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A PRELIMINARY STUDY OF THE INFLUENCE OF BREEDING AREA DENSITY ON SANDHILL CRANE HABITAT SELECTION IN SOUTH-CENTRAL WISCONSIN

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Abstract: We hypothesized that territorial sandhill cranes (*Grus canadensis*) in densely populated breeding areas occupy smaller home ranges that are richer in optimal habitat than those in less densely populated breeding areas. We analyzed satellite telemetry data collected from 2012 to 2016 for 3 and 2 sandhill cranes from dense and less dense breeding areas, respectively. Tracked sandhill cranes in a dense breeding area tended to have smaller home ranges (0.37-14.25 km^2) with higher concentrations of wetlands (27%) and row crops (40%) than tracked sandhill cranes in the less dense breeding area (8.80-48.81 km^2, 14% wetlands and 26% row crops). Studies on variation of breeding season habitat use will help to better understand the areas where breeding sandhill cranes are likely to congregate and can inform management and harvest decisions for sandhill cranes.

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Key words: breeding density, compositional analysis, *Grus canadensis*, habitat selection, home range, sandhill crane, Wisconsin.

Wisconsin has the highest density of resident sandhill cranes (*Grus canadensis*) in the Eastern Population and has remained the geographic mean center of the population for the last 47 years (Lacy et al. 2015, Barzen et al. 2016). Citizen scientists counted 10,757 sandhill cranes during the 2016 Annual Midwest Crane Count in Wisconsin, but only 27 of the 59 counties surveyed submitted counts of more than 100 sandhill cranes and 3 counties reported over 1,000 sandhill cranes. Why are sandhill cranes patchily distributed across Wisconsin? Several factors affect how a species uses and selects habitat, including what habitats are available on the landscape (Ryan et al. 1984) and how habitat patches are spatially arranged (Saab 1999). At broad and local geographic scales, sandhill crane density strongly correlates with the proportion of emergent wetland in an area (Su 2003); this habitat type is patchily distributed across much of the species' range. On a finer scale, sandhill cranes also select for corn and soybean fields; individuals can spend up to 40% of their time in cornfields during the summer (Su 2003, Barzen et al. 2018).

Crane researchers have a well-developed understanding of habitat types that sandhill cranes select within their home ranges, but little is known about the variability of home range sizes and compositions between densely populated and sparsely populated breeding areas. In this study, we tested the prediction that territorial sandhill cranes in a less dense breeding area exhibit larger breeding home range sizes than those in a dense breeding area. We also predicted that territorial sandhill cranes in a less dense breeding area have a smaller proportion of optimal habitat (e.g., agricultural lands and wetlands) in their breeding home ranges than those in a dense breeding area. Sparsely populated breeding areas may attract fewer breeding sandhill cranes due to fragmentation and paucity of optimal habitat, and the lack of optimal habitat could cause sandhill cranes that do breed in these sparser areas to expand their search for essential resources.

The 2 areas used in this project included the greater Briggsville area near the intersection of Marquette, Columbia, and Adams Counties, and the northern Baraboo area in Sauk County (Fig. 1). The Briggsville area is well-known and studied for its abundance and high density of breeding and non-breeding sandhill cranes (Su 2003, Barzen et al. 2016). All available breeding territories in Briggsville seem to be occupied (Hayes 2015), and its average density of 5.25 nests/km^2 of wetland indicates that the area may be at carrying capacity for breeding sandhill cranes (Barzen et al. 2016). A relatively smaller density of breeding sandhill cranes occupies the nearby Baraboo area. North American Breeding Bird Survey participants in 2017 recorded 35 sandhill cranes in Briggsville and only 3 in North Freedom, which is approximately 15 km southwest of the northern Baraboo area (Pardieck et al. 2018).

