EFFECTS OF FOREST DEVELOPMENT NEAR NEST SITES ON THE REPRODUCTIVE SUCCESS OF NORTHERN GOSHAWKS (*ACCIPITER GENTILIS*): AN ADAPTIVE MANAGEMENT APPROACH

2005/2006 ANNUAL REPORT

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BABINE FOREST PRODUCTS
CANADIAN FOREST PRODUCTS
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EXECUTIVE SUMMARY

The northern goshawk (*Accipiter gentilis*, hereafter goshawk) is widely recognized as a species sensitive to forest development. Forest development activities that affect the nest area represent the most direct potential impact to goshawks because: 1) of the critical importance of the nest area for reproduction of the species, 2) the relatively small size of the nest area (~24 ha) makes it susceptible to being completely removed by a cutblock, 3) goshawks exhibit very strong site fidelity to nest areas, often using them for periods of years or decades, and it is unknown how successfully they can establish a new nest area once an original one becomes unavailable, and 4) there is high overlap with suitable nest area habitat and the Timber Harvesting Land Base .

This project directly assesses the response of northern goshawks to forest development within or immediately adjacent to known goshawk nest areas within an adaptive management framework. The goal of this adaptive management strategy is to provide forestry planners and regulatory agencies with local empirical data to confidently design and approve stand level forestry development plans that will maintain use of goshawk nest areas while minimizing impacts to timber development. This is the most comprehensive study to date that directly assesses the response of goshawk nest area use to stand level forest development, and will make a significant contribution to goshawk conservation and forest management at the regional, provincial, and international levels. The results presented here are a combination of data from two concurrent studies in west-central British Columbia, one in the Sub-Boreal Spruce biogeoclimatic zones and one in the Interior-Cedar-Hemlock[1] biogeoclimatic zone. The results for the two projects are combined in this one report to maximize the sample size and power of our analysis.

We are assessing the effects of forest development activities on goshawk breeding success with respect to two reproductive parameters. The primary factor is the rate of reoccupation of nest areas at the incubation stage. This is a critical stage in the breeding period because the birds are committing themselves to the nest area by laying eggs, and it implies that they have made a choice that the area is suitable for breeding. The second factor we examine is the number of chicks that successfully fledge from each nest area (nest productivity). This is a secondary factor because nest productivity is more a factor of foraging area quality than nest area quality.

We estimated the average size of nest areas to be 24 ha using a 200m buffer around multiple nest sites within a nest area. The buffer area is based on observed distance of nest sites from forest edges, concentrated goshawk sign (plucking perches, white wash, roosts), juvenile movement during the post-fledging period, and nest defense behaviours displayed by adult birds. Impacts to the nest area resulting from forest development are measured with respect to 1) amount of mature forest removed from the nest area, and 2) the isolation of the nest area from

[1] Funding for the ICH monitoring is provided by the federal Sustainable Forest Management Network through the

adjacent contiguous forest. The treatment levels of management trials range from minimal disturbance along one edge of a nest area to complete timber harvesting of a nest area and all known nests within it. Treatment and control nest areas are monitored annually to assess rates of nest area re-occupancy and nest productivity.

Forest harvesting trials have been conducted at 35 of 88 known nest areas (15 in the ICH and 20 in the SBS). To date, there is no difference in re-occupancy rates of nest areas between treatment and control areas (X^2=0.020, p=0.99). This pattern is similar in both the Kispiox and Lakes/Morice studies independently (P values >0.25). Since 1997, when multiple post-treatment nest areas became available, the total re-occupancy rates have been for 47% at treatment areas (n=161 potential breeding attempts) and 48% at controls (n=270) (37% and 43% in the Kispiox, and 46% and 49% in the Lakes/Morice, respectively). In 2005, breeding rates were very low overall and the re-occupation rates were 9% for treatment areas (n=33) and 11% for control nest areas (n=48).

The results to date indicate that goshawks can tolerate some level of forest development within their nest area without decreased reproductive success. However, due to high annual variation and a potential lag effect exhibited by the goshawks, these preliminary results must be interpreted with caution. A minimum of five years post-treatment monitoring is required to confidently determine the ultimate response of these trials. This will be especially important to be able to quantify potential thresholds in timber development that impact reproductive success. As of 2005, most of the treatment nest areas have been monitored for four breeding seasons post-treatment. Unfortunately the low overall breeding rates in 2005 resulted in low samples sizes that do not provide much additional information about the responses of goshawks to the trials. At least one additional year of monitoring with normal breeding rates is key to quantifying the relationship between re-occupation and harvest levels.

Assuming the lack of response we have currently observed holds over a longer period, however, this would indicate that goshawk reproductive success is more dependent on habitat condition at a larger territory scale, than impacts to nest area habitat. Examining this issue is the focus of a new component of the Nadina project. Specifically we are examining how quantity and quality of habitat, at multiple territory scales, relates to long-term reproductive success of goshawks. We have secured funding for a portion of this work through the national Sustainable Forest Management Network and Todd Mahon will be conducting this research as part of a PhD program at the University of Alberta.

University of Alberta.

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Morice & Lakes Innovative Forest Practices Agreement

Babine Forest Products

Houston Forest Products

Canadian Forest Products

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INTRODUCTION

The Northern Goshawk (*Accipiter gentilis*; hereafter goshawk) is a circumpolar species inhabiting a variety of coniferous and mixed deciduous-coniferous forests. These forests include the boreal forest (Godfrey 1986), heavily managed coniferous forests in Europe (Kostrzewa and Kostrzewa 1990), mixed deciduous-coniferous forest of eastern North America (Speiser and Bosakowsi 1987), montane forests in western North America (Hayward and Escano 1989) and temperate rainforest from California to Alaska (Reynolds *et al*. 1982, Squires and Reynolds 1997). Despite the wide range of habitats utilized, structural requirements for nesting habitat are similar and are typically high value stands from a timber perspective, resulting in resource management conflicts.

The Northern Goshawk is widely recognized as a species sensitive to forest development (Squires and Reynolds 1997). In British Columbia the species was classified as an 'Identified Wildlife Species' under the Forest Practices Code (FPC) (BC Ministry of Forests and BC Ministry of Environment 1999)[2]. This status indicates that the coarse filter management recommendations of the FPC Biodiversity Guidebook (BC Ministry of Forests and BC Ministry of Environment 1995) are unlikely to maintain the habitat requirements of the species and that special management guidelines are required. Knowledge of goshawk habitat requirements and population status in ICH, CWH, and SBS biogeoclimatic zones (see study area below) was inadequate to incorporate stand and landscape level habitat requirements into strategic landscape level plans and stand level development prescriptions. To address these concerns two concurrent studies examining goshawk habitat requirements and population status were initiated, one in the Kispiox Timber supply Area of the Skeena-Stikine Forest District (formerly Kispiox Forest District) (1996-2002) and one in the Nadina Forest District (formerly Lakes and Morice Forest Districts) (1998-2004). For more information on the objectives and findings of those studies, refer to previous annual reports (Doyle and Mahon 2000; Mahon and Doyle 2003). One component of those projects was to directly monitor the response of goshawks to timber development within, or immediately adjacent to, established nest areas within an adaptive management trial framework. This report summarizes the results of these trials to date. Interim results of the trials to 2002 have been recently published in the Journal of Raptor Research (Mahon and Doyle 2005).

A goshawk's breeding home range is traditionally described as having 3 hierarchically organized components: the foraging area, post-fledging area (PFA), and nest area (NA) (Figure 1). The foraging area encompasses all of the breeding season home range and generally includes a variety of forest cover types, seral stages and landforms. The PFA is the area used by the juveniles for the month or so after fledging, when the young are still dependent on the adults for food and possibly on the forest vegetation as cover from predators (Reynolds *et al.* 1992). The nest area is the centre of breeding activities throughout the reproductive season – mid February

[2] Status is currently under review and will likely be delisted, however, alternative management strategies specific to

to the end of August (Squires and Reynolds 1997). The nest area usually includes multiple nest sites, plucking perches, and roosts, and remains the centre of activity for newly fledged young. The estimated size of nest areas ranges from 8 ha (Reynolds 1983) to 50 ha (McCarthy *et al.* 1989). From a sample of >40 nest areas in the ICH and SBS biogeoclimatic zones in the Prince Rupert Forest Region we estimated nest area size to be 24 ha (Mahon and Doyle 2000a). Once established, goshawks exhibit a very strong fidelity to nest areas, often using them intermittently for periods of years or decades (Reynolds 1983). Nest areas are typically characterized by a relatively homogeneous stand of mature forest with high canopy closure, which are also the prime stands selected for timber extraction. Due to the critical importance of the nest area for reproduction, strong site fidelity of goshawks to established nest areas, and the potential for direct stand level impact of forest development, the nest area is the focal territory component examined in this study.

