BIOREGIONAL MONITORING FOR NORTHERN GOSHAWKS IN THE WESTERN GREAT LAKES[1]

FINAL REPORT

By

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EXECUTIVE SUMMARY

Uncertainties about factors affecting Northern Goshawk (*Accipiter gentilis*) ecology and the status of populations have added to the challenge of managing for the species, which has involved maintaining suitable nesting and foraging habitat while simultaneously allowing for timber harvest and other activities. To address data needs for determining the status of goshawk populations, Hargis and Woodbridge (2006) developed a bioregional monitoring protocol. The goal of our study was to implement this protocol and collect data to determine goshawk population status in the western Great Lakes bioregion, which encompassed portions of Minnesota, Wisconsin, and Michigan. Project collaborators surveyed 86 Primary Sampling Units (PSUs) throughout the bioregion for goshawk presence between mid-May and late June 2008, and again between July and mid-August 2008, and recorded 30 goshawk detections in 21 different PSUs. Based on these surveys, we estimated that there were 5,184 ± 199 (standard error) PSUs with goshawk occupancy in 2008, which comprised approximately 27% of the PSUs in our survey area. Maximum likelihood estimates of detection probabilities for the first and second visits were 0.549 ± 0.118 and 0.750 ± 0.126, respectively. For the portions of individual states included in our survey area, we estimated that there were 1,413 ± 96, 3,949 ± 176, and 903 ± 110 PSUs with goshawk occupancy in Michigan's Upper Peninsula, Minnesota, and Wisconsin, respectively. We estimated that there were 265 ± 145 and 145 ± 139 PSUs occupied by goshawks in Michigan's Ottawa and Hiawatha National Forests, respectively. In Minnesota's Chippewa and Superior National Forests, we estimated that there were 271 ± 146 and 216 ± 210 PSUs, respectively, with goshawk occupancy. Finally, for Wisconsin's Chequamegon-Nicolet National Forest, we estimated that there were 442 ± 244 PSUs occupied by goshawks.

We used information-theoretic techniques to evaluate competing hypotheses regarding the influence of forest canopy cover, successional stage, heights of the canopy top and base, and deciduous and coniferous forest types on the odds of goshawk landscape use in 2008 throughout the western Great Lakes bioregion. We also used historical data of goshawk locations in the bioregion from 1979-2008 to evaluate the same competing hypotheses to elucidate long-term trends in use. The odds of goshawk use in 2008, and from 1979-2008, were positively correlated with the average percent canopy cover within each PSU. In the top approximating models from the 1979-2008 data the odds of use were positively correlated with the percentages of each PSU having canopy heights between 10 m and 25 m, and 25 m and 50 m, and the amount of variability in canopy base height. Also, the odds of use were negatively correlated with the average height at the canopy base during 1979-2008. Our results suggest multiple habitat factors affected goshawk use and these attributes are in general agreement with previous studies in the western Great Lakes, and more extensive research in western North America and Europe.

While our results indicated goshawks are widely distributed and occur at significant densities throughout the western Great Lakes region, additional monitoring is required to determine a population trend. We suggest that bioregional goshawk surveys and associated habitat data collection be repeated every five years, which would result in the next survey being conducted in 2013. This five-year interval between surveys has the following benefits. First, it provides a trade-off of information obtained for money spent. Second, collection of habitat data is necessary only every several years because of the time scale on which successional processes operate in forests. Third, planning of surveys in 2013 affords project collaborators time to decide on their financial and in-kind contributions well ahead of the surveys, which is necessary given the time-intensive nature of planning this type of effort.

INTRODUCTION

The challenge of managing forest resources for Northern Goshawk (*Accipiter gentilis*) populations in North America has involved maintaining suitable nesting and foraging habitat while simultaneously allowing for timber harvest and other activities (Woodbridge and Hargis 2006). Uncertainties about factors affecting goshawk ecology and the status of populations have added to the difficulty of managing forested landscapes to incorporate considerations for goshawks, and have hindered efforts to assess population status in response to petitions to list goshawks under the Endangered Species Act (Andersen et al. 2005, Squires and Kennedy 2006). Goshawks have been associated with mature forests because of the structure that stands with relatively large trees and high canopy closure provide for nest sites (Squires and Reynolds 1997, Boal et al. 2005). However, much regional variation exists in tree species and sizes used for nests (Siders and Kennedy 1994, Squires and Ruggerio 1996, Boal et al. 2006). Suitable foraging habitat for goshawks may encompass a broader range of forest types and structure than that for nests (Boal et al. 2005, Reynolds et al. 2008), but goshawk diets are diverse across their breeding range (Doyle and Smith 2001, Salafsky et al. 2005, Smithers et al. 2005). In some areas goshawks may switch from preferred to alternative prey species depending on prey densities (Salafsky et al. 2005), potentially resulting in corresponding changes in foraging habitats. Because much of the literature on goshawk nesting, foraging, movements, and demography has come from research in the southwestern and western United States (e.g., Andersen et al. 2005, Fairhurst and Bechard 2005, Reynolds et al. 2005, Wiens et al. 2006), additional uncertainty exists in managing populations elsewhere in North America.

The assumption that goshawk populations are declining has lead to litigation regarding forest management practices and listing the goshawk as a threatened species (Squires and

Kennedy 2006). However, the data do not exist either to know whether goshawk populations are decreasing, stationary, or increasing, or to determine the extent of natural variation in population sizes between years for most populations. Large scale, regional trends in goshawk populations have not been documented (e.g., Andersen et al. 2005) and the majority of monitoring efforts have been limited to small scales (e.g., nests; territories) or individual national forests (Hargis and Woodbridge 2006). Because goshawks use resources over large spatial scales and are not limited in range to only national forest lands, population trends for national forests alone are insufficient to determine the status of populations (Hargis and Woodbridge 2006). To address the data needs for sufficiently determining the status of goshawk populations throughout the United States, Woodbridge and Hargis (2006) developed a goshawk monitoring protocol for use in designing monitoring plans for 10 "bioregions" throughout the country. The objectives of bioregional monitoring were to: (1) estimate the frequency of occurrence of goshawks within each bioregion; (2) assess changes in the frequency of occurrence over time, and (3) determine whether any changes in the frequency of occurrence were related to habitat change (Hargis and Woodbridge 2006). A regional scale for goshawk monitoring was suggested because surveying only national forest lands is problematic owing to ecological and sampling reasons (Hargis and Woodbridge 2006). Goshawks may use resources over scales much larger than only a national forest and obtaining an adequate sample size within one forest to determine a change in population abundance with sufficient power is costly (Hargis and Woodbridge 2006).

Within the western Great Lakes bioregion that encompasses portions of Minnesota, Wisconsin, and Michigan, information on goshawk ecology is limited (Boal et al. 2006). Boal et al. (2005) used radiotelemetry to examine habitat preferences of breeding goshawks in northern Minnesota between 1998 and 2000, and found that foraging goshawks used mature and young forests more and less than expected, respectively, based on availability of these stand types. The stands used by goshawks for foraging and nesting were structurally similar and had high canopy closure, high canopy and understory stem densities, and substantial amounts of shrub cover and woody debris that provided habitat for prey (Boal et al. 2005). However, nest stands consisted of larger and taller canopy trees, and fewer understory trees than foraging stands (Boal et al. 2005). In Wisconsin, Rosenfield et al. (1998) found nests in a wide variety of forest types with the majority (78%) of nests located in deciduous trees. Goshawks are considered to be prey generalists (Squires and Kennedy 2006), but only the 2000-2002 study by Smithers et al. (2005) provides a quantitative measure of goshawk diet in the western Great Lakes region. Mammals accounted for 61% of biomass delivered to nests with snowshoe hares (*Lepus americanus*), red squirrels (*Tamiasciurus hudsonicus*), and eastern chipmunks (*Tamias striatus*) comprising the majority of these prey items (Smithers et al. 2005). Birds comprised 39% of prey biomass with Ruffed Grouse (*Bonasa umbellus*), American Crows (*Corvus brachyrhynchos*), and diving ducks (*Aythya* spp.) accounting for the majority of bird species (Smithers et al. 2005). Goshawk monitoring in the western Great Lakes area has mostly been confined to known nest sites in a few study areas (Boal et al. 2006). Therefore, in addition to limited knowledge of goshawk ecology in the region, the large-scale population status of the species is unknown.

The goal of this study was to begin to address data needs for determining goshawk population status in the western Great Lakes bioregion in 2008 using the goshawk monitoring protocol of Hargis and Woodbridge (2006). Project collaborators surveyed sampling units throughout the bioregion for goshawk presence between mid-May and mid-August 2008 using the broadcast acoustical method (Kennedy and Stahlecker 1993). We then estimated the number of sampling units with goshawk occupancy and detection probabilities for the bioregion and

Michigan, Minnesota, and Wisconsin. We used information-theoretic techniques to evaluate competing hypotheses regarding the influence of forest canopy cover, successional stage, heights of the canopy top and base, and deciduous and coniferous forest types on the odds of goshawk landscape use in 2008 throughout the western Great Lakes bioregion. We also used historical data of goshawk locations in the bioregion from 1979-2008 to evaluate the same competing hypotheses to elucidate long-term trends in goshawk landscape use. This work provides the first estimate of goshawk occupancy for the western Great Lakes population and offers additional insight into habitat associations of goshawks across large scales in this region.

METHODOLOGY

Study Area

The western Great Lakes bioregion consists of lands in northeast and north-central Minnesota, northern Wisconsin, and northern Michigan (Woodbridge and Hargis 2006), and our study area within the bioregion encompassed the approximate goshawk breeding range as delineated based on historical goshawk observations (Figure 1*a*). Owing to funding limitations for surveying the entire goshawk range, we delineated the sampling universe based on seven ecological subregions (McNab et al. 2007) totaling 135,074 km^2 in area (Figure 1*b*) within the Laurentian Mixed Forest Province Bailey's Ecoregion (Bailey 1995). The ecological subregions within the sampling universe were the southern, western, and northern Superior uplands, northern Minnesota drift and lake plains, northern highlands, and portions of the eastern and northern Upper Peninsula sections (McNab et al. 2007). Subregions consisted of a combination of private and public lands. The subregions not included in the sampling universe because either they were on the periphery of the goshawk range or did not include national forests were the northern Minnesota and Ontario, southwest Lake Superior clay plain, north-central Wisconsin uplands, Wisconsin central sands, and northern Green Bay lobe sections (McNab et al. 2007). Despite containing national forest lands, the northern Lower Peninsula section in Michigan (McNab et al. 2007) was not included because of lack of stakeholder interest.

The study area was typified by deciduous hardwood, coniferous, mixed deciduous and coniferous, and boreal forests with elevations ranging between 200-560 m (Lapinski 2000, Boal et al. 2005, Boal et al. 2006). Numerous wooded wetlands, open wetlands, and swamp habitats were interspersed amidst forests in the study area. The western Superior uplands were characterized by level and rolling glacial drift plains with forest vegetation of aspen (*Populus* spp.) and birch (*Betula* spp.), maple (*Acer* spp.) and birch, and spruce (*Picea* spp.) and balsam fir (*Abies balsamea*) cover types (McNab et al. 2007). The northern Superior uplands consisted of a glacially scoured plain with lakes, highlands, and uplands of low hills across the Mesabi Range (McNab et al. 2007). Forest vegetation was mostly aspen-birch, spruce-fir, pine, and oak (*Quercus* spp.) (McNab et al. 2007). The southern Superior uplands contained glacial landscapes with level lowlands and lacustrine plains with hilly uplands (McNab et al. 2007). Forests consisted primarily of maple, birch, and aspen species (McNab et al. 2007). Level to gently rolling lowlands characterized by glacial features comprised the northern Minnesota drift and lake plains region with forest cover consisting of aspen-birch, pine (*Pinus* spp.), and spruce-fir (McNab et al. 2007). The northern highlands section was comprised of a glacial plain with kettle lakes and moraines, and forest cover types of spruce-fir, pine, maple, aspen, and birch (McNab et al. 2007). The eastern Upper Peninsula region consisted of flat to gently rolling plains with aspen-birch, maple-birch, pine, and spruce-fir cover types, while the northern Upper Peninsula landscape was comprised of flat plains with exposed bedrock and forest vegetation of maple-birch, and aspen-birch (McNab et al. 2007). Additional tree species found throughout the study area included basswood (*Tilia americana*), black ash (*Fraxinus nigra*), green ash (*F. pensylvanica*), eastern hemlock (*Tsuga canadensis*), tamarack (*Larix laricina*), and northern white-cedar (*Thuja occidentalis*).

Development of a Stratified Random Sampling Design

We divided the goshawk range in the western Great Lakes bioregion into 49,146 600 ha squares called Primary Sampling Units (PSUs; Hargis and Woodbridge 2006). The size of each PSU approximated the size of one goshawk territory based on existing data (Woodbridge and Hargis 2006). We used existing goshawk location data and GIS layers to classify each PSU into one of five categories: (1) primary goshawk habitat/difficult access; (2) primary habitat/easy access; (3) secondary habitat/difficult access; (4) secondary habitat/easy access, and (5) non-habitat. We obtained locations of 366 historical goshawk sightings throughout the western Great Lakes bioregion dating from 1979 to 2006 from multiple sources including the Michigan Natural Features Inventory, Minnesota Department of Natural Resources, and Wisconsin Department of Natural Resources. These locations consisted of active nests, known territories, telemetry locations, and opportunistic observations. Around each location we created a 600 ha square and within the square randomly placed 120 points. For each of the 366 goshawk locations we also randomly distributed 20 600 ha squares, each containing 120 randomly located points, throughout the entire goshawk range. This resulted in 7,320 randomly placed squares. We used GIS data layers to determine 20 habitat attribute covariates for each 600 ha square. We used an United States Geological Survey (USGS) forest canopy cover layer with 30 m x 30 m resolution (Huang et al. 2003) to determine the percent canopy cover at each random point and then calculated the following for each square: average percent canopy cover; maximum percent canopy cover; standard deviation of percent canopy cover, and the percent of square with canopy cover between 0-9%, 10-19%, 20-29%, 30-39%, 40-49%, 50-59%, 60-69%, 70-79%, 80-89%, and 90-100%. We used a USGS land cover layer with 30 m x 30 m resolution (Homer et al. 2004) to classify the habitat type of each random point and calculated the percent of each square consisting of the following habitats: aquatic; deciduous forest; coniferous forest; mixed deciduous and coniferous forest; shrub and grassland; agricultural/crops, and wetland and forested wetland.

We conducted an exploratory modeling analysis to develop a model predicting goshawk landscape use in the western Great Lakes bioregion. The squares consisting of goshawk locations were assigned a “1” and randomly placed squares were assigned a “0” as a binary response variable. We developed 105 logistic regression use/availability models (Hosmer and Lemeshow 2000) consisting of models from four covariate categories: land cover; forest canopy; land cover and forest canopy, and percent of forest canopy. We used PROC LOGISTIC in SAS version 9.1 (Allison 1999, SAS Institute 2003) to fit models and estimate covariate coefficients. For each model we calculated an Akaike’s Information Criterion (AIC) value and then ranked and selected top models from each of the four categories using ΔAIC values (Burnham and Anderson 2002). We combined top models from each of the four categories into 24 additional models, fit these models in SAS version 9.1 (SAS Institute 2003), calculated an AIC value for each model, and ranked and selected the top 11 models using ΔAIC values (Burnham and Anderson 2002). We then added one of nine covariate interactions to each of these 11 models resulting in a final list of 43 models. We fit the 43 models and estimated parameter coefficients for each in SAS version 9.1 (SAS Institute 2003), calculated an AIC value for each model, and ranked and selected the top models using ΔAIC values (Burnham and Anderson 2002). Tables of exploratory models and model results are provided in Appendix A.

To obtain an idea of the range of predicted probabilities at known goshawk locations, we used the top model with the most support in the data to estimate the probability of goshawk occurrence at each of the 366 locations. We then examined a distribution of the probability values to determine ranges for primary, secondary, and non-habitat classifications. The probability of use ranged between 0.001 and 0.567 [mean = 0.111; standard deviation (SD) = 0.082; standard error (SE) = 0.004]. We considered primary goshawk habitat to have a probability of use ≥ 0.111, secondary habitat to have a probability of use between 0.028 and 0.111 (i.e., between the mean – 1 SD and the mean), and non-habitat to have a probability of use < 0.028. Within each PSU we randomly placed 120 points and calculated the 20 covariates described above that we used in the exploratory modeling. We used the top model to predict the probability of goshawk use in each of the 49,146 PSUs and then classified each PSU as primary, secondary, or non-habitat. Overall, we categorized 6,860 PSUs as primary habitat, 25,750 as secondary habitat, and 16,536 as non-habitat.

We used GIS layers of federal and state land ownership, and major roads for Michigan, Minnesota, and Wisconsin to determine PSU accessibility. We calculated the nearest Euclidean distance from the centroid of each PSU to a road (paved or Forest Service), and the proportion of each PSU that consisted of project collaborators' lands (e.g., national forests and parks; state forests and parks; tribal organizations). The proportion of each PSU that was comprised of project collaborators' lands ranged between 0 and 1 (mean = 0.533; SE = 0.002), and the distance of each PSU to the nearest road ranged between 0 km and 48 km (mean = 5.00; SE = 0.02). We classified any PSU that had either a proportion of collaborator land ownership <

0.533 or a distance to road > 10 km (i.e., mean + 1 SD) as difficult access. We classified easy access PSUs as only those that had both a proportion of collaborator land ownership ≥ 0.533 and a distance to road ≤ 10 km. After we finished with stratification, the number of PSUs within each of the four strata was: (1) 2,079 in primary habitat/difficult access; (2) 4,781 in primary habitat/easy access; (3) 13,501 in secondary habitat/difficult access, and (4) 12,249 in secondary habitat/easy access.