International Crane Foundation staff captured 4 adult sandhill cranes near Briggsville, Wisconsin, in September

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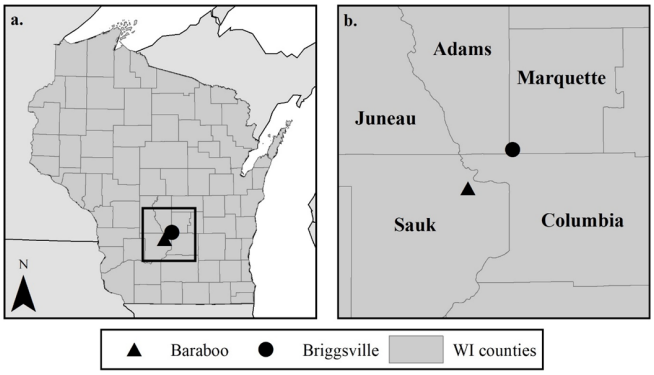

Figure 1. (a) Map of Wisconsin with county boundaries and an extent indicator for inset map (b) showing locations of study areas for sandhill cranes in Baraboo and Briggsville areas of south-central Wisconsin, 2012-2016.

2012 and 2 adult sandhill cranes in Baraboo, Wisconsin, in September 2014, by using alpha-chloralose capture methods (Bishop 1991, Hartup et al. 2014). They attached a unique combination of colored bands and a platform transmitter terminal (PTT) fitted in a backpack harness onto each sandhill crane. The PTT recorded an hourly global positioning system (GPS) location from when the marked crane was released until the transmitter stopped functioning. We incorporated data from 3 Briggsville sandhill cranes tracked 2-4 years and 2 Baraboo sandhill cranes tracked 1-3 years. We used all diurnal points accurate to less than 100 m collected between spring arrival and fall departure for this study; this amounted to 3,725-11,619 locations ($\bar{x}$ = 5,836) collected over 441-1,599 ($\bar{x}$ = 767) days per individual.

We conducted all spatial analyses through ArcGIS 10.5 (ESRI 2017). To define the annual home range, we used the Minimum Bounding Geometry tool in ArcGIS to create minimum convex polygons (MCP), which encapsulate 95% of GPS points collected throughout each breeding season. We included post-breeding, pre-migration spatial data (i.e., data collected July-November) along with breeding season spatial data in our analyses because the tracked Baraboo cranes were not monitored closely enough to determine dates for fledging, nest failure, or nestling deaths. We used the area of each MCP to quantify annual home range size. Due to small sample sizes, we did not use any statistical analyses to compare the effect of breeding area density on home range size or composition.

We acquired 2012-2016 landcover data layers from the National Agriculture Statistics Service's CropScape database (USDA 2012-2016). Satellite telemetry data from each year of our study were overlaid on the corresponding year's CropScape data (e.g., 2015 home ranges were analyzed with 2015 CropScape landcover data). Following the design of Miller and Barzen (2016), we categorized the CropScape data into 8 habitat types: Row Crop (e.g., corn), Short Crop (e.g., alfalfa), Vegetable Crop (e.g., potatoes), Upland Forest, Forested Wetland, Wetland (including open water), Grassland (including shrubland), and Developed. We later added the Vegetable Crop data to the Row Crop data due to their structural similarity to Row Crops and to the scarcity and limited use of Vegetable Crops within the home ranges.

To determine habitat composition within home ranges, we calculated the proportion of each habitat type in each MCP. To determine individual habitat use within each home range, we calculated the proportion of locations recorded within each habitat type in each annual home range. We conducted separate compositional analyses for the averaged values of tracked Briggsville sandhill cranes and tracked Baraboo sandhill cranes to measure how they used habitat types in relation to their availability within the home range and established a hierarchy of valued habitat types (Aebischer et al. 1993). As an additional measure of habitat selection, we calculated preference ratios (PR) by dividing the percentage of locations in a habitat type within the home range by the percentage of the home range comprised by that habitat type (Taft et al. 2008, Thompson and Lacy 2016).

Although not compared statistically, the annual home range size of the tracked Baraboo sandhill cranes tended to be larger than that of the tracked Briggsville sandhill cranes (see Fig. 2). Baraboo home range sizes ranged from 8.80 km^2 to 48.81 km^2, while Briggsville home range sizes ranged from 0.37 km^2 to 14.25 km^2. The home range size of all individuals changed year-to-year, but to different extents. For example, Briggsville C home range sizes stayed between 2.09 and 3.29 km^2, while Briggsville A home ranges varied between 0.37 and 14.25 km^2.

