

**INVENTORY OF THE NORTHERN GOSHAWK (*ACCIPITER GENTILIS*)
IN THE KISPIOX FOREST DISTRICT**

1999/2000 ANNUAL REPORT

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EXECUTIVE SUMMARY

The purpose of this inventory project is to assess stand level (nest area and post-fledging area) habitat requirements of the Northern Goshawk (*Accipiter gentilis*, hereafter goshawk) within the Interior-Cedar-Hemlock (ICH) biogeoclimatic zone in the Kispiox Forest District (KFD). This information will be used to develop forest management recommendations for strategic landscape level planning and stand level development prescriptions. This was the 4th year of a 5-year project.

Inventory this year focused on monitoring activities associated with the 14 previously known nest areas, however, limited call playback surveys were conducted in the Gail Creek area to try to locate goshawk nests in the Engelmann Spruce-Sub-alpine Fir biogeoclimatic zone. Within the Gail Creek area 166 playback stations, along 66.4 km of transect, covering approximately 2000 ha were surveyed in 1999. No goshawks were detected during these surveys. Within the ICH and Coastal Western Hemlock zone 7 goshawk sightings were reported to us that resulted in the location of 6 new nest areas. One other goshawk nest was found by following up a 1998 sighting and another was found by chance. A total of 22 Goshawk nest areas have now been located within the KFD. Eighteen of the 22 confirmed sites were known to be active this year. Population density estimates in the KFD are 1.5 pairs per 100 km².

Nest area, nest tree and nest parameters were quite similar among the 22 known nest areas. Most nest areas are in mesic, age class 8 or 9 hemlock dominated forest, with moderate to high crown closure and sparse herb and shrub development in the understory. On average, there are 1.9 nests per nest area (range 1-5) and 94% of the nests (n = 48) are in western hemlock and the other 3 are in amabilis fir. The mean DBH of nest trees is 58.8 cm (SD ± 12.4 cm) and all nest trees exceed 15.25 m in height (mean = 27.6 m, SD ± 5.8 m). Nests are all situated on lower branches of the main canopy against the trunk of the tree, with a mean height of 16.2 (SD ± 3.87 m). 50% of the nests had a northwest aspect. All 22 nest areas are in stands rated as high value nest area habitat, based on a habitat suitability model developed in 1997.

Re-use of nest areas by goshawks over the life of the study has been 100%, but in any one year the re-use of nest areas varies widely, 55% in 1998 and 90% in 1999. This year egg laying started in early-April and dispersal of young occurred in early-mid August. On average 2.7 (S.D. = 1.1) young fledged per active nest compared to 1.7 the previous year and 2.2 in 1997, and 90% fledged young compared to 80% last year and 100% in 1997.

Post-fledging area requirements of the young were measured again this year and the patterns of movement (size of area, habitat and topographical location) we saw in the 2 previous years were repeated. Juveniles stayed within 400m of the nest for a 4-6 weeks after fledging. The young typically moved along or down slope of the nest area, and within similar habitat to the nest area. From 1997–1999 the average post-fledging area size estimated using 90% Adaptive Kernel analysis (ADK)) ranged from 7.3 (SD = 4.5) in 1998, to 12.1 ha (SD = 5.4) in 1999; using 90% Minimum Convex Polygon (MCP) this area ranged from 3.6 ha (SD = 1.7) in

1998 to 5.7 ha (SD = 3.0) in 1999. In contrast to general similarities in the size of the PFA at the same nest between years, the exact location of the PFA relative to the nest tended to vary.

Morphological measurements for 8 juveniles and four adults that have been captured over the last three years, suggest that the sub-species *laingi* or a transition between it and the larger *atricapillus* may be present in the KFD, but many more birds need to be measured and blood samples analyzed to verify this.

As observed last year the main prey of the goshawks was primarily red squirrels and both corvids and passerines (primarily jays, thrushes and woodpeckers). Other prey seen this year included a young Barred Owl.

Thirteen of the 22 known nest areas are within, or adjacent to proposed timber development. The response of the goshawks to this development is being monitored as part of an adaptive management component of this study. Preliminary observations at 3 nest areas with nearby forest development are discussed and the range of development proposed near the other nests is presented.

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TABLE OF CONTENTS

| | |
|--|------------|
| EXECUTIVE SUMMARY | I |
| ACKNOWLEDGMENTS | III |
| LIST OF TABLES | V |
| LIST OF FIGURES | V |
| LIST OF APPENDICES | VI |
| INTRODUCTION | 1 |
| STUDY AREA | 2 |
| METHODOLOGY | 5 |
| Call Playback Surveys | 5 |
| Public Awareness | 6 |
| Nest Area Habitat Data | 6 |
| Nest Tree and Nest Area Fidelity | 7 |
| Breeding Chronology | 7 |
| Reproductive Parameters | 8 |
| Post-fledging Area Assessment | 8 |
| Trapping and Handling | 10 |
| Prey Remain and Pellet Analysis | 11 |
| Adaptive Management Program | 11 |
| RESULTS | 13 |
| Call Playback Surveys | 13 |
| Public Awareness | 13 |
| Nest, Nest Site and Nest Area Habitat Data | 15 |
| Comparison of Nest Site and Nest Area Habitat | 20 |
| <i>Differences between nest sites and random plots within the nest area</i> | <i>20</i> |
| <i>Similarities between nest sites and the nest area</i> | <i>21</i> |
| Nest Area Location in Relation to Roads and Cutblocks | 21 |
| Nest Tree and Nest Area Fidelity | 22 |
| Breeding Chronology | 23 |
| Reproductive Parameters | 24 |
| Post-fledging Area Assessment | 26 |
| Prey Remain and Pellet Analysis | 28 |
| Adaptive Management Program | 29 |
| DISCUSSION | 32 |
| Goshawk Density | 32 |
| Habitat | 32 |
| Variation in reproductive success and exploring its possible links with forestry | 33 |
| Post-fledging Areas | 35 |
| Prey Remain and Pellet Analyses | 39 |
| Subspecies <i>laingi</i> ? | 40 |
| Effects of timber extraction on goshawks | 40 |
| MANAGEMENT RECOMMENDATIONS | 44 |
| INVENTORY CRITIQUE | 44 |
| LITERATURE CITED | 45 |

LIST OF TABLES

| | |
|---|----|
| Table 1. Hierarchical structure of goshawk nest area..... | 7 |
| Table 2. Summary of call playback effort and results in the KFD in 1999. | 13 |
| Table 3. A summary of potential goshawk sightings reported to the project within the Kispiox Forest District in 1999..... | 14 |
| Table 4. Distribution of goshawk nest areas in major watersheds and BEC zones of the KFD.. | 15 |
| Table 5. Summary of forest cover information for goshawk nest areas in the KFD. | 16 |
| Table 6. Tree and nest characteristics for 33 northern goshawk nests located in the Kispiox FD up to 1998..... | 19 |
| Table 7. Ecological characteristics of 14 goshawk nest areas in the Kispiox Forest District known up to 1998 (see Appendices 2, 3 and 4 for coding) | 20 |
| Table 8. Nest area fidelity by goshawks in the Kispiox Forest District. | 22 |
| Table 9. Breeding chronology of 10 goshawk nests in the Kispiox Forest District in 1999. | 23 |
| Table 10. Summary of nest productivity for goshawk nests in the KFD in 1999. | 24 |
| Table 11. Number of young fledged per breeding attempt..... | 25 |
| Table 12. Number of young fledged per successful nest. | 25 |
| Table 13. Estimates of post-fledging area size (ha) for 1999 nests using ADK and MCP..... | 27 |
| Table 14. Estimates of post-fledging area size (ha) for 1999 nests using harmonic mean method. | 27 |
| Table 15. Topographic location of young fledged in 1999 in relation to their natal nest site. | 28 |
| Table 16. Summary of prey occurrence in a sub-sample of goshawk pellets in the KFD in 1998 (and 1997 in brackets). | 29 |
| Table 17. Proposed or completed timber development near goshawk nest areas in the KFD..... | 31 |
| Table 18. Post-fledging areas (ha) at 90% ADK and MCP 1997-1999..... | 35 |

LIST OF FIGURES

| | |
|--|----|
| Figure 1. Location of the Kispiox Forest District..... | 4 |
| Figure 2. Forest Cover age class of 22 nest areas in the KFD..... | 17 |
| Figure 3. Forest Cover crown closure for 22 nest areas in the KFD. | 17 |
| Figure 4. Relationship between the mean number of fledged young per breeding attempt and per successful pair per year and the timing of breeding (Julian days). ($r^2 = -0.95$ for both comparisons)..... | 34 |
| Figure 5. Post-fledging area used by young at the Pope nest in 1998 and 1999. | 37 |

LIST OF APPENDICES

- Appendix 1. British Columbia Resource Inventory wildlife tree coding for Decay Class.
- Appendix 2. British Columbia Resource Inventory coding for Structural Stage.
- Appendix 3. British Columbia Resource Inventory coding for Successional Status.
- Appendix 4. British Columbia Resource Inventory coding for Site Series.
- Appendix 5. British Columbia Forest Cover Inventory coding.
- Appendix 6. Measurements of trapped goshawk.
- Appendix 7. Post-fledging area maps.

INTRODUCTION

The Northern Goshawk (*Accipiter gentilis*) is a circumpolar species inhabiting a variety of coniferous and mixed deciduous-coniferous forest. These forests include the boreal forest (Godfrey 1986), heavily managed coniferous forest in Europe (Kostrzewa and Kostrzewa 1990), mixed deciduous-coniferous forest of eastern North America (Speiser and Bosakowski 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 critical nesting habitat are similar and are typically high value stands from a timber perspective, resulting in resource management conflicts.

A goshawk's home range is composed of hierarchically organized nest sites, nest areas (NA), a post-fledging area (PFA) and a foraging area. A nest site is defined as a 1 ha area centered on a nest tree. The nest area, which may contain several nest sites, is 8-20 ha in size (Reynolds *et al.* 1992, Schaffer *et al.* 1995). Habitat selection for nesting appears to be focused on this territory component. Nest areas are typically characterized by a relatively homogeneous stand of mature forest with high canopy closure. This area is the center of all breeding activity from courtship through fledging. This, coupled with strong fidelity (hereafter in this report: re-occupation of an area by goshawks, although not necessarily by the same individuals) to these nest areas from year to year, makes them the habitat component most sensitive to timber development activities. Within a goshawk's overall home range there may be 1 or 2 alternate nest areas in addition to the active nest area, all usually within 1 km of each other (Crocker-Bedford and Chaney 1988). 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). While the PFA is usually more heterogeneous than the NA, it is still often dominated by closed canopy forest similar to the NA. The foraging area encompasses all of the home range and generally includes a variety of forest cover types, seral stages and landforms.

Habitat requirements for the Nest Area and Post-Fledging Area may necessitate special forest management. In British Columbia, the Northern Goshawk is an "Identified Wildlife Species" under the Forest Practices Code (FPC reference). This status indicates that the recommendations of the FPC Biodiversity Guidebook (reference) are unlikely to maintain the

habitat requirements of the species and that special management guidelines are required. The current level of knowledge of the frequency, distribution and viability of the northern goshawk in the Kispiox Forest District is inadequate to incorporate stand and landscape level habitat requirements into strategic landscape level plans and stand level development prescriptions. Therefore, a comprehensive inventory of nesting locations, stand and landscape level habitat use, population size and distribution is required. The end goal of this inventory project is to provide forestry planners and regulatory agencies with the necessary information to design and approve stand and landscape level development plans in an expeditious fashion, while maintaining appropriate Northern Goshawk habitat within the managed forests of the Kispiox Forest District.

This was the fourth year of a 5-year project. The specific objectives of the project during 1999 were to:

1. Survey the 14 known and 1 suspected nest areas from 1995-1998 to assess re-occupancy.
2. Assess breeding chronology and reproductive success and to collect pellets and prey remains at active nests.
3. Conduct nest searches in areas where forestry workers and the general public have reported goshawk sightings.
4. Determine post-fledging area use by juveniles through a combination of visual locations and radio telemetry.
5. Radio tag adult goshawks using nest areas near proposed forest development activities to assess the fidelity of the birds to these areas once harvesting has occurred.
6. Conduct broadcast call surveys and nest searches (as appropriate) within ESSF portions of the Gail Creek area (funding permitting).
7. Conduct detailed habitat descriptions of nest tree, nest site (1ha) and nest area (12ha) for each new nest found.

STUDY AREA

Inventory was conducted throughout the Kispiox Forest District (Figure 1) within portions of the Interior Cedar Hemlock (ICH) and Coastal Western Hemlock (CWH) biogeoclimatic zones (Banner *et al.* 1993). This area falls primarily within the Northern Mountain Skeena Mountains Ecoregion of the Sub-Boreal Interior Skeena Mountains Ecoregion and also partly in the Nass Ranges Ecoregion. Survey activities are focused in the Kispiox Valley. This intensively monitored area stretched from km 29 - 80 km along the Kispiox Trail Forest Service Road and to about 700 meters elevation along the mountains to the north-east and

the south-west of the valley, covering approximately 500 km². This area was chosen due to the wide range of representative habitat types available, the presence of active and past logging, and the accessibility of the area, which in turn facilitates an effective inventory of the area.

Outside of the Kispiox Valley, nest checks and follow up searches were made at all previously known Goshawk nest areas. Nest searches were also carried out in areas where personnel had made goshawk sightings (including personnel from the Ministry of Forest, Skeena Cellulose Inc., other forestry contractors and the general public).

