Red-shouldered Hawk Productivity, Landscape Analysis, and Nest Site Selection on State Forest Lands in Northern Michigan: Year 2000 Report

Prepared by:
Jeffrey L. Cooper
David L. Cuthrell
Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

For:
Michigan Department of Natural Resources
Forest Management Division
Wildlife Division - Natural Heritage Program

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ABSTRACT

In the early part of the 20th century the red-shouldered hawk (*Buteo lineatus*) was a common bird in southern Michigan. Since then their breeding range may have shifted from southern Michigan to the Northern Lower Peninsula (NLP). Currently the red-shouldered hawk is listed as state threatened in Michigan. We conducted systematic surveys in four state forest areas (Pigeon River, Indian River, Gaylord, and Traverse City). A total of 90 compartments were intensively surveyed during a three year period (1998 – 2000). Nest productivity surveys were also conducted over a three year period to assess the status of populations in Michigan's NLP. Over 80 nests were assessed for nest productivity measures such as nest-site fidelity, nest success, average brood size, and nest predation rates. We also analyzed habitat at the landscape, local site, and nest tree levels.

We found that nesting territories during this study had a high re-occupancy rate (80%) among areas surveyed over the three year study period. Further, territories tended to be evenly distributed in areas that contained large contiguous tracts of suitable habitat (1.5 km $\pm$ 2.6 km). Nest productivity during this study tended to be high (73% successful nests) and brood size averaged 2.2 young per successful nest. Nest predation rates were fairly low with 20% of nests being depredated. Our habitat analysis indicated that nests typically were located within a heavily forested landscape (71% forest cover $\pm$ 3%), primarily composed of upland deciduous forests (53% upland deciduous forest cover $\pm$ 6%). Nests were typically located in northern hardwood stands with well-stocked pole or saw timber (90.2% of all nests documented). Nests also tended to be located near wetlands (80% within 0.4 km) and upland openings (181 m $\pm$ 46 m).

Our data indicates that nest trees tended to be deciduous, primarily beech, however any tree with the right structure, i.e., a multi-pronged crotch, could be suitable. Nests tended to be placed in large, mature, super-canopy trees and the nest itself was placed on average 14.1 m $\pm$ 1.2 m above the ground. At the local site level, canopy height, basal area, tree density, canopy closure, and average tree diameter at breast height (dbh) appear important in nest selection. By utilizing both a landscape and micro nest site approach, insight on distribution and habitat use can be gained which will facilitate sound management of this species. Information from this study is also being used to assess abundance and distribution, which will help determine the appropriate state listing status for this raptor species.

INTRODUCTION

The red-shouldered hawk (*Buteo lineatus*) is currently listed as a state threatened species in Michigan. Historically it was considered one of the most common diurnal raptors in the Southern Lower Peninsula (SLP) (Barrows 1912). However, by the mid-1900's this species had become uncommon in southern Michigan. Population declines have been primarily attributed to loss of forest and wetland habitats. Presumably, as a result of habitat loss, populations shifted their breeding range from southern Michigan to the more forested portions of the state in the Northern Lower Peninsula (NLP) (Brewer et al. 1991). Currently, there are two primary sources of distributional information concerning this species in Michigan. These include the Breeding Bird Atlas with 119 confirmed nests documented during the 1980's (Brewer et al. 1991), and the Michigan Natural Features Inventory's Biological Conservation Database with ~ 250 confirmed nests documented since the early 1980's (Natural Heritage Biological and Conservation Data System 1999). Distributional patterns from each of these databases mirror each other rather closely. Two distinct population clusters are evident, one centered in the NLP including Emmet and Cheboygan counties and the other centered on the Manistee County area. Only scattered occurrences of confirmed red-shouldered hawk nests occur in the SLP and the Upper Peninsula (see special animal abstract in Appendix VI).

This species is a woodland raptor that requires forested landscapes composed of deciduous or mixed forests. The prototypical habitat for this species is mature forested floodplains (Johnsgard 1990). Upland hardwood systems are also utilized when wetland complexes are juxtaposed or interspersed among them (Craighead and Craighead 1969, Postupalsky 1980, Bednarz and Dinsmore 1981, Cooper et al. 1999). In Michigan this species has been most frequently documented in hardwood stands composed of well stocked pole or saw timber, particularly hardwood complexes with associated wetland habitats. Birds have also been documented in older aspen stands (A6/9), lowland poplar stands (P6), cedar swamps (C6/9), lowland conifers (Q6/9), and occasionally in pine communities (W8/9) (Cooper et al. 1999). Red-shouldered hawks are strongly associated with wetlands and the core of a breeding pair's territory typically encompasses wetland habitat. Wetlands such as beaver ponds, wet meadows, and lowland forests are utilized primarily for foraging purposes (Howell and Chapman 1997). Small upland openings are also used to some extent for foraging habitat (Evers 1994). Red-shouldered hawks typically nest in stands of timber with greater than 70% canopy closure (Bryant 1986) and relatively open understories (Evers 1994). Nests are most frequently placed high (usually just below the canopy) in mature deciduous trees and within close proximity of wetland habitat (Titus and Mosher 1981, Woodfry 1986, Ebbers 1986, Cooper et al. 1999). Mature maple, beech, birch, and aspen are frequently used nest trees in Michigan (Ebbers 1989, Cooper et al. 1999). However, any tree species with the appropriate structure (i.e., a multi-pronged crotch just below the canopy) can be utilized.

Purpose of the Inventory

Currently, there is a lack of information on this species' distribution and productivity on Michigan state forest lands. In addition the impacts of forest management practices on habitat use and nest productivity have not been evaluated. This project, which will continue over the next three years, entails systematic surveys on state forest lands, reconfirmation of historical nest sites, and monitoring productivity on a representative subset of nest sites in each state forest area (see Appendix I for five-year work plan, revisions in workplan are highlighted in red). Information gathered from surveys and nest monitoring can be used to identify core areas of nest site concentrations on state forest lands, identify areas that support long-term population viability, and facilitate development of management guidelines. Further, this project, coupled with other related inventories (e.g., red-shouldered hawk inventories on state parks lands, natural areas,

national forest lands, and state game areas) should facilitate assessment of the appropriate state listing status. This report focuses on the first three years of a six year study and includes an assessment of territorial re-occupancy, nest site re-occupancy, and nest productivity. Further, habitat data at the landscape and micro habitat scales from confirmed nest sites and random points are included in this report.

METHODS

Establishment of Calling Stations

Surveys were conducted from early April – mid-May of 1998 - 2000. High priority forest compartments at the Pigeon River Country (PRC) Forest Management Unit, the Indian River (IR) area of the Gaylord Forest Management Unit, the Gaylord South Management Unit (GA), and portions of the Traverse City Forest Management Unit (TC) were intensively surveyed for red-shouldered hawks. Surveys in the TC Forest Management Unit will continue in 2001, since large areas of high quality habitat are still in need of surveys. Large deciduous or mixed forest complexes composed of medium to well stocked pole or saw timber (stocking density 5/6, or 8/9) with wetland habitats juxtaposed or interspersed among them were targeted for surveys. Also, select coniferous forest communities, both wetland and upland, that had a deciduous component and associated wetland habitat were surveyed as well (see Appendix II for cover types surveyed). These types of forest/wetland complexes were delineated by analyzing forest operational inventory (OI) maps, USGS topographical maps, 1978 current land cover maps, 1998 air photos, and by consulting with Michigan Department of Natural Resources (MDNR) Forest Management Division (FMD) and Wildlife Division personnel. Transects were placed every ¼ mile through forest habitats within compartments selected for surveys. Along each respective transect a calling station was placed every ¼ mile. At each calling station a taped conspecific red-shouldered hawk call was broadcast with a predator caller three times: at 60 degrees for 10 seconds, 180 degrees for 10 seconds, and 300 degrees for 10 seconds. This was followed by 30 seconds of listening. This calling sequence was repeated three times at each calling station. When hawks responded to the taped calls observers intensively searched for birds and/or a nest in the direction the call was initially heard (Kennedy and Stahlecker 1993, Bowerman pers. comm.). In addition 2-3 random calling stations were established per compartment surveyed and the same calling sequence mentioned above was utilized. Random calling stations were added to surveys during 1999 for future statistical comparisons in order to differentiate habitat patterns around nest sites from habitat patterns that occur throughout the larger landscape (Moritz, pers. comm.). Currently, over 100 random points have been surveyed in northern Michigan forest areas. Raptor nest reporting forms (Appendix III) were filled out at each survey site and random point. Confirmed nest locations were transcribed and entered into the Michigan Natural Features Inventory's Biological Conservation Database.

Productivity Surveys

During early June of 1998 - 2000, a representative subset of nests were re-visited at least once to assess productivity. Only those nests where incubation was confirmed during April surveys were considered active. Surveys were timed during the later part of nestling stage, usually within a couple weeks of fledging, because young birds are more conspicuous at this time. Two methods were used to assess productivity. These included on-the-ground surveys where the nest is observed from a vantage point or the base of the nest tree is inspected for white wash. A second more definitive method was looking into the nest with a mirror attached to a 15 m (50 ft)

pole. A nest was considered successful if at least one young 80% of the fledgling age was produced (Kochert 1986).

Habitat Structure

Landscape Scale

Habitat data around nest locations documented at the PRC and IR were summarized by utilization of 1998 air photos, OI maps, USGS topographical maps, 1978 current land cover maps, and some limited ground truthing. The percentage of nests occurring in the following categories was calculated: cover type (OI designations), location in upland or lowland, proximity to wetland, distance to nearest upland opening, and stocking density/size class (OI designations). The percent cover of habitat types (Table 1) around nest sites (n=51) and random points (n=48) were calculated by centering the nest site within a 1.8 km x 1.8 km (1 mi x1mi) quadrat (Ebbers 1989, Bowerman pers. comm.). The percent cover of each habitat type was estimated by laying a film transparency grid over the quadrat and counting the number of intersects per habitat type within the grid. The number of intersects per habitat type was divided by the total number of intersects per grid (n = 361) to calculate percent cover per nest site and random point. Percent cover for nest sites and random points was expressed as a mean percent and 95% confidence intervals for each mean percent was calculated as well. Each respective cover type was delineated by utilizing 1998 air photos and OI maps. Distance to wetland habitat and upland openings were measured in the field by pacing if distances were less than 200 m. If distances were greater than 200 m, measurements were derived from 1998 air photos by utilizing a parallax wedge.

Table 1. Description of landscape-level attributes.

Variable	Definition
% Forest	Forest cover included deciduous or coniferous cover that was composed of pole or saw timber
% Open	Area open included grassland, seedling stands, clear-cuts, lowland brush, upland brush, and open water.
% Upland Deciduous Forest	Upland deciduous forest included all forest communities dominated (> 50%) by deciduous trees in upland habitat.
% Wetland Deciduous Forest	Wetland deciduous forest included all forest communities dominated (> 50%) by deciduous trees in wet habitat.
% Upland Conifer Forest	Upland conifer forest included all forest communities dominated (> 50%) by coniferous trees in upland habitat.
% Lowland Conifer Forest	Lowland conifer forest included all forest communities dominated (> 50%) by coniferous trees in wetland habitat.
% Open Water	Open water included lakes, ponds, and impoundments of water
% Wetland Opening	Wetland openings included marsh and lowland brush

Nest Site Variables

Various habitat attributes were summarized during August 2000 at 19 nest sites and 18 random points by centering the nest site in a 0.04 ha (1/10 ac.) plot. These variables included (Trexel et al. 1999):

1) **Nest tree diameter breast height (DBH):** Diameter (cm) at breast height of nest tree.
2) **Nest tree height:** Height (m) of the nest tree estimated by use of a clinometer.

