ORNL/TM-2012/388

Interior Forest Areas

of the OAK RIDGE RESERVATION

prepared by

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September 2012

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INTERIOR FOREST AREAS OF THE OAK RIDGE ENVIRONMENTAL RESEARCH PARK

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ACRONYMS AND ABBREVIATIONS

DOE	Department of Energy
MOU	Memorandum of Understanding
OREIS	Oak Ridge Environmental Information System
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PIF	Partners in Flight
USFWS	US Fish and Wildlife Service
WMU	wildlife management unit

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EXECUTIVE SUMMARY

This report summarizes an interior forest survey conducted May 2011 through September 2012 on the Oak Ridge Environmental Research Park (Research Park). The task was implemented through the Oak Ridge National Laboratory (ORNL) Natural Resources Management Program and included researchers from the ORNL Environmental Sciences Division and interns in the Oak Ridge Institute for Science and Education Higher Education Research Experiences Program.

The survey was conducted in an effort to map and determine the total acreage of interior forest on the Research Park. This data collection effort was in support of the approved Wildlife Management Plan for the Oak Ridge Reservation (ORR), a major goal of which is to maintain and enhance quality wildlife habitat and biodiversity on the ORR. This study recorded 3924 acres (1589 ha) of interior forest acreage for the Research Park. The interior forest on the Research Park is a valuable wildlife and overall natural resource, and protecting it is vital to the preservation of interior forest species. Fragmentation of the interior forest occurs when features such as roads, power lines, or buildings cause a break in the forest canopy. The break creates edge habitat that allows predators access to the area, resulting in potential impacts to interior forest wildlife species. This report provides an update of the previous 2006 Research Park interior forest map. Research Park interior forest dynamics are constantly changing due to new construction projects, road improvements, road abandonment, and other factors. This report documents current forest canopy conditions and interior forest blocks for the Research Park.

1. INTRODUCTION

The Oak Ridge Environmental Research Park (Research Park) is an area of historic and environmental significance. Ever since the end of World War II, the Department of Energy (DOE) Oak Ridge Reservation (ORR) has been an area of study and environmental remediation. One of the most important aspects of the Reservation today is the interior forest. Interior forests are important not only because they are a diminishing resource throughout the world, but also because they support a number of unique and ecologically significant plant communities and wildlife species not found in urban environments. It is important for interior forests to be routinely monitored because changes to the forest structure occur on a regular basis. Forested areas may be altered by building projects, new roads, road improvements, power lines, and other activities. Conversely, interior forest acreage may increase in other areas that are allowed to revert back to a more natural closed-canopy setting. As is the case in many areas, interior forest on the Reservation is a valuable resource worthy of protection. This study was conducted to update and refine information on Research Park interior forest acreage that was last evaluated in 2006 (OREIS 2006).

This data collection effort was in support of the approved *Wildlife Management Plan for the Oak Ridge Reservation* (Giffen, Evans, and Parr 2007), a major goal of which is to maintain and enhance quality wildlife habitat and biodiversity on the ORR. The study was conducted May 2011 through September 2012 and was coordinated through the Oak Ridge National Laboratory (ORNL) Natural Resources Management Program and led by researchers in the ORNL Environmental Sciences Division and Oak Ridge Institute for Science and Education (ORISE) interns participating in the ORISE Higher Education Research Experiences program at ORNL.

The Research Park has experienced a number of changes since the last interior forest acreage evaluation, with potential influences on this important Reservation resource. This study was designed to document those changes and gather more quantitative data on the current amount of interior forest on the Research Park as well as determine those locations with large acreages of contiguous forest. Ultimately, the goal of the study was to produce a more accurate map of interior forest on the Reservation. A greater knowledge of the amount and locations of interior forest on the Research Park provides important information for forest and wildlife managers, allowing them to more effectively manage the resource.

2. METHODS AND MATERIALS

The extent of forested areas at the Research Park was determined through extensive field reconnaissance and review of aerial photographs. During field surveys typical contributors to forest fragmentation were evaluated, including roads, power line corridors, and other man-induced or natural disturbances. Because many of the roads on the Research Park are narrow and unpaved, they may have little to no effect on the continuity of the interior forest. This is also the case for some other potential forest disturbances, including minor construction projects, tree blowdowns, and tree die-offs related to disease or insect infestation. The degree of disruption to the forest canopy is ultimately dependent on the extent of disturbance to the natural community.

The major field portion of this project was conducted May through August 2011. The Research Park currently contains 33,516 acres (13,569 ha) of federal land, and the land is divided into 28 individual management units. Select units of the 28 individual management units are split up into sections for fire management purposes, resulting in a total of 35 wildland management unit (WMU) maps. The WMU maps of the individual units were used in the field to mark areas of forest as well as canopy openings. Canopy openings were primarily identified by visual observation along with use of aerial photography.

After the results of the 2011 field survey were recorded on all WMU maps, the data were then compared to the 2006 aerial photo by the Oak Ridge Environmental Information System (OREIS) (2006) and the natural outlines layer delineated from that photograph. The natural outlines layer was then edited to represent the contiguous forest based on the 2011 field survey, 2006 aerial photo, 2010 aerial photo, and 2011 aerial photo (Bing Maps 2012). This process was followed by additional field verification of areas still in question.

Studies conducted by wildlife biologist Stanley Temple indicated that an "edge effect" extends into a forest as much as 656 ft (200 m) (Temple and Cary 1988). This effect would include potential impacts from predators, nest parasites (brown-headed cowbird), and other similar disturbances to nesting success. Thus, researchers have used this distance as a criterion for identifying "interior" forest areas that would remain unaffected by forest fragmentation. When the 656 ft (200 m) buffer area is taken into consideration, the true nonimpacted interior forest may be eliminated or reduced to very small and/or narrow areas when encroached upon by surrounding roads, power line corridors, and other openings. Other researchers have used the benchmark of 50 acres (20 ha) of forest with 10 acres (4 ha) of forest interior to identify habitat for forest interior bird species (Jones, McCann, and McConville 2001). To give a more accurate depiction of viable interior forest habitat on the Research Park, the aforementioned buffer and acreage criteria were implemented as a further refinement. ArcGIS (ESRI 2011) was used to select contiguous forest areas of at least 50 acres (20 ha) in size, create 656 ft (200 m) buffers from edges of contiguous forested areas, and calculate the areas of the resulting interior forested areas (10 acres [4 ha]).

