Movements of the Northern Goshawk (*Accipiter gentiles atricapillus*) In A Fragmented Forest Landscape

Preliminary Results from the
East Kootenay Northern Goshawk Research Program

2004/2005 Annual Report

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2.0 Abstract:

In southeastern British Columbia, the northern goshawk (*Accipiter gentiles atricapillus*) is under consideration as one of a suite of focal species that will be used to guide forest management. Despite the interest in this animal, specific information on its critical resource requirements is lacking. This project was designed to fill this knowledge gap. Specifically, we are: (1) determining the survival of goshawks during the post-fledgling period; (2) documenting how current forest practices around goshawk nest areas influence the post-fledging movements of fledgling birds; (3) examining how the movements of adult goshawks, during the breeding and rearing season, influence the movements of fledgling birds within the post-fledging area; and (4) documenting the extent of adult goshawk winter movements and nest area fidelity. During the spring of 2004, we captured and radio-tagged 27 goshawks (15 juvenile and 12 adults) at 10 nest sites in the East Kootenay region of southeastern British Columbia. Due to the mortality of 4 juvenile goshawks, we were successful documenting the breeding and rearing season movements of adult and fledgling goshawks at 6 nest sites. Fledgling goshawks remained close to the nest. During the first 25 days of the post-fledging period fledglings, 98% of locations were within 300 m of the nest. After 25 days post-fledging, 96% of locations obtained within 500m of the nest site. The average home range of fledglings was estimated to be 20.2ha (±17.5 SD, n=11). Adult female goshawks range on average 991 m (±423 SD, n=96) from the nest during this period and we estimated their home range size to be 3036.6 ha (±2577.9 SD, n=6). In contrast, adult males remained closer to nest sites, with an average home range of 1707.0 ha (±713.7 SD, n=2). Winter movements suggest that the majority of adult female goshawks from the East Kootenays remain within our study area during the winter months and move on average only 6.4 km (±6.0 SD, n=34) from their previous years nest area. Both adult males moved out of the study area. These preliminary results will help us to develop effective hypotheses regarding the factors influencing the movements of goshawks within the East Kootenay region and allow us to guide future investigations. This information will be used to develop effective management plans for this species.

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6.0 Introduction:

6.1 Ecological and Applied Context:

The northern goshawk (*Accipiter gentiles atricapillus*) is a strong candidate for selection as an indicator of ecological forest management in southeastern British Columbia (i.e., forest management that incorporates the protection of biodiversity and maintenance of ecological function into forest harvest plans). A major reason for this consideration is that this animal is closely associated with old and mature forests (McGrath *et al.* 2003; Patla 1997; Reynolds *et al*. 1992; Crocker-Bedford 1990). This situation somewhat parallels the case of the northern spotted owl in coastal forests. However, unlike spotted owls, goshawks are not restricted to coastal forests and as such may pose a greater management concern over a much greater geographic area (McGrath *et al.* 2003; DeStefano 1998). Further, the goshawk is a wide-ranging forest raptor, hunting under the forest canopy for mid-sized prey such as hare, grouse, and squirrels (Squires and Reynolds 1997). The goshawk also requires suitable, large trees in which to perch and nest. Therefore, the presence of goshawks is thought to suggest suitable 'mature' forest structure as well as abundant prey species (Reynolds *et al*. 1992). These and other general habitat requirements are reasonably well known; however, precise data are lacking on certain critical stages in the goshawk's life history.

Although we lack information on the exact patterns and causes of dispersal and reproduction for most organisms, this shortcoming is especially critical when dealing with species, such as the northern goshawk, that are under consideration as indicator or focal species guiding ecosystem management (Roberge and Angelstam 2004). To effectively use of this species as an indicator of ecological forest management, we need to understand how critical life-history stages, such as behaviour and survival in and around the post-fledging area, are impacted by disturbances such as logging. We must also document the foraging areas and winter movements of adult goshawks, within specific regional populations, in an attempt to identify critical areas in specific life-history stages. Without these data, the management actions required to maintain goshawks on the landscape cannot be completely defined. This research project will fill this knowledge gap, and in doing so, will allow the forest industry to move forward with a pro-active sustainable forest management plans.

In the United States, a comprehensive goshawk management strategy was developed for southwestern forests by the United States Forest Service (Reynolds *et al*. 1992). These recommendations require maintaining various percentages of six, forest structural stages surrounding identified nests. This management plan focuses on not only protecting structural forest characteristics required by goshawks, but also suggests management for productive prey populations (Reynolds *et al*. 1992). In British Columbia, goshawk management to date has consisted primarily of placing a no-harvest zone immediately around nest trees and reducing harvest in a 240 ha area surrounding the nest (BC MELP 1999). However, new provincial guidelines (McClaren 2004) have reduced protections for the interior subspecies of goshawk (*Accipiter gentilis atricapillus*). Current management procedures provide specific management proceedures for the coastal subspecies of goshawk (*Accipiter gentilis laingi*), but only protect specific nest trees for the interior subspecies (McClaren 2004). This change in management strategy reflects the perceived stability of goshawk populations within interior forests.

As mentioned, the specific area(s) and feature(s) selected by juvenile goshawks during the post-fledging period and the resources selected by adult goshawks during nest site selection remain unclear; much less the degree to which forest harvest may occur around nest trees without impacting goshawks. Recent suggestions have been made that management planning on two scales (30 ha and 170 ha) surrounding identified nest areas may be needed to protect goshawks during the post-fledging life-stage (McGrath *et al.* 2003). These scales may also be important in adult nest site selection prior to breeding. At larger scales, partial cutting may in fact benefit long-term goshawk persistence by maintaining heterogeneous environments in dynamic forest ecosystems (McGrath *et al.* 2003; Graham *et al.* 1994). These suggestions need to be addressed by further research. In British Columbia, the guidelines for the coastal goshawk suggest the establishment of a 200 ha Wildlife Habitat Areas (WHAs) surrounding active nest sites. Within these areas foresters are directed to restrict road building, harvest, and thinning. Management recommendations are also made that allow commercial harvest and thinning within a 2200 ha management area surrounding nest sites as long as forestry activities promote forest structural characteristics essential for goshawk foraging. Recommendations are also made for landscape level planning. The identified wildlife guidelines suggest: maintenance of late structural stages across the landscape; ensure that these patches exist in a variety of sizes; ensure breeding habitat every 6-8 km; maximize connectivity between suitable nesting, post-fledging, and foraging habitat; and maintain suitable foraging habitats within 2200 ha surrounding the post-fledging area (McClaren 2004).