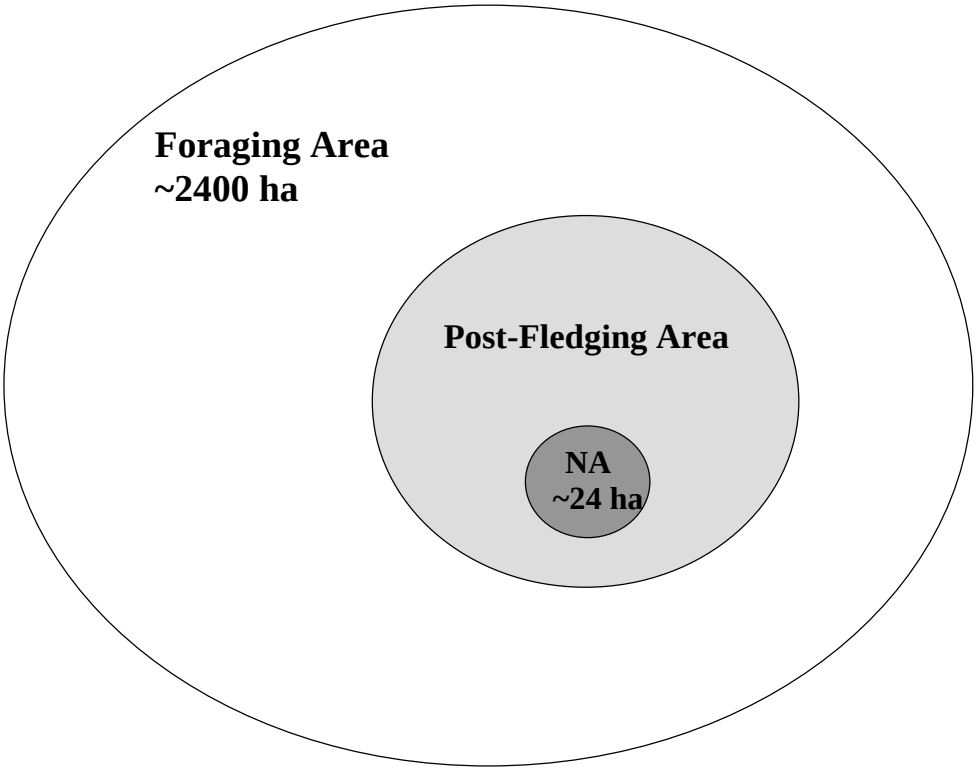


Figure 1. Conceptual arrangement of hierarchical components of a goshawk's territory (NA=Nest Area).

Despite a fairly large body of literature providing forest management recommendations for goshawks, few studies have actually monitored the response of goshawks to habitat change resulting from forest harvesting operations near active nest areas. Management recommendations suggest a protective reserve of 8-50 ha to maintain occupancy of a goshawk

nest areas will concurrently be released (Stewart Guy, WLAP, pers. comm..)

nest area (Reynolds 1983 – 8 ha; Reynolds *et al*. 1994 – 10 ha; Reynolds *et al*. 1992 – 12ha; Kennedy 1990 – 20 ha; McCarthy *et al.* 1989 – 50 ha). One study that examined the success of reserves in maintaining goshawk occupation in nest areas surrounded by large partial-cut units (1000-5000 ha), however, found only 25% of 12 treatment territories were reoccupied at least once over a 3-year period, compared to 79% of 19 control areas that were reoccupied (Crocker-Bedford 1990). This low reoccupation rate occurred despite relatively large retention areas of 16-200 ha. Two other studies documenting impacts of more traditional stand scale clearcut harvesting also showed decreased nest area occupancy by goshawks following nearby timber development (Patla 1997; Widen 1997). Only one recent paper in Europe suggests that goshawks may be able to tolerate timber harvesting (up to 30%) within a nest stand without reducing reproductive productivity (Penteriani and Faivre 2001).

In contrast to the majority of previous studies that link nest area habitat impacts to decreased reproductive success, we made two types of observations early on in the Kispiox and the Lakes and Morice studies that suggested goshawk breeding success might not be as negatively impacted by timber development adjacent to active nest areas. First, we observed 6 active nests <100m from road or cutblock edges. In these 6 instances the nest areas were all part of larger contiguous mature forest stands and the goshawks could have selected more interior conditions if they so chose. Also, nest area occupation and productivity did not differ from nest areas further away from edges. This suggested that nests within 100 m of edges may not have been less suitable with respect to reproductive success. The second factor was our observation of 5 nest areas adjacent to recent cutblocks that appeared, through retrospective assessment, to have originally contained all or part of the original nest area. In these cases the goshawks appeared to have shifted their nest area to remaining or alternate habitat immediately adjacent to the new cutblock. Again, nesting success was not reduced for goshawks in these situations. One possible explanation for the differences we observed compared to results in the literature may be the predominance of mature seral stage forest in our study areas compared to other studies (e.g. Crocker-Bedford 1990; Patla 1997; Widen 1997).

Previous studies that have reported impacts of forest development on goshawk nest area occupancy and reproductive success have generally been weak in a number of areas:

- Sample sizes of treatment and control nest areas have been small
- A priori experimental designs have not been well defined and generally treatment levels (e.g. amount of nest area impacted) have not been measured/reported.
- monitoring effort has not been consistent among nest areas or years
- monitoring has generally been less than 3 years

This study is uniquely positioned to meet its objective, and overcomes the weaknesses of previous studies for several reasons:

1. Forest licensees, Ministry of Forests, Ministry of Water, Land and Air Protection, and Ministry of Sustainable Resource Management are supportive of this research, and have facilitated the prescription and approval of a range of harvesting trials.
2. The experimental design, including definition of treatment and response variables, is

formalized within an adaptive management strategy.

3. There is a commitment by all participants to continue the long-term monitoring required to determine the results of the trials.
4. We have a comparatively large sample size, with a combined total of 81 nest areas (33 current treatments, 48 control).
5. Population estimates indicate that moderate goshawk densities occur in both study areas and our trials are unlikely to have a significant impact on the overall goshawk population in the event that management trials do result in reduced reproductive output (Doyle and Mahon 2000; Mahon and Doyle 2003).

Ultimately, the only way to conclusively determine how different levels of forest development operations affect goshawk nest area use is to proceed with development and assess how the birds respond. The detailed objectives, monitoring protocols, and financial and administrative responsibilities of project partners within this adaptive management strategy have been formalized in the document "An Assessment of Northern Goshawk Nest Site Choice and Reproductive Success in Proximity to Forest Harvesting: an Adaptive Management Strategy" (Mahon and Doyle 2000a). For a more detailed synopsis of this strategy please refer to that document.

The primary objective of the this project during 2004 was to assess re-occupancy and breeding success of goshawks at the 42 known nest areas (known prior to 2004) within the Nadina Forest Districts and the 39 nest areas in the Kispiox TSA and to compare the results between treatment and control nest areas. In addition to nest monitoring we also investigated reports of possible goshawk sightings by forestry workers and the public, documented breeding chronology, and collect pellets and prey remains at active nests for diet analysis.

STUDY AREA

This study is replicated in two different forest biomes within the Northern Interior Forest Region in west-central British Columbia – pine dominated forests in the Lakes and Morice Timber Supply Areas (TSAs) of the Nadina Forest Districts and hemlock dominated forests in the Kispiox and Cranberry TSAs of the Skeena-Stikine Forest District (Figure 2).

The first study area is in the Sub-Boreal Spruce biogeoclimatic zone (Banner *et al.* 1993) in the Lakes and Morice TSAs (N54^{o} 25', W126^{o} 00'). It occurs on the interior Nechako Plateau with elevations of 500 to 1000m. The sub-boreal climate is primarily continental and is characterized by greater seasonal temperature extremes, with cold, snowy winters and relatively warm, moist, short summers. Annual precipitation is 440-650 mm (Banner *et al.* 1993) with rain occurring on less than 20% of the days during the breeding seasons we monitored. Forests in the SBS have been subject to frequent fires (average fire interval <150 years) and zonal sites are frequently dominated by mature seral stands of lodgepole pine (*Pinus contorta)* with subalpine fir, hybrid white spruce (*Picea glauca x engelmannii*), and trembling aspen (*Populus*

tremuloides). The shrub and forb layers are usually quite sparse, though variable, and are generally more developed than in the ICH. In the SBS forested areas account for 80% of the land base with 51% as mature forest, 32% young forest, and 18% shrub/herb.

The second study area is within the Interior Cedar Hemlock (ICH) and Coastal Western Hemlock (CWH) biogeoclimatic zones (Banner *et al.* 1993) in the Kispiox TSA (N55^{o} 25', W127^{o} 45'N). This area is along the eastern side of the Coast Mountain Range and consists of mountain ranges bisected by broad glaciated valleys with an elevation range of 200m – 2500m. The climate is transitional between cool, wet coastal conditions and drier more extreme temperatures associated with interior conditions east of the Coast Mountains. The average annual precipitation varies from 600 and 1200 mm (Banner *et al.* 1993) with rain occurring on half the days during the breeding seasons we monitored. Forests within the ICH and CWH are predominantly old growth (>200 years) coniferous stands dominated by western hemlock (*Tsuga heterophylla*), but including subalpine fir (*Abies lasiocarpa*), western redcedar (*Thuja plicata*), and Roche spruce (*Picea sitchensis x glauca*). Zonal ecosystems consist of hemlock forests with moderate-high canopy closure, sparse shrub and herb layers and a thick feathermoss carpet. Forested areas, which account for 90% of the land base, consist of 62% mature forest (>120 years), 21% young forest (40-120 years) and 17% shrub/herb (<40 years) stages. Forestry roads and clearcuts are present in all portions of both study areas and account for the majority of area in the shrub/herb stage.

Minimum goshawk densities of approximately 4 pairs per 100km^2 are similar between the SBS and ICH based on inventory work in core portions of each study area (Mahon and Doyle 2003; Doyle and Mahon 2000). Potential avian competitors for nest sites and habitat occur at low density but included red-tailed hawks (*Buteo jamaicensis*), which are found in open areas, barred owls (*Strix varia*), mostly in the ICH, and great horned owls (*Bubo virginianus*), which typically occur within riparian and mixed forest habitats at lower elevations throughout the entire region. Prey biomass during the breeding seasons consists predominantly of red squirrels (*Tamiasciurus hudsonicus*) in both study areas (73% ICH, 45% SBS), with secondary prey dominated by medium sized passerines (typically jays, woodpeckers and thrushes; 15% ICH, 9% SBS), grouse (*Bonasa umbellus*, *Falcipennis canadensis* and *Dendragapus obscurus*; 6% ICH, 19% SBS), and snowshoe hares (*Lepus americanus*; 0.1% ICH, 15% SBS) (Doyle and Mahon 2000; Mahon and Doyle 2003).