3. RESULTS

The interior forest boundaries and 656 ft (200 m) buffers determined by this study are depicted on an overall map of the Research Park (Fig. 1). All areas depicted on the map also meet the criteria of being at least 50 acres (20 ha) in size, with an interior forest area of at least 10 acres (4 ha). Power line corridors always resulted in canopy openings, and fire roads on the edges of the units usually caused openings in the canopy. A total of 3924 acres (1589 ha) of interior forest were recorded for the Research Park during this study. This acreage corresponds relatively closely to estimates from the 2006 interior forest study (4100 acres [1660 ha]) (Parr and Hughes 2006). Figure 2 depicts representative closed-canopy areas, and Fig. 3 shows representative open-canopy areas around the Research Park.

4. DISCUSSION

As human populations continue to increase and expand, large tracts of contiguous forest are becoming smaller and being broken into a greater number of pieces. Forest area is lost to clearing of land for industry, agriculture, and residential development, and the remaining forest is further fragmented by associated roads and utility corridors. Fragmentation creates an edge effect that alters habitat conditions such as moisture regime, microclimate, and light penetration and can result in the introduction and spread of predators harmful to forest-dependent wildlife species.

The Research Park maintains extensive interior forest acreage not present in adjacent suburban areas. In fact, the ORR is recognized as the largest contiguous protected land ownership in the southern Valley and Ridge Physiographic Province. These relatively large forested tracts provide habitat conditions that support wildlife species either uncommon in or absent from surrounding areas. In an assessment of the Research Park's Natural Areas, Baranski (2009) developed a set of ranking criteria to reflect the value of interior forests, recognizing that the larger the acreage, the greater the ability of the site to sustain natural processes without intrusion or disturbance.

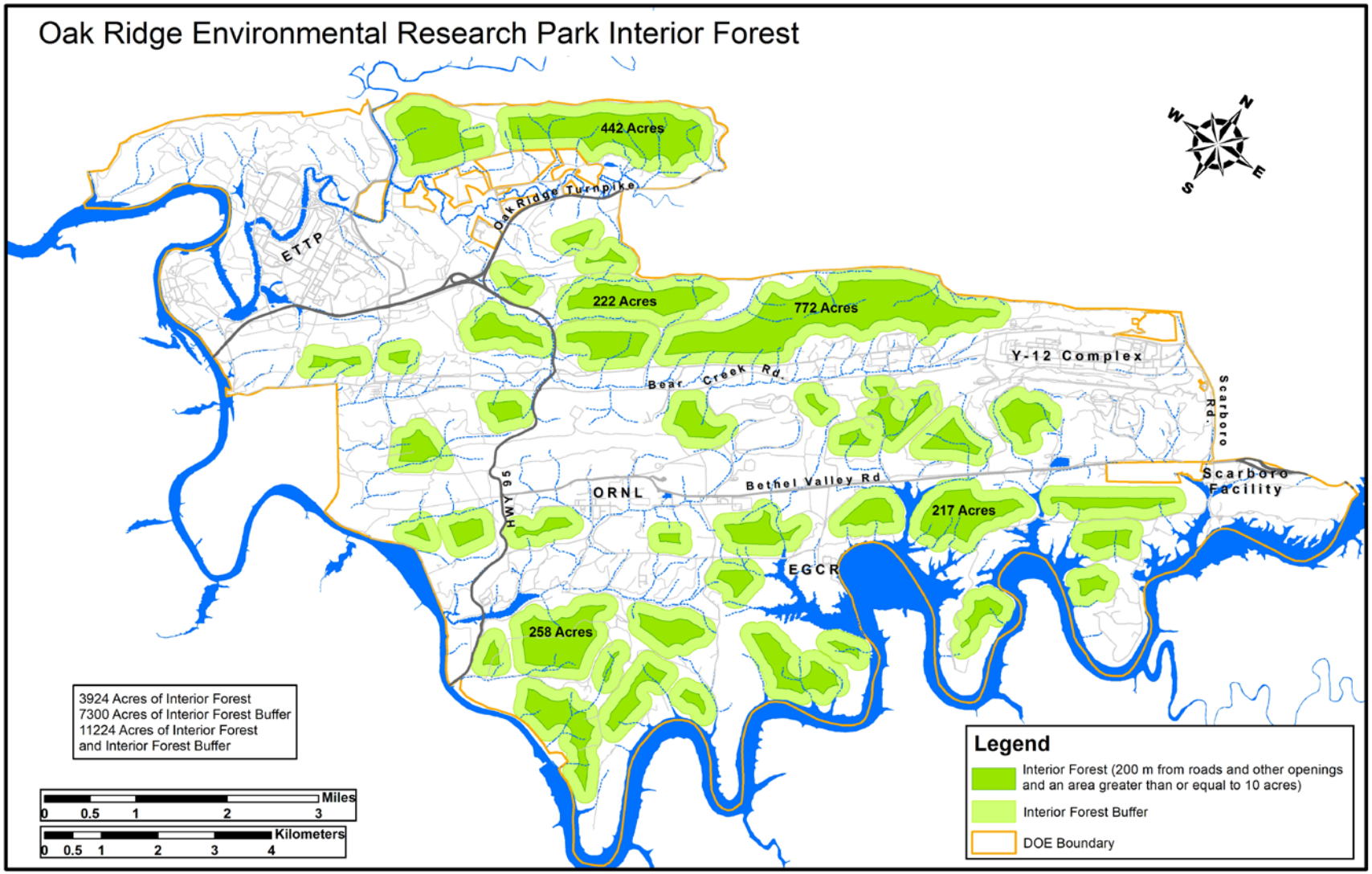
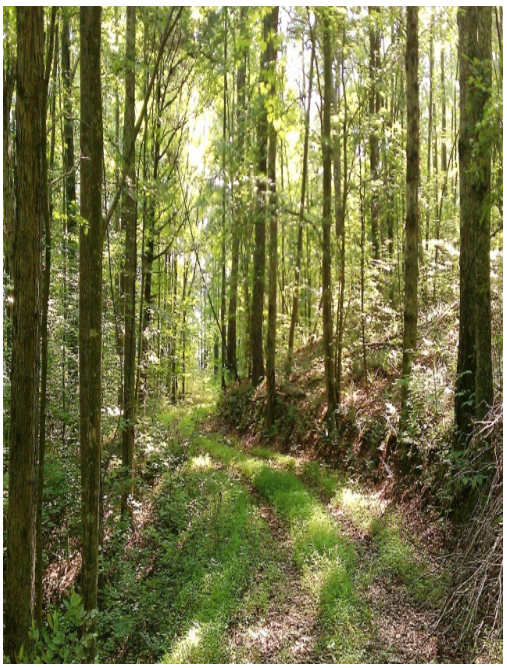


