Home Range of a Breeding Male Bald Eagle (*Haliaeetus leucocephalus*) Tracked via Satellite Telemetry in Kentucky

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Abstract - *Haliaeetus leucocephalus* (Bald Eagle) is a well-studied species, and information on their nest abundance and population trends is widely available. However, research on the movements and home range of nesting Bald Eagles in the interior US is lacking. In this study, we used a solar-powered Argos platform transmitter terminal (PTT) with global positioning system (GPS) capabilities to monitor the movements of an adult, breeding male Bald Eagle, captured at Ballard Wildlife Management Area, KY, from 29 April 2012 to 23 October 2013. We generated minimum convex polygons (MCP) for comparisons to previous studies and used 95% and 50% fixed kernel density estimators (KDE) to estimate home-range size and core-use areas, respectively, during nesting and non-nesting periods. Estimates of home range and core-use areas were slightly larger during the non-nesting period (MCP = 420.0 km^2, 95% KDE = 1.6 km^2, 50% KDE = 0.2 km^2) when compared to the nesting period (nesting MCP=415.0 km^2, 95% KDE =1.3 km^2, 50% KDE = 0.01 km^2). Our home range and core-use estimates were smaller than previous studies using comparable methods, suggesting that habitat quality at this site may be high.

Introduction

Haliaeetus leucocephalus (Bald Eagle) was removed from the United States Fish and Wildlife Service endangered species list in 2007 (USFWS 2007). Nonetheless, conservation concern has continued for this species, and the Kentucky Department of Fish and Wildlife Resources (KDFWR) lists the Bald Eagle as a species of greatest conservation need in Kentucky's State Wildlife Action Plan (KDFWR 2013). The KDFWR has since monitored the nesting population in Kentucky annually, documenting a steady increase in nest numbers (Slankard 2019).

Anecdotal observations and long-term monitoring efforts suggest Kentucky's nesting Bald Eagle population is non-migratory, residing at territories year-round (Slankard 2019). However, studies on the movement ecology of Bald Eagles in the central, interior US are sparse. Mandernack et al. (2012) used Argos satellite transmitters to describe the migration of Bald Eagles tagged in Wisconsin. Smith et al. (2017) studied the migration of Bald Eagles from Louisiana through central North America and the breeding home range of 2 individuals in Louisiana. To our knowledge, no prior studies have used satellite GPS technology to describe the home range of non-migratory Bald Eagles in the central US.

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Estimating home ranges can provide insight into a species' behavior, spatial requirements, and limiting factors that are critical for effective conservation management (Peery 2000). In this study, we used a solar-powered, Argos platform transmitter terminal (PTT) with global positioning system (GPS) capabilities to track the movements of a breeding male Bald Eagle in western Kentucky. We describe estimated home-range size and core-use areas during the non-nesting season and the nesting season.

Field-site Description

We captured the Bald Eagle at Ballard Wildlife Management Area (WMA) in Ballard County, KY. This property is managed by KDFWR and is comprised mostly of cypress (*Cupressus* spp.) sloughs and bottomland hardwood forest, with some agricultural areas interspersed.

Methods

We captured the Bald Eagle (ID# 117531) with a rocket net baited with *Hypophthalmichthys molitrix* (Valenciennes) (Silver Carp) near its nest site on 29 April 2012 (Grubb 1988). The bird was previously banded while in rehabilitation (19 April 2010–4 July 2010) for a gunshot wound in 2010. After successful rehabilitation, the bird was released near to its capture location and reclaimed the same territory it had occupied prior to the injury.

After capture in 2012, we took morphological measurements and attached a 70-g (1.6% body weight), solar-powered, Argos/GPS satellite transmitter (PTT-100; Microwave Telemetry, Inc., Columbia, MD) via a backpack harness with Teflon straps to the Bald Eagle (Buehler et al. 1995). Based on the recapture record, the bird was at least 7 years old at this time. The US Geological Survey Bird Banding Lab permitted all banding and marking (Permit #23400).

The transmitter collected GPS data accurate to ±18 m and transmitted via the Argos system. We programmed the PTT to take 1 location per hour for daylight hours and 1 location after dark (every day). We excluded all 2D fixes from this analysis (total excluded data = 2 fixes). We pooled GPS fixes among years and categorized them into non-nesting (16 July–31 Oct) and nesting seasons (1 Nov–15 July).

