

**LOCATION INFORMATION HAS BEEN REMOVED FROM THIS  
DOCUMENT TO PROTECT SENSITIVE SPECIES' POPULATIONS.**

**Assessing Breeding Activity in Northern Goshawk Territories  
in Northern Minnesota**

Gaea E. Crozier  
Ecological Resources Nongame Specialist

and

Maya Hamady  
Ecological Resources Regional Nongame Specialist

2006-2007 Final Report

March 2008  
Nongame Program  
Division of Ecological Resources  
Minnesota Department of Natural Resources  
Grand Rapids, MN

## TABLE OF CONTENTS

Abstract.....	page 3
Introduction.....	page 3
Methods.....	page 4
Results.....	page 7
Discussion.....	page 11
Acknowledgements.....	page 15
Literature Cited.....	page 16
Tables.....	page 17
Figures.....	page 23
Appendix 1.....	page 25
Appendix 2.....	page 31

## ABSTRACT

We monitored breeding activity in Northern Goshawk (*Accipiter gentilis*) territories in northern Minnesota during the 2006-2007 breeding seasons and compared these data with monitoring results from 2003-2005 to examine 5-year averages and trends. Monitoring goshawk territories in Minnesota has been a collaborative, interagency effort. Through this partnership, 72 territories were monitored in 2006-2007. In total, we know of 98 areas in Minnesota in which goshawk breeding activity has occurred since the early 1990s. Of these, there are 66 territories that are currently active (defined as having a nest attempt in the last 5 years) with an average of 29 (SD = 5) territories with nest attempts each year. From 2003-2007, an average of 79% (SD = 10) of occupied territories had been occupied the previous year. An average of 80% (SD = 9) of occupied territories had nest attempts each year and 68% (SD = 15) of nest attempts were successful. Average productivity was 1.01 young/nest attempt (SD = 0.17) or 1.51 young/successful nest (SD = 0.21). The minimum percentage of nests that failed due to predation averaged 8% (SD = 6). We found that some territories were consistently more productive than others. Over the past 5 years, 32% of the territories produced 60% of the young. The average distance between alternate nests within a territory used in consecutive years was 235 m (SD = 151, n = 59), and the shortest distance documented between two territories with nest attempts in the same year was 1.75 miles. Recommendations on ways to strengthen the monitoring methodology and the state of Minnesota's goshawk management recommendations are provided.

## INTRODUCTION

The Northern Goshawk (*Accipiter gentilis*) is a large, forest-dwelling raptor that requires large patches of mature and old upland forest for nesting and foraging. There is concern for the goshawk because it is a rare species that is dependent on habitat vulnerable to human activities such as logging and development. The amount of mature and old forest in northern Minnesota has substantially decreased since pre-settlement times and the amount of young and early successional forest has increased. There has been extensive forest fragmentation across the region and remaining patches of forest have become heavily fragmented. As a result, the Minnesota Department of Natural Resources (MN DNR) recently recommended that the state status of the goshawk be elevated to Species of Special Concern. The goshawk is also listed as a Species of Greatest Conservation Need (SGCN) in Tomorrow's Habitat for the Wild and Rare (the MN DNR's Comprehensive Wildlife Conservation Strategy; MN DNR 2006).

As part of a collaborative effort among various agencies and organizations in the state, information has been collected on goshawk breeding activity in known goshawk territories. This effort is a step towards understanding and managing towards the sustainability of the goshawk population in Minnesota. The MN DNR has been involved in monitoring efforts since 2003 and has been using a standardized methodology developed by the University of Minnesota (Andersen et al. 2003). Results from the 2003-2005 monitoring efforts can be found in the 2003-2005 final report (Crozier et al. 2006). This 2006-2007 final report gives results of monitoring efforts from 2006-2007 and examines trends since 2003. This project was funded with a State Wildlife Grant with matching funding from the MN DNR.

Collecting standardized information on goshawk breeding activity provides us with baseline data that is lacking in Minnesota. Long-term monitoring provides us with insights into how goshawks respond to habitat changes in their territories due to forest management, and it can help us detect trends in breeding activity. Monitoring also keeps managers up to date on which goshawk territories are active, and therefore, where MN DNR's Northern Goshawk Management Considerations (MN DNR 2003) are applicable. Stands proposed for harvest each year are examined to see if they occur within active goshawk territories and if the harvests are consistent with the recommendations outlined in the Northern Goshawk Management Considerations. Knowing the location of active goshawk territories is also valuable in MN DNR's forest planning efforts known as Subsection Forest Resource Management Plans (SFRMP). The presence of an active territory is one of the factors used in helping to determine the placement of extended rotation forest, designated large old patches of forest, and old forest management complexes.

Information obtained from this project will help the MN DNR and other agencies in the region more effectively manage for goshawks. By managing for a sustainable goshawk population, we protect not only goshawks but a multitude of other species that have the same habitat requirements as the goshawk (forest interior species and mature/old forest specialists). Many of these species have been identified as SGCN in *Tomorrow's Habitat* (MN DNR 2006). MN DNR's focus on the goshawk as a guide for forest management is based on the goshawk's role as an umbrella species rather than single-species management.

The main objectives of this project were to 1) determine occupancy, nesting, and nesting success rates in at least 25 territories in 2006 and 2007 using the standardized methodology, 2) collaborate with other goshawk surveyors in Minnesota and coordinate monitoring efforts among agencies, and 3) compile all monitoring data in the MN DNR's Northern Goshawk Territory Database and Natural Heritage Database.

## **METHODS**

### *Territory Selection*

Minnesota's goshawk territories are located within the Laurentian Mixed Forest Province of north-central and northeastern Minnesota. At the start of this project in March 2006, there were 86 known areas in which goshawk breeding activity had occurred in the past 15 years in Minnesota. Because the goshawks are not banded, we do not know if these 86 breeding areas are 86 separate territories. However, due to the distance between these breeding areas (67% are a minimum of 4 miles from another breeding area and another 13% are less than 4 miles from another area but it has been confirmed that they are separate territories based on simultaneous nest attempts), we believe the vast majority are separate territories and they will be referred to as such throughout the rest of this report.