Based on the amount of project funding available for 2008 we then limited the sampling universe to the seven ecological subregions (McNab 2007) that spanned northeastern and north-central Minnesota, northern Wisconsin, and the Upper Peninsula of Michigan (Figure 1*b*). The 23,989 PSUs within this sampling universe were distributed among strata as follows: (1) 1,293 in primary habitat/difficult access; (2) 3,564 in primary habitat/easy access; (3) 7,047 in secondary habitat/difficult access, and (4) 7,602 in secondary habitat/easy access (Figure 2*a*), and represented 60% of the total available across the region. There were an additional 4,483 PSUs classified as non-habitat. We used an optimal sample size allocation algorithm developed by Jim Baldwin, United States Forest Service (USFS), Pacific Southwest Research Station to determine the number of PSUs per stratum that could be surveyed given project funding (Hargis and Woodbridge 2006). Our sample of 86 PSUs consisted of seven in the primary habitat/difficult access stratum, 27 in primary habitat/easy access, 22 in secondary habitat/difficult access, and 30 in secondary habitat/easy access (Figure 2*b*).

Goshawk Surveys and Habitat Data Collection

Between mid-May and mid-August 2008, surveyors systematically surveyed the 86 PSUs (Figure 2*b*) for goshawk presence or absence in accordance with the Northern Goshawk

Inventory and Monitoring Technical Guide (Woodbridge and Hargis 2006). Each 600 ha PSU contained 120 call stations located on 10 transects that were 250 m apart (Figure 3; Woodbridge and Hargis 2006). Along each transect were 12 call stations separated by 200 m, with adjacent transect call stations offset by 100 m from north to south to maximize coverage (Figure 3) (Woodbridge and Hargis 2006). Surveyors used vocal and/or visual responses by goshawks to the broadcast acoustical method (Kennedy and Stahlecker 1993) and sightings of recent goshawk activity (e.g., active nests; freshly molted feathers; plucking posts and whitewash) to determine goshawk presence or absence at and between call stations. Call stations were surveyed until either a goshawk was detected or all 120 stations in the PSU were surveyed (Woodbridge and Hargis 2006). If a detection occurred, then the survey for the PSU was complete (Woodbridge and Hargis 2006). Two visits per PSU were scheduled with the first survey conducted between mid-May through late June (i.e., the nestling period) and the second between July and mid-August (i.e., the fledgling period). Using either a Western Rivers Predation or FoxPro FX3 digital caller (use of trade names does not imply endorsement by either the U.S. Geological Survey or the University of Minnesota), surveyors broadcast a goshawk alarm call (Woodbridge and Hargis 2006) at a minimum of 95 dB at each station during the nestling period and alternated between the alarm call and a juvenile food-begging call (Woodbridge and Hargis 2006) at stations during the fledgling period. At each station, surveyors broadcast the call for 10 seconds, listened for a response for 30 seconds, rotated 120º, and repeated the call/listening sequence. A total of six calling sequences encompassing two complete 360º turns were made at each station. If a detection did not occur during the first visit, then a second visit was required. However, if a detection occurred during the first visit, then a second visit was required only for a subsample of PSUs for the purpose of calculating detection probabilities (Woodbridge and Hargis 2006).

Surveyors also recorded habitat data at each call station surveyed for goshawks including the primary and secondary/conifer forest types, and structural stage around the station. The primary forest type was the dominant species, or multiple species, and could be classified as either deciduous or coniferous. A secondary/conifer type was recorded only when a coniferous species, or multiple coniferous species, was present, but was not the dominant type. Deciduous forest types were categorized as: (1) aspen; (2) white birch (*Betula papyrifera*); (3) oak; (4) northern hardwood (combinations of maple, oak, basswood, and ash); (5) northern hardwood with yellow birch (*Betula alleghaniensis*), or (6) swamp hardwood (maple, black ash). Coniferous types were classified as: (1) white pine (*Pinus strobus*); (2) red pine (*Pinus resinosa*); (3) jack pine (*Pinus banksiana*); (4) hemlock; (5) spruce/balsam fir, or (6) swamp conifer [combinations of black spruce (*Picea mariana*), tamarack, or cedar]. Surveyors also recorded if any of the pine species were part of a pine plantation. Surveyors classified stations that were surrounded by meadows, water, or developed land as "non-forested," and habitat types other than those listed above as "other." At each station, surveyors classified the predominant structural stage into one of five categories: (1) grass, forbs, shrubs, or seedlings; (2) sapling-pole with canopy closure < 75% [trees ranging between 2.5 cm and 23 cm diameter at breast height (DBH) size for softwoods and 2.5 cm and 28 cm for hardwoods]; (3) sapling-pole with canopy closure > 75% (trees ranging between 2.5 cm and 23 cm DBH size for softwoods and 2.5 cm and 28 cm for hardwoods); (4) late-successional with canopy closure < 75% (trees > 23 cm DBH for softwoods and > 28 cm DBH for hardwoods), and (5) late-successional with canopy closure > 75% (trees > 23 cm DBH for softwoods and > 28 cm DBH for hardwoods).

Estimation of Goshawk Occupancy and Detection Probabilities

We used the survey results to estimate the number of PSUs occupied by goshawks for the bioregion, and for Michigan, Minnesota, and Wisconsin. For the bioregion, we used maximum likelihood techniques to estimate the proportion of PSUs with goshawk presence (P_i) for each stratum ($1 \leq i \leq 4$), and the probabilities of missing presence for visit no. 1 (q_1) and visit no. 2 (q_2) (Hargis and Woodbridge 2006). Calculation of detection probabilities was based on presence/absence data recorded for the two visits to each PSU that resulted in one of the following sequences: 00, 01, 10, 1*, or 11, where a 1 denotes presence and 0 an absence (Hargis and Woodbridge 2006). The 1* sequence applied to PSUs that were surveyed in visit no. 1 and where a goshawk was detected, but not surveyed again (Hargis and Woodbridge 2006). We estimated standard errors for each P_i, q_1, and q_2 using bootstrap methods (Efron and Tibshirani 1993) with 1,000 bootstrap samples created for each parameter using random sampling with replacement. We then used stratified random sampling equations (Thompson 2002) to estimate the total number of PSUs with goshawk occupancy and associated variance.

Because of sample size limitations with presence/absence sequences for each state, we pooled data for both primary habitat strata and both secondary habitat strata, which resulted in two strata for each state. For Minnesota and Wisconsin, we used maximum likelihood techniques to estimate the proportion of PSUs with goshawk presence for the primary (P_p) and secondary habitat strata (P_s), and q_1 and q_2. We estimated standard errors for P_p, P_s, q_1, and q_2 for each state using bootstrap methods (Efron and Tibshirani 1993) with 1,000 bootstrap samples created using random sampling with replacement. For Michigan, use of maximum likelihood methods to estimate detection probabilities was not possible owing to presence/absence sequences of only 11 and 00 for the primary habitat stratum. Therefore, we calculated P_p, P_s, q_1, and q_2 directly from the survey results, and estimated standard errors for each using bootstrap methods (Efron and Tibshirani 1993) with 1,000 bootstrap samples created using random sampling with replacement. We then used stratified random sampling equations (Thompson 2002) to estimate the total number of PSUs with goshawk occupancy in each state and the associated variance. Because we pooled data from easy and difficult access strata, the statewide goshawk occupancy estimates do not afford insight into differences in occupancy between public and private lands.

Because of the small numbers of PSUs surveyed and goshawk detections within each national forest, we pooled data from all four strata for each forest. For each national forest we calculated P (overall proportion of PSUs with goshawk presence) directly from the survey results and estimated the standard error using bootstrap methods (Efron and Tibshirani 1993) with 1,000 bootstrap samples created using random sampling with replacement. Because of sample size limitations with the number of detections and presence/absence sequences, we assumed $q_1 = q_2 = 1$ for each forest. We then used stratified random sampling equations (Thompson 2002) to estimate the total number of PSUs with goshawk occupancy in each national forest and the associated variance.

Goshawk Landscape Use Model Development and Statistical Analyses

We conducted two separate analyses to determine the influence of habitat attributes on the probability of goshawk landscape use throughout the western Great Lakes bioregion. The first analysis evaluated only locations obtained during the 2008 surveys, whereas the second considered observations collected between 1979 and 2006 along with the 2008 locations. For the

2008 data analysis we denoted each PSU that had goshawk presence during either the first or second survey as "used" and assigned each a "1" as a coded binary response variable (Manly et al. 2002). We denoted PSUs that were surveyed and had no goshawk presence, along with the remainder of the 23,968 PSUs not surveyed during 2008, as "available" and assigned each a "0" as a response variable (Manly et al. 2002). The PSUs that were surveyed and had no goshawk presence were considered available to goshawks because our survey methods could not definitively determine absence. For the 1979-2008 data analysis we determined the PSUs that had a previous goshawk location or locations and assigned each a "1," and then assigned a "0" to the remaining 23,776 PSUs considered as available goshawk habitat. We considered all PSUs classified as non-habitat as part of the sampling design to be available to goshawks as part of our modeling analyses because of the potential importance of habitat covariates affecting use in these "poor" quality PSUs.

Within each PSU we created 120 random points and then used several GIS data layers to determine habitat attribute covariates. We used a USGS forest canopy cover layer (Huang et al. 2003) to determine the percent canopy cover at each random point and then calculated the average percent cover ($COVER_{avg}$), standard deviation of percent cover ($COVER_{sd}$), and maximum percent cover ($COVER_{max}$) for each PSU. We used a Landfire GIS layer of succession classifications with 30 m x 30 m resolution (The National Map LANDFIRE 2008) to assign a seral stage to each random point and then calculated the percent of early ($SUCCESSION_{early}$), mid- ($SUCCESSION_{mid}$), and late ($SUCCESSION_{late}$) seral stage forest within each PSU. Early seral stage forest was considered to be of a single canopy layer with standing dead and downed trees. Mid-seral stage forest was comprised of either closed forest with one or two upper canopy layer size classes, with standing dead and downed trees and litter/duff on the forest floor, or open forest with one size class in the upper canopy layer and scattered standing dead and downed trees. Late seral stage forest consisted of either open forest with single upper tree layer and one to three size classes in the upper layer, and scattered standing dead and downed trees, or closed forest with multiple upper canopy layers and size classes, a shade-tolerant understory, standing dead and downed trees, and litter/duff on the forest floor. We used a LANDFIRE GIS layer of average canopy height with 30 m x 30 m resolution (The National Map LANDFIRE 2008) to determine the estimated height at the top of the canopy at each random point, and then calculated the percent of forest within each PSU with a canopy height between 10 m and 25 m ($CANOPY_{10to25}$), and between 25 m and 50 m ($CANOPY_{25to50}$). We used a LANDFIRE GIS layer of average canopy base height with 30 m x 30 m resolution (The National Map LANDFIRE 2008) to determine the estimated height at the bottom of the canopy at each random point, and then calculated the average canopy base height ($BASE_{avg}$) and standard deviation of canopy base height ($BASE_{sd}$) within each PSU. Finally, we used a USGS land cover layer (Homer et al. 2004) to classify the habitat type of each random point and calculated the percentages of deciduous (DECIDUOUS) and coniferous forest (CONIFEROUS) within each PSU.

We developed and compared *a priori* hypotheses, expressed as multiple logistic regression use/availability models (Hosmer and Lemeshow 2000), to estimate the relative contributions of forest canopy cover, successional stage, canopy height, and canopy base height in affecting the odds of goshawk use for both the 2008 and 1979-2008 data sets. Owing to the number of covariates calculated and resulting large number of potential models, we limited covariates used in the *a priori* analyses to those we thought would be most relevant to goshawk ecology, which were $COVER_{avg}$, $COVER_{sd}$, $SUCCESSION_{mid}$, $CANOPY_{10to25}$, $CANOPY_{25to50}$,

$BASE_{avg}$, and $BASE_{sd}$. We kept the remaining five covariates for use in exploratory analyses. While forming the *a priori* model list we calculated variance inflation factors (VIFs; Neter et al. 1996) to quantify multicollinearity between model predictors and removed models containing covariates having a VIF > 10 from the *a priori* list. As a result of multicollinearity, no interactions between covariates were included in the model list. Hypotheses were expressed as 64 candidate models (Table 1).

We formulated an *a priori* hypothesis for each covariate regarding the direction of its effect on the odds response. First, we hypothesized that the odds of goshawk landscape use would be positively correlated with the average percent canopy cover within a PSU because increased cover would afford better nesting habitat and potentially increased prey availability, such as squirrels, chipmunks, hares, and grouse, within forested areas (Boal et al. 2005, Smithers et al. 2005, Boal et al. 2006). Second, we predicted goshawk use would be negatively correlated with the standard deviation of percent canopy cover because goshawks would likely avoid PSUs with a heterogeneous habitat mosaic of open meadows and/or clear cuts interspersed with forest owing to limited resource availability in open areas (Boal et al. 2005). Third, we hypothesized that goshawk use would be positively correlated with higher percentages of mid-seral stage successional forest and canopy heights between 10 m and 25 m. Forested areas with these mid-seral stage characteristics are likely to offer increased prey availability and some trees with sufficient height and attributes for building nests (Boal et al. 2005). Likewise, we predicted that goshawk use would be positively correlated with higher percentages of canopy heights between 25 m and 50 m because of the attributes that mature trees have (e.g., greater heights; larger diameters; more structure and canopy closure) for building nests (Boal et al. 2005). Fourth, we expected goshawk use to be positively correlated with average canopy base height within a PSU because of the need for adequate space between the canopy bottom and top of understory growth for goshawks to fly and maneuver while foraging (Boal et al. 2005). Likewise, we predicted that goshawk use would be negatively correlated with the standard deviation of canopy base height.

We used logistic regression techniques in R version 2.8.1 (R Development Core Team 2008) to fit models and estimate predictor coefficients for both the 2008 and 1979-2008 data. We calculated an AIC value for each model and then ranked and selected the best approximating models for each data set using ΔAIC values (Burnham and Anderson 2002). We then calculated Akaike weights (*w*) for each model to obtain a measure of model selection uncertainty (Burnham and Anderson 2002). Using the top approximating models from the 2008 and 1979-2008 analyses we conducted exploratory analyses by separately adding each of the five exploratory covariates ($COVER_{max}$, $SUCCESSION_{early}$, $SUCCESSION_{late}$, DECIDUOUS, CONIFEROUS) to the top models. We then calculated an AIC value for each exploratory model and compared it to the AIC value for the corresponding *a priori* model.

RESULTS

Goshawk Distributions and Sampling Unit Occupancy

During the first survey visits that lasted from mid-May through June 2008, surveyors detected goshawk presence in 13 of 86 PSUs, resulting in an overall detection rate of 0.151 for the bioregion (Figure 4*a*). In the second round of survey visits, conducted between July and mid-August 2008, surveyors detected goshawk presence in 17 of 85 PSUs for a detection rate of 0.200 (Figure 4*b*). One PSU surveyed in the first round and found to have goshawk presence was not visited again in the second round owing to time constraints. Of the 30 total goshawk detections between the two surveys, 21 occurred in different PSUs with nine PSUs having goshawk presence during both visits.

The 30 goshawk detections occurred at 23 different call stations having forest structural stages ranging between categories 2 and 5 with 52% of locations in stage 3 forest, 22% in stage 5, 13% in stage 4, and 13% in stage 2. Goshawk locations occurred at call stations consisting of 12 different primary forest types, although the majority (30%) of locations was in northern hardwood forest and 13% were in aspen/white birch forest. Aspen, northern hardwood with yellow birch, and swamp conifer forest types each had 2 goshawk locations, while hemlock/white pine, hemlock/northern hardwood, oak/aspen/white birch, red pine, spruce/fir, swamp hardwood, and white birch forest types each had 1 location. Twelve of the locations also had secondary/conifer forest types, of which 33% were in spruce/fir, 25% in spruce/fir/pine, and 17% in white pine. The remaining 3 locations were in hemlock, red pine plantation, and white pine/red pine conifer types.

In Michigan's Upper Peninsula region, surveyors detected goshawks in five of 26 PSUs (19.2%) during the first round of surveys and in six of 25 PSUs (24.0%) during the second round. Seven different PSUs had goshawk presence throughout Michigan (Figure 5). In Minnesota, surveyors detected goshawks in four of 33 PSUs (12.1%) during the first round of surveys and in seven of 33 PSUs (21.2%) during the second round, with nine different PSUs having goshawk presence (Figure 6). In Wisconsin, surveyors detected goshawks in four of 27 PSUs (14.8%) for each round of surveys with five different PSUs having goshawk presence (Figure 7). Goshawk response varied among strata with detection rates of 0.176 and 0.135 in primary and secondary habitat PSUs, respectively, in the first round of surveys (Table 2). In the second round of surveys, the detection rates were 0.294 and 0.137 in primary and secondary habitat PSUs, respectively (Table 2).

In Michigan's Ottawa National Forest, surveyors detected goshawk presence in one of eight (12.5%) and two of eight (25.0%) PSUs during the first and second surveys, respectively (Figure 8). Surveyors detected goshawks in both primary and secondary habitat strata in the Ottawa National Forest (Table 3). Surveyors detected goshawk presence in one of six (16.7%) PSUs during both visits within Michigan's Hiawatha National Forest with the detection occurring in a secondary habitat stratum (Figure 9; Table 3). In Minnesota's Chippewa National Forest, surveyors detected goshawks in two of seven (28.6%) and one of seven (14.3%) PSUs during the first and second surveys, respectively (Figure 10). The two unique detections were in primary and secondary stratum PSUs (Table 3). Surveyors detected goshawk presence in zero of 12 (0.0%) PSUs during the first visit, and one of 12 (8.3%) PSUs during the second visit in Minnesota's Superior National Forest with the detection occurring in a primary habitat stratum PSU (Figure 11; Table 3). In Wisconsin's Chequamegon-Nicolet National Forest, surveyors detected goshawks in one of seven (14.3%) and two of seven (28.6%) PSUs during first and second surveys, respectively (Figure 12). Both unique detections occurred in a primary habitat stratum (Table 3).