3) **Nest percentage:** Nest height/tree height X 100.
4) **Canopy Height:** Mean height, from the forest floor to the lower portion of the canopy, at five randomly chosen trees within plot.
5) **Canopy closure:** The percentage of the area over the plot occluded by overstory foliage, measured by 40 ocular tube readings.
6) **Ground cover:** The percentage of the ground covered by ground-layer foliage. This was measured by systematically placing 10 sampling points radiating from the nest tree in each of the four cardinal directions. Ground cover was measured by placing a meter stick vertically to the ground every meter along the transect line. When vegetation contacted the front edge of the stick it was counted as a hit. Total ground cover was calculated as the total number of hits/total number of points X 100 (Roberts pers. comm.).
7) **Sapling Density:** The number of woody stems greater than shoulder height and less that 12.7 cm DBH and contained within ½ of the 0.04ha plot.
8) **Shrub Density:** The number of low shrubs < 12.7 cm DBH and shorter than shoulder height contained within ¼ of the plot.
9) **Tree density:** The number of trees $\geq$ 15 cm DBH per 0.04 ha plot.
10) **Basal Area:** m^2/ha trees.
11) **Mean DBH:** Mean DBH (cm) of trees in study plot.

RESULTS AND DISCUSSION

Compartments Surveyed

A total of 40 PRC, 25 IR, 16 GA, and 9 TC compartments (90 total) were systematically surveyed during 1998 – 2000 (Appendix II). In addition, over 100 random points were surveyed in compartments that were systematically surveyed. The majority of compartments containing high quality habitat (i.e., large deciduous or mixed, pole/saw timber complexes juxtaposed or interspersed with wetland habitat) in the PRC, IR and GA areas have been surveyed at least one time. However, large areas of high quality habitat at the TC Forest Management Unit have not been surveyed but are slated for systematic surveys during 2001. Since the amount of suitable habitat within each compartment varied, some compartments were more intensively surveyed than others. Further, a wide range of cover types of varying stocking densities were intensively surveyed for red-shouldered hawks (Appendix II). Varying landscape positions such as very dry upland forest (up to a mile from wetland habitat) and wet lowland forest were systematically surveyed as well. A few habitat types were under represented during surveys and these included red pine stands, white pine stands, and lowland conifers (Q and C types). These habitat types are not typically exploited by red-shouldered hawks for nesting purposes (Johnsgard 1990). However, lowland conifer and white pine stands with a deciduous tree component could provide good nesting habitat for red-shouldered hawks and these habitats will be more intensively surveyed in the future.

Systematic inventories were not conducted at the PRC or IR during 2000 and only a representative sub-set of territories were monitored (PRC = 37 territories monitored and IR 16 territories monitored). This accounts for lower numbers of active territories being documented during 2000 than in previous years when the PRC and IR were intensively surveyed for new nests and territories (Table 2).

Territory Activity

A total of 38 active territories (i.e., area where hawks were heard or had a freshly tended nest) were documented during 1998, 105 active territories during 1999, and 80 active territories during 2000 surveys. (Table 2). Among theses active territories, 28 active nests (i.e., where incubation was confirmed) were located during 1998, 39 during 1999, and 26 during 2000, for a total of 93 nest sites found between 1998-2000. No nests were found near random points. The number of active territories and nests varied annually and by Forest Management Unit (Table 2). Survey and monitoring efforts in the GA and PRC were hampered during 2000 due to cold temperatures and high winds. Poor weather conditions, particularly high winds tends to decrease avian activity in general (Bibby et al. 1992) as well as red-shouldered hawk response rates to con-specific calls. The result was most likely a lower detection rate of territorial and nesting birds at the GA and PRC Forest Management Units.

Territorial re-occupancy (i.e., territories occupied during successive years) was high among all forest areas (Table 2). During 1999, 78% of the territories documented during 1998 (n=27) were re-occupied, 81% of the territories documented during 1999 (n=52) were re-occupied by territorial hawks during 2000. The overall re-occupancy rate of territories during successive years of the study has been high (80%) (Table 2). Jacobs and Jacobs (1997) reported that an 83% re-occupancy rate (range = 53% - 83%) was the highest they have documented in Wisconsin between the years of 1992 – 1997. The percentage of territories re-occupied between 1998 and 2000 at Northern Lower Michigan forest management units compares rather well to the high re-occupancy rate documented by Jacobs and Jacobs (1997).

Nest site fidelity, which occurs when a pair utilizes the same nest as the previous year, was high as well during 1999 and 2000 (Table 2). Fifty percent of the nests utilized in each forest area (PRC, n=18; IR, n=8) during 1998 were re-occupied during 1999 and 60% of nests utilized during 1999 were used as nest structures in 2000 (PRC, n=14; IR, n=7; GA, n=2; TC, n=2) for a two year average of 55%. Johnsgard (1990) felt that a nest re-occupancy rate of 37%, which was documented by Jacobs et al. (1988) in Wisconsin, was high. Dijak et al. (1990) in Missouri found a 35% re-occupancy of nests in successive years, which is similar to the rate reported in Wisconsin. Nest site fidelity on Michigan state forest lands clearly exceeds rates documented in Wisconsin and Missouri.

At the PRC, known active nest sites were distributed rather evenly throughout large contiguous hardwood/wetland complexes during 1999. The average distance between nests within these complexes was 1.5 km $\pm$ 0.26 km (0.93 mi $\pm$ 0.16 mi). In large contiguous areas of suitable habitat in Maryland and Georgia the average distance between nest sites was 2.1 km and 2.0 km, respectively (Stewart 1949, Howell and Chapman 1997). Uniform nest site spacing is a phenomenon that typically happens in large contiguous areas of suitable nesting habitat in order to abate territorial overlap, thus reducing interference in breeding and hunting among pairs (Howell and Chapman 1997). This phenomenon was evident at the PRC during this study, which suggests that large areas of the PRC Forest Management Unit offer suitable nesting habitat for the red-shouldered hawk, provided sufficient prey base is available in a given year. Uniform nest spacing at the IR, GA, and TC forest area was not as apparent. This could be attributed to differences in landscape composition. Also, fragmented ownership patterns did not allow entire forest complexes to be surveyed due to private in-holdings.

Table 2. Breeding territory activity at four northern Michigan state forest areas (1998 – 2000).

Reproductive Variable	Pigeon River	Indian River	Gaylord	Traverse City	Overall
Number of Territories[1]	**1998** - 21	**1998** - 17	**1998** - NA	**1998** - NA	**1998** - 38
	1999 - 49	**1999** - 30	**1999** - 18	**1999** - 8	**1999** - 105
	2000 - 22	**2000** - 17	**2000** - 18	**2000** - 23	**2000** - 80
Territories Reoccupied [2]	**1999**- 14 /19 (74%)	**1999** - 7 / 8 (88%)	**1999** - NA	**1999** - NA	**1999** - 21 /27 (78%)
	2000 – 22/ 27 (59%)	**2000** – 12 /16 (75%)	**2000** – 6/7 (86%)	**2000** - 2/ 2 (100%)	**2000** – 42 /52 (81%)
					Average - 80%
New Nests [3]	**1998** - 19	**1998** - 9	**1998** – NA	**1998** – NA	**1998** - 28
	1999 - 18	**1999** - 8	**1999** – 8	**1999** – 5	**1999** - 39
	2000 - 7	**2000** - 4	**2000** - 4	**2000** - 11	**2000** - 26
					3-year total - 93
Nest Site Fidelity [4]	**1999** - 9 /18 (50%)	**1999** - 4 / 8 (50%)	**1999** - NA	**1999** - NA	**1999** - 13/ 26 (50%)
	2000 - 8/14 (57%)	**2000** - 5/7 (71%)	**2000** - 0/2 (0%)	**2000** - 2/2 (100%)	**2000** - 15/25 (60%)
					Average - (55%)

[1] Areas where red-shouldered hawks were observed, heard, or had a freshly tended nest during the breeding season.
[2] The percentage of territories re-utilized during successive years.
[3] The number of newly discovered active hawk nests.
[4] The percentage of nests re-utilized during successive years.

Nest Productivity

A representative sub-set of the nests documented during this study were re-visited during June, 1998 - 2000 (Table 3). Nest productivity among northern Michigan forest areas surveyed was high (73% successful) (Table 3). Average brood size (number of young per successful nest), from nest site data combined for all forest areas between the years of 1998 - 2000 was 2.2 young per successful nest (n=24) (Table 3).

Nest predation was confirmed (e.g., claw marks on trees, den tree nearby, nests torn apart, remains of adult hawk, etc.) at 20% of occupied nests between 1998 – 2000 (Table 3). The fate of the remainder of the nests (7%) is unknown. The primary nest predator implicated was the raccoon (*Procyon lotor*) and great-horned owl (*Bubo virginianus*). Five adult red-shouldered hawks were killed during 2000 on or near the nest. These deaths were most likely the result of predation by great-horned owls. Jacobs and Jacobs (1997) and Ebbers (1989) also documented the raccoon and great-horned owl as primary predators of red-shouldered hawks in Wisconsin and Michigan, respectively. In addition, a few instances black bear (*Ursus americana*) were implicated in nest predation..

Table 3. Productivity of red-shouldered hawk nests at four northern Michigan state forest areas (1998 – 2000).

Reproductive Variable	Pigeon River	Indian River	Gaylord	Traverse City	Overall
Percentage of Successful Nests [1]	**1998** - 8 /13 (62%) **1999** - 16 / 21 (76%) **2000** - 10/16 (63%)	**1998**- 5 /7 (71%) **1999** - 9 /9 (100%) **2000** - 7/9 (78%)	**1998** - NA **1999** - 3/4 (75%) **2000** - 2/4 (50%)	**1998** - NA **1999** - NA **2000** - 5/6 (83%)	**1998** - 13 /20 (65%) **1999** - 28 /34 (82%) **2000** - 24/35 (69%) **Average** - 65/89 (73%)
Number of Young per Successful Nest [2]	**1999** - 2.3 (n=7) **2000** - 1.7 (n=3)	**1999** - 2.3 (n=3) **2000** - 2.5 (n=7)	**1999** - 2 (n=1) **2000** - 2.0 (n=1)	**1999** – NA **2000** – 2.0 (n=4)	**1999** - 2.36 (n=11) **2000** - 2.1 (n=12) **Average** - 2.2 (n=23)
Predation Rates [3]	**1998** - 3 /13 (23%) **1999** - 3 /21 (14%) **2000** - 5/16 (31%)	**1998** - 1 /7 (14%) **1999** - 0 / 9 (0%) **2000** - 2/9 (22%)	**1998** - NA **1999** - 1/4 (25%) **2000** - 2/4 (50%)	**1998** - NA **1999** - NA **2000** - 1/6 (17%)	**1998** - 4 /20 (20%) **1999** - 4 /34 (12%) **2000** - 10/35 (29%) **Average** - 18/89 (20%)

[1] The percentage of nests with $\geq$ 1 young produced to 80% of the fledgling age (4 – 4.5 weeks old)
[2] The average number of nestlings 80% of the fledgling age per successful nest
[3] The percentage of nests that were destroyed by a nest predator

Nest success rates were good over the past three years and compare rather favorably with other studies concerning this species (Table 4). However, wide variations in nesting success rates can occur annually (Jacobs and Jacobs 1997, Stavers et al. 1995, and Henny et al. 1973). Monitoring of nest success rates at all forest areas only spans a three year period and varied somewhat between years. Therefore, in order to fully assess population viability at northern Michigan state forest areas, monitoring will need to continue over the next several years. Monitoring of nest sites is tentatively planned until 2003. Henny et al. (1973) felt that a recruitment rate of 1.95 young per successful nest with at least 77% of all nesting attempts being successful was needed to replace annual mortality. Jacobs and Jacobs (1998) argued that Henny's model was biased too high due to a small sample size and large variation in the range of recruitment rates among years. Jacobs and Jacobs (1998) analyzed productivity data from Wisconsin using a computer population model (PD: Population Dynamics Modeling, Version 4.0 C). From this model they estimated that a recruitment rate of 1.4 young per successful nest with over 50% of nesting attempts being successful was needed to replace annual mortality (Jacobs pers. comm.). Recruitment rates and nest success during this study slightly exceeded Henny's viability estimate and clearly exceeded Jacob and Jacobs estimates. This may suggest that over the past three years red-shouldered hawk recruitment has exceeded annual mortality and the population in the study area may have produced a surplus of birds.

