# Department of Defense

# Legacy Resource Management Program

PROJECT 13-634

## Establishing Regional Mentor Sites for the Management of the Cerulean Warbler and other Mature Forest Avifauna

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## EXECUTIVE SUMMARY

This Department of Defense Legacy Resource Management Program report seeks to facilitate regional management for Department of Defense sites with Cerulean Warblers, a declining species associated with high quality mature forest. Three sets of case studies with management recommendations were developed to describe Cerulean Warbler habitat use within Bird Conservation Regions (BCR) 22, 23, and 24. Study sites varied in management practices and were selected because they supported Cerulean populations, conducted previous research on the species, and had available spatial data layers for habitat analyses. These case studies and management recommendations provide a model for additional DoD installations that may have only recently gained knowledge of Cerulean presence, or are within the same BCR and possess similar habitats.

## INTRODUCTION

Lands managed by the Department of Defense (DoD) in the United States cover almost thirty million acres, and span a wide array of different ecosystems. These areas represent many of the major land and climate types in which soldiers may be expected to fight wars, making it important to better understand these systems. Therefore, the military has made a commitment to understanding and documenting the plant and animal life found on its lands, as a means both to comply with environmental regulations and to work proactively to sustain its resource base. DoD Natural Resource Managers support military mission objectives and also aim to protect biodiversity. Through compliance with their Integrated Natural Resources Management Plans (INRMP) and the Sikes Act, military bases aim to manage the land in ways that benefit naturally occurring bird populations.

The Cerulean Warbler *(Setophaga cerulean*; hereafter Cerulean) is one of the fastest declining Neotropical migratory warblers, with high ratings of vulnerability from Partners in Flight (PIF), due to breeding and non-breeding threats. The primary cause of decline is attributed to habitat loss and fragmentation (Hamel 2000). Cerulean Warblers are now listed as a species of concern in 13 states, threatened in 2 states, and endangered in 1 state. Because of the need for more data concerning the Cerulean's status across its range, this project aimed to study populations and habitat characteristics at DoD sites within different Bird Conservation Regions (BCRs). From this, it was our goal to provide management recommendations for these installations and other areas with similar habitats.

Bird Conservation Regions (BCR) are areas, defined by the North American Bird Conservation Initiative (NABCI), that encompass landscapes having similar bird communities, habitats, and resource issues. We selected three military installations located in three a different BCRs to serve as mentor sites for that region (Fig 1.). These three BCRs were selected among the 10 BCRs with Cerulean Warbler, due to their location relatively north of the heart of the range where most research has been focused. These areas could become of increasing importance as many avian species ranges are shifting with climate change. Hamel (2004) found that the Cerulean range has shifted north eastward, likely due

to the loss of bottomland hardwoods in the southeast portion of the range and maturing second growth in the northeast. Another study found northward latitudinal range shifts for a variety of species (Hitch and Leberg 2007). Therefore, research in these BCRs may capture unique information about Ceruleans.

DoD Natural Resource Managers are expected to sustain viable populations of all species on their lands, which requires an understanding how wildlife populations respond to forest management practices. One recent technological advancement that is leading to a better understanding of forest management is the use of lidar data. Lidar stands for light detection and ranging, and is airborne optical remote-sensing technology that measures scattered light to find range and other information on a distant target. In forestry, lidar can be used to measure the three-dimensional structure of a forest stand. The structure of the forest will typically generate a first return from the uppermost limit of the canopy, followed by less intense returns through the canopy, down to the underlying terrain. An increasing number of forestry and land management organizations are using lidar for forest inventory measurements (ESRI 2011). Because Cerulean Warblers are a canopy species, we wanted to explore lidar data at our study sites to help identify forestry structures that may better describe their habitat needs.

We chose the following three mentor sites for this study: Fort Custer Training Center (Prairie Hardwood Transition, BCA 23), Fort Leavenworth (Eastern Tallgrass Prairie, BCR 22), and NSA Crane (Central Hardwoods, BCA 24). Our goals for each site were as follows: 1) conduct field surveys to document warbler territories and nests if possible, 2) conduct forestry surveys in areas of use and non-use, 3) examine forest history and management practices, and 4) use Geographic Information Systems (GIS) and spatial data layers to examine forest composition.

This report summarizes our work in the form of a case study for each of the three study sites within their respective BCR. The methods used at each of the sites differs depending site management and research history. First, we introduce the Cerulean Warbler and its natural history and conservation needs. Then, we present each case study including a site description, a brief history of avian research, past land management information, methods used, data summary, and conclusions.

## CERULEAN WARBLER NATURAL HISTORY

The Cerulean Warbler is a migratory songbird that breeds in mature deciduous forests of eastern North America and winters in northern South America (Buehler et al. 2013). Formerly one of the most abundant breeding warblers in the Ohio and Mississippi River valleys, Cerulean populations declined sharply during the 20$^{th}$ century. Conversion of mature deciduous forest to agricultural or urban areas, fragmentation of remaining mature deciduous forests, shorter forestry rotation periods and even-aged management, and loss of key tree species to disease are all breeding season constraints (Hamel 2000).
The warbler's preferred habitat is large areas of mature or old growth deciduous forests, where it forages and nests high in the canopy. They tend to use territories in forests with

higher canopy height, greater canopy cover (85%) and larger trees (Roth and Islam 2008). The heart of their range is in the Appalachian forests, where they prefer nesting on ridge tops and slopes. They are generally associated with oak-dominated stands that contain canopy gaps, large diameter trees (>16 in. dbh), and that have well-developed understory and upper canopy layers (Wood et al. 2013). Researchers have identified many habitat characteristics that are beneficial to Ceruleans, particularly within the heart of their range (Hamel 2006, 2007, 2010), however, there is variation from region to region in terms of tract size, type of site utilized and possibly other characteristics. Habitat management is a high priority for this species due to its severely declining numbers. While worthy of conservation concern as a single species, Ceruleans are found alongside a diverse avian community, which also benefits from long-term management of mature forest ecosystems.

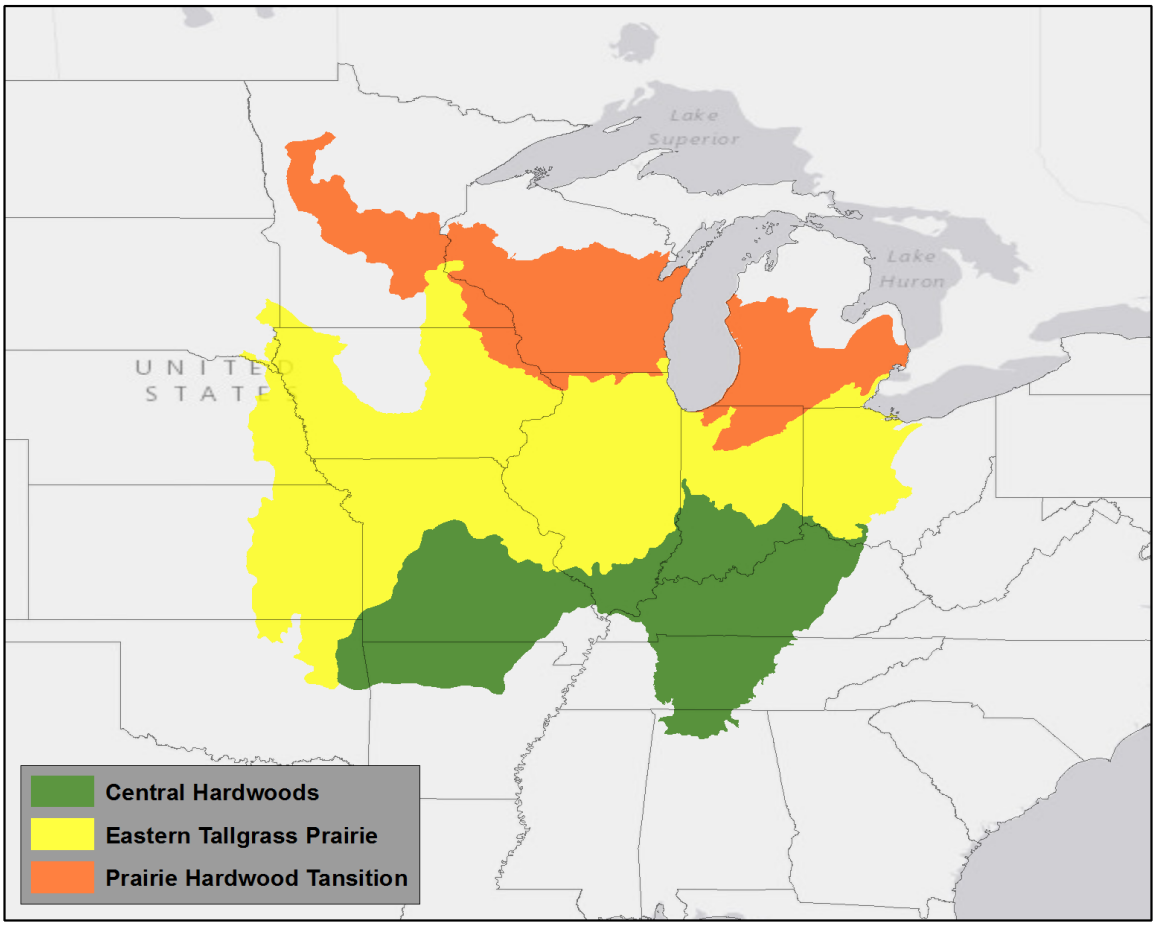



Figure 1. Map of the three focal Bird Conservation Regions.

# CASE STUDY I: Fort Custer Training Center, Augusta, Michigan

## BACKGROUND

Fort Custer Training Center (FCTC) is a Michigan Army National Guard training facility that occupies land in both Kalamazoo and Calhoun counties (Fig. 2). FCTC contains approximately 7570 acres of land including wetlands, prairie/savannah, grasslands, and deciduous forest (INRMP 2012). Fort Custer Recreation Area (FCRA) is a 3,000-acre State Recreation Area adjoining FCTC and includes trails for hiking, biking, and horseback riding. More than 65% of FCTC is forested, and together with the FCRA, creates one of the largest forested tracts in southwestern Michigan.

Fort Custer's land management history is extensive and is described in detail in one of our annual reports (KNC 2012). Much of the land had been converted to agriculture by the early 1940s. A plan from 1956/1972 identified agriculture and grazing as an unacceptable land use at FCTC and identified forestry and wildlife habitat as a more sustainable use. Now FCTC supports 21 natural community types, where MNFI documented 835 vascular plants, approximately 30% of the known plants of Michigan (Herman et al. 1996). MNFI also identified four distinct upland forest types and three lowland (wetland) forest types at FCTC (Thomas, et. al, 2009-10). An inventory of fauna found 407 species, 14 of which are state-listed threatened, endangered, or special concern species. An additional 12 state-listed or special concern animals potentially occur at FCTC (Cohen et al., 2009).

A total of 146 bird species were found during surveys performed by MNFI and KNC during breeding bird surveys. FCTC is designated an Important Bird Area (IBA) because it is globally important habitat for the conservation of bird populations. FCTC is also within BCA 23, Prairie Hardwood Transition, where prairies dominated in the west and south and beech-maple forest in the north and east, separated by an oak savannah. There are still remnant populations of Ceruleans and other forest breeding migrants in this region, making it an important area for conservation efforts and learning about the species outside of the Appalachians.