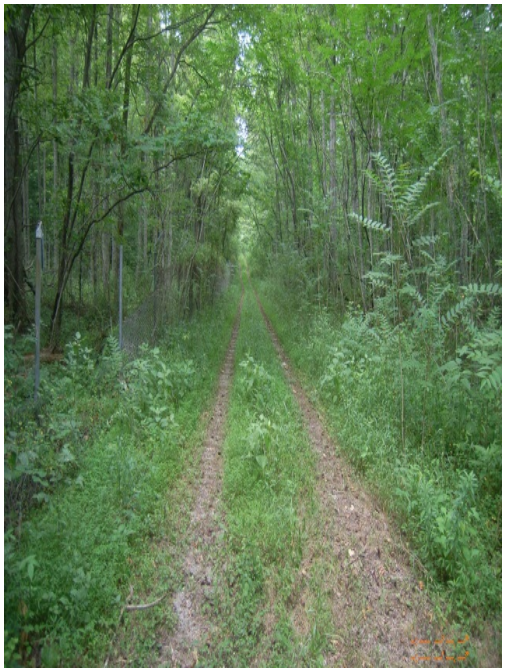
Fig. 1. Oak Ridge Environmental Research Park interior forest areas.



EGCR WMU, C-22 Access Road

Park City WMU, Woods Access Road

Park City WMU, Price Road



DOSAR WMU, HPRR East Fence Access Trail

Fig. 2. Representative closed-canopy situations on the Oak Ridge Environmental Research Park. (photos by D.C. Wade)

Horizon WMU, Poplar Creek Road

McNew WMU, Midway Turnpike

McNew WMU, McNew Hollow Road

Park City WMU, Price Road

Fig. 3. Representative open-canopy situations on the Oak Ridge Environmental Research Park. (photos by D.C. Wade)

An important barometer in the determination of forest-habitat quality is the presence of certain neotropical migrant bird species, many of which are experiencing population declines. These species are impacted by decreases in acreage and the fragmentation of forest habitats. Causes of decline in these bird populations may include loss of breeding habitat, wintering habitat, and migration stopover points. It has been hypothesized that species declines have been the result of negative impacts on breeding success due to habitat fragmentation. Nesting forest birds increasingly fall prey to predators associated with edge habitat such as feral cats, raccoons, and certain snake species. The creation of cleared areas throughout forests also opens the area to the brown-headed cowbird, a common nest parasite that uses edge habitat and parasitizes nests of forest birds. Cowbirds fly in from the edges to lay their eggs in the nests of forest birds, where the larger, more aggressive cowbird young out-compete the fledglings of the forest bird species. As more edges are created through the forest, cowbird penetration and associated nest predation on forest species increase (Gates and Gysel 1978; Robbins 1980; Robinson et al. 1995).

Yearly breeding bird surveys (May–June) have been conducted on the Research Park since 1995 as part of the international Partners in Flight (PIF) Program. Through this program, bird numbers are monitored to track increases and declines in species populations. The program divides the United States into a number of regions to monitor populations at a finer scale. The Research Park is within the Appalachian Mountains region. Sixty-two of the bird species listed by PIF as being of Regional Importance in 2012 have been recorded on the Research Park. Of these 62 species, 15 are area-sensitive forest species that are known or possible breeders on the Research Park. Many of these species are long-distance neotropical migrants also impacted by loss of habitat in their tropical wintering areas. Table 1 lists these 15 species, plus additional area-sensitive forest bird species that have been recorded on the Research Park.

Figure 4 depicts interior forest areas on the Research Park in four acreage categories. These areas range in size from 11 acres (4.5 ha) to 772 acres (313 ha). Acreages for the largest areas (greater than 200 acres [81 ha]) are specifically noted on the map. Research Park PIF data for these areas support the importance of larger tracts to interior forest bird species.

The largest contiguous tract of interior forest (772 acres [313 ha]) on the Research Park is along Pine Ridge (Fig. 5). In close proximity to this tract to the west is the fourth largest interior forest tract (222 acres [90 ha]) on the Research Park (Fig. 6). Combined these two areas provide almost 1000 acres (405 ha) of interior forest habitat. Fifteen species of interior forest birds are known to frequent this area (Table 2).

The second largest contiguous tract (442 acres [179 ha]) is located along Black Oak Ridge (Fig. 7). In close proximity to this tract to the west is the fifth largest interior forest tract (217 acres [88 ha]) on the Research Park (Fig. 8). Combined these two areas provide more than 650 acres (263 ha) of interior forest habitat. Eighteen species of interior forest birds are known to frequent this area (Table 2). Of particular significance in this area are historic records of cerulean warbler (*Setophaga cerulea*), a species on the Tennessee In Need of Management list and one that is considered to be declining faster than any other eastern songbird (http://www.tnwatchablewildlife.org/birds.cfm).

Equal in size to the smaller interior forest tract (217 acres [88 ha]) on Black Oak Ridge is an area on Haw Ridge (Fig. 9). Fifteen species of interior forest birds are known to frequent this area (Table 2).

Table 1. Oak Ridge Research Park area-sensitive forest bird species

Common Name	Scientific Name	Known Breeder	Possible Breeder
Red-shouldered Hawk[1,3]	*Buteo lineatus*	X	
Barred Owl[3]	*Strix varia*	X	
Whip-poor-will[1,2]	*Caprimulgus vociferus*	X	
Pileated Woodpecker[3]	*Dryocopus pileatus*	X	
Acadian Flycatcher[1,2]	*Empidonax virescens*	X	
Wood Thrush[1,2]	*Hylocichla mustelina*	X	
Red-eyed Vireo[2]	*Vireo olivaceus*	X	
Yellow-throated Vireo[1,2]	*Vireo flavifrons*	X	
Blue-gray Gnatcatcher[2]	*Polioptila caerulea*	X	
Ovenbird[2]	*Seiurus aurocapilla*	X	
Northern Parula[2]	*Setophaga americana*	X	
Cerulean Warbler[1,2,4]	*Setophaga cerulea*		X
Worm-eating Warbler[1,2]	*Helmitheros vermivorum*	X	
Kentucky Warbler[1,2]	*Geothlypis formosa*	X	
Black-and-white Warbler[1,2]	*Mniotilta varia*		X
Louisiana Waterthrush[1,2]	*Parkesia motacilla*		X
Yellow-throated Warbler[1,2]	*Setophaga dominica*	X	
Hooded Warbler[1,2]	*Setophaga citrina*	X	
Prothonotary Warbler[1,2]	*Protonotaria citrea*	X	
Summer Tanager[1,2]	*Piranga rubra*	X	
Scarlet Tanager[1,2]	*Piranga olivacea*	X	

[1]Designated by Partners in Flight to be of Regional Importance (2010).
[2]Neotropical migrant.
[3]Permanent resident.
[4]On state of Tennessee In Need of Management list.