The results from this study are counter to results obtained by Ebbers (1989) which documented a moderate nest success rate (56.8% nest success) and low numbers of young produced per successful nest (1.2 young per successful nest). In fact, Ebbers felt that the red-shouldered hawk population in the Straits region functioned as a population "sink" (i.e., annual mortality was greater than annual recruitment) and that the population in the Manistee County area functioned as a "source" population (annual recruitment was greater than annual mortality). Our study suggests that the red-shouldered hawk population in the Straits region between the years of 1998 – 2000 may have been functioning as a source population and not a sink. The

reason nest success and recruitment rates differed between Ebbers study and this study is probably due to multiple reasons, many of which may never be fully understood. One explanation for these differences may be due to weather. Jacobs and Jacobs (1997) and Newton (1979) felt that weather and prey availability can influence nesting success in multiple ways. During mild weather, prey base (e.g., small mammals, frogs, snakes, etc.) most likely is higher and red-shouldered hawks have more to eat and more food to feed their broods, which leads to higher reproductive success. Also, if prey base is high, predators probably exploit these animals as a food resource rather than killing red-shouldered hawks (Jacobs and Jacobs 1997). During the three years that surveys were conducted on state forest lands, particularly during 1999, winters were very mild and spring weather began earlier than normal. During Ebbers study weather may have been more severe and the winter weather may have lasted longer. Therefore, mild weather conditions during this study may have produced a greater prey base, which may have reduced the rates of predation on red-shouldered hawk nests, and increased food availability, and ultimately increased nesting success. Other reasons for different estimates of nest success and recruitment rates between this study and Ebbers' study may include differences in survey methodology, maturation of forests, changing habitat structure, differences in sample sizes between studies (Table 4), and changes in the abundance of nest predators/competitors in the region. Continued monitoring of productivity over a period of several years within each forest area will provide a six year data set which should reveal factors that limit or enhance nest productivity.

Table 4. Comparison of red-shouldered hawk nest success rate at four northern Michigan state forest areas with eight other studies.

Location	No. Nests Studied	% of Nests Successful	No. Young Fledged / Successful Nest	Source
California	29	66	1.3	Wiley 1975
Central and ne. Wisconsin 1990-97	449	50	1.1	Jacobs and Jacobs 1997
Central Maryland	74	68	1.6	Henny et al. 1973
Central Ontario	6	83	1.8	Armstrong and Euler 1982
Iowa	8	88	2.9	Bednarz 1979
Missouri	9	100	2.6	Kimmel and Fredrickson 1981
Northern Michigan 1986-1988	44	57	1.2	Ebbers 1989
Northern Michigan 1998-1999	**89**	**73**	**2.2**	**This report**
Western Maryland	17	53	1.8	Janik and Mosher 1982

Habitat Structure

One of the objectives of this study was to determine if red-shouldered hawks use select portions of the landscape for nesting habitat. Varying cover types (e.g., open habitat, deciduous forest, coniferous forest, etc.) and landscape positions such as very dry upland forest (up to a mile from wetland habitat) and wet lowland forest were extensively and systematically surveyed

among four state forest area over the past three years. A few habitat types were under represented during surveys and these included red pine stands, white pine stands, and lowland conifers (Q and C types). These habitat types are not believed to be typically exploited by red-shouldered hawks for nesting purposes (Johnsgard 1990). However, lowland conifer and white pine stands with a deciduous tree component could provide good nesting habitat for red-shouldered hawks. In addition over 100 random points among forest area compartments surveyed were sampled. No nest sites were found near random points (> 100 sampled). Occasionally a territorial bird responded to a con-specific call from a random point in habitat that was presumed to be inactive and not suitable for nesting. However, in virtually every case, observers followed the bird quite a distance from the random point into more "ideal" red-shouldered hawk habitat (e.g., deciduous/mixed forest near wetland habitat). These results indicate that red-shouldered hawks do not occur randomly on the landscape and that certain habitat attributes at the landscape and micro scales appear to influence selection of nesting habitat. Important attributes at both scales are discussed below.

Landscape Scale

Analysis of landscape-level attributes revealed some interesting patterns around nest sites. Fifty-one nest sites and 48 random points were analyzed for landscape composition. The majority of the landscape surrounding both nest sites and random points was largely forested (71% $\pm$ 3% forest cover and 66% $\pm$ 5% forest cover, respectively) (Table 5). However, nest sites tended to be located in more heavily forested portions of the landscape. In contrast, random points had larger percentages of open-land habitat (Table 5). Nest sites were also surrounded by greater percentages of upland deciduous forest than random points (53% $\pm$ 6% upland deciduous forest cover for nest sites and 45 % $\pm$ 7% upland deciduous forest cover for random points). Further, random points had a greater portion of the landscape composed of upland conifer forest than nest sites (11% $\pm$ 4% and 7% $\pm$ 3%, respectively). The percent cover of wetland deciduous forest, lowland conifers, and open water was quite variable and occurred in small percentages for both nest sites and random points (Table 5). Nest sites tended to be located very near wetland habitat and upland openings (Table 5). In comparison, random points had highly variable distances to both wetlands and upland openings (Table 5).

The vast majority of nest sites (79.3%) were located in northern hardwood stands. Stands of aspen, oak, lowland conifer, and white pine contained smaller percentages of nest sites (Table 5). Random points were located in northern hardwoods at much lower percentages (Table 5). The vast majority of nests (90.2%) were also located in well stocked pole/saw timber stands. Nests were never located in poorly stocked pole timber stands or seedling stands and occurred in small percentages in poorly and medium stocked saw log stands (Table 5). Nests and random points occurred in the exact same percentages for upland and lowland habitat (Table 5).

Throughout the species' range, red-shouldered hawks are generally associated with floodplain forests (Evers 1994). However, Bednarz and Dinsmore (1981) found that red-shouldered hawks will use large, contiguous upland forest complexes, which may compensate for a lack of floodplain habitat. Postupalsky (1980) and Ebbers (1989) also documented red-shouldered hawks utilizing upland forest adjacent to wetland habitats in northern Michigan. In northern Michigan forest areas, extensive tracts of floodplain forest are lacking. However, landscapes in these forest areas are composed of a complex matrix of upland forests and a variety of wetland habitats. Red-shouldered hawks in the forest areas studied appear to select more heavily forested portions of the landscapes for nesting habitat that contain dense stands of deciduous/mixed forest. This is apparent when one compares nest sites to random points. Nest sites had higher percentages of forest cover and markedly higher percentages of upland deciduous forest cover. Random points had more open habitat and markedly higher percentage of upland confer forest. Howell and Chapman (1997) and Johnsgard (1990) found that red-shouldered hawks nests tended to occur

most frequently in forested landscapes composed of deciduous/mixed forest and tended to use coniferous forest sparingly. Results from this concur with Howell and Chapman and Johnsgard's results. Nests also tended to be located in denser stands of timber (i.e., well stocked pole/saw timber) and were not found or occurred in smaller percentages in seedling stands and poorly to medium stocked pole/saw timber (Table 5). In contrast, random points occurred in all stocking classes, with the exception of classes 0 and 1 (Table 5). The percent of nests occurring in well stocked saw timber, when compared to random points, was considerably higher (40.2% and 15.0%, respectively). These results give credence to the theory that red-shouldered hawks prefer relatively mature stands of deciduous/mixed forest for nesting habitat. Preston et al. 1989 and Jacobs and Jacobs (1997) describe red-shouldered hawks as using relatively mature stands of timber for nesting.

Red-shouldered hawk nests also tended to be located very near wetland habitats (80 % within 463 m). The mean distance of nest sites to wetland habitat had a tight confidence interval (362 m $\pm$ 97 m), whereas the confidence interval for random points was quite variable (394 m $\pm$ 234 m) (Appendix IV). What this data suggests is that red-shouldered hawks prefer portions of the landscape near wetlands for nest placement. Random point distance to wetland habitat in the study area was quite variable. Howell and Chapman (1997) also found that red-shouldered hawks heavily exploit the ecotone between uplands and wetlands in Georgia. The consistent documentation of nests near wetlands in our study follows habitat patterns noted by Howell and Chapman. Red-shouldered hawk nests also tended to be located close to upland openings and the confidence interval for the mean distance to upland openings was fairly tight (Table 5 and Appendix IV). In comparison, random points had a confidence interval for mean distance to upland opening that was quite large (Table 5 and Appendix IV). What this suggests is that red-shouldered hawks prefer to place nests near small upland openings. Boskowski and Smith (1997) found that red-shouldered hawks tended to place nests close to upland openings and wetlands. Results from this study follow similar patters.

Even though red-shouldered hawk nests tend to be relatively close to upland openings, it cannot be over emphasized that an increase in forest fragmentation (i.e., significant reduction in overall forest cover) across a landscape could likely result in an influx of nest competitors such as the red-tailed hawk (*Buteo jamaicensis*) and nest predators such as the great-horned owl. Both of these raptor species respond favorably to reduced forest cover (Bosakowski and Smith 1997), which could significantly inhibit red-shouldered hawk nesting success (Bryant 1986, Bosakowski and Smith 1997). Abatement of forest fragmentation can reduce the influx of nest predators and competitors. Currently, the red-tailed hawk population in the forest areas studied appears to be low, which is probably due to the heavy forest cover throughout the larger landscape. In fact, less than 10 red-tailed hawks have been observed during three years of survey effort and these observations were largely confined to edges of large openings and major highways. In addition, no documented red-tailed hawk nests were ever found during this study period. During the 1980's, Breeding Bird Atlas surveyors documented low to moderate numbers of red-tailed hawks in the current study area (Brewer et al. 1991). Furthermore, Ebbers (1989) also felt that red-tailed hawks were not a limiting factor in the forest areas surveyed. Great-horned owl abundance in the study area is not known. However, overall numbers for this species are probably low to moderate due to the landscape being largely forested. Breeding Bird Atlas data from the 1980's indicates that great-horned owl numbers were low to moderate in the forest areas studied. However, in localized areas/sites this species may inhibit nest success of red-shouldered hawks. During 2000 surveys, five adult red-shouldered hawks were killed on or near the nest during the incubation or during the brood rearing stage. Based on evidence at the nest site (i.e., remains of a plucked bird), great-horned owls were most likely the predator that killed adults. Moreover, Ebbers (1989) felt that in northern Michigan great-horned owls may be a factor that limits nest success in localized areas.

Table 5. Landscape-level attributes around red-shouldered hawk nest sites at the Pigeon River Country (PRC) and Indian River (IR) forest areas (1998 – 2000).

Landscape Variable	Nest Sites	Random Points
% Forest	71% ± 3% (n=51)	66% ± 5% (n = 48)
% Open Habitat	29% ± 3% (n=51)	34% ± 5% (n = 48)
% Upland Forest	53% ± 6% (n=51)	45% ± 7% (n = 48)
% Wetland Deciduous Forest	3% ± 2% (n=51)	2% ± 1% (n = 48)
% Upland Conifer Forest	7% ± 3% (n=51)	11% ± 4% (n = 48)
% Upland Opening	24% ± 1% (n=51)	27% ± 4% (n = 48)
% Lowland Conifer	8% ± 3% (n=51)	8% ± 2% (n = 48)
% Open Water	2% ± 2% (n=51)	1% ± 1% (n = 48)
% Wetland Opening	3% ± 1% (n=51)	6% ± 3% (n = 48)
Cover Type[1]	Northern Hardwoods - 79.3% (n = 82) Oak - 3.7% (n=82) Aspen - 6.1% (n=82) White Pine - 2.4% (n=82) Birch - 2.4% (n=82) Lowland Conifer - 2.4% (n=82) Cedar - 2.4% (n=82) Lowland Hardwood - 1.3 (n=82)	Northern Hardwoods - 26.5% (n = 48) Oak - 4.1% (n = 48) Aspen - 43% (n = 48) White Pine - 4.1% (n = 48) Birch - 2.0% (n = 48) Lowland Conifer - 6.1% (n = 48) Cedar - 4.1% (n = 48) Fir - 2.0% (n = 48) Grass - 2.0 (n = 48) Red Pine - 6.1% (n = 48)
Stocking Density/Size Class[2]	2 = 0% (n=82) 3 = 0% (n=82) 4 = 0% (n=82) 5 = 4.9% (n=82) 6 = 50% (n=82) 7 = 1.2% (n=82) 8 = 3.7% (n=82) 9 = 40.2% (n=82)	2 = 4.3% (n = 48) 3 = 19.1% (n = 48) 4 = 8.5% (n = 48) 5 = 8.5% (n = 48) 6 = 40.4% (n = 48) 7 = 2.1% (n = 48) 8 = 2.1% (n = 48) 9 = 15.0% (n = 48)
Location of Nest (upland or lowland)	85% Upland (n=82) 15% Lowland (n=82)	85% Upland (n = 48) 15% Lowland (n = 48)
Proximity to Upland Opening	181 m ± 46 (n=51)	231 m ± 184 m (n = 48)
Proximity to Wetland	362 m ± 97 m (n=51)	395 m ± 234 m (n = 48)

[1] The number of nests/random points, expressed as a percentage, occurring in a cover type.
[2] The number of nests/random points, expressed as a percentage, occurring in the following stocking density/size classes: 2 = medium stocked seedlings, 3 = well stocked seedlings, 4 = poorly stocked pole timber, 5 = medium stocked pole timber, 6 = well stocked pole timber, 7 = poorly stocked saw timber, 8 = medium stocked saw timber, and 9 = well stocked saw timber.

