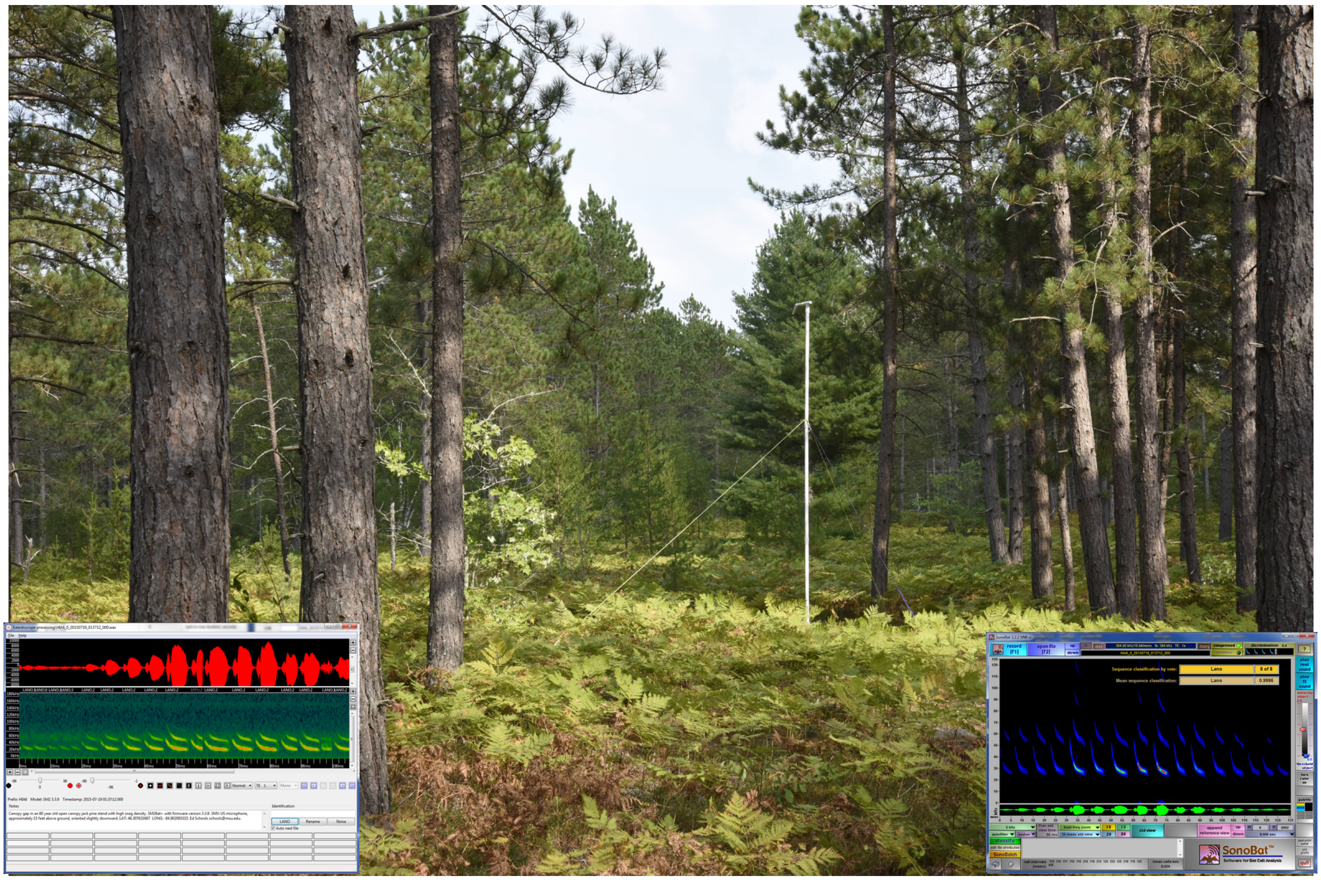
Acoustic Monitoring for Northern Long-eared Bat On the Hiawatha National Forest



Prepared By:

Edward H. Schools and Brian J. Klatt
Michigan Natural Features Inventory
Michigan State University Extension
P.O. Box 30444
Lansing, MI 48909-7944

Prepared For:

Hiawatha National Forest

December 23, 2015

MNFI Report Number 2015-28

Michigan Natural Features Inventory
Discover. Define. Deliver.

MICHIGAN STATE UNIVERSITY | Extension

Suggested Citation:

Schools, E.H., and B.J.Klatt. 2015. Acoustic Monitoring for Northern Long-eared Bat on the Hiawatha National Forest. Michigan Natural Features Inventory, Report Number 2015-28, Lansing, MI. Copyright 2015

Table of Contents

List of Tables

Photo Credits: Edward H. Schools, MSU Extension, Michigan Natural Features Inventory.

Abstract

The US Fish and Wildlife Service has recently designated the Northern long-eared bat (*Myotis septentrionalis*) as threatened and promulgated an interim 4(d) rule with respect to activities that may affect this species. The listing and rule has the potential to affect forestry operations on both private and public lands. In order to better understand and conserve this species, while at the same time continuing use of the national forests, the US Forest Service contracted with the Michigan Natural Features Inventory (MNFI) of Michigan State University Extension to examine the distribution of this species in the Hiawatha National Forest (HNF). MNFI used acoustic monitors to determine the presence of *M. septentrionalis* at sites on the Hiawatha National Forest. The acoustic monitors were placed at ten locations, in different forest treatments, during both the summer roosting season and the post summer roosting season. Our results showed substantially more *M. septentrionalis* activity at the sites in the Western Unit of the Hiawatha National Forest than the sites on the Eastern Unit.

Background and Purpose

Bats are thought to serve a crucial role with respect to ecosystem services by reducing pest populations, especially in agricultural systems where they feed extensively on Coleopterans and Lepidopterans. The magnitude of their exact role remains unclear, but Maine and Boyles (2015) reported that bats can reduce crop damage to corn by 60%; potentially saving corn farmers over $1 billion on an annual basis worldwide and $23 billion per year across all crops worldwide. It is probable that they also play a significant role in reducing pest populations in other systems, such as forests, though this has not been measured.

Being crepuscular/nocturnal, bats have been studied less by biologists, relative to other taxa, largely due to the difficulty in studying them. However, as a group they have been receiving increased attention in research circles for two reasons. First, it has been found that they suffer significant levels of mortality due to interactions with wind farms (National Academy of Sciences 2007, Strickland et al. 2011). Indeed, it is now estimated that more bats are killed annually at wind farms than birds, 600,000 vs. 500,000 (Hayes 2013). Second, a fungus, *Pseudogymnoascus destructans (White Nose Syndrom (WNS)),* introduced to North America from Europe has caused massive die-offs among the cave-hibernating bats. Effective control measures to stop the spread of this fungus do not yet exist.

In April of 2015, The US Fish and Wildlife Service listed the Northern Long-eared Bat (*Myotis septentrionalis* as a threatened species under Rule 4(d) of the Endangered Species Act, (USFWSa 2015) due to the high mortality rates due to WNS and lack of an effective control. This listing has the potential to impact Hiawatha National Forest management decisions. The bulk of *M. septentrionalis* data come from winter surveys (USFWSa 2015), necessitating the need for better information about *M. septentrionalis* summer habitat preferences. As overall population levels of this species continue to decline, local populations, and the resources they depend on, such as maternity roost trees will become increasingly important The purpose of this project was to determine the presence of *M. septentrionalis* (or MYSE) in areas of different management regimes on the Hiawatha National Forest using acoustic monitoring techniques. A better understanding of the distribution of Northern Long-eared Bats on the landscape, should allow forestry practices to continue, while at the same time, help conserve this species.

Procedure

The scope of this project was limited to acoustic monitoring. Live-capture techniques and detailed measures of habitat parameters were beyond the project scope. While limited in scope, the results of this project can provide a basis for further, more detailed and exhaustive work.

Management Regime and Monitor Locations

Monitors were deployed in ten locations, five on the HNF East Unit and five on the HNF West Unit, with management areas designated by HNF personnel. Table 1 gives the latitude and longitude of each monitor and attributes taken from the HNF forest stand descriptions. While all of the areas are subject to management and therefore are not natural communities per se, Table 1 also indicates what natural community the area most resembles. Figures 1 and 2 show the monitor locations. Aerial photos of each monitoring site at two spatial scales, 1:1200 and 1:10,000, can be found in Appendix I. Photographs of each monitoring site can be found in Appendix II.