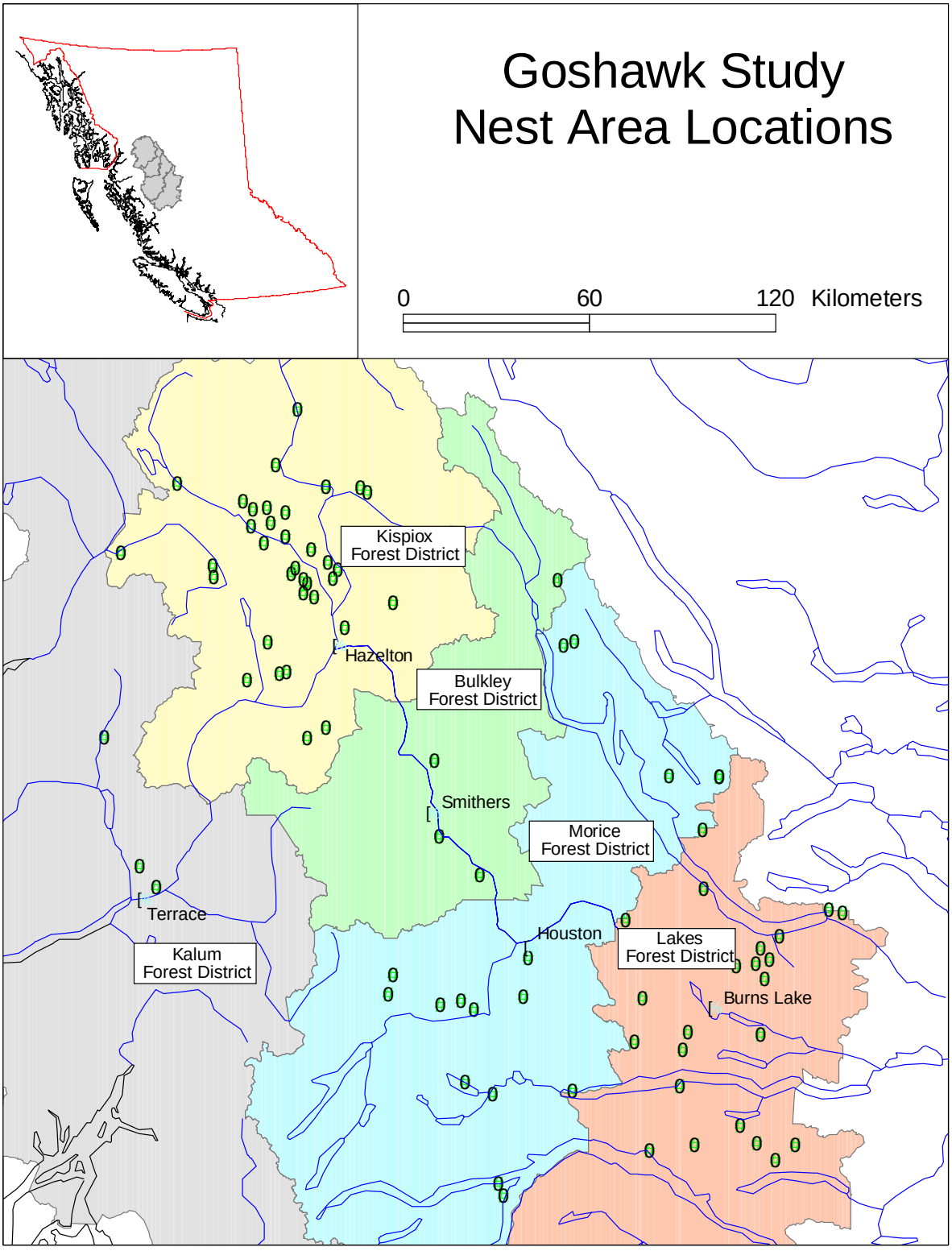


Figure 2. Overview map of the study area.

METHODOLOGY

Adaptive Management Strategy

There are 6 main steps in an adaptive management process (Figure 3) (Taylor 1996). Step 1 involves the definition of the management concern, including the scope of the problem, a synthesis of existing knowledge relevant to the system, and forecasts of outcomes of management actions. Step 2 involves the design of a management program, including definition of treatment and response variables, and monitoring program that will yield information to fill in the knowledge gaps identified in step 1. In step 3 the management trials are implemented. In step 4 the response variables are monitored to determine how effective actions are in meeting management objectives, and to test the hypothesized relationships that formed the basis for the forecasts. Step 5 involves evaluating the actual outcomes relative to original forecasts and interpreting the reason underlying any differences. In step 6 the results of the trials are incorporated to adjust the original objective, models and practices to reflect new understanding. For a detailed discussion of each of these steps as applied to this study please refer to Mahon and Doyle (2000a).

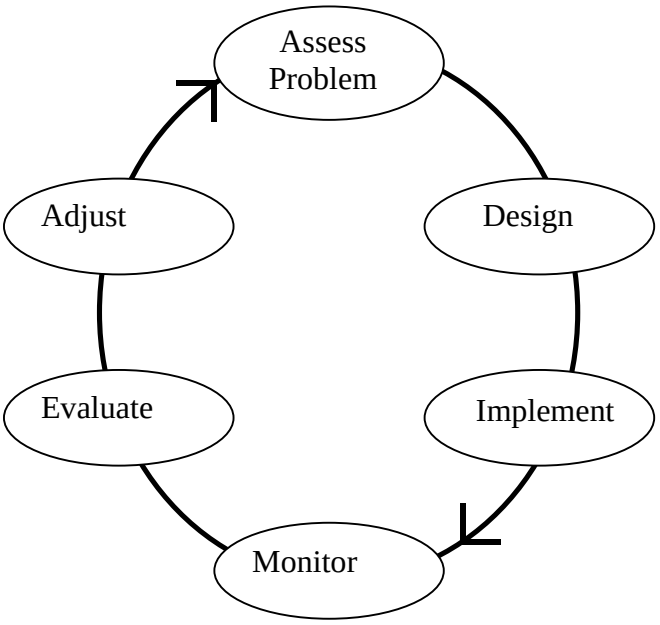


Figure 3. A framework for adaptive management trials (after Taylor 1996).

Experimental Design

For nest areas with adjacent forest development proposed we have provided forest managers with management recommendations that we believed had a reasonable likelihood of maintaining use of the nest areas. Our recommendations are generally based on the maintenance of core nest area habitat (as evidenced by habitat type, alternate nest locations, plucking sites and juvenile use patterns, when available) and a buffer of 100 – 200m around the known nest trees. Forest managers have incorporated these recommendations, to varying degrees, resulting in a range of development scenarios adjacent to nest areas. As these areas are harvested we are monitoring them to assess whether development affects reoccupation of the nest area and overall nesting success. Specifically, we are assessing the null hypothesis that a pair of goshawks will return to the established nest area after timber development occurs:

H_o: Goshawks return to their established nest area after timber harvest near or within that area (24 ha nest area)

and considering 3 alternate hypotheses:

H_{a1}: The goshawks establish a new nest area nearby (<800m).

H_{a2}: The goshawks establish a new nest area in a completely different location (>800m).

H_{a3}: The goshawks do not attempt to breed.

Definition of Nest Area

The key features that determine the boundaries of a goshawk nest area are the locations of multiple nest trees, defensive behavior of the adults, sign from the adults (white wash, feathers, plucking perches), and the movements and behavior of the newly fledged young. Based on our assessment of these attributes, goshawk nest areas exhibit considerable variation with respect to size and configuration. For some nest areas this variation seems to depend on topography and habitat; however, variation among individual goshawks with respect to habitat selection and use patterns also seems to be a major factor.

The nest area is the sample unit within this study, and accurately defining that area is of critical importance to effectively assessing a response to a management trial. We considered two ways of defining the nest area. The first approach would be to assess the size of and shape of each nest area individually based on the criteria above. This approach is problematic because it requires extensive surveys within each nest area, in multiple years, and at different times of the breeding season, and because it is subject to surveyor bias. It would also result in different nest area sizes for each territory, which would complicate, and possibly further bias, assessment of treatment effects. The second method, which we have chosen to use, is a more systematic approach. To calculate a theoretical "typical" nest area size we took the average number of nest sites within a nest area and the average spacing distance among nest sites, for 21 nest areas located early in the study, and applied a 200m buffer around the nests. The 200m buffer distance

is based on observed distance of nest sites from forest edges, concentrated sign (plucking perches, white wash, roosts), juvenile movement during the post-fledging period (Doyle and Mahon 2000, Mahon and Doyle 2002), and nest defense behaviours displayed by adult birds. Using our average of 3 nests per nest area, and an average spacing between nest trees of 185 m, the application of a 200 m buffer results in a nest area size of 24 ha.

To test the appropriateness of this theoretical nest area size for the larger sample of nest areas known now, we overlaid a 24ha circle over every known nest area to assess how many nests sites were encompassed within the 24ha circular area. On the basis that only 4% of the nest sites fell outside of the 24 ha circles, we accepted that it was an appropriate size to use. Future analysis will consider multiple sizes around nest areas ranging from 10-240 ha.

Treatment Variables

Definition of appropriate primary treatment variables for assessment in these trials is the most problematic aspect of this strategy for a number of reasons. Treatment variables likely do not exert a univariate effect but more likely have complex multivariate effects. The interaction of treatment variables also likely varies over the range of the variables and at different scales. Treatment effects are likely not linear with respect to their influence on nest area habitat suitability but rather exhibit a threshold influence. At any rate, threshold responses of the goshawks (used successfully or not) will be what we are primarily able to monitor. Also, based on the observed variation in "natural" nest area habitat selection among different goshawks, it is likely that individual preference/selection could add considerable variation to responses.

Based on nest area selection observed in our study areas and documented in other studies, primary variables likely to affect goshawk nest area suitability include:

1. Amount of nest area impacted by development (Beier and Drennan 1997; Bright-Smith and Mannan 1994; Crocker-Bedford 1990, 1995; Patla 1997, Penteriani and Faivre 2001).
2. Isolation of nest area from adjacent contiguous mature forest (Woodbridge and Deitrich 1994)
3. Patch size of nest area stand (Paton 1994)
4. Spatial configuration of harvest units around nest area
5. Distance of edge of harvest unit or road right-of-way to nest sites (Speiser 1992; Toyne 1997)
6. Type of development: clearcut, partial cut, road right-of-way (Crocker-Bedford 1990, Penteriani and Faivre 2001)

Of these variables, the first two appear to be the most significant and are our primary variables for *a priori* treatment tests. Other variables may be considered in the future depending on the outcome of our principle tests and the sample sizes we are able to obtain.
Assessment of the primary treatment variables may be confounded by several other factors.