Nest Site Variables

The majority of nests were placed in mature beech trees (39%); only a few nests occurred in conifers (2%) (Table 6). Apfelbaum and Seelbach (1983) examined 283 red-shouldered hawk nests nation-wide and found that 90% of nest trees were deciduous and the most commonly used

genera were oaks (*Quercus* spp.) and beech (*Fagus* spp.). Beech trees frequently provide optimal structure (i.e., multi-pronged crotch just below the canopy) and the presence of mature beech trees in hardwood stands may be a very important micro-habitat factor that influences hawk utilization of nesting habitat (Ebbers 1989). However, the diversity of nest trees utilized in Michigan seems to indicate that tree structure and not the type species is the most important factor that influences use of a tree for nest placement. Nests were typically placed high (14.3 m $\pm$ 1.2 m) and within a multi-pronged crotch of the tree, which concurs with results obtained by Titus and Mosher (1981). Nest trees also tended to be mature, tall, super-canopy trees (height = 27.7 m $\pm$ 1.6 m, dbh = 52.8 cm in $\pm$ 6.4 cm). Nest percent (i.e., the nest height divided by the overall tree height X 100) was 52%. In a northern Michigan study conducted by Ebbers (1989) and a study in Maryland (Titus and Mosher 1981), nests were usually placed between 10.6 m – 18.3 m above the ground and 1/2 – 2/3 the way up the nest tree. Results from this study mirror rather closely the descriptions of nest tree structure in northern Michigan and Maryland. Nineteen plots (0.04 ha) around nest sites and 18 plots (0.04 ha) around random points were sampled for structural attributes (Table 7). Stands of timber that housed red-shouldered hawk nests had higher canopies than random points. Basal area, tree density, canopy closure, and average dbh per plot was greater around nest sites than random points. Sapling density and shrub density were highly variable for both nest sites and random points. Ground cover was virtually identical for nest sites and random points (Table 7).

On average, stands of timber that housed red-shouldered hawk nests were taller and denser than random points and the 95% confidence interval for mean canopy height was rather narrow for nest sites and random points. This data may reflect red-shouldered hawks preferring taller stands of timber within forest complexes for nesting. Preston et al. (1989), Titus and Mosher (1981), and McLeod (2000) also found that red-shouldered hawks prefer stands of timber with high canopies. Basal area around nest sites was high with little variation around the mean (Table 7, Appendix IV). In contrast, random points had a fairly high basal area but greater variation around the mean was evident (Table 7, Appendix IV). These results may suggest that red-shouldered hawks select stands of timber with higher basal areas and in un-occupied habitat basal area varies considerably. Kimmel and Fredrickson (1981), Portney and Dodge (1979), and Parker (1986) all found that red-shouldered hawks prefer stands of timber for nest placement that have high basal areas (99.5 ft^2 – 159 $ft.^2$). This study supports the results obtained by these researchers. Other nest site variables with tight confidence intervals that were greater than attributes at random points included tree density, canopy closure, and average dbh per plot. All of these variables suggest that red-shouldered hawks prefer the dense, relatively mature portions of forest complexes for nesting habitat. Further, these results are consistent with studies conducted by Ebbers (1989), Titus and Mosher (1981), and McLeod (2000).

Table 6. Nest tree species utilized by red-shouldered hawk at four northern Michigan state forest areas (1998 – 2000).

Tree Species	Percent Used (n = 94)
American Beech (*Fagus grandifolia*)	39%
Sugar Maple (*Acer saccharum*)	19%
White birch (*Betula papyrifera*)	14%
Basswood (*Tilia americana*)	9%
Aspen (*Populus* spp.)	9%
Red Oak (*Quercus rubra*)	3%
White ash (*Fraxinus americana*)	3%
Yellow birch (*Betula lutea*)	1%
American Elm (*Ulmus americana*)	1%
Jack Pine (*Pinus banksiana*)	1%
White pine (*Pinus strobus*)	1%

Table 7. Red-shouldered hawk nest site characteristics at four northern Michigan state forest areas (1998 – 2000).

Structural Attribute	Nest Site (n = 19)	Random Point (n = 18)
Nest Height	14.3 m ± 1.2 m (47.2 ft ± 4.0 ft)	NA
Nest Tree Height	27.7 m ± 1.6 m (91.3 ft ± 5.2 ft)	NA
Nest Percent	52.0% ± 4.5%	NA
Nest Tree dbh	52.8 cm ± 6.4 cm (20.8 in ± 2.5 in)	NA
Canopy Height	13 m ± 1.0 m (43.0 ft ± 3.4 ft)	8.2 ± 2.1 m (27.0 ft ± 7.0 ft)
Basal Area	10 m2 ± 1.2 m^2 (112 ft^2 ± 12.7 ft^2)	9.3 m2 ± 2.7 m^2 (100 ft^2 ± 29 ft^2)
Tree Density/0.04 plot	18.9 ± 2.9	13.8 ± 4.5
Sapling Density	36.9 ± 17	36.7 ± 23.7
Shrub Density	66.4 ± 41	44.4 ± 34.2
Canopy Closure	89.4% ± 2.5%	71.3% ± 16.9%
Average Tree dbh/0.04 plot	11.05 ± 0.74	10.0 ± 4.9
Ground Cover	60.0% ± 9.7%	60.0% ± 15%

CONCLUSIONS

Hawk surveys on northern Michigan state forest areas were highly successful and greater insight into habitat utilization and distribution patterns within each forest area was gained. Further, all reproductive parameters (i.e., territorial re-occupancy, nest site fidelity, nest success, brood size) compare favorably with other studies concerning this species. However, long-term trend data concerning productivity measures is needed to fully assess population viablity. The results from inventories and nest monitoring, at state forest areas studied, as well as future work in other Northern Lower and Upper Peninsula forest areas, should provide very valuable information. This information can be used to identify core areas of nest site concentration that support long-term viability, facilitate development of management guidelines, assess the impacts of forest management practices on habitat use and productivity, and evaluate the hawk's status in Michigan.

FUTURE WORK

Over the next three years at least 20 representative nest sites (if available) on six forest areas in the NLP, and possibly several more in the UP, will be monitored for territorial re-occupancy, nest site fidelity, nest success, and brood size (Appendix I). Habitat parameters (landscape and micro-habitat scales) will continue to be quantified and summarized for all nest locations documented to date. Random point data was collected in all compartments surveyed and half of the random points
(n = 48) sampled have had habitat parameters quantified and summarized at the landscape scale. Eighteen of the random points have been summarized and quantified at the micro-habitat scale. Data from random points will continue to be collected, summarized, and analyzed for current forest areas surveyed as well as areas to be surveyed over the next three years. Nest site data and random point data will be statistically compared to differentiate habitat patterns around nest sites from habitats patterns that occur throughout the larger landscape. Ultimately, habitat data from

multiple scales will be used to develop a predictive habitat model to facilitate management decisions. Finally, by the end of this multi-year project, we hope to compare attributes around successful nests and unsuccessful nests to better evaluate efforts to enhance reproductive success.

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Color Plates

Photo Captions

a.) Jeff Cooper (MNFI) broadcasting con-specific red-shouldered hawk call with game caller, Indian River State Forest Area, April 2000.

b.) Adult red-shouldered hawks soaring high in sky, Gaylord State Forest Area, June 2000.

c.) Active red-shouldered hawk nest in a mixed conifer swamp (Q9 stand), Traverse City State Forest Area, April 2000.

d.) Close-up of active red-shouldered hawk nest in white birch tree, Traverse City State Forest Area, April 2000.

e.) Red-shouldered hawk nestling peeking over nest in white birch tree, Traverse City State Forest Area, June 2000.

Photo Plate I

a.

b.

c.

d.

e.

Photo Captions

a.) David Cuthrell (MNFI) recording micro-site data under red-shouldered hawk nest, Indian River State Forest Area, August 2000.

b.) Jeff Cooper using a clinometer to measure tree heights in micro-habitat plot, Indian River State Forest Area, August 2000.

c.) Jeff Cooper using Biltmore stick to measure diameter at breast height (dbh) of nest tree, Indian River State Forest Area, August 2000.

Photo Plate II

a.

b.

c.

Photo Captions

a.) Close-up view of mirror pole with mirror positioned above active red-shouldered hawk nest, Pigeon River County State Forest Area, June 2000. Two red-shouldered nestlings are visible in mirror.

b.) Immature red-shouldered hawk standing on edge of nest, Traverse City State Forest Area, June 2000.

Photo Plate III

a.

b.

Photo Captions

a.) Jeff Cooper with mirror pole fully extended to height of active nest (~ 50 ft), Traverse City State Forest Area, June 2000.

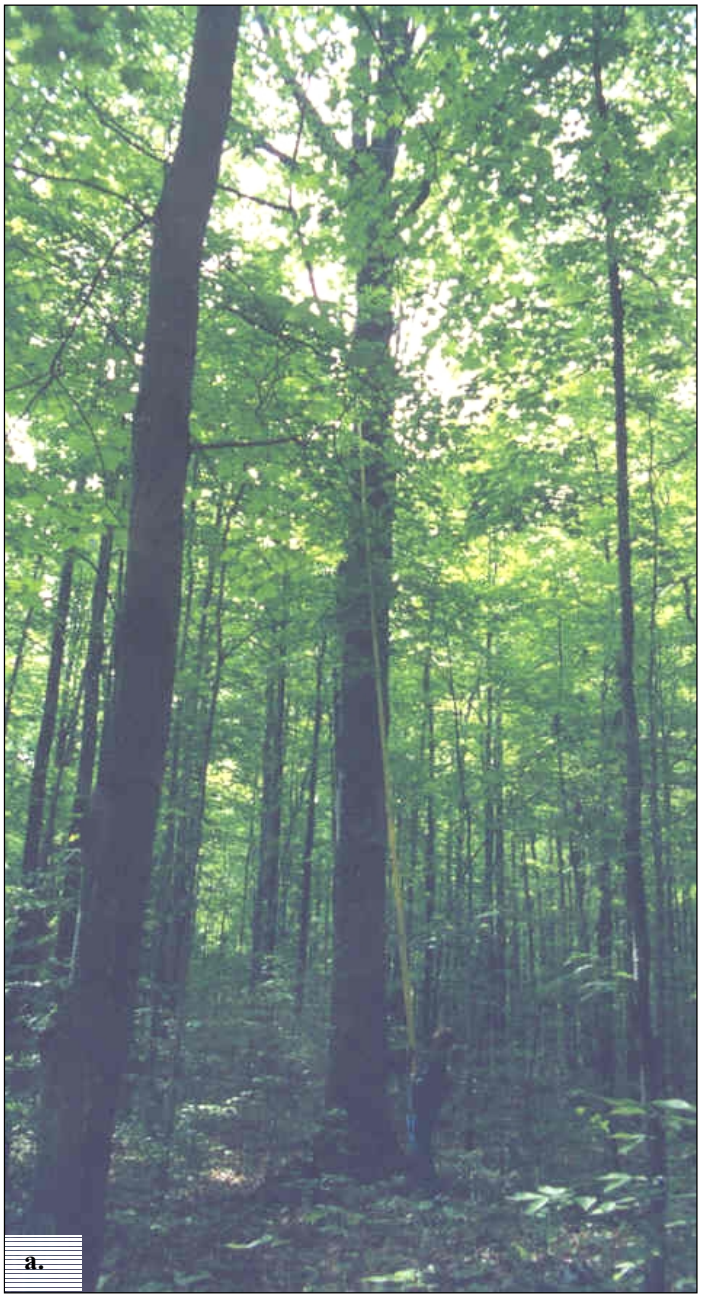
b.) Close-up view of mirror pole with one red-shouldered hawk nestling visible, Pigeon River State Forest Area, June 2000.

c.) Arch Reeves (retired FMD forester) providing verbal guidance as Jeff Cooper extends mirror pole above active red-shouldered hawk nest, Pigeon River Country State Forest Area, June 2000.

d.) Two of three red-shouldered hawk nestlings visible at nest, Traverse City State Forest Area, June 2000.

e.) Close-up view of red-shouldered hawk nestlings in nest, Traverse City State Forest Area, June 2000.