Although these recommendations only concern the coastal goshawk, they are currently the only management recommendations available to forest managers throughout the province. Additionally, these recommendations suffer from an inherent lack of information. Specifically:

(1) The exact nature of the post-fledging area and the thresholds of forest harvest that will impact this area have not yet been determined. Although harvest in the adult foraging areas, that surround the post-fledging area, may benefit goshawks (McGrath *et al.* 2003; Graham *et al.* 1994) harvest within the post-fledging areas presumably negatively impacts juvenile birds (Crocker and Bedford 1990). Harvest may impact the post-fledging area in two ways: it may result in abandonment of the areas by adult pairs prior to breeding; or it may result in increased mortality of juvenile goshawks during the post-fledging period (predation or starvation) due to substantial reductions in the amount of forest surrounding the nest site. To determine the type of logging that will impact the post-fledging area we must first define how juvenile goshawks utilize various configurations of the post-fledging area and combine this with long term monitoring of nest area utilization. Mahon and Doyle (2003a) suggest that goshawks may be tolerant of a selective harvest of up to 30% of the nest stand. However, they also suggest that the configuration of the post-fledging area may be offset from the nest. Therefore, the size and configuration of the post-fledging areas used by juvenile birds may be impacted by the location of adult foraging areas and the direction from which food deliveries to the nest are made (Kenward *et al.* 1993b). Describing the impact of the interaction between forest structure and goshawk behaviour on the post-fledging area may help managers determine the specific requirements of fledgling goshawks.
(2) The nature and extent of adult foraging areas during the breeding season has not been described for southern interior forests. Although coastal goshawks hunt close to nest areas and hunt primarily under forest canopy, interior goshawks may use areas with significant

amounts of the canopy cover removed (McGrath *et al.* 2003; Graham *et al.* 1994). Foraging areas may encompass areas of both mature forest and areas of partial cuts (or the edges between them). Therefore, without specific information regarding foraging areas during the breeding season we cannot define harvest prescriptions for their maintenance or the maintenance of connectivity between foraging areas, the nest, and post-fledging areas. This includes the type and distribution of landscape features surrounding the post-fledging area. Landscape level management recommendations cannot be established without some understanding of the distribution of foraging areas and the type of management prescriptions goshawks will tolerate.

(3) To date, descriptions of the winter movements of goshawks have been sporadic. Goshawks may migrate (Hoffman *et al.* 2002), make large movements away from summer foraging areas (Squires and Ruggiero 1995; Doyle and Smith 1994), or may remain within breeding home ranges (Drennan and Beier 2003). Within southern interior forests winter movements are completely unknown. Winter may be a crucial time in the life cycle of adult birds. If goshawks remain in breeding home ranges, management recommendations must also reflect winter resource requirements.

6.2 Industrial Context:

The forest industry in British Columbia is under increasing pressure to harvest wood in a sustainable fashion. Market forces requiring forest certification and new provincial and federal regulations, geared towards the protection of biodiversity, have increased pressure on forest companies. Further, the growing number of threatened or endangered species means foresters are confronted with the overwhelming task of ensuring sustainable populations for a large number of species. The use of ‘indicator species’ has been widely touted as one means to simplify the management of multiple species and habitats on the landscape (e.g., Lambeck 1997; Simberloff 1998). In theory, maintaining viable populations of an indicator species ensures that the resource requirements for a large number of other species are met, thus alleviating the need to monitor and plan for a whole host of species. Further, management of the forest for the protection or persistence of a host of focal species, each representative of a specific suit of forest values, will provide a simplified framework that encompasses many more forest values that just those protected by managing for a single indicator species (Roberge and Angelstam 2004). Tembec Inc. has developed a management plan geared at meeting their objective of obtaining forest certification and managing forests in a sustainable fashion. This research is a component of that plan and will feed information directly into Tembec’s Criteria and Indicators Framework for Sustainable Forest Management. This framework defines key management objectives and identifies specific indicators that will be monitored in order to determine Tembec’s performance in meeting management objectives. This information will be used to guide adaptive management plans (e.g., Walters 1986) to protect biodiversity, and maintain ecological integrity on public forest lands.

6.3 Objectives:

Our specific objectives for this 3-year project are as follows:

Objective 1: To determine the survival of fledgling goshawks between fledging and dispersal.

Objective 2: To describe the movements of fledgling goshawks within the area surrounding the active nest site in order to determine the nature and extent of the post-fledging area.

Objective 3: To examine how the movements of fledgling goshawks within the area surrounding the nest site are impacted by forest structure, fragmentation, and movements of adult birds.

Objective 4: To determine the nature and distribution of adult goshawk foraging areas surrounding identified nest sites and describe how the distribution of foraging areas impacts fledgling bird movements (this is directly related to Objective 3).

Objective 5: To document the winter movements of adult goshawks through coarse-scale monitoring. Specifically, we will determine the extent of winter migratory movements of adult goshawks within the East Kootenays.

Objective 6: To determine the extent of nest site fidelity of breeding goshawks within the East Kootenays through an examination of a sample of adult pairs.

This report summarizes the findings of the first year of a three year study of goshawk movements, behaviour, and resource use within the East Kootenay region of British Columbia. This project is a collaboration among Tembec Inc., Thompson Rivers University, and the University of Victoria, and will supplement existing Tembec survey and nest monitoring work with detail information on specific life-history stages. The project is funded by the BC Ministry of Forests, Forest Science Program (FSP), the National Centers for Excellence, Sustainable Forest Management Network (NCE-SFM), the National Science and Engineering Council (NSERC), and Tembec Inc. Our goal in this report is to outline preliminary findings and directions for research in years two and three of this project. As this is only the first year of a three year project, we have not fully completed data collection or analysis. For example, due to the logistical constraints of obtaining and interpreting new Vegetation Resource Inventory (VRI) data for the East Kootenay region, we were unable to complete the resource use analysis. However, we are currently working the Tembec's GIS staff to reconcile these difficulties and complete this analysis for presentation in year two of this project. However, we do have preliminary results on the natural history and movements of goshawks within our region and can now make informed decisions that will guide future efforts.

7.0 Study Area:

Our study is focused on the northern goshawk populations within the Kootenay and Columbia River drainages in southeastern British Columbia. Our study lies primarily within the Rocky Mountain Forest District; an area of approximately 2.6 million hectares (Figure 1). This a diverse area of the province with large grassland/wetland river valleys (i.e., Southern Rocky Mountain Trench Ecoregion) extending though a mid-elevation forest belt to high alpine tundra and un-vegetated areas (i.e., Columbia Mountains and Highlands and Southern Rocky Mountains

Ecoregions). The climate is characterized by warm, dry summers and cold winters. Dry valley bottoms occur primarily due to the rain shadow effects of the Columbia Mountains on the western boarder of the region; however, with increasing elevation, precipitation increases significantly and forest and alpine ecosystems become more prominent.

