Characteristics of Pileated Woodpecker (*Dryocopus pileatus)* Cavity Trees in Edge Habitat of a Northern Mixed Conifer-Hardwood Forest

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Abstract

Pileated woodpeckers function as important primary nest cavity excavators extending nesting and roosting benefits to many other local species. However, information about pileated woodpeckers is limited in the northern mixed conifer-hardwood forests of North America. This study examined several characteristics of nest and non-nest cavity trees along roadways at the University of Notre Dame's Environmental Research Center in Michigan to fill this information gap. At UNDERC pileated woodpeckers used larger (diameter at breast height = 44.1 vs. 37.4 cm; $P = 0.006$) and less decayed (mean decay class = 2.5 vs. 3.8; $P < 0.001$) trees for nesting than non-nesting behavior while average tree stand age had no influence on use ($P = 0.22$). Pileated woodpeckers also preferentially used sugar maple ($P < 0.001$) more for nest cavities than they did for non-nest cavities. These results can act as a baseline for further research and management in northern mixed conifer-hardwood forests of the Great Lakes region as the pileated woodpecker faces the consequences of global climate change.

Introduction

Pileated woodpeckers (*Dryocopus pileatus*) are the largest extant woodpecker species in North America. As such, they function as important primary nest cavity excavators and have been fittingly labeled as "ecosystem engineers" by the United States Forest Service (Aubry & Raley 2003). Each season, pileated woodpeckers move to new trees and create new nests leaving vacant cavities throughout the forest that many other species of animals can inhabit (Hartwig et al. 2004). This influence, combined with their creation of large foraging cavities, constitutes their placement as a keystone species throughout their range. In the northwestern United States, pileated woodpeckers were even used as a management indicator species for mature and old-growth forest until the creation of the Northwest Forest Plan in 1994 saw the end to single-species monitoring (Aubry & Raley 2003).

Despite their strong influence on community structure, pileated woodpeckers have only been extensively studied in portions of their range. Earlier studies concluded that pileated woodpeckers require extensive large diameter, old-growth trees to support nesting activities while foraging activities require that the wood be in a further decayed state (Bull & Meslow; Bull 1987; Flemming et al. 1999; McClelland & McClelland 1999). Forest management practices have led to a focus on the effect of disturbance on pileated woodpeckers in their habitats along the Atlantic and Pacific coasts and in the western and southern portions of their range (Bull et al. 2007; Newell et al. 2009; Drever & Martin 2010). Meanwhile, few studies have examined pileated woodpecker ecology or disturbance in northern or eastern forests despite the shift in forest structure across the entirety of North America over the past three centuries (Gronewold et al. 2010; Blanc & Martin 2012).

In the Great Lakes region, logging during the 19^{th} and 20^{th} centuries was common and has had lasting effects including the loss of nearly all old-growth forest. Today the area is dominated by secondary-growth forests (Bunn 2008). More recently, remaining old-growth and secondary-growth forests have lost much of their complexity as management has focused on removing “undesirable” trees such as snags, coarse woody debris (CWD), and large decaying trees (Holloway et al. 2007; Gronewold et al. 2010). Woodpecker species rely on these “undesirable” trees, especially on large diameter, decadent trees. However, only in the past two decades has there been a growing consideration for the value of such complexity as a means to protect ecosystem biodiversity (Gunn & Hagan 2000; Hanowski et al. 2006; Silver et al. 2013).

The purpose of this study was to gather information on the characteristics and differences between nest and non-nest cavity trees along roadways and determine whether there was a connection between forest stand age (as a result of previous logging) and pileated woodpecker activity. Building on previous research performed by Irby (2005) at the University of Notre Dame's Environmental Research Center (UNDERC), this study will contribute to a further understanding of this "ecosystem engineer" in the Great Lakes region. Snag characteristics of the forest collected by Irby (2005) on the UNDERC property were ≥10 m from roads and were focused on differences between stand types, but not individual tree species. Mahon (2003) collected data on the history of logging at UNDERC and determined the age of 30 stands of trees around the property. By combining the ideas and slightly altering the methods of these studies, this study aims to reveal trends in pileated woodpecker cavity tree selection so as to compare with data collected from dissimilar forests. Similarities would provide for the opportunity to utilize and adapt management plans already in place from across the continent to ensure that pileated woodpeckers remain in northern mixed conifer-hardwood forests.