The Cerulean Warbler is listed as threatened in the state of Michigan (MNFI 2007). Breeding Bird Survey routes in Michigan show a decline of 6.1% per year (±4.1%, n=6) but this could be attributed to the low number of routes within their range (Sauer et al. 2008). Cerulean monitoring began at FCTC when the Michigan Natural Features Inventory (MNFI) surveyed the site in 1994 and 1995 and reported several sightings of Cerulean Warblers (Comer et al. 1995). In 1997, biologists at the Kalamazoo Nature Center (KNC) detected 24 Cerulean Warblers while conducting point counts and estimated that a total of 46 males were present. Since then, KNC has continued their research in order to monitor population trends, document distributions, and estimate survival rates of the Cerulean Warblers on FCTC. FCTC works with national and international organizations to assist the conservation effort to keep this species from becoming federally listed.

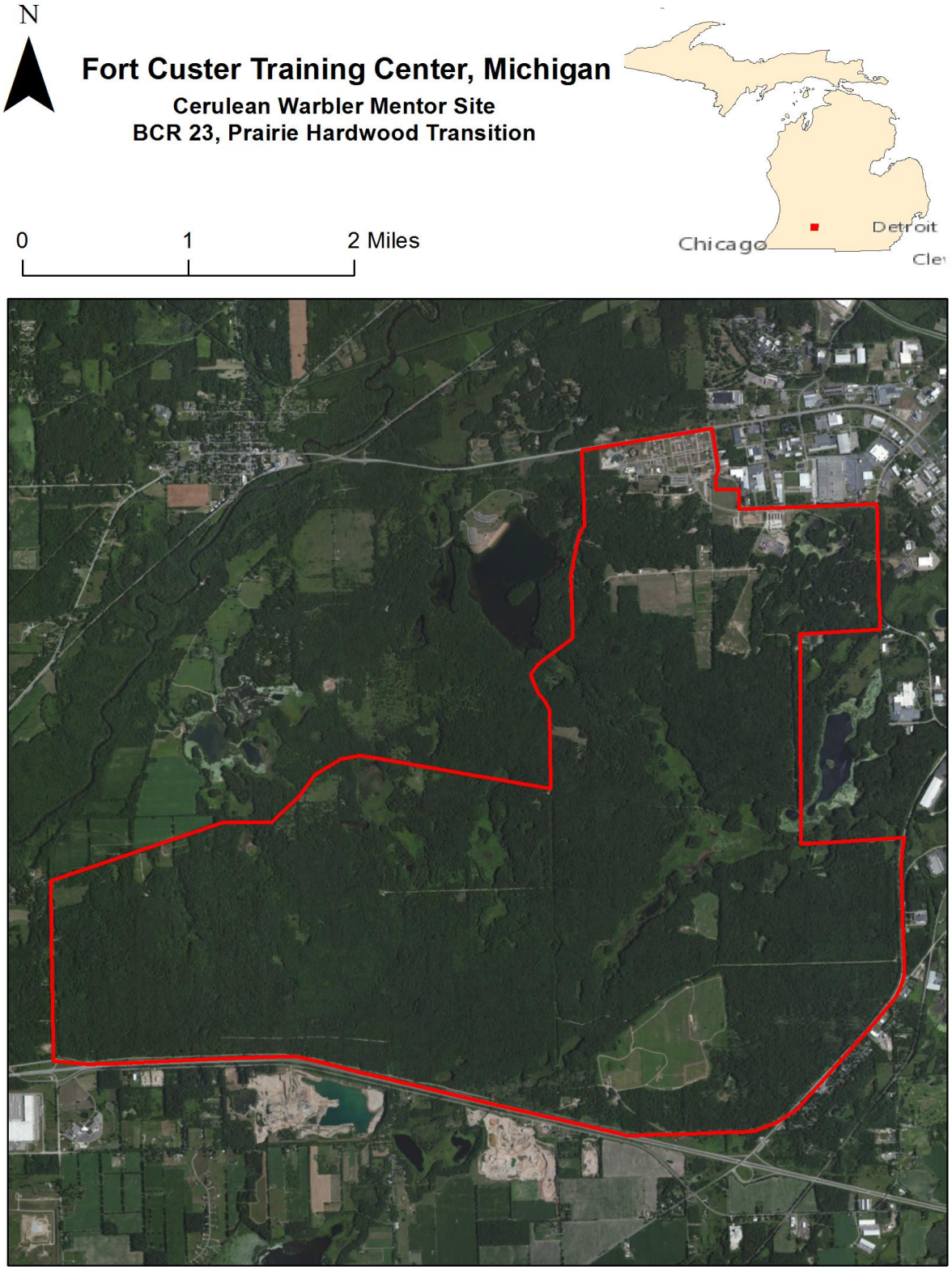



Figure 2. Map of Fort Custer Training Center in Michigan.

## METHODS

### Avian surveys

Monitoring of Ceruleans at FCTC and the FCRA has been an on-going project for several years at KNC, but we used data from 2011 for this particular study. We color banded Ceruleans during May and early June when males are most aggressive and territorial. We used a standard 12m long net with 32mm mesh, sometimes formed into a V shape with three 10-ft metal poles. We placed a wooden decoy with a speaker below playing Cerulean songs and calls. Once caught in the net, birds were quickly extracted, processed, and released.

We attached a USGS aluminum band with a unique nine-digit number and one or two color bands to the bird's legs, creating a unique combination. Birds were later identified and resighted by their band combinations; for example, in ROAO, R stands for red, O means a second band was not used on that leg, an A stands for the aluminum band and the second O indicates no second band. We determined age as either ASY (after second year) or SY (second year). We took measurements of the wing chord, longest secondary and tail (mm) and weight (g). The cloacal protuberance (CP) was rated from 0 (none) to 3 (fully enlarged). We released the birds as quickly as possible, usually within 5 minutes of capture.

We resighted previously color-banded birds by broadcasting songs, and sometimes using a wooden decoy. We documented resight locations at least once for each bird using a GPS unit. During subsequent visits to each territory, we observed birds with binoculars or a spotting scope, without the aid of song broadcasting.

### Forestry surveys

We gathered information on forest characteristics in Cerulean Warbler territories by collecting timber cruise data at point count locations and nest sites. Point counts where singing males were most frequently noted (1997-2010) were used to represent male territories. Nest sites from the 2011 field season were used to represent female territories. We used current methods of the Timber Cruising Handbook (USDA-FS Undated) and point surveys with a fixed length angle gauge at basal area factor (BAF) 10 (with the exception of one point which did not have enough samples using BAF 10 and BAF 5 was used). This information was used to calculate basal area (BA), and trees per acre (TPA). The surveys of point counts representing male territories were performed 24 February, and 2-3 March 2011. The nest sites are used to represent habitat that is desirable by females were surveyed 28 July 2011. Points selected for use are shown in Figure 3. Nest sites are labeled with the color-band combination of banded birds, while point count locations are labeled by their compartment-stand combination.

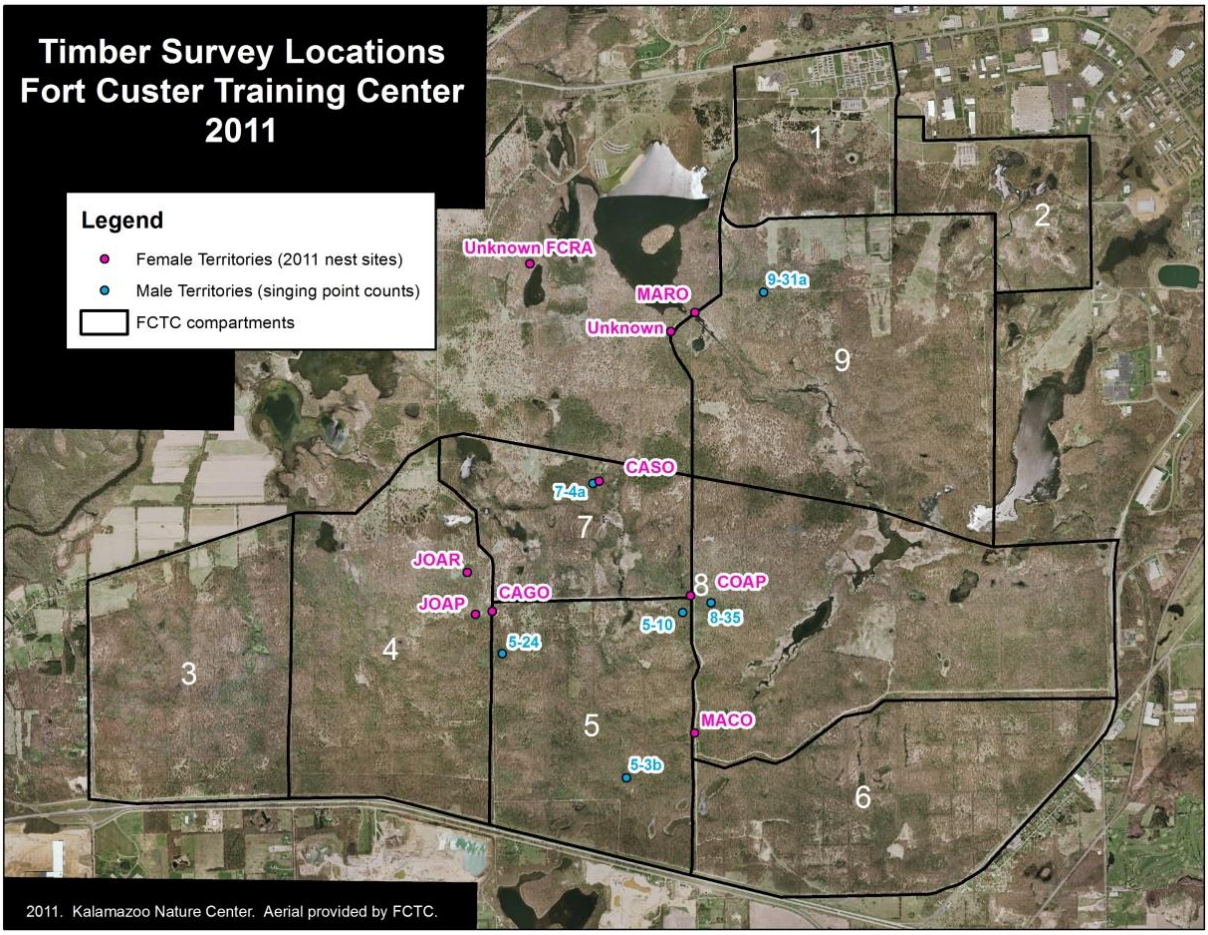



Figure 3. Map of Cerulean warbler territories and nests used for forestry surveys in 2011.

**Habitat observations**

Tallies of behavior observations associated with vegetation used were recorded in a spreadsheet to examine habitat use by male and female Cerulean Warblers in 2011. Types of observations were categorized by sex of the bird, whether foraging was occurring, and the duration of the observation. Field observations were made during all activities, including locating un-banded birds for capture, re-sighting color-banded birds, while following the one radio-tagged female, and during the observation of nine Cerulean Warbler nests.