Goshawks occur primarily within forested areas and we therefore restrict our investigations to these areas. Forested areas lie primarily between 800 and 2100 meters in elevation and can be classified into Ponderosa Pine (PP), Interior Douglas-fir (IDF), Interior Cedar-Hemlock (ICH), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF) biogeoclimatic zones (Meidinger and Pojar 1991). Forests are dominated by interior Douglas-fir (*Pseudotsuga menziesii*), hybrid white spruce (*Picea glauca x engelmannii*), and western larch (*Larix occidentalis*) and western red cedar (*Thuja plicata*). Engelmann spruce (*Picea engelmannii*) and sub-alpine fir (*Abies lasiocarpa*) occur at higher elevations. Extensive early seral stands of lodgepole pine (*Pinus contorta*) are common due to widespread fires, and trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) are also common. Ponderosa pine (*Pinus ponderosa*), occurs primarily at low elevations along the grassland forest interface. Our study is restricted primarily to IDF, ICH, and MS biogeoclimatic zones.

Anthropogenic disturbance of forest lands consists primarily of logging, fire suppression, and cattle grazing, with greater than 1.6 million cubic meters of wood harvested each year (BC Ministry of Forests; http://www.for.gov.bc.ca/drm/DistrictMap/about.htm). Substantial amounts of coal mining also occur locally within the Elk Valley. The tourism industry is increasing yearly, adding substantial development to valley bottoms. However, logging and fire suppression are still the main impact to goshawk populations.

8.0 Methods:

8.1 Nest Area Selection:

We investigated and selected nests in conjunction with Tembec's, Northern Goshawk Nest Area Monitoring Project (Stuart-Smith and Bachman 2004). Tembec has identified 75 nests at 30 actively used sites since 1998, and we coordinate our nest checking, monitoring, and nest area selection activities with Tembec's project each spring. In 2004, Tembec identified 17 active nests in the Rocky Mountain Forest District (Figure 1), and we selected a subset of these sites at which to mark and follow goshawks. We selected nests based on a series of criteria. We selected nests with a range of disturbance by logging treatments (20% - 90% old or mature forest within an 800m radius of the nest). We used the 800 m radius from the nest site because this was the largest linear extent that juvenile birds were expected to fly from the nest tree during the post-fledging period (Kennedy *et al.* 1994). We restricted the nests that we sample to a number of biogeoclimatic zones. We only selected nests to sample within Interior Douglas Fir (IDF), Montane Spruce (MS), and Interior Cedar Hemlock (ICH) zones in order to reduce variability in forest structure due to elevational changes in ecosystem type. We also selected nests based on the distribution of nests within the study area in order to reduce travel time between nests and increase the number of nests we were able to sample.

8.2 Live Trapping and Tagging:

We monitored active nest sites during late May and early June in order to determine the exact number and ages of nestlings at selected sites. We attempted to capture and tag goshawk

nestlings when they were between 20 and 30 days old. We aged nestlings using visual observation of feather development following Boal (1994). When appropriate capture dates were determined, we entered nest areas and attempted to capture both adult goshawks and all juvenile siblings at a site. We attempted to capture both adults in order to determine breeding and winter season movements of adult birds, and to determine if the specific movements of adult influence juvenile goshawk movements. We marked all siblings at a nest in order to determine annual nest area production (number of nestlings produced, corrected for post-fledging mortality), and to determine if large differences exist between the movements of siblings.

Before climbing trees to obtain juvenile goshawks, we attempted to capture the adults. We captured adult goshawks using a modified Dho-gaza trap lured with a live, permanently-injured, non-releasable, great-horned owl (*Bubo virginianus*). Adult birds were measured (weight, tarsus width, wing cord, talon length, beak length, moult status, etc.), radio-tagged, and samples taken for DNA analysis and West Nile virus monitoring. Adult birds were outfitted with backpack style, VHF radio transmitters (18g, Biotrack Limited, Dorset UK, Model# TW51 with mortality switches). Backpack straps were built from ¼" Teflon webbing. These transmitters were designed to provide 1.5-years (male) to 2.5-years (female) of monitoring. Upon completion of the study, each adult will be recaptured to remove transmitters. Following the capture of adult birds, we climbed nest trees in order to obtain nestlings. Nestlings were processed in a similar manner to adult birds; however, they were outfitted with 8.5g, tarsal mount, VHF radio transmitters (Advanced Telemetry Systems, Isanti MN USA, Model# A5040 with mortality switches) and returned to the nest. These transmitters were attached so that the transmitter would fall away from the tarsus after approximately six months. All birds were banded with United States Fish and Wildlife (USFW) and colour auxiliary bands (Acraft Sign and Name Plate Company, Edmonton AB, Canada) to facilitate the remote determination of the sex of birds we observed during field activities and the return of birds that left the study area. We determined the sex of birds we handled using tarsal width measurements, following Kenward *et al.* (1993a).

8.3 Monitoring:

We began monitoring both juvenile and adult birds immediately following capture. We determined the exact fledging date (the first day that juveniles were located away from the nest tree), juvenile movements within the nest stand, and dispersal date (the movement of juvenile bird greater than 1.5 km from the nest tree for two consecutive days). We feel that this definition of dispersal provided us with an effective measure of dispersal timing as birds were rarely if ever located back at the nest site following movements of greater than 1.5 km from the nest. We located fledgling goshawks daily, using walk-in visual locations. A single crew member would attempt to approach fledglings using radio-telemetry equipment without influencing the birds' movements. All locations were made with a handheld, 3-element Yagi antenna. Once located locations were obtained by averaging >100 successive locations from a handheld Global Positioning System (GPS) unit (Garmin International, Olathe KS USA, Model #GPS72 or GPS76). Averaging was used to minimize the error associated with GPS locations, and each location was averaged in order to obtain an estimated accuracy of <10m. Following dispersal from the nest area we attempted to located juvenile animals by ground telemetry. This was highly unsuccessful. Therefore, we attempted aerial telemetry locations in conjunction with aerial telemetry locations for the seasonal movements of adult birds (see below). However, due to the extensive dispersal movements of juvenile birds (Weins 2004), operating times of tarsal

mount transmitters, and the limited resources for aerial flights, no information was collected on the natal dispersal movements of juvenile birds.