The 86 goshawk territories were ranked to determine which should be given priority for the MN DNR's monitoring efforts in 2006 and 2007. Territories given the highest priority were territories with large amounts of state land, territories in which MN DNR management plans were available (Crozier and Hamady 2006), territories that had been monitored by the MN DNR

from 2003-2005 (Crozier et al. 2006), and territories with a long history of activity. Territories given the lowest priority were territories in which there had been no breeding activity for five consecutive years. As a result, the MN DNR selected 37 territories for monitoring. Because these territories were not randomly selected, inferences from these data should be made with caution.

Monitoring Minnesota's goshawk territories has been done in partnership with various agencies and organization within the state: Chippewa National Forest (NF), Superior NF, University of Minnesota, Wolf Ridge Environmental Learning Center, and as of 2006 the Fond du Lac Indian Reservation. The MN DNR led the effort to coordinate monitoring between these groups to ensure that all high priority territories in Minnesota were monitored and there was not a duplication of monitoring effort between groups. These agencies and organizations committed to monitoring about 20 additional goshawk territories, and they have been generous in sharing their monitoring data with the MN DNR.

### *Monitoring Methodology*

A standardized methodology was developed by Andersen et al. (2003) for monitoring breeding activity in known goshawk territories in Minnesota. The MN DNR made minor refinements to these methods and developed accompanying data sheets. The survey area is a 500-m radius circle centered on the most recently active nest in the territory. The monitoring is conducted in three stages (see Appendix 1 for a detailed description of the methodology):

#### Stage 1: Territory Occupancy Survey

This survey occurs during the courtship period (early March-mid April) to determine if the territory is occupied by goshawks. All known nest locations are examined for signs of activity, the adult alarm call is systematically broadcast at up to eight points in the survey area, and suitable goshawk habitat (upland mature and old forest) in the survey area is searched for signs of occupancy or new nests. This survey is repeated in June for any territory that appears to be unoccupied or for any territory that was occupied but no active nest was found during the Breeding Status Survey.

#### Stage 2: Breeding Status Survey

This survey occurs during the incubation period (late April-early May) in all occupied territories to determine if the goshawks are nesting in the territory and to locate the active nest. All known nest locations are examined and all suitable goshawk habitat in the survey area is searched for an active nest.

#### Stage 3. Nest Fate Survey

This survey occurs during the fledging period (late June-July) in all territories with active nests to determine if the nests failed or were successful and if successful, to determine the number of young present. If no young are present in the nest area, the juvenile food-begging call is broadcast several times and the nest area is searched for signs of nest success or nest failure. Nests are considered successful if at least one young is observed in the nest or nest area or if there are signs of nest success like copious amounts of whitewash in the nest area. In general, if there were not signs of nest success, the nest was considered failed.

The methodology and data sheets in Appendix 1 were distributed to all the goshawk surveyors, and surveyors were encouraged to follow the methodology and fill out data sheets so data were comparable among surveyors. The MN DNR surveyors (including MN DNR employees, MN DNR contractors, and MCC crews) were trained to carefully follow the methodology. The non-DNR surveyors follow the basics of the methodology and most fill out data sheets. However, it appears that some of the surveyors make modifications in the survey details such as changes in the number of broadcasts conducted, changes in the location of broadcasts, and changes in the timing and number of survey stages completed.

At the completion of monitoring surveys each year, each territory is given a final status; No Detection (no evidence of goshawk activity detected in the territory), Occupied (goshawk present or evidence of goshawk activity observed in the territory but no nest attempt was found), Successful (nest attempt observed which was successful), Failed (nest attempt observed which failed and no chicks survived), Active (nest attempt observed but nest fate unknown), or Not Checked (territory not monitored). For successful nests, the number of young was recorded during the Nest Fate survey in late June or July. Most of the young observed during this time period were fledged or close to fledging. However, in some cases the young were partially downy chicks. If a nest was successful but the number of young was uncertain, a “+” was recorded next to the minimum number of young believed to be fledged from the nest.

#### *Data Analysis*

The MN DNR compiled the monitoring data from all goshawk surveyors in Minnesota. Results from the goshawk surveys were entered into the MN DNR’s Northern Goshawk Territory Database (which includes all known goshawk territories in Minnesota since 1991), and the database was distributed to all goshawk surveyors and other involved parties. These data were also entered into the MN DNR’s Natural Heritage Database. The 2006 and 2007 ancillary breeding data were summarized including breeding phenology, species of nest tree, habitat type of the nest stand, history of nests selected for use, number of territories in which breeding owls were present, and number of territories in which predation or adult mortality occurred.

Goshawk territories were monitored from 2003-2005 (Crozier et al. 2006) using the same methodology that was used to monitor territories in 2006-2007. Summary statistics were calculated for 2006 and 2007 and were compared to data from 2003-2005. To ensure that data were comparable within and among years, data for a territory were removed from the analysis if the territory was not surveyed following the standardized methodology. Territories considered to be inactive (i.e., had not had an active nest from 2003-2007) were also removed from the analysis. Data were not used for territories for the year in which they were discovered or confirmed because these territories are generally found based on the presence of an active or successful nest, which biases the results.

Breeding rates were calculated for each year. The territory occupancy rate was calculated in two ways: 1) the number of occupied territories (i.e., all territories with goshawk activity or nest attempts) divided by the number of monitored territories, and 2) the number of occupied territories that had been occupied the previous year divided by the number of occupied territories from the previous year. The nesting rate was also calculated in two ways: 1) the number of

territories with nest attempts divided by the number of monitored territories, and 2) the number of territories with nest attempts divided by the number of occupied territories. The nest success rate was calculated as the number of successful nests divided by the number of nest attempts in which nest fate was known. The minimum predation rate was calculated as the number of predated nests divided by the number of nest attempts in which nest fate was known. This is a minimum predation rate because only nests in which there were clear signs of predation were included in the calculation (i.e., observed predated carcass of chicks or adult, claw marks on tree, nest ripped apart). The productivity rate was calculated in two ways: 1) the number of young divided by the number of nest attempts in which nest fate was known, and 2) the number of young divided by the number of successful nests. In addition, a 5-year average for each of these rates was calculated based on the 2003-2007 data.