This study will also provide a baseline for further study on constant human disturbance and the possible deviations from trends seen *within* forest stands. Historically, dense canopy closure has been used as a baseline for the habitat requirements of the pileated woodpecker, but I want to know if this holds up where there is thin or absent canopy closure along forest roadways (Bull et al. 2007). My specific hypotheses are as follows: (1) nest cavities will occur in older stands of trees than non-nest cavities; (2) nest cavity trees will be less decayed and larger in diameter at breast height (DBH) than non-nest cavity trees; and (3) there will be a difference between tree species selected for foraging and nesting.

Methods

Study Site

The study area consisted of approximately 37 kilometers of actively maintained dirt and gravel roads at UNDERC which is located on the border of Wisconsin and Michigan's Upper Peninsula. Previous studies have estimated that logging was completed on property by the early 1900s, but new evidence in archived documents and tree core samples has revealed that clear-cuts were performed in the 1950s until the property was closed to all logging activity in 1968 (Mahon 2003). Dominant forest stand structure in the area consists of Sugar Maple, Aspen-Sugar Maple, and mixed hardwood-conifer (Irby 2005). Five sections of roads not surveyed due to limited access/non-maintenance and the presence of telephone lines are shown in Figure 1.

Data Collection

All trees considered in the survey were ≤10 m (in contrast to Irby 2005) from the roadway and ≥4 m in height. Trees not meeting these specifications were not considered because they showed considerable signs of decay and damage past my ability to determine the extent of pileated woodpecker-created cavities. When located, each tree's coordinates were taken on a GPS and DBH was measured. I observed each tree for all possible cavities, taking note of the number and type of each cavity. As described by Hoyt (1957), nest cavities were considered to be of nest or roost origin if they were circular in shape and deep enough that I could not see the interior of the tree. I did not make the distinction between nest and roosting sites because of the difficulty in determining cavity origin between the two. All other cavities – in particular large, rectangular cavities lower on the bole – were treated to be of foraging origin. Lastly, the tree or snag was assigned to a decay class, found in Table 1, adapted from Harmon et al. 2011 (Table 1).

Data Analysis

Diameter at breast height data was non normal and therefore was log transformed. Then data was run through a two-way ANOVA and a Tukey's post-hoc analysis to test for differences between tree cavity type and tree species and DBH.

Non-parametric tests were used to analyze DBH, decay class and stand age. A Mann-Whitney *U*-test was used to determine differences in average DBH, decay class, and tree stand age between cavity tree types. A Fisher's exact test was used to run a comparison between all decay classes (Lowry, 2013). To compensate for small sample sizes, individual classes within tree species or decay class were run using either a Fisher's exact test or Pearson's chi-square against the sum of the remaining classes following the methods of Hartwig et al. (2004).

Results

One hundred fifty five pileated cavity trees were found, 128 of which were non-nest cavity trees and 27 of which were nest cavity trees. I detected no significant difference in average tree stand age between nest and non-nest cavity trees (U =97; df =1; p=0.22; Table 2) based on comparisons of my GIS data to the tree stand map of Mahon (2003). Ages were only applied to 29.7% of the total trees surveyed due to limited data on forest stand age data. However, there was a significant difference in tree species selection between nesting and non-nesting activities. Sugar maple was significantly more likely to be used for nest cavities (χ^2 =13.71; df =1; p <0.001) while white birch was significantly more likely to be used for non-nest cavities (χ^2 = 5.47; df =1; p =0.02).

Nest cavity trees differed significantly from non-nest cavity trees for the remaining characteristics (Table 2). Nest cavity trees were significantly larger in diameter (44.1±2.4 cm) than trees with non-nest cavities (37.4±1.0 cm) (U =1148; df =1; p =0.006; Table 3). Also, nest cavity trees were significantly different in their decay classes than non-nest cavity trees (*U* =2619; df =1; p <0.001). Live, healthy trees (Class 1) were used significantly more for nesting (df =1; p <0.001) while trees belonging to the highest two decay classes (4 & 5) were used significantly more for non-nest cavities (df =1; p =0.04; df =1; p =0.02, respectively).

Discussion

The results support my hypotheses that nest cavity trees of pileated woodpeckers are larger in diameter, less decadent and differ in tree species use compared to non-nest cavity trees. However, it is apparent that these characteristics can be highly variable across locations and habitats as is the case with nest tree diameter (Table 4), especially in western U.S. forests with dominant coniferous tree species (Hartwig et al. 2004). In addition, the characteristics found in this study may not accurately represent those found in mature northern mixed conifer-hardwood forest because of the focus on roadways and the fact that it is a secondary-growth forest. Roadways have human and natural disturbances as a result of vehicle traffic and wind events. These disturbances may reduce woodpecker use and/or decrease the availability of larger diameter trees. None-the-less, the results, and their stark contrast from studies across North America, illustrate the importance of studies, such as this one, focused on dissimilar habitats.