## Spatial analysis

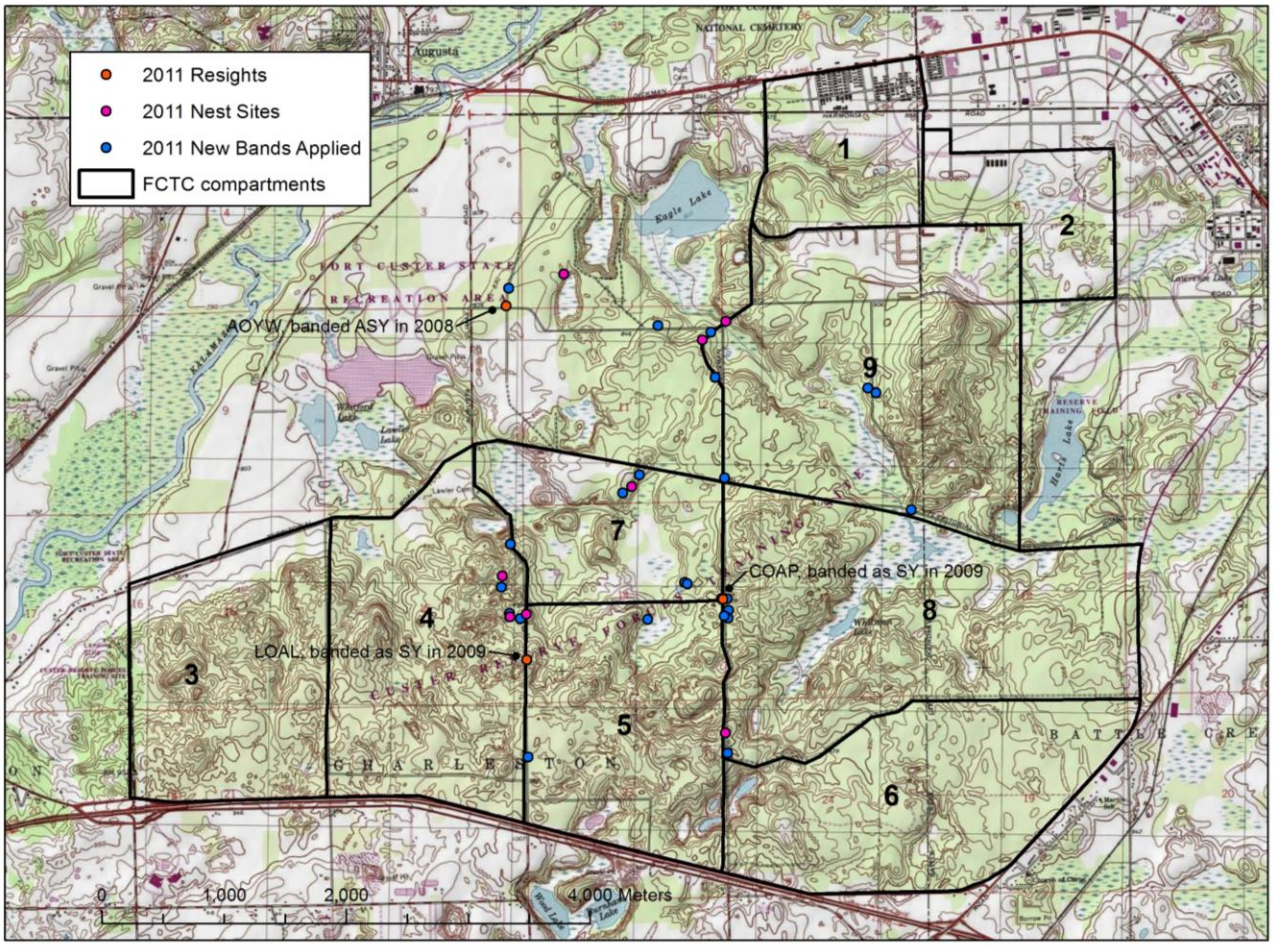
We obtained lidar (2010) and other spatial data layers from FCTC. We followed methods provided by the ESRI white paper, "Lidar Analysis in ArcGIS for Forestry Applications", and other current literature to determine measurements of forest complexity and gaps, both of

which are extremely important forest characteristics for this species (Lefsky et al. 1999, Lefsky et al. 2002). Canopy height and canopy density were the focus of the analysis.

## RESULTS

### Avian surveys

Twenty-five Cerulean Warblers were banded in 2011 (**Error! Reference source not found.**. 4). The 2011 nests associated with these birds, and resights (birds banded in previous years) are also shown.




2011. Kalamazoo Nature Center. 2011 Field work GPS locations withESRI online provided topographic map.

Figure 4. Map of Cerulean Warbler activities (resights, nests and banded birds) from 2011 at FCTC.

**Forestry surveys**

*Male territories.* We performed forestry surveys at point count locations 5-10, 5-24, 5-3b, 7-4a, 8-35, and 9-31a. Results for these points are shown in Tables 1 and Table . DBH averaged 16.2" among 125 survey trees at 6 sites, averaging 21 trees per survey. While many trees were identified, the degree of uncertainty for winter identifications makes a quantitative evaluation of species unreasonable.

Table 1. Trees per acre in male territories.

| Trees Per Acre (TPA), male territories | | | |
|---|---|---|---|
| Point | Dead | Live | Total |
| 5-10 | 6 | 187 | 193 |
| 5-24 | 0 | 180 | 180 |
| 5-3b | 8 | 109 | 117 |
| 7-4a | 0 | 204 | 204 |
| 9-31a | 0 | 85 | 85 |
| 8-35 | 8 | 126 | 134 |
| Average | 4 | 149 | 152 |

Table 2. Basal area (square feet), male territories.

| Basal Area (BA) (square feet), male territories | | | |
|---|---|---|---|
| Point | Dead | Live | Total |
| 5-10 | 10 | 150 | 160 |
| 5-24 | 0 | 140 | 140 |
| 5-3b | 10 | 80 | 90 |
| 7-4a | 0 | 210 | 210 |
| 9-31a | 0 | 100 | 100 |
| 8-35 | 10 | 120 | 130 |
| Average | 5 | 133 | 138 |

*Female territories.* We surveyed all nest sites located in 2011, with the trees per acre and basal area as follows (Tables 3 and 4). Female territories tended towards fewer trees per acre and less basal area. This was primarily due to located nests being more often found at roadsides or other openings. Point surveys at nest sites using BAF 10 usually sighted trees only for 180 degrees of the circle, with trees across the road falling out of the count circle. DBH averaged 17.8" among 79 survey trees at 9 sites.

Table 3. Trees per acre, nest sites

| Trees Per Acre (TPA), nest sites | | | |
|---|---|---|---|
| Nest site (nest tree species) | Dead | Live | Total |
| CAGO (Black Walnut) | 0 | 77 | 77 |
| CASO/CAPO (Black Cherry) | 0 | 53 | 53 |
| COAP (Black Locust) | 10 | 233 | 243 |
| JOAP (Black Walnut) | 0 | 49 | 49 |
| JOAR (Slippery Elm) | 0 | 73 | 73 |
| MACO (White Oak) | 0 | 35 | 35 |
| MARO (Black Walnut) | 0 | 57 | 57 |
| FCRA Unknown Male Nest (Black Oak) | 4 | 70 | 74 |
| Unknown Male Nest site (Black Locust) | 0 | 80 | 80 |
| Average | 2 | 81 | 83 |

Table 4. Basal Area in square feet, nest sites

| Basal Area (square feet), nest sites | | | |
|---|---|---|---|
| Nest site | Dead | Live | Total |
| CAGO | 0 | 80 | 80 |
| CASO/CAPO | 0 | 70 | 70 |
| COAP | 10 | 140 | 150 |
| JOAP | 0 | 60 | 60 |
| JOAR | 0 | 90 | 90 |
| MACO | 0 | 50 | 50 |
| MARO | 0 | 60 | 60 |
| Unknown male nest site | 0 | 90 | 90 |
| FCRA – unknown male | 10 | 130 | 140 |
| Average | 2 | 86 | 88 |

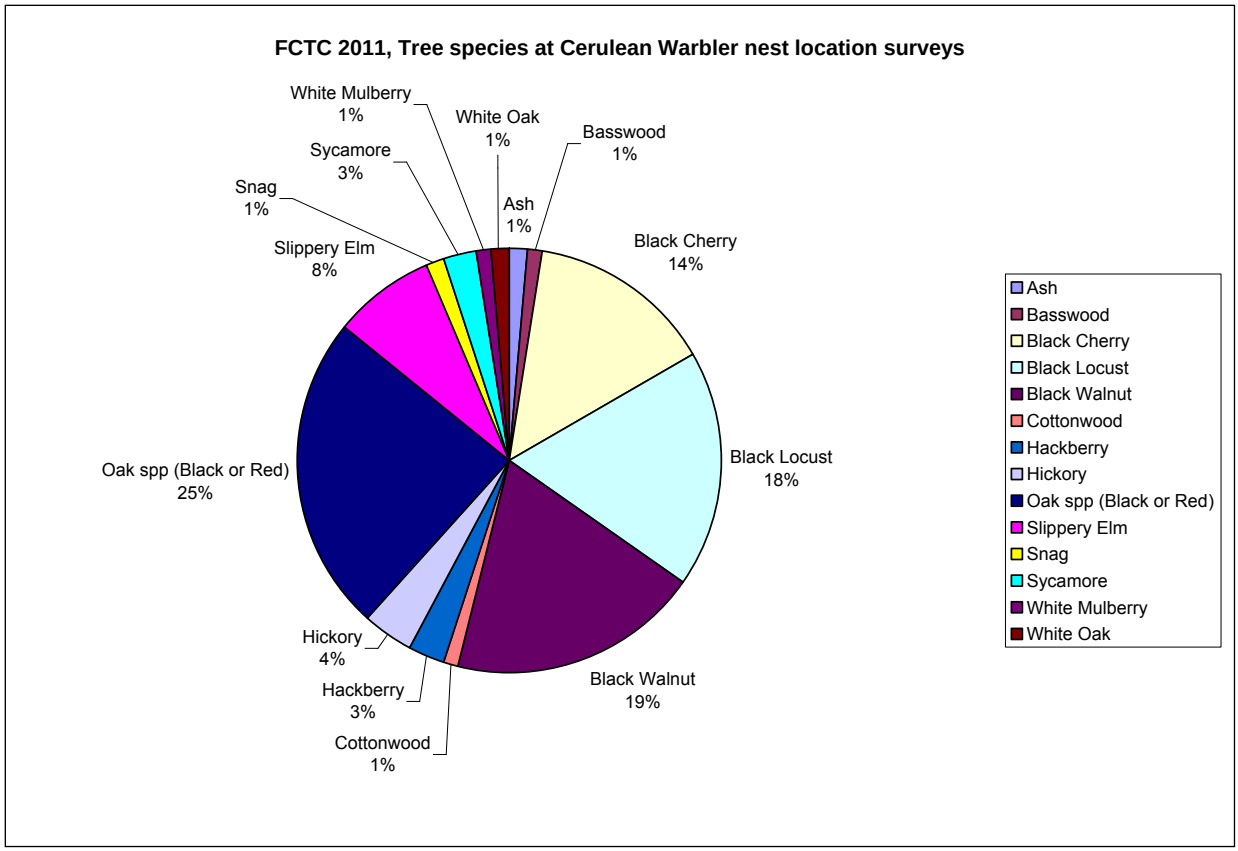



Figure 5. Tree species found at Cerulean Warbler nest locations in 2011.

## Habitat observations

We tallied observations of Cerulean Warblers utilizing elements of their habitat in 2011 (Table 5). While most observations of males and females included foraging, other common observations were the collection of nest material by females, while song display and territorial disputes between males. Oak was the most frequent vegetation observed, and more frequented by males than females. We did not classify Oak by species, due to the hybridization of some trees on the property, however most were either Red or Black. Some preference seems to be given to the White Oak, with trees being utilized whenever present, and some birds took foraging excursions into the recreation area where White Oak seems more prevalent. The Shagbark, Bitternut, and undesignated Hickories were also grouped together.