Estimating Goshawk Occupancy for the Bioregion, States, and National Forests

Based on survey data, we estimated that there were 5,184 ± 199 (SE) PSUs with goshawk occupancy throughout our study area in the western Great Lakes bioregion in 2008 (Table 4). Maximum likelihood estimates of the proportion of PSUs with goshawk occupancy for each stratum were 0.483 ± 0.190, 0.292 ± 0.083, 0.256 ± 0.088, and 0.225 ± 0.072 for the primary habitat/difficult access, primary habitat/easy access, secondary habitat/difficult access, and secondary habitat/easy access strata, respectively (Table 4). Goshawk detection probabilities for the bioregion were 0.549 ± 0.118 for the first visit to PSUs and 0.750 ± 0.126 for the second visit (Table 4).

We estimated that there were 1,413 ± 96 PSUs with goshawk occupancy in Michigan's Upper Peninsula in 2008 (Table 5). The proportion of PSUs with goshawk occupancy was 0.200 ± 0.131 and 0.313 ± 0.111 for primary and secondary habitat strata, respectively (Table 5). The detection probability for the first visit to PSUs was 0.667 ± 0.188 (Table 5). Because all PSUs that had goshawks in the first visit also were found to have goshawks in the second visit, the detection probability based on direct calculation was one. The standard error for the second visit detection probability was not meaningful because all bootstrap samples had the same mean, resulting in a standard error of zero. The portion of Minnesota included in the sampling universe contained an estimated 3,949 ± 176 PSUs occupied by goshawks in 2008 with maximum likelihood estimates of 0.556 ± 0.127 and 0.327 ± 0.093 for the proportion of primary and secondary habitat PSUs occupied, respectively (Table 6). Detection probabilities for surveys in Minnesota were 0.286 ± 0.173 and 0.500 ± 0.247 for the first and second visits, respectively (Table 6). We estimated that there were 903 ± 110 PSUs occupied by goshawks in the portion of Wisconsin included in the sampling universe in 2008 with proportions of PSUs occupied of 0.320 ± 0.143 and 0.125 ± 0.084 for primary and secondary habitat PSUs, respectively (Table 7). The detection probabilities for Wisconsin surveys were 0.750 ± 0.218 and 0.750 ± 0.221 for the first and second visits, respectively (Table 7).

We estimated that there were 265 ± 145 PSUs with goshawk occupancy in Michigan's Ottawa National Forest in 2008 with a proportion of occupied PSUs of 0.250 ± 0.152 (Table 8).

For Michigan's Hiawatha National Forest we estimated that there were 145 ± 139 PSUs with goshawk occupancy and the proportion of occupied PSUs to be 0.167 ± 0.155 (Table 8). In Minnesota, we estimated that there were 271 ± 146 and 216 ± 210 PSUs with goshawk occupancy in the Chippewa and Superior National Forests, respectively (Table 8). In the Chippewa National Forest the proportion of occupied PSUs was 0.286 ± 0.167 and that for the Superior National Forest was 0.083 ± 0.079. We estimated that there were 442 ± 244 PSUs with goshawk occupancy in Wisconsin's Chequamegon-Nicolet National Forest with a proportion of occupied PSUs of 0.286 ± 0.176 (Table 8).

Modeling the Probability of Goshawk Landscape Use

Data for the 2008 modeling analysis consisted of 21 PSUs used by goshawks and 23,968 available PSUs. There were six models with ΔAIC < 2 for the 2008 data analysis (Table 9; Appendix B) with the top model having *w* = 0.117 and a relative likelihood of 1.9 compared to the second best model, indicating nearly twice as much support in the data for the top model. The top approximating model included a significant, positive $COVER_{avg}$ covariate that had 95% confidence intervals that did not overlap zero (Table 10). The second-best model had ΔAIC = 1.23 (Table 9) and included a positive $COVER_{avg}$ covariate with confidence intervals spanning zero and a negative $COVER_{sd}$ effect that had confidence intervals that overlapped zero (Table 10). The remaining four most highly supported models each contained a significant, positive $COVER_{avg}$ covariate with confidence intervals not overlapping zero (Table 10).

The 1979-2008 data set of goshawk locations consisted of 213 PSUs used by goshawks and 23,776 available PSUs. There were three models with ΔAIC < 2 for the 1979-2008 data analysis (Table 11; Appendix B) with the top model having *w* = 0.417 and relative likelihoods of

1.4 and 2.6 compared to the second and third best models, respectively. The top approximating model included significant, positive $COVER_{avg}$, $BASE_{sd}$, $CANOPY_{10to25}$, and $CANOPY_{25to50}$ covariates, and a significant, negative $BASE_{avg}$ effect that each had 95% confidence intervals that did not overlap zero (Table 12). The second-best model had ΔAIC = 0.60 (Table 11) and included the same five significant covariates as the top model, but also contained a positive $SUCCESSION_{mid}$ effect that had confidence intervals spanning zero (Table 12). The third-best model had ΔAIC = 1.94 (Table 11), included the same five significant covariates as the top two models, but also contained a $COVER_{sd}$ effect that had confidence intervals that overlapped zero (Table 12).

Exploratory modeling analyses for the 2008 data resulted in no improvement for any of the top approximating *a priori* models. Adding $COVER_{max}$, $SUCCESSION_{early}$, $SUCCESSION_{late}$, DECIDUOUS, and CONIFEROUS covariates separately to each of the six top *a priori* models increased each model's AIC value relative to that for the *a priori* model. The exploratory modeling done for the 1979-2008 data did result in an improvement when adding $SUCCESSION_{early}$, $SUCCESSION_{late}$, or DECIDUOUS to each of the three top approximating *a priori* models (Table 13). The largest decreases in AIC values, between 4.7 and 13.7 AIC units, occurred when adding the $SUCCESSION_{late}$ covariate, which had confidence intervals that did not overlap zero in all models (Tables 13 and 14). The $SUCCESSION_{early}$ and DECIDUOUS covariates each had confidence intervals that spanned zero in all three models (Tables 15 and 16). When adding $COVER_{max}$ or CONIFEROUS, AIC values for each model increased relative to the value for the *a priori* model. While addition of $SUCCESSION_{early}$, $SUCCESSION_{late}$, or DECIDUOUS to the top *a priori* models lowered AIC values, it also resulted in excessive multicollinearity among some model predictors with all exploratory models having at least one covariate with a VIF > 10. Parameter coefficient estimates for the exploratory models that included $SUCCESSION_{late}$, $SUCCESSION_{early}$, and DECIDUOUS are provided in Tables 14, 15, and 16, respectively. However, because of the multicollinearity among some predictors in the models, interpretation of individual coefficient estimates may be problematic.

DISCUSSION

There were 5,184 (95% confidence interval (CI): 4,795, 5,573) PSUs estimated to have goshawk occupancy in our study area in the western Great Lakes bioregion in 2008. The sampling universe of the ecological subregions contained 19,506 PSUs classified as potential goshawk habitat and, therefore, goshawks were estimated to occupy nearly 27% of this area. These results provide a baseline estimate of goshawk occupancy in the region and, while additional years of data are required to determine a trend, suggest that goshawks are widely distributed and occur at significant densities throughout the region. The western Great Lakes bioregion includes the southern periphery of the goshawk breeding range that extends north into Canada (Squires and Reynolds 1997) and, therefore, the area may provide habitat that supports lower densities of goshawks than at the core of the range (Caughley et al. 1988). Home range size of goshawks in the western Great Lakes region has been estimated to be up to 44% larger (Boal et al. 2003) than used to make management recommendations in the southwestern United States (Reynolds et al. 1992).

As hypothesized, goshawk landscape use in the western Great Lakes bioregion in 2008, and historically from 1979-2008, was related to the amount of forest canopy cover as the odds of use were positively correlated with the average percent canopy cover within each PSU in the top approximating models. In addition to the positive correlation between use and cover that was derived from satellite imagery, habitat data recorded at calling stations during 2008 further indicated the importance of high amounts of canopy cover on goshawk presence. A total of 74% of goshawk detections occurred at call stations having forest succession categories of seral stage 3 or 5, both of which were defined to have canopy closure > 75%. These results reinforce the need for maintaining contiguous forested areas having high amounts of canopy cover to provide adequate resources for goshawks. Key prey species, such as red squirrels, eastern chipmunks, and snowshoe hares (Smithers et al. 2005), are primarily found in forested habitats, especially those with understory growth and woody debris (Litvaitis et al. 1985, Bayne and Hobson 2000). In agreement with our work, previous studies of goshawk nesting habitat in the western Great Lakes region also indicated the importance of mature stands with high amounts of canopy cover (Rosenfield et al. 1998, Boal et al. 2005).

Tree canopy height within stands was related to patterns in goshawk landscape use from 1979-2008 as the odds of use were positively correlated with the percentages of each PSU having canopy heights between 10 m and 25 m, and 25 m and 50 m. Goshawks have been documented to nest in the relatively tallest and largest trees in the western Great Lakes region and elsewhere (Squires and Ruggiero 1996, Squires and Reynolds 1997, Daw et al. 1998, Andersen et al. 2005, Boal et al. 2005, Boal et al. 2006). In Wisconsin, Rosenfield et al. (1998) recorded attributes of trees with goshawk nests and found a mean tree height of 24.6 m and a mean nest height of 14.7 m. Large, tall trees associated with mature forests are also more likely to provide the canopy closure and structure necessary for building nests (Penteriani et al. 2001). The top approximating models for the 1979-2008 data included forest canopy base height covariates with the average height at the base of the canopy within each PSU being negatively correlated with the odds of goshawk use, which was contrary to our hypothesis. Also opposite of our prediction, the amount of variability in canopy base height was positively correlated with the odds of use. The height of the canopy at its base may influence goshawks in a couple of ways. Higher canopy base heights may provide more area for flying and maneuvering between the canopy and understory, or canopy and shrub layers for forests with minimal understory growth, while hunting for prey (Penteriani 2002, Boal et al. 2005). Increased canopy volume, which is related to both taller canopy heights and shorter base heights, may provide more potential for nest sites resulting from higher stem densities and more structure for supporting nests (Penteriani et al. 2001). In Minnesota, stands with goshawk nests had average canopy crown and base heights of 17 m and 9.5 m, respectively, along with high stem densities (Boal et al. 2005). Additionally, there were up to 4 m and 3.5 m layers in nest and foraging stands, respectively, between the canopy base and top of the understory that provided unobstructed flight paths (Boal et al. 2005). Because our GIS layers did not include information on the height of understory layers it is difficult to fully evaluate the negative correlation between canopy base height and goshawk use. There may be a trade-off between the attributes that canopies with high volumes provide for nests and the amount of space available for flying. The positive correlation between variability in canopy base height and goshawk use suggests that stands providing a combination of trees with high canopy volume and adequate space for flying may have the best combination of resources for both nesting and foraging.

Our estimates of detection probabilities for the bioregion were lower for the first survey visit (0.549; 95% CI: 0.318, 0.781) than for the second (0.750; 95% CI: 0.503, 0.997), although confidence intervals overlapped slightly. Of particular note is the difference in detection rates for primary habitat strata between the two visits as surveyors recorded goshawk presence in

17.6% and 29.4% of PSUs for the first and second rounds of surveys, respectively. Factors that may attribute to lower detectability of goshawks during the nestling period, specifically during May, include variability in spring weather that may affect nest success during incubation and differences among individual goshawks with respect to parental care (Dewey and Kennedy 2001). Roberson et al. (2005) documented detection rates of only 28% during the nestling phase compared to 68% in the fledgling phase for goshawk surveys in Minnesota. Our detection probability estimates for Minnesota were the lowest of all three states in the bioregion with first and second visit estimates of 0.286 (95% CI: 0.000, 0.624) and 0.500 (95% CI: 0.015, 0.985), respectively. In contrast, estimates for detection probabilities in Wisconsin were similar between the two visits at 0.750 (95% CI: 0.322, 1.000) for the first survey round and 0.750 (95% CI: 0.317, 1.000) for the second. One possible explanation for the lower detection probability in Minnesota was that field crews in the state were among the least experienced of those in the bioregion. It is also possible that local scale climate that may influence timing of nesting affected detectability in northern Minnesota. While the occupancy estimate was higher for Minnesota than the other states, the number of PSUs within the sampling universe for Minnesota was considerably higher (9,702 PSUs) than for either Michigan (4,024 PSUs) or Wisconsin (5,949 PSUs). The estimated proportion of PSUs occupied by goshawks in Minnesota was 40.7%, while that for Michigan and Wisconsin was 35.1% and 15.2%, respectively. Continued monitoring is needed to determine if differences in detection probabilities and goshawk occupancy among states are consistent or variable among years.

While our results provide a baseline for goshawk monitoring and new insights into factors affecting landscape use by goshawks in the western Great Lakes bioregion, we acknowledge some limitations of our study. Except for the 2008 locations that were collected based on a stratified random sampling design, the historical locations from 1979-2006 were obtained with assorted methods including many opportunistic sightings near roads or searching what was considered high quality goshawk habitat. Whether opportunistic locations created a bias with respect to significant habitat covariates in the top models is unknown. However, some previous studies on goshawk habitat use have evaluated the bias associated with opportunistically compared to systematically obtained nest locations. In Oregon, Daw et al. (1998) found similar levels of canopy closure and densities of large trees around nests that were found using opportunistic and systematic search methods. The Wisconsin study by Rosenfield et al. (1998) also documented no statistical difference between 23 habitat features recorded at nests found by unbiased compared to potentially biased means. Despite these studies, results from the goshawk monitoring implemented in 2008 illustrate the importance of using a sampling design for obtaining locations. Of the 21 goshawk detections that occurred in different PSUs, 11 were located in PSUs in a secondary habitat strata with at least several of these detections in what would have been considered to be poor quality habitat prior to the 2008 surveys. The results of Beier et al. (2008) that documented lower goshawk productivity in areas previously considered to have beneficial forest structure from established guidelines, illustrate the importance of empirical data when devising goshawk management plans and forest management specifications.

Another limitation of our modeling analyses is use of dated GIS layers, particularly for the historic analysis of 1979-2008 locations. The forest canopy cover and land cover GIS layers were based on 2001 data, while the LANDFIRE succession, canopy height, and canopy base height layers were developed based on post-1999 data. Because of the dynamic nature of forest environments, attributing a canopy cover value based on 2001 data to a location recorded in 1985, for example, is somewhat problematic. However, a lack of freely available older and more recent GIS layers necessitated our approach. Furthermore, the majority of the locations from 1979-2008 was relatively recent with 63% occurring between 2000 and 2008 and 34% between 1990 and 1999. The unexpected correlations between the odds of use and canopy base height and canopy base height variability may be related to the GIS layer being derived based on a predictive model. The LANDFIRE map of canopy base height was generated using predictive modeling to relate satellite imagery and spatial environmental variables to field measurements of canopy base height (The National Map LANDFIRE 2008). Despite these factors related to the GIS data we used, results from our modeling analyses make biological sense relative to goshawk ecology.

Overall, our results suggest multiple habitat factors affected goshawk landscape use and that these attributes are in general agreement with those from the few studies in the western Great Lakes region (Rosenfield et al. 1998, Boal et al. 2005, Roberson et al. 2005, Boal et al. 2006) and the more ample literature from research in the western United States and Europe (Hayward and Escano 1989, Bright-Smith and Mannan 1994, Beier and Drennan 1997, Daw and DeStefano 2001, Penteriani 2002, Andersen et al. 2005). The odds of goshawk use were greater in areas with higher canopy cover, higher percentage of tall trees, lower canopy base heights, and high amounts of variability in canopy base height. While much research is necessary in the western Great Lakes region to better elucidate goshawk demographic patterns, movements, and predator-prey relationships during the breeding and non-breeding periods, continued monitoring is just as important to determine population trends for the bioregion and for Michigan, Minnesota, and Wisconsin.

FUTURE BIOREGIONAL MONITORING CONSIDERATIONS

While results of the 2008 surveys indicated goshawks are widely distributed and occur at significant densities throughout the western Great Lakes region, additional monitoring is required to determine a population trend. We suggest that the coordinated bioregional goshawk surveys and associated habitat data collection be repeated every five years, which would result in the next survey being conducted in 2013. This five-year interval between surveys has the following benefits. First, it provides a trade-off of information obtained for money spent. Annual surveys, while ideal for determining population trend relatively quickly, are too costly and time intensive given the budgetary constraints facing federal and state agencies. Additionally, surveys require the cooperation of private landowners and some may be reluctant to grant access every year. Our occupancy estimates suggest the western Great Lakes goshawk population may be able to be monitored using surveys with less than annual frequency. If results from the planned 2013 surveys provide occupancy estimates significantly lower than those from 2008, then surveys more frequent than every five years may be warranted. Second, other than in PSUs having disturbance after 2008 (e.g., fire; forest thinning or clear cutting), collection of habitat data at call stations is necessary only every several years because of the time scale on which successional processes operate in forests. Collecting habitat data on five-year intervals will provide a data set that can be examined for both small and large spatial scale changes in forest structure and species composition in the PSUs surveyed. Third, planning of surveys in 2013 affords project collaborators time to decide on their financial and in-kind contributions well ahead of the surveys, which is necessary given the time intensive nature of planning this type of effort. On the individual state or national forest level, we encourage repeated monitoring of PSUs in the years between the bioregional surveys. If all PSUs within a state or national forest that were surveyed in 2008 can be resurveyed, then an occupancy estimate can be compared to our result to determine a short-term trend. More intensive monitoring and research in those PSUs having goshawk presence in 2008 may also be beneficial. The surveys documented 18 previously unknown goshawk locations that may provide additional insights into nest site characteristics and productivity.

Improvements and additions can be made to the modeling analyses with data from continued bioregional monitoring along with independent data collection from project collaborators. Multiple years of goshawk occupancy estimates will afford incorporation of climate covariates for the bioregion, states, or individual PSUs into models such as cumulative spring and summer precipitation, cumulative snowpack depth during the preceding winter, and average maximum and minimum temperatures during the spring nestling period. Development of spatially explicit precipitation models throughout the bioregion will complement examination of habitat attributes influencing goshawk landscape use. In addition, concurrently collected data on reproductive success and productivity could be used to aid in further understanding goshawk-habitat associations. Finally, to examine potential human influence on goshawk landscape use, incorporation of distance to roads, developed campsites, and other human-related activities could be included in models.