As a secondary-growth forest, some tree species have not achieved maturity, or classification as old-growth, and will not for another hundred years. This is especially true of sugar maple which has been reported to have an average DBH of 80.3 cm in Warren Woods, Michigan – an established old-growth forest – nearly twice the DBH of sugar maple trees (43.2 cm) found in my study (Poulson & Platt 1996). Aspens have a different life span, however, ranging from 70-100 years. Consequentially, they may be used as a more reliable measure for consistency across the continent or at least with British Colombia (BC) where trembling aspen is the preferred nesting tree. In south-central BC, trembling aspen diameter ranges from 40 to 46 cm for nest trees (Table 4) which is very similar to what I found in my study (44.0 cm) for nest cavity trees (Harestad and Keisker 1989; Steeger et al. 1996). I would expect that as longer lived trees continue to age, tree characteristics preferred for nesting will change accordingly because the most sought after trees are just not available yet.

My results did not support the hypothesis that there was a difference in average tree stand age between cavity tree types. This may be the result of using a non-interactive map where I had to approximate which trees fell into the thirty plots surveyed by Mahon (2003). A more accurate measure of age difference between nest cavity and non-nest cavity trees would be to core the surveyed trees although this would be somewhat linked to DBH. In addition, the property could be fairly even-aged with just a few pockets of older trees that have not been cut due to difficult terrain. It may also be plausible that woodpeckers do not prefer certain ages of tree stands as long as there are trees with the characteristics they need to form a nest cavity.

Preference for sugar maple trees as nest cavity trees was an interesting find because during my academic literature research, I found little information on sugar maple use by pileated woodpeckers. Pileated woodpecker use of sugar maple was to some extent not surprising due to sugar maple's dominance on the property. White birch, on the other hand, was found to be preferred for non-nest cavities. Naylor et al. (1996) describe management differences between the two species that may help explain these findings. Sugar maple is a tolerant hardwood tree while white birch is intolerant. This means that woodpeckers may be selecting trees where their nest cavities will hold together, or where dead branches will stay on the tree, longer than is necessary for foraging activities. Decay develops more quickly in intolerant hardwoods and therefore holes in intolerant hardwoods are easier to excavate during insect foraging (Naylor et al. 1996).

The results of a woodpecker species-wide study on nest tree decay class in aspens by Blanc and Martin (2012) found that the majority of pileated woodpecker nest trees were classified as live and unhealthy which is similar to the results of this study. Our results diverge from previous studies that have focused survey efforts on only dead or dying trees and snags (Bull & Meslow 1977; Bull 1987). While the majority of trees with nest cavities were found to have large, dead limbs in my study, the remaining live portion of the trees had crowns full of vegetation. This may be important in future studies so that possible nest trees are not eliminated from the study beforehand due to a narrow search. That being said, I was unable to track and locate pileated woodpeckers to active nests during the study unlike most other studies. Time constraints, limited resources (i.e. banding) and limited study area contributed to this limitation.

It appears that constant human disturbance by means of road traffic is not having a large impact on pileated woodpecker activity at UNDERC due to their utilization of over 150 trees. Without a study on tree characteristics of pileated woodpecker cavity trees within northern mixed conifer-hardwood forests to compare to, this cannot be said for certain. All previous studies in North America have been focused on tree characteristics in the interior of forests and therefore are not comparable either. In addition, Irby (2005) focused on snag characteristics (no live trees) without emphasizing pileated woodpecker use, so it is unclear from this study what actual tree characteristics used for cavities are.

One possible explanation for extensive pileated woodpecker use along the roads on the UNDERC property is that the forest gaps, resulting from the roads themselves, are less prominent during the year once foliage appears in late spring/early summer. Any gaps remaining may not be of sufficient size to have a measurable effect, especially on foraging habits where the woodpecker may only spend part of a day. Nest cavities, however, may be the result of limited traffic throughout most of the year. Only about 10 km of road are considered main roads while all other roads only see increased traffic during the summer field work months: June – September. Further studies on roadway disturbance may be better focused on roads that have year-round traffic, differing amounts of canopy gap, and more tree characteristics than touched upon in this study.