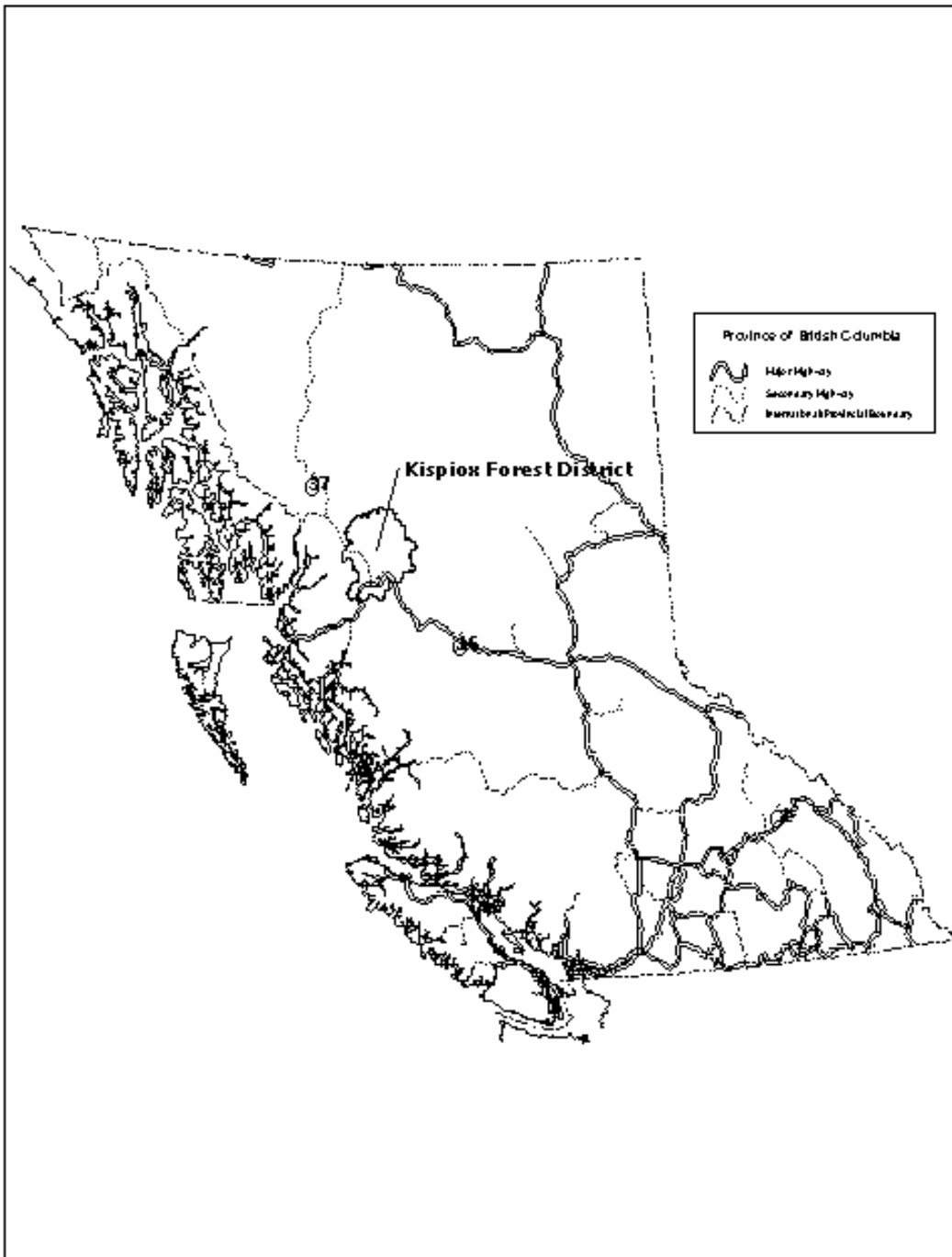


Figure 1. Location of the Kispiox Forest District.

METHODOLOGY

Call Playback Surveys

Standardized inventory methods, adapted from for the Resource Inventory Committee (RIC 1995), were utilized for all surveys. Modifications based on the work of Bosakowski and Vaughn (1994) tailor the methodology for work in steep, rugged terrain similar to that found in the ICH and CWH. Survey crews were given megaphones (broadcasting calls a minimum of 200 m), portable CD players and CD recordings of northern goshawk adult alarm and juvenile begging calls (Queen Charlotte Island adult alarm and juvenile begging calls supplied by P. Chytk). While call playback surveys are the most efficient means of detecting active nests Kennedy and Stahlecker (1993), it does though have limitations, with non-breeding pairs or failed pairs detected less readily using this technique (Watson *et al.* 1999). Surveys were therefore conducted in many areas in consecutive years particularly within the intensive study area or areas where birds had been seen, or where birds responded to playbacks but where no nests were detected.

Following Kennedy and Stahlecker (1993), surveys took place during the nestling and fledgling portions of the breeding phenology (late May to late August) when response rates are highest. Different calls were utilized to suit the phenology of the young. During the nestling period in the spring, alarm calls, characteristic of territorial defense by goshawks, were broadcast. During July and August, playback switched to food begging calls, which have been found to be more effective at the fledgling stage of development (Joy *et al.* 1994).

Crews broadcast calls from stations placed at 400 m intervals along transects. At each station, surveyors broadcasted 3 bouts of 15 second long calls with 60 second intervals between bouts in which to detect responses. Each of the 3 broadcasts was played in a different direction with the megaphone being rotated 120° between calls. At the end of the 3 broadcasts, an additional 5 minutes was spent listening and visually searching for birds at each station. Broadcast calls were played at a volume that produced sound audible to a human ear at a minimum of 200 m. Call surveys were discontinued during rain or winds exceeding 20 km/h because of a potential interference on both the effectiveness of call playbacks and detection of

any responses. The area (km²) covered by the survey was calculated by taking the effective search distance to be within 200 meters of this point.

All survey crews were trained to distinguish goshawks from other hawks (Cooper's hawk *Accipiter cooperii*, sharp-shinned hawk *Accipiter striatus*, red-tailed hawk *Buteo jamaicensis*, and merlin *Falco columbaris*) and from goshawk mimics (jays and sapsuckers). Crews recorded any responses to a broadcast including those from other hawks and mimics, in addition to the time, species, sex, age and type of response (visual/aural). In addition, crews were required to estimate the initial distance and compass bearing to any hawk, and direction of departure (when appropriate) as these provide clues to the proximity and direction of a nest. When a broadcast elicited a response from a northern goshawk, crews mapped the location and conducted an intense search for active nests within a 300 m radius of the detection.

Public Awareness

As with previous years, a concerted effort was made to solicit information regarding goshawk sightings and encounters throughout the Kispiox Forest District. Goshawk identification posters with a contact telephone number were placed at Band offices, Forest District and forest company offices, pine mushroom depots and lodges within the District. Contractors and employees working regularly in our search area were contacted directly and provided information on goshawk identification including photos and a recording of the Goshawk alarm and begging call.

Nest Area Habitat Data

Goshawk nesting habitat was described rigorously at the 3 spatial scales of nest tree, nest site and nest area as outlined below in Table 1. At all nest sites Ecosystem Field Forms were completed as per RIC standards. The ecological attributes of nest sites and of 4 random plots within each nest area were collected to describe the types of sites goshawks were selected for nesting. Random plots were restricted to each cardinal direction and to a maximum of 200 m from the nest tree (The 200 m boundary for the 4 nest area plots corresponds to the 12 ha nest area size noted in the draft Managing Identified Wildlife Guidebook (Forest Practices Code 1996) and generally reported in the literature (Reynolds *et al.* 1992)). Within this 200 meter limit a random distances were computed using a Microsoft Excel random number generator program. As well, we compared nest site plots to the four nest area plots to determine if the nest site was

different in some way from the nest area as a whole. This was done both from the viewpoint of helping to locate nests and to help develop management prescriptions for the goshawk nest area. With these goals in mind the habitat information we collected included the standard information required on Ecosystem Field Forms and information corresponding to variables in the Forest Cover database.

Table 1. Hierarchical structure of goshawk nest area.

| Scale | Extent of Sampling | Habitat Attributes Measured |
|-----------|---|--|
| Nest Tree | Nest tree only. | Tree species, height, dbh (diameter at breast height), decay class, nest height, nest aspect, nest dimensions, supporting branch pattern, nest position with respect to canopy foliage |
| Nest Site | 0.04 ha plot (centered around nest tree) | Slope, aspect, tree density, tree species, tree height, dbh, basal area, canopy closure, ecosystem type, % shrub and herb coverage, CWD (Coarse Woody Debris) volume |
| Nest Area | Four 0.04 ha plots (<200m from nest tree) | Slope, aspect, tree density, tree species, tree height, dbh, basal area, canopy closure, ecosystem type, % shrub and herb coverage, CWD volume |

Nest Tree and Nest Area Fidelity

Information on the reuse of a nest and nest area by goshawks is needed for developing management guidelines at both the stand and landscape level. If goshawks re-use an area repeatedly over a long period of time and these areas can be identified, or the attributes typical to such sites can be identified, then we can develop and refine management models accordingly. If we can collect enough years of information, including monitoring of nests found in stands of different age classes we can also give broad boundaries on how long a nest area is used by the birds. To assess nest tree and nest area fidelity we revisited all known and suspected nest areas during May 1995-1999 to see if they were occupied. If old nests were not being utilized, call surveys and nest searches were conducted several times through the breeding season to locate alternate nest sites and nest areas within 1 km of historical nest trees.

Breeding Chronology

Breeding chronology for goshawks in interior northwestern British Columbia is unknown. Active nests and post-fledging areas were monitored at least weekly through the breeding season to determine breeding chronology in the Kispiox District. This information will be used to determine operational timing windows for timber development activity near/within

nest areas and post-fledging areas. Timing of hatching and laying were calculated by using the observed fledging dates (gained from ground observations of the nests, conducted every 2-3 days during the fledging period) from 15 nesting attempts and then by backdating from this, by using breeding parameters in Ehrlich *et al.* (1988). If more than one chick was present in a nest, a mid-point between the fledge date of the first and last chick to fledge was used as the fledge date. From this estimated date a mean fledging date for the year was then calculated using all nests.

Reproductive Parameters

The productivity of the nests located will be used in conjunction with other information (diet, timing of breeding) to determine annual breeding success. This information can be used, in part, to determine how successful stratified surveys will have been that year in locating nesting birds. It will also provide information on annual variability in breeding success, which will be used when assessing the effectiveness of ecosystem-specific management strategies for this species. Productivity of pairs will also be compared to other studies in North America and Europe to help assess the health of the birds in the KFD compared to these other studies.

On an individual basis, productivity can be used in conjunction with other information (radio transmitters on the birds) to determine the effects of various harvest prescriptions on breeding pairs.

Post-fledging Area Assessment

Determination of PFA size and juvenile habitat use within the PFA was again the primary focus of this year's project. At each nest site where intensive monitoring (daily locations) of the fledged young was to take place, a grid was flagged in the field to facilitate the plotting of accurate juvenile locations relative to the nest. Each grid was laid out in 4 cardinal directions from the nest tree, up to 200 m from the nest, with flagging every 10-20m, showing distance and direction from nest. If birds moved further than 200 m from the nest tree the grid was expanded to encompass those movements. At distances greater than 150 m from the nest tree, flagged lines were also laid out perpendicular to the cardinal lines and 100-200 m in either direction. As with the cardinal lines these were marked to show distance and direction from the nest.

Location of located birds was then determined by walking towards and perpendicular to the nearest transect line, from the location of the bird(s) using a hip chain.

Juvenile locations were determined two ways. The first involved walking into the nest area and listening for juvenile vocalizations. If a juvenile was not detected within 20 minutes of entering the nest area we played a recording of a juvenile begging call from the nest site to stimulate a response. Birds detected in this manner call from their perch and then fly towards the observer calling (pers. obs.). If the original location of the bird was in doubt locations for the bird were not recorded. The other method for determining juvenile locations was ground-based telemetry tracking of a sub-sample of radio-tagged juveniles, which were trapped in a mist net with the aid of a lure (see Trapping and Handling below). Once the young were detected we approached each individual until we could confirm its position and plot it on a grid map.

For each juvenile we found we recorded its grid coordinates, its behavior, whether it was calling, call type, whether it was with another juvenile, canopy position, slope position and habitat type. Canopy position was defined as Ground, Lower third, Middle third, Upper third or Flying. Slope position refers to whether the bird was Upslope, Downslope or Same elevation (± 20 m) as the nest. For habitat we recorded whether the juvenile was in the same Forest Cover polygon as the nest area, and if not we recorded the different label.

Determination of PFA size was done using Minimum Convex Polygon (MCP), Adaptive Kernel (ADK) and Harmonic Mean (HM) analysis estimates. These home range estimators are regularly used in plotting home ranges of wildlife and both have drawbacks and advantages (see review Lawson and Rodgers 1997). We present all sets of results in our analysis as individual researchers have different preference. The results from MCP and ADK area estimators are presented both in graph and table form and the results from HM area estimator is presented in table form only.

Post-fledging area sizes were estimated using the programs CALHOME (Kie *et al.* 1994) and HOME RANGE (Ackerman *et al.* 1990). We used the adaptive kernel (ADK) and minimum convex polygon (MCP) methods in CALHOME to estimate the area used by fledgings. Juvenile goshawks typically remain together within the post-fledging area (Kenward *et al.* 1993b), but these analysis techniques assume that each location is spatially and temporally independent. To conform with these rules of independence we therefore obtained the coordinates of only one

chick per visit and did not include points which were recorded < 15 min apart when using these methods.

ADK calculates a probability distribution based on a specified percentage of chick locations (e.g. 100%, 90%), essentially estimating the area that the chicks' likely use. ADK tends to give slightly higher estimates than MCP. MCP estimates the area used by connecting the outer coordinates of the chick locations and calculating the smallest area enclosed by these outer-most points. We therefore also used harmonic mean (HM) range estimator that allows the use of all points, with the use of prior weighting of points. This technique also has drawbacks (see below for details) and the results from this analysis are only presented in Table form.

Worton (1987) does not recommend harmonic mean analysis, as it is sensitive to changes in the grid size (or scale) at which the data is examined. However, in the program HOME RANGE, this method has the advantage of allowing all points (even when they are correlated) to be used in the analysis provided they are weighted accordingly. Therefore more of the available information can be used in this analysis. For example, if three points are collected that are potentially correlated (i.e. 3 chicks) all three can be used in the analysis if each is assigned a weight which, when summed, equals 1.00 (e.g. 0.5, 0.25, 0.25). We weighted each point within an independent nest visit and generally gave a higher weighting to the first chick that was observed and a smaller weighting to the remaining birds (i.e. 2 chicks: 0.75, 0.25; 3 chicks: 0.5, 0.25, 0.25; 4 chicks: 0.4, 0.2, 0.2, 0.2). Similarly, if 2 or more locations of the same bird were taken within 15 min, yet were substantially distant (>~75m), we gave the first sighting a higher weight. If the location of the first chick appeared to be an outlier or was less precise (i.e. an estimate), we reversed the weightings so that the more accurate locations had the highest weighting. Occasionally some birds were located far from other points during the very later stages of the post-fledging period (usually via telemetry) and these locations were assigned a weighting of 0.5 in these cases

Trapping and Handling

Under dry weather conditions, adults were trapped around nest areas once juveniles were >20 days old, using Swedish falling lid goshawk traps, baited with pigeons placed in a separate compartment (Kenward and Marcstrom 1983). Juveniles were caught using mist nets, with the aid of a taped juvenile begging call as a lure to bring the birds into the area and a tethered pigeon

to lure the birds into the nets. Nets were placed such that the pigeon was not harmed.

Trapped birds were measured (wing cord, wing flat, 4th and 8th primaries, weight, tarsus width, tail length and age), a drop of blood was taken from the main vein in the wing. Birds were color banded, or were color banded and fitted with a tail-mount transmitter if a suitable feather was available (Biotrack). Tail-mount transmitters were then retrieved from the molted feather the following year, and a new battery installed before the transmitter was used again.