Continued collection of habitat data at call stations will enable analyses on forest change both in PSUs occupied by goshawks and those that are available to goshawks. Comparisons can be made of structural stage and species composition between PSUs that were occupied by goshawks in 2008 and those occupied again in 2013. Comparisons can also be made of forest attributes for PSUs having goshawk occupancy in one survey year, but not the other to determine what habitat factors may have influenced goshawk use of the PSU and habitat changes occurring in the survey area. With repeated measures analytical methods a habitat use/availability analysis can be conducted to gain insight into what attributes may affect goshawk use of PSUs among those surveyed. Also, to investigate differences between publicly and privately managed forests, analysis of habitat data by land ownership type can be done for comparison of suitable goshawk habitat and to elucidate changes that may be either beneficial or detrimental to goshawks.

Finally, because we used the same forest canopy cover and land cover GIS layers for developing the stratified random sampling design as we did the modeling analyses, improvements could potentially be made to the stratification classification of PSUs. The 2008 survey results indicated similar detection rates between primary and secondary strata PSUs for the first round of surveys (Table 2). While the similarity likely results from the lower detection probability during the nestling phase as mentioned above, use of relatively coarse-scale and dated GIS layers may account for the comparable detection rates. However, obtaining fine-scale GIS layers for forest attributes for all private and public lands throughout the entire bioregion would be prohibitively expensive if not impossible because of the lack of data for areas with private land ownership. Given the importance of continuing bioregional monitoring we suggest the best use of project funding is towards field efforts, data collection, and analyses. Updated and freely available forest attribute GIS layers may be accessible before the next planned round of surveys in 2013. The 2008 surveys documented several PSUs that contained either recently cut forest or many call stations classified as non-habitat, and these PSUs will be replaced before the next surveys are conducted.

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TABLES

Model	Model Structure
1	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg}$
2	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd}$
3	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{sd}$
4	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}SUCCESSION_{mid}$
5	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{10to25}$
6	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd}$
7	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}BASE_{sd}$
8	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}SUCCESSION_{mid}$
9	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}CANOPY_{10to25}$
10	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd} + \beta_3{*}BASE_{sd}$
11	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd} + \beta_3{*}SUCCESSION_{mid}$
12	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd} + \beta_3{*}CANOPY_{10to25}$
13	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{sd} + \beta_3{*}SUCCESSION_{mid}$
14	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{sd} + \beta_3{*}CANOPY_{10to25}$
15	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}SUCCESSION_{mid} + \beta_3{*}CANOPY_{10to25}$
16	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd} + \beta_4{*}BASE_{sd}$
17	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd} + \beta_4{*}SUCCESSION_{mid}$
18	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd} + \beta_4{*}CANOPY_{10to25}$
19	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}BASE_{sd} + \beta_4{*}SUCCESSION_{mid}$
20	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}BASE_{sd} + \beta_4{*}CANOPY_{10to25}$
21	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}SUCCESSION_{mid} + \beta_4{*}CANOPY_{10to25}$
22	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd} + \beta_3{*}BASE_{sd} + \beta_4{*}SUCCESSION_{mid}$
23	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd} + \beta_3{*}SUCCESSION_{mid} + \beta_4{*}CANOPY_{10to25}$
24	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd} + \beta_3{*}BASE_{sd} + \beta_4{*}CANOPY_{10to25}$
25	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{sd} + \beta_3{*}SUCCESSION_{mid} + \beta_4{*}CANOPY_{10to25}$
26	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd} + \beta_4{*}BASE_{sd} + \beta_5{*}SUCCESSION_{mid}$
27	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd} + \beta_4{*}BASE_{sd} + \beta_5{*}CANOPY_{10to25}$
28	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd} + \beta_4{*}SUCCESSION_{mid} + \beta_5{*}CANOPY_{10to25}$
29	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}BASE_{sd} + \beta_4{*}SUCCESSION_{mid} + \beta_5{*}CANOPY_{10to25}$
30	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}COVER_{sd} + \beta_3{*}BASE_{sd} + \beta_4{*}SUCCESSION_{mid} + \beta_5{*}CANOPY_{10to25}$
31	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}BASE_{avg} + \beta_3{*}COVER_{sd} + \beta_4{*}BASE_{sd} + \beta_5{*}SUCCESSION_{mid} + \beta_6{*}CANOPY_{10to25}$
32	$g(x) = \beta_0 + \beta_1{*}COVER_{avg}$
33	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50}$
34	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}BASE_{avg}$
35	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}COVER_{sd}$
36	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}BASE_{sd}$
37	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}SUCCESSION_{mid}$
38	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}CANOPY_{10to25}$
39	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}BASE_{avg} + \beta_4{*}COVER_{sd}$
40	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}BASE_{avg} + \beta_4{*}BASE_{sd}$
41	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}BASE_{avg} + \beta_4{*}SUCCESSION_{mid}$
42	$g(x) = \beta_0 + \beta_1{*}COVER_{avg} + \beta_2{*}CANOPY_{25to50} + \beta_3{*}BASE_{avg} + \beta_4{*}CANOPY_{10to25}$

Table 1 continued

43	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*COVER$_{sd}$ + β_4*BASE$_{sd}$
44	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*COVER$_{sd}$ + β_4*SUCCESSION$_{mid}$
45	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*COVER$_{sd}$ + β_4*CANOPY$_{10to25}$
46	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{sd}$ + β_4*SUCCESSION$_{mid}$
47	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{sd}$ + β_4*CANOPY$_{10to25}$
48	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*SUCCESSION$_{mid}$ + β_4*CANOPY$_{10to25}$
49	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*COVER$_{sd}$ + β_5*BASE$_{sd}$
50	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*COVER$_{sd}$ + β_5*SUCCESSION$_{mid}$
51	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*COVER$_{sd}$ + β_5*CANOPY$_{10to25}$
52	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*BASE$_{sd}$ + β_5*SUCCESSION$_{mid}$
53	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*BASE$_{sd}$ + β_5*CANOPY$_{10to25}$
54	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*SUCCESSION$_{mid}$ + β_5*CANOPY$_{10to25}$
55	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*COVER$_{sd}$ + β_4*BASE$_{sd}$ + β_5*SUCCESSION$_{mid}$
56	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*COVER$_{sd}$ + β_4*SUCCESSION$_{mid}$ + β_5*CANOPY$_{10to25}$
57	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*COVER$_{sd}$ + β_4*BASE$_{sd}$ + β_5*CANOPY$_{10to25}$
58	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{sd}$ + β_4*SUCCESSION$_{mid}$ + β_5*CANOPY$_{10to25}$
59	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*COVER$_{sd}$ + β_5*BASE$_{sd}$ + β_6*SUCCESSION$_{mid}$
60	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*COVER$_{sd}$ + β_5*BASE$_{sd}$ + β_6*CANOPY$_{10to25}$
61	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*COVER$_{sd}$ + β_5*SUCCESSION$_{mid}$ + β_6*CANOPY$_{10to25}$
62	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*BASE$_{sd}$ + β_5*SUCCESSION$_{mid}$ + β_6*CANOPY$_{10to25}$
63	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*COVER$_{sd}$ + β_4*BASE$_{sd}$ + β_5*SUCCESSION$_{mid}$ + β_6*CANOPY$_{10to25}$
64	$g(x) = \beta_0 + \beta_1$*COVER$_{avg}$ + β_2*CANOPY$_{25to50}$ + β_3*BASE$_{avg}$ + β_4*COVER$_{sd}$ + β_5*BASE$_{sd}$ + β_6*SUCCESSION$_{mid}$ + β_7*CANOPY$_{10to25}$

Table 1. The 64 *a priori* hypothesized models developed to examine the affect of habitat attributes on the odds of goshawk landscape use in the western Great Lakes region. The response variable, g(x), is the logit and covariates are described in the text.

Stratum	Number of Detections	Number of PSUs Surveyed	Detection Rate
	Survey Visit No. 1		
Primary habitat / easy access	3	27	0.111
Primary habitat / difficult access	3	7	0.429
Primary habitat (Overall)	**6**	**34**	**0.176**
Secondary habitat / easy access	4	30	0.133
Secondary habitat / difficult access	3	22	0.136
Secondary habitat (Overall)	**7**	**52**	**0.135**
	Survey Visit No. 2		
Primary habitat / easy access	7	27	0.259
Primary habitat / difficult access	3	7	0.429
Primary habitat (Overall)	**10**	**34**	**0.294**
Secondary habitat / easy access	4	29	0.138
Secondary habitat / difficult access	3	22	0.136
Secondary habitat (Overall)	**7**	**51**	**0.137**

Table 2. The goshawk detection rate by stratum for visits one and two for goshawk surveys conducted between mid-May and mid-August 2008 in the western Great Lakes bioregion.

Stratum	Number of Unique Detections	Number of PSUs Surveyed	Detection Rate
Ottawa National Forest			
Primary habitat / easy access	0	3	0.000
Primary habitat / difficult access	1	1	1.000
Primary habitat (Overall)	**1**	**4**	**0.250**
Secondary habitat / easy access	1	3	0.333
Secondary habitat / difficult access	0	1	0.000
Secondary habitat (Overall)	**1**	**4**	**0.250**
Hiawatha National Forest			
Primary habitat / easy access	0	1	0.000
Primary habitat / difficult access	0	1	0.000
Primary habitat (Overall)	**0**	**2**	**0.000**
Secondary habitat / easy access	1	4	0.250
Secondary habitat / difficult access	0	0	N/A
Secondary habitat (Overall)	**1**	**4**	**0.250**
Chippewa National Forest			
Primary habitat / easy access	1	3	0.333
Primary habitat / difficult access	0	0	N/A
Primary habitat (Overall)	**1**	**3**	**0.333**
Secondary habitat / easy access	1	3	0.333
Secondary habitat / difficult access	0	1	0.000
Secondary habitat (Overall)	**1**	**4**	**0.250**
Superior National Forest			
Primary habitat / easy access	1	3	0.333
Primary habitat / difficult access	0	2	0.000
Primary habitat (Overall)	**1**	**5**	**0.200**
Secondary habitat / easy access	0	5	0.000
Secondary habitat / difficult access	0	2	0.000
Secondary habitat (Overall)	**0**	**7**	**0.000**
Chequamegon-Nicolet National Forest			
Primary habitat / easy access	2	4	0.500
Primary habitat / difficult access	0	0	N/A
Primary habitat (Overall)	**2**	**4**	**0.500**
Secondary habitat / easy access	0	1	0.000
Secondary habitat / difficult access	0	2	0.000
Secondary habitat (Overall)	**0**	**3**	**0.000**

Table 3. The overall goshawk detection rate by stratum and national forest for goshawk surveys conducted between mid-May and mid-August 2008 in the western Great Lakes bioregion.

Parameter	Estimate	Standard Error	Lower 95% CI	Upper 95% CI
N	5,184	199	4,795	5,573
P_1	0.483	0.190	0.110	0.856
P_2	0.292	0.083	0.129	0.456
P_3	0.256	0.088	0.083	0.429
P_4	0.225	0.072	0.084	0.367
$1 - q_1$	0.549	0.118	0.318	0.781
$1 - q_2$	0.750	0.126	0.503	0.997

Table 4. Parameter estimates, standard errors, and lower and upper 95% confidence intervals (CI) for goshawk occupancy and detection probability for the western Great Lakes bioregion based on data from 2008 surveys. Parameter definitions are as follows. N: the number of Primary Sampling Units (PSUs) with goshawk occupancy; P_1: the proportion of PSUs with goshawk occupancy in stratum 1 (primary habitat/difficult access); P_2: the proportion of PSUs with goshawk occupancy in stratum 2 (primary habitat/easy access); P_3: the proportion of PSUs with goshawk occupancy in stratum 3 (secondary habitat/difficult access); P_4: the proportion of PSUs with goshawk occupancy in stratum 4 (secondary habitat/easy access); $1 - q_1$: the detection probability for visit no. 1; $1 - q_2$: the detection probability for visit no. 2.

Parameter	Estimate	Standard Error	Lower 95% CI	Upper 95% CI
N	1,413	96	1,224	1,602
P_p	0.200	0.131	0.000	0.457
P_s	0.313	0.111	0.095	0.530
$1 - q_1$	0.667	0.188	0.298	1.000
$1 - q_2$	1.000	N/A	N/A	N/A

Table 5. Parameter estimates, standard errors, and lower and upper 95% confidence intervals (CI) for goshawk occupancy and detection probability for the Upper Peninsula of Michigan based on data from 2008 surveys. Parameter definitions are as follows. N: the number of Primary Sampling Units (PSUs) with goshawk occupancy; P_p: the proportion of PSUs with goshawk occupancy in all primary habitat strata (primary habitat/difficult access and primary habitat/easy access); P_p: the proportion of PSUs with goshawk occupancy in all secondary habitat strata (secondary habitat/difficult access and secondary habitat/easy access); $1 - q_1$: the detection probability for visit no. 1; $1 - q_2$: the detection probability for visit no. 2. “N/A” denotes the value was not able to be estimated.

Parameter	Estimate	Standard Error	Lower 95% CI	Upper 95% CI
N	3,949	176	3,603	4,294
P_p	0.556	0.127	0.307	0.804
P_s	0.327	0.093	0.146	0.509
$1 - q_1$	0.286	0.173	0.000	0.624
$1 - q_2$	0.500	0.247	0.015	0.985

Table 6. Parameter estimates, standard errors, and lower and upper 95% confidence intervals (CI) for goshawk occupancy and detection probability for Minnesota based on data from 2008 surveys. Parameter definitions are as follows. N: the number of Primary Sampling Units (PSUs) with goshawk occupancy; P_p: the proportion of PSUs with goshawk occupancy in all primary habitat strata (primary habitat/difficult access and primary habitat/easy access); P_p: the proportion of PSUs with goshawk occupancy in all secondary habitat strata (secondary habitat/difficult access and secondary habitat/easy access); $1 - q_1$: the detection probability for visit no. 1; $1 - q_2$: the detection probability for visit no. 2.

Parameter	Estimate	Standard Error	Lower 95% CI	Upper 95% CI
N	903	110	687	1,119
P_p	0.320	0.143	0.040	0.600
P_s	0.125	0.084	0.000	0.289
$1 - q_1$	0.750	0.218	0.322	1.000
$1 - q_2$	0.750	0.221	0.317	1.000

Table 7. Parameter estimates, standard errors, and lower and upper 95% confidence intervals (CI) for goshawk occupancy and detection probability for Wisconsin based on data from 2008 surveys. Parameter definitions are as follows. N: the number of Primary Sampling Units (PSUs) with goshawk occupancy; P_p: the proportion of PSUs with goshawk occupancy in all primary habitat strata (primary habitat/difficult access and primary habitat/easy access); P_p: the proportion of PSUs with goshawk occupancy in all secondary habitat strata (secondary habitat/difficult access and secondary habitat/easy access); $1 - q_1$: the detection probability for visit no. 1; $1 - q_2$: the detection probability for visit no. 2.

National Forest	N	Standard Error	Lower 95% CI	Upper 95% CI
Chequamegon-Nicolet, Wisconsin	442	244	0	920
Chippewa, Minnesota	271	146	0	558
Hiawatha, Michigan	145	139	0	419
Ottawa, Michigan	265	145	0	549
Superior, Minnesota	216	210	0	626

Table 8. The estimated number of Primary Sampling Units with goshawk occupancy (N), and associated standard error and lower and upper 95% confidence intervals (CI) for each of the five national forests surveyed in 2008.

Model	Model Structure	K	ΔAIC	*w*
32	$g(x) = \beta_0 + \beta_1$*$COVER_{avg}$	2	0.00	0.118
2	$g(x) = \beta_0 + \beta_1$*$COVER_{avg}$ + β_2*$COVER_{sd}$	3	1.23	0.064
5	$g(x) = \beta_0 + \beta_1$*$COVER_{avg}$ + β_2*$CANOPY_{10to25}$	3	1.48	0.056
33	$g(x) = \beta_0 + \beta_1$*$COVER_{avg}$ + β_2*$CANOPY_{25to50}$	3	1.88	0.046
4	$g(x) = \beta_0 + \beta_1$*$COVER_{avg}$ + β_2*$SUCCESSION_{mid}$	3	1.93	0.045
3	$g(x) = \beta_0 + \beta_1$*$COVER_{avg}$ + β_2*$BASE_{sd}$	3	1.95	0.044

Table 9. Model selection results for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion in 2008. The six top approximating models are listed along with the number of parameters (K), ΔAIC value, and Akaike weight (*w*). The response variable, *g*(x), is the logit, and covariates are described in the text.

Covariate	**Model 32** β_i (SE)	**Model 2** β_i (SE)	**Model 5** β_i (SE)	**Model 33** β_i (SE)	**Model 4** β_i (SE)	**Model 3** β_i (SE)
Intercept	**-10.74 (1.33)**	**-8.96 (2.20)**	**-11.14 (1.50)**	**-10.79 (1.34)**	**-10.75 (1.33)**	**-10.37 (2.15)**
$COVER_{avg}$	**0.054 (0.018)**	0.038 (0.023)	**0.051 (0.019)**	**0.055 (0.018)**	**0.053 (0.018)**	**0.051 (0.021)**
$COVER_{sd}$	N/A	-0.030 (0.033)	N/A	N/A	N/A	N/A
$CANOPY_{10to25}$	N/A	N/A	0.008 (0.012)	N/A	N/A	N/A
$CANOPY_{25to50}$	N/A	N/A	N/A	-0.004 (0.011)	N/A	N/A
$SUCCESSION_{mid}$	N/A	N/A	N/A	N/A	0.002 (0.009)	N/A
$BASE_{sd}$	N/A	N/A	N/A	N/A	N/A	-0.062 (0.288)

Table 10. Parameter estimates (β_i) and standard errors (SE) for covariates contained in the six top approximating models for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion in 2008. Covariates are described in the text; bold notation denotes statistical significance at $\alpha = 0.05$; "N/A" denotes the covariate was not included in the model.