Exploratory statistical analyses were performed using SAS (version 9.1). The results from the exploratory analyses identify statistically significant patterns rather than provide information on cause and effect. To compare productivity between years, an analysis of variance (ANOVA) was conducted with productivity (either young/nest or young/successful nest) as the dependent variable and year as the independent variable. To compare productivity between territories located within the Chippewa NF versus Superior NF boundaries, an ANOVA was conducted with productivity as the dependent variable and territory location as the independent variable. Territories that had been surveyed using the standardized methodology in 4 out of 5 years from 2003-2007 were included in the analysis, and the average number of young fledged/year was calculated for each territory. This analysis was conducted because it has been suggested that goshawk breeding activity appears to be lower on the Superior NF than on the Chippewa NF.

Using the GPS nest locations for all known nest attempts since 1991, spatial analyses were conducted in ArcView. The number of territories less than 4 miles apart and the minimum distance between territories with simultaneous nest attempts were calculated. The average distance between alternate nests within a territory was calculated for all territories that had nest attempts in two consecutive years. The percentage of nests that were located within the 500-m survey area in each territory in 2004 was calculated.

## **RESULTS**

### *2006 and 2007 Ancillary Breeding Data*

In 2006, 66 territories were monitored for goshawk breeding activity by cooperating agencies and organizations in Minnesota (Table 1 and 2). Nine of the 66 territories were discovered in 2006. The first nest with signs of activity was observed on March 27<sup>th</sup>. The first nest with an incubating bird was observed on April 12<sup>th</sup>, and the first fledgling was observed on June 27<sup>th</sup> (Table 3). After the 2006 breeding season, the decision was made to discontinue monitoring two territories because they had not had any goshawk activity for five consecutive years and were considered inactive.

In 2007, 68 territories were monitored for goshawk breeding activity by cooperating agencies and organizations (Table 1 and 2). Of the 68 territories, 1 territory was discovered and 2 territories were confirmed in 2007 (there was evidence of goshawk activity in these 2 territories

the previous year, but a nesting attempt was not documented until 2007). In 2007, the first nest with signs of activity was observed on March 15<sup>th</sup>. The first nest with an incubating bird was observed on April 12<sup>th</sup>, and the first fledgling was observed on June 25<sup>th</sup> (Table 3). A detailed description of the 2006 and 2007 survey results for each territory is given in Appendix 2.

The majority of the trees used for nesting in 2006 and 2007 were aspen with 90% and 74% of the nesting attempts, respectively, occurring in aspen trees (Table 4). The vast majority of the nests were built in the primary crotch of the tree (95% in 2006 and 89% in 2007). The habitat type of the nest stand was variable. In 2006, nests were almost equally split between Upland Deciduous, Upland Coniferous, and Upland Mixed stands (Table 5). In 2007, Upland Mixed and Upland Coniferous stands accounted for 77% of the nest stands. Over 50% of the nest attempts in 2006 and 2007 occurred in nests that had no history of previous use by goshawks (either because the nest was first found that year or because the nest had been found in a previous year but goshawk activity had never been observed at the nest [i.e., a possible nest]). In 2006, 55% of the nest attempts occurred in nests with no history of previous use and 15% occurred in the nest used the previous year (Table 6). In 2007, 62% of the nest attempts occurred in nests with no history of previous use and 19% occurred in the nest used the previous year.

Surveyors typically documented the presence of owls nesting in goshawk territories when it was observed. In 2006, 7 goshawk territories had owls nesting in them (4 Great Gray and 3 Great Horned Owls) of which 5 of the owls nested in a former goshawk nests. Three of these 7 territories that had nesting owls (1 Great Horned and 2 Great Gray Owls) also had nesting goshawks. In 2007, 4 goshawk territories had owls nesting in them (1 Great Gray and 3 Great Horned Owls) of which 1 of the owls nested in a former goshawk nest. One of these territories that had a nesting owl (Great Horned Owl) also had a nesting goshawk. The closest distance recorded between an active goshawk and owl nest (Great Gray Owl) was 207m, and both nests were successful.

When possible, surveyors documented the cause of nest failures and adult mortality at the nest site. Of the six nests that clearly failed in 2006, two had signs of predation in that one nest appeared to have been predated by an owl and the other nest had the predated remains of the adult female under the nest tree. The cause of failure for the other 4 nests is unknown. Of the five nests that clearly failed in 2007, one had signs of predation in that the predated remains of the adult female by an owl was found under the nest tree. Of the other four nests that failed, one nest had received considerable wind damage and the cause of failure for the other three nests is unknown. No nesting owls were documented in any of the territories that were predated in 2006 or 2007; however, the territories were not specifically surveyed for nesting owls so they could have been present. Ancillary data for the 2003-2005 surveys can be found at Crozier et al. (2006).

#### *2003-2007 Goshawk Breeding Activity*

The 2006 and 2007 monitoring results are shown in Table 7. This table includes the survey results for all territories that were monitored during these two years including territories with minimal survey effort, territories that are inactive (defined as a territory with no nest attempt for 5 years), and newly discovered territories which are confirmed based on a nest attempt. Therefore, these raw data are potentially biased and should be used with caution. To minimize



these sources of bias, a subset of the data was used to calculate breeding rates to ensure that data were comparable within and among years. Table 8 only includes data for territories that were surveyed following the standardized methodology and considered active (having had at least one nest attempt in the last 5 years). We did not include data for a territory for the first year it was discovered or confirmed. For the remainder of this report, all breeding rates will be based on the data shown in Table 8.

In general, 2006 and 2007 were relatively similar in terms of breeding activity (Table 8, Fig. 1). The percentage of territories that were occupied (for territories that were occupied the previous year) was 68% and 74% in 2006 and 2007, respectively. The percentage of occupied territories that had nest attempts in 2006 and 2007 was 80% and 75%, respectively. The percentage of nests that were successful in 2006 and 2007 was 78% and 72%, respectively. Productivity was 1.43 and 1.31 young/successful nest in 2006 and 2007, respectively (Fig. 2). The minimum number of nests that were predated was 0% in 2006 and 6% in 2007.

We combined the goshawk monitoring data from 2003-2005 and 2006-2007 to examine patterns and trends that have occurred over the past 5 years. At the conclusion of the 2007 breeding season, there were 98 known territories in Minnesota in which goshawk breeding activity had occurred since 1991 (Fig. 3), of which 72 were monitored between 2006-2007. Of the 98 known goshawk territories in Minnesota, 66 had at least one active nest from 2003-2007 and 72 were occupied at least once from 2003-2007. We are considering 26 territories to be inactive in that there has been no goshawk activity documented in the territories in the past 5 years. Nest attempts occurred in an average of 29 territories each year (SD = 5) from 2003-2007.