Prey Remain and Pellet Analysis

The diet of the goshawks within the Kispiox Forest District was assessed by analyzing pellets and prey remains collected underneath active nests and at plucking sites. Pellets and prey remains were collected twice weekly at all nests, from the time the nest was discovered until the young had left the post-fledging area. All items individually bagged, dated and air-dried in a 'dry greenhouse' and later in a convection-drying oven, until all moisture removed.

Pellets were dissected using techniques described by Errington (1930) and Marti (1987). A minimum count of unique bones, nail, etc, was used to identify the number of individuals of each species in a pellet. A locally obtained prey specimen reference collection and other reference material (e.g. Banfield 1974) were used to aid identification to species, family or group. Feather fragments were identified in pellets to species where possible, otherwise samples were keyed out to Family or size class as appropriate (Small bird (\leq Sparrow), Medium bird (Sparrow $>$ to \leq Stellers Jay) Large bird (Stellers Jay $>$). Analysis of the pellet information was conducted to determine the proportion of the main prey types taken by this species, and any marked differences in the diet between years.

Adaptive Management Program

Despite a fairly large body of literature providing forest management recommendations for goshawks, few studies have actually monitored the response of goshawks to forest harvesting operations near active nest areas. Management guidelines for the species have been primarily developed based on observed nest area and PFA sizes and nest area selection relative to existing forest development. Ultimately, the only way to determine how different types of forest development operations affect goshawk nest area use is to proceed with development and see how the birds respond. This study is in a unique position to assess a variety of timber development prescriptions near active nest areas.

For nest areas with adjacent forest development proposed we have provided management recommendations to forest managers 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 variables, alternate nest locations, plucking sites and juvenile use patterns, when available) and buffer distances consistent with our observations of distances of other nests from existing road and cutblock edges. 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 previous nest 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_0 : Goshawks return to their established nest area after timber harvest near or within that area; and considering 3 alternate hypotheses:

H_{a1} : The goshawks establish a new nest area nearby.

H_{a2} : The goshawks establish a new nest area in a completely different location.

H_{a3} : The goshawks abandon any breeding attempt for that year.

We are evaluating these hypotheses by attempting to radio tag one or both of the adults prior to timber harvest and use radio telemetry to locate their nests in the spring following development activities. To provide a control against our radio-tagging “treatment” we are also capturing adult goshawks at nest areas where no timber harvest is proposed. Control birds are measured and marked with color leg bands but do not have a radio tag attached. For areas where we are unable to radio tag an adult before timber harvest, we conduct extensive call playback surveys and nest searches within 1 km of the original nest area to try to determine if the birds have returned nearby. Nest areas affected by development will be monitored every year for the duration of the project in case there is a delayed response in returning to the area after disturbance.

RESULTS

Call Playback Surveys

Survey effort and results are summarized in Table 2. A total of 166 call stations along 66.4 km of road transects (covering approximately 27 km²) were conducted in the ESSF, but no goshawk were detected.

Table 2. Summary of call playback effort and results in the KFD in 1999.

| | |
|--|-------|
| Number of playbacks conducted | 166 |
| Km surveyed using playback | 66.4 |
| Km ² surveyed using playback | 26.7 |
| Number of responses to playback | 0 |
| Responses per playback | 0.000 |
| Km per response | 0 |
| Number of birds seen (independent of playback) | 0 |
| Number of nests located using playback | 0 |
| Number of goshawk sighting reports from the public | 7 |
| Number of nests located through follow up investigations of reported sightings | 6 |

Public Awareness

In the past 3 years an intensive effort has been made to inform personnel working and living in the Kispiox Forest District of our interest in locating goshawks and their nests. In the past two years 5 of 15 reports of birds resulted in the location of new goshawk nest areas. This year reports of birds produced 6 new nest areas from 7 sightings of birds (Table 3). The higher reliability of the reports this year is probably in part due to the high breeding success of pairs this year compared to other years (see details below) and possibly due to the increased awareness and knowledge of personnel and forestry workers in the KFD.

Table 3. A summary of potential goshawk sightings reported to the project within the Kispiox Forest District in 1999.

| Location | Report Source | Background Information | Survey Findings |
|-----------------------------|------------------------------|---|--|
| Shedin | SCI Phil Carruthers | <ul style="list-style-type: none"> Goshawks seen by forestry crew | <ul style="list-style-type: none"> Active goshawk nest located in centre of block |
| Iltzul | Bell Pole Rico | <ul style="list-style-type: none"> Goshawk swooping/calling | <ul style="list-style-type: none"> Fledged chicks located Active nest found 30 m outside of block |
| Weber Creek | Bell Pole Rico | <ul style="list-style-type: none"> Goshawk juveniles calling | <ul style="list-style-type: none"> Active nest located |
| Upper Cranberry | Bell Pole Rico | <ul style="list-style-type: none"> Goshawk juveniles calling | <ul style="list-style-type: none"> Active goshawk nest located |
| Smokee | Sam Hardy | <ul style="list-style-type: none"> Hawk seen swooping/calling | <ul style="list-style-type: none"> Active goshawk nest found in proposed block. Buffer placed around nest area |
| Corral | Silvicon Christian | <ul style="list-style-type: none"> Unknown hawks calling and following layout crew | <ul style="list-style-type: none"> Active goshawk nest located 70 m in from SE edge of block. Fledglings, whitewash and plucking sites 50 m SW of nest |
| Kitwanga back road km 27-28 | Kitwanga Mill Rob Barbosa | <ul style="list-style-type: none"> Unknown hawk calling and circling | <ul style="list-style-type: none"> Poor open habitat, search 90 minutes no birds seen or heard. |

Twenty-two nest areas are now known in the Kispiox Forest District. Seven of these occur within our core study area, the Kispiox Valley, corresponding to a minimum density of 1.5 breeding pairs/100 km². The general locations of the nests within major watersheds and biogeoclimatic zones of the KFD are summarized in Table 4.

Table 4. Distribution of goshawk nest areas in major watersheds and BEC zones of the KFD.

| Watersheds | Number | BEC Subzone |
|--------------------|--------|-------------|
| Cranberry | 3 | CWHws2*** |
| Kitwanga | 1 | ICHmc2** |
| Suskwa (Iltzul) | 1 | ICHmc1* |
| Kispiox | 10 | ICHmc1 & 2 |
| Kitsuns | 1 | CWHws2 |
| Upper Skeena/Kuldo | 2 | ICHmc1* |
| Mid Skeena | 1 | ICHmc1 |
| Shedin | 1 | ICHmc1 |
| 26 Mile | 2 | CWHws2 |

*= Interior Cedar Hemlock moist cold subzone; Nass Variant.

** = Interior Cedar Hemlock moist cold subzone; Hazelton Variant.

*** = Coastal Western Hemlock subzone; Montane Variant.

Nest, Nest Site and Nest Area Habitat Data

Due to reduced funding and the extra time required for follow up investigations of goshawk sighting reports, no detailed habitat information was collected at the new nests located in 1999. This information will be deferred until next year. Summary information from Forest Cover maps was collected for the new nest areas and is presented in Table 5. The Forest Cover information provides an effective base map for goshawk habitat because it stratifies forest stand types at a scale appropriate to goshawks and includes important habitat attributes such as age class (1st no. in label), stand height (2nd no. in label) and crown closure (4th no. in label) (see Appendix 2 - 4 for detailed description). The percentages of nest areas in stands of each age class and crown class are presented in Figures 2 and 3, respectively.

Table 5. Summary of forest cover information for goshawk nest areas in the KFD.

| Nest Area | Mapsheet | FC Polygon # | Forest Cover | Forest Cover Label |
|-----------------|----------|--------------|--------------|--------------------|
| Bailey | 103P 070 | 186 | HB(S) | 9416 – 14 |
| Blackstock | 103P 060 | 163 | H(B) | 9316 – 10 |
| Cranberry | 103P 057 | 38 | H(S) | 8417 – 13 |
| Corral | 103P 070 | 75 | HB(S) | 941M5 |
| Date | 93M 042 | 465 | HPI | 9417 – 12 |
| Flatfish | 103P 078 | ? | H(B) | 831P5 |
| Helen | 93M 061 | 311 | HB | 9417 – 13 |
| Iltzul | 93M 044 | 260 | H(B) | 9416 – 14 |
| Ironside | 103P 070 | 378 | H(Pl) | 8316 – 9 |
| Kitsun's | 93L 092 | 28 | H(B) | 9315 – 12 |
| Kuldo | 93M 071 | 6 | H(B) | 8415 – 18 |
| Mill Creek | 103P 020 | 143 | HC(B) | 8417 – 12 |
| Muldoe | 93M 052 | 453 | H(Pl) | 8316 – 16 |
| Pope | 93M 052 | 201 | H(CBS) | 7316 – 11 |
| Shedin | 103P 073 | 274 | HBPI | 8316 – 11 |
| Skeena-Carrigan | 93M 072 | 363 | H(B) | 9416 – 15 |
| Smokee | 93M 091 | 242 | HCt(S) | 841m4 |
| Sunday Lake | 93M 041 | 207 | H | 8316 – 14 |
| Tea Lake | 93M 011 | 790 | H | 9416 – 13 |
| Ten Link | 93M 021 | 111 | H(B) | 8414 |
| Upper Cranberry | 103P 049 | 148 | H(C) | 9516 – 16 |
| Weber Creek | 103P 049 | 245 | H(B) | 9416 – 14 |

See Appendix 5 for explanation of coding.

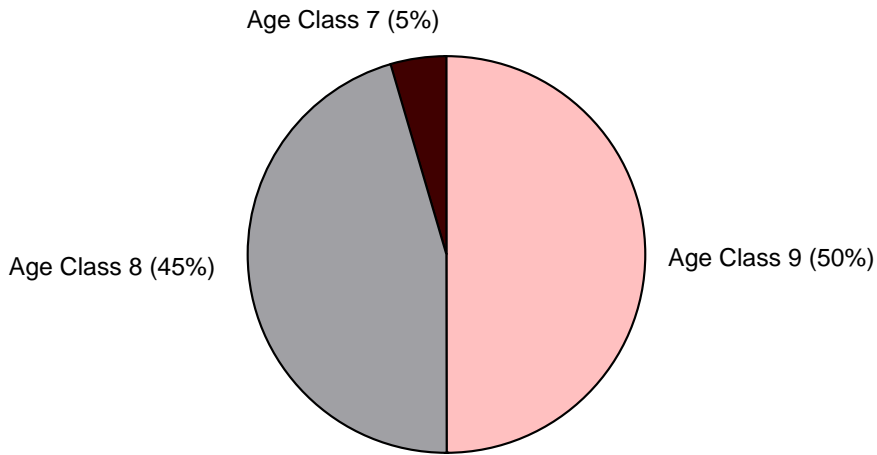


Figure 2. Forest Cover age class of 22 nest areas in the KFD.

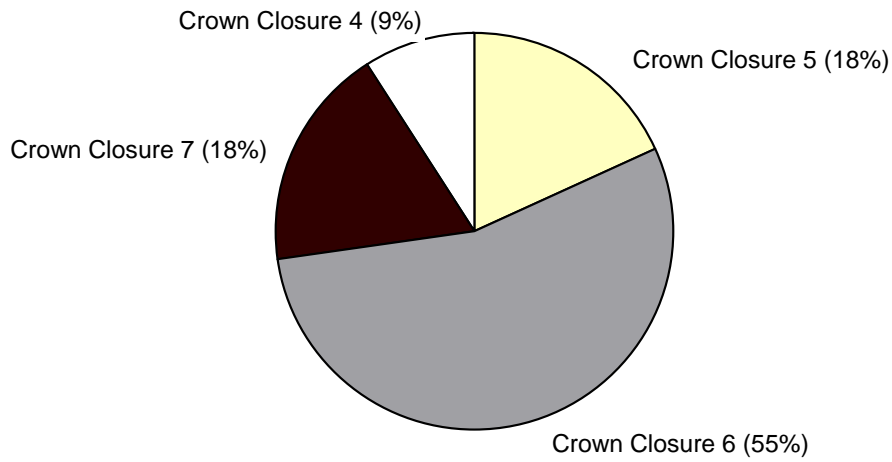


Figure 3. Forest Cover crown closure for 22 nest areas in the KFD.

Information on habitat data from the detailed work carried out at the 15 nest areas known from previous years is presented below for those who are unfamiliar with previous year's reports. That data for each nest tree and nest area is summarized in Tables 6 and 7, respectively. Out of the 48 nests that were known at the end of this year 45 (94%) are in Hw trees, while the other 3 are in Ba. From the 33 nests located up to last year, nest tree heights ranged from 15.3 to 37.8 m, with a mean of 27.6 m (SD = 5.2). DBH of nest trees ranged from 39 to 72 cm, with a mean of 58.8 (SD = 12.4, n = 33). Nest heights range from 10.3 to 28.5 m, with a mean of 16.2 m (SD = 3.9, n = 33). In 81 % of these nest sites (n = 19), the nest tree was the largest tree within that site (0.04 ha plot). Nests are usually 60 - 80 cm broad, 20 - 30 cm deep, and situated against the trunk.

Within the nest area (nest site and 4 random nest area plots pooled), the 22 nest areas are in age class 8 or 9, hemlock dominated forest, mesic Hw-Step moss or Hw-Oak Fern sites. Using the forest cover label, crown class at the 22 nest areas varied between 4 and 7 (55% = 6, 18% = 5, 18% = 7 and 9% = 4) (Fig. 3). Canopy closure, measured at the center of each plot using a densiometer, ranged from 35 to 85% with a mean of 75.4% (SD = 15.4) (n = 14) (Table 7). Shrub cover is sparse, with a mean of 17.4% (SD = 13.6) (n = 14). Nest areas were most frequently found on mid slope positions (45%), with the remainder of locations split evenly between Lower, Bench and Crest slope positions. The average slope was 12.1% (SD = 6.9, range 0-25). Topographic elevation of the nest areas ranges from 240 - 930 meters above sea level, but 12 of 14 nest areas are located between 400 - 600 m.