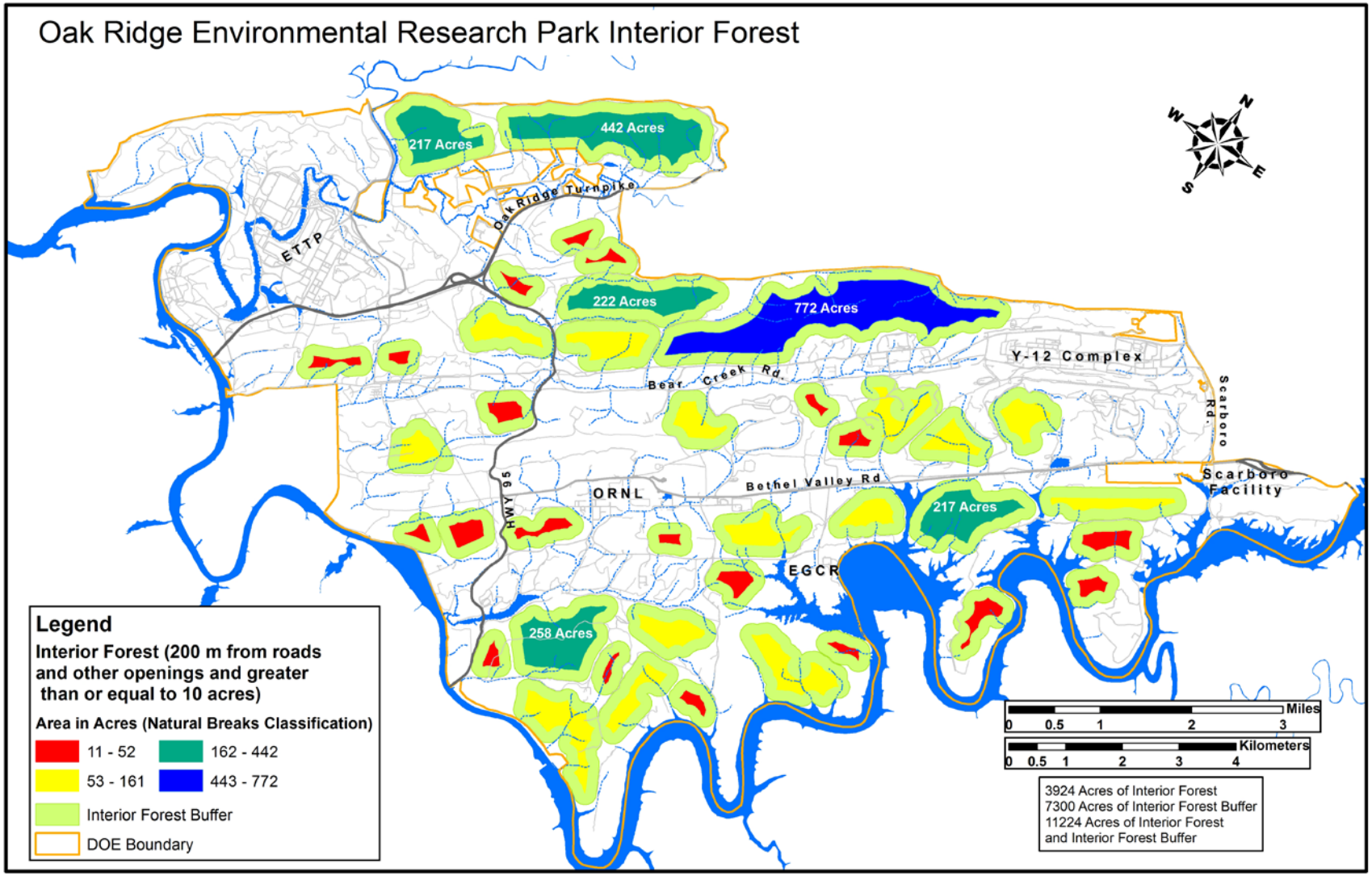


Fig. 4. Oak Ridge Research Park interior forest areas by acreage category.