We performed spatial analyses using ArcMap 10.5.1 (ESRI, Redlands, CA). For comparison to older studies, we generated a 100% minimum convex polygon (MCP) for each season. We utilized 95% kernel density estimator (KDE) to estimate seasonal home range and 50% KDE to estimate core-use areas (Tétreault and Franke 2017). We generated KDEs from GPS fixes using the kernel density tool, in the ArcMap spatial analysis toolset. We set the search radius (bandwidth) to 1000 km. We calculated areas by converting KDEs to contours, using the 'surface contour' tool, and then to polygons with the 'feature to polygon' tool. We truncated data for mapping the final dispersal path by removing consecutive fixes in the vector that were less than 5 km apart; 108 fixes were removed (Fig. 1).

During this study, we monitored all Bald Eagle nests in Ballard, McCracken, and Carlisle counties, KY, via helicopter surveys in early March (incubation/early nestling) and late April (mid-nestling) 2012–2013. We recorded nest locations and contents during these surveys as part of long-term annual monitoring.

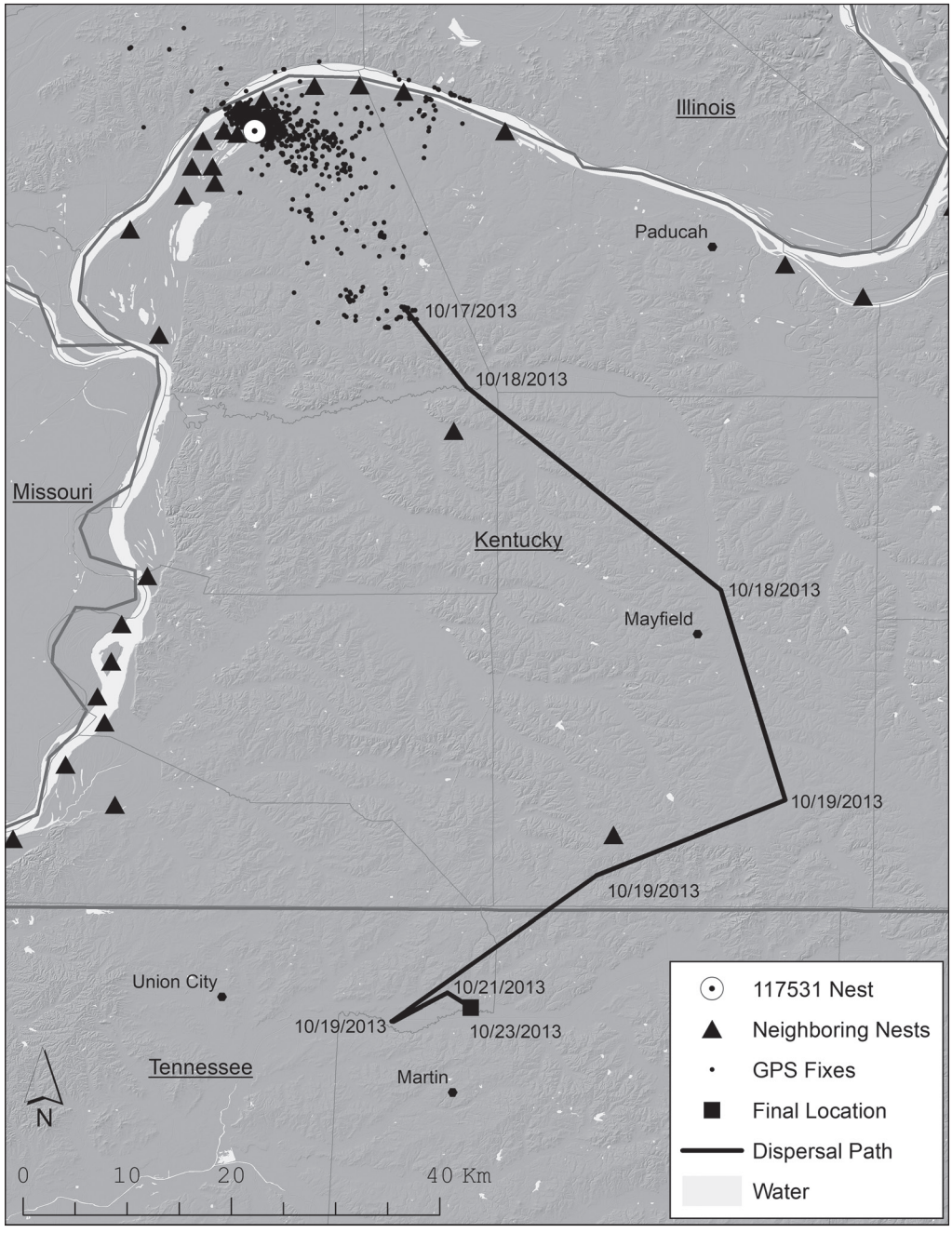

Figure 1. Dispersal of adult male Bald Eagle from nesting territory in western Kentucky to location of its death in Tennessee in fall 2013.