Photo Plate IV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APPENDIX I

Red-shouldered hawk five year work plan for surveys on state forest lands in Michigan.

Forest Management Division

Red-shouldered Hawk 5-Year Work Plan

Statement of need

The Forest Management Division and Wildlife Division are jointly responsible for management of the State Forests for perpetuation of the resources of forest products, recreation and wildlife habitat. In addition, the Divisions are responsible for assuring that management activities do not harm threatened and endangered species. The red-shouldered hawk is a state threatened species for which concern has been expressed regarding impacts of management. Currently, there is a lack of information on this species' distribution and productivity on state forest lands as well as the impacts of forest management practices. This project will entail systematic surveys on state forest lands, reconfirmation of historic nest sites, and monitoring of productivity of a subset of nest sites in each state forest area. Information gathered from surveys and nest monitoring can be used to identify core areas of nest site concentrations on state forest lands, identify areas that support long-term viability, facilitate development of management guidelines, evaluate the appropriate state listing status, and assess the impacts of forest management on habitat use and nest productivity. This project continues the work of last year's highly successful systematic surveys of the Pigeon River and Indian River Forest Areas. These surveys resulted in identification of core areas of nest-site concentration, productivity of nests, and insights on habitat use. This information facilitated development of draft management guidelines by DNR's Woodland Raptor Working Group. Although the project initially does not specifically address assessment of management impacts we will be actively pursuing opportunities to incorporate this component into the study during subsequent years.

* Changes from original workplan are highlighted in red. Changes were due to a variety of reasons including: a reduction in the proposed budget, larger amounts of suitable habitat in the study area than anticipated, as well as a greater number of nesting territories documented.

Work Plan

Year 1

- Finish systematic surveys in the Pigeon River and Indian River Forest Areas.
- Re-check nesting areas documented during 1998 at the Pigeon River and Indian River Forest Areas.
- Systematically survey the South Gaylord Forest Management Unit
- Monitor 20 nests, or as many as available if less than 20 nests sites, in each forest area

Year 2

- Check nest territories documented during previous years in Pigeon River, Indian River, and S. Gaylord Management Unit to locate active nests
- Begin systematic surveys in the Traverse City Forest Management Unit and finish systematic surveys in the Gaylord South Forest Management Unit.
- Monitor 20 nests, or as many as available if less than 20 nest sites, in each forest area

Year 3

- Check nest territories documented during previous years in Pigeon River, Indian River, S. Gaylord, and Traverse City.
- Begin systematic surveys in the Gladwin Forest Management Unit, select areas in the UP, and finish systematic inventories in the Traverse City and Cadillac Forest Management Unit.
- Monitor 20 nests, or as many as available if less than 20 nest sites, in each forest area

Year 4

- Check nest territories documented during previous years in Pigeon River, Indian River, S. Gaylord, Traverse City, Cadillac, Gladwin, and the UP
- Begin systematic surveys in the Atlanta Forest Management Unit, select areas in the UP, and finish systematic inventories in the Gladwin Forest Management Unit.
- Monitor 20 nests, or as many as available if less than 20 nest sites, in each forest area

Year 5

- Check nest Territories documented during previous years in Pigeon River, Indian River, S. Gaylord. Traverse City, Cadillac, Gladwin, Atlanta, and the UP
- Finish systematic surveys in Atlanta and the UP
- Monitor 20 nests, or as many as available if less than 20 nest sites, in each forest area

APPENDIX II

Forest Compartments and stands surveyed for red-shouldered hawks at four northern Michigan state forest areas.

The following table show compartments and stands surveyed and habitat types targeted for surveys at the Pigeon River and Indian River forest areas

Compartment Surveyed	Stands Surveyed	Habitat(s) Surveyed [1]
PRC-4	Special Management Unit	M9
PRC-6	10	A6
PRC-7	18, 43, 53, 59, 60, 61, 8, 56	A6, M6, M9, W6, A5
PRC-8	12	M9
PRC-9	5, 4, 1 15, 10, 22, 21, 20, 33, 31, 33, 39, 62, 46, 59, 51, 44	A6, E6, M6, M9, Q6
PRC-10	10, 5, 18, 21, 35, 34, 40, 44, 55, 58, 65, 25, 26	M6, A6, A2
PRC-11	52, 53, 50, 58, 22	M9, E6, A6, A9,A3
PRC-12	17, 22, 33, 51, 84	A6, M6, E6, A3
PRC-13	12, 2, 7, 6, 5, 18, 53	M6, M9,A3
PRC-14	1, 4, 31, 35, 37, 50, 47, 55, 59, 60	M9, M6, A5, E9
PRC-15	26, 60, 62, 46, 66, 75, 76, 73, 72, 71, 78, 77, 80, 53	E5, M6, M8, A6, P5, Q6, W6, E6,A3
PRC-16	52, 47, 44, 16, 40	M6, M8, M5, W8
PRC-17	13, 21, 23, 100, 62	M6, M9, M5, G, R9
PRC-18	45	M6/9
PRC-20	69, 41, 5, 8	M6, A6, C6, A0
PRC-21	58, 38, 14, 4, 58	A5, M6, E5, E6, R9
PRC-22	1, 17, 26, 7	M6/9
PRC-23	48, 67	A5, A6, M6, E5, O6, A3, F2
PRC-24	38, 40, 41, 34, 92, 85, 33, 47, 24, 21, 53, 56, 49, 50, 94	M6, E5, A5, B6, A4
PRC-26	13, 8, 25, 28	O9, M6
PRC-29	16, 12, 14	E6, M6
PRC-30	119, 30, 10, 8	M6/9
PRC-33	72, 74, 46, 36, 31, 29, 44, 27, 32, 18, 28, 21, 18, 9	A5, M6, M9, A3
PRC-35	21, 33, 20, 16, 29	M6, O9, M9, R6
PRC-37	9, 6, 7, 12, 14, 15, 51	M6, M8, M9, O8, M5, W8
PRC-39	21, 22, 56, 27, 28, 59, 38, 39, 2, 1	M6, O5, M9, B6, Q5
PRC-40	39	O7, A2, R8, W5/7
PRC-41	1, 39, 56, 62, 71, 9	A6, O6, M6, C6, W9, O7, T4
PRC-42	62, 57, 53, 38, 37, 35, 11, 30, 9, 6	A5, M5, M6, O5, R7, J5
PRC-43	24, 25	M8, W8, A2
PRC-46	36, 130	M6, Q6, W8, L
PRC-47	7, 4, 2, 17, 13, 15, 17, 22, 27, 23, 26, 28, 29, 30, 32, 39, 50, 56, 62, 64, 56, 57	O6, M6, M9, B6, O9, W9
PRC-48	14, 5, 1, 9, 19, 23, 34, 37, 35, 48, 44, 56, 37	A6, M6, O6, A1, Q4
PRC-49	21, 15, 6, 55	A5, J3
PRC-52	56, 41, 56	O6, M5, C4

Compartment Surveyed	Stands Surveyed	Habitat(s) Surveyed [1]
PRC-53	60, 81, 56, 42, 39, 38, 37, 14, 11, 4	M5, M6, E5, A5, A6, M9, C6
PRC-54	1, 2, 19, 22, 7, 6, 5, 21, 25	M5, M8
PRC-55	6	M6
PRC-56	11, 10, 15, 16, 19, 22	A6, O6
PRC-57	30, 29, 26	M6
IR4	46, 40, 45, 47, 48, 21, 22, 23, 24, 26, 27, 13, 12, 11, 20, 14, 32, 54, 6, 7,	A6/9, M6/9
IR6	9, 24, 20	A5/66
IR15	19, 14, 5, 6, 13, 19, 29, 36, 44, 43, 33, 47, 46	M6/9, A6
IR16	2, 3, 5, 15, 9, 17, 10, 23, 44, 49, 41, 45, 11, 52, 55, 42, 39, 51	M6/9, A6
IR21	1, 22, 19, 23, 24, 26, 28, 30	M6/9, A5, A9, A3, W8, C6
IR22	3, 7, 11, 21, 19, 12, 15, 28, 7, 26	M6/9, W8, A3
IR30	17, 18, 21	E6, E8, B6
IR36	1, 3, 4, 13, 44, 47, 39, 23, 36, 28,	O6, A6, R6
IR39	4, 5, 2, 1	E6, M9, A9, A3
IR50	11	M9
IR57	117, 317, 417, 310,	M6
IR58	34, 37, 30, 29, 28, 27, 33, 35, 10, 4, 2, 3, 25, 21, 17, 44, 48, 46, 54, 55, 63, 60, 66, 59,l 67, 68	M6/9, P5, A6
IR59	6, 10, 1, 3, 13, 36, 37, 41, 38,	M6/9, E5
IR76	40, 7, 14, 39, 22, 39, 40,	A6/9, Q6, B6, P6
IR78	1, 11, 30,	A6/9, M6/9
IR82	2, 6, 9, 19	M6/9,
IR83	90, 84, 103, 86, 100	B6, M6, A5
IR88	3	M6
IR89	15, 8, 35, 235, 244, 38, 37, 28, 2, 1, 236, 36, 39, 139, 136,	M6/9, A6/9, B6, A3, G, C6, L
IR100	19 (Atlanta 174)	B6
IR106	18, 118, 1	E9, P6, A6, A3, J5
IR109	9, 12, 15, 18,19,	E9, A6/9, A4, R6
IR110	14	A6
IR111	33, 36, 31, 28, 29, 28,	A6, M6
IR153	60	A6
GA 34	47, 27,23, 18, 13	M6, A3, M9, G
GA 44	67, 73, 66, 24	A9, M9, M6, Q6
GA54	18, 15, 37	M6, Q6
GA 39	113, 222, 112, 111, 115, 114, 221, 110, 109, 223, 220, 107, 72, 119, 73, 47, 22, 1, 2, 5, 7, 24, 182	M6, E6, A6, E3, G, M9, A3
GA 40	23, 2, 9, 13, 50, 54, 56, 54, 72, 60	Q6, R9, M6, M8, M5, N
GA 41	30, 50, 24, 49, 26, 43, 21, 44, 52	A3, M6, G, O9, M9, M5
GA 50	8, 7, 10, 12, 20, 21, 22, 23, 34, 24, 37, 28, 26, 27	M9, M6, F6, M6, G, M5
GA 55	51, 42, 11, 43, 44, 18, 45, 4, 2, 35	G, M5, M7, M6, A3
GA 51	56, 50, 59, 51, 52, 49, 48	C3, A6, Q6, L, G, A3