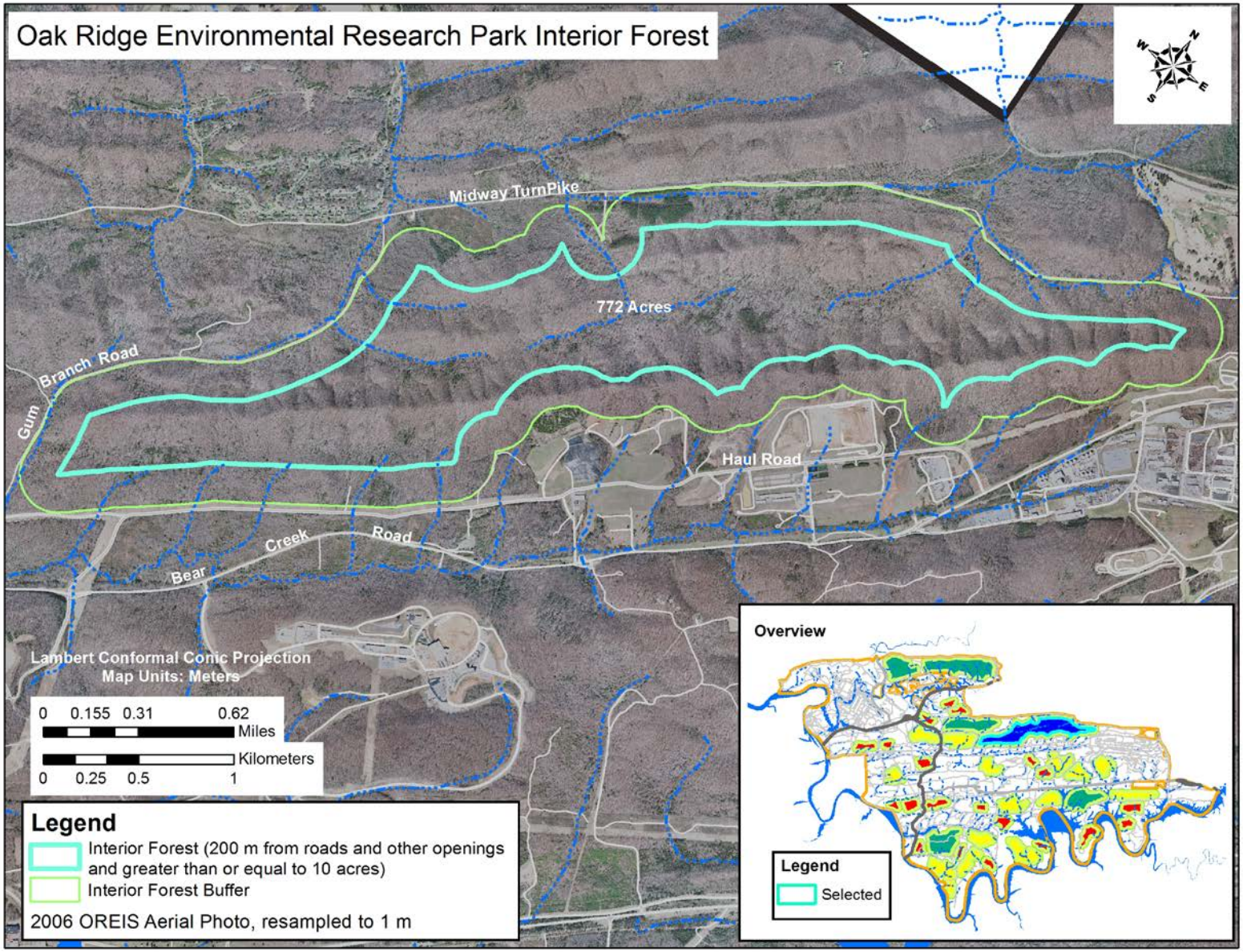


Fig. 5. Interior forest area on Pine Ridge, Oak Ridge Research Park.

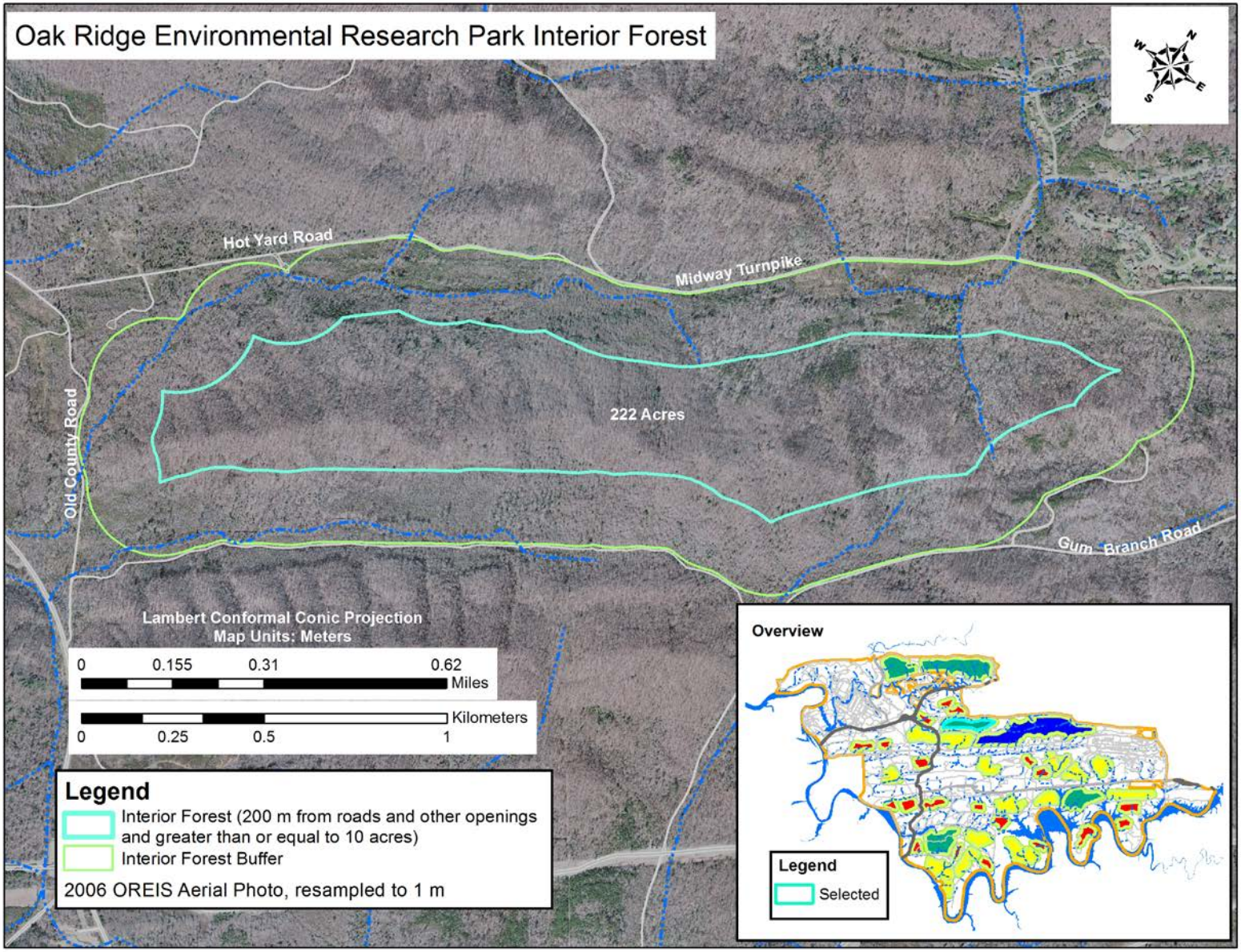


Fig. 6. Interior forest area on Pine Ridge (west), Oak Ridge Research Park.