These include:

1. Amount of suitable alternate nest area habitat available
2. Occurrence of human activities in the vicinity of the nest area during the breeding period (February 15-August 15)
3. Seral stage distributions (especially as influenced by timber harvesting) at different scales surrounding the nest area.
4. Configuration of seral stage distributions.
5. Secondary treatment effects, such as windthrow, affecting nest area suitability after the initial treatment.

To maximize the likelihood that observed goshawk responses are a result of the primary treatment variables these confounding effects have been minimized wherever possible. Steps to avoid confounding factors include only conducting treatments in areas where there area at least 2 stands of suitable habitat greater than 50 ha that could be used as alternate nest areas, and by ensuring appropriate work windows are incorporated into harvest prescriptions.

Response Variables

Effects of the harvesting trials will be assessed by comparing reproductive variables between trial areas and controls and among trial areas relative to the intensity of the treatment. The two primary response variables that we are examining are:

1) Nest area reoccupation rates into the incubation period.
2) Fledging rates.

In past years we also examined:

3) Nest area reoccupation rates during the courtship period

For our determination of success or failure of a trial in maintaining nest area suitability our primary response variable is the reoccupation of the nest area and realization of egg laying. This is the most significant variable because it represents the commitment of the goshawks to use a nest area. It is also valuable to assess points 2 and 3, above, as secondary response variables. Since annual reoccupation rates in our studies have averaged ~60%, it is important to know whether the absence of goshawks in the remaining nest areas is actually due to the impacts of forest harvesting, or is part of the natural variation in the number of pairs that breed annually. By assessing the nest area during the courtship and nest-building period in late February and early March we can determine this. If the birds return to the nest area during the courtship period, but do not lay eggs there, we can make a much more confident conclusion about the suitability of the modified area than if we do not know whether the birds even returned to the area at all. Once the goshawks have laid eggs and effectively committed themselves to that area,

it is also valuable to determine if success in fledging young is affected (point 3).

Confounding factors associated with these response variables include intermittent and variable rates of annual nest area occupation, and variation associated with the age of the breeding goshawk (adult vs subadult). As discussed above, early season monitoring of nest areas during the courtship period will partly address this issue of annual variation in occupancy rates. Multiyear monitoring is the key requirement to address this variation and potential lag effects in response.

Monitoring Protocol

We have used a combination of telemetry tagging and nest area searches, at areas without tagged birds, to monitor annual occupation and fledging rates at treatment and control nest areas. Initially we attempted to radiotag an individual at every treatment area and at a subsample of the control areas. As the study progressed, however, we found that we did not gain any additional information from the tagged birds that we would not have obtained from the nest area searches. Given this, plus the higher effort and costs associated with radiotagging, and the potential impacts of radiotagging on the goshawks, we have reduced our annual sample of nest areas with tagged birds to approximately 10%, and only tag birds at treatment areas. Adult goshawks are captured and tagged during the late nesting period and early post-fledging period using box traps baited with pigeons (Kenward and Marcstrom 1983) and/or mist nets around a tethered pigeon or owl decoy. Tail mounted radios are used instead of backpacks to minimize potential adverse effects of the radios on the goshawks. Tagged birds are located the following breeding season using ground-based telemetry tracking to determine whether they have returned to the original nest area. In 2004 we did not tag any goshawks as part of this project because of limited funding, however, 6 goshawks were tagged as part of the SFMN project and will be available for us to locate in 2005.

For nest areas without tagged birds we conduct intensive ground searches within approximately 1 km of the original nest area to ascertain the occupancy of each nest area. This involves surveying all known nests within a nest area, and, if none of the known nests are active, intensive searching for new nests and other signs of use such as presence of goshawks, whitewash, and plucking perches. If no sign is found we then conduct systematic call playback surveys (Kennedy and Stahlecker 1993) over a 300x300 m grid to try to elicit responses from the goshawks if are in the vicinity. Nest area searching is conducted during the courtship, incubation and post-fledging periods. All active nests are monitored weekly to determine their success and fledging rates. All treatment areas will be monitored a minimum of 3 years, and most for ≥ 5 years, post-treatment to account for annual variation and a potential lag effect expressed by the goshawks.

RESULTS

Implementation of Harvesting Trials

Of the 88 nest areas located in the two study areas, 35 (20 in the SBS and 15 in the ICH) have been affected by timber development. Harvesting has been proposed at another 25 nest areas. Tables 1 and 2 summarize the level of impact to the nest areas with respect to the percent of nest area to be logged and the percent edge of nest area isolated. The level of treatment ranges from marginal influence along one edge of a nest area to harvesting of the entire nest area including all known nests. Oblique aerial photos of 4 of the treatment nest areas are provided in Appendix 1.

Table 1. Summary of proposed and completed timber development near goshawk nest areas in the Sub-Boreal Spruce BEC zone.

Nest Area	Licensee	Harvest Date	% Nest Area Harvested	% Nest Area Edge Isolated	% Nest Area Edge Isolated (Road)	Prescription
AILPRT	BCTS	Unknown	25	30	0	>200m buffer to be maintained around 2000 nest with connectivity to valley north of nest area; area south of nest to be CC
AUGI72	BFP	Unknown				Under development; nest found during initial layout
BALSAM	BCTS	Unknown			15	Under development – large multi-patch unit with at least 24ha reserve around nest area
BF137-1	BFP	2001-2002	10	75	0	Clearcut with ~20 ha reserve over nest area
BF155-1	BFP	Winter 1999/2000	60	60	0	Clearcut (CC) with 2 ha WTP around 1999 nest site and limited connectivity to creek valley south of block; majority of original nest area harvested in 1999/00; female radio-tagged in 1999
BF225-1 Sag Lake	BFP	Winter 1999/2000	40	65	0	150m reserve centered on nest, feathered partial cut of 50% - 100% removal over next 100m radius
BF254-1	BFP	Unknown				CC with WTPs; nest found during final layout stages; block modification to protect nest area is under development
BF316-1	BFP	2001-2002	35	50	0	Large clearcut with reserve over nest area and connection to contiguous forest outside of block
BF437-3	BFP	2002	35	60	0	Clearcut with reserves
BF517-02 Colleymount	BFP	Unknown	10	0	40	Unknown; presently planned as clearcut with WTP but likely to change to incorporate plan for goshawk nest area; data here represents existing development
BRAUNW	WDL#1537	Summer 1999 + 2005	95	95	25	Original nest was within 20 ha clearcut as evidenced by dead nestling found on ground during harvesting operations. Harvesting in 2005 removed virtually all of original NA and adjacent alternative habitat.
CF186-2 Gloyazikut	Canfor	Winter 1999/2000; 2000/2001	35	60	20	CC logged in 2000/2001. Originally a 92ha block layout, 16ha were left as a WTP around NOGO nest area. In 1999/2000 a road was cut within 125m of the 1999 nest
CF606-05 Tochcha	Canfor	Unknown	20	25	0	85 ha clearcut with WTPs; NE corner of the block will be converted to a WTP to provide 200m buffer around 1999 nest

Nest Area	Licensee	Harvest Date	% Nest Area Harvested	% Nest Area Edge Isolated	% Nest Area Edge Isolated (Road)	Prescription
GULL75	BFP	2002-2003?	50	90		CC with WTPs; 2 nests incorporated into large WTP surrounding wetland in centre of block, but <50 buffer around each nest
HF026-1	HFP	Unknown				Under development
HF036-1	HFP	Unknown				Exact prescription still unknown. CC planned over most of block but with significant retention around 2000 and alternate nest.
HF208-01 Whitesail	HFP	1998/99	75	100	0	≈40ha CC with WTPs; uncertain if original nest area was in block, however, detections of goshawks in block for 2 prior seasons suggest it likely was.
HF562-2 Morrison	HFP	Summer 1999 Winter 1999/2000	100	100	0	CC with WTPs; nest was found by loggers in August 1999; harvesting delayed 2 weeks until young dispersed; nest area was in the centre of the block and was completely harvested.
HF563-4	HFP	Unknown				presently planned as clearcut with WTP but likely to change to incorporate plan for goshawk nest area; mountain pine beetle mgmt. concerns may affect harvest plan as well
HF586-1	HFP	2002-03	50	60	0	Currently clearcut with WTPs; 1999 nest within WTP at NW corner of block.
HF582	HFP	2004-2005	40?	40?		CC with WTPs; nest area found during logging and block modifications to protect the nest area are under development
HF614-1	HFP	Winter 1999/2000 Summer 2001	25	60	0	Much of a >200ha CC logged in summer of 2001. Retention of nest within 25 ha WTP in the centre, additional riparian reserve strips retained to provide limited connectivity to adjacent forest. Cutblock comes to within 300m of the 2000 nest. Approximately the northern half of block harvested in winter 99/00 to within 150 m of 1999 nest
HOUSTN	BCTS	Winter 04/05	25	0		Several 0.5-2 ha beetle patches
HOWELL	Canfor	Roads-Winter 1999/2000 Harvest-Unknown	15	0	50	Mainline and spur roads constructed within nest area during courtship period to within 53m of 2000 nest; adjacent cutblocks planned for harvest in future
KNAPP5	BCTS	Unknown				Unknown; beetle patches currently laid out

Nest Area	Licensee	Harvest Date	% Nest Area Harvested	% Nest Area Edge Isolated	% Nest Area Edge Isolated (Road)	Prescription
MAXAN	Canfor	Summer 1999	10	20	20	Reactivation of deactivated road 150m from 1999 nest; road building through PFA period.
MEADCR	PIR	Winter 1999/2000 Spring 2001	20	60	25	Heli-logging operation across valley with flight path nearly overhead of nest 2001 during nest building and incubation stages. Nest area in 400 m wide leavestrip between 2 clearcuts with small scale beetle salvage (<1ha) patches in leavestrip; harvesting and hauling intermittent through breeding season
NAD-20	HFP	????	-	-	-	Under development; clearcut with reserves
OCTOLK	WDL#118	Winter 1998/99 Winter 04/05	70	80	0	2 CC north and south of 98 nest; CC over 60% of nest area to within 120 m of 98 nest and 50 m of alt. nest 2; alt nests 1, 4, and poss. 3 still to be logged; CC south of nest was mostly logged in winter 98/99, remainder and block north of nest still to be harvested.
OOTS21	BFP	2002-2003	55	80	20	10 ha WTP over known nest, surrounding area mostly clearcut . Will substantially reduce amount of high value nest habitat within 1 km.
UNCHAL	BFP	2002-2003?				Unknown, recent beetle patches in area

Licensee = BCTS = BC Timber Sales, BFP-Babine Forest Products, WDL-Woodlot, HFP-Houston Forest Products, PIR-Pacific Inland Resources.