Compartment Surveyed	Stands Surveyed	Habitat(s) Surveyed [1]
GA 37	61, 63, 18, 67	C7, M8, M6, M7, Q9
GA 43	22, 19, 24, 27	M9, A3
GA 57	3, 7, 31, 36, 5, 11, 19, 15, 15, 35	Q6, A5, M6, G, A6, A5
GA 49	2, 39, 40, 3, 43, 7, 51, 4, 31, 33, 17	M6, M9, R2, U, A6
GA 48	10, 11, 6, 8, 24, 25, 32, 43, 44, 45, 46, 34, 26	M8, M6, M7, Q6, N, M4, G, A3
GA 47	1, 37, 2, 31, 41, 40, 13, 44, 14, 16, 23, 22, 18, 47, 33, 46, 27, 28	M5, M6, M7, M8, G, Q6, N, A3, C4, M4, L
GA 36	1, 52, 12, 54, 53, 17, 16, 15, 55, 3, 28, 27, 45, 46, 5, 3, 1, 61, 62,	A3, A6, G, R9, R6, A3, M5, M7, M9, M8
TC 34	4, 6, 8, 9, 100, 24, 29, 54, 42, 3, 83, 105, 60, 68, 41, 42, 43, 74, 33, 63, 75, 80	R6, A6, A3, M6, M9, M5, A3, G, E6, E9, E1
TC4	111, 40, 33, 44, 46, 85, 95, 91, 82, 94, 99, 101, 72, 70, 69, 64, 68, 63, 72, 98, 101, 90, 110, 107, 25, 19, 7, 103, 78	L, M9, M4, G, M6, A6, W7, M5, A4, M8, M5, M4, M8, W6, R6
TC 7	17, 10, 52, 16, 15, 53	M9, M6
TC 16	63, 113, 54, 57	M8, M9, M7, M6, A3
TC 49	86, 85, 95, 96, 93, 100, 8, 4, 30, 28, 66, 61, 51, 19	A3, C6, A4, E9, E6, M6, R6
TC39	23, 49, 22, 83, 3, 19, 20, 75	L, E6, G, W9, E7, E5, P3
TC9	3, 35, 36, 37, 39, 41, 3, 2, 11, 12, 15, 5, 21, 20, 22, 19, 25	M6, G, M9, A6, R6
TC36	115, 26, 25, 23, 18	E1, M9, Q6, W6, A6
TC35	34, 41	M6, W6

[1] Habitat types follow Michigan Department of Natural Resources Forest Operational Inventory (OI) designations and are defined as follows: M = northern hardwoods, E = lowland hardwoods, B = birch, A = aspen, W = white pine, P = balsam poplar, R = red pine, C = Cedar, F = spruce-fir J = jack pine, L = lowland brush, G = grass, O = oak, and Q = lowland conifers. Corresponding numerical values follow OI stocking density/size classes and are defined as follows: 0 = non-stocked, 1 = poorly stocked seedling/sapling, 2 = medium stocked seedling/sapling, 3 = well stocked seedling/sapling, 4 = poorly stocked pole timber, 5 = medium stocked pole timber, 6 = well stocked pole timber, 7 = poorly stocked saw timber, 8 = medium stocked saw timber, and 9 = well stocked saw timber.

APPENDIX III

MNFI Raptor Nest Reporting Form

MICHIGAN STATE UNIVERSITY EXTENSION
Michigan Natural Features Inventory

RAPTOR NEST REPORTING FORM

For Office Use Only

Ouad Code:_____
Air Photo:_____
Basal Area:_____

Site Information
Observer(s) Name:_____ **Phone**:_____ **email**:_____

County:_____ **State Forest Area**:_____ **Compartment/stand**:_____

Date of Observation:_____ **Township/Range/Section:**_____
Directions to Site:_____
_____
_____

Survey and Biological Data
Weather (check): sunny ☐ mostly sunny ☐ partly cloudy ☐ mostly cloudy ☐ cloudy ☐
winds: 0-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ 20+ ☐ **Temperature:** _____ **Precipitation**: rain ☐ snow ☐

Circumstance of Observation: deliberate search ☐ accidental observation ☐ responded to taped call ☐

Raptor Species Observed: red-shouldered hawk red-tailed hawk broadwing hawk northern goshawk

Cooper's hawk northern harrier bald eagle osprey peregrine falcon merlin kestrel

short-eared owl long-eared owl great horned owl other_____
Rank your identification: extremely confident confident some reservation not sure no clue

Describe individuals observed: # of adults_____# of juveniles_____
(check all that apply) birds heard calling ☐ birds observed but not calling ☐ birds observed & heard ☐

Nest Found (check all that apply): no☐ yes ☐; if yes nest decorated ☐ not decorated ☐ old nest ☐
presence of down ☐ evidence of new construction ☐ bird on nest ☐ birds heard in immediate vicinity of nest ☐

Nest tree species:_____ **Nest height:** 10-20' ☐ 21-30' ☐ 31-40' ☐ 41-50' ☐ 50'+ ☐

Nest tree DBH :_____**Age class**: Even ☐ Uneven ☐ **Presence of flight lane**: yes ☐ no ☐

Landscape Position: Slope ☐ Flat ☐ Upland ☐ Lowland ☐ **Canopy layers**: 1 ☐ 2 ☐ 3 ☐

Proximity to wetland (mi.): < 1/8 ☐ >1/8<1/4 ☐ >1/4<1/2 ☐ >1/2 ☐

Type of wetland habitat nearby: Conifer ☐ Hardwood ☐ Emergent ☐ Vernal Pool ☐ Shrub ☐
Other: _____

Understory density: Dense ☐ Moderate ☐ Sparse ☐ **Cover type**: M☐ A☐ B☐ O☐ Other_____
Stocking density: 5☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐

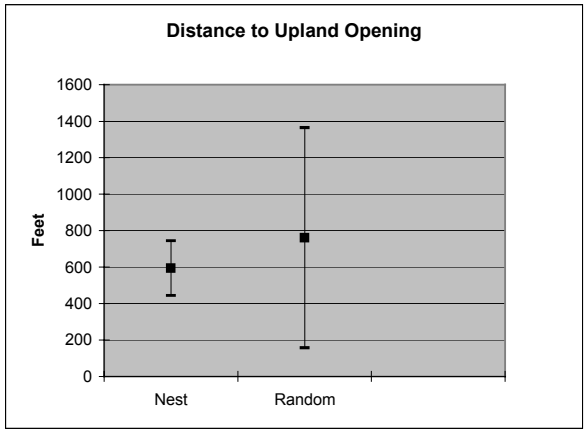
Productivity Surveys (if conducted)
Date:_____ **Observer(s):**_____ **Active**: Yes ☐, if yes young in nest ☐ whitewash at base of tree ☐ young of year in nearby trees ☐ No ☐ **Number of Young**: _____
If inactive was there evidence of predation: no ☐ yes ☐If yes, nest torn apart ☐ claw marks on tree ☐
dead bird in or near nest ☐ other_____
Additional notes: _____
_____
_____

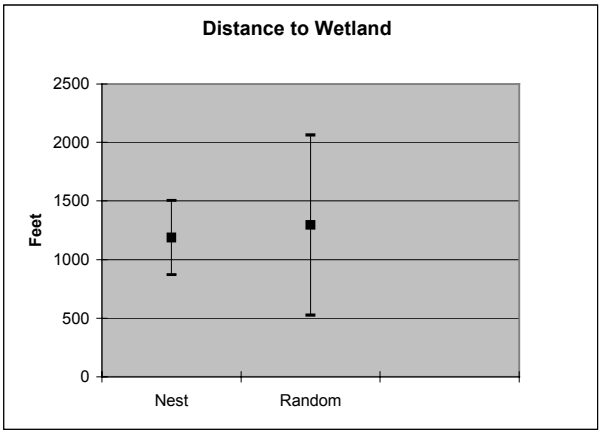
Please draw a map of nest site on back of form or attach compartment map or topographic map
Send completed form to:
Jeff Cooper, Michigan Natural Features Inventory, P.O. Box 30444, Lansing, Michigan 48909
For additional information: Jeff Cooper, zoologist (517) 241-2027

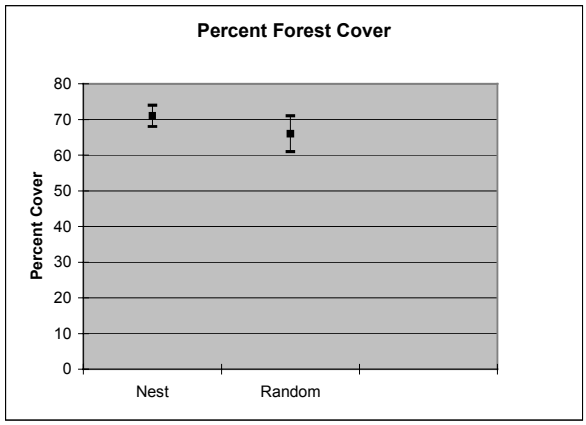
APPENDIX IV

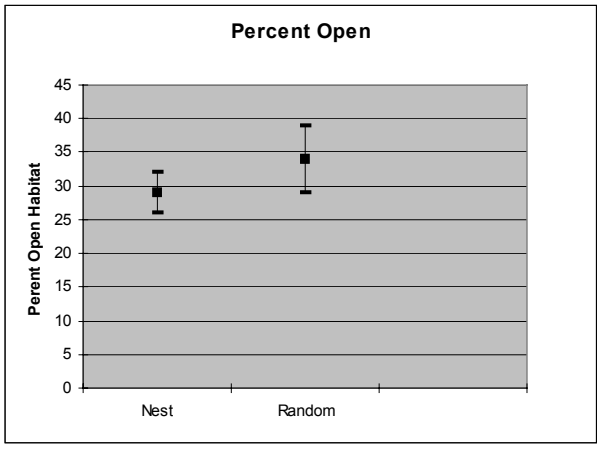
Confidence Intervals (95%) for Landscape and Micro-habitat Variables for nest sites and random points

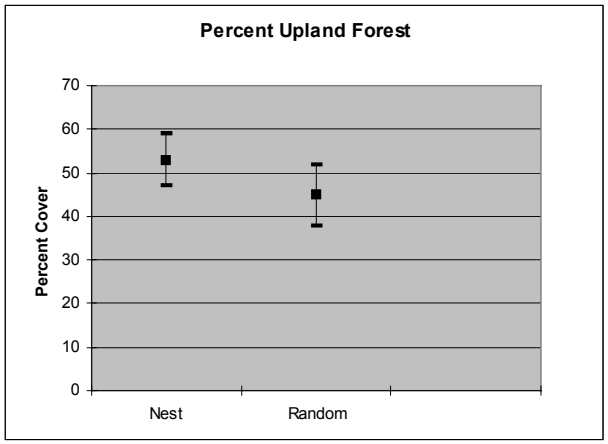
Landscape Attributes (n = 51 for nest sites and n = 48 for random points)