We display locations for neighboring nests in Figures 1–3 to show how 117531 moved in relation to nests of other Bald Eagles. We continued nest monitoring (by

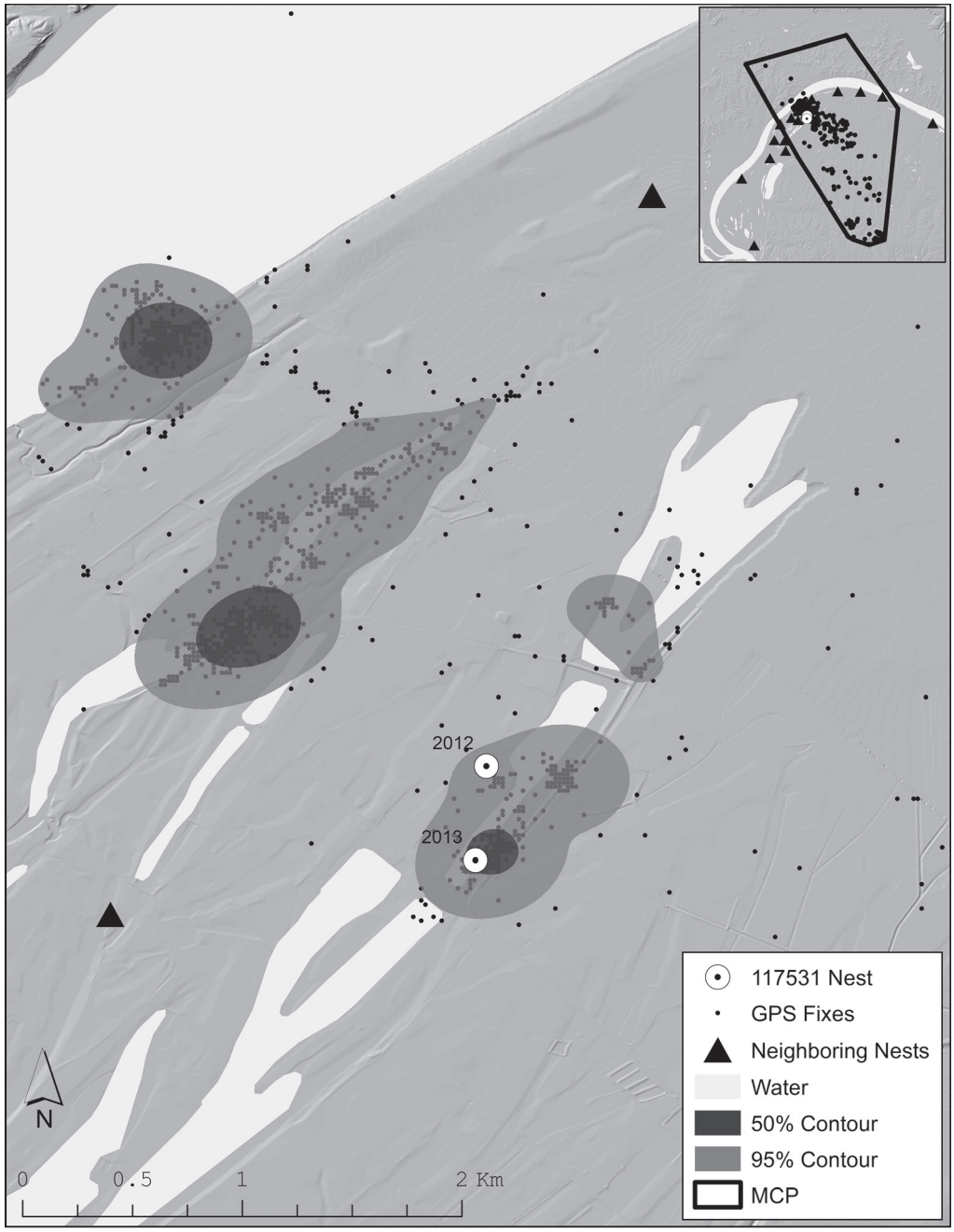

Figure 2. Non-nesting season locations of an adult male Bald Eagle in western Kentucky during 2012 and 2013. Inset shows 100% minimum convex polygon, GPS fixes, and regional location, and larger map shows home-range and core-use areas determined by kernel density estimators (50% and 95% contours, respectively). Neighboring nest sites also shown. Background is USGS 3D elevation.

ground, every 2 weeks) at the nest of the tagged bird after the April flight until his young fledged.