Table 2. Summary of proposed and completed timber development near goshawk nest areas in the Interior-Cedar-Hemlock BEC zone.

Nest Area	Licensee / Block #	Year of Harvest	% Nest Area Harvested	% Nest Area Edge Isolated	% Nest Area Edge Isolated (Road)	Prescription
BIGCED	SCI-T	2002/2003	0	60	40	Large cutblock leaving 40% connectivity to mature forest, however that strip will be bisected by a road
CANC79	SCI TBA 79	Unknown	?	?	?	Presently on N edge of proposed 28ha block. Unknown to what degree nest area will be buffered.
CORR74	SCI 385-74	1999/2000	25	40	20	Nest in SW corner of block. 9 ha wildlife tree patch around nest, connected to contiguous forest to the south.
CRANB1	CGED 9-01	Possibly 2002/2003	25	55	20	25 ha clearcut with the retention of the 1997 nest within a 3 ha WTP in the centre of the block; 1998 nest will be logged
DATE10	BCTS DA506	Unknown	65	60	25	Buffer or possibly partial cut, still under discussion with Norm Bilodeau.
DEEPCR	SCI-T	2000/2001	40	60	0	Large cutblock coming to approximately 50m from nest on one side.
FOOTSO	SCI CP 395 rd	Unknown	5	0	40	Road Right-of-Way will bisect the nest area to within 150m of 1999 nest and 20m of an alternate nest.
HELEN5	BCTS	1998/1999	15	0	70	Partial cut to within 50m of nest.
ILTZ14	BP 206-014	Unknown	40	25	20	Nest 35 m from block; no development to date
KIT229	KLC 229-1	1999/00	30	55	45	Combination of 2 clearcut openings (4-10 ha) and small group selection patches (<0.5 ha) around a 20 ha reserve approximately centered on the nest area; in-block road to within 35 m of 1997 nest.
KULD14	SCI 615-14	1996/97	5	0	20	30 ha clearcut within 325 m of 1996 nest; road within 110 m; retention of alternate nest within a 1.5 ha WTP.
LAURAC	BP	??????	0	0	10	In proposed block. Unknown prescription.
MAROON	SCI-T	1999/2000	80	100	0	Entire nest area harvested. Nest left in wildlife tree patch (<1ha).
MESSIN	WDL140	2002/2003?	10	0	40	Road to be built through nest area in 2002/2003
MESSIS	WDL140	2001/2002	30	30	0	Cutblock to within 40m of 2002 nest. Partial cutting, shelterwood, and small skid roads also enter nest area.

Nest Area	Licensee / Block #	Year of Harvest	% Nest Area Harvested	% Nest Area Edge Isolated	% Nest Area Edge Isolated (Road)	Prescription
MIL243	KLC 243-1	2000/2001 and 2001/2002	50	25	20	18 ha clearcut to within 15m of the 2000 nest and 100 m of 1995/98 nest. The 1997 and 1999 nests will be removed during harvesting.
NASNY9	BCTS NY9	Unknown	10	25	0	Presently near the W edge of proposed 28ha block. Unknown to what degree nest area will be buffered.
SHED17	SCI 802-1	Summer 1999 (Road Built) Harvest date unknown	100	100	0	Road was built through the nest area to within 40m of 1999 nest. Nest in center of proposed block. Clear cutting to proceed as part of an aggressive trial to determine what birds do if their nest area is logged.
SHED20	SCI 805-3	Summer 1999 (Road Built) Harvest date unknown	15	15	35	Road was built through the nest area to within 120m of an alternate nest and 10m of 2000 nest. Block to be harvested area includes four patches between 4.4 and 6.6ha surrounding 17 ha WTP that contains the two known nests.
SKEE83	SCI 704-83	1999/2000	40	70	0	40 ha clearcut to within 50 m of nearest nest; 3 nests retained in WTP contiguous adjacent forest; retention of WTPs and single WTs to maintain some cover across cutblock.
SMOKE6	SCI 653-3	Unknown	70	85	15	Nest in NW corner of block, with 200 m buffer on three sides and attached to contiguous forest on the west side of the block
SUNNEW	BCTS	??????	5	30	0	Reserve to encompass most of nest area – unsure of exact details.
TEALAK	BCTS A37692	1998/99	25	20	45	Single tree selection (50% removal) to within 35 m of active 1996 nest and 2 other alternate nests; within 125 m of 1997 nest.
TEN222	KLC 222-1	1994/95	35	80	5	Logged within 100m of nest area on two sides and nest area also bisected by road.
UCR198	BP TBA 198	Unknown	40	45	0	Nest in center of block. Prescription yet to be developed with stakeholder.
WDL138	WDL-138	??????	35	80	0	~ 24 ha block to within 50m of nest.

Licensee = BP-Bell Pole, C'GED - C'GED Forest Development, KLC-Kitwanga Lumber Company, SCI-Skeena Cellulose Inc[3]., BCTS = BC Timber Sales

[3] Skeena Cellulose was dissolved in 2004, however, we continue to refer to their former tenure as SCI because no new licensee has been allocated their chart areas.

Nest Area Reoccupation

We express reoccupation rates in two ways. Total reoccupation refers to the rate of reoccupation (# reoccupied nest areas at incubation / total # of potential breeding attempts at previously known nest areas) since the projects were initiated. Annual reoccupation rates refer to reoccupation rates for specific years. To derive an estimate of variation we also calculated the average and standard deviation of the annual reoccupation rates. These calculations must be interpreted with caution as data is biased by small maple sizes in the initial years of the project.

The total reoccupation rate far all nests over the past 7 years monitoring in the SBS and 9 years in the ICH was 48% (48% in the SBS and 47% in the ICH). In 2005, overall nest area reoccupation was very low: 10% (15% (n=47) in the SBS; 3% (n=34) in the ICH). A summary of annual reoccupation (at incubation stage) for each nest area is provided in Tables 3 and 4 (SBS and ICH, respectively).

For the breeding data gathered to date, there is no difference in re-occupancy rates of nest areas between treatment and control areas (X^2=0.02, p=0.99). Since 1997, when multiple post-treatment nest areas became available, the total re-occupancy rates have been 47% at treatment areas (n=161 potential breeding attempts) and 48% (n=270) at controls. This pattern of no statistical difference between treatments and controls is consistent when the study areas are tested separately over all years and for each year individually (all P values > 0.10). Annual reoccupation rates are presented in Figure 5. The pattern of little difference between treatment and controls is consistent across years with greater variation among years than between treatments and controls.

To assess the effect of treatment level (amount of nest area harvested) we also summarized the reoccupation rates separately for treatments areas that had >50% of the nest area stand removed, and which we had monitored for at least 2 years post-treatment. There are 8 areas where timber development has removed at least 50% of the nest area habitat, and which we have been able to monitor for at least 3 years post treatment. At all 8 of these nest areas goshawks have returned and successfully bred in at least one year since harvesting was conducted. Further, the total reoccupation rate for these nest areas is higher than for controls when compared annually or for the entire time period (2000-2004 treatments >50% removal = 57%, controls = 50%). It is worth noting, however, that at 2 of these areas birds have not been detected for the last 3 years. Also, 3 additional pairs have established new nest sites in more contiguous forest stands 300-1200m from the original nest area centres.

Table 3. Annual nest area occupation by goshawks at 48 nest areas in the Sub-Boreal Spruce BEC zone. Bold cells indicate post-treatment years.

Nest Area	Eventual Trial Status	Current Trial Status	Licensee	Years Occupied 1998	1999	2000	2001	2002	2003	2004	2005
AILPRT	Treatment	Control	BCTS			Y	Y	Y	Y	N	Y
ANDERS	Control	Control	BFP					Y	Y	N	N
AUGI26	Control	Control	BFP		Y	Y	Y	Y	Y	N	N
AUGI72	Treatment	Control	BFP							Y	Y
AUGILK	Treatment	Treatment	BFP						Y	Y	N
BALSAM	Treatment	Control	BCTS			Y	Y	Y	Y	Y	Y
BARTEA	Control	Control	BFP					Y	Y	N	N
BF137-1	Treatment	Treatment	BFP			Y	N	Y	N	Y	Y
BF155-1	Treatment	Treatment	BFP		Y	Y	Y	Y	Y	N	N
BF225-1	Treatment	Treatment	BFP	Y	N	N	N	N	N	N	N
BF254-1	Treatment	Control	BFP							?	N
BF316-1	Treatment	Treatment	BFP				N	N	N	N	N
BF437-3	Treatment	Treatment	BFP				Y	N	Y	N	N
BF517-2	Treatment	Control	BFP	Y	Y	Y	Y	Y	N	N	N
BRAUNW	Treatment	Treatment	Woodlot #1537		Y	Y	N	Y	Y	N	N
CANYON	Control	Control	Canfor		Y	Y	N	N	Y	N	N
CF186-2	Treatment	Treatment	Canfor	Y	Y	Y	N	Y	Y	Y	N
CF606-5	Treatment	Control	Canfor	Y	Y	Y	N	N	Y	N	N
COMFOR	Treatment	Control	Comm. Forest					Y	Y	Y	N
DAWSON	Control	Control	HFP							N	N
GREIDR	Control	Control	Private				Y	N	Y	Y	N
GRZZLY	Control	Control	BFP		Y	Y	Y	Y	Y	Y	Y
HF026	Treatment	Control	HFP							?	N
HF036-1	Treatment	Control	HFP			Y	N	Y	N	N	N
HF208-1	Treatment	Treatment	HFP	Y	Y	Y	Y	Y	Y	Y	N
HF562-2	Treatment	Treatment	HFP		Y	Y	N	N	N	N	N
HF563-4	Treatment	Control	HFP		Y	Y	N	Y	Y	N	N
HF582	Treatment	Treatment	HFP							Y	N
HF586-1	Treatment	Treatment	HFP		Y	Y	N	N	Y	Y	Y
HF614-1	Treatment	Treatment	HFP		Y	Y	N	N	N	N	N
HFNAD-20	Treatment	Control	HFP					Y	Y	Y	N
HOUSTN	Treatment	Treatment	Comm. Forest			Y	N	N	Y	N	N