General site descriptions

HIA1 was located at the junction of two linear corridors through red pine plantations. While there appears to be little in the way of *M. septentrionalis* roosting habitat, the understory is relative free from clutter and provides good foraging habitat and the corridors connect areas that could be foraging or roosting habitat. Four *M. septentrionalis* were live captured at this site in the summer of 2012 (Gehring and Klatt 2012).

HIA2 was located in an area that was treated for beech bark disease. The vegetation at this site resembles the mesic northern forest MNFI natural community type. The area contained canopy openings and a number of dead trees with exfoliating bark. There is also a lake approximately 275 meters from the monitoring site.

HIA3 was located by a road through a stand with few dead trees. The vegetation at this site resembles the mesic to dry-mesic northern forest MNFI natural community types. There are some canopy openings in the vicinity of the monitor. Additionally, there is an open stream corridor approximately 200 meters north of the monitor site, and an open area approximately 200 meters east of the site.

HIA4 is located close to a road, immediately adjacent to a tree with a blown out top as well as other standing snags. The vegetation at this site resembles the mesic to dry-mesic northern forest MNFI natural community types. There is an open wetland area approximately 150 meters to the west and a lake approximately 200 meters to the west.

HIA5 is within a power line corridor that connects a runway to the south with open residential areas to the north. The adjoining forest stands may have some roosting cavities, but there does not appear to be a large number of trees with defoliating bark. The vegetation of the adjoining forest stands resembles the mesic northern forest MNFI natural community type.

HIA6 is located in an 80 year old open canopy jack pine forest. The vegetation at this site resembles the dry northern forest MNFI natural community type. There is a high density of snags in the immediate area. In addition to the open canopy system, there is a large Muskeg approximately 400 meters to the west and open areas to the east of the monitor location.

HIA7 is located along a road through a 50 year old red pine stand. The vegetation at this site resembles the dry northern forest MNFI natural community type. The red pine stand has a low snag density.

While the canopy of the immediate stand is relatively closed, there are canopy gaps approximately 50 meters to the northeast and a large open area 75 meters to the west.

HIA8 is along a road through a 50 year old closed canopy jack pine stand. The vegetation at this site resembles the dry northern forest MNFI natural community type. The closed canopy extends further around HIA8. The nearest large openings are approximately 200 meters to the south and approximately 250 meters to the east.

HIA9 is located in a canopy gap within an open canopy pine/oak/aspen stand. The stand has a moderate snag density. The vegetation at this site resembles the dry northern forest MNFI natural community type.

HIA10 is located in a canopy gap within an open canopy 60 year old red pine stand. The stand has a low snag density. The nearest large open area is approximately 400 meters to the west. The vegetation at this site resembles the dry northern forest MNFI natural community type.

Monitor descriptions

The acoustic monitors consisted of Wildlife Acoustics SM2Bat+ monitors and SM-UX microphones with foam windscreens. Microphones were placed approximately 15 feet above ground level and were oriented slightly downward to protect the microphones from precipitation. At sites where there was an obvious flight corridor, microphones were oriented parallel to the flight path. Monitors were in place for approximately ten consecutive days during the summer residence period, May 15 – August 15, as defined by the U.S. Fish and Wildlife Service Range Wide Indiana Bat Summer Survey Guideline (USFWSb 2015). Monitors were also put in place for ten days after the summer residence time period, when migrating species are assumed to be leaving for hibernacula or the southern area of the U.S in the case of the “tree bats”. For the summer residency monitoring period, monitors were jointly deployed by MNFI and USFS personnel and then retrieved and data downloaded by USFS personnel. USFS personnel redeployed the monitors for the post residency period and the monitors were retrieved by MNFI personnel. All data processing was performed by MNFI personnel.

Acoustic analysis

Acoustic data were analyzed using the automatic classification routine of Wildlife Acoustics’ Kaleidoscope software, version 3.1.2. Kaleidoscope is approved by the US FWS for automatic identification of bat calls. A subset of summer residence calls were also manually vetted and/or tested with Sonobat acoustic software to provide additional verification of species’ presence.

Results

While the focus of the study was the Northern long-eared bat, results for all species are presented. The four letter code used for each species is presented in table 2, along with the scientific name and the common name. Results for both the summer residency period, and the post residency period, are presented in Tables 3 through 6. The counts presented are for bat passes recorded at each monitor. The number of passes should not be confused with the number of bats present at a site. Table 7 presents the number of *M. septentrionalis* passes and the number of days that *M. septentrionalis* were recorded at each site. The more days a *M. septentrionalis* is detected at a site, the less likely the recordings are a result of transitory bats and increased evidence of bat residency.

The results of the acoustic monitoring show Northern long-eared bats present at three of the five East

Table 1. Site Lat/Long positions, forest stand descriptions, and MNFI natural community types.

	LATITUDE	LONGITUDE	STAND_CO_2	EV_NAME	SITE_INDEX	MNFI Natural Community
HIA1	46.04665	-86.77601	Inadequately stocked/Non-stocked	Open	ULAM	Pine plantation
HIA2	46.12433	-86.45945	Mature sawtimber	Sugar maple-beech/yellow birch	ACSA3	Mesic northern forest
HIA3	46.21713	-86.39580	Immature pole timber	Red pine	PIRE	Mesic to dry-mesic northern forest
HIA4	46.30997	-86.66086	Two-aged management	Eastern white pine-hemlock	PIST	mesic to dry-mesic northern Forest
HIA5	46.37099	-86.61675	Sparse sawtimber	Sugar maple-beech/yellow birch	ACSA3	Mesic northern forest
HIA6	46.30763	-84.90209	Forest pest infestation	Jack pine	PIBA2	Dry northern forest
HIA7	46.25060	-84.93090	Sparse pole timber	Red pine	PIRE	Dry northern forest
HIA8	46.24355	-84.89054	Sparse pole timber	Jack pine	PIBA2	Dry northern forest
HIA9	46.36971	-84.84346	Inadequately stocked/Non-stocked	Open	QURU	Dry northern forest
HIA10	46.39350	-84.72780	Mature sawtimber	Red pine	PIRE	Dry northern forest

Table 2. Bat species alpha codes

Alpha code	Scientific name	Common name
EPFU	Eptesicus fuscus	Big brown bat
LABO	Lasiurus borealis	Eastern red bat
LACI	Lasiurus cinereus	Hoary bat
LANO	Lasionycteris noctivagans	Silver-haired bat
MYLU	Myotis lucifugus	Little brown bat
MYSE	Myotis septentrionalis	Northern long-eared bat
PESU	Perimyotis subflavus	Tricolored bat