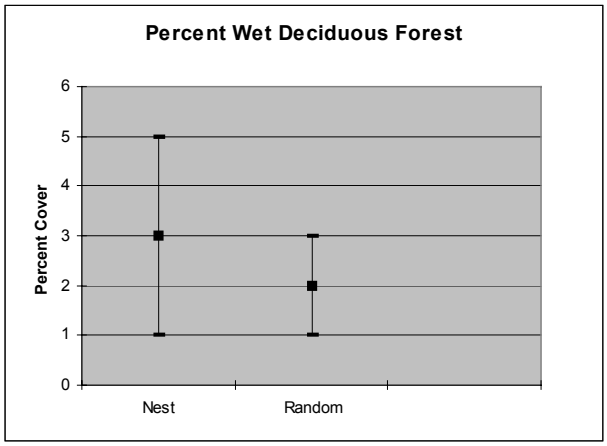


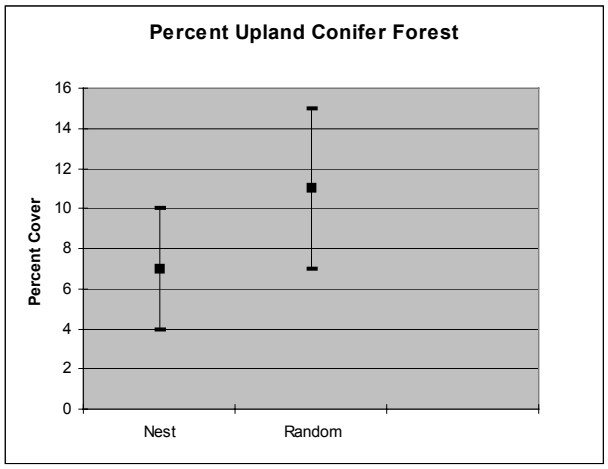


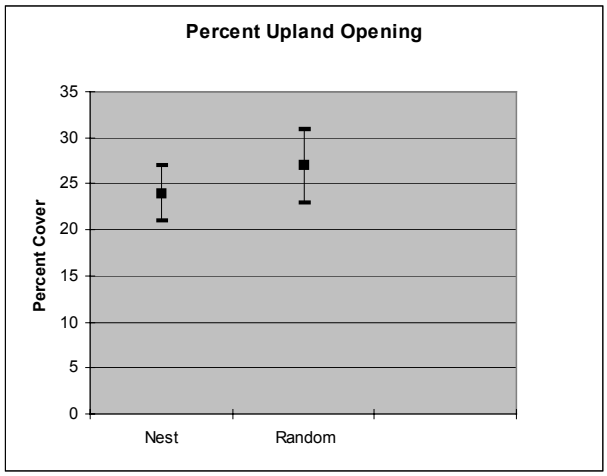


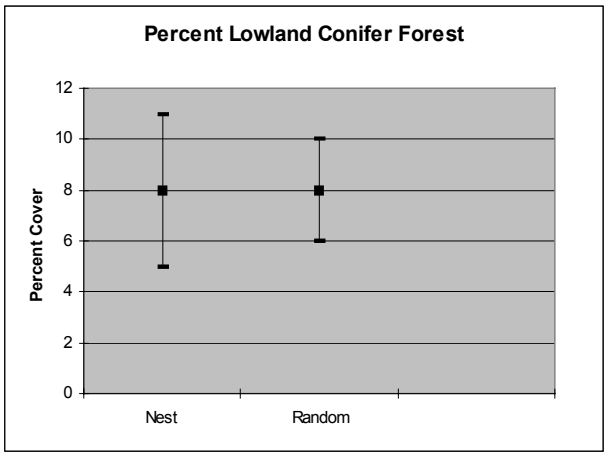


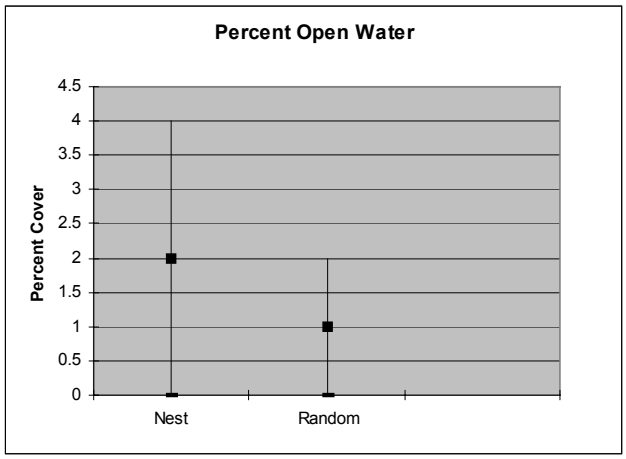


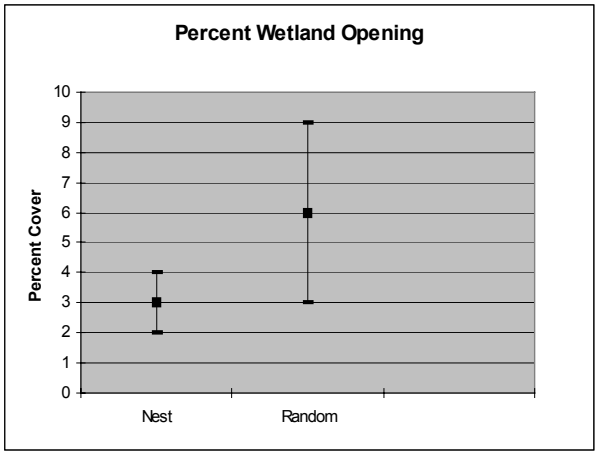



Percent Upland Conifer Forest
Percent Cover
16
14
12
10
8
6
4
2
0
Nest
Random

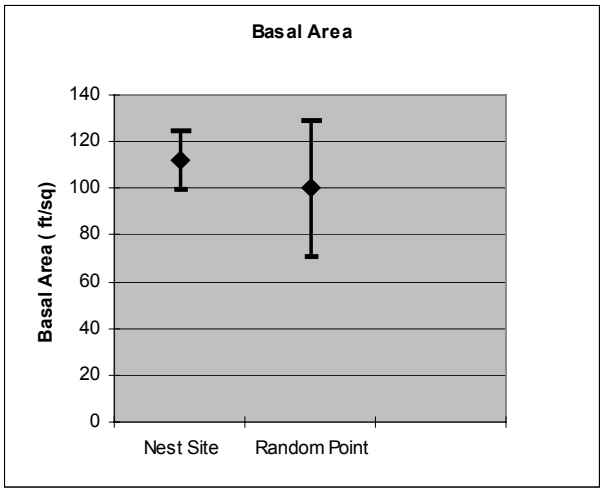

Percent Upland Opening
Percent Cover
35
30
25
20
15
10
5
0
Nest
Random

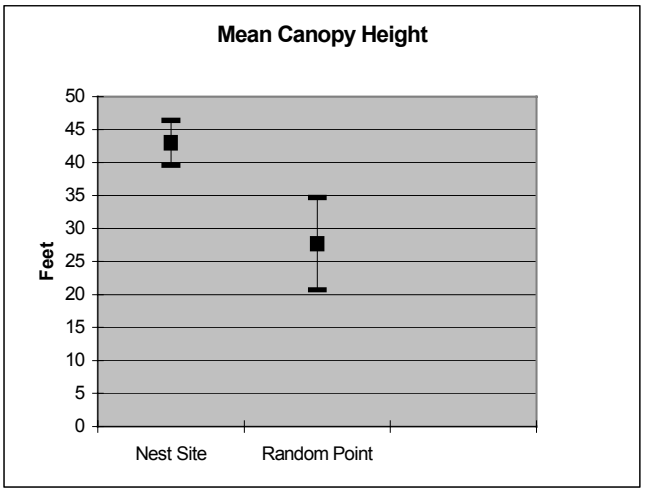

Percent Lowland Conifer Forest
Percent Cover
12
10
8
6
4
2
0
Nest
Random

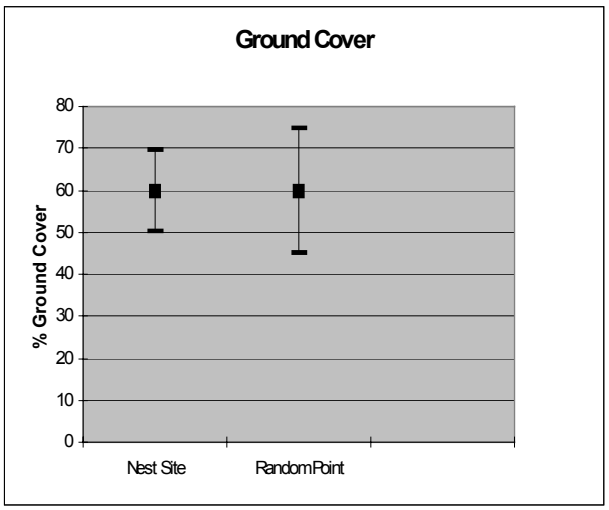

Percent Open Water
Percent Cover
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Nest
Random

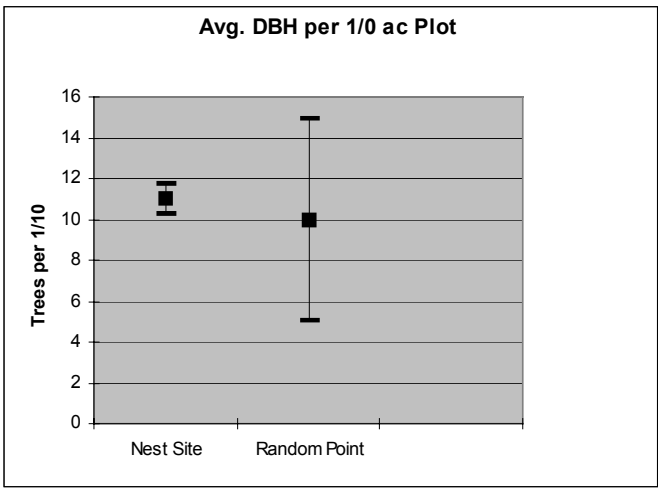

Percent Wetland Opening
Percent Cover
10
9
8
7
6
5
4
3
2
1
0
Nest
Random

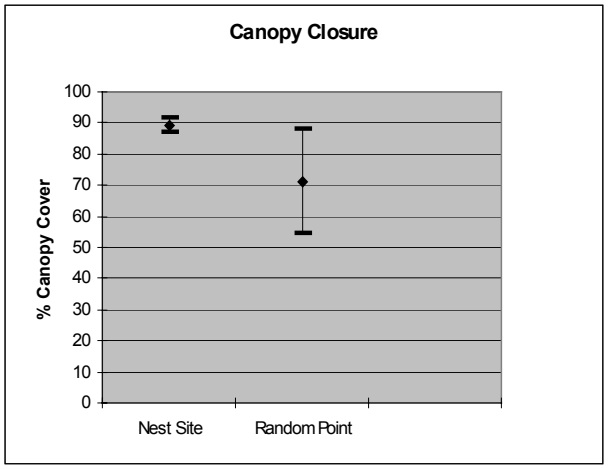
Micro-habitat Attributes (n = 19 for nest sites and n = 18 for random points)

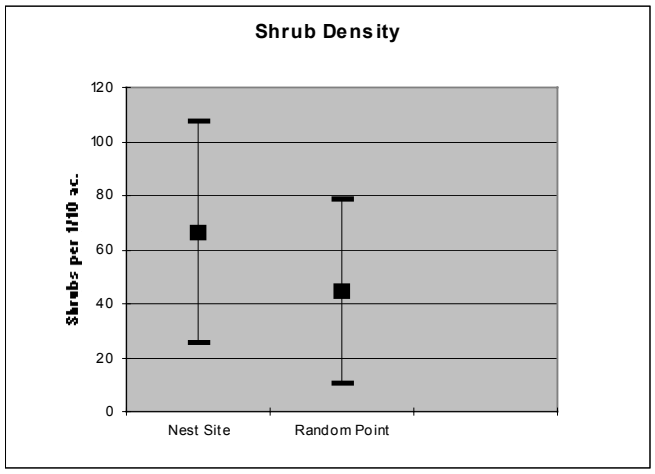


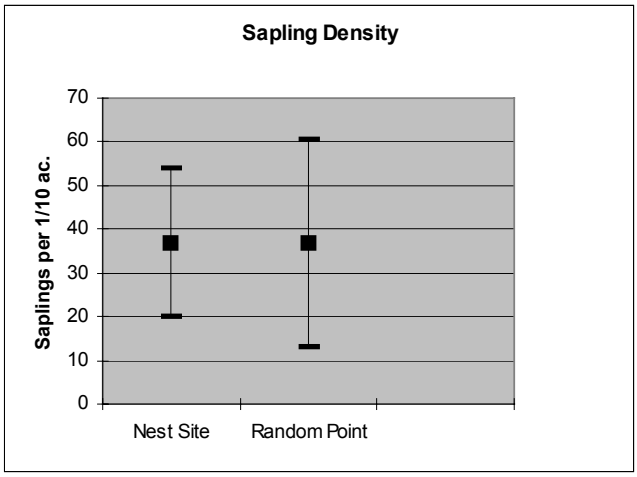


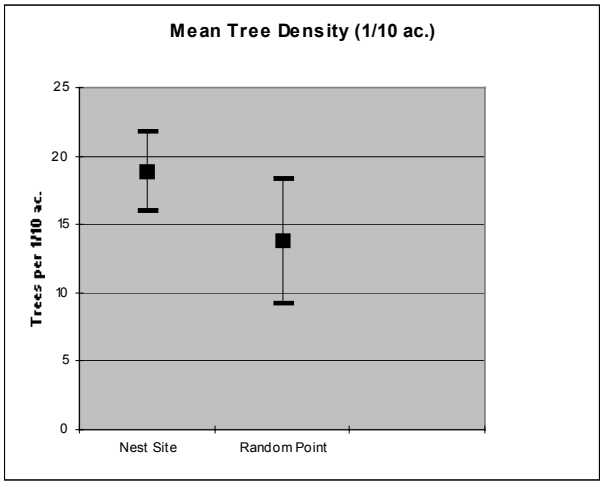









Sapling Density
Saplings per 1/10 ac.
70
60
50
40
30
20
10
0
Nest Site
Random Point


Mean Tree Density (1/10 ac.)
Trees per 1/10 ac.
25
20
15
10
5
0
Nest Site
Random Point

APPENDIX V

Locational data of red-shouldered hawk nests at four Michigan state forest areas.