Adult goshawks were located opportunistically during the summer with a minimum of one location per week obtained on each bird. However, at nest sites where we tagged juvenile birds, this number of locations was often exceeded. Adult birds were located using triangulation techniques as birds were generally too mobile to locate with walk-in locations. We attempted triangulation locations in order to achieve a minimum of five bearings on the bird with a minimum 90-degree angle between the two outside bearings. Bearings were plotted daily on 1:20 000 topographic and forest cover maps to estimate the location of birds within specific stands. Preliminary analysis (this paper) will use these estimated locations only; however, later analysis will use locations calculated from triangulations. We corrected observers for telemetry error using triangulation on transmitters placed at predetermined locations.

Adult birds were also located using aerial telemetry during winter months (October through March). Locations were attempted monthly in an effort to document the broad-scale seasonal movements of adult birds. A Cessna 182 airplane was used to search for the radio transmitter signals and to locate each goshawk. We used a scanning telemetry receiver (Communications Specialists Incorporated, Orange CA USA, Model #R-1000) set to a 2-second scan interval to pick up radio signals from transmitters. Our standard search path covered the Rocky Mountain Trench and associated side drainages from approximately Fairmont Hot Springs Resort south to the United States-Canada border. We also searched the southeast corner of the Rocky Mountain Forest District, east to the Alberta-British Columbia border; including the Elk Valley and Flat Head regions of southeastern British Columbia. This search area encompassed the majority of the southern half of the Rocky Mountain Forest District and covered a large area surrounding the nests of marked goshawks. We are confident we located each bird that did not make significant movements away from the study area.

We attempted a preliminary investigation of the effectiveness of intensive telemetry locations on juvenile and adult birds. The purpose of this exercise was to: (1) determine if we were able to document hourly movements of juvenile birds without substantially impacting their movements; (2) define the operational requirements of obtaining hourly locations on adult and juvenile goshawks at a single site; (3) assess whether we were adequately documenting the distribution of juvenile movements with daily locations; and (4) to obtain preliminary data on the movements of juvenile birds in relation to adults during food delivery events. We located juvenile birds hourly during all daylight hours. We also determined the directional location and direction of food delivery event by adult birds during these days.

8.4 Movement Analysis:

We documented the extent of juvenile and adult movements away from the nest tree during the post-fledging period. Additionally, we performed a fixed kernel analysis with least squares cross validation (Hooge and Eichenlaub 1997) of juvenile goshawk locations during the post-fledging period (fledging to dispersal) and assessed the breeding season movements of adult birds using mean convex polygons (Hooge and Eichenlaub 1997). We obtained enough locations of juvenile birds in order to adequately document their range using fixed kernel analysis. We did not obtain enough locations on adult birds, nor do we feel the accuracy of these locations (using preliminary

analysis techniques) is sufficient to use kernel methods. Therefore, we only present the results of mean convex polygon analysis here.

9.0 Results:

9.1 Capture and Mortality:

During the 2004, we were successful in capturing and radio-tagging 27 goshawks at 10 nest sites (Figure 1). We captured 15 juvenile goshawks (8 female and 7 male) at eight individual nest sites (Table 1). We were only unsuccessful in capturing all siblings at a nest site on one occasion. At each of these eight sites and two more (10 total) we captured the adult female goshawk. We attempted capture of nestling birds at these two sites; however, the nestlings were too mobile to be removed from the nest safely. We radio-tagged the two additional adult females in order to obtain information on nest site re-occupancy, winter movements, and survival; however, these birds were not monitored as intensively as adults at nests where fledglings were marked during the summer season. At two of the sites in which we had both adult female and juveniles tagged we were successful in capturing the adult male goshawk. Fledgling birds were monitored intensively from the middle of June until late August and we were successful in obtaining 460 locations on these 15 fledglings (Table 1). We were successful in obtaining 164 locations on adult goshawks (Table 1).

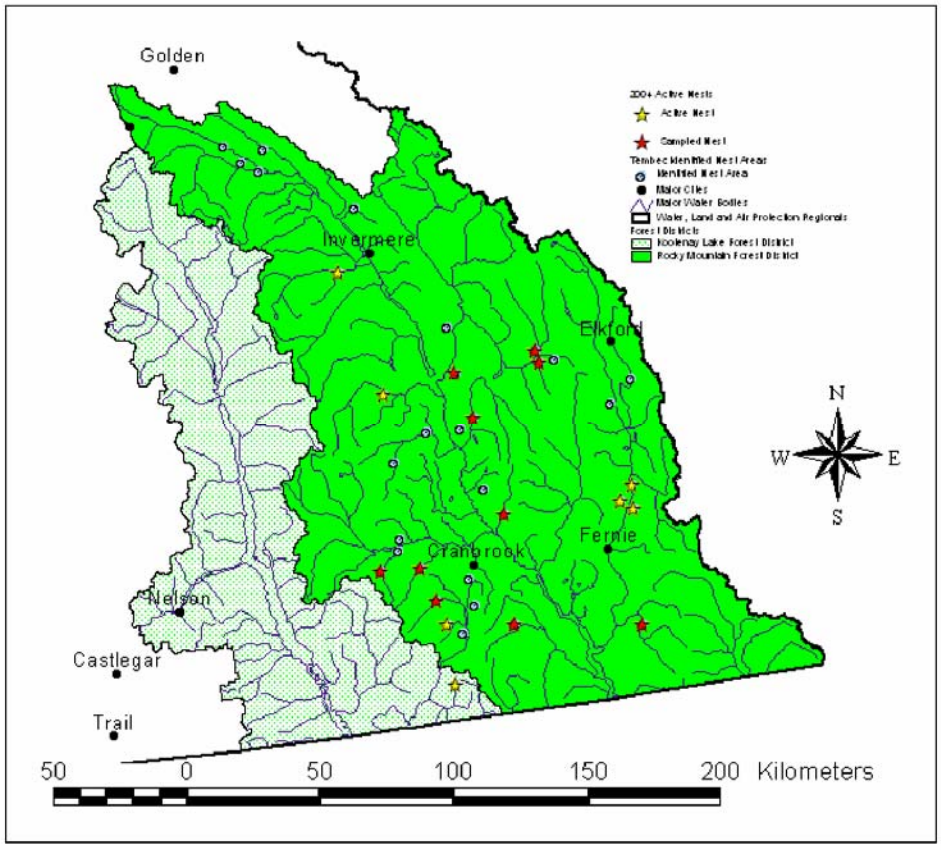

Figure 1: Distribution of nest areas and location of the study area of East Kootenay Goshawk Project. Nest areas are indicated as: historic sites (circles), active in 2004 (light stars), and sample sites in which birds were radio-tagged (dark stars).