From 2003-2007, the occupancy and nesting rates (defined as the number of monitored territories that were occupied and had nest attempts, respectively) have declined steadily over this 5-year period. It is likely that this is an artifact caused by increasingly more territories becoming abandoned each year (but they are not yet considered inactive in our analysis because they had nesting activity since 2003), and this makes each year appear to have a progressively lower breeding rate. Therefore, we recommend that the best measure to estimate occupancy rate is the percentage of occupied territories that were occupied the previous year, and the best measure to estimate nesting rate is the percentage of occupied territories with nest attempts. These are the occupancy and nesting rates that are referred to throughout the rest of this report.

The occupancy rate has been relatively constant from 2003-2007 (Table 8, Fig. 1). The average occupancy rate is 79% (SD = 10) with 2004 and 2005 having higher and 2006 and 2007 having lower occupancy rates. The nesting rate also has been relatively constant from 2003-2007. The average nesting rate is 80% (SD = 9) with 2004 having an extremely high nesting rate of 96%. In contrast, nest success and productivity have fluctuated more from year to year. On average, 68% of nests are successful (SD = 15). Nest success in 2003 was quite high (86%), and then dropped in 2004 and 2005 to around 50%. Nest success increased again in 2006 and 2007 to about 75%. Productivity also fluctuated with an average of 1.01 young/nest (SD = 0.17) or 1.51 young/successful nest (SD = 0.21; Fig. 2). Productivity from successful nests increased from 2003 to 2004, and then decreased continuously from 2005-2007. The number of young/nest was not significantly different among years. However, there was a significant difference in the

number of young/successful nest between 2004 and 2007 ( $n = 26$ ,  $p = 0.02$ ) with 2004 producing significantly more young/successful nest than in 2007.

Using territories that were surveyed using the standardized methodology in 4 out of 5 years from 2003-2007 ( $n = 34$ ), we examined productivity to determine if some territories were consistently more productive than others. We defined a highly productive territory as one that produced an average of at least 1 young/year (based on a natural break in the data at this point). We identified 11 territories as highly productive (Table 9). These highly productive territories represent 32% of the territories but produced 60% of the young over this 5-year period. XXXXXXXXXXXXXXXX  
XX  
XX  
XX

When comparing productivity between territories located within the boundaries of the Chippewa NF ( $n=14$ ) versus Superior NF ( $n=12$ ), location did not significantly affect productivity. However, territories on the Chippewa NF did have higher productivity (average = 0.78 young/year) compared to the Superior NF (average = 0.57 young/year).

As of 2007, there were 98 known areas in Minnesota in which goshawk breeding activity had occurred since the early 1990s, which we have been referring to as territories. However, because these birds are not marked some of these areas might be the same territory. We are confident that 78 of the 98 areas are separate territories because they are at least 4 miles away from another territory (65 territories) or if territories are less than 4 miles apart, there have been nest attempts in both territories in the same year (13 territories). There are 7 pairs of territories that might be the same territory based on the fact that they are less than 4 miles apart and have never had a nest attempt in the same year (Table 10). The majority of the 98 territories are about 5-6 miles from another known goshawk territory. However, since most of the territories were discovered by chance rather than through systematic surveys, this does not give us information on the density of territories in Minnesota. Since the early 1990s, the closest distance documented between two goshawk territories with nest attempts in the same year was 1.75 miles (XXXX and XXXX in 2006; both nests were successful). Since the early 1990s, we have documented 5 pairs of territories with nest attempts in the same year that were less than 3 miles apart.

To determine the average distance between alternate nests within a territory, we calculated the distance between nests for any territory that had nest attempts in two consecutive years using data since the early 1990s. If the same nest was used each year, these data were not included in the analysis. The average distance between two nests used in consecutive years within a territory was 235m ( $n = 59$ ,  $SD = 151$ m). The shortest distance between nests was 47m and the farthest distance was 756m. However, because the survey area for many of the territories was roughly a 500-m radius circle around the last known nest (although this does vary somewhat based on the surveyor), there may have been nest attempts that occurred outside of the survey area that were not detected. To estimate how many nesting attempts might occur outside the survey area, we examined the year in which we had the highest rate of finding nest attempts. In 2004, we found nest attempts in 96% of territories that were occupied (25 out of 26 territories; Table 8). 22 of the 25 nests were located within the 500-m radius survey area. In addition, there was one territory which was occupied but no nest was found (possibly because it was outside of the

survey area). So a maximum of 4 territories in 2004 (15%) had or might have had nests outside of the survey area. The average distance between the 2003 and 2004 nests within a territory was 251m (n = 11, SD = 191m).

When it was observed, MN DNR surveyors documented forest harvests that occurred close to goshawk nests. From 2003-2007, the MN DNR encountered 10 territories that had harvests occur within 500m of the most recently used nest in the territory. Harvests ranged from several acres to over 100 acres. In 3 of the territories, the nest stand was cut. It is too early to determine if these territories have been abandoned, but it appears that at least 2 of these territories might no longer be active. We also compiled a list of areas that might be possible goshawk territories based on reports of goshawk activity, such as a goshawk observed but no active nest found. There are 16 areas in which there has been some evidence of goshawk activity, but a territory has not yet been confirmed with a documented nest attempt (Table 11).

## **DISCUSSION**

Through the collaborative monitoring efforts of various agencies and organizations over the past 5 years, we have increased our knowledge about goshawk breeding patterns in Minnesota and established baseline data on breeding rates. In addition, we have obtained valuable ancillary information on goshawk breeding such as breeding phenology, nest tree species selection, nest stand selection, owl use of goshawk nests, patterns of alternate nest use, and predation at nest sites. These data have helped to enhance our understanding of goshawk breeding activity in Minnesota and will further our ability to effectively manage for goshawks.

In total, there are 98 known areas in which goshawks have nested in Minnesota since the early 1990s. Because there have been no large-scale, systematic surveys for goshawks in Minnesota, the majority of goshawk territories were located by chance or through small-scale surveys for goshawks in specific areas. Therefore, the current distribution of known goshawk territories in Minnesota may not be indicative of their actual distribution or density. The large number of territories located on the XXXX is likely an artifact of more intensive searches for goshawks in this area. At a minimum, there are currently 66 active goshawk territories in the state. On average, there is a minimum of 29 territories with active nests each year.