(Copies distributed to MDNR area managers only)

Sensitive data, do not distribute

Forest Area[1]	Nest Number	Location (TRS)	Compartment	Stand	Date first obs
PRC	PRC1	T33N, R1W, S.13 sw sw	PRC 12	84	04/22/1998
PRC	PRC2	T33, R1W, S.14 nw nw ne	PRC 11	52	04/20/1998
PRC	PRC3	T33N, R1W, S.30 ne ne	PRC 13	12	04/20/1997
PRC	PRC4	T33N, R1W, S.29 ne ne nw	PRC 14	31	04/21/1998
PRC	PRC5	T33N, R1W, S.32	PRC14	55	04/21/1998
PRC	PRC6	T33N, R1W, S.7 sw sw	PRC 7	53	04/22/1998
PRC	PRC7	T33N, R1W, S.18 se	PRC 7	61	04/23/1998
PRC	PRC8	T33N, R1W, S.4 se se	PRC 9	15	04/20/1998
PRC	PRC9	T33N, R1W, S.16 se	PRC 9	46	04/22/1998
PRC	PRC10	T33N, R1W, S.10 ne ne	PRC 10	26	04/21/1998
PRC	PRC11	T33N, R1W, S.3	PRC10	10	04/20/1998
PRC	PRC12	T33N, R1W, S.34 se se	PRC 16	52	04/20/1998
PRC	PRC13	T32N, R1W, S.1 nw sw	PRC 33	18	04/20/1998
PRC	PRC14	T32N, R1W, S.13 sw se	PRC 37	7	22-Apr
PRC	PRC15	T32N, R1W, S.11 sw sw	PRC 35	21	04/22/1998
PRC	PRC16	T32N,R1W, S.22 nw	PRC39	21	04/23/1998
PRC	PRC17	T32N, R1W, S.34 se se	PRC43	24	May-98
PRC	PRC18	T34N, R1E, S.33 ne sw	PRC 20	69	04/23/1998
PRC	PRC19	T34N, R1E, S.1 ne ne ne	PRC 20	5	04/15/1998
PRC	PRC20	T33N R1W S.13 sw sw ne	PRC12	84	04/20/1999
PRC	PRC21	T33n R20W S. nw nw nw	PRC14	1	04/19/1999
PRC	PRC22	T33N R1W S.9 ne ne sw	PRC9	21	04/19/1999
PRC	PRC23	T33N R1W S. 34 ne ne	PRC16	47	04/20/1999
PRC	PRC24	T34N R1W S.34 S center	PRC4	DL MGT[2]	04/21/1999
PRC	PRC25	T33N R1W S.22se se ne	PRC16	16	04/21/1999
PRC	PRC26	T33N R1W S.28sw ne sw	PRC15	80	04/22/1999
PRC	PRC27	T33N R1E S.10 sw sw sw	PRC 24	92	04/22/1999
PRC	PRC28	T33N R1E S 7ne ne	PRC23	48	04/21/1999
PRC	PRC29	T32N R2W, S.19 sw sw se	Private land	NA	04/20/1999
PRC	PRC30	T33N R1E S.4 sw sw ne	PRC21	14	04/21/1999
PRC	PRC31	T31N R1W S.35&36	PRC52	56	04/20/1999
PRC	PRC32	T31N R1W S.10	PRC47	28	04/20/1999
PRC	PRC33	T31N R1W S.14 nw	PRC48	34	04/22/1999
PRC	PRC34	T31N R1W S.3	PRC 47	22	04/21/1999
PRC	PRC35	T34N R1E S. 6 ne	PRC 21	35	06/09/1999
PRC	PRC36	T33N R1W S.33 sw se	PRC15	73	04/08/1999
PRC	PRC37	NA	Private land		06/08/1999
PRC	PRC38	T34N R1W S.34	Special Unit		06/08/2000
PRC	PRC39	T34N R1W S21 se se se	PRC38	6	04/13/1999
PRC	PRC40	T33N R1W S. 12 n 1/2	PRC35	29	04/12/2000
PRC	PRC41	T33N R1E S.31 sw sw	PRC29	47	04/12/2000
PRC	PRC42	T33N R1W S. 15 se1/2 se 1/4	PRC10	65	04/13/2000
PRC	PRC43	T33N R1W S. 28 ne sw	PRC15	60	05/28/2000
PRC	PRC44	T33N R1W S.24 ne sw	PRC18	6	04/13/2000
PRC	PRC45	T33N R1W S. 12 se se nw	PRC12	51	04/26/1999
PRC	PRC46	T33N R1W S.30 ne ne	PRC13	12	04/25/1999
IR	IR1	T34N, R3W, S.9 nw	IR50	11	04/09/1998
IR	IR2	T33N, R3W, S.33	IR57	117	May-98
IR	IR3	T36N, R5W, S.11 sw sw	IR16	26	04/15/1998
IR	IR4	T33N, R3W, S.27	IR58	44	04/24/1998

Forest Area	Nest Number	Location (TRS)	Compartment	Stand	Date first obs
IR	IR5	T33N, R3W, S23	IR58	21	04/15/1998
IR	IR6	T34N, R1W, S.3 sw sw se	IR182	2	04/15/1998
IR	IR7	T34N, R1W, S.11 sw nw	IR183	104	04/15/1998
IR	IR8	T34N, R1E, S.9 ne ne se	IR111	36	04/15/1998
IR	IR9	T34N, R1E, S.17	PVT/IR111	near 23	04/15/1998
IR	IR10	T36N R6W S.10 nw	IR4	21	04/01/1999
IR	IR11	T37N R3W S.9 sw sw	IR39	4	04/09/1999
IR	IR12	T33N R2W S.36 ne ne	IR178	11	04/14/1999
IR(ATL)	IR13	T37N R1E S.36 se	IR100 (Atl174)	19	06/11/1999
IR	IR14	T36N R5W S.22ne sw	IR15	19	04/15/1999
IR	IR15	T37N R4W S.31	IR22	26	04/14/1999
IR	IR16	T35N R2W S.14 nw nw nw	IR176	40	04/12/1999
IR	IR17	T39N R3W S.4 sw sw	IR 139	4	04/14/1999
IR	IR18	T37N R3W S.8 se se nw	Private land	NA	05/01/2000
IR	IR19	T37N R6W S.21 nw sw	IR1	2	06/08/2000
IR	IR20	T35N R2W S.12	IR177	51	07/12/2000
Gaylord	GA1	T30N R6W S.5	GA54	18	04/29/1999
Gaylord	GA2	T32N R5W S.32 sw	GA44	19	04/29/1999
Gaylord	GA3	T33N R5W S.25 se ne ne	GA39	221	04/27/1999
Gaylord	GA4	T33N R5W, S. 26 sw sw ne	GA39	47	04/27/1999
Gaylord	GA5	T32N R4W S. 21 ne nw se	GA40	22	04/26/1999
Gaylord	GA6	T33N R4W S.4	GA43	17	04/29/1999
Gaylord	GA7	T33N R4W S.16 se	GA 35	19	04/27/1999
Gaylord	GA8	T31N R6W S.36 sw sw	GA50	37	04/29/1999
Gaylord	GA9	T30N R5W S.6	GA59	1	04/14/2000
Gaylord	GA10	T30N R6W S.9	GA55	51	04/12/2000
Gaylord	GA11	T31N R6W S.17	GA51	52	04/09/2000
Gaylord	GA12	T32NR4W S.10	GA43	22	04/01/1999
Trav. City	TC1	T24N R14W S.19 se se	TC34	60	04/08/1999
Trav City	TC2	T24N R15W S. 26 sw nw	TC34	26	04/07/1999
Trav City	TC3	T24N R15W S.23 ne se	TC34	24	04/28/1999
Trav City	TC4	T24N R15W S.25 nw	TC34	28	04/28/1998
Trav City	TC5	T24N R14WS.16 ne ne	PVT	NA	04/08/1999
Trav. City	TC6	T24N R15W S.25	TC34	33	04/18/2000
Trav. City	TC7	T24N R15W S.14	TC34	8	04/18/2000
Trav. City	TC8	T27NM R13W S.7	TC4	near 111	04/26/2000
Trav. City	TC9	T27N R14W S.13	TC4	73	04/18/2000
Trav. City	TC10	T27N R14W S.13	TC4	78	04/18/2000
Trav. City	TC11	T27N R14W S.32	TC7	17	04/17/2000
Trav. City	TC12	T27N R14W S.33	TC7	17	04/17/2000
Trav. City	TC13	T26N R13W S.31	TC16	63	04/26/2000
Trav. City	TC14	T26N R11W S.24	TC49	85, 86	04/26/2000
Trav. City	TC15	T26N R11W S.27	TC49	30	04/26/2000
Trav. City	TC16	T28N R7W S.15	TC30	42	05/15/2000
Cadillac	Cad1	T24N R9W S.9	Cad126	71	04/20/2000

[1] PRC = Pigeon River Country Forest Management Unit, IR = Indian River Forest Area of the Gaylord Forest Management Unit, Gaylord = Gaylord South Management Unit, Trav. City = Traverse City Forest Management Unit, Cadillac = Cadillac Forest Management Unit.
[2] DL MGT = Dog Lake Special Management Unit.

APPENDIX VI

Red-shouldered hawk Special Animal Abstract

ABOUT THE AUTHORS

Jeffrey L. Cooper received a M.S. in Wildlife Biology from Tennessee Technological University and a B.S. in Environmental Science with emphasis in Wildlife Biology from Ferrum College. Jeff currently is a zoologist for the Michigan Natural Features Inventory, Michigan State University Extension program, a position he has held since 1997. Jeff has had an interest in raptors since a young child growing up in the heart of red-shouldered hawk country. His other current research activities include managing Michigan State Parks inventories, developing woodland raptor workshops, participating in the state forest compartment review process, conducting animal surveys, data analysis and processing, and environmental review assessments. Jeff's professional interests include grassland bird and upland game bird management, forest management and agricultural practices that are compatible with wildlife, raptor management, furbearer management, deer management, and vertebrate taxonomy.

Phone: 517-241-2027 *email: cooperj@state.mi.us*

David L. Cuthrell received a M.S. Degree in Entomology from North Dakota State University and a B.A. Degree in Biology from the University of Northern Iowa. Currently David is a zoologist with the Michigan Natural Features Inventory, Michigan State University Extension program a position he has held since 1994. David has been surveying for woodland raptors since 1995. David is responsible for planning and conducting inventories for rare invertebrate and vertebrate animals, processing rare animal data, and some environmental review assessments. Some recent projects David has been involved with include a study of insects associated with lakeplain prairie remnants, a survey for rare lotic dragonflies in northern Michigan, woodland raptor training, and a survey of alvar (limestone grassland) inhabiting animals. David's research interests include prairie and barrens associated insects, pollinators of rare plants, grassland birds, and raptors.

Phone: 517-335-6627 *email: cuthreld@state.mi.us*

Cover Photo Identification and Credits:

Immature red-shouldered hawk, Traverse City Forest Area, June 2000, by David L. Cuthrell

Top left inset: Using mirror pole to assess productivity, Indian River Forest Area, June 2000, by Jeffrey L. Cooper

Top right inset: Measuring nest tree dbh of active red-shouldered hawk nest in the Indian River Forest Area, June 1999, by David L. Cuthrell

Bottom left inset: Immature red-shouldered hawk peeking over nest edge, Traverse City Forest Area, June 1999, by David L. Cuthrell

Bottom right inset: Ernie Houghton and Scott Lint (MDNR Forest Management Division) and Jeff Cooper (MNFI) viewing active red-shouldered hawk nest off Springdale Road, May 2000, by David L. Cuthrell