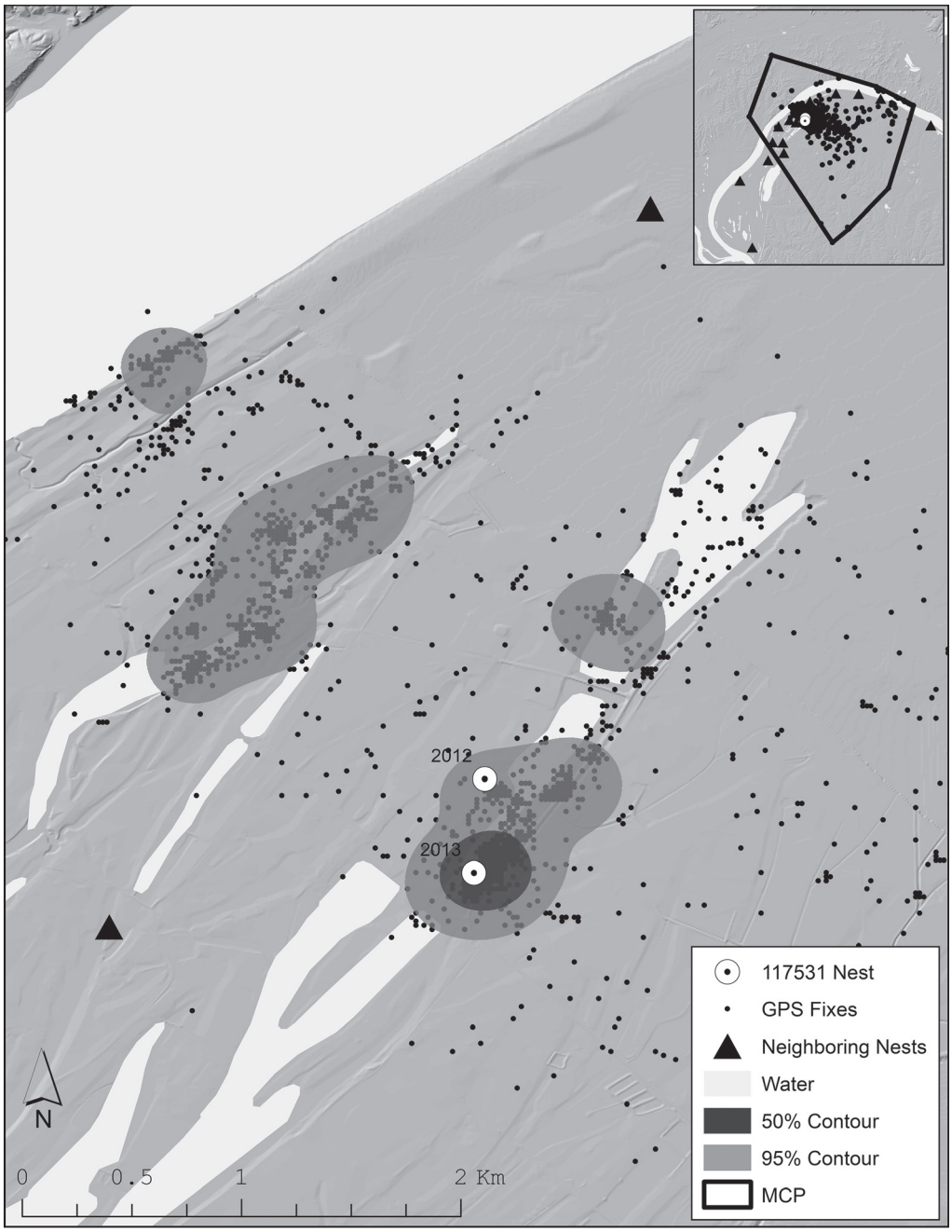

Figure 3. Nesting season locations of an adult male Bald Eagle in western Kentucky during 2012 and 2013. Inset shows 100% minimum convex polygon, GPS fixes, and regional location, and larger map shows home-range and core-use areas determined by kernel density estimators (50% and 95% contours, respectively). Neighboring nest sites also shown. Background is USGS 3D elevation.