Table 6. Tree and nest characteristics for 33 northern goshawk nests located in the Kispiox FD up to 1998.

| Nest Area | Nest Label | Active | | | Nest tree | | | Nest | | | | | |
|------------|------------|--------|----|----|-----------|--------------|----------|------------|------------|------------|-------------|------------|------------|
| | | 96 | 97 | 98 | Species | Decay Stage* | DBH (cm) | Height (m) | Height (m) | Aspect (°) | Length (cm) | Width (cm) | Depth (cm) |
| Bailey | CULL_97_1 | 3 | 3 | | Hw | E3 | 69 | 32.0 | 18.6 | 242 | 100 | 70 | - |
| | CULL_97_2 | | | | Hw | - | - | 29.5 | 14.5 | 290 | 85 | 63 | 37 |
| Blackstock | BLAC_98_1 | | | 3 | Hw | E1 | 57 | 28.1 | 13.3 | 200 | 60 | 70 | 25 |
| Cranberry | CRAN_97_1 | 3 | | | Hw | E1 | 41 | 34.0 | 28.5 | 175 | 97 | 55 | 17 |
| | CRAN_98_1 | | | 3 | Hw | E1 | 66 | 34.2 | 16.2 | 180 | 60 | 60 | 30 |
| Date Creek | DATE_97_1 | 3 | | | Hw | E2 | 72 | 25.3 | 16.8 | 4 | 80 | 80 | - |
| | DATE_98_1 | | | | Hw | E1 | 58 | 30.3 | 17.5 | 192 | 60 | 60 | 30 |
| | DATE_98_2 | | | | Hw | E3 | 90 | 33.8 | 22.0 | 150 | 60 | 70 | 35 |
| Helen Lake | HELE_98_1 | | | 3 | Hw | E1 | 58 | 31.3 | 15.3 | 300 | 60 | 50 | 25 |
| Ironsides | IRON_97_1 | 3 | | | Hw | E1 | 40 | 26.1 | 18.0 | 240 | - | - | - |
| | IRON_98_1 | | | 3 | Hw | E3 | 54 | 27.5 | 17.0 | 2 | 60 | 50 | 20 |
| Kitsuns | KITS_96_1 | 3 | 3 | | Ba | E1 | 56 | 35.3 | 20.6 | 170 | 80 | 56 | 25 |
| | KITS_96_2 | | | | Ba | E1 | 56 | 35.3 | 11.6 | 150 | 70 | 65 | 23 |
| | KITS_96_3 | | | | Ba | E1 | 53 | 28.9 | 17.3 | 150 | 73 | 47 | 17 |
| | KITS_97_1 | | | 3 | Hw | E1 | 52 | 27.0 | 14.7 | 50 | 75 | 40 | 22 |
| Kuldo | KULD_96_1 | | | | Hw | E1 | 67 | 30.5 | 21.0 | 185 | 55 | 55 | 28 |
| | KULD_96_2 | | | | Hw | E2 | 52 | 34.2 | 15.5 | 360 | 90 | 65 | 23 |
| | KULD_97_1 | 3 | | | Hw | E1 | 54 | 28.8 | 18.0 | 326 | - | - | - |
| | KULD_98_1 | | | 3 | Hw | E1 | 28 | 28.8 | 10.5 | 306 | 70 | 30 | 10 |
| Mill Creek | MILL_96_1 | 3 | | 3 | Hw | E1 | 68 | 37.8 | 13.0 | 260 | 80 | 60 | 15 |
| | MILL_97_1 | | 3 | | Hw | E1 | 39 | 16.8 | 15.6 | 350 | 70 | 60 | 30 |
| | MILL_98_1 | | | | Hw | E1 | 54 | 30.0 | 18.3 | 84 | 60 | 60 | 30 |
| Muldoe | MULD_97_1 | 3 | | | Hw | E1 | 51 | 23.8 | 13.8 | 140 | 79 | 74 | 12 |
| | MULD_98_1 | | | 3 | Hw | E1 | 31 | 27.3 | 13.5 | 74 | 60 | 60 | 30 |
| Pope | POPE_97_1 | 3 | 3 | | Hw | E2 | 55 | 17.2 | 8.0 | 160 | 88 | 73 | 24 |
| Skeena- | SKEE_97_1 | 3 | | | Hw | E2 | 40 | 24.2 | 20.0 | 250 | 100 | 65 | - |
| Tea Lake | TEAL_96_1 | 3 | | | Hw | E1 | 61 | 29.4 | 15.8 | 300 | 86 | 63 | 27 |
| | TEAL_96_2 | | | | Hw | E1 | 64 | 33.1 | 12.4 | 330 | 80 | 57 | 25 |
| | TEAL_96_3 | | | | Hw | E1 | 51 | 29.1 | 15.7 | 45 | 89 | 71 | 20 |
| | TEAL_96_4 | | | | Hw | E1 | 61 | 28.1 | 18.8 | 215 | 55 | 50 | 18 |
| | TEAL_97_1 | | 3 | | Hw | E1 | 51 | 28.5 | 17.1 | 283 | 100 | 50 | - |
| Ten Link | TENL_97_1 | 3 | | | Hw | E1 | 50 | 29.5 | 15.5 | 183 | 88 | 84 | 19 |
| | TENL_97_2 | | | | Hw | E2 | 39 | 17.5 | 10.3 | 120 | - | - | - |

* Wildlife Tree Classification System coding (E = evergreen; 1-9 decay class)

A blank 'Active' box indicates no sign of breeding was detected.

See Appendix 1 for explanation of coding.

Table 7. Ecological characteristics of 14 goshawk nest areas in the Kispiox Forest District known up to 1998 (see Appendices 2, 3 and 4 for coding)

| Nest Area | Year Active | | | Forest Cover | Site Series | Struct. Stage* | Succ. Status* | Canopy closure (%) | Shrub cover (%) | Slope (%) | Aspect (°) | Meso slope position |
|-----------------|-------------|----|----|--------------|-------------|----------------|---------------|--------------------|-----------------|-----------|------------|---------------------|
| | 96 | 97 | 98 | | | | | | | | | |
| Bailey | 3 | 3 | | HB(S) | 01 | 7s | Mcc | 85 | 30 | 5 | 48 | mid |
| Blackstock | | | 3 | H(B) | 03 | 7s | Mcc | 86 | 45 | 15 | 200 | mid |
| Cranberry | 3 | 3 | | H(S) | 03 | 7s | Mcc | 77 | 15 | 25 | 335 | Lower |
| Date Creek | 3 | | | H | 01 | 7s | Mcc | 76 | <1 | 15 | 100 | Bench |
| Helen** | 3 | 3 | | HB | 03 | 7m | Mcc | 86 | 25 | 10 | 30 | mid |
| Ironside | 3 | 3 | | H(Pl) | 01 | 7s | Mcc | 86 | 1 | 15 | 195 | Upper |
| Kitsuns | 3 | 3 | 3 | H(B) | 01 | 7s | Mcc | 70 | 13 | 15 | 330 | mid |
| Kuldo | | | 3 | H(B) | 01 | 7s | Mcc | 75 | 13 | 7 | 320 | Crest |
| Mill Creek | 3 | 3 | | HC(B) | 01 | 7s | Mcc | 76 | 5 | 10 | 220 | Lower |
| Muldoe | 3 | 3 | | H(Pl) | 01 | 7s-m | Mc | 89 | <1 | 5 | 320 | Upper |
| Pope | 3 | 3 | | H(CBS) | 01 | 7s | Mcc | 83 | 15 | 10 | 250 | mid |
| Skeena-Carrigan | 3 | | | H(B) | 01 | 7s | Mcc | 74 | 30 | 30 | 360 | Upper |
| Tea Lake | 3 | | | H | 01 | 7m | Mcc | 85 | 18 | 5 | 330 | Lower |
| Ten Link | 3 | | | H(B) | 01 | 7s | Mcc | 65 | 10 | 9 | 150 | mid |

*For code definitions refer to Field Manual for Describing Terrestrial Ecosystems (BC MELP and BC MoF, 1998). A blank 'Active' box indicates no sign of breeding was detected.

** In 1997 reports of begging juveniles were received after the young birds had dispersed from the nest area, and the nest area was not pinpointed until this year.

Comparison of Nest Site and Nest Area Habitat

To help in our understanding of goshawk habitat selection, a preliminary analysis of the habitat similarities between the nest site plot and the nest area was conducted in 1998..

Similarities and differences between nest sites and nest areas are identified below based on a preliminary analysis. Differences are not statistically significant (Chi-square X^2) but showed consistent trends among nest areas.

Differences between nest sites and random plots within the nest area

Comparisons between the nest site plot and 4 random plots in the nest area show the nest site has less large regeneration (trees DBH>7.5 and DBH<15 cm) than nest area plots in 80% of cases (n=20). Nest sites also had more coarse woody debris than random plots in 70 % of cases (n=20).

Similarities between nest sites and the nest area

No differences were seen in site series, age class, vegetation composition (all layers), canopy closure, number of stems/ha, percent shrub cover, small regeneration (<7.5 cm DBH.) or basal area between nest sites and the nest area.

A more thorough analysis of this data will take place for inclusion in the final project report, but although some differences between the nest plot and random sites may occur, we still cannot identify these as a prior when looking for a goshawk nest in the field. It is therefore unlikely that these fine scale differences can be used as goshawk management tool.

Nest Area Location in Relation to Roads and Cutblocks

Stratified surveys for goshawks within the KFD took place in 1996 (Mahon and Franklin 1997) and since then remaining habitat has been both systematically surveyed (in areas not covered in 1997) and non-systematically surveyed using the access offered by logging roads. Throughout this time no trend has been seen in location of nests in relation to the location of roads or cutblocks. Pooled information for nests and nest areas is presented below. However, it should be noted that we have no information on whether nests were situated in there prent locations prior to or after logging/road construction.

The median distance of active nests to roads was 300 m, (range 35-1500 m, n = 34). Usually the nearest road was a spur road with fairly low levels of traffic. The Pope nest, however, was within 300 m of the Pope mainline. Active hauling occurred on this road through the winter until approximately March 15 and again throughout the summer commencing approximately June 15. This nest successfully fledged young in the year the nest was discovered (1997) and was also successful in 1998 and 1999. The median distance to the nearest cutblock edge for all nest areas located was also 300 m (range 47-1500 m, n = 23). However, caution is needed in the interpretation of these results, as to the significance of the distance of roads or cutblocks to the location of nests, as we do not know if nests were built prior to or after the road or cutblock were created. Nests close to these features may still fail in the long term and continued monitoring of these sites is therefore necessary.

We also looked at the topographical location of the nests in relation to cut blocks and roads <300 m, to see if they influenced location of nest areas. Of the 12 nest areas that had

cutblocks and roads <300 m away 20% had cutblocks below the nest area, 27% were at the same elevation (either side along the same slope) and 53% were above.

Nest Tree and Nest Area Fidelity

Of the 14 previously known nest areas 10 (71%) were active this year. A summary of nest area occupancy from 1995-1999 is presented in Table 8.

Nest area fidelity (i.e. re-use of same nest area) is 92 % for nest areas where we have conducted 2 or more years of surveying. The number of nests located in each nest area ranges from 1 - 5 with an average of 2.6 (SD = 1.2) nests per nest area. Most nests are within 200 m of each other, with a median distance of 120 meters between nests, and a range of 0 - 500 m.

Table 8. Nest area fidelity by goshawks in the Kispiox Forest District.

| Nest Area | Evidence of Multi-year Use* | Type of Evidence | Years Used | | | | |
|-----------------|-----------------------------|------------------|------------|------|------|------|------|
| | | | 1995 | 1996 | 1997 | 1998 | 1999 |
| Bailey | Y | M | | Y | Y | Y | Y |
| Blackstock | Y | M | | | | Y | Y |
| Corral | N | | | | | | Y |
| Cranberry | Y | M | | | Y | Y | N |
| Date | N | | | | | | Y |
| Flatfish | Y | M | | | | | Y |
| Helen | Y | M | | | Y | Y | Y |
| Iltzul | N | | | | | | Y |
| Ironside | Y | M | Y | Y | Y | Y | Y |
| Kitsun's | Y | M | | Y | N | Y | Y |
| Kuldo | Y | M | Y | N | N | Y | Y |
| Mill Creek | Y | M | | | Y | Y | Y |
| Muldoe | Y | M | | | Y | Y | Y |
| Pope | Y | R | | | Y | Y | Y |
| Shedin | Y | R | | | | | Y |
| Skeena | Y | M | | | Y | N | Y |
| Smokee | Y | F | | | | | Y |
| Sunday Lake | Y | M | | | Y | N | N |
| Tea Lake | Y | M | Y | Y | Y | N | N |
| Ten Link | Y | M | | | Y | N | N |
| Upper Cranberry | N | | | | | | Y |
| Weber Ck. | Y | R | | | | | Y |

M = Multiple nests, R = Re-use of a nest in different years, F = Fledged young detected in previous years.

*Use = Breeding attempt initiated. Y = breeding attempt, N = breeding not attempted.

Breeding Chronology

Nest activity was monitored at least weekly between May 15 and 20th August, 1999 at all known nests. Information on the timing of laying to the dispersal of young from the PFAs was obtained from 8 nests and summarized below in Table 9. Laying and hatching dates were obtained by backdating fledging dates using the average development time of males and females (Ehrlich *et al.* 1988)

Timing of breeding was the earliest recorded in the past three years, with mean laying date 13 days earlier than the previous earliest average date in 1997 (23rd April). This, coupled with high breeding success (see Reproductive Parameters below), suggests that the birds were in good condition.

The information obtained on the timing of laying can be used to help identify when raptors are using nest areas, a period when we know that birds are vulnerable to disturbance (Nelson and Titus 1989). In goshawk's nest areas are used 2-4 weeks prior to laying (Jones 1979), and in the Kispiox Study therefore birds can be expected to be using nest areas from early March onwards.

Dispersal of the birds took place in late July and early August (Table 9) with young from most nests dispersing in the first week of August.

Table 9. Breeding chronology of 10 goshawk nests in the Kispiox Forest District in 1999.

| Breeding Event | Average Date | S.D.. (days) | Date Range |
|----------------|------------------------|------------------|---------------------|
| Laying | 7 th April | n/a – back dated | |
| Hatching | 16 th May | n/a – back dated | |
| Fledging | 24 th June | 5.8 | June 16 – June 30 |
| Dispersal | 6 th August | 5.0 | July 30 – August 14 |

Reproductive Parameters

The number of young fledged this year ranged from 0 – 4 with most breeding pairs fledging 2-3 young (Table 10-). Three nests were reported to us very late in the season, and although we know these pairs did fledge young the exact number is unknown and they were therefore excluded from further analysis.

Table 10. Summary of nest productivity for goshawk nests in the KFD in 1999.

| Nest | # of chicks | # fledged | # dispersed | Nest successful in dispersing young |
|-----------------|-------------|-----------|-------------|-------------------------------------|
| Bailey* | 0 | 0 | 0 | No |
| Blackstock | 2 | 2 | 2 | Yes |
| Corral | | 3 | 3 | Yes |
| Cranberry | 2 | 2 | 2 | Yes |
| Date | 3 | 3 | 3 | Yes |
| Flatfish | 2 | 2 | 2 | Yes |
| Helen Lake | | 3 | 3 | Yes |
| Ironside | 3 | 3 | 3 | Yes |
| Iltzul | | 3 | | |
| Kitsuns | 3 | 3 | 3 | Yes |
| Kuldo | 3 | 3 | 3 | Yes |
| Mill Creek | 3 | 3 | | |
| Muldoe | 3 | 3 | 3 | Yes |
| Pope | 4 | 4 | 4 | Yes |
| Shedin | | | ≥1 | Yes |
| Skeena-Carrigan | | 3 | | |
| Smokee | | 3 | | |
| Sunday Lake | 0 | 0 | 0 | No |
| Tea | 0 | 0 | 0 | No |
| Ten | 0 | 0 | 0 | No |
| Upper Cranberry | | | ≥1 | Yes |
| Weber Ck. | | | >2 | Yes |

*Nest failed at egg stage. ■ = Nest not located and information not available.