Table 2. Interior forest bird species recorded during PIF surveys in areas of larger interior forest tracts on the Oak Ridge Research Park

Common Name	Scientific Name	Pine Ridge[1] (994 acres [403 ha])	Black Oak Ridge[2] (659 acres [267 ha])	Haw Ridge[3] (217 acres [88 ha])
Red-shouldered Hawk	*Buteo lineatus*		X	
Barred Owl	*Strix varia*			
Whip-poor-will	*Caprimulgus vociferus*			
Pileated Woodpecker	*Dryocopus pileatus*	X	X	X
Acadian Flycatcher	*Empidonax virescens*	X	X	X
Wood Thrush	*Hylocichla mustelina*	X	X	X
Red-eyed Vireo	*Vireo olivaceus*	X	X	X
Yellow-throated Vireo	*Vireo flavifrons*	X	X	X
Blue-gray Gnatcatcher	*Polioptila caerulea*	X	X	X
Ovenbird	*Seiurus aurocapilla*	X	X	X
Northern Parula	*Setophaga americana*	X	X	X
Cerulean Warbler	*Setophaga cerulea*		X	
Worm-eating Warbler	*Helmitheros vermivorum*	X	X	X
Kentucky Warbler	*Geothlypis formosa*	X	X	X
Black-and-white Warbler	*Mniotilta varia*			
Louisiana Waterthrush	*Parkesia motacilla*	X	X	X
Yellow-throated Warbler	*Setophaga dominica*	X	X	X
Hooded Warbler	*Setophaga citrina*	X	X	X
Prothonotary Warbler	*Protonotaria citrea*		X	
Summer Tanager	*Piranga rubra*	X	X	X
Scarlet Tanager	*Piranga olivacea*	X	X	X
	TOTAL SPECIES	**15**	**18**	**15**

[1]Data from 1995–2012 McNew Hollow Road PIF Route.
[2]Data from 1995–2012 East Fork Poplar Creek PIF Route.
[3]Data from 1995–2012 Gallaher Bend PIF Route.

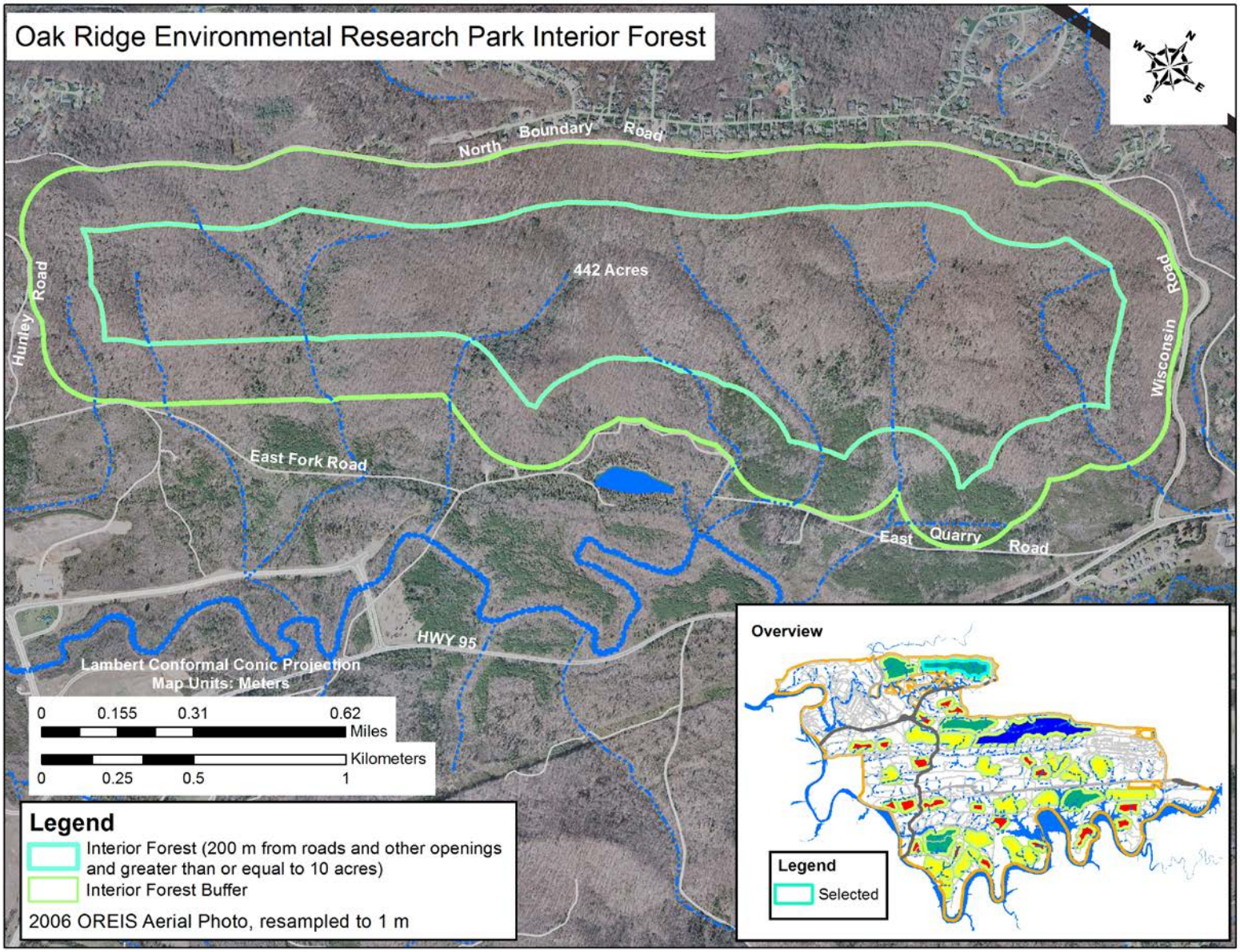


Fig. 7. Interior forest area on Black Oak Ridge, Oak Ridge Research Park.