Table 5. All Cerulean Warbler habitat use observations in 2011.

| Species | Female | Male | All |
|---|---|---|---|
| Ash | 0 | 1 | 1 |
| Basswood | 0 | 2 | 2 |
| Black Cherry | 6 | 7 | 13 |
| Black Locust | 5 | 11 | 16 |
| Black Walnut | 4 | 9 | 14 |
| Cottonwood | 0 | 2 | 2 |
| Ground | 1 | 1 | 2 |
| Hackberry | 5 | 2 | 7 |
| Hickory | 1 | 3 | 4 |
| Oak | 10 | 22 | 32 |
| Slippery Elm | 4 | 2 | 6 |
| Summer Grape | 3 | 0 | 3 |
| Maple | 1 | 6 | 7 |
| Grand Total | 40 | 68 | 109 |

## Spatial analysis

Cerulean Warblers can be found most frequently in portions of compartments 4, 7, 9, and along the divisions between 5 and 9, showing the tendency for the birds to use territories near roads and gaps. Canopy height across the FCTC landscape, created using lidar data, is shown in Figure 6.

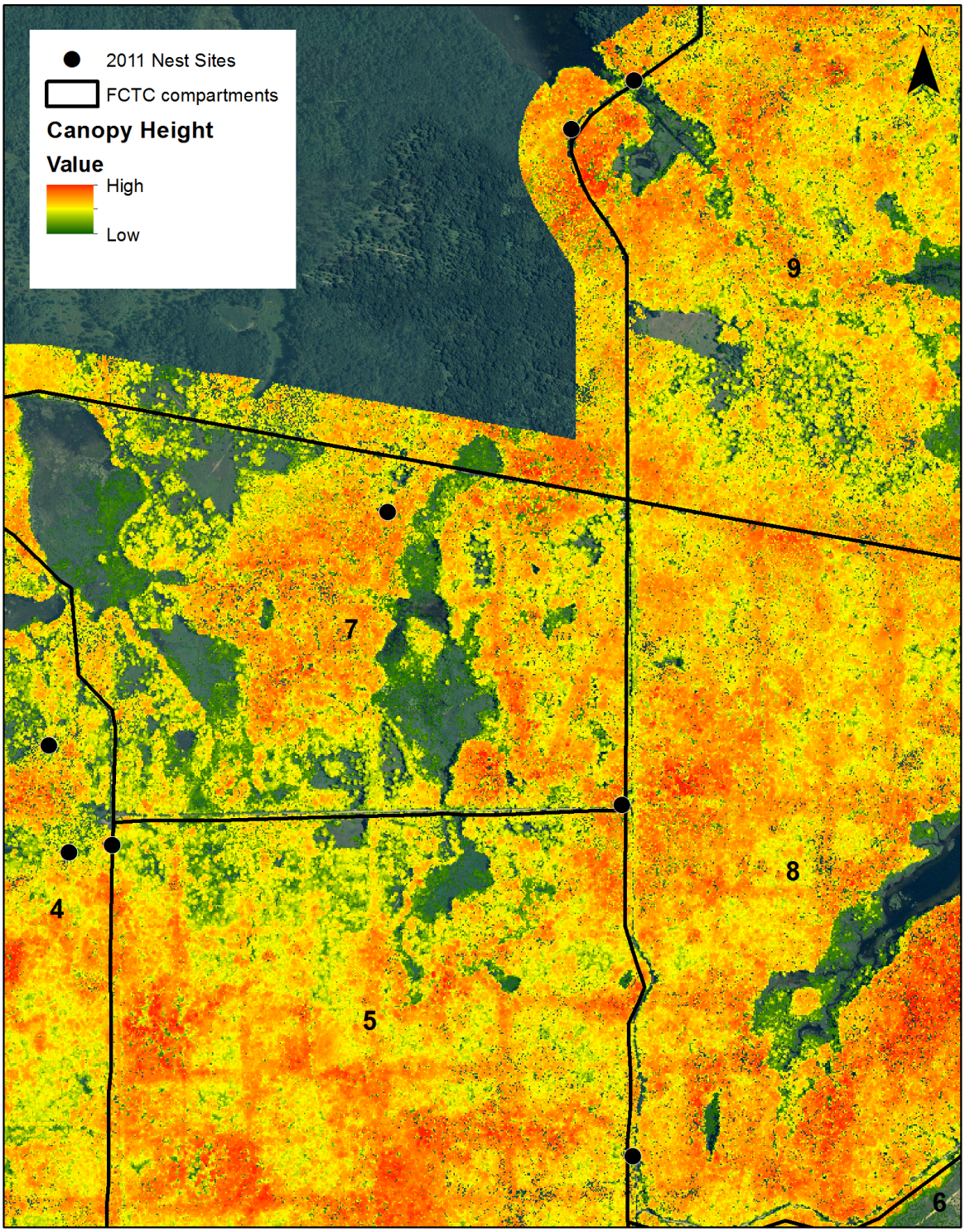



Figure 6. Showing canopy height changes (from lidar data) across the FCTC landscape in relation to Cerulean Warbler nest sites in 2011.

## CONCLUSIONS

FCTC is a 7,500-acre installation that provides trained forces in support of state, local and regional emergencies. It also has a number of significant natural features within in a matrix of woodlands, wetlands and remnant prairies, which provides important habitat for a variety of threatened and endangered species, including birds. Fort Custer's natural resources staff is committed to maintaining a balance between environmental management and the Michigan Army National Guard's mission.

The breeding population of Cerulean Warblers at Fort Custer has oscillated over the years of the study with no obvious trend. Cerulean Warblers tend to use Black Locust, Black Walnut, and Black Cherry for both nesting and foraging in greater proportion than these species' prevalence at FCTC. They also tend to nest in clusters, with a number of males having territories immediately adjoining each other. Their territories are also often near roads or natural openings.

We recommend continuing to monitor Cerulean Warbler populations at Fort Custer through color banding and nest searching. Although Ceruleans are not as numerous at this site compared to other areas in the region, it is important that this population remain steady. As a rather unique location away from the heart of the range, results could help uncover migration patterns and strategies. One management recommendation for FCTC is to use selective cutting to favor large, old trees in stands with Cerulean Warblers. We also suggest preserving tree species most commonly used by the warblers, including Black Locust, Black Walnut, and Black Cherry.

More information is certainly needed on threats to the wintering grounds. This could be studies through methods such as geolocators, which are lightweight, electronic tracking devices, used to map migration routes and identify important staging areas. A geolocator periodically records ambient light level to determine location. Use of these methods in a place like Fort Custer where site fidelity is relatively high could be very beneficial to learning more about this species of concern.

## CASE STUDY II: Fort Leavenworth, Kansas

### BACKGROUND

Fort Leavenworth Military Reservation (FLMR) is an Army installation located in Leavenworth County, Kansas (Fig. 7). This installation is situated at a bend in the Missouri River and contains 1,300 acres of mature bottomland hardwoods. Rich alluvial soils at bends along this stretch of river are more commonly converted to agriculture or urbanized. The bottomland forest is composed of two types of forest: cottonwood-sycamore forest and pecan -sugarberry forest (Freeman et al. 1997). Other trees include box elder, red mulberry, green ash, and American elm. The forest floor is swampy with open, waterlogged zones in old meander scrolls. The bottomland forests at Fort Leavenworth are believed to be the largest old-growth stands remaining in the lower Missouri River valley (Freeman et al., 1997). These forests have developed in a dynamic river system that floods periodically, like in 1993 when the Missouri River completely inundated the Fort Leavenworth bottomland, and more recently, in 2011 (see more below). For more information on the characteristics and temporal changes in FLMR forest cover from 1987 to 1997, please see Aber et al. 2002.

FLMR has had very little harvest or forest management activity over the past two decades M. Nowak, pers. comm.). Only a small (< 80 acres) harvest for sub 12-in DBH cottonwood for fuel wood chips and a salvage harvest of some of the walnut after a 1993 flood have occurred. Therefore, this area has been left relatively unmanaged and provides wildlife habitat, especially for deep floodplain forest bird species like Ceruleans. Therefore, the majority of changes to the forest have been due to storms and natural weather occurrences. Most recently, on June 22, 2011, Leavenworth closed Sherman Army Airfield due to a flood. On June 29, the levee was breached and water reached the hangars, which had been evacuated. This storm caused significant tree fall in the bottom woods, particularly of cottonwoods, which opened up the canopy and increased understory growth (J. Schukman, pers. comm).

In 1997, the Kansas Natural Heritage Inventory documented nine natural communities on the installation: four forest types, two herbaceous types, one sparse vegetation type, and two riverine types. Field surveys confirmed that the floodplain forest was globally significant, among the largest old growth stands left in the lower Missouri River valley, and provided habitat for nearly two-dozen globally rare or state-rare species (Freeman et al. 1997). A total of 253 vertebrate species were confirmed, including 179 birds, 33 mammals, 28 reptiles, and 13 amphibians. A two-year field study was conducted in 2002 and 2003 on FLMR to update the previous research.

FLMR is within BCR 22, Eastern Tallgrass Prairie. This region includes what was formerly the tallest and lushest grasslands of the Great Plains. Threats to the upland and wetland habitats of this region include urbanization, development, and agricultural expansion. FLMR is located in extreme eastern Kansas, at or near the western edge of the

Cerulean Warbler's breeding range. Therefore, it is considered a rare breeder here (Thompson and Ely 1992). The Cerulean population at Fort Leavenworth appears to have declined over the past several years (J. Schukman, pers. comm), possibly due to a regional reduction of mature bottomland hardwoods, range wide population declines, or changes occurring at the local level.

Historical monitoring at this site has captured some aspects of Cerulean habitat use in this location (Schukman 1996, Freeman et al. 2003). In 1994, Schukman conducted a study to describe the timing of arrival, abundance, and spatial relationships of the Cerulean Warbler, Yellow-throated Warbler, and Northern Parula in bottomland forest of Fort Leavenworth. A mean of 1.38 (0-3) Ceruleans were found on the primary census and 3.60 (0-5) on both census routes with an estimated eight territories (three on the primary and five on the secondary census). Of 20 observations of this species, he observed 14 in pecans, 3 in sycamores, 2 in cottonwood and 1 in green ash (Schukman 1996).

More recent studies also indicted a small or declining population of Ceruleans on in FLMR. The 2003 Kansas Natural Heritage Inventory documented 1–4 breeding pairs of Ceruleans during their study. The Institute for Bird Populations conducted the Monitoring Avian Productivity and Survivorship (MAPS) program on FLMR from 1993–2002. They used point counts and constant-effort mist-netting during the breeding season to study reproductive success and population demography. Four sites, two in upland forest and two in bottomland forest, were studied during the 8-year effort. No Ceruleans were captured during this study, although canopy nesting species are less likely to be captured using these methods.

FLMR contains one of the few areas of mature bottomwood hardwoods within this region and represents a site that could support or disprove a northeastern range shift for the Cerulean Warbler. Being a site with historical abundance data, we aimed to gain knowledge about the species' current use of this study site. If the Cerulean Warbler population has been extirpated from the site, it still allows an interesting look at how habitat at a broader scale can affect individual sites.