In 1999 an average of 2.7 juveniles (SD = 1.1, range 0-3, n = 16) fledged per breeding attempt in 1999 (Table 11) based on nests detected and monitored early in the breeding season. The one nest failure was in a known nest area where a new nest was built and adult(s) were present but failed to lay or failed at the egg stage from an unknown cause. It is notable that this is one of the same nest areas that failed in 1997, and is an area free from disturbance at the present time.

Table 11. Number of young fledged per breeding attempt.

| <u>Year</u> | <u>Young per pair</u> | <u>SD</u> | <u>Sample size</u> | <u>Failed nests</u> |
|-------------|-----------------------|-----------|--------------------|---------------------|
| 1997 | 2.2 | 0.7 | 9 | 0 |
| 1998 | 1.7 | 1.1 | 10 | 2 |
| 1999 | 2.7 | 1.1 | 16 | 1 |

Of 10 active nest areas located early in the breeding season (first half of the incubation period) (a time that reduces the possibility that early nest failures were missed), 90(91?)% fledged young (Table 10) compared to 80% of nests last year and 100% in 1997 (a year when early nest failures may have been missed).

The number of young fledged from successful nests and that were located early enough in the season to allow the total number of young to be counted, saw 2.7 chicks fledging per pair this year (Table 12). This indicates that food supply was abundant this year, influencing positively both the number of eggs laid and the survival of those young, compared to other years. No correlation's with weather patterns were observed.

Table 12. Number of young fledged per successful nest.

| <u>Year</u> | <u>Young per pair</u> | <u>SD</u> | <u>Sample size</u> |
|-------------|-----------------------|-----------|--------------------|
| 1997 | 2.2 | 0.7 | 9 |
| 1998 | 1.7 | 1.1 | 8 |
| 1999 | 2.9 | 0.5 | 15 |

Post-fledging Area Assessment

We monitored juvenile post-fledging locations at 9 nest areas in 1999. For analysis of the post-fledging area sizes we graphed the 90% and 100% area estimators (Appendix 7). The 90% area we felt best represented the primary area of use by the juveniles and we present these results in detail. From the 90 - 100% area estimators we see a large increase in area primarily due to few outlier points (Table 13), but presentation of a 100% area allows us to compare our results with the limited data available from other studies.

The size of the 90% ADK estimate for post-fledging area sizes ranged from 4.8 – 19.2 ha, with an average area of 12.1 ha (SD = 5.4, n = 9), at 100% this area increases in range from 7.00 – 40.8 ha, with an average of 21.6 ha (SD = 12.8, n = 9). For comparison the Minimum Convex Polygon (MCP) had a 90 % core area ranging from 2.5 – 11.9 ha with an average size of 5.7 ha (SD = 3.0, n = 9) and 100% ranging from 3.1 – 19.0 with an average size of 10.3 (SD = 6.1, n = 9). At 90% area Harmonic Mean analysis (HM) provides a range of area from 5.6 – 59.6 ha with an average of 25.9 ha (SD = 17.3, n = 9) (Table 14).

The PFA seems to correspond to the nest area both in size and habitat characteristics. We typically found the juveniles within the 200 m radius defining the nest area and within the same forest cover polygon as the nest. Towards the end of the fledgling period some juveniles made exploratory trips outside the core PFA (points typically represented in the 95-100% area estimators) into a variety of habitats often including clearcut edges.

Table 13. Estimates of post-fledging area size (ha) for 1999 nests using ADK and MCP.

| Location | ADK | | | MCP | | | N |
|------------|------|------|------|------|------|------|----|
| | 100% | 95% | 90% | 100% | 95% | 90% | |
| Blackstock | 11.7 | 6.8 | 5.8 | 4.7 | 4.7 | 2.8 | 13 |
| Corral | 39.0 | 34.4 | 19.2 | 19.0 | 15.2 | 11.9 | 20 |
| Date | 33.7 | 27.8 | 15.2 | 15.9 | 11.6 | 7.4 | 24 |
| Helen Lk. | 17.9 | 12.7 | 12.6 | 9.7 | 5.6 | 5.2 | 20 |
| Ironside | 7.0 | 5.0 | 4.8 | 3.1 | 3.1 | 2.5 | 19 |
| Kitsuns | 19.6 | 14.0 | 11.9 | 8.4 | 8.4 | 5.9 | 15 |
| Kuldo | 13.9 | 13.9 | 12.9 | 9.6 | 9.6 | 4.2 | 17 |
| Muldoe | 40.8 | 28.4 | 19.2 | 18.3 | 10.7 | 8.1 | 25 |
| Pope | 11.0 | 7.8 | 7.0 | 4.1 | 4.1 | 3.3 | 17 |

Table 14. Estimates of post-fledging area size (ha) for 1999 nests using harmonic mean method.

| Location | Harmonic Mean | | | N |
|------------|---------------|------|------|----|
| | 100% | 95% | 90% | |
| Blackstock | 8.6 | 7.8 | 5.6 | 20 |
| Corral | 46.3 | 38.3 | 33.3 | 39 |
| Date | 28.4 | 24.2 | 21.3 | 51 |
| Helen Lk. | 63.3 | 49.9 | 39.6 | 40 |
| Ironside | 12.8 | 11.6 | 9.5 | 39 |
| Kitsuns | 46.2 | 37.5 | 34.6 | 30 |
| Kuldo | 17.3 | 13.6 | 12.6 | 34 |
| Muldoe | 93.7 | 75.8 | 59.6 | 51 |
| Pope | 21.7 | 18.9 | 17.3 | 40 |

As an aid to management of goshawk nest areas we have been recording the topographic position of the post-fledging areas in relation to the location of the nest. This year 8 of the 9 nests areas monitored were situated on sites where a pronounced slope was present (<10 % within the nest area). Of these young (Table 15), those from 3 nests were typically found down slope from the nest, at 3 nests young were typically found equally at the same elevation to the nest or down

slope from the nest. In one case young were typically found equally below/above and at the same elevation as the nest and only in one case (Kitsuns) were young typically located above the nest. Pooling the observations from all nests, 45% of all locations were down from the nest, 34% the same elevation as the nest and 21% above the nest.

Table 15. Topographic location of young fledged in 1999 in relation to their natal nest site.

| Nest | Chick location relative to nest | | | |
|------------|---------------------------------|-------|-------|---------|
| | Same | Below | Above | Unknown |
| Blackstock | 6 | 8 | 5 | 2 |
| Corral | 14 | 12 | 13 | 2 |
| Helen | 5 | 23 | 10 | 1 |
| Ironside | 12 | 13 | 9 | 14 |
| Kitsuns | 3 | 2 | 13 | 12 |
| Kuldo | 10 | 21 | 0 | 3 |
| Muldoe | 18 | 25 | 6 | 2 |
| Pope | 21 | 15 | 1 | 2 |
| Total | 89 | 119 | 57 | 38 |

Prey Remain and Pellet Analysis

Emphasis was not placed on pellet analysis this year, but pellets and prey remains were collected at all active nests, as has been the case over the last 4 years. Looking at the prey remains found around nests this year no dramatic shift in prey is expected, although as usual there were the few unusual prey items which this year included a young Barred Owl. Analysis of goshawk diet was conducted last year and this information has been included for those who are unfamiliar with last years report. Dietary analysis was not conducted this year, as we focused upon other parts of the project. Analysis of this years pellets and a larger sample from previous years will take place in the final year of the project. In 1998, a sub-sample of 40 pellets from 4 nests (10 at each nest) was analyzed. From this sub-sample 72 prey items were identified (Table 16), 40 of which were mammals and 32 birds. The types of prey species and the proportion of those species in pellets or as a proportion of the prey items as a whole were very similar to the previous years (1997). Red squirrel continues to be the main prey species detected and remnants were present in 83% of pellets (93% last year n = 198). Birds (primarily

medium sized passerines) were found in 80% of the pellets in 1998 compared to 70% in 1997. No statistically significant shift in diet was detected. A few of the more unusual prey items identified this year included raven, flying squirrel and 2 ducks. Sample sizes between nest areas were too small to test for significant differences in the diet between nest areas.

Table 16. Summary of prey occurrence in a sub-sample of goshawk pellets in the KFD in 1998 (and 1997 in brackets).

| SPECIES (or FAMILY/GROUP) | Occurrence in No. pellets | Occurrence % of Pellets | Proportion of Total Prey Items |
|----------------------------------|--------------------------------------|------------------------------------|---|
| RED SQUIRREL | 33 (185) | 0.83 (0.93) | 0.46 (0.55) |
| SNOWSHOE HARE | --- (2) | --- (0.01) | --- (0.006) |
| RED-BACKED VOLE | --- (5) | --- (0.01) | --- (0.006) |
| MICROTUS SP. | --- (4) | --- (0.01) | --- (0.006) |
| UNKNOWN VOLE SP. | 6 (1) | 0.15 (0.06) | 0.08 (0.003) |
| UNKNOWN MAMMAL | 1 (0) | 0.03 (0.0) | 0.01 (0.0) |
| SHREW SP. | --- (1) | --- (0.005) | 0.000 (0.003) |
| MAMMAL TOTAL | 40 (198) | 1.00 (1.00) | 0.56 (0.59) |
| NORTHERN FLICKER | 3 (13) | 0.08 (0.07) | 0.04 (0.04) |
| RED-BREASTED SAPSUCKER | 1 (4) | 0.03 (0.02) | 0.01 (0.01) |
| THREE-TOED WOODPECKER | --- (1) | --- (0.001) | --- (0.001) |
| WOODPECKER SP. | 1 (6) | 0.03 (0.03) | 0.01 (0.02) |
| STELLER'S JAY | 4 (4) | 0.10 (0.02) | 0.06 (0.01) |
| THRUSH SP. | 1 (8) | 0.03 (0.04) | 0.01 (0.02) |
| VARIED THRUSH | 4 (8) | 0.10 (0.04) | 0.06 (0.02) |
| UNKNOWN BIRD | 18 (95) | 0.45 (0.48) | 0.25 (0.28) |
| BIRD TOTAL | 32 (139) | 0.80 (0.70) | 0.44 (0.41) |

Adaptive Management Program

Of the 22 nest areas located in the forest district 13 areas have been or will be affected by harvesting/road building activity within 300 meters of known nests (Table 17). Within all these areas harvesting activity will potentially (as assessed from the furthest movement of the young within the post-fledging areas at monitored nests) encroach on the post-fledging area of the young.

So far harvesting activity has taken place <300 meters of nests at 4 sites. During the winter of 1996/97 logging occurred near (distance road = 110m, distance to cutblock edge = 325m) the 1996 Kuldo nest. One alternate nest actually occurred within the clearcut and was

retained in a 1.5 ha Wildlife Tree Patch. Active logging and hauling continued in the block until the end of February 1997. We conducted extensive call playback surveys and nest searches within a 1 km radius of the 1996 nest throughout 1997 but failed to detect any goshawks in the area. In 1998 we did find an active goshawk nest in the area approximately 125 m north of the 1996 nest, 190 m from the spur road and 400 m from the new cutblock, and this year birds bred at another nest located 200 m SW of the 1998 nest.

At Tea Lake selective logging took place in the winter of 1998/99 within the nest area and to within 35 meters of nests that were used last in 1995 and 1996, and within 150 meters of the 1997 nest. No goshawks were located in the vicinity in 1998 or 1999 during the incubation, chick or fledging stage. At the Cranberry nest, logging has yet to take place within the block, but logging took place up slope and 250 meters from the nest in the winter 1998/99 and no birds bred in 1999. At Ten Link logging took place within 100 meters of active nests in 1994/1995, isolating the nest area in a 250 m wide leavestrip with a 25 year old cutblock on one end of the cutblock. Goshawks are known to have occupied the nest area in 1996 (possibly 1995) but have not used the area in the last two years.

For those areas that are to be logged this winter we will conduct comprehensive call playback surveys in the vicinity of the old nest areas and surrounding habitat to try to determine the response or relocation of nest area by those pairs in 2000. Where possible this process will be aided by the use of radio transmitters attached to adults in the summer prior to harvest.

Table 17. Proposed or completed timber development near goshawk nest areas in the KFD.

| Nest Area | Year of Harvest | Prescription |
|-----------------|-----------------|--|
| Kuldo | 1996/97 | 30 ha clearcut within 325 m of 1996 nest; road within 110 m; retention of alternate nest within a 1.5 ha WTP. |
| Skeena-Carrigan | 2000/01 | 40 ha clearcut to within 50 m of active nest; retention of WTPs and single WTs to maintain some cover across cutblock. |
| Upper Cranberry | 2000/01 | Nest in center of block. Prescription yet to be developed with stakeholder. |
| Kitsun's | 1999/00 | 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. |
| Mill Creek | 1999/00 | 30 ha clearcut to within 100 m of 1995/98 nest. |
| Shedin | 2000/01 | Nest in center of block. Clear cutting to proceed as part of an aggressive trial to determine what birds do if their nest area is logged. Cutting will take place outside the breeding season and adult(s) will be radio tagged. |
| Smokee | 2000/01 | 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. Birds will be radio tagged to monitor movement after winter logging. |
| Corral | 2000/01 | Nest in SW corner of block. 9 ha wildlife tree patch around nest, connected to contiguous forest to the south. |
| Date | 2000/01 | Buffer or possibly partial cut, still under discussion with Norm Bilodeau. |
| Iltzul | 2000/01 | Nest 35 m from block with no action developed to date |
| Ten Link | 1997/98 | Logged within 100m of nest area on two sides and neat area bisected by road. |
| Tea Lake | 1998/99 | Single tree selection (50% removal) to within 35 m of active 1996 nest and 2 other alternate nests; within 125 m of 1997 nest. |
| Cranberry | 2000/01?? | 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 |

DISCUSSION

Goshawk Density

Eight new active nest areas were located. Only two (Corral and Date) were in the center of the study area, the others six were scattered in the Skeena, Cranberry and Suskwa watersheds. The estimated minimum density of nesting pairs of goshawks within the Kispiox valley in 1999 (1.5 per 100 km²), was the same as estimated for 1997 and 1998. In other North American studies the reported population densities vary widely. In the boreal forest of Alaska McGowan (1975) reported a density of 0.18 -1.5 pairs/100 km² and in the Yukon, Doyle and Smith (1994) reported annual populations ranging from 1.0 - 10.0 pairs 100 km². The large ranges in the number of pairs in both studies were attributed to dramatic changes in the prey available. In other North American studies outside the boreal forest the population densities range from 1.17 - 10.7 pairs 100 km² (Squires and Reynolds 1997). No density estimates are available from any of the recent and on-going studies within British Columbia.