We observed four juvenile mortalities and the death of one adult female. The death of each juvenile occurred within days of the fledging period and the adult female mortality occurred in early winter. When recoverable, the remains of each animal were examined by a wildlife veterinarian in order to determine the cause of death. One juvenile goshawk was predated from the nest by a mammalian predator, one juvenile goshawk starved to death, and two juveniles were presumably killed an avian predator. The adult female goshawk starved to death. These mortalities left us with six active nest sites at which we had all fledglings and the adult female radio-tagged. Additionally, at two of the sites we also had the adult male goshawk radio-tagged.

Table 1: Summary of capture, mortality, and location results for the radio-tagging of northern goshawks at 10 nest sites during the 2004 summer season.

Nest Area #	Juveniles Captured (# hatched)	Adults Captured	Mortalities (cause of death)	Juvenile Locations (summer)	Adult Locations (summer)
NA-01	2 (2)	female and male	one juvenile (predation)	46	39
NA-02	1 (1)	female and male	none	47	46
NA-03	2 (2)	female only	none	97	11
NA-04	3 (3)	female only	none	112	16
NA-05	1 (3)*	female only	one juvenile (predation) adult female (starvation)	3	6
NA-06	3 (3)	female only	one juvenile	75	13
NA-07	1 (1)	female only	one juvenile(predation)	2	6
NA-08	2 (2)	female only	none	78	17
NA-09	0 (2)**	female only	none	n/a	4
NA-10	0 (2)**	female only	none	n/a	6
Totals	**15**	**10 Females and 2 Males**	**4 juveniles and 1 adult female**	**460**	**164**

* this was the only nest site where we were unable to mark all nestlings
**nestlings were too mature and mobile in order to handle safely

We estimated the hatching date of juveniles from sampled nests by counting back from the estimated ages of nestlings. The average hatching date was May 25th with the earliest hatching on the May 21st and the latest on May 29th (Table 2). Between 1 and 3 chicks were hatched at each nest. On average, nestlings remained in the nest for 41 days (36 to 45 days) providing an average fledging date of July 7th. Surviving fledglings left the nest area when they were between 72 and 87 days old (mean = 80 days). The average date of dispersal was the August 13th. From these dates we calculated the average length of the post-fledging period to be 39 days (33 to 48 days).

Table 2: Summary of hatching dates of northern goshawk nestlings from sampled nests. The number of days as nestlings (Hatch-Fledge), the age at dispersal (Hatch-Dispersal) and number of days as fledglings (Fledge-Dispersal) are indicated along with mean, maximum, and minimum dates.

NOGH ID	Hatching Date	Hatch-Fledge (days)	Hatch-Dispersal (days)	Fledge-Dispersal (days)
Mean	25/05/2004	41	80	39
Minimum	21/05/2004	36	72	33
Maximum	29/05/2004	45	87	48
St. Dev.	n/a	2.62	5.08	5.32

9.2 Movements and Home Range:

Fledgling goshawks were almost always recorded within 300 m of the nest and only 1% of locations were greater than 500 m from the nest (Figure 2). No movements over 1000 m were observed prior to dispersal from the nest area (defined as locations greater than 1.5 km from the nest for 2 consecutive days). Kenward *et al.* (1993a) describe the hardening of fledgling goshawk flight feathers at approximately 25 days post-fledging and suggest that birds may be capable of dispersal at this time. We found that during the first 25 days post-fledging only 2% of locations were greater than 300 m from the nest site and that no locations were greater than 500 m of the nest tree. For birds that were older than 25 days post-fledging, 20% of locations were greater than 300 m from the nest tree. However, only 4% of locations were greater than 500 m from the nest. Generally, fledgling goshawks increased their exploratory movements away from the nest tree with time. However, all birds made movements back to the nest tree during the entire post-fledging period.

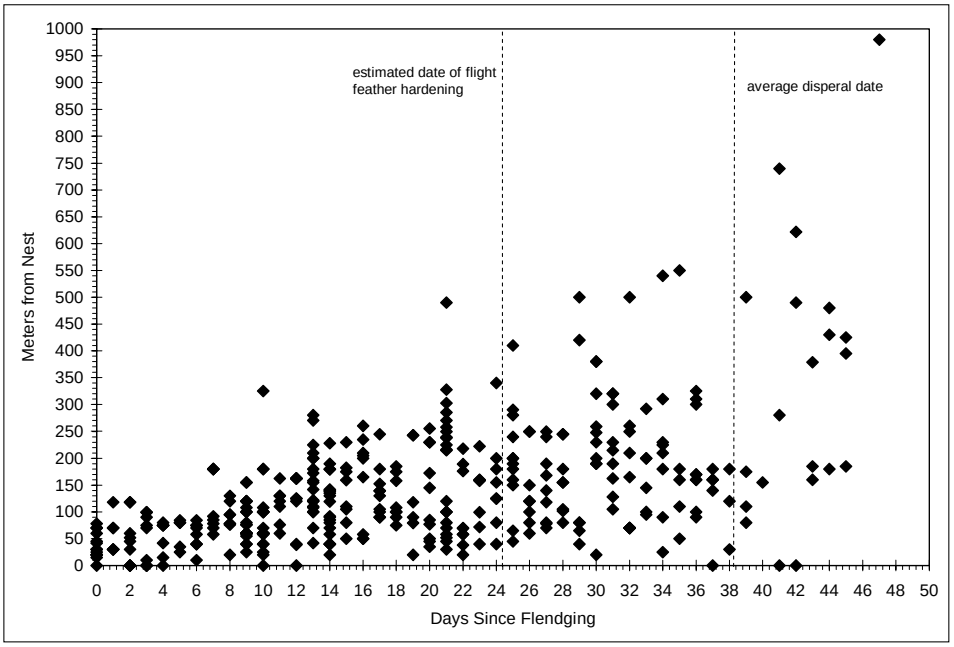

Figure 2: Distribution of the movements of fledgling goshawks away from the nest during the 2004 post-fledging period. Hardening of flight feathers occurs at approximately 25 days and allows for greater mobility of fledglings. The average date of dispersal for fledglings monitored in 2004 was 39 days.

The average fledgling home range from fixed kernel methods ranged from 0.04 km^2 to 0.62 km^2, with an average home range of 0.20 ha (±0.18 SD, n=6; Table 3). This is extremely similar to the average home range calculated by mean convex polygon methods (0.2 km^2, ±0.2 SD, n=6).

The six adult females with sufficient data, were located an average of 991 m from the nest (±423 SD, n=96). Adult females did make extensive movements away from the nest but generally remained close to the nest site (Figure 3). The average 100% mean convex polygon home range for adult female goshawks was 30.4 km^2 (±25.9 SD, n=6) and ranged from 3.9 km^2 to 79.9 km^2 (Table 3).