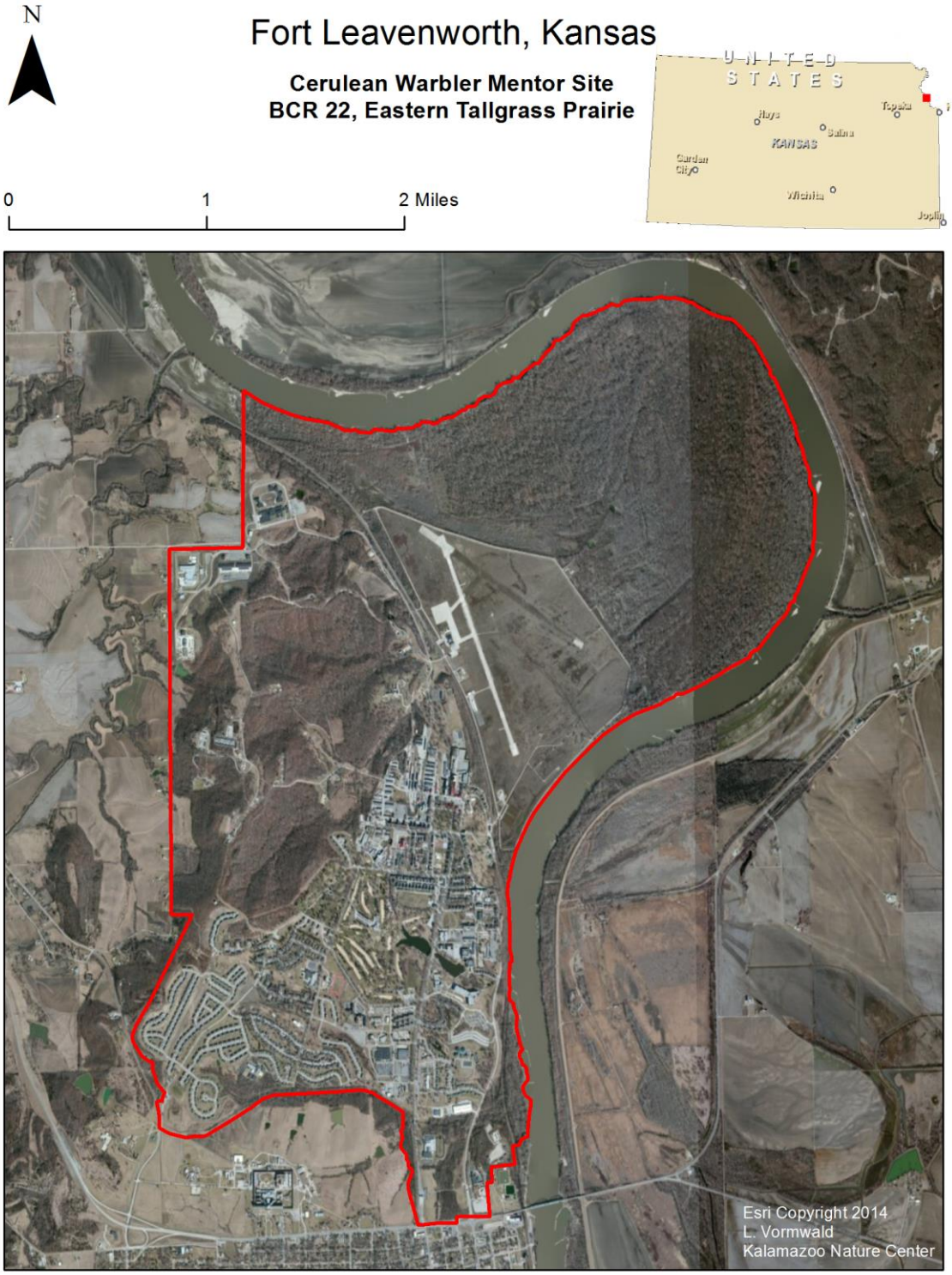



Figure 7. Map of Fort Leavenworth Military Reservation boundary in Kansas.

## METHODS

### Avian surveys

We visited FLMR May 19 -22, 2014 to conduct Cerulean Warbler point counts and area searches. Using historical locations and knowledge of Cerulean Warbler detections at FLMR in previous years, we determined 14 point count locations within the bottomland forest that could be potential Cerulean habitat (Fig. 8). Points were at least 200m apart from each other. Each point was surveyed for 5 minutes, initially listening for 2 minutes, then broadcast a male Cerulean Warbler song using an MP3 player with a speaker for 1 min, and remained listening for 2 minutes. General area searches were conducted while watching between point count locations.

### Forestry surveys

We used current methods of the Timber Cruising Handbook (USDA-FS Undated) and point surveys with a fixed length angle gauge at basal area factor (BAF) 10. We hired a forestry contractor to perform BAF 10 surveys at areas of importance to Cerulean Warblers and random locations which are not used. Because we were unable to detect any cerulean in 2014, we used the same point count locations used for the avian surveys to conduct the forestry surveys. This did not give us habitat characteristics of "use" and "non-use" but it provided a baseline of current forest species composition, trees per acre, and basal area for the areas surveyed.

### Spatial analysis

We obtained lidar (2010) and other spatial data layers from the Kansas Data Access and Support Center. We followed methods provided by the ESRI white paper, "Lidar Analysis in ArcGIS for Forestry Applications", and other current literature to determine measurements of forest complexity and gaps, both of which are extremely important forest characteristics for this species (Lefsky et al. 1999, Lefsky et al. 2002).

Since we gained knowledge of the Missouri Flood of 2011 and suspected that it significantly altered the bottomlands, we used Google Earth to create a simple visual example of the difference pre-and post-flood (Fig. 7). Because the lidar data was collected in 2010 and the flood occurred in 2011, we decided not to focus on the results because it would not be representative of the habitat that is currently there.

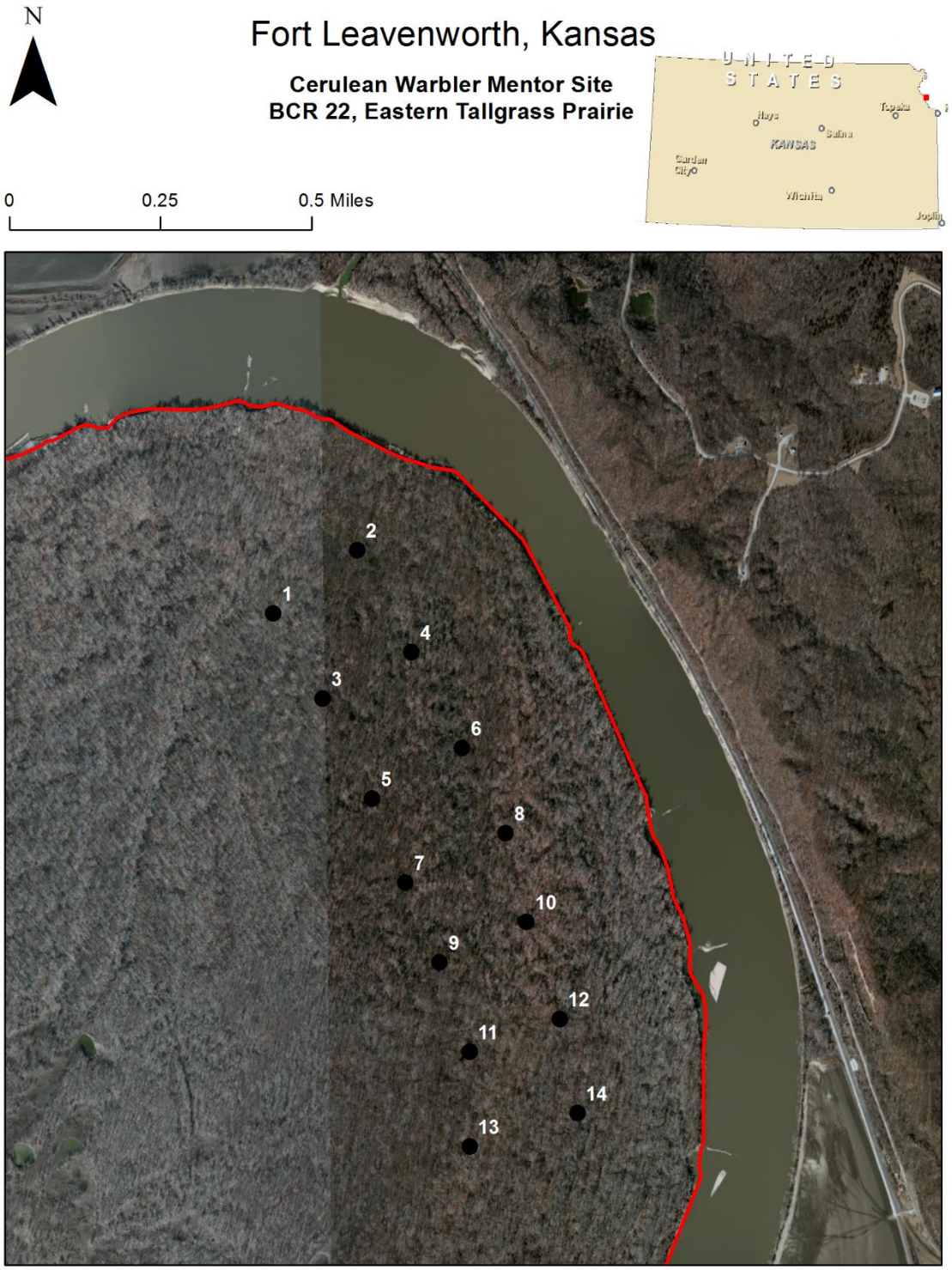



Figure 8. Map showing point count locations within Fort Leavenworth Military Reserve that were surveyed for Cerulean Warblers in 2014.

## RESULTS

### Avian surveys

No cerulean warblers were detected during our surveys in May 2014. The most common warbler species detected were American Redstart and, to a lesser extent, Northern Parula.

### Forestry surveys

A forester conducted surveys at 14 points located in the bottomlands of FLMR on November 18 - 19, 2014. A total of 95 trees were included, 14 of which were dead. The average DBH was 27.9 and it included 15 different tree species. The most common tree was the American Sycamore. Figure 6 shows the tree species breakdown for all points surveyed. Table 1 shows the site number, number of trees (live vs. dead), the average DBH, and a description for each site. The site descriptions indicate a significant amount of woody debris, fallen and dead trees at the majority of the locations.

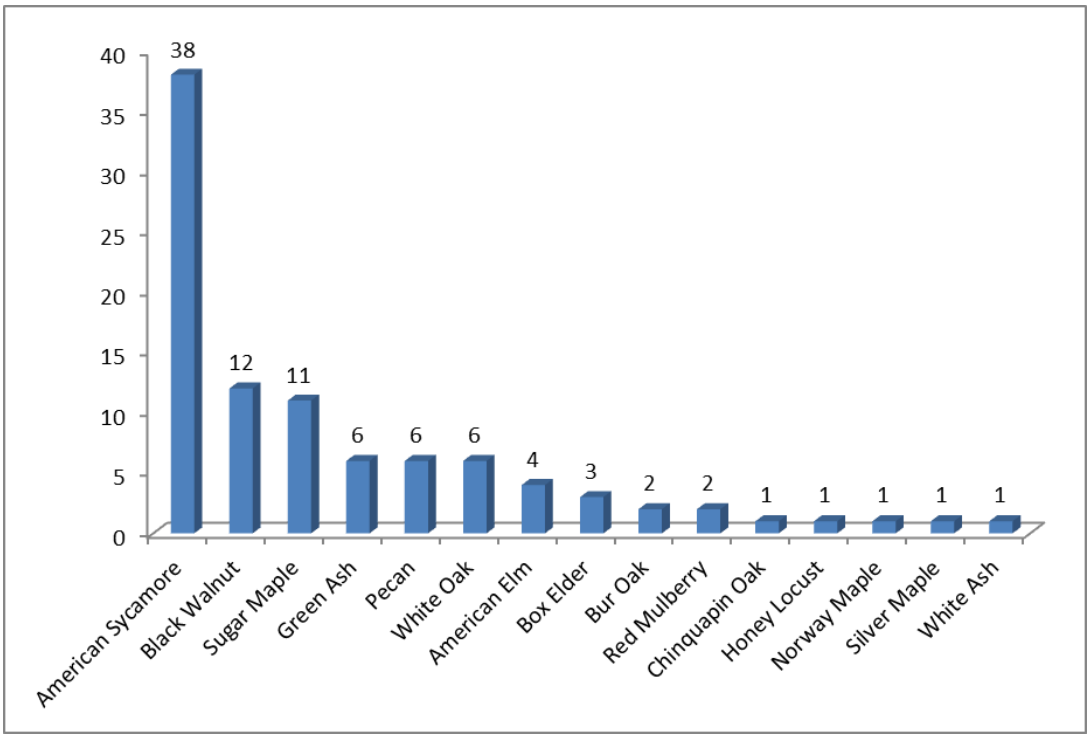



Figure 9. Number of each tree species measured during forestry surveys at Fort Leavenworth Military Reserve. Data collected in November of 2014. *Of the 38 American Sycamores, 10 were snags.