By using the number of responses to playback in itself as an index of breeding abundance, we can compare the results from call playback stations in similar habitat to our own both in B.C. and Alaska. These results show a nest detection rate per station of 0.0018 in this district in 1997 (Doyle and Mahon 1998), compared to 0.0010 on the Queen Charlottes Islands (Chytyk 1996) and a rate of between 0.000 - 0.0015 per station in 5 S.E. Alaskan studies (Iverson *et al.* 1996). In contrast, an ongoing study in the Lakes Forest District indicated a higher density with 0.008 nest located per playback (Mahon and Doyle 2000). This information suggests that populations are comparable or possibly slightly higher in the Kispiox, than other areas along the adjacent coast, but lower than drier areas further inland.

Habitat

The general habitat of all 22 nest areas in the Kispiox is quite similar. All nests areas are in mature (age class 7-9), Hw dominated forest, mesic Hw-Step moss or Hw-Oak Fern sites. In previous years our surveys included systematic call playback within stratified habitat types from the valley floor to the sub-alpine in the Kispiox Valley. Due to variable response rates to playback calls a negative response cannot be used with any confidence to infer that a goshawk nest area does not occur within the effective sample area on a station by station basis. However, with large numbers of survey stations and wide geographic coverage the detection of goshawk

nests using call playback has been shown to represent habitat preferences within fairly broad habitat types (Daw *et al.* 1998). Major habitat types within the Kispiox Valley where playback surveys have been conducted, but birds and nests not found, include deciduous and mixed forest stands across the valley floor (corresponding to site series ICHmc2-06, 51, 52, 53, 54) and Bl or Sx leading forest (usually with more open canopies and often corresponding to moister, richer sites ICHmc2-04, 05, 07). This year systematic call playback surveys in the ESSF, also failed to detect any birds and their nests. Where nests are found they appear to be evenly spaced along either side of the valley at roughly 20-km intervals and future work will continue to look at the spatial distribution of these areas. Recent results from a long term study on the Kaibab Plateau, Arizona (Reynolds and Joy 1998) identified a regular spacing of nest areas across the landscape and found spacing distance to be an effective variable for predicting nest area locations.

Variation in reproductive success and exploring its possible links with forestry

The timing of breeding in 1999 was thirteen days earlier than in any year previously. We also saw higher productivity from pairs when looking at all pairs located (Table 9), or just at those pairs that were for successful in fledging young (Table 12). Combined this suggests that breeding females were in better body condition than last year (Newton 1998, Perrins 1970). The period of time from fledging to dispersal was shorter last year (around a week) than this year, which suggests that food supply during this period was limited (Kenward *et al.* 1993a) through the entire breeding season, when compared to this year. When we look at all three years we find that this relationship between timing of breeding and productivity is significant (Fig. 4). This could be due to poor food supply, over the previous winter (Olsen and Olsen 1989), with birds only coming into breeding condition later in the season. Later breeding in a year typically results in fewer young being raised (Newton 1998), and several explanations have been proposed to explain this pattern: (i) late breeders are in poor body condition which either prevents or impairs egg formation, (ii) late breeders are inexperienced or less committed parents and therefore they raise fewer young, or (iii) late breeders choose to lay fewer eggs because their offspring are less likely to recruit into the breeding population, (independent of seasonal food supply; Drent and Daan 1980; Daan *et al.* 1988; 1990).

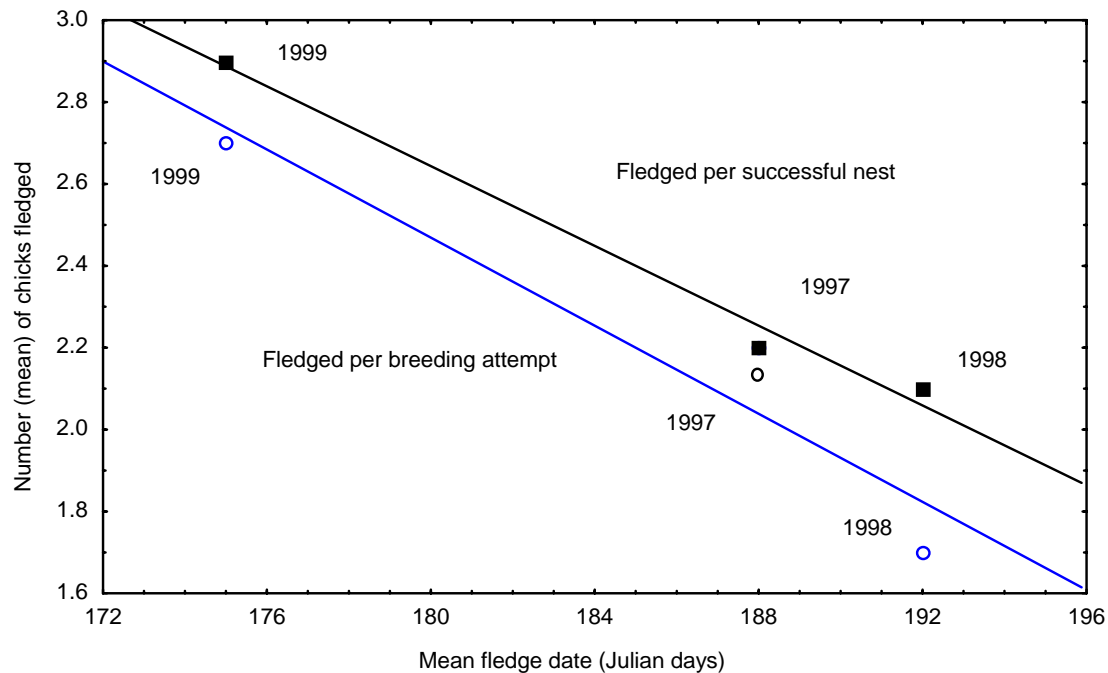


Figure 4. Relationship between the mean number of fledged young per breeding attempt and per successful pair per year and the timing of breeding (Julian days). ($r^2 = -0.95$ for both comparisons).

Nest area fidelity is very high with 100% of sites (at sites which have been known for more than one year) showing re-use of those sites over a number of years. When this dependence on a particular area is combined with the reduced breeding success the later in a season a pair breeds, it indicates that any activity in a nest area that delays the timing of breeding is detrimental to the health of a population. From a forestry viewpoint we will continue to monitor any activity near nests in the March/April period a time when birds are laying, to determine if there is any information that these activities do delay laying and the consequent productivity of those pairs.

Fledging success in the Kispiox (1.7 – 2.7 chick/pair 1997-1999) is within the expected range compared to other studies in North America, with 0.5 - 2.8 fledged per nesting attempt, from 12 studies (Iverson *et al.* 1996). When compared to *Accipiter g. laingi* on Vancouver Island (McClaren 1998), where reproductive output (chicks fledged) from successful nests

ranged from 1.7 (n =15) in 1994 to 2.2 (n = 6) in 1995, the range of our results in the last couple of years are similar, 2.1(n = 10) to 2.9 (n = 14). In northern boreal forests 2.0 (n = 33) chicks fledged per nest in northern Alaska (McGowan 1975) and 2.8 (n = 19) chicks fledged in Yukon (Doyle and Smith 1994). The fledging success from this study therefore is typical for the species across a range of habitats.

The percentage of nest areas where breeding birds are detected in any given year in the Kispiox appears to be typical for the species, with breeding attempts taking place in 55%, n = 9 (1998) and 90%, n = 10 (1999) of territories that were active in previous years. This rate of re-occupancy is within the range seen in other studies, with 63% reported in the Cascade Mountains (Woodbridge and Detrich 1994) and 67% in the Kaibab Plateau (Crocker – Bedford 1990), but this figure varies greatly (0 – 92%) and is thought to be dependent on winter conditions and food availability (Squires and Reynolds 1997). In our study the high percentage of areas showing re-use (90%) supports the earlier conclusion that breeding conditions this year were optimal.

Post-fledging Areas

Post-fledging areas have now been mapped for the young at 19 nests over the past 3 years. After our initial development year (1997), we have developed a standardized and effective range of techniques to accurately map this post-fledging area. The post-fledging area for ADK and MCP has fluctuated between years (Table 18) but the large variation between nests probably accounts for much of the difference.

Table 18. Post-fledging areas (ha) at 90% ADK and MCP 1997-1999.

| Year | ADK | SD | Range | MCP | SD | Range | N |
|------|------|-----|----------|-----|-----|----------|---|
| 1997 | 8.2 | 2 | 6.0-10.5 | 4.5 | 1.5 | 2.3-5.6 | 4 |
| 1998 | 7.3 | 4.5 | 2.5-14.7 | 3.6 | 1.7 | 1.4-5.3 | 6 |
| 1999 | 12.1 | 5.4 | 4.8-19.2 | 5.7 | 3 | 2.5-11.9 | 9 |

Our estimates of post-fledging area size from 19 nests in the Kispiox over the past 2 years are generally smaller than those reported in the literature. Comparing the size of our PFA's to other studies is problematic as methods for estimating this area vary in the literature

and because very little work in this detail has been conducted. Few other studies have similar detailed information of PFA's of the young and none are in Hemlock dominated forests. One of these studies was in the aspen forests of northeast Nevada by Shipman (1998 and unpubl.data), where the average 90% PFA using MCP = 10.4ha (SD = 7.0, range = 22.6 – 3.1 ha, n = 7) (no information is available on ADK area). A similar study was initiated last year in the sub-boreal spruce of the Lakes Forest District and here the PFA at 90% MCP = 9.7 ha (SD = 5.03, range = 15.6 – 4.5, n = 4) and ADK = 20.9 ha (SD = 9.44, range = 32.8 – 13.4, n = 4) (Mahon and Doyle 2000). In both these studies therefore the PFA's using the MCP area estimator are very similar in size, in contrast to the Kispiox where this area is half the size.

There is little information available on the size of PFA's from other studies. What is available uses observed distances of the young from the nest and assumes this distance is the same 360 degrees around the nest, rather than an estimation of the area used using an appropriate area use estimator. The most exhaustive assessment of juvenile goshawk movements was conducted by Kenward *et al.* (1993a) in the boreal forests of Sweden. In this Swedish study they found post-fledging (sample of 221 juveniles) movements were generally <400 m from the nests, corresponding to an area of 20-50 ha. A management paper by Reynolds *et al.* (1992) suggests that PFAs are much larger – more in the area of 200 ha (800 m radius around the nest) but it is unclear what data they are basing this on. A study by Kennedy *et al.* (1994) in New Mexico's ponderosa pine, showed that during the first 4 weeks after fledging 88 % of all chick locations (n = 193, 16 nestlings, 6 nests) were within 200 m of the nest and during the next 2 -3 weeks 76% of location (n = 108) were within 800 m of the nest (no area given). In contrast a much smaller area of use was seen in the Kispiox, with juveniles staying within a relatively small core area (<200m from the nest) until making long distance dispersal trips out of the PFA. Two of the radio-tagged juveniles in 1998 had a more intermediary stage of 5-10 days during which they more slowly expanded out of the core PFA to distances up to 400 m from the nest. This year four more juveniles were radioed, and all stayed within the documented nest area, until they made long range movements (>5 km) from this area.

Why the post-fledging area in the Kispiox is smaller than other studies is unknown, but the wide range of PFA size among all studies may be attributable to different habitat types, and differences in juvenile behavior and habitat use within these habitats.

In this study, we are the first to have the opportunity to look at post-fledging area use by the young from the same nest in consecutive years. The adult bird used exactly the same nest

(Pope), and the post-fledging area using 90% ADK was 7.0 ha this year and 8.2 ha in 1998. In contrast the area used by the birds was different, with only a quarter of the area overlapping with the previous year (Fig. 5).

Our study is also unique in being able to look at PFA's for the young fledged from other nests within the same nest area in consecutive years, and again the variability seen in the size of area used by young from the same nest in consecutive years was also present. Movements of the young from the same nest areas were monitored in 1998 and 1999 at four sites, with the largest change in PFA size occurring at the Kuldo nest (90% ADK) from 2.6 ha in 1998 to 12.9 ha in 1999. The smallest change in area use was seen at Blackstock, from 3.2 ha in 1998 to 5.8 ha in 1999. The reasons for these changes in area are unclear (see below for further discussion), but this shift in size and position of the post-fledging area needs to be taken into account when managing for nest areas in the landscape.

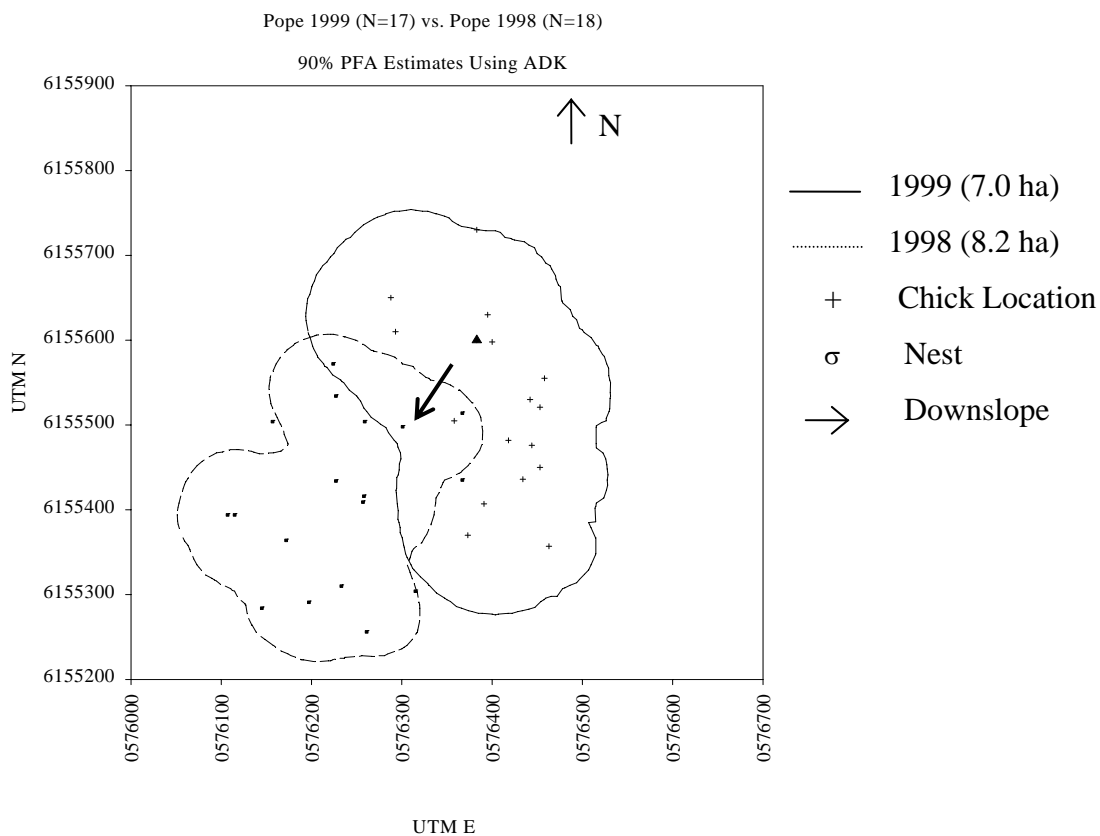


Figure 5. Post-fledging area used by young at the Pope nest in 1998 and 1999.