Model	Model Structure	K	ΔAIC	w
53	$g(x) = \beta_0 + \beta_1$*$COVER_{avg} + \beta_2$*$CANOPY_{25to50} + \beta_3$*$BASE_{avg} + \beta_4$*$BASE_{sd} + \beta_5$*$CANOPY_{10to25}$	6	0.00	0.417
62	$g(x) = \beta_0 + \beta_1$*$COVER_{avg} + \beta_2$*$CANOPY_{25to50} + \beta_3$*$BASE_{avg} + \beta_4$*$BASE_{sd} + \beta_5$*$SUCCESSION_{mid} + \beta_6$*$CANOPY_{10to25}$	7	0.60	0.309
60	$g(x) = \beta_0 + \beta_1$*$COVER_{avg} + \beta_2$*$CANOPY_{25to50} + \beta_3$*$BASE_{avg} + \beta_4$*$COVER_{sd} + \beta_5$*$BASE_{sd} + \beta_6$*$CANOPY_{10to25}$	7	1.94	0.158

Table 11. Model selection results for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion from 1979-2008. The three top approximating models are listed along with the number of parameters (K), ΔAIC value, and Akaike weight (w). The response variable, g(x), is the logit, and covariates are described in the text.

	Model 53	**Model 62**	**Model 60**
Covariate	β_i (SE)	β_i (SE)	β_i (SE)
Intercept	**-12.68**	**-12.33**	**-12.50**
	(1.25)	**(1.27)**	**(1.44)**
$COVER_{avg}$	**0.030**	**0.029**	**0.029**
	(0.010)	**(0.010)**	**(0.012)**
$COVER_{sd}$	N/A	N/A	-0.003
			(0.015)
$CANOPY_{10to25}$	**0.073**	**0.072**	**0.073**
	(0.015)	**(0.015)**	**(0.015)**
$CANOPY_{25to50}$	**0.062**	**0.060**	**0.061**
	(0.015)	**(0.015)**	**(0.015)**
$BASE_{avg}$	**-0.328**	**-0.354**	**-0.326**
	(0.064)	**(0.066)**	**(0.064)**
$BASE_{sd}$	**0.642**	**0.597**	**0.653**
	(0.148)	**(0.150)**	**(0.154)**
$SUCCESSION_{mid}$	N/A	0.004	N/A
		(0.004)	

Table 12. Parameter estimates (β_i) and standard errors (SE) for covariates contained in the three top approximating models for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion from 1979-2008. Covariates are described in the text; bold notation denotes statistical significance at $\alpha = 0.05$; "N/A" denotes the covariate was not included in the model.

a priori Model No.	Exploratory Model Structure	$AIC_{exploratory}$	$AIC_{exploratory} - AIC_{apriori}$
	Addition of $SUCCESSION_{early}$		
53	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*BASE_{sd} + \beta_5*CANOPY_{10to25} + \beta_6*SUCCESSION_{early}$	2,313.27	-0.47
62	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*BASE_{sd} + \beta_5*SUCCESSION_{mid} + \beta_6*CANOPY_{10to25} + \beta_7*SUCCESSION_{early}$	2,313.67	-0.66
60	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*COVER_{sd} + \beta_5*BASE_{sd} + \beta_6*CANOPY_{10to25} + \beta_7*SUCCESSION_{early}$	2,315.16	-0.51
	Addition of $SUCCESSION_{late}$		
53	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*BASE_{sd} + \beta_5*CANOPY_{10to25} + \beta_6*SUCCESSION_{late}$	2,308.95	-4.79
62	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*BASE_{sd} + \beta_5*SUCCESSION_{mid} + \beta_6*CANOPY_{10to25} + \beta_7*SUCCESSION_{late}$	2,300.61	-13.72
60	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*COVER_{sd} + \beta_5*BASE_{sd} + \beta_6*CANOPY_{10to25} + \beta_7*SUCCESSION_{late}$	2,310.95	-4.73
	Addition of DECIDUOUS		
53	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*BASE_{sd} + \beta_5*CANOPY_{10to25} + \beta_6*DECIDUOUS$	2,313.56	-0.18
62	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*BASE_{sd} + \beta_5*SUCCESSION_{mid} + \beta_6*CANOPY_{10to25} + \beta_7*DECIDUOUS$	2,313.06	-1.27
60	$g(x) = \beta_0 + \beta_1*COVER_{avg} + \beta_2*CANOPY_{25to50} + \beta_3*BASE_{avg} + \beta_4*COVER_{sd} + \beta_5*BASE_{sd} + \beta_6*CANOPY_{10to25} + \beta_7*DECIDUOUS$	2,315.54	-0.13

Table 13. Exploratory modeling results evaluating the separate additions of $SUCCESSION_{early}$, $SUCCESSION_{late}$, and DECIDUOUS covariates to each of the three top approximating *a priori* models from the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion from 1979-2008. The AIC value for the exploratory model ($AIC_{exploratory}$) is provided along with the change in AIC relative to the corresponding *a priori* model ($AIC_{exploratory} - AIC_{apriori}$). The response variable, *g*(x), is the logit; covariates are described in the text.

Covariate	**Exploratory Model 53** β_i (SE)	**Exploratory Model 62** β_i (SE)	**Exploratory Model 60** β_i (SE)
Intercept	**-11.75**	**-11.30**	**-11.77**
	(1.25)	**(1.24)**	**(1.42)**
$COVER_{avg}$	**0.028**	**0.032**	**0.029**
	(0.010)	**(0.010)**	**(0.012)**
$COVER_{sd}$	N/A	N/A	0.0004
			(0.0145)
$CANOPY_{10to25}$	**0.077**	**0.097**	**0.077**
	(0.015)	**(0.016)**	**(0.015)**
$CANOPY_{25to50}$	**0.065**	**0.085**	**0.065**
	(0.015)	**(0.016)**	**(0.015)**
$BASE_{avg}$	**-0.391**	**-0.394**	**-0.391**
	(0.066)	**(0.067)**	**(0.067)**
$BASE_{sd}$	**0.529**	**0.483**	**0.527**
	(0.149)	**(0.150)**	**(0.158)**
$SUCCESSION_{mid}$	N/A	**-0.028**	N/A
		(0.008)	
$SUCCESSION_{late}$	**-0.009**	**-0.035**	**-0.009**
	(0.004)	**(0.008)**	**(0.004)**

Table 14. Parameter estimates (β_i) and standard errors (SE) for covariates contained in the three exploratory models containing the $SUCCESSION_{late}$ covariate for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion from 1979-2008. Covariates are described in the text; bold notation denotes statistical significance at $\alpha = 0.05$; “N/A” denotes the covariate was not included in the model.

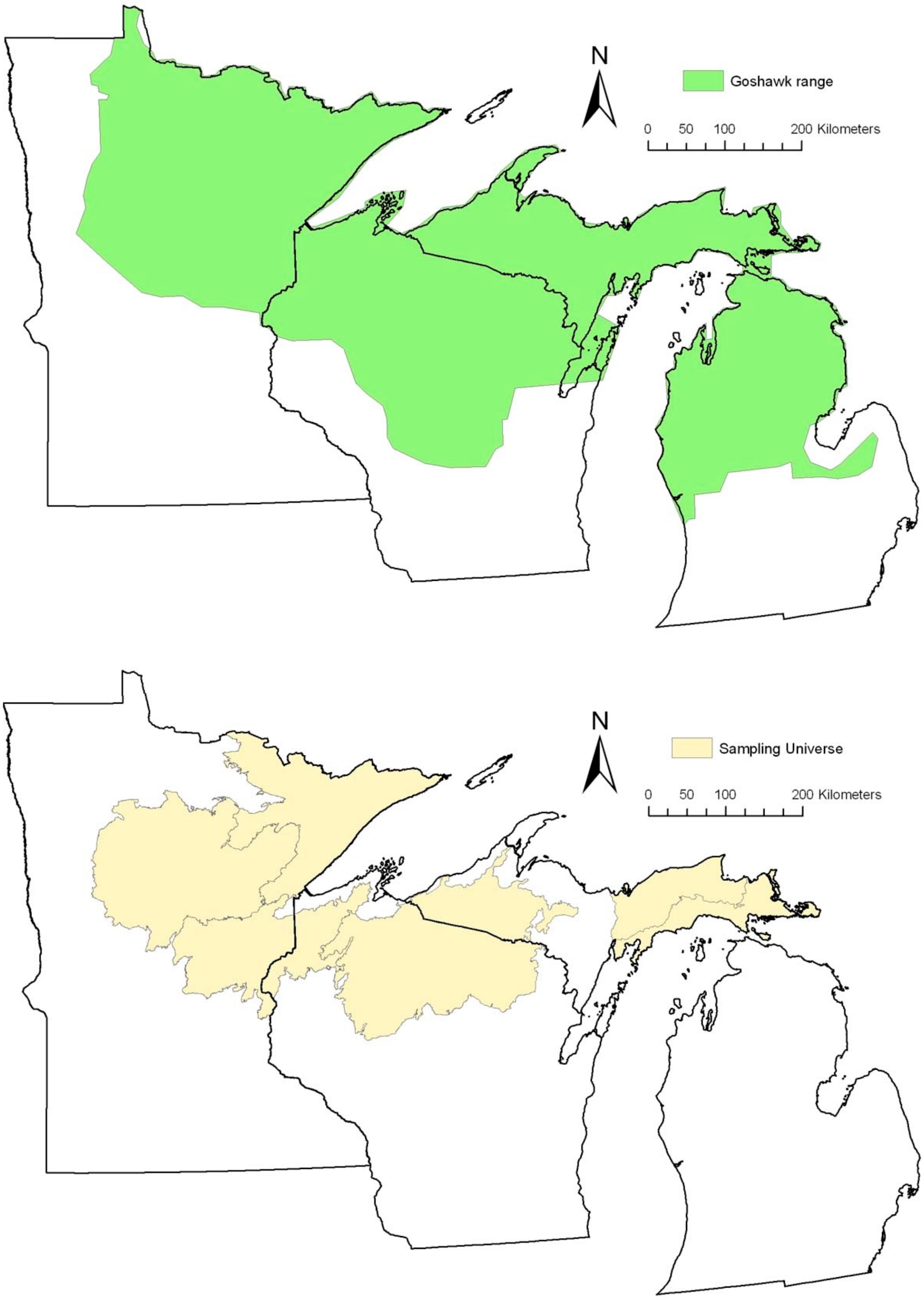
Covariate	Exploratory Model 53 β_i (SE)	Exploratory Model 62 β_i (SE)	Exploratory Model 60 β_i (SE)
Intercept	**-12.23** **(1.26)**	**-11.84** **(1.27)**	**-11.99** **(1.44)**
$COVER_{avg}$	**0.028** **(0.010)**	**0.027** **(0.010)**	**0.027** **(0.012)**
$COVER_{sd}$	N/A	N/A	-0.005 (0.014)
$CANOPY_{10to25}$	**0.071** **(0.015)**	**0.069** **(0.015)**	**0.071** **(0.015)**
$CANOPY_{25to50}$	**0.061** **(0.015)**	**0.059** **(0.015)**	**0.060** **(0.015)**
$BASE_{avg}$	**-0.337** **(0.064)**	**-0.365** **(0.066)**	**-0.334** **(0.064)**
$BASE_{sd}$	**0.636** **(0.146)**	**0.587** **(0.149)**	**0.650** **(0.152)**
$SUCCESSION_{mid}$	N/A	0.005 (0.004)	N/A
$SUCCESSION_{early}$	-0.048 (0.032)	-0.050 (0.032)	-0.048 (0.032)

Table 15. Parameter estimates (β_i) and standard errors (SE) for covariates contained in the three exploratory models containing the $SUCCESSION_{early}$ covariate for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion from 1979-2008. Covariates are described in the text; bold notation denotes statistical significance at $\alpha = 0.05$; "N/A" denotes the covariate was not included in the model.

Covariate	Exploratory Model 53 β_i (SE)	Exploratory Model 62 β_i (SE)	Exploratory Model 60 β_i (SE)
Intercept	**-12.52**	**-12.01**	**-12.44**
	(1.25)	**(1.26)**	**(1.44)**
$COVER_{avg}$	**0.033**	**0.032**	**0.032**
	(0.010)	**(0.010)**	**(0.012)**
$COVER_{sd}$	N/A	N/A	-0.02
			(0.015)
$CANOPY_{10to25}$	**0.068**	**0.064**	**0.068**
	(0.015)	**(0.015)**	**(0.016)**
$CANOPY_{25to50}$	**0.056**	**0.051**	**0.055**
	(0.016)	**(0.016)**	**(0.016)**
$BASE_{avg}$	**-0.255**	**-0.270**	**-0.254**
	(0.080)	**(0.080)**	**(0.081)**
$BASE_{sd}$	**0.611**	**0.542**	**0.617**
	(0.148)	**(0.152)**	**(0.156)**
$SUCCESSION_{mid}$	N/A	0.006	N/A
		(0.004)	
DECIDUOUS	-0.006	-0.008	-0.006
	(0.004)	(0.004)	(0.004)

Table 16. Parameter estimates (β_i) and standard errors (SE) for covariates contained in the three exploratory models containing the DECIDUOUS covariate for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion from 1979-2008. Covariates are described in the text; bold notation denotes statistical significance at $\alpha = 0.05$; "N/A" denotes the covariate was not included in the model.

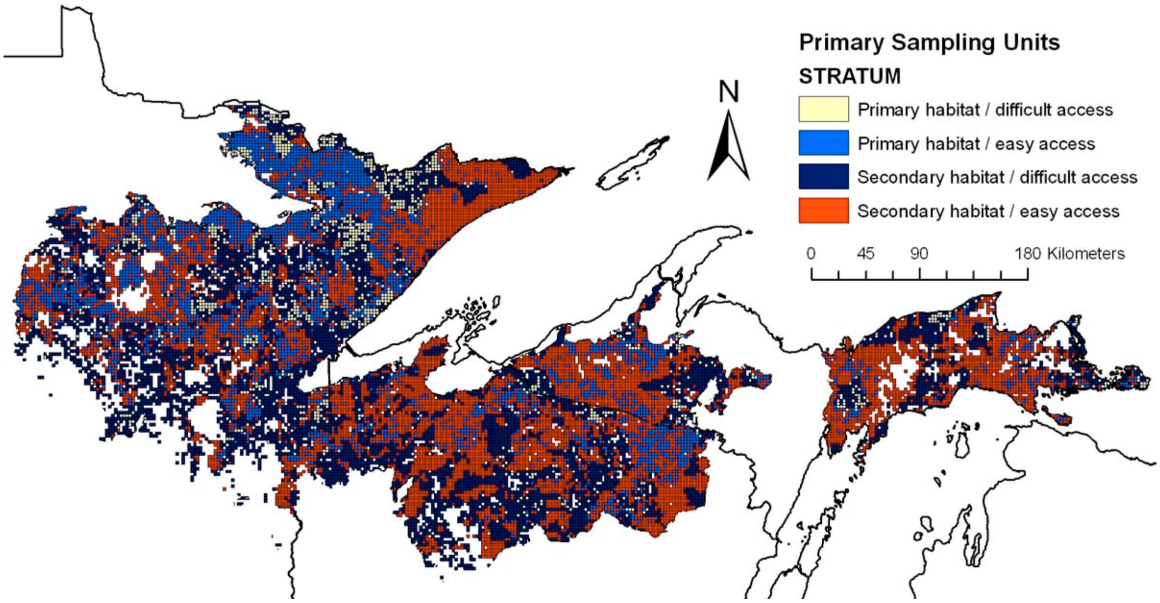
FIGURES



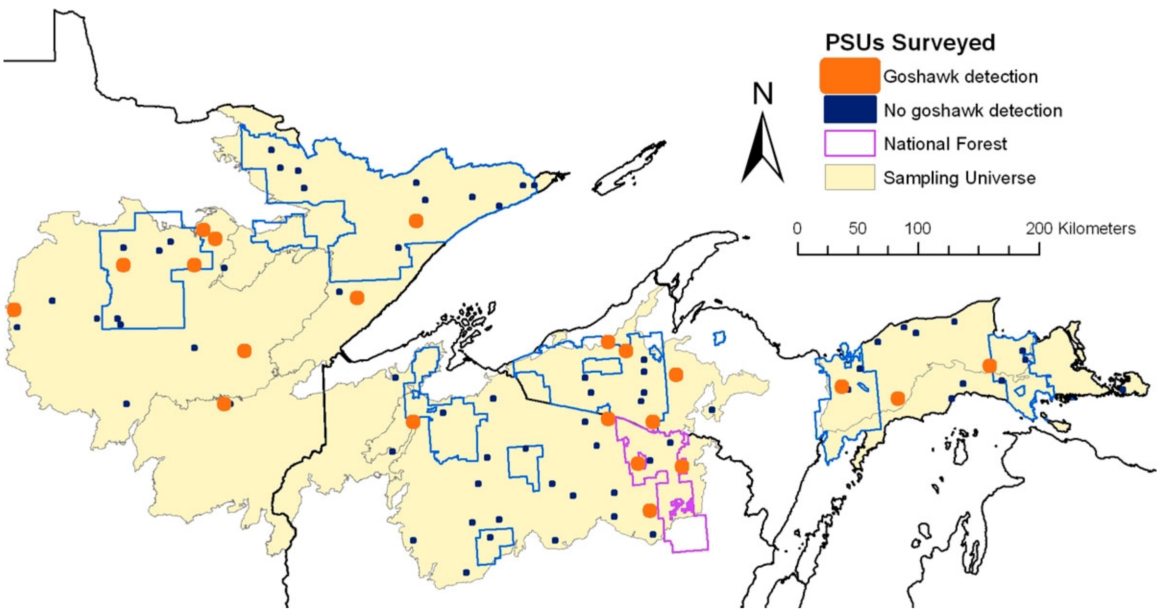
(*a*)

(*b*)

Figure 1. The (*a*) approximate northern goshawk range and (*b*) six Bailey's ecoregions that comprised the sampling universe in the western Great Lakes bioregion.



(***a***)



(***b***)

Figure 2. The (*a*) sampling universe of 19,506 Primary Sampling Units (PSUs) throughout Minnesota, Wisconsin, and Michigan's Upper Peninsula, and (*b*) 86 PSUs surveyed for goshawk presence during summer 2008 with those having goshawk occupancy denoted in red and those with no detection in dark navy.

