home ranges usually had several core areas distributed across a larger area (Fig. 3). Those birds would generally stay in a specific core area for several days and then move to a new core area, where they would again stay for a few days. They would continue moving between core areas as they moved about their home range, sometimes returning to the same core areas.

All tracked birds (n = 10) spent the winter breeding season in Louisiana and revisited at least part of their winter breeding home range in subsequent years, using, on average, 36 ± 6% of the area in multiple years (Table 1). Similarly, all but one tracked bird returned to the same general summer nonbreeding area in subsequent years (Fig. 1). However, average overlap of summer nonbreeding home ranges was about half that of winter breeding home ranges (21 ± 7%; Table 1). None of the tracked individuals had summer nonbreeding home ranges that overlapped another individual’s home range (Fig. 1). Conversely, all tracked birds had winter breeding home ranges that overlapped another individual’s winter breeding home range and all were established in relatively the same 80 km radius area around Houma, Louisiana wherein they were trapped (Figs. 1, 3).

**DISCUSSION**

Bald Eagles captured on their winter breeding areas in Louisiana exhibited spatial and temporal behavior similar to Bald Eagles from other southern latitudes (Broley, 1947; Hunt et al., 1992; Mabie et al., 1994; Buehler, 2000; Linthicum et al., 2007; Mojica et al., 2008; Hunt et al., 2009) but dissimilar to most birds in North America. Rather than nesting in summer and migrating south to nonbreeding areas, they migrated north to nonbreeding areas in the spring and returned south to their winter breeding areas. These intraspecific differences along with morphometric variations (Smith et al., 2016b) have caused debate as to whether the Bald

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<tbody>
<tr>
<td>Adults, Nesting</td>
<td>2</td>
<td>35.9 ± 8.0</td>
<td>1</td>
<td>65.8 ± 0.0</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>45.9 ± 11.0</td>
</tr>
<tr>
<td>Adults, Nonnesting</td>
<td>3</td>
<td>125.7 ± 85.4</td>
<td>4</td>
<td>594.2 ± 208.6</td>
<td>5</td>
<td>1123.4 ± 293.5</td>
<td>12</td>
<td>730.3 ± 183.4</td>
</tr>
<tr>
<td>Adults</td>
<td>5</td>
<td>89.7 ± 51.7</td>
<td>5</td>
<td>488.5 ± 193.1</td>
<td>5</td>
<td>1123.4 ± 293.5</td>
<td>15</td>
<td>602.0 ± 163.2</td>
</tr>
<tr>
<td>Subadults</td>
<td>4</td>
<td>773.3 ± 188.6</td>
<td>4</td>
<td>1183.8 ± 271.7</td>
<td>4</td>
<td>690.2 ± 29.6</td>
<td>12</td>
<td>899.9 ± 129.2</td>
</tr>
<tr>
<td>All</td>
<td>9</td>
<td>393.5 ± 145.2</td>
<td>9</td>
<td>797.5 ± 193.9</td>
<td>9</td>
<td>979.0 ± 202.9</td>
<td>27</td>
<td>723.4 ± 112.0</td>
</tr>
</tbody>
</table>

**Table 2.—Mean size of winter breeding and summer nonbreeding home ranges of satellite tracked Bald Eagles from Louisiana as calculated using 95% Brownian bridge movement models and displayed as x ± se (km²)**

<table>
<thead>
<tr>
<th>Summer Nonbreeding</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults, Nesting</td>
<td>1</td>
<td>97.3 ± 0.0</td>
<td>1</td>
</tr>
<tr>
<td>Adults, Nonnesting</td>
<td>3</td>
<td>524.2 ± 248.1</td>
<td>3</td>
</tr>
<tr>
<td>Adults</td>
<td>4</td>
<td>417.5 ± 205.4</td>
<td>4</td>
</tr>
<tr>
<td>Subadults</td>
<td>4</td>
<td>185.0 ± 33.1</td>
<td>4</td>
</tr>
<tr>
<td>All</td>
<td>8</td>
<td>301.2 ± 105.9</td>
<td>8</td>
</tr>
</tbody>
</table>
Eagle is two subspecies (northern and southern; Buehler, 2000; Ferguson-Lees and Christie, 2001) while genetics may suggest a clinal variation (Morizot et al., 1985). Our results further highlight some of the seasonality and migratory differences between Bald Eagles from northern and southern latitudes, which may warrant further phylogenetic investigation.

Our estimated home range sizes were considerably smaller than those observed for subadults in Florida using satellite transmitters and a fixed kernel density estimator (Mojica, 2006). Part of this difference may be due to the fact the BBMM does not assume independence between points and rather uses time data to predict the area utilized between locations (Fischer et al., 2013). Therefore, the BBMM may provide a more conservative representation of areas where a bird only traveled between core areas, which was prevalent in nonnesting birds as depicted in their utilization distributions (Fig. 2). Nonnesting birds generally moved between multiple core areas that were distributed over a large area of their home range, whereas nesting adults generally had a singular, central core area (Fig. 2). Conversely, our estimate of home range size for nesting adults was similar to those in Oregon and Washington (Garrett et al., 1993; Watson, 2002) using harmonic mean contours. These results may be more similar due to a lack of long distance travels between core areas. Therefore, various home range techniques may provide comparable results for nesting birds, whereas the BBMM should provide a more conservative representation of home range size.
for nonnesting birds that make long distance movements over a short period of time (Walter et al., 2011; Fischer et al., 2013). Furthermore, biological differences may also be occurring among studies, but the lack of comparability between techniques makes it difficult to decipher such differences.