Work in the remaining years of the project will continue to focus on PFA use due to the potential vulnerability of the juveniles during this period and the importance of defining this area accurately for the effective management of this species. . Specifically we will continue to focus on PFA habitat composition, juvenile habitat use and behavior, and temporal changes in use as the juvenile mature. While the size of PFAs has been previously examined in other areas, its position in relation to the nest has not been. This may have implications on the shape of a management zone that is left around the nest site. This year the topographical location of young in relation to the nest was very similar to last year with 45% down slope from nests (n = 265) in 1999 and 52% (n = 205) down slope from the nest in 1998. We did see an increase in the number of birds located above the nest (8% in 1998 to 21 % this year) but the same trend was also evident in 1997, with 68% of locations below the nest and 12% above (n = 127 locations, and 4 nest areas). Reasons for a shift to more observations above the nest may be due to sample size, but it is also possible that the factors driving the size and shape of the PFA's change annually (see below for further discussion).

We are also able to look at the movement of chicks and shape of the PFA in relation to man made disturbance in the form of clearcuts and roads. Detailed analysis has yet to take place, but as the fledged young get older they appear to move further from the nest, and in the latter stages of the post-fledging period they are seen frequently perched on edge trees adjacent to clearcuts and roads. A similar study was initiated this year in the Lakes Forest District (Mahon and Doyle 2000) and in the five nest areas monitored this year the young appear to utilize habitat in relation to its availability within the PFA. In one case logging took place within 100 m of the nest in the previous winter, the birds still bred successfully and late in the post-fledging period the young moved out of the forest and into wildlife tree patches in the cut block.

One suggestion for the shape of individual PFA's is that the young move in the direction of the typical returning adult (Kenward *et al.* 1993a). If this is true, then the placement of a road or cutblock may affect the choice of nest site. For example birds may be unwilling to fly across large open areas when carrying prey (although we already have some anecdotal evidence from the Pope nest that this is not the case). To assess the effects of openings on nest site selection we are looking at the position of individual nest sites in relation to the nearest cutblock edge (median distance = 300 m, n = 23). No data is available for this year, but 50% of nests in 1998 (n = 14) had cutblocks adjacent to the nest along the same hillside, 24% above the nest and 26% below the nest. In the next few years of this study we will continue to focus on the re-use of

nest areas, to determine if nest areas effected by harvesting activity are abandoned disproportionately to control nest areas. We will also focus on identifying features (size, shape, habitat) of the PFA's that are common to all sites, which can then be used by forest managers to ensure effective management of the breeding site requirements of this species.

Prey Remain and Pellet Analyses

Diet of the goshawk within the KFD (primarily Interior Cedar Hemlock) has not changed significantly over the last few years with a diet dominated by red squirrels and medium sized passerines. Red squirrels were present in 83% of pellets analyzed in 1998, and in 93% of pellets in 1997. The percentage of birds in the diet changed from 70% of pellets in 1997 to 80% of pellets in 1998. This consistency in the diet suggests there was not a major change in prey population from 1997 to 1998, and from remains found at nests in 1999 no major shift in diet is expected. McGowan (1975) and Doyle and Smith (1994) found that major changes in diet were correlated to major fluctuation in prey populations.

Within B.C. and S.E. Alaska, goshawk diet has been analyzed using different analytical techniques and therefore direct comparisons are only possible between our study and 2 others on the Queen Charlotte and Vancouver Islands (both Coastal Western Hemlock). On Vancouver Island red squirrels were the dominant prey item at the majority of monitored nests (80%, n = 15; Ethier 1997 no reference). On the Queen Charlotte Islands a very similar pattern was seen with red squirrels being present in 89% of the pellets (44 pellets from 4 nests; Roberts 1996). Pellets from 4 nests in the Lakes District (unpub.data) were also collected in 1998, and analysis of 40 pellets shows that within the Sub-Boreal Spruce BGC zone red squirrels were only present in 60% of pellets with medium - large birds making up more of the diet. In Alaska diet analysis has been conducted using prey remains (Iverson *et al.* 1996) and birds dominated the diet, but strong biases towards the recovery of feathers versus squirrel fur (Simmons *et al.* 1991) make comparisons impractical.

The dominance of red squirrels and medium sized passerines in the diet within the Kispiox is not surprising given the available prey species, detailed analysis of prey densities has yet to be conducted, but, species typical in the goshawk diet across N. America (review in Squires and Reynolds 1997) are uncommon or absent within the KFD. The average size of these prey species (236 grams Red Squirrel and 50 grams passerines; Doyle and Smith 1994) are

smaller than average prey sizes seen in many other studies (review in Squires and Reynolds 1997) where snowshoe hares, ground squirrels or higher densities of grouse were available. Availability of red squirrels, as the primary prey species in the Kispiox (especially in winter when fewer passerines are around), may be a key factor to goshawk presence and reproductive success (Perrins 1970) in the District.

Funding permitting we are now in a position (large sample size and multiple years of samples) to conduct analysis of the diets from birds within territories that produce many young versus those that do not produce many young. This will enable us to see if nests in particular habitats are more productive than others, with a link between habitat and the availability of particular prey.

The large sample of nest areas also allows us to collect sufficient pellets and remains at nests early in the season to establish a guide to the winter dietary requirements of this species. We will therefore visit nest areas in late February - early April to collect remains prior to the arrival of migrant prey.

Subspecies *laingi*?

Morphological measurements taken of the 4 resident adults females and 8 juvenile goshawks captured over the 2 years in the Kispiox (Appendix 6) are more similar in size and markings to the *laingi* sub-species (McClaren 1998) than to the *atricapillus* subspecies (Squires and Reynolds 1997). Blood samples have been collected from the 6 individuals examined in 1998 and DNA analysis will hopefully take place in the near future. A detailed analysis and an expanded discussion of the taxonomic association of the goshawks present in the KFD will take place in the final report from this inventory project, by which time a larger sample of trapped birds and the results of DNA analysis will hopefully be available.

Effects of timber extraction on goshawks

Little information is available on the effects of logging on goshawk populations, however, we do know that nest failure can be directly attributed to harvesting activities near to nests during the breeding season (Boal and Mannan 1994, Speiser 1992), particularly during the pre-laying and incubation periods (Toyne 1997). It has also been observed that nests were further than expected from human habitation, in proportion to the available habitat (Speiser and Bosakowski 1987).

On a fine scale the observations by Toyne (1997) at 9 nests, is the most detailed study to date on the effects of disturbance on nesting success of birds. In this study four nests were subject to disturbance (harvesting activity, road building) within 100 meters of an active nest which contained eggs or young <10 days old. In all cases nest failed. One other nest at the same stage in the breeding season did successfully raise young when logging activity was 300 meters from the nest. The remaining four sites were subject to harvest operations from 60 - 400 m from the nest after the chicks had fledged. The young left the nest stand where operations were taking place and moved to adjacent areas. No information is available on how many of these young survived.

In the Kispiox, no active nests have been subject to this kind of activity close (≤ 300 m) to nests during the breeding season, and from our observations the occasional presence of layout crews or others in the nest area has not caused any nest failures. But, it is also noted that forestry personnel in the district are typically aware of the sensitivity of the birds to disturbance and avoid prolonged time near to active nests. The presence of active logging roads >300 meters from nests also appears to have no effect on the birds (Pope, Corral, Date) and a study by Grubb *et al.* (1998) showed that truck noise 500 meters from a breeding bird caused no reaction.

Other factors can cause nest failure, but timber harvest is the primary threat to nesting birds (Reynolds 1989, Crocker-Bedford 1990), and in the boreal forest many nests in the landscape are probably logged without the knowledge that birds are present in a stand (pers. obs). It has also been observed that in harvested landscapes, fragmentation of forests through forestry does not necessarily reduce the density of birds, however, nest areas associated with contiguous forest were more consistently used when compared to those in highly fragmented stands (Woodbridge and Detrich 1994). Further, it has also been shown that nest areas have a higher basal area than random plots in the landscape (Hargis *et al.* 1994). At what point fragmentation of a landscape or nest area causes a decline in populations is unknown, and it is also probably dependent on the rate of fragmentation, and the rate of growth of new habitat (in our case forest) and increases in its associated prey.

Systematic monitoring of individuals effected by different types of forestry prescription did take place around active nest areas in the Kaibab Plateau of Arizona (Crocker-Bedford 1990). In this 10-year study, buffers were place around nest trees with small buffers of 1.2 – 2.4 ha and large buffers of 16 - 200 ha. Both showed a significant decline in re-occupancy by birds compared to control populations. Unfortunately, this study did not radio mark birds, and

therefore it could be argued that its main conclusion is simply that where fragmentation does occur birds are likely to abandon the nest area. We cannot be sure that birds did not just move to more contiguous areas of forest outside the expected nest areas, or if the number of birds actually declined.

Further, it may be impractical to make conclusions about probable effects of forestry on goshawk populations in the ICH and CWH, from the patterns seen in other landscapes. The density of birds in the ICH is very low (0.015 km² per pair) versus population in the Kaibab Plateau area of Arizona for example where goshawk densities are 10 times higher (0.14 km² pair). The smaller territories of birds in the Kaibab may lead to large localized effects of logging due to forest fragmentation on the individual pairs. Even if logging occurs around a nest area in the ICH and CWH, and goshawk pairs leave as suggested by the Crocker-Bedford study, are the birds necessarily lost from our landscape at this stage in the rotation? In the Kispiox ICH the necessary suitable contiguous forest stands required for nesting, as suggested by Woodbridge and Detrich (1994) are available for most birds within their present home range at this stage in the rotation.

A similar argument can be made for the difficulties in trying to compare loss of foraging habitat through fragmentation. In Scandinavia, historic densities were around 0.2 km² and Widen (1997) argues that the loss of foraging habitat through fragmentation rather than the loss of the nest itself has caused a population decline in goshawks. In the densely forested landscape of the ICH and CWH it may be argued that an increase in edges, which are utilized as a preferred hunting habitat in some landscapes (Kenward 1982), and the growth of a new forest and its associated prey (e.g. ruffed grouse. pers.obs.), outweighs any threats to the birds from habitat loss at this stage in the harvest rotation.

Another possible effect of landscape change on the density of goshawks is the displacement of goshawks by other raptors and predators either by directly competing for food, competing for nest sites, or indirectly through predation of young and/or adults Kenward (1996). At the present time there is no obvious increase in any species that are likely predators of goshawks, probably due to the same reason we see a low density of goshawks, the low density of winter prey. In contrast, there may be competition for summer prey, but the most common potential competitor the red-tailed hawk, is at present at lower densities in the ICH and CWH than goshawks (pers. obs.). It has also been observed that no goshawk nests have failed from starvation in the period that red-tailed hawks are present, which in this area is just in the summer

months. Predation of nestlings at this stage in the rotation in the Kispiox Forest District, also appear to be not an issue with no nest failures from predation occurring in the 37 breeding attempts monitored in the last three years.

In the Kispiox study, 13 of the 22 nest areas (Table 17) located are or will be effected by various harvest prescriptions, and 12 sites in all have logging within 300 meters of the nest. This spring 4 of the 14 known nest areas (Table 10) did not show any sign of breeding activity, and 3 of these were those most recently affected by logging. At two sites logging took place last winter within 300 meters of a known nest (Cranberry and Tea Lake) and at the other site logging has taken place on 3 of the 4 sides (Ten Link) around the nest area in recent years. At the one other site (Sunday Lake) no logging took place near the nest area. This sample size is too small to allow for a critical evaluation of this trend, but the large number of nests to be effected by harvesting in the future, both here and in the Lakes Forest District, will enable us to evaluate the significance of these observations. In contrast, we can show now that many nest areas (12 of 22) are within 300 meters of logged edges (road and clearcut), and yet 9 of these bred successfully this year. Time will tell if these are just short term or long term nest area placements. Time will also tell if the failure of 3 nests near actively logged edges was caused by the short-term disturbance of a site, rather than along term abandonment of a site. Many of those nests closer than 300 meters to an artificial edge may also have been placed there by the birds after harvest, we do not know. Whenever the birds began to use a site, the fact that so many nests are within 300 meters of artificial edges suggests that the edge in itself is not the cause of nest area abandonment.

One of the more consistent features of goshawk nest site requirements both in the Kispiox and other studies that may have an influence on harvesting activities in nest areas, is canopy closure. Canopy closure at nest sites and in the nest area in the Kispiox is typically high with a mean of 75% using the densiometer. This is also typical of other studies (Hall 1984, Reynolds *et al.* 1992) and this feature is highlighted in a review of goshawk nesting attributes (Squires and Reynolds 1997), as a consistent feature for goshawk nesting requirements across N. America. Not surprisingly therefore observers have pointed to any forest practices in the nest area that reduce canopy closure beneath 50% as detrimental to the occupancy or re-occupancy of that site by nesting goshawks (Bright-Smith and Mannan 1994, Breier and Drennan 1997). What had not be tested at this stage is the effects of selective logging in the nest area, that still retains a high degree of canopy closure.

We will be able to test many of these questions in conjunction with the harvesting prescriptions taking place around nests this next winter, both in the Kispiox and as part of a similar study (with a comparable sample size) in the Lakes Forest District.. The more fundamental question of the effects of landscape fragmentation on the population of goshawks as a whole will come from the continued monitoring of this large sample of goshawk nest areas, thus allowing for a better understanding of goshawk management considerations in a harvested landscape.

MANAGEMENT RECOMMENDATIONS

Because this is the 4th year of a 5-year project and data collection and analysis are ongoing, development of management recommendations would be inappropriate at this time. Multiple years of data are required because nest areas, the basis for all other aspects of the study, are difficult to find and it has taken several years to find enough of them to produce a sample from which statistically significant information can be derived. As well, high annual variation in nest area occupancy and reproductive parameters require multiple years of data to achieve meaningful sample sizes and to determine consistent trends. Final analysis of the data for most aspects of the study next year, coupled with the assessment of adaptive management trials near nests will allow us to provide effective management direction upon completion of the study.