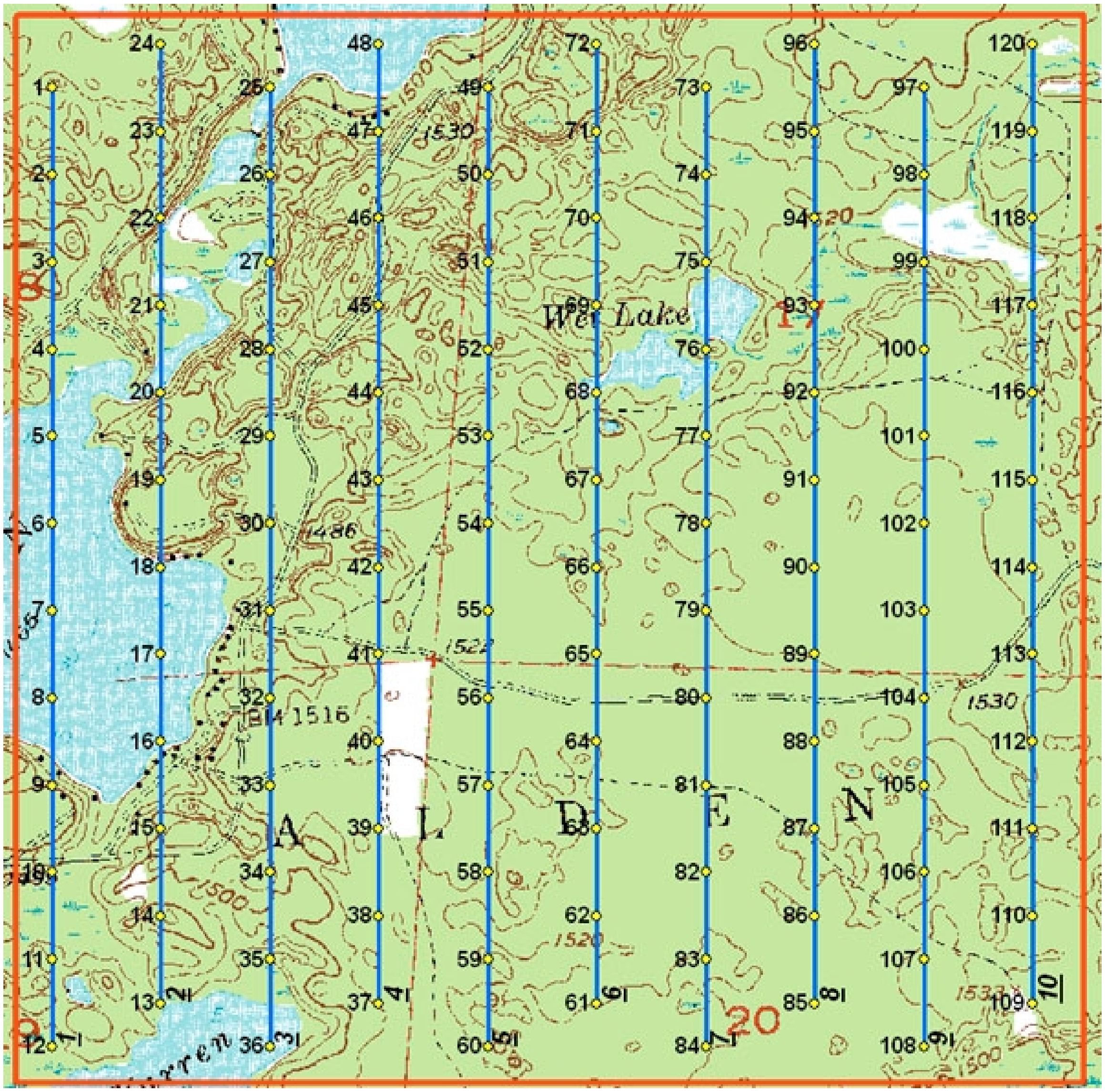


Figure 3. An example of one of the Primary Sampling Units (PSUs) surveyed during 2008. Each 600 ha PSU (boundary in red) contained 120 call stations (in yellow) located on 10 transects (in blue). Call stations were separated by 200 m from north to south; transects were separated by 250 m from west to east, and adjacent transect call stations were offset by 100 m north to south.

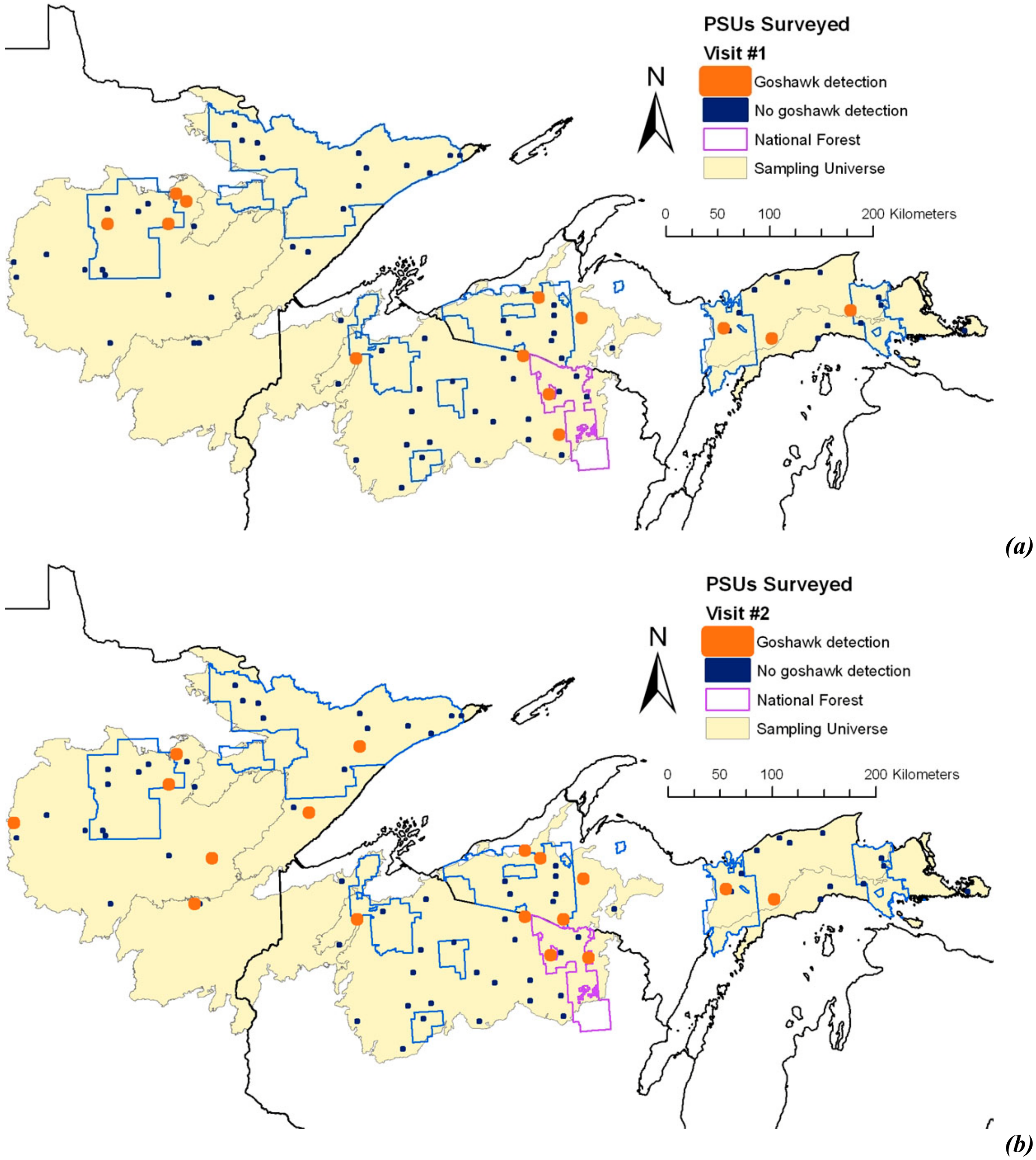


Figure 4. Northern goshawk survey results for (*a*) visit no. 1 and (*b*) visit no. 2 to Primary Sampling Units (PSUs) in Minnesota, Wisconsin, and Michigan. The PSUs with goshawk presence are depicted in red and those with no goshawk detection are depicted in dark navy. During the first round of surveys that lasted from mid-May through June, surveyors detected goshawk presence in 13 of 86 PSUs, and in the second round of surveys, conducted between July and mid-August, surveyors detected goshawk presence in 17 of 85 PSUs.

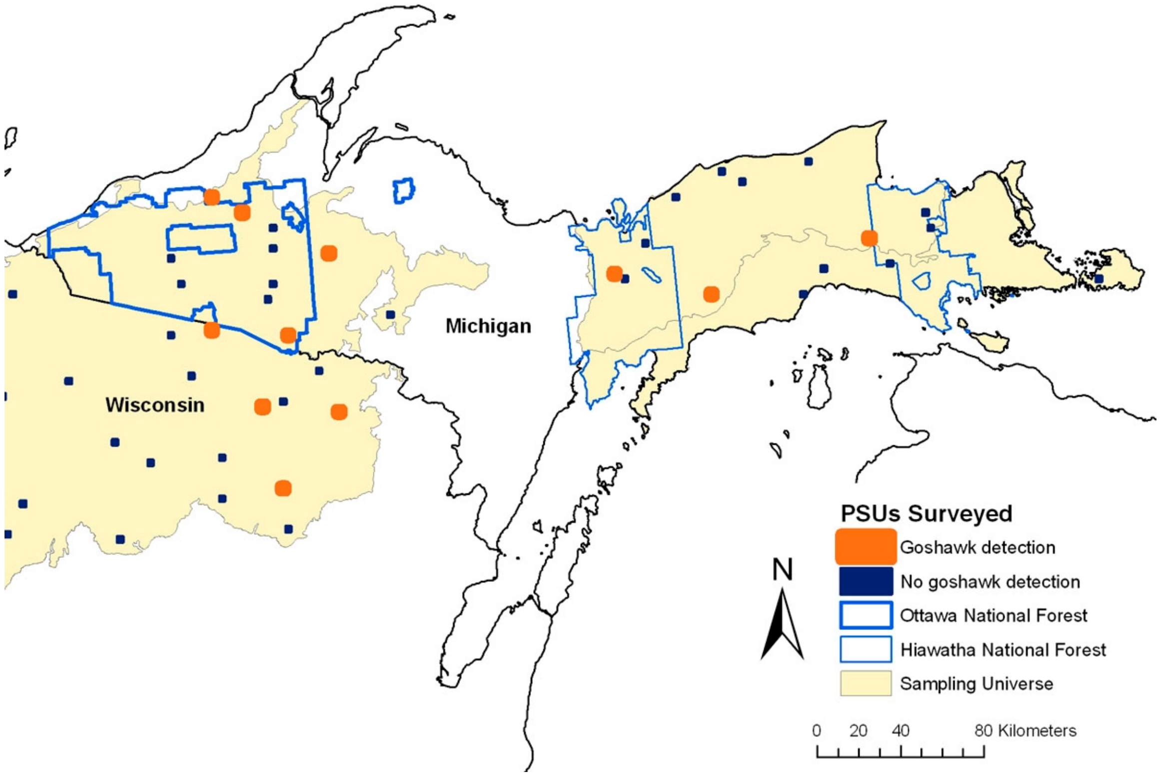


Figure 5. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in Michigan's Upper Peninsula. Seven different PSUs had goshawk presence throughout Michigan.

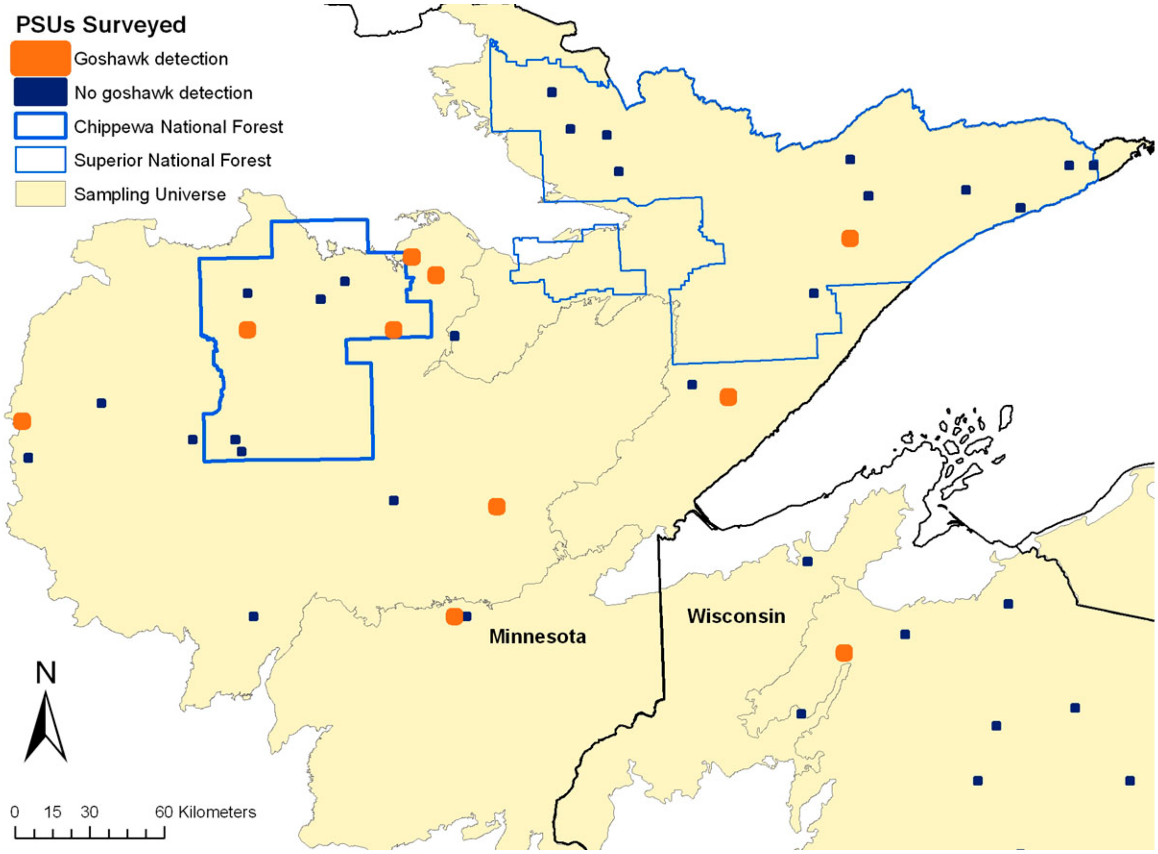


Figure 6. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in Minnesota. Nine different PSUs had goshawk presence throughout Minnesota.

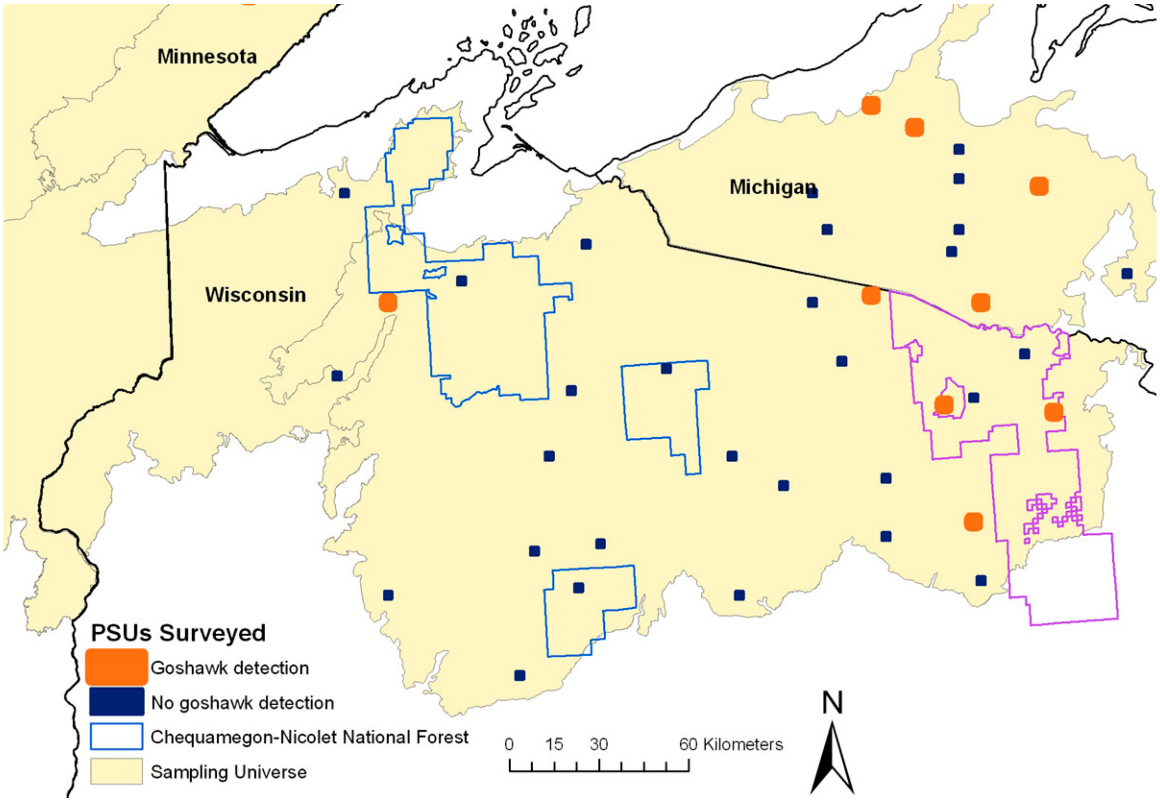


Figure 7. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in Wisconsin. Five different PSUs had goshawk presence in Wisconsin.