Row Crop was the most abundant habitat type within the average annual home ranges of both Baraboo and Briggsville tracked sandhill cranes, but there were few other similarities in home range composition. The average home range of a tracked Baraboo sandhill crane contained smaller proportions of Row Crop and Wetland habitats and greater proportions of Upland Forest, Forested Wetland, and Short Crop habitats than that of a tracked Briggsville sandhill crane (see

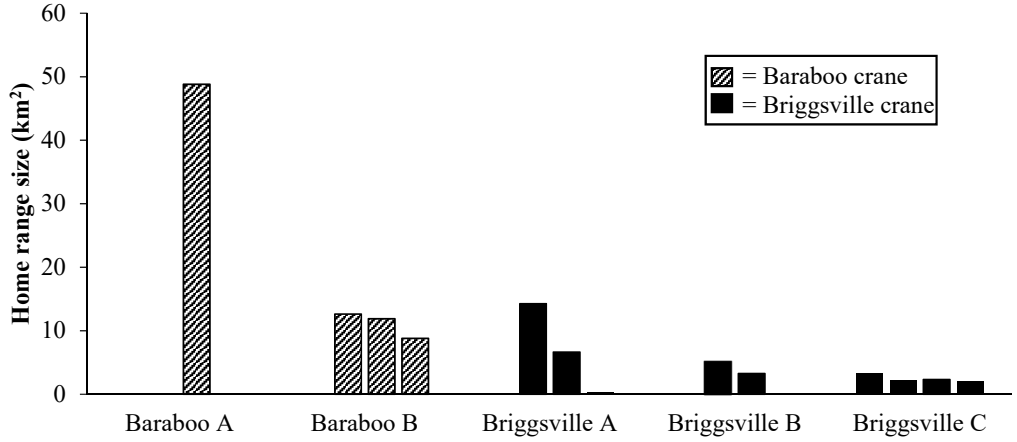

Figure 2. Annual home range sizes of 5 individual sandhill cranes in Baraboo and Briggsville areas of south-central Wisconsin. The home range was calculated for Baraboo A in 2014, for Baraboo B in 2014-2016, Briggsville A in 2012-2014, Briggsville B in 2012-2013, and Briggsville C in 2012-2016.

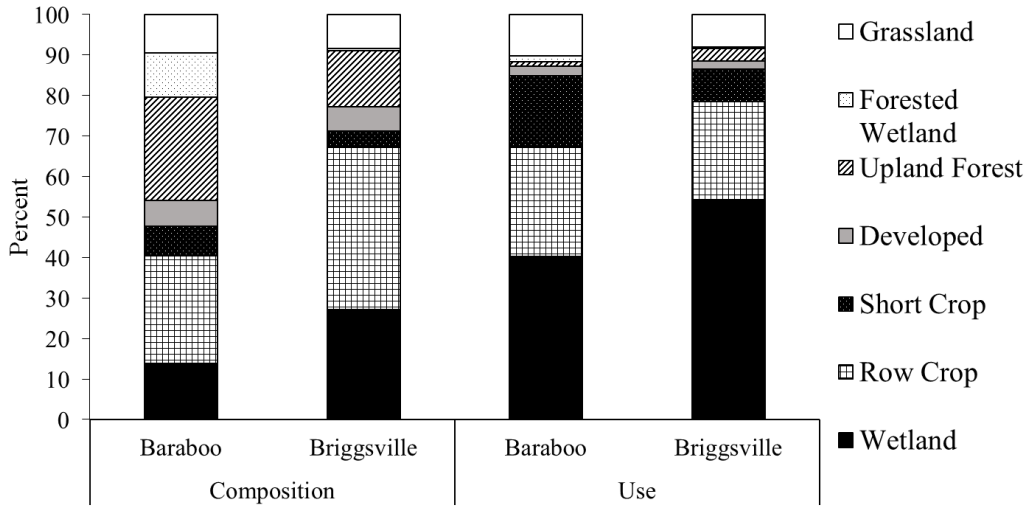

Figure 3. Average habitat composition and the average proportional use of habitat types within annual home ranges of tracked sandhill cranes in Baraboo and Briggsville areas of south-central Wisconsin, 2012-2016.