Table 6. Results of forestry surveys at each of the point count locations at Fort Leavenworth Military Reserve. Data collected in November of 2014.

| Site # | Total | Dead | Live | Ave. DBH | Site Description |
|---|---|---|---|---|---|
| **1** | 8 | 1 | 7 | 24.1 | Abundance of woody debris/dead and fallen trees. Dense sycamore saplings. Dense understory vegetation. |
| **2** | 7 | 1 | 6 | 21.6 | Level grade, green vegetation and relatively open understory, plot is adjacent to drainage feature with evidence of emergent wetland vegetation present |
| **3** | 9 | 2 | 7 | 23.4 | Abundance of snags and woody debris/dead and fallen trees. Dense sycamore saplings. Dense understory vegetation. |
| **4** | 6 | 0 | 6 | 25.7 | Slight depression area, reeds abundant in understory, relatively open canopy |
| **5** | 8 | 2 | 6 | 30.2 | Edge of basin area, emergent wetland features nearby, abundant snags and saplings in understory |
| **6** | 6 | 0 | 6 | 30.4 | Slight depression area, reeds abundant in understory, relatively open canopy |
| **7** | 12 | 4 | 8 | 31.5 | Edge of basin area, emergent wetland features nearby, abundant woody debris/dead and fallen trees, abundant snags, abundant saplings |
| **8** | 6 | 0 | 6 | 24.0 | Saplings very abundant and dense in understory, relatively open canopy, abundant woody debris/dead and fallen trees, numerous snags |
| **9** | 5 | 2 | 3 | 37.9 | Plot located near apparent remnants of skid trail, some woody debris/dead and fallen trees, numerous snags, relatively open canopy |
| **10** | 5 | 0 | 5 | 31.1 | Understory primarily comprised of very dense saplings, abundant snags and woody debris/dead and fallen trees |
| **11** | 7 | 0 | 7 | 32.8 | Understory primarily comprised of very dense saplings, abundant snags and woody debris/dead and fallen trees |
| **12** | 6 | 0 | 6 | 19.6 | Abundant snags and woody debris/dead and fallen trees |
| **13** | 6 | 2 | 4 | 30.8 | Very dense understory comprised of saplings and brambles/thicket, abundant woody debris/dead and fallen trees |
| **14** | 4 | 0 | 4 | 27.7 | Slight depression area, dense understory of saplings and brambles/thicket, relatively open canopy, abundant snags and woody debris/dead and fallen trees |
| **Total** | **95** | **14** | **81** | **27.9** | |

**Spatial analysis**

Google Earth imagery (Fig. 10) shows extensive tree damage from the 2011 flooding event. Unfortunately, the lidar data were collected prior to the flood and we do not have any occupancy or abundance data for Ceruleans for those years. Therefore, we felt we should not focus on this for our study.

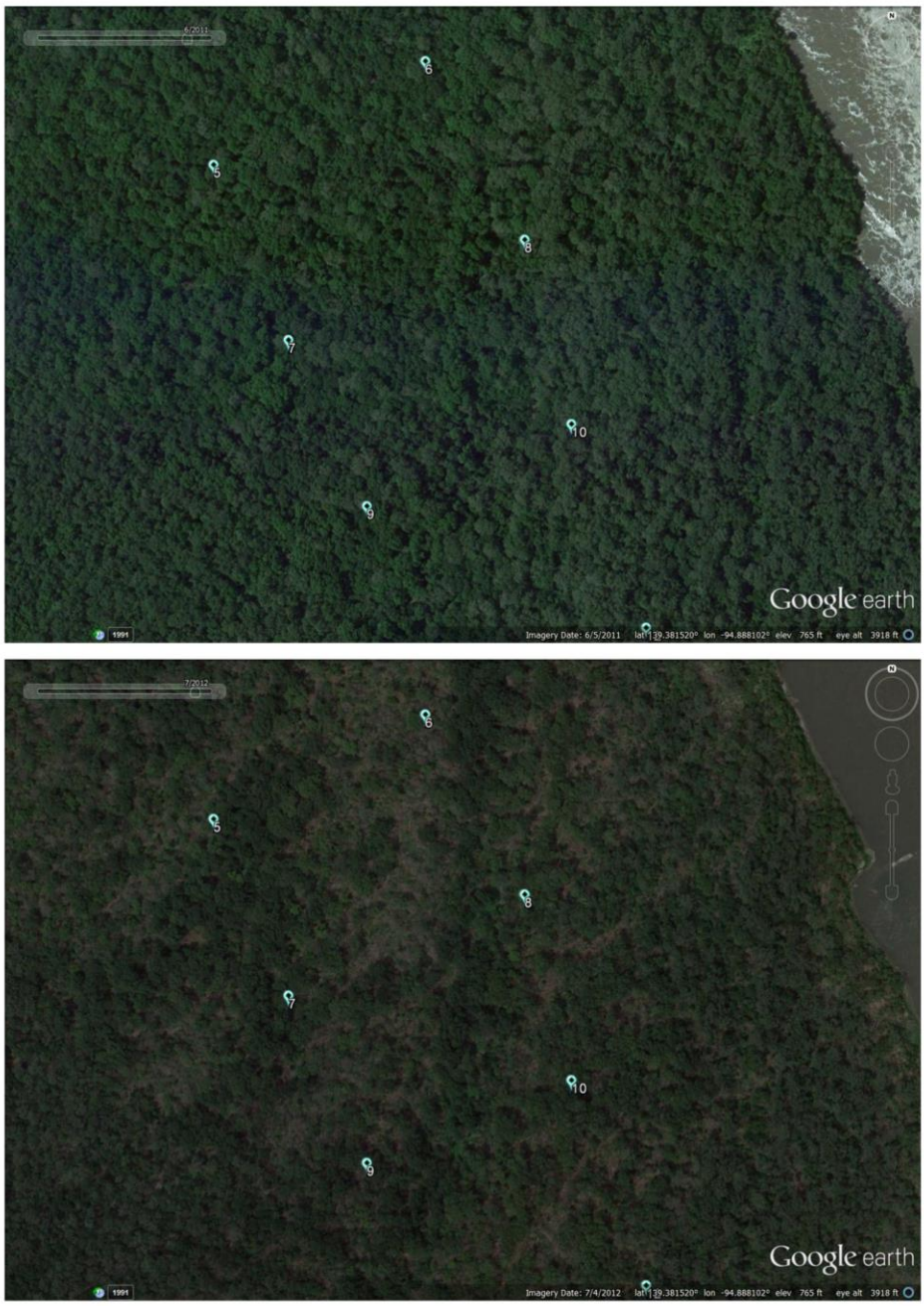



Figure 10. Satellite images comparing areas used by Cerulean Warblers at Fort Leavenworth. The images from June 2011 (top) and July 2012 (bottom) show the extensive tree fall caused by the Missouri Flood of June 2011.

## CONCLUSIONS

Maintenance of the large tracts of mature bottomland forest is essential for species such as the Cerulean Warbler, which are sensitive to forest fragmentation and disturbance. Extensive logging or disturbance of the mature bottomland forest probably would eliminate the small populations at FLMR. Even-aged stands that develop following extensive harvests typically create a relatively homogenous canopy structure (e.g., a closed canopy forest with an undeveloped understory and/or midstory). Natural Resource managers at FLMR have mostly left the bottomlands "as is" for wildlife rather than actively manage the land. In the absence of harvests, tree mortality from old age, floods, windstorms, ice damage, and fire contributes to the development of structurally complex and relatively open stands in which large canopy trees are dominant. Unfortunately, the Missouri River flood of 2011 has likely temporarily altered the bottomland habitat in a way that is not beneficial to species that depend on a thick forest canopy. However, over time this could lead to better bird habitat in the future.

Our forestry surveys and satellite images showed extensive damage to large canopy trees in the areas were Ceruleans used to hold territories. However, without specific pre-storm data on either the vegetation or birds, it is hard to speculate how the damage may have affected the Ceruleans. Although the flooding event was a natural occurrence, it appears to have changed the vegetation structure significantly. The most common canopy tree species encountered in our surveys was the American Sycamore. Previous Cerulean observations at FLMR indicated frequent use of Pecans, of which we only had six. If the majority of the flood damage impacted the Pecans, it could have changed the habitat needs of the Ceruleans enough to displace the last few remaining birds to another location. Some observations have been recorded at West Bend State Park, directly across the Missouri River from FLMR. However, it is not known if they were breeders or just migrating through.

It is likely that the dwindling Cerulean population at FLMR has finally been extirpated from this area. However, without more extensive surveys, we cannot be sure. Our recommendation would be to continue monitoring of FLMR for Cerulean Warblers to determine if the species still breeds at this site, to see how the vegetation and birds respond together over the next several years. Ceruleans favor the complex canopy structure characteristics that these types of natural occurrences create, such as uneven-aged stands and old growth forest. As the mid-level vegetation begins to grow back, it may provide suitable Cerulean habitat.

# CASE STUDY III: NSA Crane, Indiana

## BACKGROUND

Navel Support Activity Crane (NSA Crane; hereafter) is a United States Navy installation located approximately 25 miles (40 km) southwest of Bloomington, Indiana (Fig. 11) and predominantly located in Martin County, but small parts also extend into Greene and Lawrence counties. NSA Crane encompasses a major area of contiguous forest in Indiana, with 50,578 ha (83%) of forest. The forest matrix consists largely of oak-hickory timber, mixed hardwoods and bottomland hardwoods. Forest stands have been managed using a variety of silvicultural techniques, particularly an uneven-aged management scheme.

NSA Crane is listed as an Important Bird Area with over 3000 acres of wetland habitat, including Lake Greenwood and the extensive marshes of Lake Gallimore. These land characteristics, combined with a successful integration of natural resource management with military mission, have resulted in excellent habitat for a variety of wildlife. Aside from supporting significant Neotropical migrant bird populations, NSA Crane is inhabited by other animal taxa of importance, including the federally-endangered Indiana Bat.

The Institute for Bird Populations conducted a MAPS study at Crane from 1994 – 2002 and 2004 – 2008. They have detected a total of 120 species, 79 of which are known to breed on the installation, and 41 species that are passage migrants or out-of-range transients. Eight species, Acadian Flycatcher, Wood Thrush, Worm-eating Warbler, Louisiana Waterthrush, Kentucky Warbler, Blue-winged Warbler, Prairie Warbler and Field Sparrow were identified as breeding species of DoD management concern. Other species of concern known to breed at NSA Crane, but not monitored by MAPS included: Red-headed Woodpecker, Willow Flycatcher, Cerulean Warbler, and Prothonotary Warbler.

Given the timber management policies developed at the facilities, the Crane Division has been established as a model Natural Resources Conservation Program for the Navy and the Department of Defense, as recognized by Indiana State Legislature. Ironically, one of the greatest immediate threats to the bird communities at NSA Crane is the continued proceedings and judgments of the Base Realignment and Closure (BRAC) process, which threaten future operations. Should operations eventually be halted at NSA Crane, the natural resources and wildlife habitat maintained at Crane would probably be at risk to private development and unsustainable harvest.