According to Hartwig et al. (2004), the limited abundance of suitable nest trees is the limiting factor of pileated woodpeckers. As secondary-growth forest, the UNDERC property – and many other areas in the Great Lakes region – lack larger trees only seen in old-growth forest. Therefore management, which will be similar to other recommendations from past studies, should be aimed at retaining those trees approximating preferred characteristics (Hartwig et al. 2004; Newell et al. 2009). In general, larger diameter trees (>40 cm) should be kept during maintenance activities, especially sugar maple in order to ensure these birds have nesting trees. Smaller trees should also be retained so that they are able to grow into the large trees used by pileated woodpeckers. Management of roadways, even remote back-roads, remains important for safety, but may be the source of forest disturbance itself. While roads must be maintained, they should be maintained carefully to retain structural complexity associated with old-growth forests. Leaving aesthetically unattractive trees that are preferred by pileated woodpeckers for nesting is crucial to ensuring the longevity of this keystone species in northern mixed conifer-hardwood forests.

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References

Aubry, K. and C. Raley. 2003. Coming home to roost: the pileated woodpecker as ecosystem engineer. *Science Findings*: Issue 57. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 6p.

Blanc, L.A. and K. Martin. 2012. Identifying suitable woodpecker nest trees using decay selection profiles in trembling aspen (*Populus tremuloides)*. *Forest Ecology and Management* 286: 192-202.

Bull, E.L. and E.C. Meslow. 1977. Habitat requirements of the pileated woodpecker in northeastern Oregon. *Journal of Forestry* 75(6): 335-337.

Bull, E.L. 1987. Ecology of the pileated woodpecker in northeastern Oregon. *Journal of Wildlife Management* 51: 472–481.

Bull, E.L., N. Nielsen-Pincus, B.C. Wales, and J.L. Hayes. 2007. The influence of disturbance events on pileated woodpeckers in northeastern Oregon. *Forest Ecology and Management* 243: 320-329.

Bunn, L. 2008. Evaluating a stand of potential old-growth white pine-hemlock forest at the University of Notre Dame Environmental Research Center. B.S. UNDERC.

Drever, M.C. and K. Martin. 2010. Response of woodpeckers to changes in forest health and harvest: Implications for conservation of avian biodiversity. *Forest Ecology and Management* 259: 958-966.

Flemming, S.P., G.L. Holloway, E.J. Watts, and P.S. Lawrance. 1999. Characteristics of foraging trees selected by pileated woodpeckers in New Brunswick. *Journal of Wildlife Management* 63(2): 461-469.

Gronewold, C.A., A.W. D'Amato, and B.J. Palik. 2010. The influence of cutting cycle and stocking level on the structure and composition of managed old-growth northern hardwoods. *Forest Ecology and Management* 259: 1151-1160.

Gunn, J.S. and J.M. Hagan. 2000. Woodpecker abundance and tree use in uneven-aged managed, and unmanaged, forest in northern Maine. *Forest Ecology and Mangement* 126: 1-12.

Hanowski, J., N. Danz, and J. Lind. 2006. Response of breeding bird communities to forest harvest around seasonal ponds in northern forests, USA. *Forest Ecology and Management* 229: 63-72.

Harmon, M.E., C.W. Woodall, B. Fasth, J. Sexton, and M. Yatkov. 2011. Differences between standing and downed dead tree wood density reduction factors: a comparison across decay classes and tree species. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 44p.

Hartwig, C.L., D.S. Eastman, and A.S. Harestad. 2004. Characteristics of pileated woodpecker (*Dryocopus pileatus*) cavity trees and their patches on southeastern Vancouver Island, British Columbia, Canada. *Forest Ecology and Management* 187: 225-234.

Holloway, G.L., J.P. Caspersen, M.C. Vanderwel, and B.J. Naylor. 2007. Cavity tree occurrence in hardwood forests of central Ontario. *Forest Ecology and Management* 239: 191-199.

Hoyt, S.F. 1957. Ecology of pileated woodpecker. *Ecology* 38(2): 246-256.

Irby, M. 2005. Snag characteristics and evidence of woodpecker activity in deciduous and mixed stands in northern Michigan. B.S. UNDERC.

Lowry, R. 2013. 2x2 Contingency Table. VassarStats <http://www.vassarstats.net/tab2x2.html> Accessed July 18, 2013.