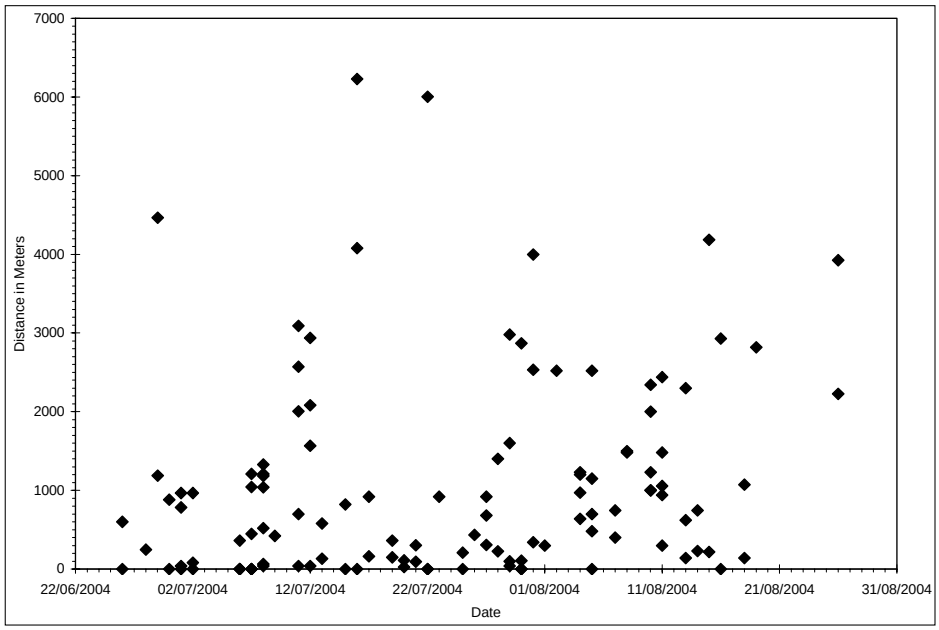

Figure 3: Movements of adult female goshawks (n=6) away from the nest site during the 2004 post-fledging period.

Adult male goshawks moved on average 1785 m (±438 SD, n=46) from the nest during the post-fledging season. Unlike adult females, adult males generally spent less time near the nest. Adult male goshawk, 100% mean convex home ranges were 12.0 km^2 and 22.1 km^2 respectively. This provided an estimated average home range of 17.1 km^2 (±7.1 SD, n=2) (Table 3). However, this estimate is base on an extremely small sample size.

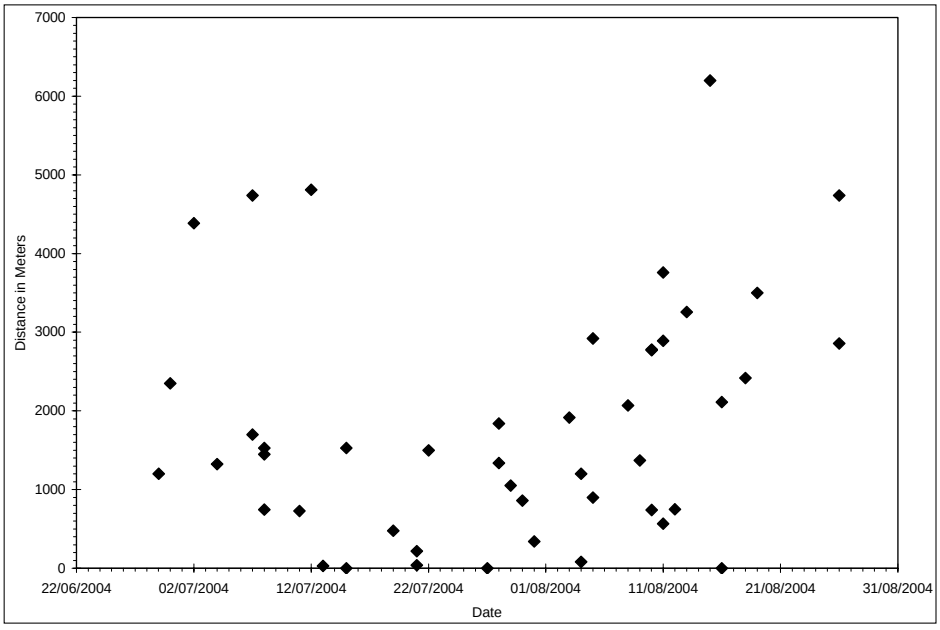

Figure 4: Movements of adult male goshawks (n=2) away from the nest during the 2004 post-fledging period.

Table 3: Fixed kernel and mean convex polygon estimates of fledgling, adult female, and adult male home ranges for the 2004 post-fledging season.

Age/Sex Class	95% Fixed Kernel ha (SD)	100% MCP in ha (SD)	Number of Nests	Average Number of Locations per bird
Fledgling	20.2 (17.5)	20.6 (22.7)	6	40.5
Adult Female	n/a	3036.6 (2577.9)	6	17.6
Adult Male	n/a	1707.0 (713.7)	2	23

9.3 Intensive Follows:

Data obtained from intensive follows (hourly locations) at nest sites provided some interesting information regarding the behaviour of goshawks. The majority of this data is observational as we were only able to document the movements of family groups at two sites. However, we have gained important preliminary information on the logistics of monitoring and documenting these movements. We will expand these activities in 2005. Additionally, this information provides valuable insight into the effectiveness of our daily monitoring program.

Fledgling birds were observed travelling out to adult goshawks that were providing food. These movements were restricted by the extent of forest occupying the site and specifically by the direction from which the food delivery was occurring. Additionally, competition between siblings seemed to influence the intensity of these moves. Adult females generally spent more time near the nest than adult males. Adult male goshawks were the main food providers to both nestlings, fledglings, and the adult female. Males spent the majority of their time away from the nest site, returning only to deliver food. Additionally, adult male and female goshawks seemed to segregate their foraging activities (Figure 5). Although there was some overlap, adult males generally only used these areas when adult females were located at the nest site (personal observation).