Over the past 5 years, we found occupancy and nesting rates have remained relatively constant each year. However, nest success and productivity have shown greater variability. Although it is premature to come to any conclusions with only 5 years of data, nest success over the past 5 years has shown a cyclical pattern with years of high nest success followed by years with dramatically lower nest success. Further data are needed to determine if this pattern, which could be caused by patterns in prey availability or weather, is consistent over time. Interestingly, the year with one of the highest occupancy and nesting rates (2004) was also the year with one of the lowest nest success rates. However, the nests that were successful in 2004 had the highest productivity observed during this 5-year period. In 2005, a similar pattern was observed of high occupancy, low nest success, and high productivity. However, in 2005 the nesting rate was the lowest observed in the 5-year period. It appears that a high occupancy rate does not necessarily indicate that the nesting rate will be high, and a high nesting rate does not always correspond to a

high rate of nest success or productivity. It is possible that cues used to decide to nest (possibly prey availability) are not always good indicators of how successful or productive nests will be and other factors such as weather, predator levels, or human disturbance may play an important role in determining nest fate. Another possibility is that when prey availability is high, more birds occupy territories but many are forced into sub-optimal territories. This could result in the patterns observed with lower nest success overall but higher productivity for successful nests.

In addition to temporal variability, we found spatial variability in goshawk productivity among the territories. It appears that some goshawk territories are more likely to have successful and productive nests each year than other territories. Presumably, these highly productive territories have higher prey availability, higher habitat quality, less predation pressure, less human disturbance, or more experienced goshawks than unproductive territories. Although 8 of the 11 territories identified as highly productive are located on the XXXX, this may be an artifact of the higher number of territories that have been discovered on the XXXX. If the goal of land management is to sustain goshawk numbers, highly productive territories should be given special management consideration when planning forest harvests. Management recommendations for goshawks should be carefully adhered to in these territories, and forest harvests should not decrease or fragment habitat availability in the nesting, post-fledging, or foraging areas. These territories may be important as a local source of goshawks for the region.

Boal et al. (2005) examined nest success and productivity in goshawk territories in Minnesota from 1998-2000. Due to a lack of known goshawk territories at the time, the sample size in this study was low and the majority of territories were clustered on the XXXX. However, their average nest success was similar to what we found (62% Boal; 68% our study), and like us they found high variability in nest success (range 38 - 83% Boal; range 50 - 86% our study). The Boal study found higher productivity than us with an average of 1.14 young/nest and a range of 0.87 - 1.85 (average 1.01, range 0.78 - 1.21 our study). The average number of young/successful nest was 1.85 with a range of 1.40 - 2.17 in the Boal study, which was higher than our average of 1.51 with a range of 1.31 - 1.85.

Nest success and productivity rates in Minnesota appear to be quite a bit lower than other areas of the country. Squires and Reynolds (1997) compiled information on breeding rates from different studies across the U.S and found much higher rates of productivity than have been documented in Minnesota. In studies where the sample size was at least 15 nests, the average number of young/nest was 1.62 (range 0.94 – 2.00) and young/successful nest was 2.20 (range 1.78 – 2.70). Interestingly, a study conducted in northern Wisconsin from 1968-1992 (Erdman et al. 1998) found productivity rates that were on par with the rest of the U.S and much higher than what has been documented in Minnesota (1.6 young/nest and 2.1 young/successful nest). However, they did notice an increase in nest failures during the last 10 years of the study which caused the number young/nest to drop (average 1.3 for 1982-1992) but young/successful nest remained constant. Erdman et al. (1998) also developed a goshawk population model which indicated that a productivity rate of 1.7 young/nest was needed to maintain a stable population of goshawks based on breeding and mortality rates from their study area. If productivity rates in northern Wisconsin are currently higher than in northern Minnesota, studies that examine factors contributing to this difference would be beneficial.

### ***Recommendations for the Monitoring Methodology***

On a few occasions from 2003-2007, a nesting attempt was identified based on secondary evidence at the nest (i.e., prey remains under the nest, small amounts of whitewash under the nest) rather than observing an incubating bird or young at the nest. The nest was then considered failed when no birds were present on the Nest Fate survey. In 2006 and 2007, the MN DNR looked for cases in which a nest might appear active based on secondary evidence but a different nest in the territory ended up having an incubating bird in it. We documented 8 cases in which there was evidence at a nest (i.e., prey remains, pellets, whitewash) but a goshawk was documented incubating in a different nest. Based on this, we suggest that secondary evidence can be used to determine occupancy of the territory but should not be used to confirm a nest attempt. The presence of an adult or young goshawk at a nest (dead or alive) should be used to confirm a nesting attempt.

We also recommend that both the juvenile food-begging call and the adult alarm call are broadcast during the Nest Fate survey at nests in which no birds are present. During the Nest Fate survey if we did not get a response to the juvenile food-begging call, we often would play the adult alarm call and would occasionally receive a response to this call. This might be the result of our juvenile food-begging call being of somewhat lower audio quality. However, to be conservative we recommend playing both calls at Nest Fate surveys when no birds are present.

We would like to emphasize the importance of repeating the Territory Occupancy survey in June for territories with no detection or territories with a detection but no nesting attempt found. In 2006-2007, there were 5 territories in which there was no detection on the first Territory Occupancy survey but goshawks were detected on the second Territory Occupancy survey in June. There were 2 territories that were occupied during the first Territory Occupancy survey but no nest was found during the Breeding Status survey; however, an active nest was found during the second Territory Occupancy survey in June. By completing all stages of the goshawk surveys, there is a consistent, standardized way of determining that a territory has no detection or no nesting attempt. When follow-up surveys are not conducted, the level of confidence in the results is reduced. Territories without follow-up surveys were not included in the analyses in this report.

### ***Recommendations for MN DNR Goshawk Management***

The MN DNR developed Northern Goshawk Management Considerations (MN DNR 2003; hereafter referred to as “Considerations”) as recommendations to forest managers for protecting goshawk territories. The Considerations apply to goshawk nests that have been active in the last two years and recommend that any tree supporting a goshawk nest is monitored and protected for at least two breeding seasons following the last known occupancy of the nest area (a 30-40 acres area surrounding the nest). Based on the monitoring data, two years may not be a long enough time period. We have records of 8 occasions in which a nest area was not used for more than 2 years and then became active again. In addition, we have records of 7 occasions in which the territory was inactive for more than 2 years and then became active again. The longest period that a nest area was not used and then became active again was at least 6 years. The longest period that a territory was inactive and then became active again was at least 4 years. When the MN DNR’s Forest Resources Issues Team (FRIT) re-evaluates the Considerations, we

recommend they consider revising the Considerations so that all nests within a territory are protected and monitored for at least 5 years following the last known occupancy of the territory.