Mahon, B. 2003. A Clear-cutting History Survey of the UNDERC Property. B.S. UNDERC.

McClelland, B.R. and P.T. McClelland. 1999. Pileated woodpecker nest and roost trees in Montana: Links with old-growth and forest "health." *Wildlife Society Bulletin* 27(3): 846-857.

Naylor, B.J., J.A. Baker, D.M. Hogg, J.G. McNicol, and W.R. Watt. 1996. Forest management guidelines for the provision of pileated woodpecker habitat. Ontario, Canada: Ministry of Natural Resources, Forest Management Branch. 34p.

Newell, P., S. King, and M. Kaller. 2009. Foraging behavior of pileated woodpeckers in partial cut and uncut bottomland hardwood forest. *Forest Ecology and Mangement* 258: 1456-1464.

Poulson, T.L. and W.J. Platt. 1996. Replacement patterns of beech and sugar maple in Warren Woods, Michigan. *Ecology* 77(4): 1234-1253.

Silver, E.J., A.W. D'Amato, S. Fraver, B.J. Palik, and J.B. Bradford. 2013. Structure and development of old-growth, unmanaged second-growth, and extended rotation *Pinus resinosa* forests in Minnesota, USA. *Forest Ecology and Management* 291: 110-118.

Tables

Table 1. Decay classification guidelines as adapted from Harmon et al. 2011.

Class 1	Live tree with large branches broken and/or decaying; crown still present.
Class 2	Half or less of tree alive; crown declining and decay is advanced where tree is dead.
Class 3	Tree is dead; no crown; majority of limbs still present.
Class 4	Few, large limb stubs remain; top is broken; bark is peeling and decay is evident.
Class 5	No branches remaining; top broken; <20 percent of bark remains; heartwood decay evident.

Table 2. Comparison of characteristics of trees and snags with a pileated woodpecker nest cavity and with those containing pileated non-nest cavities along roadways at UNDERC, 2013[a]

Characteristics	**Mean (±S.E.) or percentage**		***P***
	Nest Cavity (*n=27*)	**Non-Nest Cavity (*n=128*)**	
Diameter at breast height (cm)	44.1 (±2.4)	37.4 (±1.0)	**0.006[d]**
Decay Class	2.5 (±0.26)	3.8 (±0.09)	**<0.001[d]**
Average Forest Stand Age[b]	69.9 (±5.1)	65.1 (±2.2)	0.22[d]
Species (%)			No results[c]
Aspen	22	34	0.25[e]
Sugar Maple	59	23	**<0.001[e]**
White Birch	7	29	**0.03[f]**
Red Maple	7	2	0.21[f]
White Pine	4	2	1[f]
Balsam Fir	0	2	
Red Pine	0	7	
Yellow Birch	0	2	
Decay Class (%)			**<0.001[f]**
1 – Live, unhealthy	33	6	**<0.001[f]**
2	19	9	0.16[f]
3	15	12	0.75[f]
4	30	52	**0.04[e]**
5 – Dead, extensive decay	4	23	**0.02[e]**

[a] Bold indicates significance at $\alpha = 0.05$

b Nest cavities: $n = 9$; Non-nest cavities: $n = 39$

[c] Sample sizes too small for comparisons within all classes.

[d] Mann-Whitney *U*-test.

[e] Pearson's chi-square test.

[f] Fisher's exact test.

Table 3. Nest, non-nest and totals of cavity tree mean DBH (cm) for three tree species surveyed, 2013.

Tree Species	**Mean DBH (cm) & Sample size**					
	Nest	***n***	**Non-nest**	***n***	**Total**	***n***
Aspen	44.0	6	35.5	43	**36.6**	49
Sugar Maple	41.2	16	43.3	30	**43.2**	46
White Birch	46.5	2	32.9	37	**33**	40

Table 4. Mean diameter at breast height (DBH) of nest trees used by pileated woodpecker for nesting trees in North America as adapted from Hartwig et al 2004.