Potential differences in home range size between different age groups and different nesting statuses may have been masked by our small sample of nesting adults and large variance of nonnesting adults, as some nonnesting adults had home ranges that appeared to be more similar to subadults. Specifically, a lack of significant difference between nesting status was highly influenced by adult male 208, who had the smallest home range, and adult male 205, who had small nonnesting breeding home ranges with only a few core areas in winters 2012 and 2012–2013, but in 2013–2014 had the largest recorded home range with many core areas

Fig. 3.—Comparison of summer nonbreeding (A and B) and winter breeding (C and D) home ranges and core areas using 95% and 50% Brownian bridge movement models (BBMM) for adult female Bald Eagle 200 (A and C) and adult male Bald Eagle 205 (B and D). Figures for all ten satellite tracked Bald Eagles from Louisiana are available at https://doi.org/10.6084/m9.figshare.4876835

A Bald Eagle 200’s summer 2012 (red) and 2014 (blue) nonbreeding home ranges and core areas in Ontario, Canada (53°56’N, 90°17’W) with overlapping home ranges outlined in black. No summer 2013 home range established, but northernmost location in same general area.

B Bald Eagle 205’s summer 2012 (red), 2013 (pink), and 2014 (blue) nonbreeding home ranges in Saskatchewan, Canada (50°0’N, 101°53’W) with overlapping home ranges outlined in black.

C Bald Eagle 200’s winter 2012 (red), 2012–2013 (pink), and 2013–2014 (blue) breeding home ranges in Louisiana (29°41’N, 90°50’W) with overlapping home ranges outlined in black.

D Bald Eagle 205’s winter 2012 (red), 2012–2013 (pink), and 2013–2014 (blue) breeding home ranges in Louisiana (29°36’N, 90°31’W) with overlapping home ranges outlined in black.
Overall it appears that nesting restricts home range size, but nonnesting home range size varies based on the number and distribution of core areas regardless of age.

Variation in times of capture within winter may have affected our estimates. Potential biases that may have been incurred include: distinction of nesting status, number of locations acquired on the first year’s winter breeding home range, or capture effect which has the potential to cause change in normal behavior in movement (Proulx, 1999). The number of satellite tracked birds that were nesting could have been underestimated in our analysis of home range because some nesting birds may have had failed nests prior to being tracked and were not detected. Likewise, individuals could have had nests fail prior to our 35 d nesting criterion. Although visual confirmation of nesting was only conducted for those individuals that were presumed nesting, as determined from location data, no other individuals used the same location for multiple consecutive days; therefore, we assume that the designated nesting status for each individual was accurate during the period they were tracked. Future studies, where nesting status is presumed from location data, may want to consider visual confirmation for any bird that uses the same location for multiple consecutive days. Birds that are visually confirmed as nesting but have nests that fail prior to the full 35 d incubation period may require a status separate from nesting/nonnesting. If visual confirmation cannot logistically be obtained, the restriction of 35 consecutive days provides a conservative estimate for designating nesting status for Bald Eagles through interpretation of satellite tracking locations.

Capture date may have underestimated the first winter’s breeding home range sizes because locations were not recorded from the time birds first arrived on their 2011–2012 winter breeding home range. Although these differences may reflect biological difference between years, the greater amount of time in which locations were collected in the second and third winters provided more locations, perhaps at the boundaries of an individual’s home range, resulting in estimates of larger size (Boulanger and White, 1990; Kernohan et al., 2001). Future research into variations in home range size within a season may also show that as a bird first establishes a home range, the size is larger and subsequently decreases as birds become more familiar with an area and food sources that are available.

We found home range fidelity occurs for both summer nonbreeding and winter breeding home ranges, as eagles travel to relatively the same locations each year, but fidelity to winter breeding areas appears to be greater than to summer nonbreeding areas. Only one of the 10 satellite tracked Bald Eagles in our study did not return to the same general winter breeding or summer nonbreeding area in subsequent years (Fig. 1). Other studies also reported Bald Eagles have a high degree of fidelity to breeding areas and relatively high fidelity to nonbreeding areas (Harmata and Stahlecker, 1993; Jenkins and Jackman, 1993; McClelland et al., 1994; Linthicum et al., 2007; Mandernack et al., 2012). Fidelity of home ranges may be attributed to familiarity of the bird to the area, mate acquisition, as well as predictable suitable habitat that can provide good foraging areas, nesting and roosting trees, and protection. Accordingly, breeding area fidelity may be higher than nonbreeding area fidelity due to maintenance of resources related to nesting or an attempt to acquire or become familiar with a particular area’s resources for future nesting.

Bald Eagles 200 and 201 returned to relatively the same areas each summer, but for at least one of the summers, they did not stay for >31 d. These birds may have been exhibiting nomadic behavior wherein they moved between foraging sites > 100 km apart, as reported in other studies of Bald Eagles (Gerrard et al., 1978; McClelland et al., 1994; Laing et al., 2005; Mojica, 2006); however, nomadic movements are difficult to distinguish objectively from stopovers and migrations. For that reason, we did not attempt to define nomadic
movements, but continued tracking of Bald Eagles from this study may warrant the re-evaluation of movements for birds that did not establish defined home ranges.

Continued monitoring of tracked birds from our study should provide more insight into the spatial requirements of Bald Eagles and especially for nesting individuals. However, our baseline estimates of home range size reported here for adults and subadults on their winter breeding and summer nonbreeding areas provide basic information on the size requirements of these areas. Although nonnesting individuals had large home ranges, they may not extensively use the entirety of these areas but only small core areas, which may indicate essential foraging areas. Future research into the habitats used within core areas may be useful in ensuring the needs and future spatial requirements of Bald Eagles are met.

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