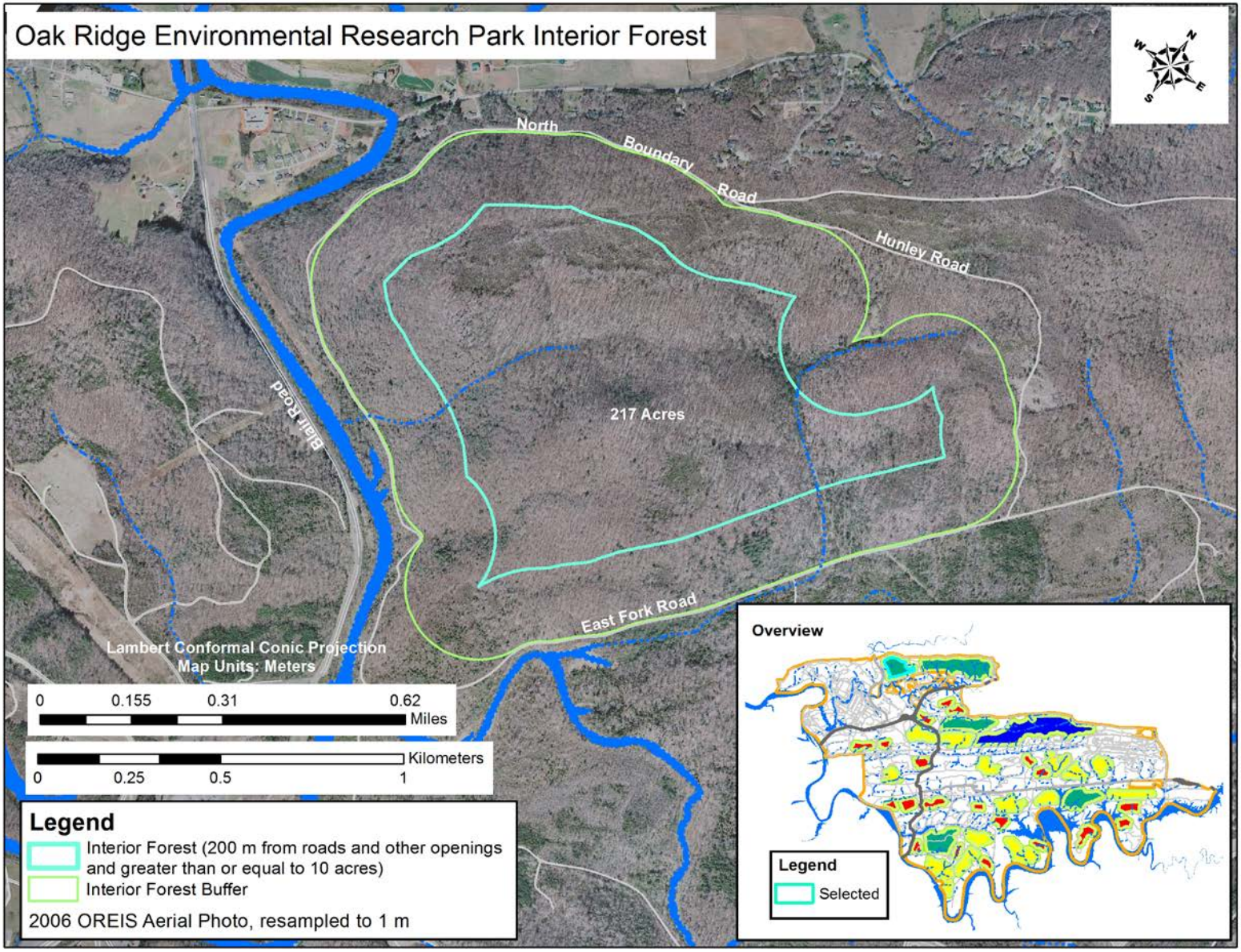


Fig. 8. Interior forest area on Black Oak Ridge (west), Oak Ridge Research Park.