Results

We tracked 117531 from 29 April 2012 through 23 October 2013 and analyzed 7298 GPS fixes from his movements during this period. We confirmed through monitoring that 117531 and his mate fledged 2 young in both 2012 and 2013. The tagged bird dispersed from its territory in October 2013 and moved south before dying near Martin, TN, on 23 October 2013 (Fig. 1). We retrieved the carcass and submitted it for testing to the University of Kentucky Veterinary Diagnostic Lab. Post-mortem diagnosis indicated that the bird likely died of a perforated intestinal ulcer, but results were inconclusive. We later observed 2 adults at 117531's 2013 nest in early November 2013.

Home-range estimates (95% KDE) were 1.6 km^2 for the non-nesting season and 1.3 km^2 for the nesting season (Figs. 2, 3). Core-use area estimates (50% KDE) were 0.2 km^2 for the non-nesting season and 0.1 km^2 for the nesting season (Figs. 2, 3). The 100% MCP was 420.0 km^2 for the non-nesting season and 415.0 km^2 for the nesting season. The tagged bird moved as far as 22.2 km from the nest during the non-nesting season and 19.3 km from the nest during the nesting season.

Discussion

Past studies have used Doppler shift data or radio telemetry data, and ours may be the first to report GPS-based home-range data for Bald Eagles in the Midwestern US (Mandernack et al. 2012). Our results may further inform future research in regard to the migration habits of interior eagles and rehabilitated eagles. Garrett et al. (1993) used radio telemetry and the harmonic mean method to estimate the home range of nesting Bald Eagles in Oregon and Washington. They found an average home range of 21.7 km^2 during the breeding season but noted that high-use areas averaged 0.4 km^2. Smith et al. (2017) used Brownian bridge movement models to determine that nesting home ranges were <66 km^2 for 2 nesting Bald Eagles in Louisiana tracked via satellite GPS transmitters. Eagle territories are dense in Ballard County, KY, with nests as close as 2 km. Nesting density and associated home-range size is ultimately related to resource density (Sarasola et al. 2018). Birds in resource-rich landscapes do not need to defend large areas because they can get the resources they need in smaller areas while minimizing energy spent on territory defense (Garrett et al. 1993, Newton 1991). Our 95% KDE (1.3 km^2) was smaller than previous studies using comparable methods, which suggests that habitat quality at our study site may be higher than at the aforementioned sites. Age and experience may also affect home-range size since individuals that have held a territory longer are likely to forage more efficiently within their territory and explore less (Mannan and Boal 2000). This behavior may further explain the small home-range size we estimated in comparison to other studies, since 117531 was at least 7 years old and had held his territory since at least 2010.

As expected, 117351 did not migrate during the non-nesting season. However, Bald Eagle territories may become more fluid in the non-nesting season, as suggested by the slight increase in 117531's home-range size during this time. Our data also show 117531's MCP extended further from water sources during the

non-nesting season, suggesting alternative hunting areas and food sources may be important during that time (Grubb 2018, Schmuecker et al. 2020).

The bird we tracked survived a gunshot wound, was rehabilitated, and was able to reclaim to the same territory it previously held. Bald eagles are known to have high site and mate fidelity (Jenkins and Jackman 1993), but we can find no other accounts in the literature of a rehabilitated adult returning to a previously held territory. Given the lack of other possible factors leading to 117531's dispersal (e.g., nest failure), we assume he was out-competed for his territory. Past reports have associated mate replacement via intraspecific competition, with the mortality of the replaced mate caused directly by a conspecific intruder (Turrin and Watts 2014). Interestingly, we found no evidence of injuries from conspecific aggression, and we instead speculate that 117531 dispersed in response to intraspecific competition and then travelled some distance before his death. Nevertheless, the quick replacement of the tagged eagle suggests competition for territories is high, that available nesting territories are limited, and a surplus of adult eagles may exist in our study area (Jenkins and Jackman 1993). As the Bald Eagle population increases (Slankard 2019), more study of intraspecific competition may be warranted.

Acknowledgments

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