Nest Area	Eventual Trial Status	Current Trial Status	Licensee	Years Occupied 1998	1999	2000	2001	2002	2003	2004	2005
HOWELL	Treatment	Treatment	Canfor			Y	N	Y	Y	Y	Y
KNAPP5	Treatment	Control	BCTS					Y	Y	Y	N
LINGLK	Control	Control	BFP				Y	Y	Y	N	N
MAXANL	Treatment	Treatment	Canfor	Y	Y	Y	N	N	Y	Y	N
MEADCR	Treatment	Treatment	PIR			Y	Y	Y	N	N	N
NORALE	Control	Control	Private?		Y	Y	N	N	Y	N	N
OCTOLK	Treatment	Treatment	Woodlot #118	Y	Y	Y	Y	Y	N	N	N
OLDCHS	Control	Control	Canfor			Y	N	N	N	Y	N
OOTCON	Control	Control	BCTS??					N	N	NS	N
OOTS21	Treatment	Treatment	BFP					Y	Y	N	N
QUICKR	Treatment	Treatment	??		Y	N	Y	Y	N	N	N
SPARK2	Control	Control	Canfor							Y	N
TALTLK	Control	Control	BFP		Y	Y	Y	Y	Y	N	N
TERCER	Treatment	Control	?						Y	NS	NS
THAU45	Control	Control	HFP	Y	UK	UK	UK	Y	Y	N	N
UNCHAL	Treatment	Control	BFP					Y	Y	N	N

Licensee : BCTS = BC Timber Sales; BFP = Babine Forest Products; HFP = Houston Forest Products; Canfor = Canadian Forest Products; PIR = Pacific Inland Resources; WDL = Woodlot;

*Occupied = Occupied into the incubation period. Y = yes, N = no, NS = not sampled, ? = inconclusive.

Shading = Years post-harvest

Table 4. Annual nest area occupation by goshawks at 39 nest areas the Interior-Cedar-Hemlock BEC zone. Bold cells indicate post-treatment years.

	Eventual	Current		Years Occupied										
Nest Area	Trial Status	Trial Status	Licensee	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
BAIL01	Control	Control	SCI								Y	N	Y	N
BAILEY	Control	Control	SCI		Y	Y	Y	Y	Y	N	Y	N	N	N
BIGCED	Treatment	Control	SCI T						Y	Y	Y	NS	NS	NS
BLACKS	Control	Control	SCI				Y	Y	Y	N	N	Y	Y	N
CANC01	Control	Control	SCI								Y	N	Y	N
CANC79	Treatment	Control	SCI						Y	Y	Y	NS	Y	N
CORR74	Treatment	Treatment	SCI					Y	Y	Y	Y	Y	Y	N
CRANB1	Treatment	Treatment	CGED			Y	Y	N	Y	N	N	NS	N	N
DATE10	Treatment	Control	BCTS					Y	Y	N	Y	Y	Y	N
DATE14	Control	Control	BCTS						Y	N	N	N	N	N
DATE23	Control	Control	BCTS						Y	N	N	N	N	N
DEEPCR	Treatment	Treatment	SCI T						Y	Y	N	NS	NS	NS
FOOTSO	Treatment	Control	SCI					Y	Y	N	N	NS	N	N
HELE21	Treatment	Control	BCTS			Y	Y	Y	Y	N	Y	Y	N	N
HELEN5	Treatment	Treatment	BCTS						UK	UK	Y	Y	Y	N
ILTZ14	Treatment	Control	BP					Y	Y	N	Y	NS	N	N
IRONSI	Control	Control	??	Y	Y	Y	Y	Y	N	N	N	Y	N	N
KIT229	Treatment	Treatment	KLC	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N
KULD14	Treatment	Treatment	SCI	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N
LAURAC	Treatment	Control	BP						Y	N	N	Y	N	Y
MAROON	Treatment	Treatment	SCI T					Y	N	UK	UK	NS	NS	NS
MESSIN	Treatment	Control	WDL140								Y	Y	Y	N
MESSIS	Treatment	Treatment	WDL140								Y	N	N	N
MIL243	Treatment	Treatment	KLC	Y	UK	Y	Y	Y	Y	N	Y	Y	N	N
MULDOE	Control	Control	BCTS			Y	Y	Y	Y	Y	Y	Y	N	N
NASNY9	Treatment	Control	BCTS						Y	N	N	NS	Y	N
NEWTON	Control	Control	BP					Y	N	N	N	NS	NS	NS
POPE	Control	Control	KFP			Y	Y	Y	N	Y	N	Y	Y	N
SHED17	Treatment	Treatment	SCI					Y	N	N	N	N	N	N
SHED20	Treatment	Treatment	SCI						Y	N	Y	Y	Y	N
SKEE83	Treatment	Treatment	SCI			Y	N	Y	Y	N	Y	NS	Y	N
SMOKE6	Treatment	Control	SCI					Y	N	N	N	NS	Y	NS

Nest Area	Eventual Trial Status	Current Trial Status	Licensee	Years Occupied 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
SUNDAY	Control	Control	BCTS			Y	N	N	N	N	N	N	N	N
SUNNEW	Treatment	Control	BCTS								Y	Y	Y	N
TEALAK	Treatment	Treatment	BCTS	Y	Y	Y	N	N	Y	N	Y	?	Y	N
TEN222	Treatment	Treatment	KLC	UK	Y	Y	N	N	N	N	N	NS	N	N
UCR198	Treatment	Control	BP					Y	Y	N	Y	NS	Y	N
WDL138	Treatment	Treatment	WDL138								Y	Y	Y	N
WEBER2	Control	Control	BP					Y	N	N	Y	NS	Y	N

Licensee : BP = Bell Pole; CGED –C'GED Forest Development; KLC = Kitwanga Lumber Company; SCI = Skeena Cellulose Inc.; SCI T = Skeena Cellulose Inc. Terrace; BCTS = BC Timber Sales; WDL = Woodlot

*Occupied = Occupied into the incubation period. Y = yes, N = no, NS = not sampled, ? = inconclusive.

Shading = Years post-harvest

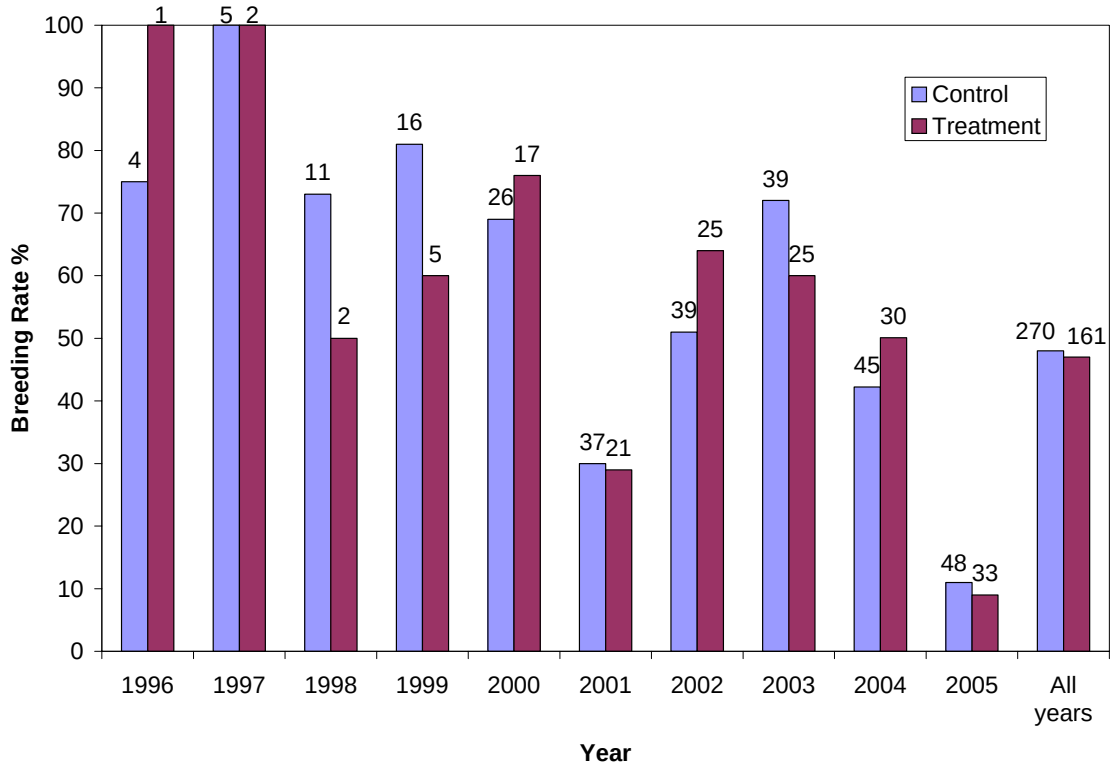


Figure 4. Reoccupation rates at goshawk nest areas for treatment and control areas by year (values above the bars = no. nest areas available for reoccupation)

Nest Productivity

Similar to reoccupation rates, the average number of chicks fledged over all years did not differ between treatments (1.58 ± 0.91 (SD) (n=76)) and controls (1.42 ± 0.94 (SD) (n=161)) (T=0.69, p=0.51). In 2005, nest productivity was very low with only 2 nests fledging young (1 in the Lakes and 1 in the Kispiox). The cause of the low breeding rates and high failures is not known but is most likely attributable to low prey supply.