Currently, the model used by the MN DNR to protect goshawk habitat is on the scale of an individual territory using the Considerations. Because we will never know the location of all the goshawk territories in the state (nor should this be a goal), it is important that we shift our emphasis from managing goshawk habitat on the scale of a territory towards managing goshawk habitat on a landscape scale. Although we will need to be involved in managing habitat in individual territories to ensure their long-term viability, focusing on conservation of goshawk habitat on a landscape scale gives us a greater ability to protect and conserve the goshawk population as a whole. To sustain goshawk populations, relatively unfragmented large patches of upland mature/old forest should be preserved across the goshawk's range in northern Minnesota. In areas where these patches do not exist, opportunities to create future large old patches should be examined so that goshawk habitat is well distributed across the region. This will provide habitat for goshawks as well as many different wildlife species that require forest interior habitat and older forest.

The MN DNR's forest planning efforts (SFRMP) are a good first step towards taking a long-term approach towards managing for older forest and large, unfragmented patches of forest on a landscape scale. The SFRMP plans create designated large old patches of forest, old forest management complexes (OFMC), and extended rotation forest (ERF) across the landscape. These efforts will enhance goshawk habitat in the region, as goshawks need these patches over a large area due to their large home range. However, these habitat features (specifically OFMC and large old patches) represent a small percentage of the forested landscape and are often not well distributed. Their ability to sustain a viable population of goshawks is questionable. Therefore, when it comes time for FRIT to re-evaluate the Considerations, we suggest that landscape-level goshawk habitat recommendations or targets are developed to conserve goshawk habitat for the population as a whole. Currently, the MN DNR is working to identify areas in northern Minnesota that have the best potential at sustaining goshawk habitat through the coming decades.

We recommend that the MN DNR continues to support goshawk territory monitoring efforts, and we appreciate the interagency cooperation that has occurred in this undertaking. Through our combined efforts and willingness to share data across agencies, we have increased our understanding of goshawk breeding activity and strengthened our ability to more effectively integrate the needs of goshawks into forest management. By tracking the location of active goshawk territories, we have helped promote habitat sustainability of these territories by implementing the Considerations, providing input on specific harvests within territories, and working with other agencies to cooperatively manage habitat within territories. Knowing the location of active goshawk territories has also been beneficial in the SFRMP planning process. The presence of active goshawk territories has been used in SFRMP to help select the location of OFMC, ERF, and large old patches of forest. This will help to maintain the habitat viability of these territories over the long term.

By continuing monitoring efforts, we will be able to continue protecting the habitat suitability of goshawk territories and continue using goshawks as a tool in guiding forest planning efforts.

Knowing the location of active goshawk territories is essential to current MN DNR goshawk management and implementation of the Considerations. It is necessary that we protect goshawk habitat at a territory-level until we are confident that landscape-level forest management is sufficient to provide habitat for the goshawk at a population-level. In addition, continuing monitoring efforts will allow us to build on the valuable information we have already gathered on goshawk breeding patterns. Through long-term monitoring, we can track changes in breeding rates over time. Combined with efforts to assess population trends (Woodbridge and Hargis 2006), we can obtain a more holistic picture as to the types of changes that are occurring in the Minnesota goshawk population. Long-term monitoring can also help us to evaluate the impact of habitat changes in goshawk territories on breeding activity. We suggest that future monitoring efforts include tracking harvest patterns within territories to examine if these disturbance patterns and habitat changes correlate with changes in breeding activity. With increasing demands on our forest resources, it is important that we continue to cooperate with other agencies and organizations to determine the best way to manage goshawk habitat in the context of forest management.

## **ACKNOWLEDGEMENTS**

We would like to thank all the biologists who have generously shared their survey data with us: Jeff Jerry, Jeremy Cable, John Casson, Dan Ryan, Melissa Grover, Susan Catton, Tim Catton, Peg Robertsen, Wayne Russ, Todd Stefanic, Mike Schrage, Christian Nelson, Peter Harris, and Steve Mortensen. We would like to thank the MN DNR staff and contractors who have conducted surveys: Matt Solensky, Michelle Crozier, Mary Novak, Mike Novak, Aaron Alto, Bruce Lenning, Katie Haws, Kevin Woizeschke, Debbie Waters, Brian Giersdorf, Shawn Conrad, MCC crews, Frank Nicoletti, Cam Trembath, David Grosshuesch, and Bill Tefft. We would like to thank Dave Andersen for developing the survey protocol and Sharron Nelson for incorporating survey data into the MN DNR's Natural Heritage Database. And last, thanks to all the private landowners that allowed us access to their land to conduct goshawk surveys.

## LITERATURE CITED

Andersen, D. E., C. W. Boal, and M. J. Solensky. 2003. Northern Goshawk nesting survey in northern Minnesota. Preliminary Project Report, 30 June 2003. Minnesota Cooperative Fish and Wildlife Research Unit, St. Paul, MN.

Boal, C. W., D. E. Andersen, and P. L. Kennedy. 2005. Productivity and mortality of Northern Goshawks in Minnesota. *Journal of Raptor Research* 39:222-228.

Crozier G. E., and M. Hamady. 2006. Northern Goshawk territories in Minnesota: landscape structure, disturbance patterns, and management recommendations. Final Report by the Nongame Program, Division of Ecological Services, Minnesota Department of Natural Resources, Grand Rapids, MN.

Crozier, M. L., M. Hamady, G. E. Crozier, and M. J. Solensky. 2006. Determining Northern Goshawk (*Accipiter gentilis*) occupancy, nesting activity, and nesting success within known territories in northern Minnesota. 2003-2005 Final Report by the Nongame Program, Division of Ecological Services, Minnesota Department of Natural Resources, Grand Rapids, MN.

Deegan, G., T. Aunan, and W. Befort. 2004. 2004 Report: Minnesota forest change monitoring. Report by the Resource Assessment, Division of Forestry, Minnesota Department of Natural Resources, Grand Rapids, MN.