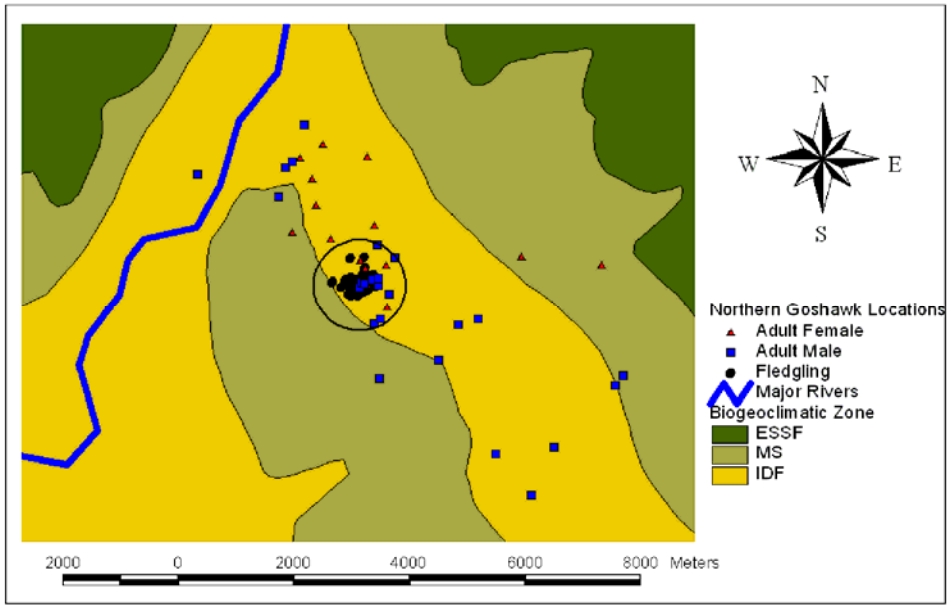

Figure 5: Sample of adult female (triangles), adult male (squares), and fledgling (circles) locations for a single nest with one fledgling. Major biogeoclimatic zones are shown, including Engelmann Spruce - Subalpine Fir (ESSF), Montane Spruce (MS), and Interior Douglas-fir (IDF). The majority of locations were made within valley bottom zones (IDF). The circle surrounding the juvenile locations represents an 800m buffer surrounding the active nest site.

9.4 Winter Movements:

We attempted to relocate 12 adult goshawks on six monthly telemetry flights during the winter of 2004-2005. Four of these birds (2 females and 2 males) were not relocated on a regular basis. As describe above, one adult female goshawk died in early winter (late December) and we have removed her from the analysis. Additionally, three birds (2 females and 2 male) left the study area in late fall. Our first flight (October 8, 2004) was successful in locating all 12 birds except the two adult male goshawks. Due to inclement weather, our next flight was not until December 6, 2004. At this time all birds were located except two adult females, and the two adult males missing from the previous attempt. The only goshawk of these four located again was a single adult male. He was located on March 11, 2005, our final flight, and may have been returning to his nest area. We were unable to locate the two missing adult female goshawks and a single male goshawk.

Adult female goshawks, resident within the study area, moved on average 6.4 km (±6.0 SD, n=34) from the nest (range=0.2-23.4 km). However, the average distance we located each birds away from the nest site was less than 11.5 km (±3.7 SD, n=7). This suggests that resident females are spending the majority of their time close to their nesting areas. We are currently in the process of relocating birds following their winter movements. This will allow us to both determine the fate of missing birds, and determine whether birds returned to their previous nest sites.

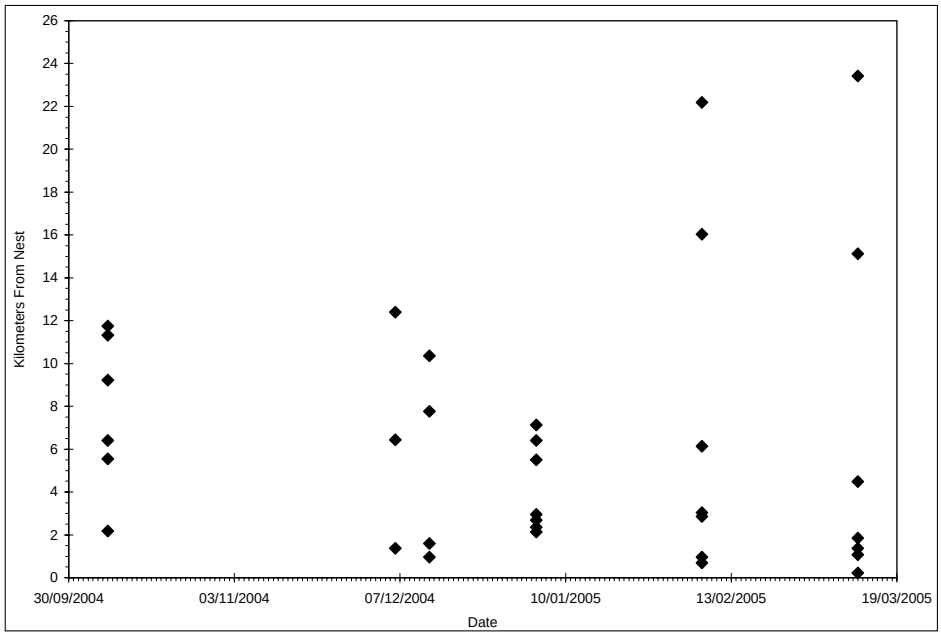

Figure 6: Winter movements of adult goshawks away from previous years nest sites for goshawks remaining in the study area (n=7).

10.0 Discussion:

Our preliminary results suggest that goshawks within the East Kootenays exhibit similar natural history characteristics to those reported in other areas. However, some differences do exist and we are continuing to determine how the movements of goshawks within our study area are impacted by resource distributions (i.e., forest structure).

Our estimated hatching dates for nests we sampled ranged from May 21st to May 29th (Boal and Mannan 1994). Given the 5-6 week incubation period, this would suggest that female goshawks laid their eggs in late April (Reynolds and Wight 1978). Goshawks may have laid more eggs than three as we were unable to observe the eggs at most sites; however, observations of nestlings suggest three was the maximum number of chicks hatched in that year.

By marking all siblings in the nest, we attempted to document the actual productivity of nest sites we sampled. Weins (2004) suggests that goshawk fledglings experience significant mortality in the days immediately following fledging. In our study area, four of 15 juvenile goshawks (27%) did not survive to disperse from the nest area. This concurs with Wiens (2004) observations and suggests that the actual productivity of nest areas is substantially lower than either the number of nestlings or the birds fledged from the nest. The actual causes of mortality within our study area are also consistent with other findings, with starvation and predation being the leading cause of death. The single fledgling that starved to death in our study area, came from a nest from which three females where fledged. Kenward *et al.* (1993b) suggest that a larger number of fledglings die in nests with more females. Additionally, the ability of adults to provision three fast growing female chicks may be limited (personal communication E. McClaren). Our assumption is that the two siblings of this bird were able to out complete it for the food deliveries provided by adults and thus it became emaciated and succumbed to a poor weather event (a localized summer snowstorm).