Radio-Tagging Efforts

Six goshawks were successfully captured and tagged in the 2005 breeding season as part of the SFMN project: BF137-1 female, both the male and female at AUGI72, and the GUYISH female. In addition the radio tags on females captured at GREIDR, OLDCHS, GRZZLY and KNAPP5 in 2004 are still active. All birds except OLDCHS have been located approximately weekly during the non-breeding season September 2005 to March 2006. OLDCHS has not been located since early December indicating that the birds either moved out of the study area or the radio failed[4]. All tagged birds have maintained winter ranges approximately centred on their nest areas. Detailed analysis of home range size and location, habitat selection, and movements will be provided in a separate report to the IFPA.

Goshawk Sighting Investigations

Three potential goshawk sightings were reported in 2005, which led to the confirmation of 2 new goshawk nest areas. Details of the reported information and our survey results are provided in Table 5.

[4] In addition to ground tracking, an aerial telemetry flight was conducted in February 2006 which covered an area approximately 50km radius around the nest area.

Table 5. A summary of potential goshawk sightings reported to the project from the Nadina Forest Districts in 2005.

Location	Report Source	Background Information	Survey Findings
Guyishton Lake	Alistair Schoff, Burns Lake Community Forest	• Nest found by layout crew • Adult vocal and aggressive	• Confirmed active nest just outside of proposed block • No additional nests found • 1 of only 2 nests in Nadina FD to fledge young in 2005 • Female radiotagged and follow through winter
Mercury FSR	Alistair Schoff, Burns Lake Community Forest	• Probable observed goshawk flying in Pl stand below canopy • No other sign over subsequent several days in area	• No response to call playback in area • No other sign detected
BCTS A56521 Tom Allin Lake	Philip Mann, BCTS	• 3 nests located within proposed block	• not surveyed due to late time in season • nests almost certainly goshawk based on description

DISCUSSION

Interpretation of Results to Date

The results to date indicate that goshawks can tolerate some level of forest development within their nest area without decreased reproductive success. However, due to high annual variation and a potential lag effect exhibited by the goshawks, these preliminary results must be interpreted with caution. At least five years post-treatment monitoring is required to confidently determine the ultimate response of these trials (Patla 1997). This will be especially important to quantify thresholds in timber development that impact reproductive success. As of 2004, most of the treatment nest areas have been monitored for 4 breeding season post treatment, and we are now at the point where we expect delayed responses, if they exist, to be expressed. Monitoring over the next 1-3 years will reveal the ultimate response of the goshawks to these trials, and allow us to confidently develop management guidelines around goshawk nest areas that address goshawk requirements while minimizing impacts to timber development.

Comparison to Other Studies

As indicated in the introduction there is a substantial body of literature that attributes reductions in goshawk reproductive success and population levels to timber development (e.g. Crocker-Bedford 1990, Patla 1997; Widen 1997). While previous research generally indicates that territory condition at multiple scales may affect breeding success, the emphasis of most of the work has been at the nest area scale. Our results to date suggest that goshawks can be much more tolerant of forest harvesting in the nest area than suggested in previous literature. Although we have not monitored most nest areas for a long enough period to account for a lag effect, our monitoring period is comparable to the few existing published studies, and our sample size of treatment and control areas exceeds those of previously published studies. Our results are also consistent with more recent research by Penteriani and Faivre (2001) in Europe, where they found that goshawks tolerated up to 30% of selective harvesting within a nest stand without reducing reproductive productivity. They also reported that when goshawks abandoned a nest area, in response to timber harvesting levels >30%, they were able to re-establish a new nest area in adjacent suitable habitat without a decrease in reproductive success.

Assuming future monitoring in this study shows the same response as our results to date, this raises the question – at what territory scale does habitat condition most

directly affect territory occupation and reproductive success? Examining this issue is the focus of a new component of the Nadina project. Specifically we are examining how quantity and quality of habitat, at multiple scales, relates to long-term reproductive success of goshawks in the territories we have discovered. We have secured funding for a portion of this work through the national Sustainable Forest Management Network and Todd Mahon will be conducting this research as part of a PhD program at the University of Alberta.

Implementation of Management Trials

Implementation of proposed management trials have been limited in the past 3 years. In the ICH this has been predominantly due to low demand for hemlock and the closure of SCI, which has resulted in very little timber harvesting in the area. In the SBS harvesting priorities have been focused extensively on controlling the current mountain beetle epidemic. This has reduced the number of potential treatment areas available, however, the positive side of this is that it provides a stronger control sample. The current ratio of treatment areas to control areas is approximately 2:3, and the total number of current treatment areas should be adequate to meet the objectives of the study. At this point it is unlikely that monitoring of new treatment areas will be able to extend for the minimum 3-year post-treatment period. We therefore recommend that new prescriptions around goshawk nest areas not be developed in the context of this adaptive management program. Where timber harvesting is carried out at currently proposed treatment areas within the remaining duration of the project we will continue to monitor those areas, recognizing that the 3-year post-treatment monitoring period may not be met.

MANAGEMENT RECOMMENDATIONS

Detailed management guidelines, that fully incorporate the results of these adaptive management trials, will be provided upon completion of this project. Interim management guideline documents are now available for both the Kispiox TSA and Nadina Forest District. These management guidelines are based largely on the results of other aspects of the goshawk studies in both the Kispiox and Lakes/Morice, but do incorporate the interim results of the adaptive management trials. A synopsis of those guidelines for the Kispiox is presented below for reference. For more detailed information refer to the appropriate documents:

Kispiox – *Kispiox focal wildlife management guidelines – Northern Goshawk.* (Mahon 2003)

Nadina – *The Northern Goshawk in the Lakes and Morice Forest Districts – 5-year project summary*. (Mahon and Doyle 2003)

General Approach

Conservation measures recommended here are focused on the nest area/post-fledging area because: 1) those territory components are well described from local studies, 2) goshawks reoccupy nest areas for many years, and 3) disturbance to or removal of nest area habitat represent an obvious and direct impact to the reproductive success of individual territories. We define the management area around a goshawk nest area as a "**Goshawk Habitat Area**" (**GHA**) in this document. These guidelines are consistent with recommended revisions for goshawk Wildlife Habitat Areas under the Identified Wildlife Management Strategy prepared by the authors.

Foraging areas, or concentrated use areas within foraging areas, may be of equal or greater importance to maintaining individual goshawks or local populations, but our current level of knowledge is inadequate to accurately define the minimum/optimal habitat requirements at the foraging area scale. Further, all forested landscapes within the study areas are likely used by goshawks for foraging, and guidelines to address foraging habitat requirements are more appropriately managed through landscape-scale higher-level plans, than for individual territories.

Due to the secretive nature of goshawks at certain times of year it is probable that the majority of nest areas are at risk of being impacted by forest development activities without their being discovered. It is therefore important to protect a high proportion of nest areas that are identified. At the same time, it is not necessary to protect every nest area. Given the known population densities in the study areas, and the observed ability

of at least some goshawks to relocate their nest areas following disturbance, protection of all nest areas is not critical to maintaining viable goshawk populations. Under the current landscape condition we recommend that at least **75% of nest areas should be protected**. This number should provide the necessary flexibility to address resource conflicts/operational constraints with specific nest areas, while protecting the majority of nest areas that are found.

Where a no protection prescription is proposed the area must meet the basic condition of having at least two potential alternative nest areas available within 1 km of the original area. Potential alternate nest areas are areas at least 50 ha in size of high value nest area habitat as identified by the nest area suitability mapping, which is available for both study areas.

Detailed management recommendations are provided in the table on the following page.

Goshawk Habitat Area Guidelines

Objective:	Maintain nesting and post-fledging habitat at known goshawk nest areas to support continued use and reproduction at those areas.
Feature:	Establish GHAs for at least 75% of known goshawk **nest areas**. Over a period of several years it may be necessary to de-list or modify GHAs as stand characteristics change and goshawks abandon or relocate nests. If a nest area is not occupied for five consecutive years, it is probably safe to say the area has been abandoned or relocated and the GHA could be de-listed. Although it is important to protect as many nest areas as possible, flexibility can be afforded in some nest areas where other resource values or operational constraints supercede goshawk values. There are known cases where goshawks have relocated new nest areas and successfully bred after an original nest area is harvested. If the impacted birds are unsuccessful in relocating, then the impact to the overall population will be small, so long as few nest areas are impacted.
Size:	The GHA should be approximately **24 ha**. This area is large enough to include, and buffer, the distribution of alternative nests, roosts, plucking perches and juvenile PFA movements typically observed at nest areas in the Kispiox FD.
Design:	The shape and boundaries of the GHA should be ecologically based to maximize the value of the area in maintaining nest area occupancy and breeding success. The primary basis for that determination should be the location of alternative nests, plucking posts, roosts, and observations of adult and juvenile movements, **as assessed by a qualified biologist**. Where multiple nests occur the GHA should be located to provide at least a **100m forested buffer around each nest**. The GHA should maximize the amount of high quality nest area habitat included within it (Hw leading, age class ≥ 8, canopy closure class ≥ 5, open understory). In addition, the GHA should maintain connectivity to adjacent mature forest habitat (at least 30% of edge).
Mechanized Activity	No activity within 500m of active nest area February 15 – August 15
Human Activity	No activity within 200m of active nests February 15 – August 15

LITERATURE CITED

Banner, A., W. MacKenzie, S. Haeussler, S. Thompson, J. Pojar and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Ministry of Forests, Research Branch, Vistoria, B.C.

BC Ministry of Forests and BC Ministry of Environment. 1995. Biodiversity guidebook. Forest Practices Code of British Columbia. Victoria, BC.