Erdman, T. C., D. F. Brinker, J. P. Jacobs, J. Wilde, and T. O. Meyer. 1998. Productivity, population trend, and status of Northern Goshawks, *Accipiter gentilis atricapillus*, in northeastern Wisconsin. *Canadian Field Naturalist* 112:17-27.

MN DNR. 2003. Northern Goshawk management considerations. Report by the Forest Resources Issues Team, Minnesota Department of Natural Resources, Grand Rapids, MN.

MN DNR. 2006. Tomorrow's habitat for the wild and rare: an action plan for Minnesota wildlife. Minnesota's Comprehensive Wildlife Conservation Strategy by the Division of Ecological Services, Minnesota Department of Natural Resources, St. Paul, MN.

Rack, J., W. Befort, and H. Schreuder. 1999. Minnesota's AFIS project: routinizing TM change analysis. Proceedings from the Pecora 14: LandSatellite Information III conference in Denver, CO.

Squires, J. R., and R. T. Reynolds. 1997. Northern Goshawk (*Accipiter gentilis*). In *The Birds of North America*, No 298 (A. Poole and F. Gill, eds). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, D.C.

Woodbridge, B., and C. D. Hargis. 2006. Northern Goshawk inventory and monitoring technical guide. Gen. Tech. Rep. WO-71. Washington, D.C. U.S. Department of Agriculture, Forest Service.



**TABLES**

**Table 1.** A list of the goshawk territories monitored in 2006 and 2007 and the surveyor.

**TABLE REMOVED FROM THIS DOCUMENT TO PROTECT SENSITIVE SPECIES.**

**Table 2.** The number of goshawk territories monitored by each organization in northern Minnesota during the 2006 and 2007 goshawk surveys.

**TABLE REMOVED FROM THIS DOCUMENT TO PROTECT SENSITIVE SPECIES.**

**Table 3.** The dates of the first survey, last survey, first nest observed with signs of goshawk activity (i.e., greenery, whitewash, prey remains, new sticks), first goshawk observed incubating on a nest, and first fledgling observed in a territory (i.e., chick observed outside of the nest) during the 2006 and 2007 goshawk surveys.

Year	First survey	Last survey	First nest with activity	First incubating bird	First fledgling
2006	March 21	July 18	March 27	April 12	June 27
2007	March 7	~August 15	March 15	April 12	June 25

**Table 4.** The percentage of nest attempts found in each tree species in 2006 (n = 29) and 2007 (n = 23). Information was not available in 2007 for one nest.

Tree species	2006	2007
Aspen	90%	74%
Birch	7%	9%
Jack Pine	3%	4%
Maple		4%
Red Pine		9%

**Table 5.** The percentage of nest attempts found in each habitat type in 2006 (n = 28) and 2007 (n = 22). Information was not available in 2006 for one nest and 2007 for two nests.

Tree species	2006	2007
Upland Coniferous	36%	36%
Upland Mixed	32%	41%
Upland Deciduous	32%	18%
Lowland Deciduous		5%

**Table 6.** The history of the nests used in 2006 (n = 20) and 2007 (n = 21). The percentage of nests used in 2006 and 2007 that had no record of previous use or were located in a nest used in a previous year is shown. The 9 territories discovered in 2006 and the 3 territories discovered/confirmed in 2007 were not included in this analysis.

Year	No record of previous use	2006 nest	2005 nest	2004 nest	2001 nest	2000 nest	1998 nest
2006	55%	n/a	15%	20%	5%	5%	
2007	62%	19%	9%		5%		5%

**Table 7.** Results of goshawk monitoring in Minnesota from 2006-2007 for all territories monitored.

	2006	2007
Number of territories monitored	66	68
Number of occupied territories	36	32
Number of territories with nest attempts	29	24
Number of successful nests*	20	16
Number of young	33	21
Minimum number of nests failed due to predation	2	1

\* There were 3 nests in which nest fate was unknown in both 2006 and 2007.

**Table 8.** Results of goshawk monitoring in Minnesota from 2003-2007 in active territories that were surveyed using the standardized methodology.

	2003	2004	2005	2006	2007	Average
Number of territories monitored	20	31	35	38	47	34
Number of occupied territories <sup>a</sup>	18 (90)	26 (84)	29 (83)	25 (66)	28 (60)	25 (76)
% of territories occupied that were occupied the previous year	NA	87	88	68	74	79
Number of territories with nest attempts <sup>a</sup>	14 (70)	25 (81)	21 (60)	20 (53)	21 (45)	20 (62)
% of occupied territories with nest attempts	78	96	72	80	75	80
Number of successful nests <sup>b</sup>	12 (86)	13 (54)	9 (50)	14 (78)	13 (72)	12 (68)
Number of young	17	24	14	20	17	18

Number of young per nest attempt <sup>c</sup>	1.21	1.00	0.78	1.11	0.94	1.01
Number of young per successful nest	1.42	1.85	1.56	1.43	1.31	1.51
Minimum number of nests failed due to predation <sup>b</sup>	1 (7)	4 (17)	2 (11)	0	1 (6)	2 (8)

Note: The percentage is in parentheses. Data were removed from the analysis for territories in the year in which they were discovered or confirmed. Data for 2003-2005 are from Crozier et al. 2006.

<sup>a</sup> The percentage is based on the total number of territories monitored.

<sup>b</sup> The percentage is based on the total number of nest attempts (not including nests in which nest fate is unknown: 0 in 2003, 1 in 2004, 3 in 2005, 2 in 2006, 3 in 2007).

<sup>c</sup> Based on nests in which nest fate is known.

**Table 9.** The most productive territories in Minnesota from 2003-2007. These territories have produced an average of at least 1 young/year. Only territories that were surveyed using the standardized methodology in 4 out of the 5 years were included in this analysis (n = 34).