In this study, NSA Crane serves as a representative of the Central Hardwoods (BCR 24), for military installations with actively managed forests that have Cerulean Warbler populations. Cerulean Warblers are a species of greatest conservation need and are listed as endangered in the state of Indiana. This research, conducted in collaboration with Kamal Islam from Ball State University, aimed to assess the relative abundance of Cerulean Warblers and the response to forest treatments based on spatial characteristics of territories during the breeding season at NSA Crane.

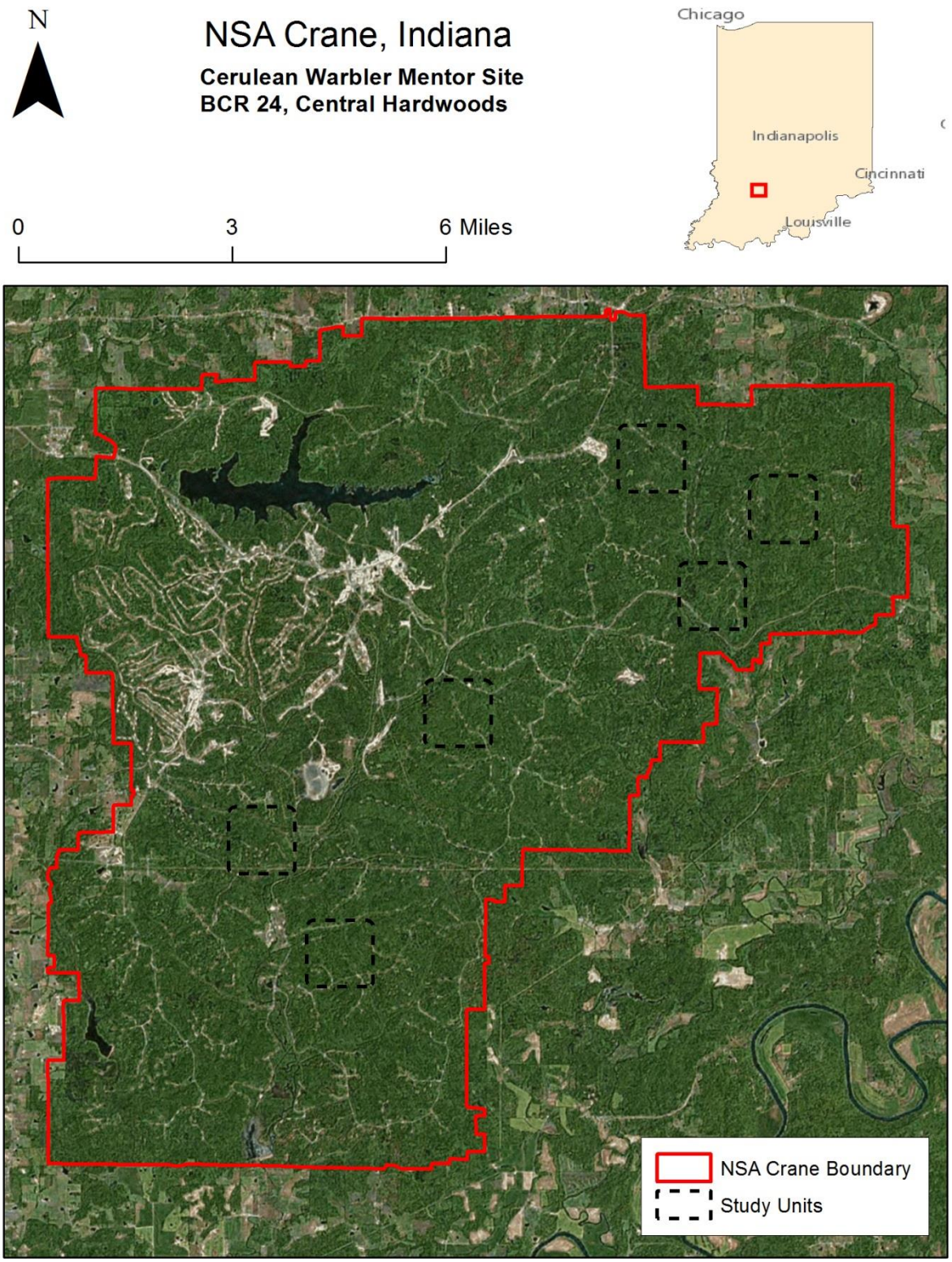



Figure 11. Map of Navel Support Activity Crane and the Cerulean Warbler study units.

## METHODS

### Avian surveys

The Cerulean Warbler field work was conducted between May 2, 2014 and July 6, 2014. We conducted point counts from May 2, 2014 to May 28, 2014. Six 225 ha units were delineated using ArcGIS 10 in areas where Cerulean Warblers had previously been recorded. Each unit had 49 points spaced 200 m apart with a 150 m buffer around the perimeter. We determined Cerulean Warbler presence at each of these points by broadcasting Cerulean Warbler vocalizations and recording Cerulean Warbler response. Upon arrival at a point, we listened for 2 minutes, broadcast vocalizations, then listened for two more minutes. We recorded the number of Cerulean Warblers detected, and their direction and distance. Surveys were not conducted during rainy or windy conditions.

During May and June, we recorded the coordinates of singing males with a Global Positioning System (GPS) unit. We attempted to record at least five song perches, however we were not always able to accomplish this, and therefore between 1 and 12 song perches were recorded per male. The species of tree in which the male sang from was recorded for each song perch.

We located Cerulean Warbler nests during point count and territory surveys by observing parental behaviors (e.g. female Cerulean Warbler carrying nest material to nest). Nest searching was conducted only as incidental observations during other activities, because it did not fulfill any of the research goals outlined in the research proposal. Nests were monitored only enough to determine whether they failed or succeeded and were visited very infrequently until the last few days of the nestling stage. Nests that survived until the nestling stage were monitored every day when the nestlings were between 6 and 10 days old, and fledglings were located. We considered a nest successful if at least one nestling fledged. We recorded nest site characteristics including: nest height, nest tree height, distance of nest to trunk and distal end of nest branch, nest tree diameter at breast height (DBH), nest tree species, nest orientation in relation to nest tree, and aspect of nest tree. We also recorded the number of each tree species within and 11.3 m radius around the nest.

### Forestry surveys

We used current methods of the Timber Cruising Handbook (USDA-FS Undated) and point surveys with a fixed length angle gauge at basal area factor (BAF) 10. This information was used to calculate basal area (BA), and trees per acre (TPA). We hired a forestry contractor to perform BAF 10 surveys at areas of importance to Cerulean Warblers and random locations where birds were not detected during the survey period.

## Spatial analysis

Lidar at NAS Crane is available from Indiana University's Indiana Spatial Data Portal. We created polygons in ArcGIS for territories using points from three or more song perches. We obtained lidar (2010) and other spatial data layers from FCTC. We followed methods provided by the ESRI white paper, "Lidar Analysis in ArcGIS for Forestry Applications", and other current literature to determine measurements of forest complexity and gaps, both of which are extremely important forest characteristics for this species (Lefsky et al. 1999, Lefsky et al. 2002). Canopy height and canopy density were the focus of the analysis.

# RESULTS

## Avian surveys

We recorded a total of 101 detections of Cerulean Warblers during point count surveys (Table 7). The mean relative abundance was 8.6 birds per square kilometer with a standard deviation of 3.9.

*Territory Mapping*: We mapped a total of 110 Cerulean Warbler territories (12 territories with 1 to 2 song perches recorded, 9 with 3 to 4 song perches and 89 with 5 to 12 song perches). Average territory size (using only territories with 5 or more points) was 0.3 ha with a standard deviation of 0.17 ha.

*Nest Monitoring*: We monitored 16 Cerulean Warbler nests of which 5 were successful and 11 failed. Of the 5 that were successful, 2 were found by locating a fledgling underneath the nest and then searching above for the nest which contained nestlings. Of the nests that failed, 1 was found torn apart; 1 disappeared from the tree limb; and 10 were still intact. We did not observe Brown-headed Cowbird nestlings in any of the nests. We recorded nest site characteristics for all 16 nests. Nest tree species were Sugar Maple (6 nests), White oak (3 nests), Slippery Elm (2 nests), Black Tupelo (2 nests), *Fraxinus sp.* (1 nest), American Sycamore (1 nest), Red oak (1 nest). Please see Ball State's report for more detailed information on nest site characteristics.

Table 7. Cerulean Warbler point count detections at NSA Crane, Indiana in 2014.

| Unit | Detections | R.A. (Detections/km2) | Territories mapped |
|---|---|---|---|
| 1 | 16 | 8.16 | 19 |
| 2 | 29 | 14.80 | 30 |
| 3 | 15 | 7.65 | 14 |
| 4 | 5 | 2.55 | 9 |
| 5 | 23 | 11.73 | 23 |
| 6 | 13 | 6.63 | 15 |
| Total | 101 | 8.59 | 110 |

**Forestry surveys**

A forester conducted surveys at 50 points located in the survey units at NSA Crane in August of 2014. 25 the points were "use" locations based on Cerulean detections and the 25 were randomly selected locations with no detections (non-use). 633 trees were included in the surveys, only 50 of which were snags. The average DBH was 16.3 and it included 33 different tree species. The most common tree was the Yellow Poplar, followed by Sugar Maple, and White Oak. Figure 12 shows the tree species breakdown for both use and non-use points. Pignut Hickory trees were more common (n=28) at use sites than non-use sites (n=11). Yellow Poplar trees were slightly more common (n=67) at non-use sites than use sites (n=56). Average DBH for use sites was 17.2, while non-use sites averaged slightly smaller at 15.6.

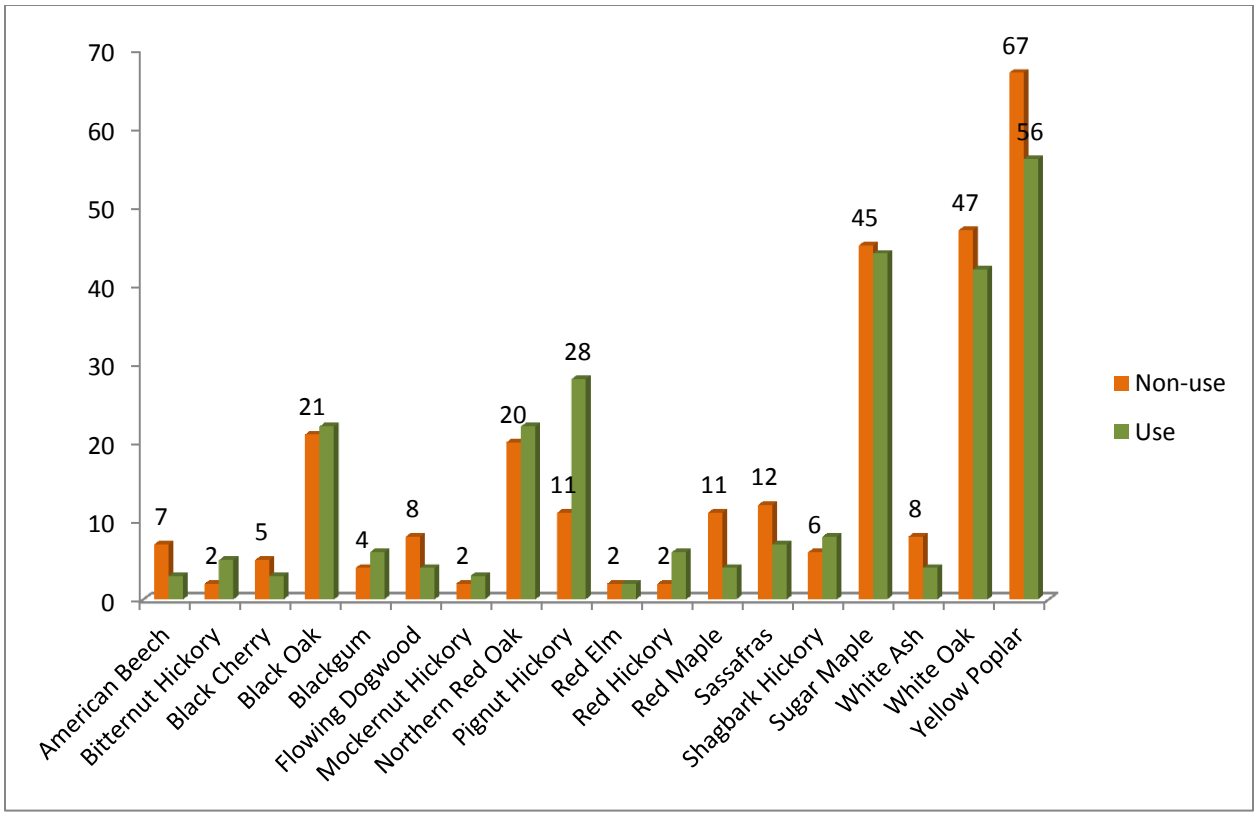



Figure 12. Number of the most common tree species measured during forestry surveys at NSA Crane. Data collected in August of 2014.