BC Ministry of Environment, Lands and Parks and BC Ministry of Forests. 1999. Managing Identified Wildlife Strategy. Forest Practices Code of British Columbia. Victoria, BC.

Breier, P. and J.E. Drennan. 1997. Forest structure and prey abundance in foraging areas of northern goshawks. Ecol.Applications 7:564-571.

Bright-Smith, D.J. and R.W. Mannan. 1994. Habitat use by breeding male northern goshawks in Arizona. Stud. Avian Biol. 16:58-65.

Crocker-Bedford, D.C. 1990. Goshawk reproduction and forest management. Wildl.Soc.Bull. 18:262-269.

Doyle, F.I. and T. Mahon. 1998. Inventory of the northern goshawk in the Kispiox Forest District. "Annual Report 1997" B.C. Ministy of Environment, Lands and Parks. Smithers.

Doyle, F.I. and T. Mahon. 1999. Inventory of the northern goshawk in the Kispiox Forest District. "Annual Report 1998" B.C. Ministy of Environment, Lands and Parks. Smithers.

Doyle, F.I. and T. Mahon. 2000. Inventory of the northern goshawk in the Kispiox Forest District. "Annual Report 1999" B.C. Ministy of Environment, Lands and Parks. Smithers.

Godfrey, W.E. 1986. The birds of Canada. National Museums of Canada.

Hayward, G.D. and R.E. Escano. 1989. Goshawk nest-site characteristics in western Montana and Northern Idaho. Condor 91:476-479.

Kennedy, P.L. 1990. Home ranges of northern goshawks in north central New Mexico. Abstract. In P.R. Klausman, and N.S. Smith. Editors. Managing wildlife in the southwest. Arizona Chapter of the Wildlife Society.

Kennedy, P.L. and D.W. Stahlecker. 1993. Responsiveness of nesting northern goshawks to taped broadcasts of 3 conspecific calls. J. Wildl. Manage. 57:249-257.

Kenward, R.E. and V. Marcstrom. 1983. The price of success in goshawk trapping. J.Raptor Research 17(3): 84-91.

Kostrzewa, A. and R. Kostrzewa. 1990. Relationship of spring and summer weather with density and breeding performance of the Buzzard (*Buteo buteo*), Goshawk (*Accipiter gentilis*) and Kestrel (*Falco tinnunculus*). Ibis 132:550-559.

Mahon, T. 2003. Kispiox focal wildlife management guidelines – Northern Goshawk. Unpubl. rep. for Skeena Cellulose Inc. Hazelton, BC. and BC Min. of Forests, Skeena-Stikine Forest District, Smithers, BC.

Mahon, T. and F. Doyle. 2000a. An assessment of northern goshawk nest site choice and reproductive success in proximity to forest harvesting: an adaptive management strategy. Unpubl. rep. for BC Min. of Environment, Smithers, BC.

Mahon, T., and F.I. Doyle. 2000b. Inventory of the northern goshawk in the Lakes Forest District. 1999 Annual Report. Unpubl. rep. for Babine Forest Products Ltd., Burns Lakes, BC and Houston Forest Products Ltd., Houston, BC.

Mahon, T., and F.I. Doyle. 2001. Inventory of the northern goshawk in the Lakes Forest District. 2000 Annual Report. Unpubl. rep. for Babine Forest Products Ltd., Burns Lakes, BC and Houston Forest Products Ltd., Houston, BC.

Mahon, T. and F. Doyle. 2003. The Northern Goshawk in the Lakes and Morice Forest Districts – 5-year project summary. Unpubl. rep. for Babine Forest Products Ltd., Burns Lakes, BC and Houston Forest Products Ltd., Houston, BC.

Mahon, T. and F. Doyle. 2005. Effect of timber harvesting near nest sites on the reproductive success of northern goshawks. J. Raptor Res. 39(3):335-341.

McCarthy, C., W.D. Carrier, W.F. Laudenslayer. 1989. Coordinating timber management activities with raptor nesting habitat requirements. Pages 229-235 *in* Proceedings of the western raptor management symposium and workshop. National Wildlife Federation, Washington, D.C.

Patla, S.M. 1997. Nesting ecology and habitat of the northern goshawk in undisturbed and timber harvest areas on the Targhee National Forest, greater Yellowstone ecosystem. M.Sc. Thesis. Idaho State University. Boise, Idaho. 1-164 p.

Paton, P. W. C. 1994. The effect of edge on avian nest success: how strong is the evidence? Conserv. Biol. 8: 17-26.

Penteriani, V. and B. Faivre 2001. Effects of harvesting timber stands on goshawk nesting in two European areas. Biological Conservation 101:211-216.

Reynolds, R.T., R.T. Graham, M.H. Reiser, R.L. Basset, P.L. Kennedy, D.A. Boyce Jr., G. Goodwin, R. Smith, & E.L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service Gen. Tech. Rep. RM-217.

Reynolds, R.T., E.C. Meslow and H.M. Wight. 1982. Nesting habitat of coexisting Acciptiter in Oregon. J. Wildl. Manage. 46(1): 124-138.

Reynolds, R.T. 1983. Management of western coniferous forest habitat for nesting accipiter hawks. General Technical Report RM-102. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Speiser, R.T. 1992. Notes on the natural history of the northern goshawk. Kingbird 42:133-137.

Speiser, R.T. and T. Bosakowski. 1987. Nest site selection by the Northern Goshawk in New Jersey and southeastern New York. Condor 89:387-394.

Squires, J.R. and R.T. Reynolds. 1997. Northern Goshawk. *In*: A. Poole and F. Gill (eds.). The birds of North America. No 298. Academy of Natural Sciences and The American Ornithologists Union, Washington, DC.

Taylor, B. 1996. An Introductory Guide to Adaptive Management for Project Leaders and Participants (Working Draft #2). BC Ministry of Forests, Forest Practices Branch, Victoria, BC. http://www.for.gov.bc.ca/hfp/amhome/introgd/toc.htm (March 20, 2000).

Toyne, E.P. 1997. Nesting chronology of northern goshawks (accipiter gentilis) in Wales: implications for forest management. Forestry. 70 (2): 121-127.

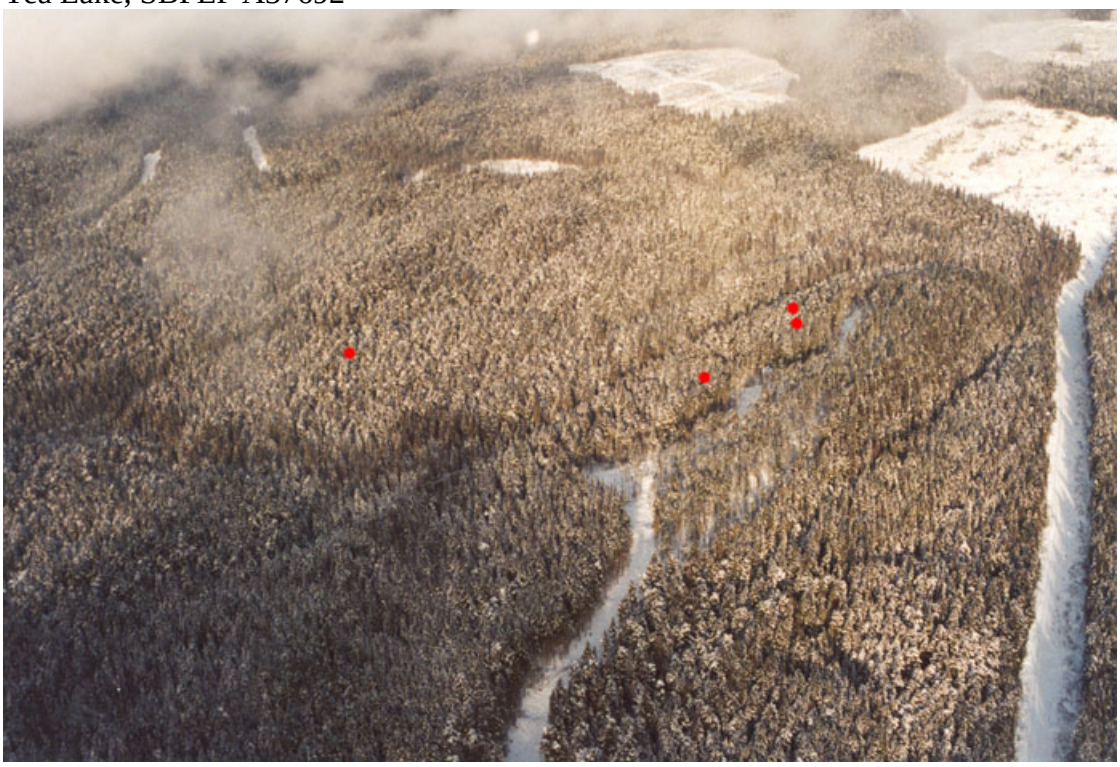
Widen, P. 1997. How and why, is the goshawk (*Accipiter gentilis*) affected by modern forest management in Fennoscandia? Journal of Raptor Research. 31(2):107-113.

Woodbridge, B. and P.J. Deitrich. 1994. Territory occupancy and habitat patch size of northern goshawks in the southern Cascades of California. Stud. Avian Biol. 16:83-87.

APPENDICES

Appendix 1. Oblique aerial photos of select management trials at known goshawk nest areas. The red dots on the photos show the location of nest sites.

Tea Lake, SBFEP A37692



Breeding 3 of 4 years pre-harvest, 3 of 6 years post-harvest.

Kitsuns, Kitwanga Lumber 229-1

Breeding 4 of 5 years pre-harvest, 4 of 5 years post-harvest.

Skeena-Carrigan SCI 704-83

Breeding 2 of 3 years pre-harvest, 2 of 3 years post-harvest.

Ten Link, Kitwanga Lumber 222-1

Breeding unknown pre-harvest (although 2 nests are older than 2 recent cutblocks), breeding 2 years immediately post-harvest but not in subsequent 7 years.