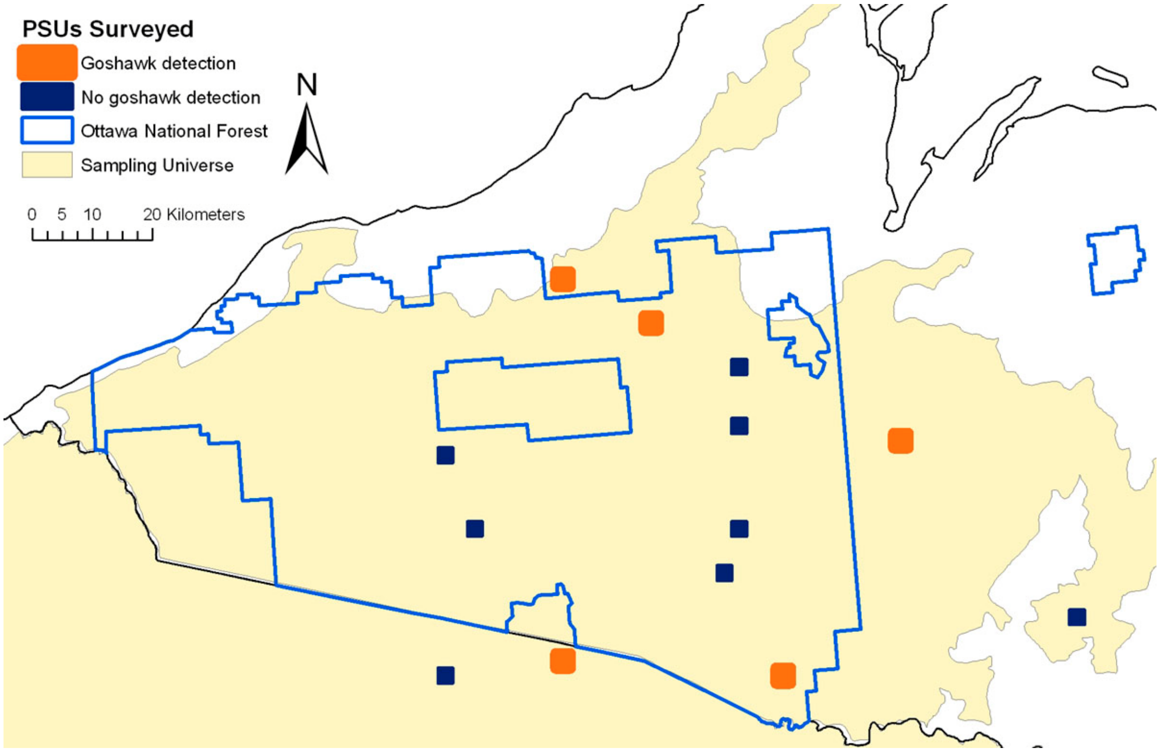


Figure 8. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in and around Michigan's Ottawa National Forest.

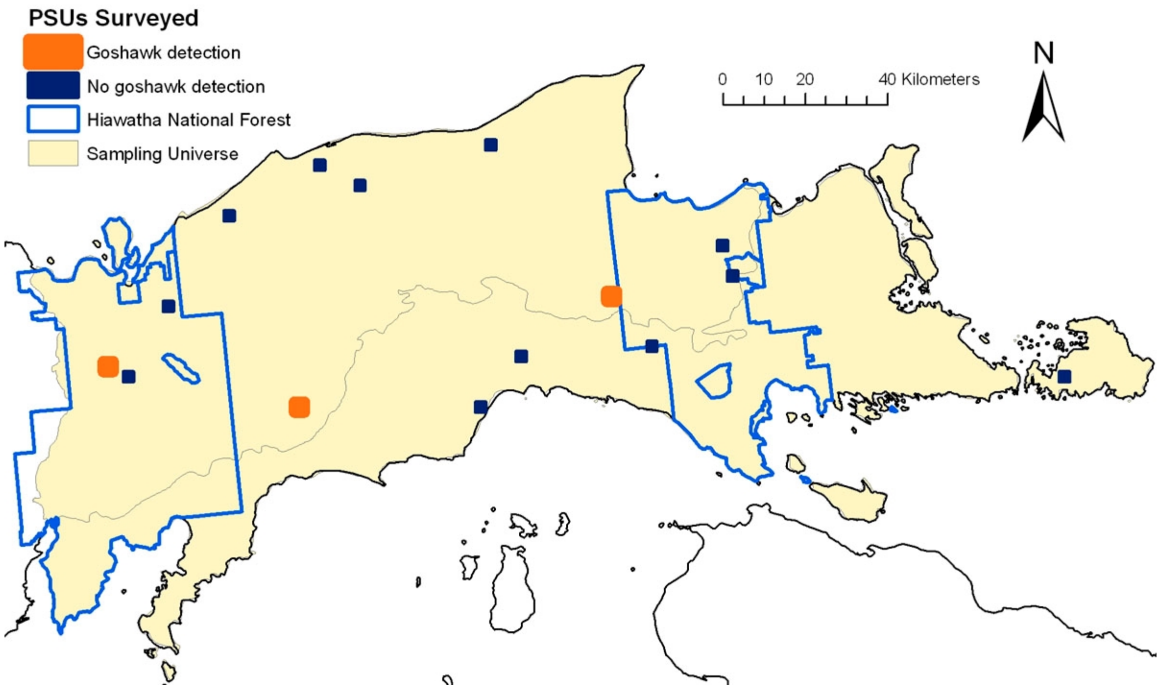


Figure 9. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in and around Michigan's Hiawatha National Forest.

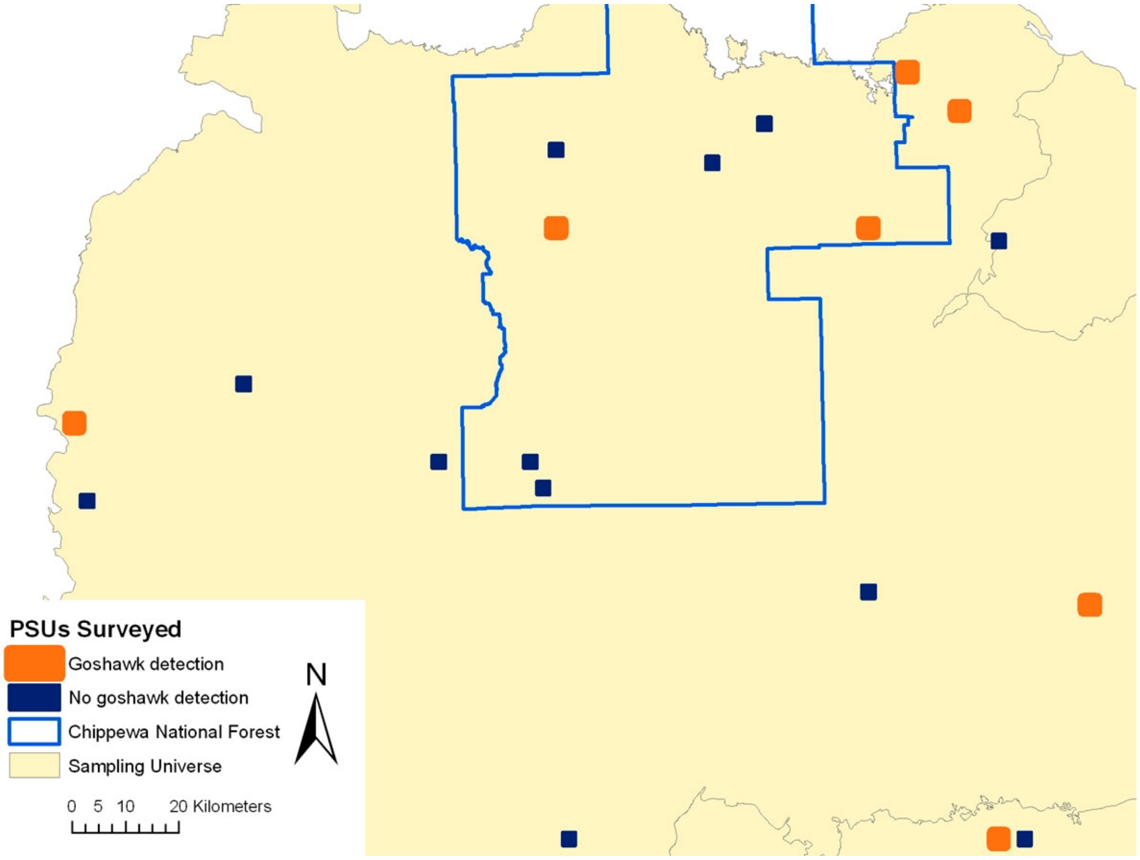


Figure 10. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in and around Minnesota's Chippewa National Forest.

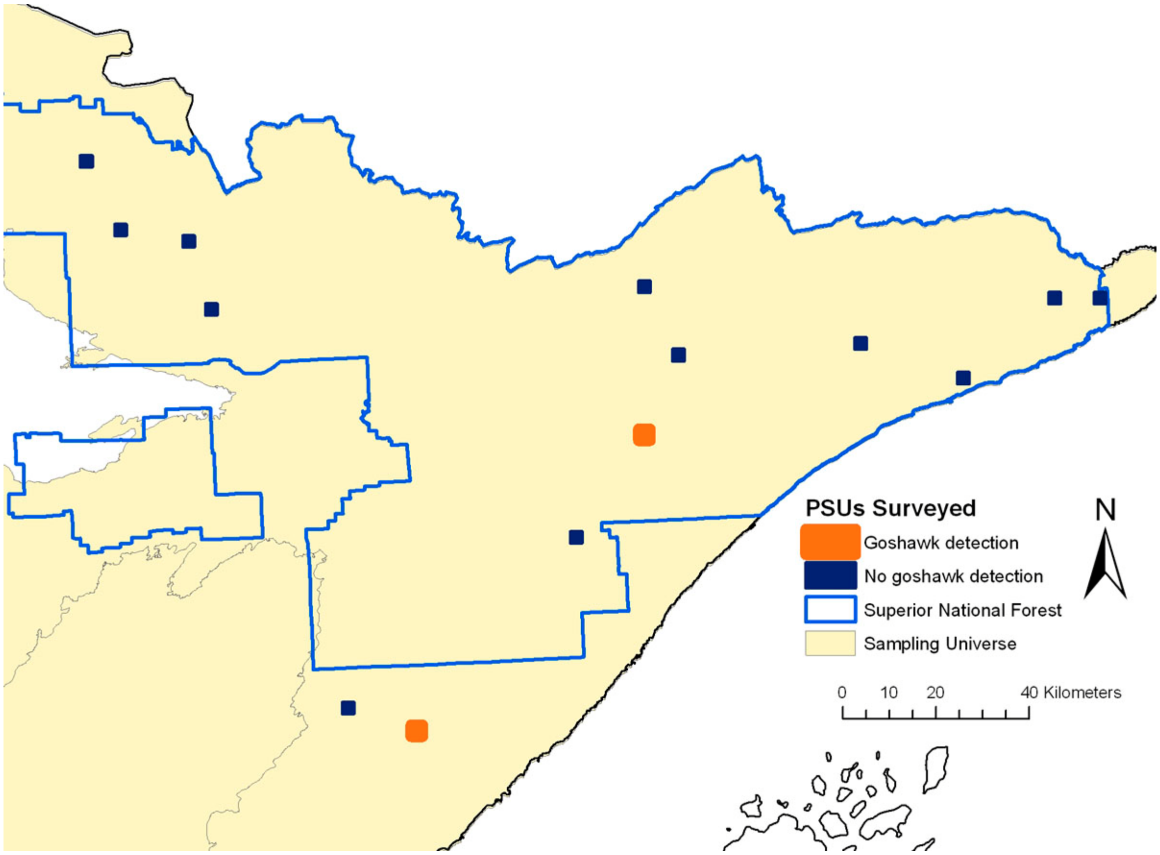
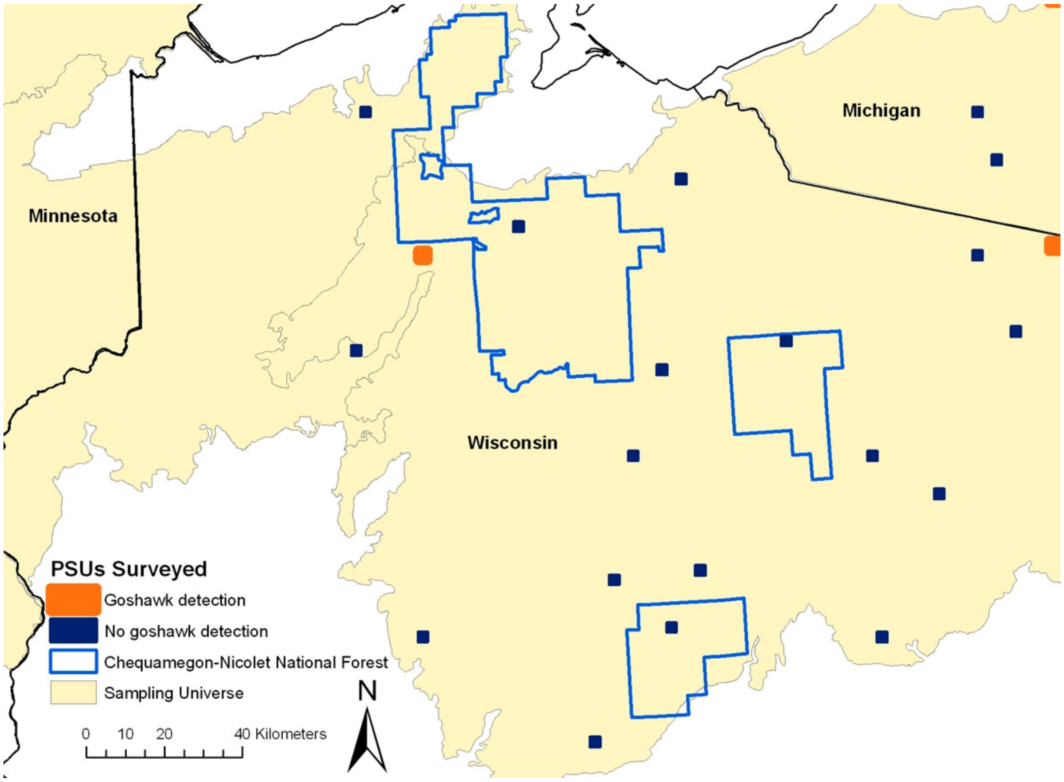
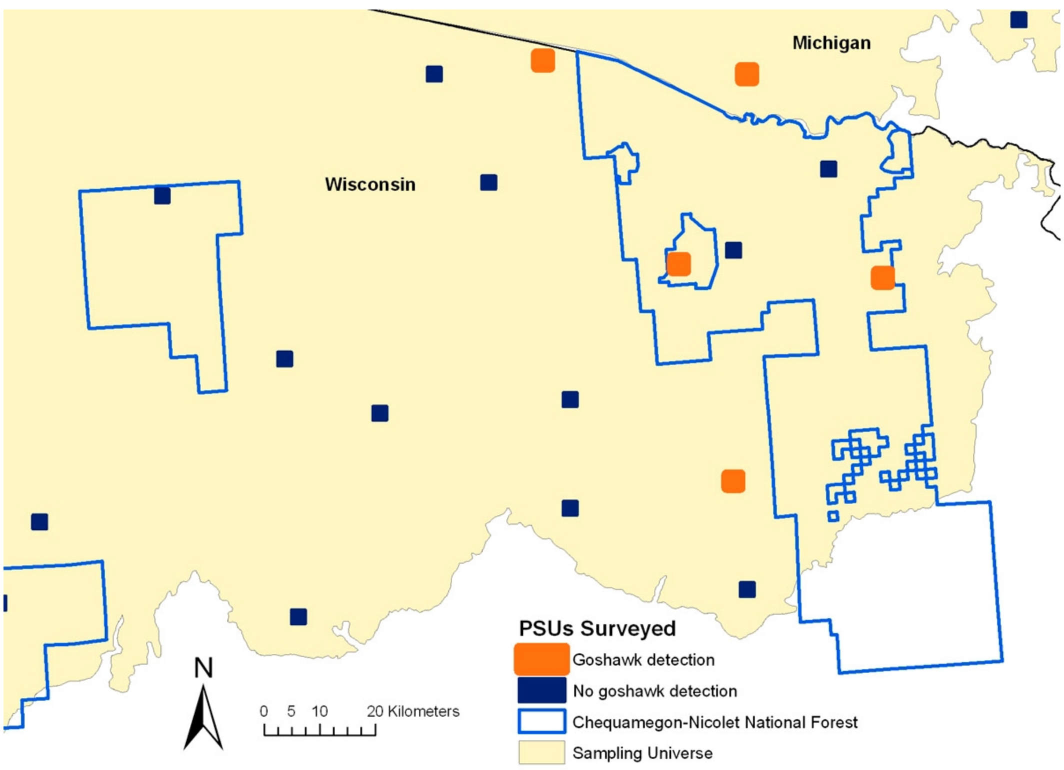


Figure 11. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in and around Minnesota's Superior National Forest.



(a)



(b)

Figure 12. The Primary Sampling Units (PSUs) with either goshawk occupancy (red squares) or no goshawk presence (dark navy squares) for both survey visits during 2008 in and around the (*a*) western, and (*b*) eastern portion of Wisconsin's Chequamegon-Nicolet National Forest.

APPENDICES

Appendix A. Tables of the covariates used, models evaluated, and model selection results for development of the stratification of Primary Sampling Units.