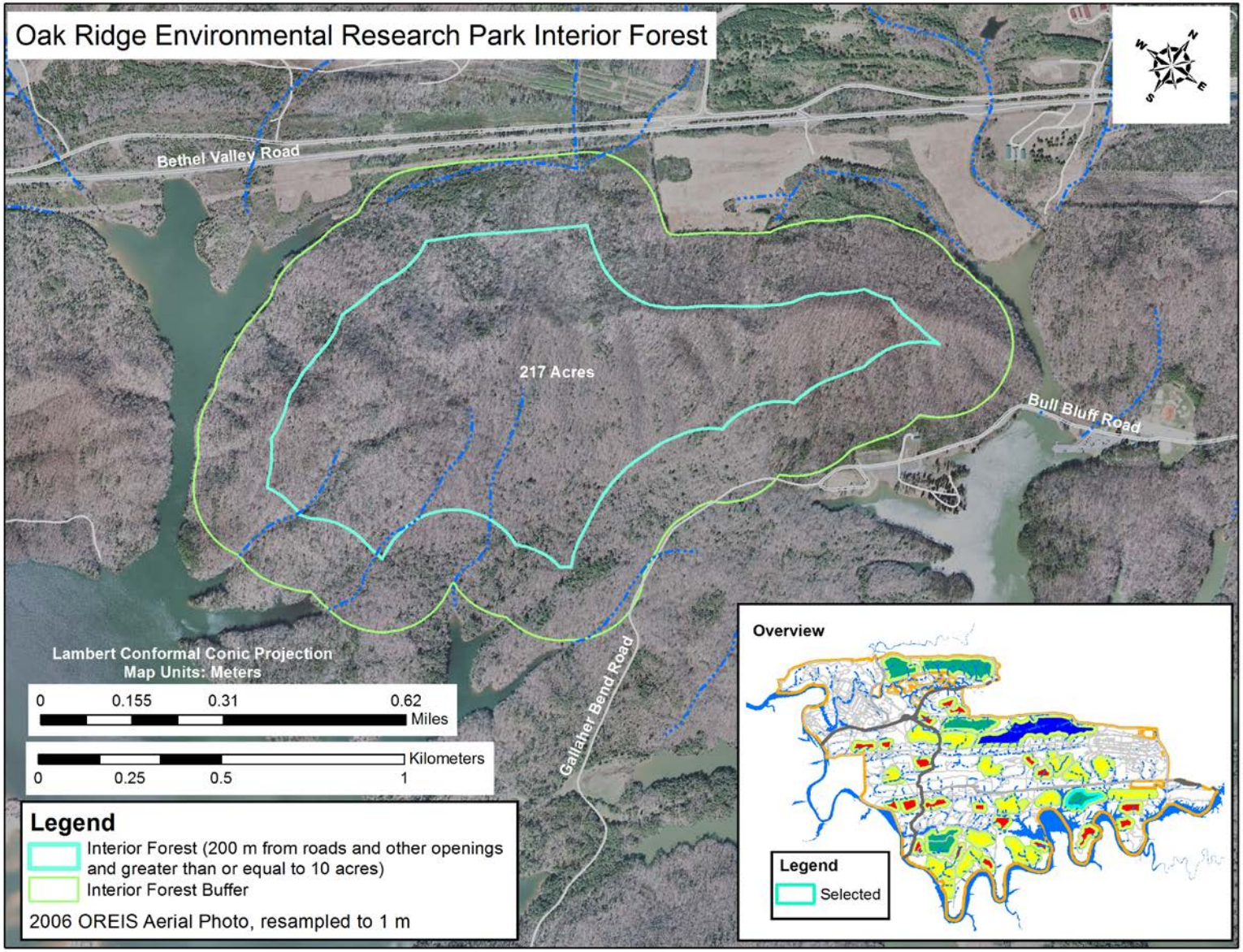


Fig. 9. Interior forest area on Haw Ridge, Oak Ridge Research Park.

The probability of occurrence in different size forest tracts can vary, even among different neotropical migrant species known to inhabit the Research Park (Tables 1 and 2). For example, one study found that for forest tracts in the 24.7–74.1 acre (10–30 ha) range, red-eyed vireos and wood thrushes were more likely to be seen than scarlet tanagers and ovenbirds. In addition, northern parulas and Kentucky warblers were rarely encountered in forest tracts less than 247 acres (100 ha) in size. Furthermore, blue-gray gnatcatchers, northern parulas, cerulean warblers, and Louisiana waterthrushes were found to exhibit a low probability of occurrence even in forests of more than 7410 acres (3000 ha) (Robbins, Dawson, and Dowell 1989).

Certain permanent resident species follow similar patterns of occurrence to neotropical migrant species. For instance, pileated woodpeckers have a maximum probability of occurrence in larger forest tracts (Robbins, Dawson, and Dowell 1989), and red-shouldered hawks may require at least 247 acres (100 ha) of contiguous forest to maintain viable breeding populations (Robbins 1979). These findings underline the importance of preserving larger forest tracts in order to maintain populations of certain species. This is of particular significance for neotropical migrants on their breeding grounds because research has shown that area-sensitivity on wintering areas may be less significant where such species have been recorded with equal abundance in small isolated and large forests (Robbins et al. 1987).

A number of factors contribute to the fact that smaller forests may not be suitable for certain bird species. These factors may include absence of certain microhabitats required by a particular species and proximity to the forest edge. Greater proximity to edge areas can result in high predation rates and lower fledging success (Gates and Gysel 1978), which can be especially damaging to single-brooded neotropical species. Avian predators (e.g., American crow, blue jay) may be more common along forest edges than in forest interiors (Robbins 1980). A number of area-sensitive species known on the Research Park (e.g., black-and-white warbler, worm-eating warbler, ovenbird, Louisiana waterthrush, Kentucky warbler) are ground nesters, making them more susceptible to predation than aboveground or cavity nesters (Wilcove 1985). Brittingham and Temple (1983) found that nest parasitism by brown-headed cowbirds decreased with increasing distance from edge areas, but extended at least 300 m into the forest. Gates and Gysel (1978) also observed cowbird parasitism to be higher near edges and seldom observed cowbirds in forest interiors, indicating that cowbirds may find it difficult to locate nests in habitats where views of nests are obscured by dense foliage. Because cowbird breeding occurs around the time that neotropical species are nesting, these birds are especially vulnerable to parasitism. Furthermore, short-term residency on breeding grounds gives neotropical migrants less time to achieve breeding success than short-distance migrants and resident species. Research Park neotropical migrant bird species known to be susceptible to brown-headed cowbird nest parasitism with reductions in forest cover include red-eyed vireo, wood thrush, Acadian flycatcher, worm-eating warbler, ovenbird, and Kentucky warbler. Similar results for nest predation have been shown for these same species as well as the scarlet tanager (Robinson et al. 1995).

A previous study conducted on the ORR found that ovenbirds and Acadian flycatchers appeared to be negatively affected by edges, and Kentucky and worm-eating warblers were less abundant near edges. Interestingly, and in contrast with certain other studies, blue-gray gnatcatchers, wood thrushes, and scarlet tanagers did not indicate a negative response to edges. It was hypothesized that responses to forest fragmentation for these three species may depend primarily on forest island size, island isolation, and factors other than edge effects (Kroodsma 1984).

The draft *Forest Management Plan for the Department of Energy Oak Ridge Reservation: An Interdisciplinary Approach for Managing a Heritage Resource* (Parr, Byrd, and Johnston 2012) considers the preservation of existing interior forested areas a priority. It also recognizes the need to evaluate existing interior forested areas and adjacent ones to determine whether the factors causing fragmentation can be eliminated or mitigated so that the forest block can be increased. The goal is the preservation of viable populations of neotropical migrant bird populations on their breeding grounds. Research has

clearly shown that the fragmentation of forested areas into smaller, more isolated tracts can increase nest parasitism and predation, while also significantly decreasing the probability that microhabitats critical to species survival remain in a particular area. Preserving forest acreage at levels that support only a few pairs of a particular species does not reach the goal of species population viability. Robbins, Dawson, and Dowell (1989) suggest that a minimum forested area of 7410 acres (3000 ha) may be required to retain all species of forest-breeding birds in the Middle Atlantic States. Comparisons with bird and habitat data from other areas of the country, including Tennessee, have concluded that habitat requirements of a particular species apply throughout its breeding range (Noon et al. 1980).

Executive Order 13186 (*Responsibilities of Federal Agencies to Protect Migratory Birds*) requires federal agencies to avoid or minimize the negative impacts of their actions on migratory birds. Agencies must actively protect birds and their surroundings by, for example, restoring and enhancing habitat, preventing or abating pollution effecting birds, and incorporating migratory bird conservation into agency planning processes. The executive order requires each agency to develop a Memorandum of Understanding (MOU) with the US Fish and Wildlife Service (USFWS) to promote the conservation of migratory bird populations. The DOE MOU commits the department to cooperate with the USFWS to "substantially contribute to the conservation and management of migratory birds and their habitats." The preservation of large contiguous tracts of interior forest by effectively mitigating potential impacts associated with fragmentation through careful road placement, minimizing road widenings, and allowing the forest canopy to close over existing roads where possible is an integral part of meeting this commitment for the DOE ORR.

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