Fig. 3). However, tracked Briggsville and Baraboo sandhill cranes exhibited the same hierarchy of habitat use: Wetland > Row Crop > Short Crop > Grassland > Upland Forest > Developed > Forested Wetland.

The compositional analyses reveal a different hierarchy of habitat preferences, with Grassland being the third most used habitat type in relation to availability and Row Crop dropped to the fourth and fifth most used (see Table 1). Wetland, Short Crop, and Grassland were the highest ranked habitat types in the compositional analyses and were the only habitat types with PRs greater than 1 for both groups; tracked sandhill cranes selected for these habitat types in both dense and less dense breeding areas. Although the Row Crop PR was less than 1 (i.e., tracked sandhill cranes used the habitat type less often than its availability would predict), it was the second most used habitat type by tracked sandhill cranes in both breeding areas.

The difference in PR values and rankings for Forested Wetland between tracked Baraboo and Briggsville sandhill cranes may be due to the abundance of Forested Wetland habitat in the average Baraboo home range. Less than 2% of locations in each breeding area are within Forested Wetland, but this habitat type comprised 14% of the Briggsville home ranges in comparison to 25% of the Baraboo home ranges.

Table 1. Habitat types, listed in order of most to least used relative to availability, used by marked sandhill cranes in the Baraboo and Briggsville areas of south-central Wisconsin. Habitat type hierarchies and preference ratios were based on the results of compositional analyses conducted separately for marked Baraboo (2014-2016) and Briggsville (2012-2016) cranes.

Baraboo (n = 2)		Briggsville (n = 3)	
Habitat type	Preference ratio	Habitat type	Preference ratio
Wetland	3.26	Wetland	2.04
Short Crop	2.76	Short Crop	1.63
Grassland	1.23	Grassland	1.03
Row Crop	0.98	Forested Wetland	0.87
Developed	0.35	Row Crop	0.59
Forested Wetland	0.13	Developed	0.30
Upland Forest	0.05	Upland Forest	0.24

The results of our compositional analyses differ from those of Miller and Barzen (2016), who ranked habitat types for 12 breeding Briggsville sandhill cranes in the following order: Wetland > Row Crop > Short Crop > Developed > Grassland > Upland Forest > Forested Wetland. Miller and Barzen (2016) found that Row Crop comprised a smaller proportion of the focal home ranges than in this study, while sandhill cranes in both studies used Row Crops in almost identical proportions. We attribute the difference in Row Crop preference to the higher prevalence of Row Crop habitat in the home ranges of the 5 focal sandhill cranes studied in this project. We also tracked fewer cranes than Miller and Barzen (2016), which may partially explain our dissimilar results.

Breeding sandhill cranes in south-central Wisconsin greatly depend upon wetlands and agricultural areas (Su 2003, Miller and Barzen 2016); our study also found that tracked sandhill cranes in Baraboo and Briggsville preferred these habitat types. The results of our preliminary study also suggest that sandhill cranes in a densely populated breeding area can use a smaller area to obtain the resources they need than those in a less densely populated breeding area, but future researchers should determine if this trend persists when a larger sample of cranes are tracked in this region or elsewhere. Satellite telemetry data and compositional analysis have been useful tools in elucidating patterns of sandhill crane habitat use and distribution (Miller and Barzen 2016, Thompson and Lacy 2016, Fronczak et al. 2017, Kruse et al. 2017), and we recommend their continued use in exploring these topics. A statewide map of sandhill crane breeding areas and known densities would also be helpful in future studies comparing cranes that breed in different parts of Wisconsin. Research on the patterns and variability of habitat selection in the species can lead to a greater understanding of the resources that sandhill cranes require to sustain a stable population in Wisconsin.

Future studies of the variation in sandhill crane habitat use will help better understand the areas where breeding sandhill cranes are likely to congregate, and will inform management and harvest decisions, as breeding individuals contribute the most to the stability and growth of a sandhill crane population (M. Wheeler, University of Wisconsin, unpublished data). To determine the effect of harvest on the Eastern Population of sandhill cranes, managers need to know and be able to predict the location of the densest aggregations of breeding sandhill cranes and how these individuals use the landscape. Further research should focus on sandhill crane habitat use in relation to the spatial arrangement of habitat types within their home range and across the landscape.

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