Figure1. General locations of the West Unit Monitors

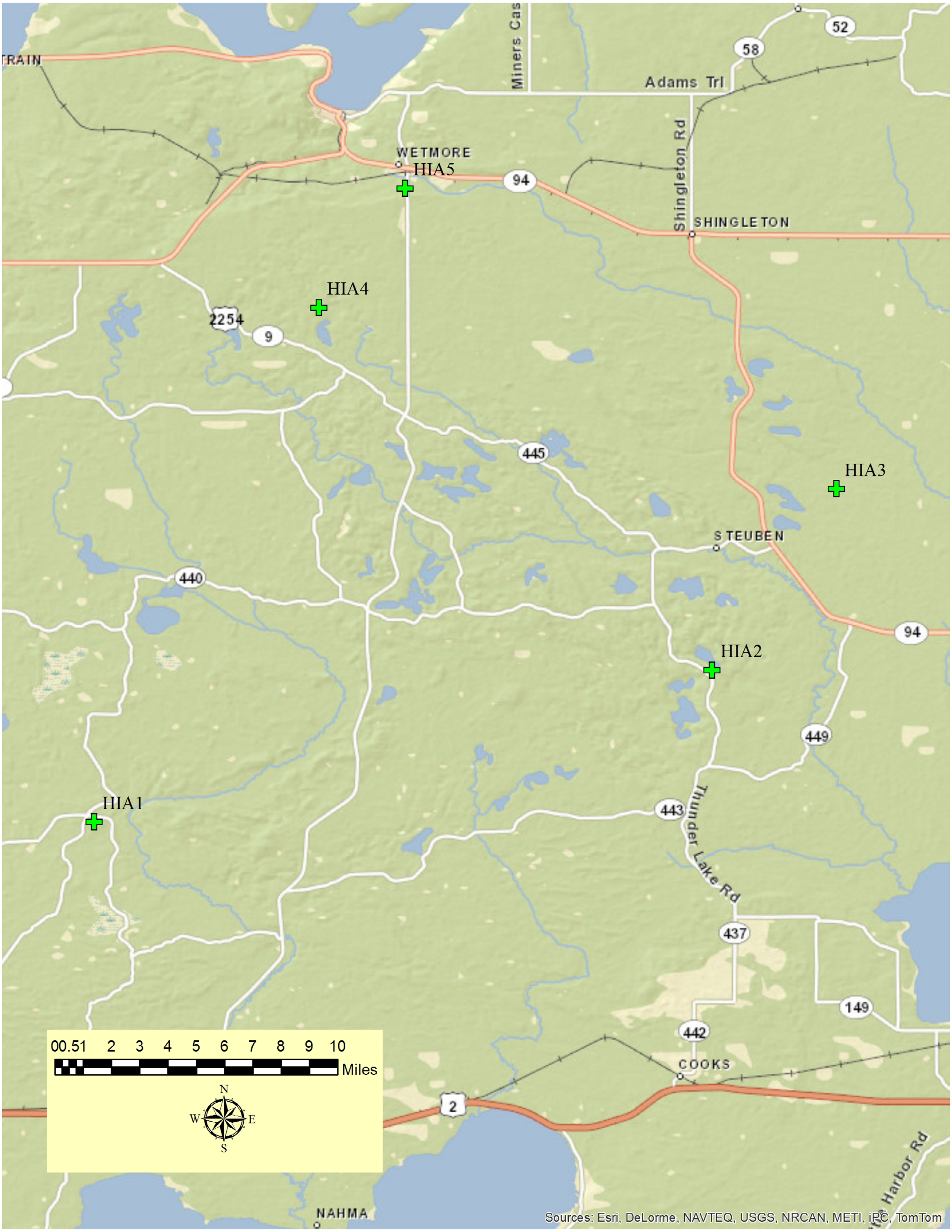
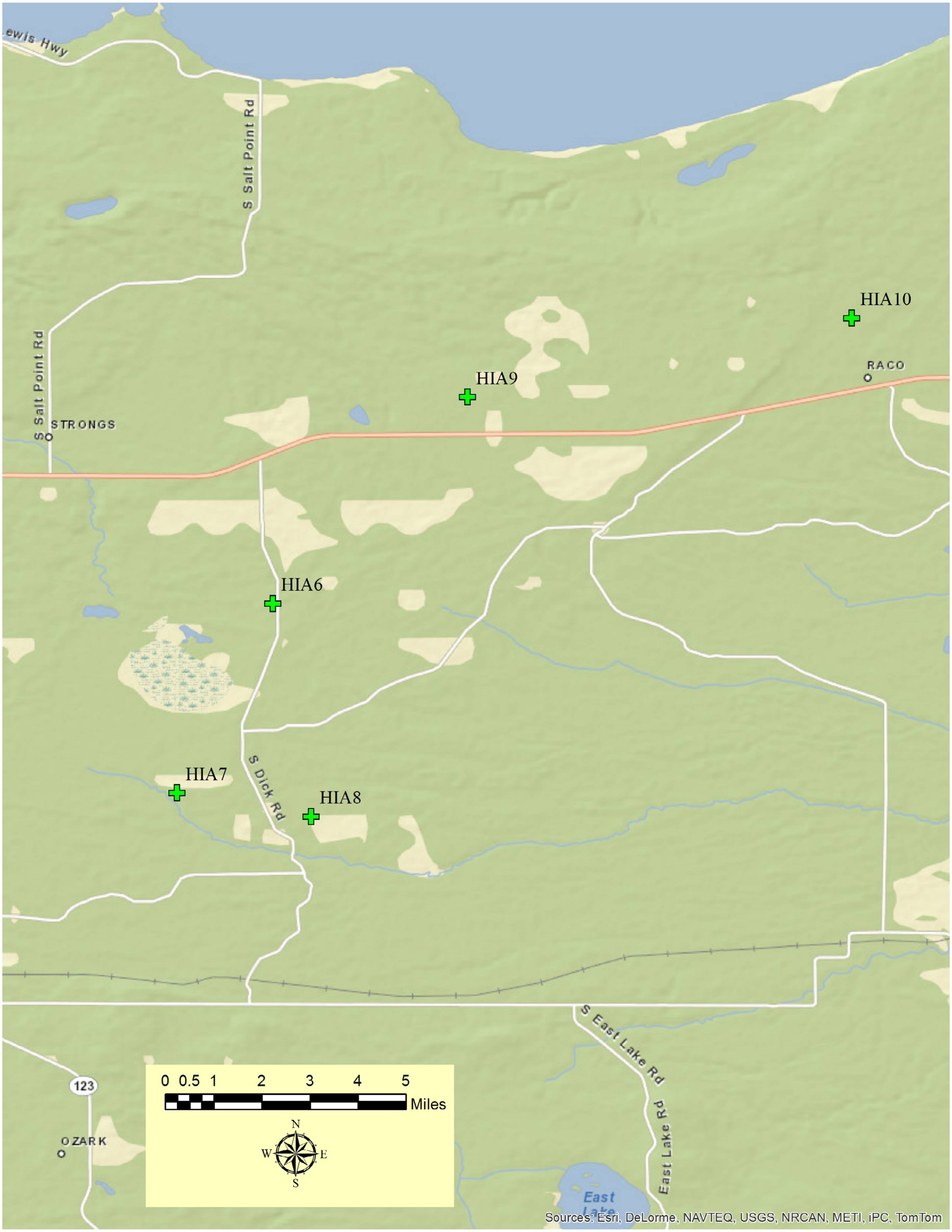


Figure2. General locations of the East Unit Monitors



Unit sites and all five of the West Unit sites. In terms of number of passes, all the West Unit sites had a greater number of *M. septentrionalis* passes. In particular, Sites HIA1, and HIA2 had the greatest number of *M. septentrionalis* passes and the greatest number of total bat passes during the summer residency period. As expected, the number of recorded bat passes for all species dropped off after the summer roosting season.

Discussion

The general consensus in the literature is that *M. septentrionalis* is an understory clutter specialist, preferring relatively closed canopy areas for both roosting and foraging, over more open canopy areas. *M. septentrionalis* foraging tends to occur in forest understory or close to forest edges. Brack and Whitaker (2001) report that most *M. septentrionalis* foraging occurs in the understory of non-riparian habitat while Henderson and Broders (2008) report that *M. septentrionalis* tend to forage in densely forested areas, but close to forested creeks, and not more than 78 meters outside of a forest edge. Hogberg, et al (2002) reported that *M. septentrionalis* were most active in post-harvest residual forest patches and along the edges of forest blocks and least active in the center of forest cuts. Owen et al (2003) found that partial timber harvests leaving a relatively closed canopy appear to promote or improve *M. septentrionalis* foraging habitat. This affinity for forests and forest edges, as opposed to open areas, is also consistent with findings of Klatt and Gehring (2013) who found that cave-hibernating species demonstrated a much higher affinity for forests and forest edge than for open agricultural areas.

M. septentrionalis roosting requirements are variable depending on gender, reproductive stage, tree type, snag condition, and geographic region. In general, *M. septentrionalis* appears to favor older forested areas with larger trees, a variety of snags with exfoliating bark or cavities, high canopy cover, and a stand canopy closure of 75% or more (Owen et al 2002, Parc 2010, Sasse 1995, Sasse and Pekins 2006, Jung et al 2004, Lacki and Schwierjohann 2001, Laci et al 2009, Ford et al 2006, Foster and Kurta 1999). *M. septentrionalis* will move between roost sites during the summer residence period. Foster and Kurta (1999) report that *M. septentrionalis* change roosts every two days, with the distance between roosts varying between 6 and 2,000 meters while Sasse (1995) reported that bats tend to use a network of trees in close proximity to each other.

Our results during the summer roosting period for the East and West Units show generally more bat activity for all bat species on the West Unit versus the East Unit. All of the monitoring sites on the West Unit detected more *M. septentrionalis* passes than the East Unit monitoring sites during the summer residence period. A qualitative examination of the aerial photographs in Appendix I shows that the sites on the West Unit tended to have a more closed canopy structure than the sites of the East unit.