The two other fledglings that died immediate following fledging were presumably killed by an avian predator. Both individuals received fatal injuries to their backs and shoulders; however, only one bird had what could be considered wounded by talons. Both birds were neither plucked, nor dismembered, and one bird was found with a half-eaten prey item. These circumstances suggest the attacks were motivated by a territoriality or similar motive and not a search for a food item. Although siblicide has been reported in goshawk nestlings (Boal and Bacorn 1994; Estes *et al.* 1999), no intra-specific attacks have been reported in fledglings. Additionally, the wounds sustained by these individuals were significant and it is doubtful if their siblings were able to manoeuvre well enough to inflict these wounds. Therefore, we would assume that both birds were killed by another adult raptor or owl. This could have been an attack by their parents; however, this is unlikely and the attack was probably inter-specific. The final mortality was a nestling predated from the nest by a mammalian predator immediately prior to fledging.

Goshawk post-fledging areas surround the nest site and provide valuable areas in which fledgling goshawks learn to fly and hunt. The post-fledging area can be likened to a natal home range in which juvenile birds gain valuable experience prior to dispersal. These experiences may influence their future success. Natal dispersal has traditionally been viewed as the immediate movement of individuals out of the natal area in response to some trigger (e.g., density dependence or food limitation). However, the timing and types of movements leading up to the dispersal event may be much more complicated and important than previously thought. Recent research has examined the importance of natal experience (i.e., imprinting) on juvenile resource selection and settlement patterns (see Davis and Stamps 2004). Experience can be gained either within the natal home range or through exploratory movements made during the process of leaving the natal home range. Therefore, the post-fledging area provides goshawks not only with a safe and secure environment to develop while still dependent on adult birds for food, but may play an important role in dispersal and resettlement patterns.

In our study area, fledgling goshawk rarely traveled further than 500 m from the nest site. Unlike previous studies, we did not see a strong relationship between the hardening of flight feathers at 25 days post-fledging, and the movements of juvenile birds. Kenward *et al.* (1993a), suggests that fledgling goshawks will travel greater distances from the nest as their mobility increases at this stage. This may mean that fledglings in our study area are restricted by some factor. Additionally, Kennedy *et al.* (1994) reported 91% of locations within 800 m of the nest. We observed 96% of locations within 500 m of the nest. This may be the result of fragmented forest environments as many of our nest areas were adjacent to cut blocks. Further analysis into forest structure should provide insight into the movements of juvenile birds.

We gained further insight into the mechanisms governing the movements of juvenile animals during hour observations of fledglings. Adult goshawks supply food to fledglings through the entire post-fledging period with the end of this stage marked by the cessation of feeding activities by adults (Kenward *et al.* 1993a). We suggest that the movements of juvenile animals away from the nest site are governed by a trade-off between two opposing forces. Fledglings regularly travel away from the nest site in order to intercept adult goshawks returning with food (Kenward *et al.* 1993b). Thus, in a homogenous environment, the movements of fledglings away from the nest should be governed by the interplay of the need to remain within the safety and

security of the nest area, and their need to obtain food from the adult. Obviously, with an increasing number of siblings at a nest site, the need for fledglings to out compete their siblings for the valuable food item is essential and may result in larger movements away from the nest. Additionally, the structure of the forest surrounding the nest site will also play a role, reducing and distance fledgling birds can travel towards returning adults while still remaining within the safety of the nest stand. Personal observations have led us to believe that this trade-off is occurring within nest areas in the East Kootenays and we are guiding future field activities in an attempt to document this process.

Goshawk breeding ranges are presumed to vary with the availability of forest structure appropriate for hunting and with prey availability (Kennedy *et al.* 1994). The breeding ranges of female goshawks within our study area are substantially larger than those reported by other researchers. For example, Kennedy *et al.* (1994) reported female breeding ranges or between 95 and 1292 ha. Our estimates ranged from 392 to 7978 ha, which shows a large amount of variability between nesting areas. Only half (three) of our intensively monitored females had ranges within Kennedy *et al.* (1994)'s estimates. Additionally, an examination of our adult female's movements away from the nest shows that females regularly travel large distances from the nest this suggest that our female goshawks are moving substantial distances to forage. The extent of these movements may mean that either foraging areas in our study area are of poor quality or that the forest surrounding nest areas is extremely fragmented, forcing goshawks to travel large distances to find effective hunting areas. Conversely, adult male goshawk ranges are within published estimates from other areas. Kennedy *et al.* (1994) reports male goshawks ranging between 1698 and 2837 ha. Our observations of two males provided home range estimates of 1202 and 2212 ha respectively. Therefore, adult male and adult female home range estimates suggest different foraging strategies within our study area. An examination of the forest structure within nest and foraging areas (which is beyond the scope of this report) should provide better insight into the mechanisms behind the observed movements.

Winter movements of adult goshawks were similar to those expected from other research (Drennan and Beier 2003; Mahon and Doyle 2003b; Squires and Ruggiero 1995, Doyle and Smith 1994). Some birds left the study area in early fall, close to the time fledgling birds dispersed from the nest area. However, many of our birds remained close to their nesting areas. Mahon and Doyle (2003b) found winter female home ranges of 6696 ha that were centered on the nest area. Squires and Ruggiero (1995) observed the winter migration of four goshawks away from their nest sites in southcentral Wyoming. Additionally, Doyle and Smith (1994) document winter migrations of adult goshawks in response to prey declines. Conversely, Drennan and Beier (2003) documented an average movement distance from the summer nest site of 6.17 km by female goshawks and an average of 7.44 km for males. Only one of their 13 birds moved >25 km from the nest during the winter (Drennan and Beier 2003). This suggests that the winter season movements of goshawks are quite variable. In our study area, we observed some goshawks leaving the study area; however, most remained. Both male goshawks we monitored left the study areas and 2 of 10 females left the study area. Further monitoring of both sexes are required to provide a plausible explanation of these movements. We are currently investigating the occupancy of nests for the 2005 summer season. This information will provide future insight into: (1) the fate of the four birds that have left the study area; and (2) the extent of re-occupancy of historical nest areas.

11.0 Conclusions and Future Research Directions:

Preliminary results have provided us insight into the mechanisms governing the movements of goshawks within the East Kootenays. Although the movements of goshawks fall within previously observed levels for most life-history stages, the restricted movements of fledgling birds and extensive breeding season movements of adult females suggest either a fragmented forest environment or a food-limited ecosystem. Future investigations of the specific forest structures used by our radio-tagged birds will allow us to develop better explanations of the reasons for deviation of our results from previous observations, and permit us to develop management recommendation for this species within British Columbia's southern interior. Additionally, we have developed hypotheses to explain one mechanism governing the movements of fledglings within the area surrounding the nest site. Future field activities will focus sampling on collecting data that will test these hypotheses. We are confident that we can maintain our previous objective while still investigating this new aspect of goshawk ecology.

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