**TABLE REMOVED FROM THIS DOCUMENT TO PROTECT SENSITIVE SPECIES.**

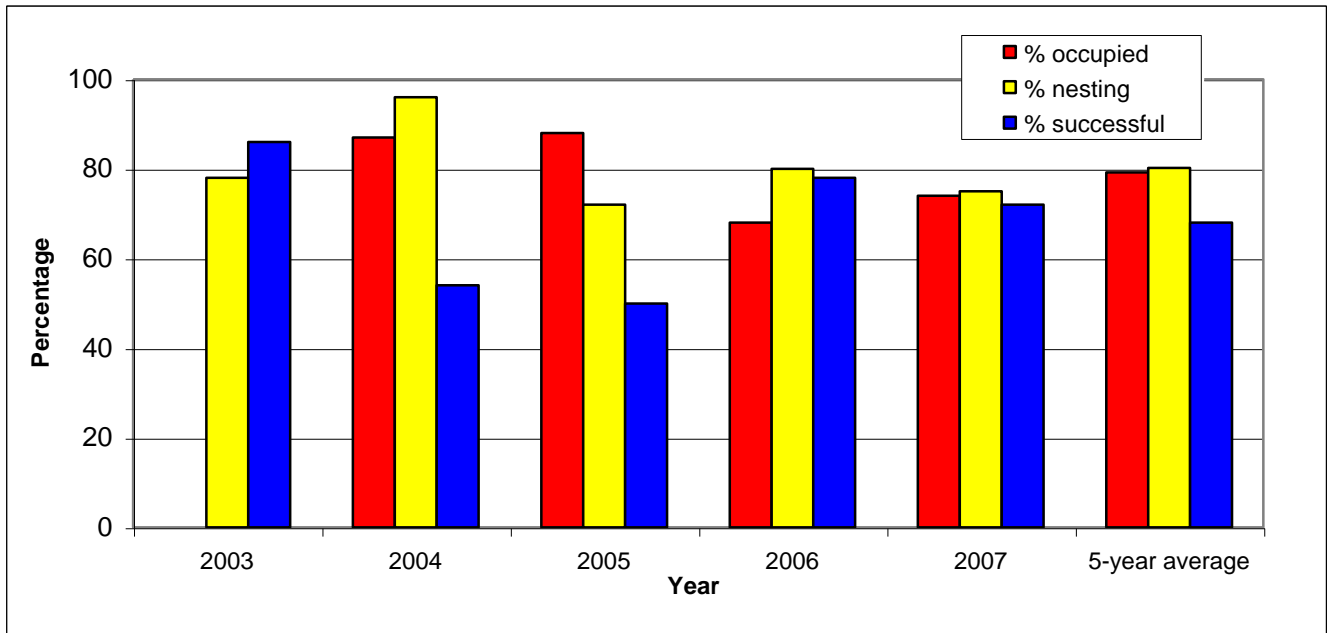
**Table 10.** Pairs of goshawk territories that might be the same territory based on proximity to each other and lack of nest attempts in the same year.

**TABLE REMOVED FROM THIS DOCUMENT TO PROTECT SENSITIVE SPECIES.**

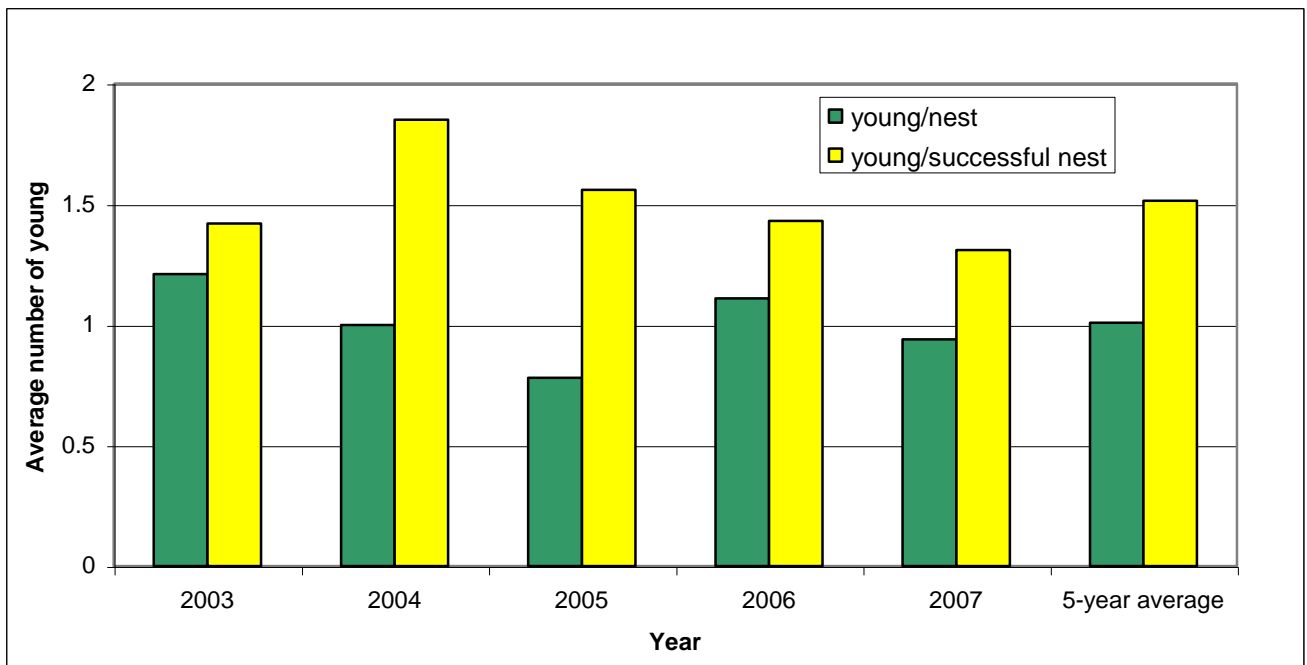
**Table 11.** The location of possible goshawk territories. These are areas where there is some evidence of a goshawk territory, but it has never been confirmed with a nest attempt.

**TABLE REMOVED FROM THIS DOCUMENT TO PROTECT SENSITIVE SPECIES.**

**FIGURES**



**Figure 1.** Occupancy, nesting, and nesting success rates from 2003-2007 and the 5-year average. The occupancy rate is the percentage of occupied territories that were occupied the previous year. The nesting rate is the percentage of occupied territories with nesting attempts.



**Figure 2.** Average productivity rates from 2003-2007 and the 5-year average.

**FIGURE REMOVED FROM THIS DOCUMENT TO PROTECT SENSITIVE SPECIES.**

**Figure 3.** Location of all known goshawk territories in Minnesota since the early 1990s. Territories in yellow were surveyed in 2006 and/or 2007.