Site HIA1, located at the junction of two forest roads, had more than twice as many recorded *M. septentrionalis* passes as any other site, and two orders of magnitude more that any East Unit site. The forest blocks surrounding site HIA1 appear to be an even age red pine monoculture. According to the literature, this type of forest is not expected to be ideal *M. septentrionalis* roosting habitat, but it does fit the criteria for foraging habitat. In addition, Owen et al (2003) reported that *M. septentrionalis* used forest road corridors more than expected based on the availability of the corridors in the study

Table 3. West Unit summer residency results

Site	HIA1		HIA2		HIA3		HIA4		HIA5	
MNFI community	Pine plantation		Mesic northern forest		Mesic to dry-mesic northern forest		Mesic to dry-mesic northern forest		Mesic northern forest	
Site_Index	ULAM		ACSA3		PIRE		PIST		ACSA3	
	# passes	vetted	# passes	vetted	# passes	vetted	# passes	vetted	# passes	vetted
EPFU	10	X	48	X	189	X	1		10	
LABO	309	X	28	X	46	X	3	X	61	X
LACI	27	X	369	X	27	X	11			
LANO	76	X	72	X	97	X	10	X	75	X
MYLU	313	X	315	X	173	X	12	X	138	X
MYSE	193	X	75	X	62	X	9		21	X
PESU	4		0		4	X	0			
NoID	36		69		31		13		71	
Total bat passes	968		976		629		59		376	

Table 4. East Unit summer residency results

Site	HIA6		HIA7		HIA8		HIA9		HIA10	
MNFI community	Dry northern forest		Dry northern forest		Dry northern forest		Dry northern forest		Dry northern forest	
Site_Index	PIBA2		PIRE		PIBA2		QURU		PIRE	
	# passes	vetted	# passes	vetted	# passes	vetted	# passes	vetted	# passes	vetted
EPFU	35	X	20		36	X	20		6	
LABO	0		3	X	31	X	36	X	7	X
LACI	5	X	46	X	5	X	11	X	15	X
LANO	172	X	102	X	427	X	256	X	199	X
MYLU	19	X	2	X	8	X	7	X	1	
MYSE	3		0		2		1	X	0	
PESU	0		0		1		2		0	
NoID	4		4		10		14		10	
Total bat passes	238		177		520		347		238	

Table 5. West Unit post summer residency results.					
	HIA1	HIA2	HIA3	HIA4	HIA5
EPFU	1	36	16	0	3
LABO	96	117	58	2	118
LACI	0	14	9	5	0
LANO	41	149	48	8	42
MYLU	52	225	51	4	50
MYSE	12	19	34	3	14
PESU	2	2	2	0	2
NoID	6	43	17	6	11
Total bat passes	210	605	235	28	240

Table 6. East Unit post summer residency results.					
	HIA6	**HIA7**	**HIA8**	**HIA9**	**HIA10**
EPFU	7	5	5	5	4
LABO	9	50	216	17	142
LACI	4	16	5	11	10
LANO	44	43	49	44	66
MYLU	2	6	18	2	14
MYSE			3	1	1
PESU			3		2
NoID	1	12	41	5	2
Total bat passes	67	132	340	85	241

Table 7. Total nunber of MYSE passes and the number of days a pass was recorded.				
	Summer roosting period		**Post summer roosting period**	
	# Passes	**# nights**	**# Passes**	**# nights**
HIA1	193	12	12	7
HIA2	75	11	19	9
HIA3	62	9	34	9
HIA4	9	5	3	3
HIA5	21	7	14	8
HIA6	3	3	0	0
HIA7	0	0	0	0
HIA8	2	2	3	3
HIA9	1	1	1	1
HIA10	0	0	1	1

area. Given the limitations of the data collection methodology, we can only determine that *M. septentrionalis* was present at the site. We cannot determine site use, whether roosting, foraging, or simply commuting through the area.

Site HIA2, the site with the second highest number of recorded *M. septentrionalis* passes, was located in an area managed for beech bark disease. Presence of *M. septentrionalis* at this site is not unexpected. Visual examination of the area showed a number of dead beech trees with exfoliating bark, making ideal bat roosting habitat. There also appears to be sufficient canopy closure in the area.

The remaining sites on the West Unit, HIA3, HIA4, and HIA5, all had *M. septentrionalis* activity on multiple days. Sites HIA3 and HIA4 had snags and dead trees in the vicinity as well as partially closed canopy. These sites appear to be appropriate for both roosting and foraging activity. No snags or dead trees were immediately apparent in the vicinity of HIA5. The canopy closure in the vicinity of HIA5 appears appropriate for *M. septentrionalis* foraging habitat and the power line corridor could be utilized for commuting.

Access to water features may also explain some of the differences in detected bat passes between the East and West Units. On the East Unit, four of the five monitoring sites were a kilometer or more from a stream or lake. On the West Unit, all monitoring sites were less than 650 meters from a lake or stream. Table 8 shows the distance to a water feature, defined here as a lake or stream.

Table 8. Distance to water features

Site	Distance (meters)
HIA1	643
HIA2	255
HIA3	214
HIA4	224
HIA5	624
HIA6	1303
HIA7	247
HIA8	1002
HIA9	1779
HIA10	3161

Conclusion

There is an order of magnitude difference in the number of detected *M. septentrionalis* passes between the East and West Units for the summer residence period. The East Unit had a total of six identified *M. septentrionalis* passes with two of the sites having no identified passes. In comparison, all West Unit sites had identified *M. septentrionalis* passes, and the lowest West Unit site count is higher than the combine counts of the all the West Unit counts.

Further on-site work is required to determine if the results are a function of landform, habitat structure, access to water, presence of karst, monitor placement or some combination of these factors. Gehring and Klatt (2012), who conducted mist-netting in the Hiawatha National Forest in some of the same sites as this study, found *M. septentrionalis* in Dry-mesic Northern Forest, Mesic Northern Forest, and pine plantation, but did not capture any *M. septentrionalis* in Poor Conifer Swamp. Thus, both this study and that of Gehring and Klatt (2012) indicate that *M. septentrionalis* occurs in a fairly broad range of forest types, but that the immediate presence of water does not seem to be dominant factor. Additionally, these results are also in agreement with acoustic monitoring conducted in 2014 (Schools, et al. 2014) which found the highest levels of *M. septentrionalis* activity in forested areas associated with karst features and with minimal understory clutter, i.e. forest areas with closed canopy, but with substantial openness in the understory.

Sole use of acoustic monitoring only allows for the determination *M. septentrionalis* presence at a site. It does not allow for determination of gender, breeding status, or site utilization. While standardized sampling methodology permits a relative comparison of bat pass counts between different sites, the number of bat passes may or may not be an accurate indicator of population density.

In addition, acoustically differentiating some bat species, especially those of the genus Myotis, can be extremely difficult because of overlapping call parameters between species within the same genus. Quality of the recorded call can also induce uncertainty into automated call detection. For instance, a partial call from one species within a genus could be misidentified as a different species within the same genus. Partial calls can also be misidentified as a species from another genus. Consequently, results from acoustic sampling should be used in conjunction with live capture techniques.

Acknowledgements

This project was made possible through funding provided by the Hiawatha National Forest. Thanks go to Derek Huebner, Janet Ekstrum, Lucas Langstaff, Anna Keenan and Vern St. John for their assistance in placing and retrieving the acoustic monitors. Particular thanks go to Kirk Piehler for his assistance in securing the project funding.

Citations

Brack, V., Jr., and J.O. Whitaker. 2001. Foods of the northern Myotis, Myotis septentrionalis, from Missouri and Indiana, with notes on foraging.

Ford, W.M, S.F. Owen, J.W. Edwards, and J.L. Rodrigue. 2006. Robinia pseudoacacia (black locust) as day-roosts of male Myotis septentrionalis (northern bats) on the Fernow Experimental Forest, West Virginia. Northeastern Naturalist 13:12-24.

Foster, R.W., and A. Kurta. 1999. Roosting ecology of the northern bat (Myotis septentonalis) and comparisons with the endangered Indiana bat (Myotis sodalis). Journal of Mammalogy 80:659-672.

Gehring, J.L. and B. J. Klatt. 2012. Mist-net Assessment of Bat Diversity in the Hiawatha National Forest: Summer 2012. MNFI report 2012 - 12

Hayes, M. A. 2013. Bats killed in large numbers at United States wind energy facilities. BioScience 63:975-979.

Henderson, L.E., and H.G. Broders. 2008. Movements and resource selection of the northern long-eared myotis (Myotis septentrionalis) in a forest-agriculture landscape. Journal of Mammalogy 89:952-963.

Hogberg, L.K., K.J. Patriquin, and R.M.R. Barclay. 2002. Use by bats of patches of residual trees in logged areas of Boreal Forest. American Midland Naturalist 148: 282-288.

Jung, T.S., I.D. Thompson, and R.D. Titman. 2004. Roost site selection by forest-dwelling male Myotis in central Ontario, Canada. Forest Ecology and Management 202:325-335.