Covariate	Description
PCTAQ	the percentage of aquatic habitat in each 600 ha square
PCTDECIDFST	the percentage of deciduous forest habitat in each 600 ha square
PCTEVERFST	the percentage of evergreen forest habitat in each 600 ha square
PCTMXDFST	the percentage of mixed deciduous/evergreen forest habitat in each 600 ha square
PCTSHRUB	the percentage of shrub and grassland habitat in each 600 ha square
PCTAG	the percentage of agricultural, pasture, or crop habitat in each 600 ha square
PCTWETLAND	the percentage of wetland and herbaceous wetland habitat in each 600 ha square
CANOPYAVG	the average percentage of forest canopy cover in each 600 ha square
CANOPYMAX	the maximum percentage of forest canopy cover in each 600 ha square
CANOPYSD	the standard deviation of forest canopy cover in each 600 ha square
PCTCANOPY0_9	the percentage of the 600 ha square with canopy cover between 0-9%
PCTCANOPY10_19	the percentage of the 600 ha square with canopy cover between 10-19%
PCTCANOPY20_29	the percentage of the 600 ha square with canopy cover between 20-29%
PCTCANOPY30_39	the percentage of the 600 ha square with canopy cover between 30-39%
PCTCANOPY40_49	the percentage of the 600 ha square with canopy cover between 40-49%
PCTCANOPY50_59	the percentage of the 600 ha square with canopy cover between 50-59%
PCTCANOPY60_69	the percentage of the 600 ha square with canopy cover between 60-69%
PCTCANOPY70_79	the percentage of the 600 ha square with canopy cover between 70-79%
PCTCANOPY80_89	the percentage of the 600 ha square with canopy cover between 80-89%
PCTCANOPY90_100	the percentage of the 600 ha square with canopy cover between 90-100%

Table A1. The covariates used in the model analysis examining habitat attribute effects on goshawk landscape use for the purpose of developing a stratification scheme for Primary Sampling Units in the western Great Lakes bioregion. Covariates were calculated based on 120 randomly placed points in 600 ha squares surrounding "used" goshawk locations from 1979-2006 and randomly placed "available" locations.

Model	Structure
	Suite 1: Land cover
1	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST
2	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB
3	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG
4	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND
5	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAQ
6	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG
7	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND
8	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAQ
9	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND
10	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTAQ
11	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ
12	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND
13	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTAQ
14	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + PCTAQ
15	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + PCTAQ
16	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + PCTAQ
	Suite 2: Forest canopy
17	g(x) = Intercept + CANOPYAVG
18	g(x) = Intercept + CANOPYMAX
19	g(x) = Intercept + CANOPYSD
20	g(x) = Intercept + CANOPYAVG + CANOPYMAX
21	g(x) = Intercept + CANOPYAVG + CANOPYSD
22	g(x) = Intercept + CANOPYMAX + CANOPYSD
23	g(x) = Intercept + CANOPYAVG + CANOPYMAX + CANOPYSD
24	g(x) = Intercept + CANOPYAVG + CANOPYSD + CANOPYAVG*CANOPYSD
25	g(x) = Intercept + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD
26	g(x) = Intercept + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD
27	g(x) = Intercept + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD
	Suite 3: Land cover + forest canopy

Table A2 continued

28	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX
29	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX
30	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX
31	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX
32	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX
33	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX
34	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX
35	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX
36	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD
37	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD
38	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD
39	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD
40	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD
41	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD
42	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD
43	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD
44	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD
45	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD
46	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD

Table A2 continued

47 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD

48 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD

49 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD

50 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD

51 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD

52 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

53 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

54 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

55 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTAG + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

56 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

57 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

58 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

59 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYAVG*CANOPYSD

Suite 4: Percentages of Various Forest Canopy Covers

60 g(x) = Intercept + PCTCANOPY0_9

61 g(x) = Intercept + PCTCANOPY10_19

62 g(x) = Intercept + PCTCANOPY20_29

63 g(x) = Intercept + PCTCANOPY30_39

64 g(x) = Intercept + PCTCANOPY0_9 + PCTCANOPY10_19

65 g(x) = Intercept + PCTCANOPY0_9 + PCTCANOPY20_29

66 g(x) = Intercept + PCTCANOPY0_9 + PCTCANOPY30_39

Table A2 continued

67 g(x) = Intercept + PCTCANOPY10_19 + PCTCANOPY20_29
68 g(x) = Intercept + PCTCANOPY10_19 + PCTCANOPY30_39
69 g(x) = Intercept + PCTCANOPY20_29 + PCTCANOPY30_39
70 g(x) = Intercept + PCTCANOPY0_9 + PCTCANOPY10_19 + PCTCANOPY20_29
71 g(x) = Intercept + PCTCANOPY0_9 + PCTCANOPY10_19 + PCTCANOPY30_39
72 g(x) = Intercept + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39
73 g(x) = Intercept + PCTCANOPY10_19 + PCTCANOPY20_29 + PCTCANOPY30_39
74 g(x) = Intercept + PCTCANOPY0_9 + PCTCANOPY10_19 + PCTCANOPY20_29 + PCTCANOPY30_39
75 g(x) = Intercept + PCTCANOPY40_49
76 g(x) = Intercept + PCTCANOPY50_59
77 g(x) = Intercept + PCTCANOPY60_69
78 g(x) = Intercept + PCTCANOPY40_49 + PCTCANOPY50_59
79 g(x) = Intercept + PCTCANOPY40_49 + PCTCANOPY60_69
80 g(x) = Intercept + PCTCANOPY50_59 + PCTCANOPY60_69
81 g(x) = Intercept + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69
82 g(x) = Intercept + PCTCANOPY70_79
83 g(x) = Intercept + PCTCANOPY80_89
84 g(x) = Intercept + PCTCANOPY90_100
85 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89
86 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY90_100
87 g(x) = Intercept + PCTCANOPY80_89 + PCTCANOPY90_100
88 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100
89 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9
90 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY10_19
91 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29
92 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY10_19 + PCTCANOPY20_29
93 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY10_19 + PCTCANOPY20_29
94 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY30_39
95 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY20_29 + PCTCANOPY30_39
96 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39
97 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY10_19 + PCTCANOPY20_29 + PCTCANOPY30_39
98 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49
99 g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59

Table A2 continued

100	g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY60_69
101	g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59
102	g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTCANOPY60_69
103	g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69
104	g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY10_19
105	g(x) = Intercept + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39 + PCTCANOPY40_49 + PCTCANOPY50_59
	Suite 5: Combinations of Top Models from Suites 1 through 4
106	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59
107	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59
108	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTCANOPY60_69
109	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69
110	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY10_19
111	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39 + PCTCANOPY40_49 + PCTCANOPY50_59

112 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59

113 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59

114 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTCANOPY60_69

115 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69

116 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY10_19

117 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39 + PCTCANOPY40_49 + PCTCANOPY50_59

118 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59

119 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59

120 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTCANOPY60_69

121 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69

122 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY10_19

123 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39 + PCTCANOPY40_49 + PCTCANOPY50_59

124 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59

125 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59

126 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTCANOPY60_69

127 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69

128 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY10_19

129 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39 + PCTCANOPY40_49 + PCTCANOPY50_59

Suite 6: Combinations of Top Models from Suite 5 and Interactions

130 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYAVG

131 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYMAX

132 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTDECIDFST*CANOPYSD

Table A2 continued

133 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTEVERFST*CANOPYAVG

134 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTEVERFST*CANOPYMAX

135 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTEVERFST*CANOPYSD

136 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTMXDFST*CANOPYAVG

137 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTMXDFST*CANOPYMAX

138 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTMXDFST*CANOPYSD

139 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYAVG

140 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYMAX

141 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYSD

142 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTEVERFST*CANOPYAVG

143 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTEVERFST*CANOPYMAX

Table A2 continued

144 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTEVERFST*CANOPYSD

145 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTMXDFST*CANOPYAVG

146 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTMXDFST*CANOPYMAX

147 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTMXDFST*CANOPYSD

148 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYAVG

149 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYMAX

150 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTDECIDFST*CANOPYSD

151 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTEVERFST*CANOPYAVG

152 g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTEVERFST*CANOPYMAX

153	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTEVERFST*CANOPYSD
154	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTMXDFST*CANOPYAVG
155	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTMXDFST*CANOPYMAX
156	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTMXDFST*CANOPYSD
157	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69 + PCTDECIDFST*CANOPYAVG
158	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69+ PCTDECIDFST*CANOPYMAX
159	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69 + PCTDECIDFST*CANOPYSD
160	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69+ PCTEVERFST*CANOPYAVG
161	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69+ PCTEVERFST*CANOPYMAX

162	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69+ PCTEVERFST*CANOPYSD
163	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69 + PCTMXDFST*CANOPYAVG
164	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69 + PCTMXDFST*CANOPYMAX
165	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69+ PCTMXDFST*CANOPYSD
166	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTEVERFST*CANOPYMAX
167	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTAG + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTCANOPY60_69+ PCTEVERFST*CANOPYMAX
168	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTEVERFST*CANOPYMAX
169	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY30_39 + PCTCANOPY40_49 + PCTCANOPY50_59 + PCTEVERFST*CANOPYMAX
170	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTSHRUB + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY40_49 + PCTCANOPY50_59+ PCTEVERFST*CANOPYMAX
171	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + PCTAQ + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59+ PCTEVERFST*CANOPYMAX

172	g(x) = Intercept + PCTDECIDFST + PCTEVERFST + PCTMXDFST + PCTWETLAND + CANOPYAVG + CANOPYMAX + CANOPYSD + CANOPYMAX*CANOPYSD + PCTCANOPY70_79 + PCTCANOPY80_89 + PCTCANOPY90_100 + PCTCANOPY0_9 + PCTCANOPY20_29 + PCTCANOPY50_59 + PCTCANOPY60_69+ PCTEVERFST*CANOPYMAX

Table A2. The 172 models evaluated to develop a stratified sampling design for Primary Sampling Units in the western Great Lakes bioregion. The response variable, *g*(x), is the logit and covariates are described in Table A1. The covariate coefficients (β_i) are not depicted in the model structure.

Model	AIC	ΔAIC	w
152	2536.731	0.000	0.1905
134	2536.925	0.194	0.1729
166	2537.911	1.180	0.1056
143	2538.043	1.312	0.0988
167	2538.691	1.960	0.0715
168	2538.734	2.003	0.0700
171	2538.768	2.037	0.0688
161	2538.888	2.157	0.0648
172	2538.921	2.190	0.0637
169	2539.361	2.630	0.0511
170	2539.885	3.154	0.0394
133	2548.917	12.186	0.0004
130	2549.520	12.789	0.0003
157	2549.561	12.830	0.0003
142	2550.256	13.525	0.0002
132	2550.297	13.566	0.0002
139	2550.299	13.568	0.0002
141	2550.541	13.810	0.0002
151	2550.816	14.085	0.0002
159	2550.994	14.263	0.0002
160	2551.058	14.327	0.0001
138	2551.275	14.544	0.0001
147	2551.459	14.728	0.0001
148	2551.520	14.789	0.0001
165	2552.216	15.485	0.0001
150	2552.231	15.500	0.0001
156	2552.789	16.058	0.0001

Table A3. The model selection results for the analysis used to develop a stratified sampling design for Primary Sampling Units in the western Great Lakes bioregion. For each model the AIC value, ΔAIC value, and Akaike weight (*w*) are provided. The model structure for each model is provided in Table A2. Results for models having $w < 0.0001$ are not listed.

Covariate	Estimate	Standard Error
Intercept	-6.5010	5.6974
PCTDECIDFST	0.0231	0.0099
PCTEVERFST	0.3693	0.0652
PCTMXDFST	0.0386	0.0116
PCTAG	-0.0182	0.0125
PCTWETLAND	0.0154	0.0089
CANOPYAVG	-0.0994	0.0844
CANOPYMAX	0.0240	0.0389
CANOPYSD	-0.0593	0.1234
CANOPYMAX*CANOPYSD	0.0008	0.0013
PCTCANOPY70_79	0.0812	0.0241
PCTCANOPY80_89	0.0892	0.0289
PCTCANOPY90_100	0.0761	0.0367
PCTCANOPY0_9	-0.0313	0.0467
PCTCANOPY20_29	-0.1052	0.0785
PCTCANOPY50_59	0.0906	0.0353
PCTEVERFST*CANOPYMAX	-0.0036	0.0007

Table A4. Covariate coefficient estimates for the top approximating model (model 152) from the model analysis examining habitat attribute effects on goshawk landscape use for the purpose of developing a stratification scheme for Primary Sampling Units in the western Great Lakes bioregion. Covariates are described in Table A1.

Appendix B. Tables of model selection results from the analyses examining habitat attribute effects on the odds of goshawk landscape use for 2008 and 1979-2008 in the western Great Lakes bioregion.

Model	**K**	**AIC**	**ΔAIC**	***w***
32	2	328.240	0.000	0.1176
2	3	329.469	1.229	0.0636
5	3	329.720	1.479	0.0561
33	3	330.119	1.878	0.0460
4	3	330.172	1.932	0.0448
3	3	330.194	1.954	0.0443
1	3	330.238	1.998	0.0433
12	4	330.945	2.705	0.0304
38	4	331.105	2.864	0.0281
35	4	331.266	3.025	0.0259
11	4	331.326	3.085	0.0251
10	4	331.348	3.107	0.0249
6	4	331.465	3.224	0.0235
15	4	331.688	3.448	0.0210
14	4	331.691	3.451	0.0209
9	4	331.718	3.478	0.0207
36	4	332.056	3.816	0.0175
37	4	332.064	3.823	0.0174
13	4	332.075	3.835	0.0173
34	4	332.118	3.877	0.0169
8	4	332.127	3.886	0.0168
7	4	332.194	3.954	0.0163
45	5	332.624	4.383	0.0131
24	5	332.786	4.545	0.0121
23	5	332.845	4.604	0.0118
18	5	332.929	4.689	0.0113
42	5	333.036	4.796	0.0107
47	5	333.052	4.812	0.0106
48	5	333.065	4.825	0.0105
44	5	333.142	4.902	0.0101
43	5	333.159	4.918	0.0101
39	5	333.229	4.989	0.0097
22	5	333.261	5.021	0.0096
17	5	333.308	5.067	0.0093
16	5	333.348	5.107	0.0091
25	5	333.630	5.390	0.0079
21	5	333.662	5.421	0.0078
20	5	333.691	5.451	0.0077
46	5	333.950	5.709	0.0068

19	5	334.037	5.797	0.0065
40	5	334.047	5.806	0.0065
41	5	334.049	5.809	0.0064
57	6	334.203	5.963	0.0060
56	6	334.521	6.281	0.0051
51	6	334.621	6.381	0.0048
30	6	334.740	6.500	0.0046
27	6	334.781	6.541	0.0045
28	6	334.842	6.602	0.0043
54	6	334.868	6.628	0.0043
53	6	334.901	6.661	0.0042
58	6	335.037	6.797	0.0039
55	6	335.084	6.844	0.0038
49	6	335.140	6.899	0.0037
50	6	335.142	6.902	0.0037
26	6	335.243	7.003	0.0035
29	6	335.609	7.368	0.0030
52	6	335.941	7.701	0.0025
60	7	336.145	7.904	0.0023
63	7	336.187	7.946	0.0022
61	7	336.452	8.212	0.0019
31	7	336.738	8.497	0.0017
62	7	336.786	8.545	0.0016
59	7	337.084	8.844	0.0014
64	8	338.073	9.832	0.0009

Table B1. Complete model selection results for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion in 2008. For each model the number of parameters (K), AIC value, ΔAIC value, and Akaike weight (*w*) are provided. The model structure for each model is provided in Table 1 of the main text.

Model	K	AIC	ΔAIC	*w*
53	6	2313.732	0.000	0.4171
62	7	2314.329	0.597	0.3094
60	7	2315.676	1.944	0.1578
64	8	2316.307	2.575	0.1151
61	7	2330.022	16.290	0.0001
54	6	2330.232	16.500	0.0001
20	5	2330.370	16.638	0.0001
29	6	2330.408	16.676	0.0001
27	6	2331.633	17.901	0.0001
31	7	2331.859	18.127	0.0000
51	6	2332.729	18.997	0.0000
42	5	2332.879	19.147	0.0000
21	5	2333.610	19.878	0.0000
9	4	2335.137	21.405	0.0000
28	6	2335.251	21.519	0.0000
18	5	2336.712	22.980	0.0000
47	5	2340.056	26.324	0.0000
58	6	2341.007	27.275	0.0000
57	6	2341.095	27.363	0.0000
63	7	2342.040	28.308	0.0000
5	3	2342.248	28.516	0.0000
14	4	2342.389	28.657	0.0000
38	4	2342.699	28.967	0.0000
24	5	2343.363	29.631	0.0000
41	5	2343.837	30.105	0.0000
25	5	2343.976	30.244	0.0000
40	5	2344.226	30.494	0.0000
15	4	2344.227	30.495	0.0000
12	4	2344.246	30.514	0.0000
52	6	2344.291	30.559	0.0000
34	4	2344.573	30.841	0.0000
45	5	2344.626	30.894	0.0000
48	5	2344.682	30.950	0.0000
30	6	2344.910	31.178	0.0000
49	6	2345.495	31.763	0.0000
59	7	2345.752	32.020	0.0000
50	6	2345.831	32.099	0.0000
19	5	2346.028	32.296	0.0000
8	4	2346.041	32.309	0.0000
23	5	2346.226	32.494	0.0000
7	4	2346.506	32.774	0.0000
39	5	2346.557	32.825	0.0000
56	6	2346.594	32.862	0.0000

Table B2 continued

1	3	2347.709	33.977	0.0000
26	6	2347.756	34.024	0.0000
17	5	2347.906	34.174	0.0000
16	5	2348.079	34.347	0.0000
33	3	2348.465	34.733	0.0000
6	4	2349.502	35.770	0.0000
36	4	2349.965	36.233	0.0000
35	4	2350.364	36.632	0.0000
37	4	2350.465	36.733	0.0000
43	5	2351.171	37.439	0.0000
46	5	2351.896	38.164	0.0000
44	5	2352.364	38.632	0.0000
55	6	2353.077	39.345	0.0000
32	2	2354.228	40.496	0.0000
3	3	2355.373	41.641	0.0000
4	3	2356.212	42.480	0.0000
2	3	2356.227	42.495	0.0000
10	4	2356.970	43.238	0.0000
13	4	2357.345	43.613	0.0000
11	4	2358.212	44.480	0.0000
22	5	2358.930	45.198	0.0000

Table B2. Complete model selection results for the analysis examining habitat attributes on the odds of goshawk landscape use in the western Great Lakes bioregion between 1979-2008. For each model the number of parameters (K), AIC value, ΔAIC value, and Akaike weight (*w*) are provided. The model structure for each model is provided in Table 1 of the main text.