Location	**Preferred Species**	**Mean DBH (cm)**	***n***	**Reference**
Western Washington	Western Hemlock Pacific silver fir	100	27	Aubrey and Raley (1995)
North-western Washington	Ponderosa pine Western Larch	84	6	Madsen (1985)
North-eastern Oregon	Ponderosa pine	84	105	Bull (1987)
Vancouver Island	Douglas-fir	82	7	Hartwig (1999)
North-western Montana	Western larch	73	113	McClelland and McClelland (1999)
Western Oregon	Douglas-fir	69	18	Mellen (1987)
Virginia	Hickory, red oak	55	14	Conner et al. (1975)
Southcentral British Columbia	Trembling Aspen	46	6	Steeger et al (1996)
Upper Peninsula, Michigan	Sugar Maple	44	27	This study (2013)
Southcentral British Columbia	Trembling Aspen	40	20	Harestad and Keisker (1989)

Figures

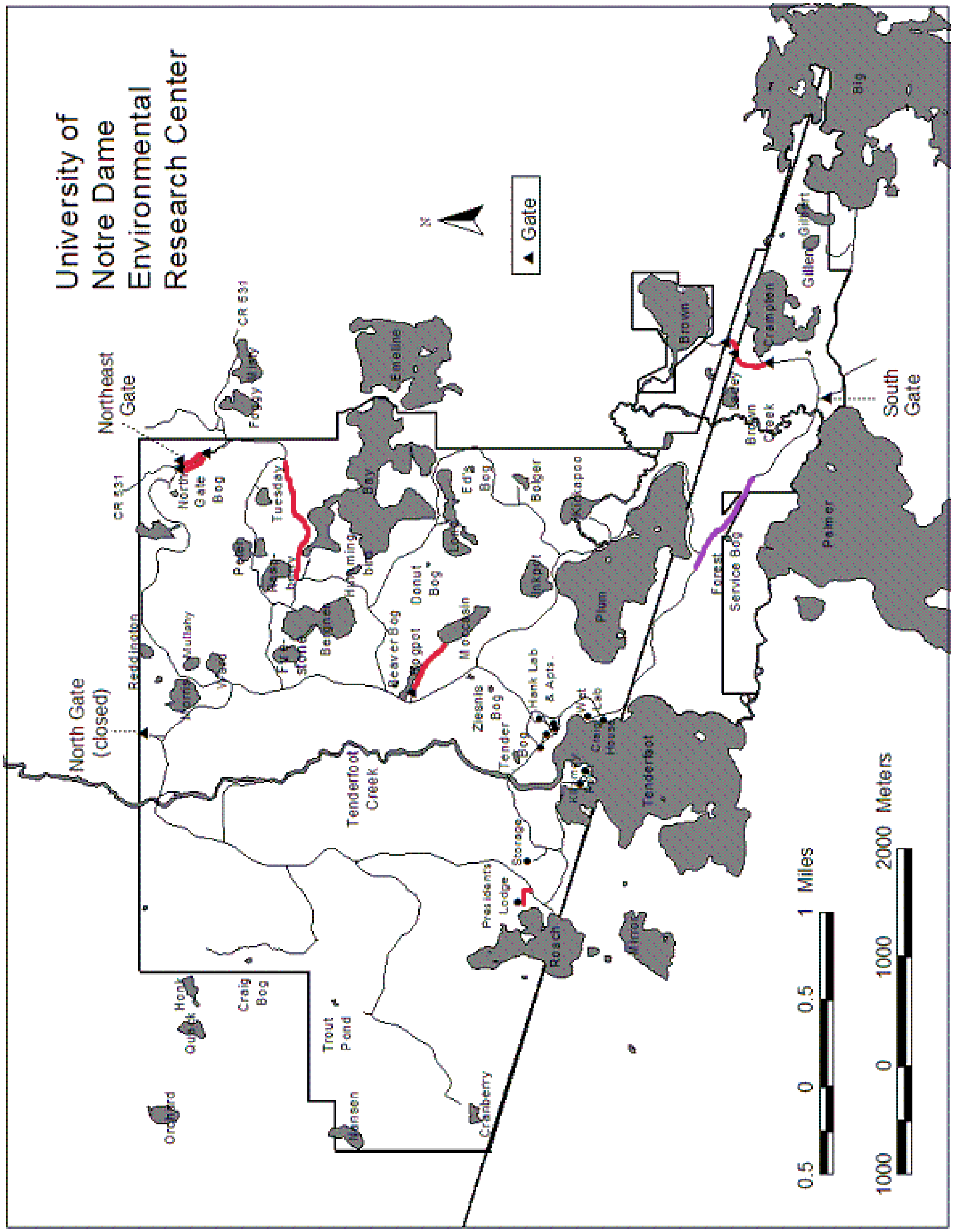

Figure 1. Road map of UNDERC-East property, 2007. Red indicates unmaintained and inaccessible roads. Purple indicates one kilometer of road not surveyed due to powerlines.