Klatt, B. J. and J. L. Gehring. 2013. Assessing Bat Community Structure in Riparian and Agricultural Habitats in a High Wind Resource Area of Southeast Michigan

– A Preliminary Analysis. Michigan Natural Features Inventory, Michigan State University, Report Number 2013-05, Lansing, MI.

Lacki, M.J., and J. Schwierjohann. 2001. Day roost characteristics of northern bats in mixed mesophytic forest. Journal of Wildlife Management 65: 482-488.

Lacki, M.J., D.R. Cox, and M.B. Dickinson. 2009. Meta-analysis of Summer Roosting Characteristics of Two Species of Myotis Bats. American Midland Naturalist. 162:318–326.

National Academy of Sciences. 2007. Environmental Impacts of Wind-Energy Projects. Committee of Environmental Impacts of Wind Energy Projects, National Research Council. 394 pp.

Owen, S.F., M.A. Menzel, W.M. Ford, J.W. Edwards, B.R. Chapman, K.V. Miller, P.B. Wood. 2002. Roost tree selection by maternal colonies of northern long-eared myotis in an intensively managed forest. USDA Forest Service, General Technical Report NE-292, Northeastern Research Station, Newtown Square, PA, p. 6.

Owen, S., M.A. Menzel, M.W. Ford, B.R. Chapman, K.V. Miller, J. Edwards, and P. Wood. 2003. Homerange size and habitat use by northern Myotis (Myotis septentrionalis). American Midland Naturalist 150:352-359.

Park, A.C. 2010. Factors affecting the distribution and roost-site selection of bats on the Island of Newfoundland. M.Sc., Saint Mary's University (Canada), 66 pages.

Sasse, D.B. 1995. Summer roosting ecology of cavity-dwelling bats in the White Mountain National Forest. M.Sc., University of New Hampshire, 74 pages.

Sasse, D.B., and P.J. Pekins. 1996. Summer roosting ecology of northern long-eared bats (Myotis septentrionalis) in the White Mountain National Forest. Bats and forests symposium. British Columbia Ministry of Forests Working Paper 23:91-101.

Schools, E. H., B. J. Klatt, and D. A. Hyde. 2014. Preliminary Assessment of Hiawatha National Forest Karst Features As Potential Northern Long-eared Bat Hibernacula. Michigan Natural Features

Inventory, Michigan State University, Report Number 2014-24, Lansing, MI.

Strickland, M.D., E.B. Arnett, W.P. Erickson, D.H. Johnson, G.D. Johnson, M.L., Morrison, J.A. Shaffer, and W. Warren-Hicks. 2011. *Comprehensive Guide to Studying Wind Energy/Wildlife Interactions.* Prepared for the National Wind Coordinating Collaborative, Washington, D.C., USA.

USFWSa 2015. 50 CFR Part 17 Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat With 4(d) Rule; Final Rule and Interim Rule. Federal Register/ Vol. 80, No. 63 / Thursday, April 2, 2015 / Rules and Regulations

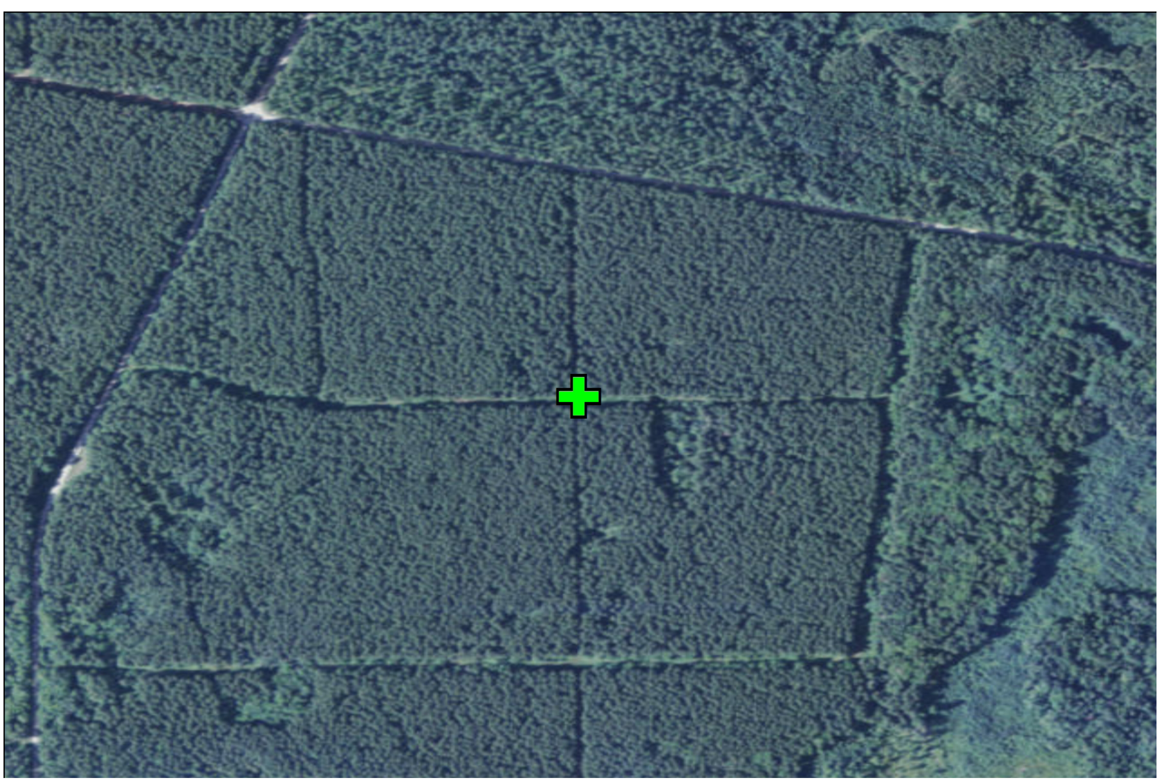
USFWSb 2015. 2015 Rangewide Indiana Bat Summer Survey Guidelines. http://www.fws.gov/midwest/endangered/mammals/inba/inbasummersurveyguidance.html.

Appendix I

Monitoring Site Aerial Photographs

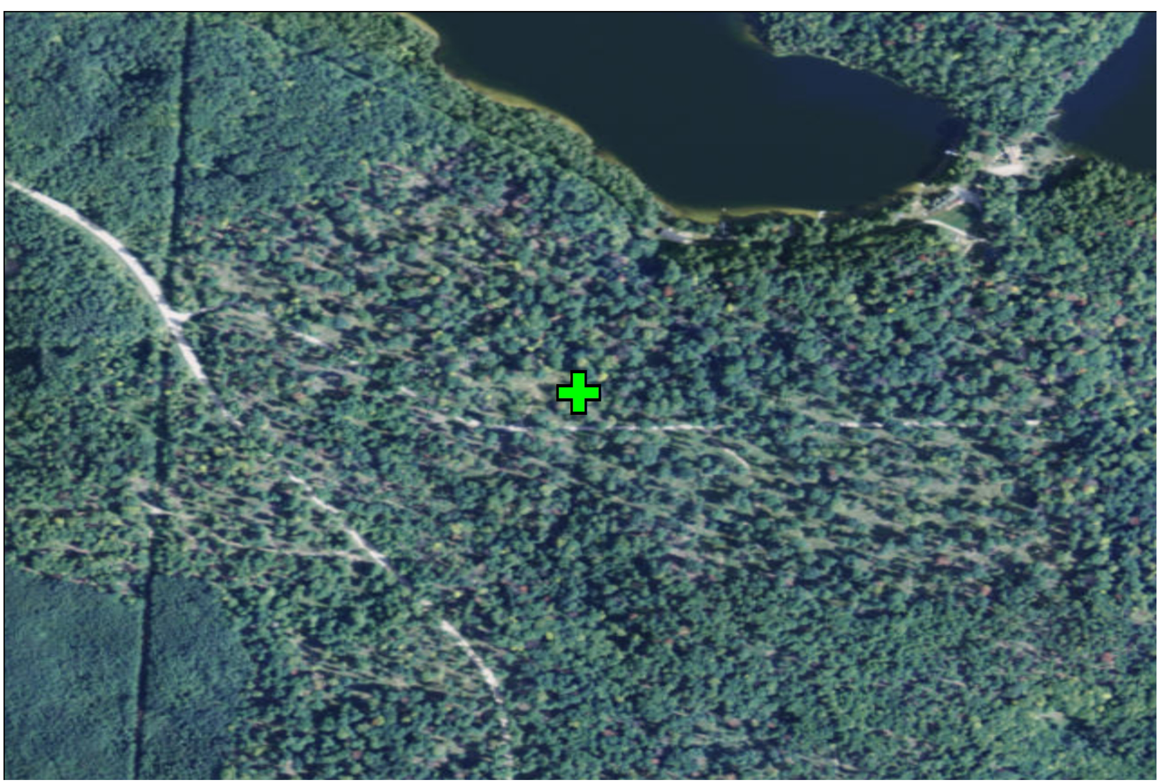
HIA1 1:1,200 Scale.