**Spatial analysis**

We examined forest characteristics within each of the 6 study units at NSA Crane (Table 8). Unit 2 had the lowest canopy height while unit 3 had the highest. Units 2 and 6 had the highest amount of open canopy. We provide an example of these spatial layers in Figures 13 and 14.

We also examined canopy height and density at locations of use and non-use within surveyed study units at NSA Crane. We use mean centers of Cerulean Warbler territories for use and the non-use areas, created a 50m buffer around those locations, and compared forestry metrics within those areas. There was no difference between average canopy heights within use (18.6m) vs. non-use (18.3m) areas.

Table 8. Habitat features of Cerulean Warbler research units at NSA Crane. These data are derived from Lidar data retrieved from IndianaMap Framework Data.

| Unit | Mean Canopy Height (m) | % Open Canopy (≤ 12 m) | % Tall Canopy (> 24 m) | Mean Beers Aspect | Mean Elevation (m) | Mean Slope (degrees) |
|---|---|---|---|---|---|---|
| 1 | 17.3 | 0.29 | 0.29 | 0.99 | 210 | 10 |
| 2 | 14.8 | 0.41 | 0.22 | 0.85 | 190 | 11 |
| 3 | 18.5 | 0.26 | 0.35 | 0.90 | 221 | 11 |
| 4 | 15.8 | 0.35 | 0.25 | 0.95 | 192 | 11 |
| 5 | 17.5 | 0.29 | 0.32 | 1.00 | 204 | 11 |
| 6 | 14.5 | 0.40 | 0.21 | 0.98 | 178 | 9 |

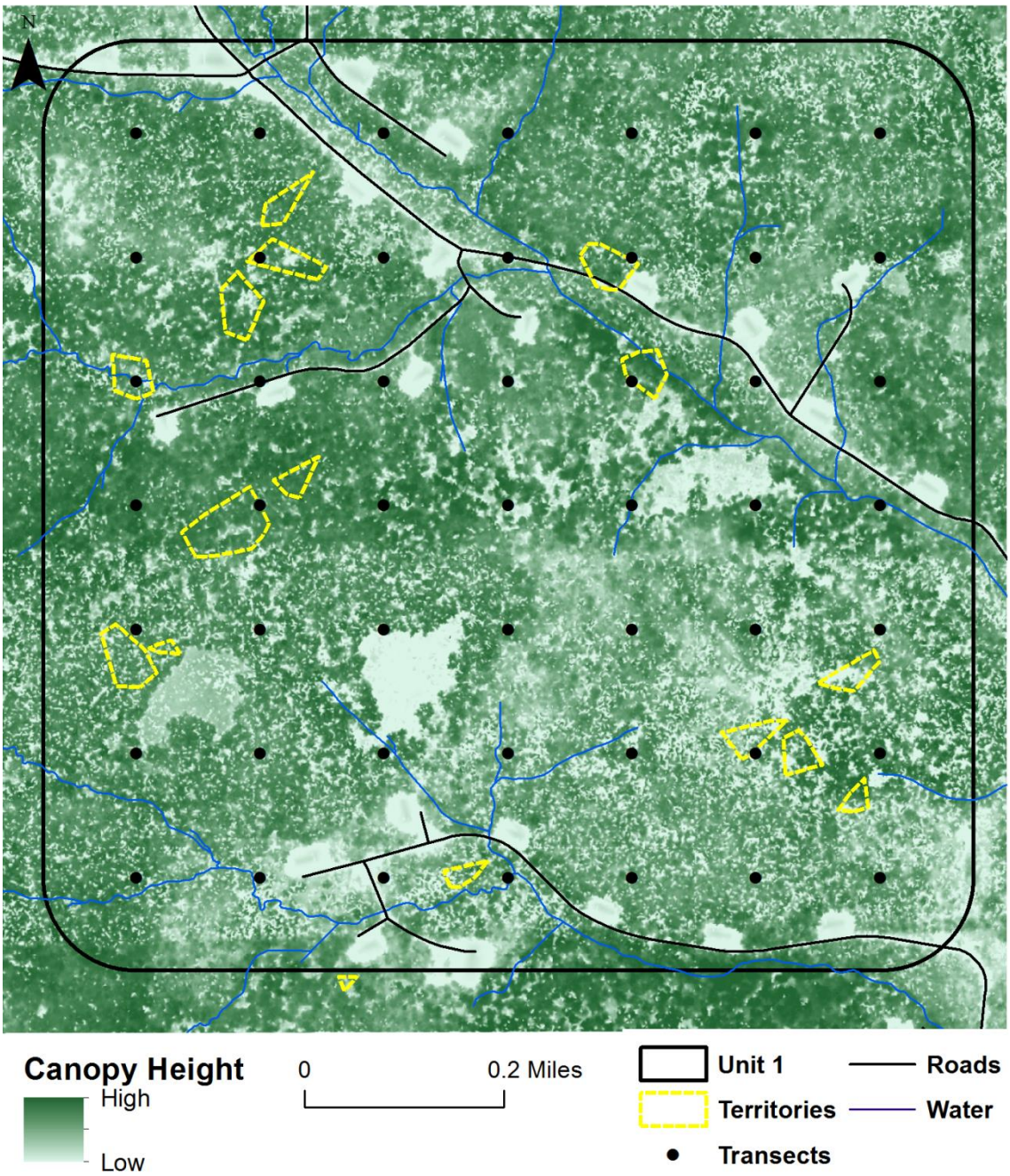



Figure 13. Map showing canopy height and Cerulean Warbler territories that were mapped in Unit 1.

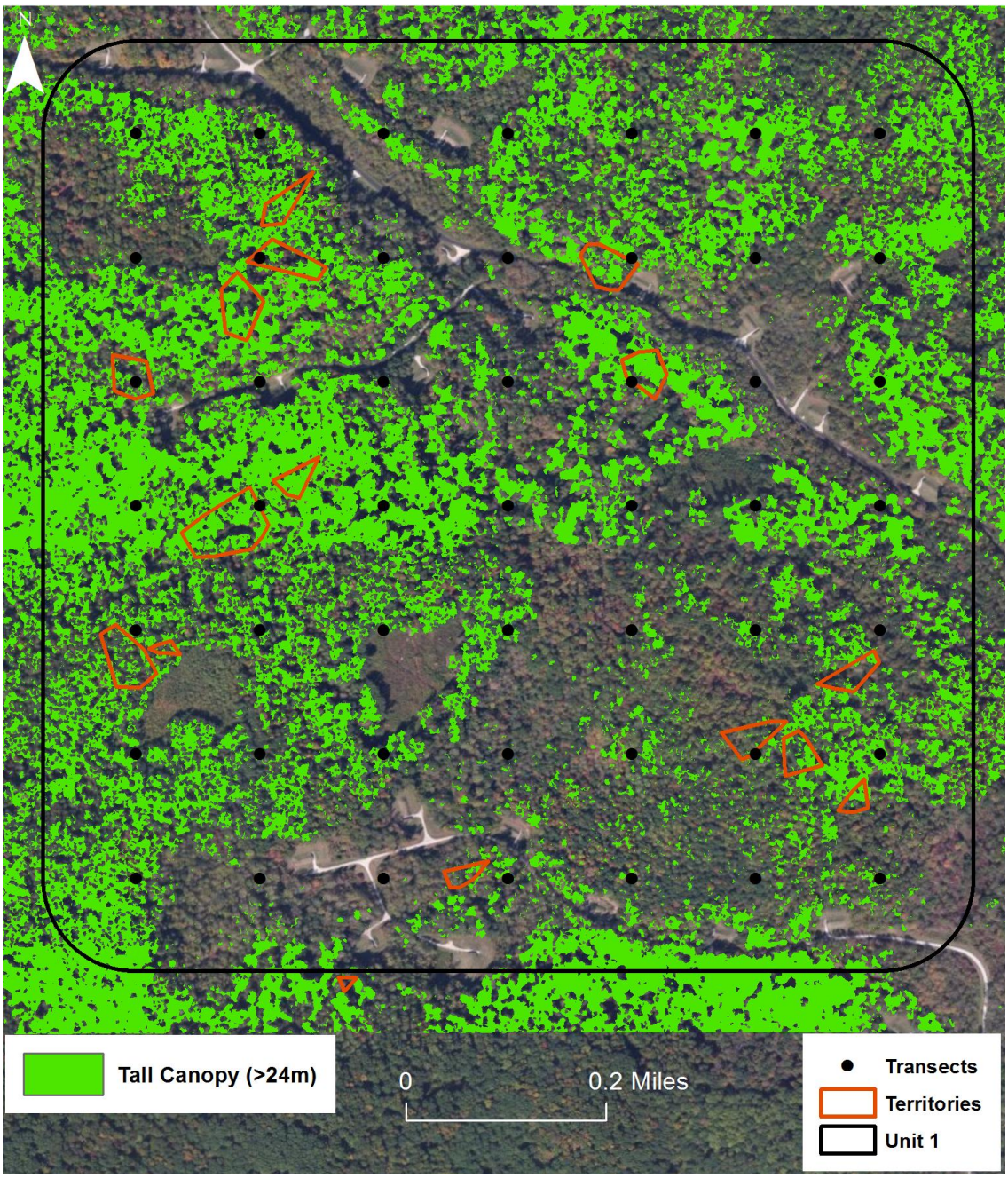



Figure 14. Map showing canopy height > 24m and Cerulean territories within Unit 1.

## CONCLUSIONS

NSA Crane currently manages 51,578 acres of forest and has used several different forest management plans since the original plan in 1959. The plan emphasizes an uneven-aged management plan, leaving the majority of acreage at sawtimber size. This kind of management has supported biodiversity and emphasized ecosystem management on the installation.

Cerulean Warblers do appear to be common breeders at NSA Crane, however we did not measure reproductive success and we only collected one year of data. Do to the endangered species listing of the warbler in the state of Indiana, we believe it is an important species to focus on over the next several years. NSA Crane is a large forested tract of land in southern Indiana and would provide an interesting comparison with other public lands in the area. It may also provide an opportunity for investigating the response of Cerulean Warblers to silvicultural treatments.

Cerulean Warbler territories at NSA Crane shared similar characteristics found in other studies (Kaminski and Islam 2013), such as being in groups (clusters), near roads and streams, and in areas with canopy gaps and openings.

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