HIA1 1:10,000 Scale.



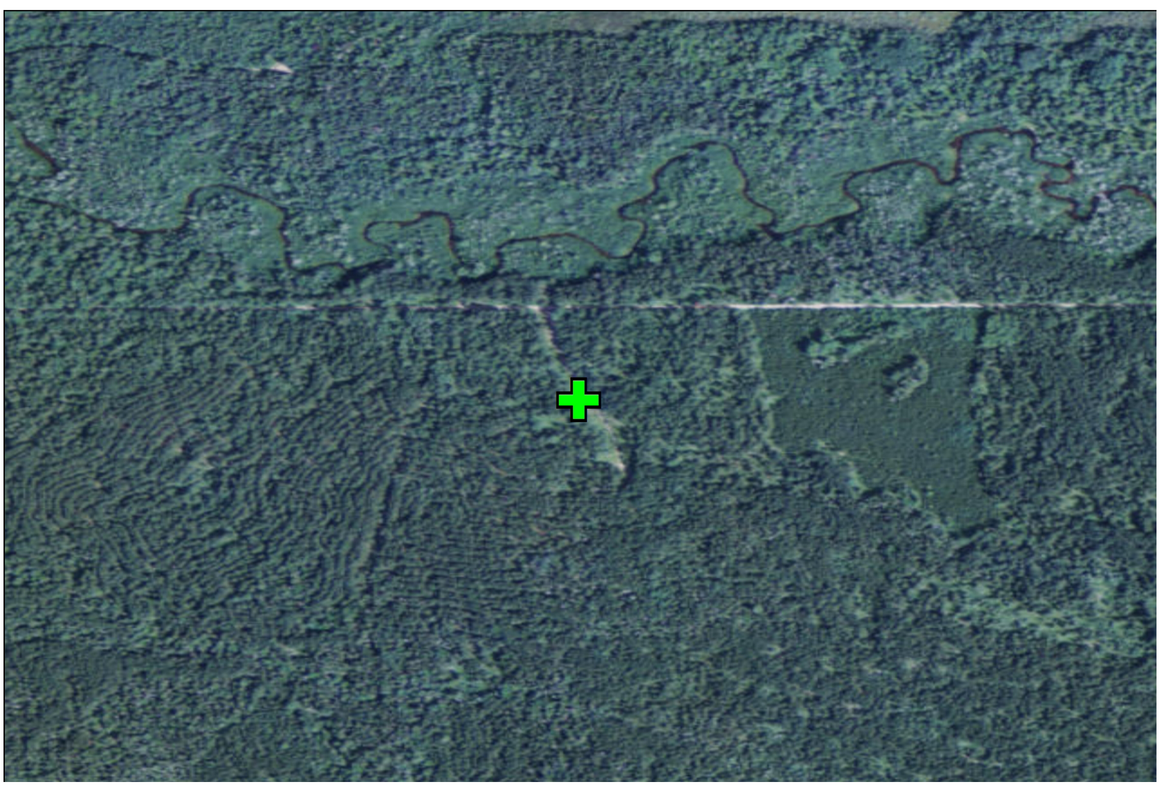
HIA2 1:1,200 Scale.

HIA2 1:10,000 Scale.



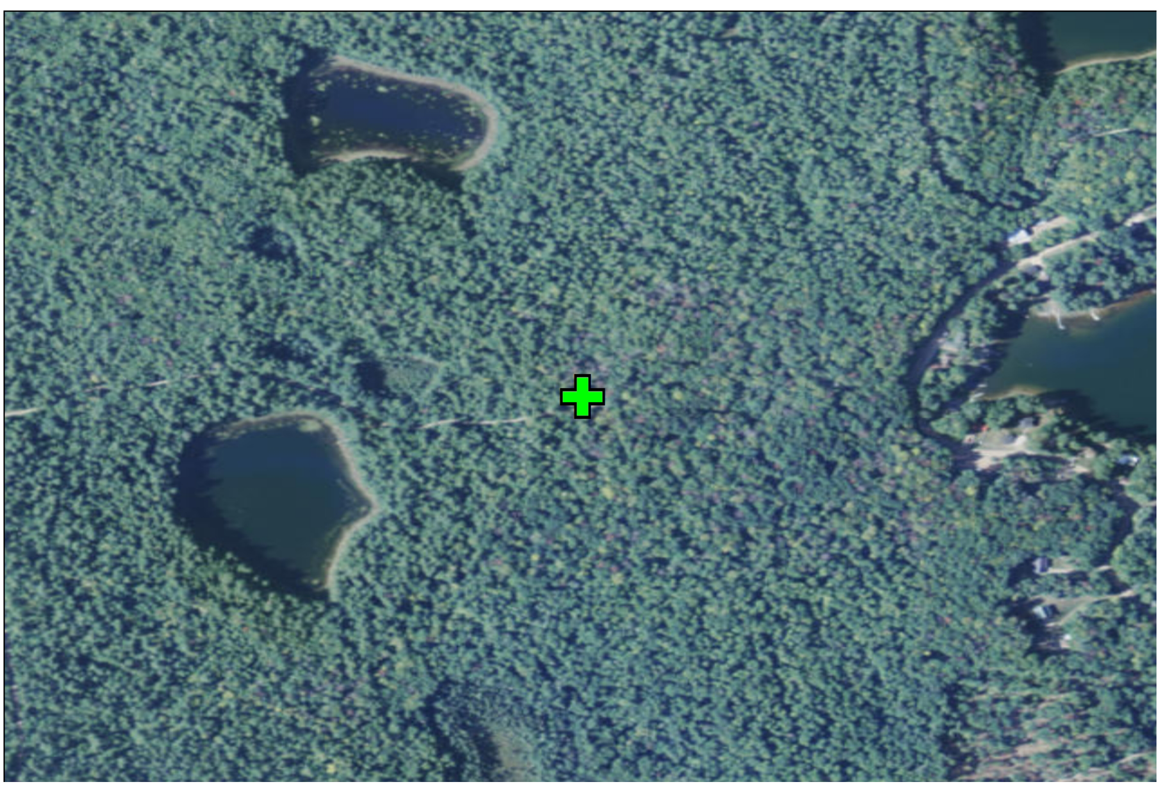
HIA3 1:1,200 Scale.

HIA3 1:10,000 Scale.



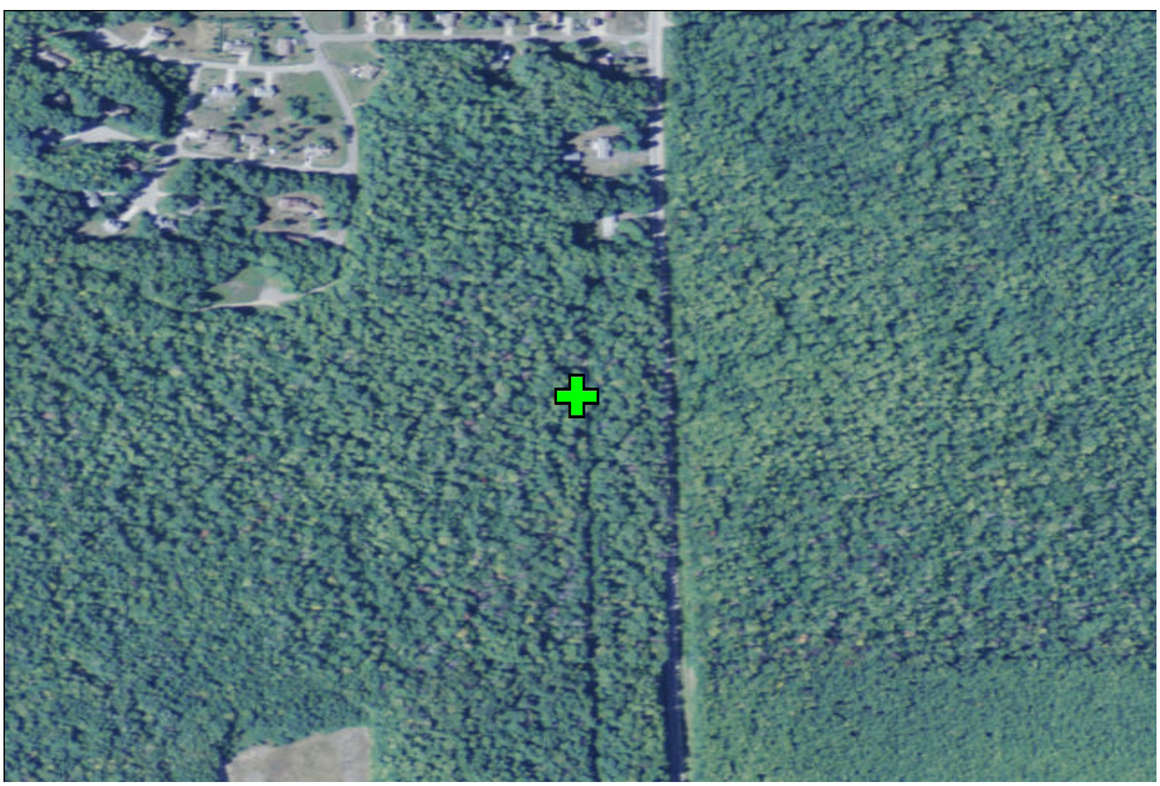
HIA4 1:1,200 Scale.

HIA4 1:10,000 Scale.



HIA5 1:1,200 Scale.

HIA5 1:10,000 Scale.

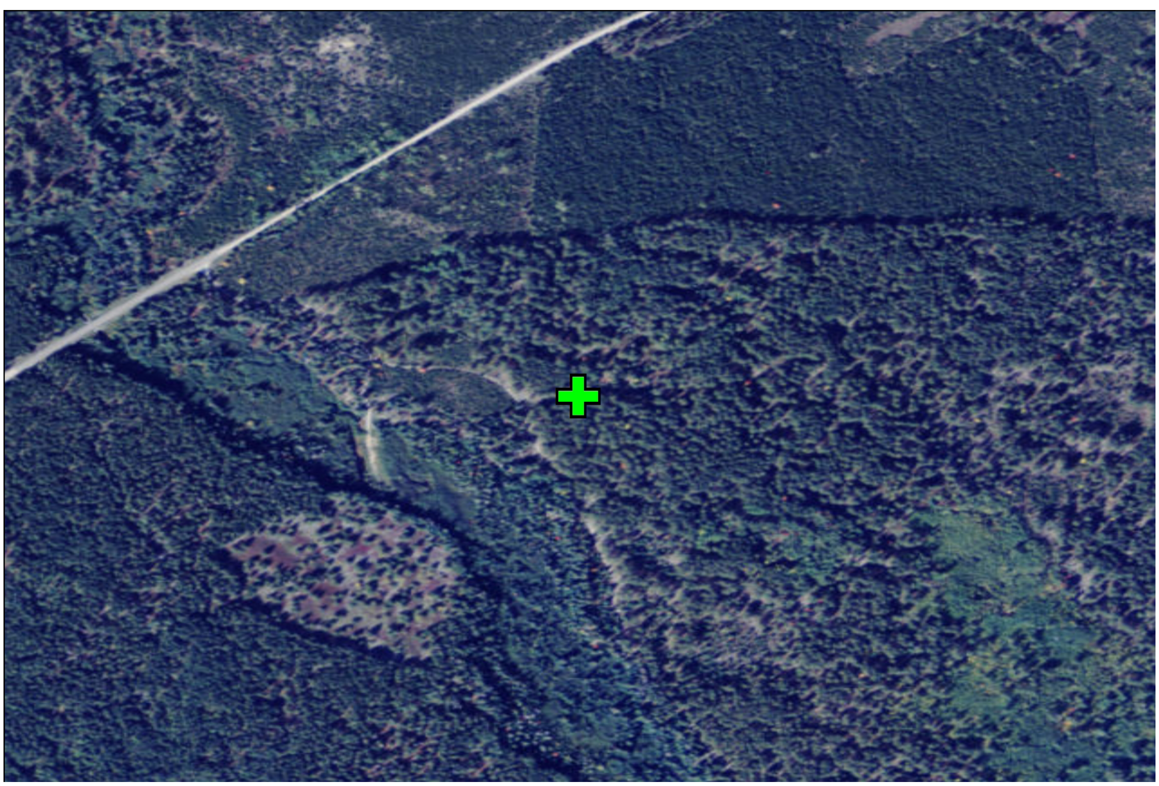


HIA6 1:1,200 Scale.

HIA6 1:10,000 Scale.

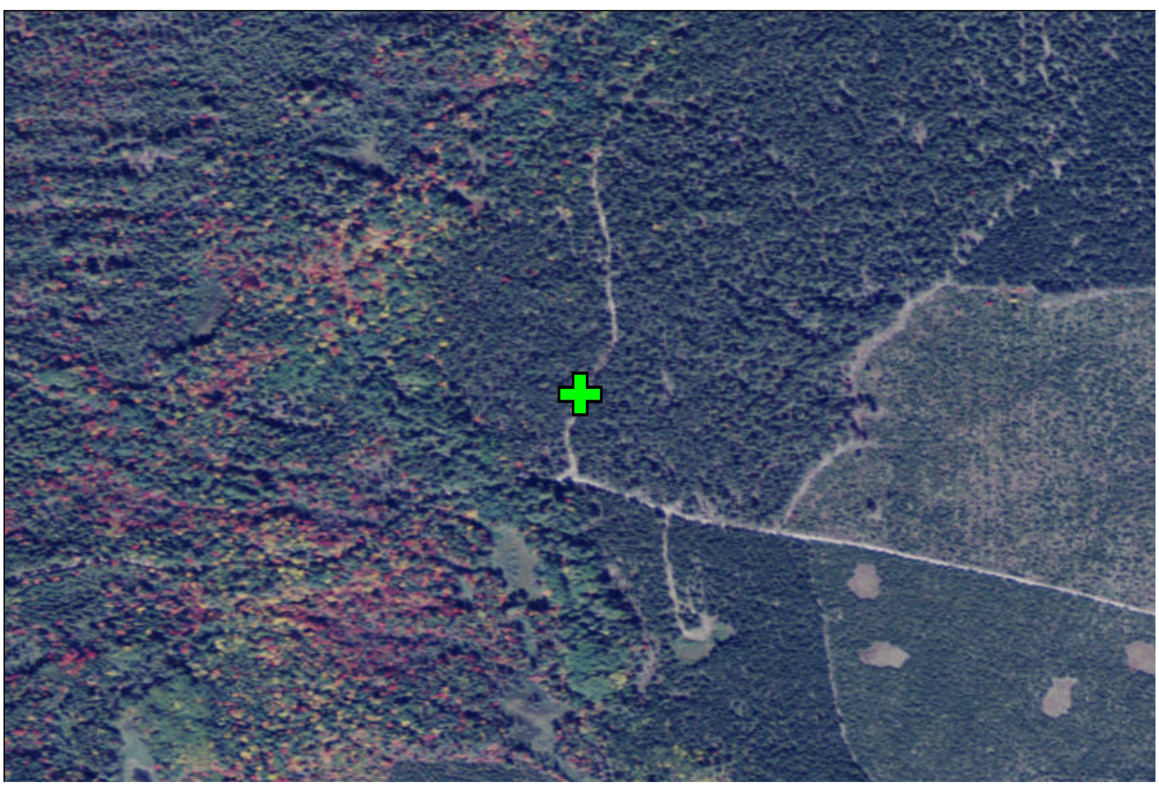
HIA7 1:1,200 Scale.

HIA7 1:10,000 Scale.



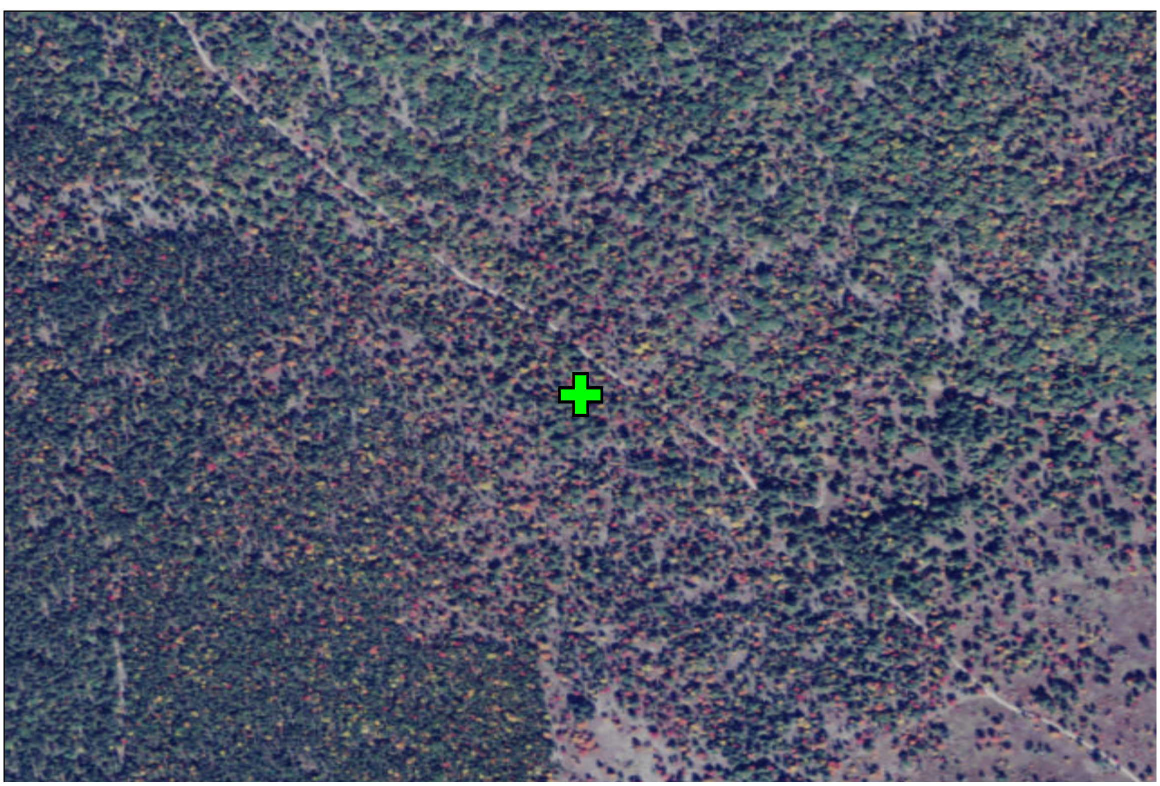
HIA8 1:1,200 Scale.

HIA8 1:10,000 Scale.



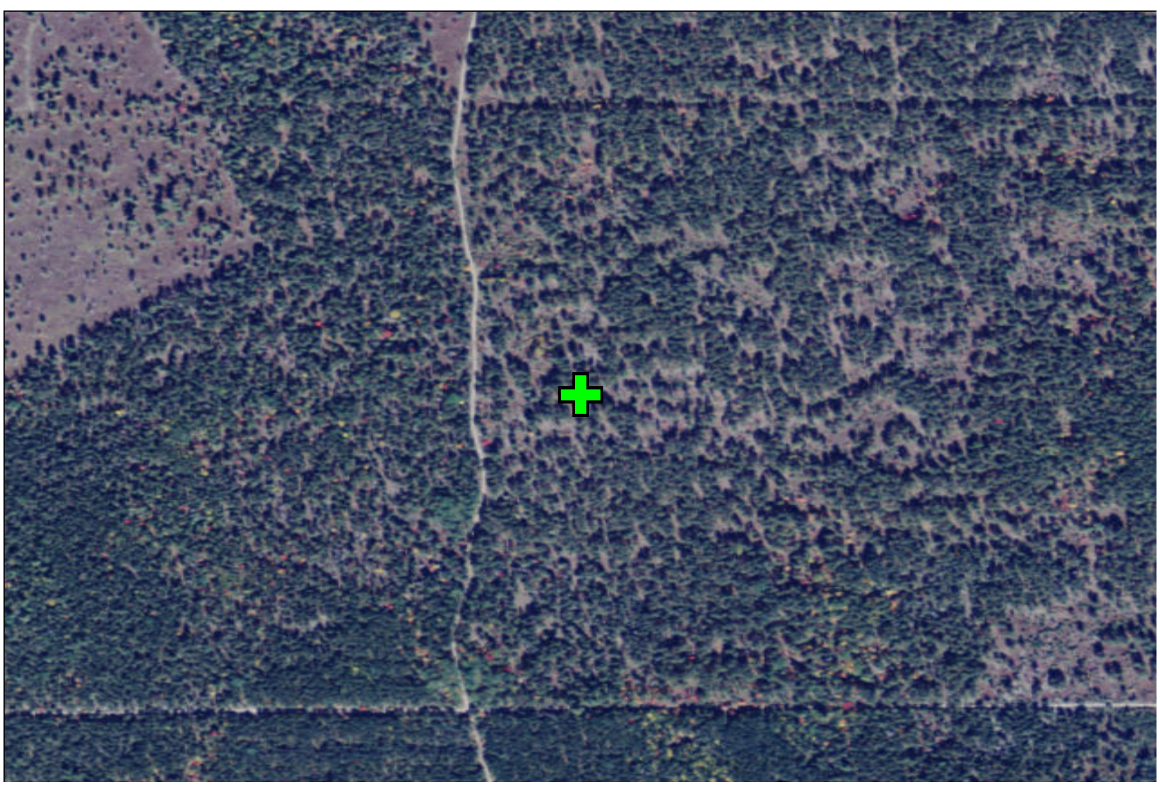
HIA9 1:1,200 Scale.

HIA9 1:10,000 Scale.



HIA10 1:1,200 Scale.

HIA10 1:10,000 Scale.



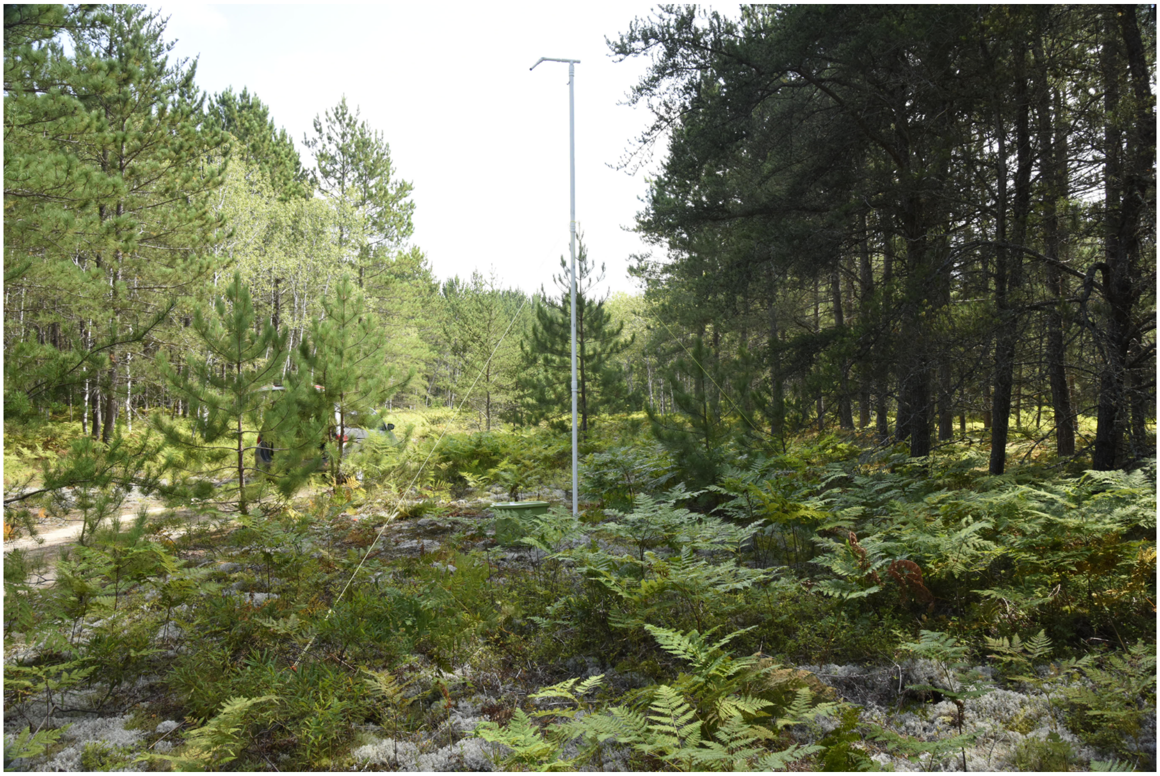
Appendix II

Monitoring Site Photographs

HIA1

HIA2

HIA3



HIA4

HIA5

HIA6

HIA7

HIA8

HIA9

HIA10