INVENTORY CRITIQUE

The primary RIC standardized inventory method used in this study is the call playback technique. This survey technique has several limitations that must be recognized in the interpretation of survey results. For goshawk inventory the use of call playbacks is limited to finding active nests and should probably not be used to infer other types of habitat use. Goshawks are much less likely to respond to call playback when they are not on the nest area, and response rates are so low that no meaningful kind of analysis can be conducted. This is not necessarily true for other raptors, especially some owls, which are more likely to respond to playback throughout their territory. Even at a nest area goshawk response rates are variable and the lack of a response cannot be used to infer that there is not an active nest within the effective survey range. Over the last 3 years, we have conducted playback at known nests to assess response rates and found adult responses of 20-60% depending on the individual bird and time within the breeding period. Juvenile response rates are much higher once they have fledged and

response rates approach 100% during the 2 weeks before they disperse.

In the remaining year of the project, systematic call playback surveys will not be used extensively as we focus on other monitoring activities at the 22 known nest areas. Call playback will be used sporadically to locate new nest sites in the known nest areas and to follow up on reported goshawk sightings. As well, limited call playback surveys may be conducted within our core study area to try to determine spacing distances between nesting pairs.

RIC standards for call playback surveys have historically required that an Ecosystem Field Form (EFF) be filled out at each station. We have criticized the EFF requirement because of the low and variable response rates discussed above (ie. no response does not mean a goshawk or nest was not there) and the inappropriate scale of the EFF (10m) relative to the scale of the call survey (200m). Discussions with members of the Resource Inventory Committee (James Quayle) and others over the last few months have resulted in the dropping of the EFF requirement for call playback standards for 1999. Collection of Forest Cover information at each playback station will continue.

For PFA assessments we will continue to use a combination of visual/aural searching and telemetry tracking to locate juveniles in the PFAs. While the telemetry tracking we did this year generally corroborated the visual/aural searches we did, validating it as an effective method, it was also apparent that some juveniles seem to expand the size of the PFA outside of the core area prior to dispersing. Telemetry tracking is required to determine the proportion of birds that exhibit this behavior and to effectively monitor them once they have left the core area.

LITERATURE CITED

- Ackerman, B.B., Leban, F.A., Samuel, M.D., and Garton, E.O. 1990. User's manual for program HOME RANGE. 2nd Edition. Technical Report 15. Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho, USA. 80pp.
- BC Ministry of Environment, Lands and Parks and BC Ministry of Forests. 1998. Field manual for describing terrestrial ecosystems. Land Management Handbook 25. Crown Publications, Victoria, BC.
- Banfield, A.W.F. 1974. The mammals of Canada. University of Toronto Press.
- 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.

Biotrack Ltd. Dorset, England. BH20 5AX

- Boal, C.W. and R.W. Mannan. 1994. Northern goshawk diets in ponderosa pine forests on the Kaibab Plateau. *Stud. Avian Biol.* 16:97-102.
- Bosakowski, T. & M.E. Vaughn. 1994. Developing a practical method for surveying Northern Goshawks in managed forests of the Western Cascades. Abstract only. Raptor Research Annual Meeting.
- 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.
- Crocker-Bedford, D.C. and B. Chaney. 1988. Characteristics of goshawk nesting stands. Pp 210-217. In: R.L. Glinski, B.G. Pendleton, M.B. Moss, M.N. LeFranc, Jr., B.A. Millsap, and S.W. Hoffman (eds.), *Proceedings of the Southwest raptor management symposium and workshop*. Nat. Wildl. Fed. Sci. Tech. Ser. No. 11.
- Chytky P. 1996. Northern population Inventory of the Queen Charlottes Islands/Haida Gwaii. Min. of Env. Lands and Parks, Smithers.
- Daan, S., C. Dijkstra, R. Drent and T. Meijer. 1988. Food supply and the annual timing of avian reproduction. Pp. 392-407 in *Acta XIX Congressus Internationalis Ornithologicae*, volume 1 (Ouellet, H. ed.). National Museum of Natural Sciences, University of Ottawa Press, Ottawa, Ontario.
- Daan, S., C. Dijkstra and J. Tinbergen. 1990. Family planning in the kestrel (*Falco tinnunculus*): the ultimate control of covariation of laying date and clutch size. *Behaviour* 114:83-116.
- Daw, S.K., DeStefano and R.J. Steidl. 1998. Does survey method bias the description of northern goshawk nest site structure? *J.Wildl.Manage.* 62(4): 1379 –1384.
- Drent, R.H. and S. Daan. 1980. The prudent parent: energetic adjustments in avian breeding. *Ardea*. 68:225-252.
- Doyle, F.I. and J.N.M. Smith. 1994. Population responses of Northern Goshawk to the 10-year cycle in numbers of Snowshoe Hares. *Studies in Avian Biology* 16: 122-129.
- Doyle, F.I. and T. Mahon. 1998. Inventory of the northern goshawk in the Kispiox Forest District. "Annual Report 1997" B.C. Ministry of Environment, Lands and Parks. Smithers.
- Ehrlich, P.R., D.S. Dobkin and D. Wheye 1988. *The Birders Handbook*. Simon and Schuster. pp. 228-229.
- Errington, P.L. 1930. The pellet analysis method of raptor food habits study. *Condor* 32:292-296.
- Godfrey, W.E. 1986. *The birds of Canada*. National Museums of Canada.
- Grubb, T.G., L.L. Pater and D.K. Delaney. 1998. Logging truck noise near nestling northern goshawks. U.S. Dept. Agri. For. Serv. Rocky Mtn. Res. Stat. Research Note. RMRS-RN-3:1-2.

- Hall, P. A. 1984. Characterization of nesting habitat of goshawks (*Accipiter gentilis*) in northwestern California. MSc. Thesis. Humboldt State University.
- Hargis, C.D., C. McCarthy and R.D. Perloff. 1994. Home ranges and habitats of northern goshawks in eastern California. *Stud. Avian Biol.* 16:66-74.
- Hayward, G.D. and R.E. Escano. 1989. Goshawk nest-site characteristics in western Montana and Northern Idaho. *Condor* 91:476-479.
- Iverson, C.G., Hayward, G.D, Titus, K., DeGayner, E., Lowell, R.E., Crocker-Bedford, D., Scheimpf, F.P., and J. Lindell. 1996. Conservation Assessment for the Northern Goshawk in Southeast Alaska. USDA Forest Service Gen. Tech. Rep. PNW-GTR-387.
- Jones, S. 1979. Habitat management series for unique or endangered species - Rep.No. 17. Tech.Note. U.S. Dept.Interior - Bureau of Land Management. 51 pp.
- Joy, S.M., Reynolds, R.T. and D.G. Leslie. 1994. Northern goshawk broadcast surveys: Hawk response variables and survey cost. *Studies of Avian Biol.* 16:24-30.
- Kie, J.G., Baldwin, J.A. and Evans, C.J. 1994. CALHOME home range analysis program. Electronic user's manual. California Department of Fish and Game
- 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.
- Kennedy, P.L., Ward, J.M., Rinker, G.A. and J.A. Geesman. 1994. Post-fledging areas in Northern Goshawk home ranges. *Studies in Avian Biology* No. 16:75 – 82.
- Kenward, R.E. 1982. Goshawk hunting behaviour, and range size as a function of habitat availability. *J. Anim. Ecol.* 51:69-80.
- Kenward, R.E. and V. Marcstrom. 1983. The price of success in goshawk trapping. *J. Raptor Research* 17(3): 84-91.
- Kenward, R.E. 1996. Goshawk adaptation to deforestation: Does Europe differ from North America? Chapter 23:233-243. *In: Raptors in Human Landscapes*. Academic Press. London.
- Kenward, R.E., V. Marcstrom and M. Karlbom. 1993a. Post-nesting behaviour in goshawks, *Accipiter gentilis*: I. The cause of dispersal. *Anim. Behav.* 46 : pp 365-370.
- Kenward, R.E., V. Marcstrom and M. Karlbom. 1993b. Post-nestling behaviour in goshawks, *Accipiter gentilis*: II. Sex differences in sociality and nest switching. *Anim. Behav.* 46 : pp 371-378.
- 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.
- Lawson, E. J.G. and A.R. Rodgers. 1997. Differences in home-range size computed in commonly used software programs. *Wild. Soc. Bull.* 25 (3) :721-729.
- Mahon, T. and S. Franklin. 1997. Inventory of the northern goshawk in the Kispiox Forest District. 1996 Annual Report. B.C. Ministry of Environment, Lands and Parks. Smithers.
- Mahon, T. and F.I. Doyle. 2000. Inventory of the northern goshawk in the Lakes Forest District. Annual Report. Unpubl. Rep. WildFor Consultants. Telkwa, BC.

- Marti, C.D. 1987. Raptor food habits studies. pp 67-79 *In*: B.A. Giron Pendleton, B.A. Millsap, K.W. Cline and D.M. Bird (eds.) Raptor Management Techniques Manual. Natl. Wildl. Fed. Washington.D.C..
- McClaren, E. 1998. "Queen Charlotte" Goshawk (*Accipiter gentilis laingi*). Population Inventory Summary for Vancouver Island, British Columbia (1997/1998). Unpub. rep. Ministry of Environment, Lands and Parks. Victoria, BC.
- McGowan, J.D., 1975. Distribution, density and productivity of Goshawks in Interior Alaska. USFG W-17-4, W-17-5, W-17-6.
- Nelson, B.B. and K. Titus. 1989. Silviculture practices and raptor habitat associations in the northeast. pp. 171-179. Giron Pendleton, B. (proj. ed.) Proc. Northeast management symposium and workshop. Natl. Wildl. Fed., Washington. D.C. 356 pp.
- Newton, I. 1997. Population ecology of raptors. T&A.D. Poyser. London.
- Newton, I. 1998. Population limitation in birds. Academic Press. London.
- Olsen, P.D. and Olsen, J. 1989. Breeding of the peregrine falcon II. Weather, nest quality and the timing of egg laying. *Emu* 89:1-5.
- Perrins, C.M. 1970. The timing of birds' breeding season. *Ibis* 112:242 – 255.
- Resource Inventory Committee (RIC). 1995. Standard methodologies for the inventory of biodiversity in British Columbia: Raptors. Min. of Environment, Victoria, B.C.
- Reynolds, R.T. 1989. Accipiters. Pp.92-101. *In* Proceedings of the Western Raptor Management Symposium and Workshop, Nat. Wildl. Fed. Sci. and Tech Series No. 12.
- 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 Accipiter in Oregon. *J. Wildl. Manage.* 46(1): 124-138.
- Reynolds, R.T. and S.M. Joy. 1998. Distribution, territory occupancy, dispersal, and demography of northern goshawks on the Kaibab Plateau, Arizona. Arizona Game and Fish. Heritage Project No. 194045.
- Roberts, Anne-Marie. 1996. Food habits of Northern Goshawks in the Queen Charlotte Islands and in the Kispiox Forest District 1996. Unpub. Rep. Ministry of Environment. Smithers, BC.
- Schaffer, W., B. Beck, J. Beck, R. Bonar & L. Hunt. 1995. Draft habitat suitability index (HSI) model. Unpub. rep. Foothills Model Forest, Hinton, Alberta.
- Shipman, M. 1998. Post-fledging area of the Northern Goshawk. M.Sc. Thesis. Boise State Univ. Idaho.
- Simmons, R.E., D.M. Avery and G. Avery. 1991. Biases in diets determined from pellet and remains: Correction factors for a mammal and bird-eating raptor. *J. Raptor Res.* 25:63-67.
- 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.
- 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.
- Watson, J.W., Hays, D.W. and D.J. Pierce. 1999. Efficacy of northern goshawk broadcast surveys in Washington State. *J.Wildl.Manage*. 63:98-106.
- 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.
- Worton, B.J. 1987. A review of models of home range for animal movement. *Ecol. Model*. 38: 277-298.

APPENDIX 1. Resource Inventory wildlife tree coding for decay class.

| Class | 1 | 2 | 3 | 4 | 5 |
|--|----------------------------|---------------------------------|-------------------------------------|-------------------------------|-------------------------------------|
| Portion on Ground | Elevated on support points | Elevated but sagging slightly | Sagging near ground, or broken | All of log on ground, sinking | All of log on ground, partly sunken |
| Twigs < 3 cm (if originally present) | Present | Absent | Absent | Absent | Absent |
| Bark | Intact | Intact or partly missing | Trace | Absent | Absent |
| Shape | Round | Round | Round | Round or oval | Oval |
| Texture | Intact, hard | Intact, hard to Partly decaying | Hard, large pieces, partly decaying | Small, blocky pieces | Many small pieces, soft portions |
| Invading Roots | None | None | In sapwood | In heartwood | In heartwood |

For more details see: Field Manual for describing Terrestrial Ecosystems. No. 25.

APPENDIX 3. Resource Inventory coding for Successional Status.

| | | |
|------------|---------------------------------|--|
| NV | Non-Vegetated | Vegetation < 5% cover |
| PS | Pioneer Seral | Vegetation occupies most of site |
| YS | Young Seral | Young stands of seral, not yet self thinning |
| MS | Maturing Seral | Mid-seral stands of mature age (60-140 yrs.) |
| OS | Overmature Seral | Upper canopy trees dying, secondary shade tolerant trees growing. |
| YC | Young Climax | Trees even aged and young < 80 yrs, species composition same as climax, but climax community structure not developed. |
| YCC | Young Climatic Climax | Zonal sites, even aged (<80 yrs.), climax community structure |
| YEC | Young Edaphic Climax | Ediphically diffeent from Zonal sites. |
| MC | Maturing Climax | Mature climax community, self thinning, developed Understory. |
| MCC | Maturing Climatic Climax | Zonal sites, climax community, approaching even age. May be gap between main and regenerating canopy. Stands at least 80-120 yrs, but usual older. |
| MEC | Maturing Edaphic Climax | Azonal sites. Differs from MCC in species composition. |
| DC | Disclimax | Self perpetuating community, normal succession arrested. |

For more details see: Field Manual for describing Terrestrial Ecosystems. No. 25.

APPENDIX 4. Resource Inventory coding for Site Series

| <u>Site Series</u> | <u>Description</u> |
|--------------------|--------------------|
|--------------------|--------------------|

| | |
|--|--------------------|
| | Zonal Sites |
| | Drier Sites |
| | Fresh to wet Sites |

APPENDIX 5. British Columbia Forest Cover coding.

Forest Cover

Major species with minor species in brackets

H = Hemlock, C = western red Cedar, B = Balsam (True Fir), S = Spruce, Pl = lodgepole Pine

Forest Cover Label

eg: 9416 - 14

First number = Age class, Second number = Height class, Third number = Stocking class. Fourth number = Crown closure.

Fifth and Sixth numbers (if present) = Site class.

Age Class: 7 = 121 - 140 yrs, 8 = 141 - 250 yrs., 9 = 251+ yrs.

Height Class: 3 = 19.5 - 28.4 m, 4 = 28.5 - 37.4 m

Stocking Class: 1 = all mature, ≥ 76 /ha stems

Crown Closure: 4 = 36-45%, 5 = 46-55%, 6 = 56-65%, 7 = 66-75%, 8 = 76-85%

Site Class: Based on species and age of leading species.

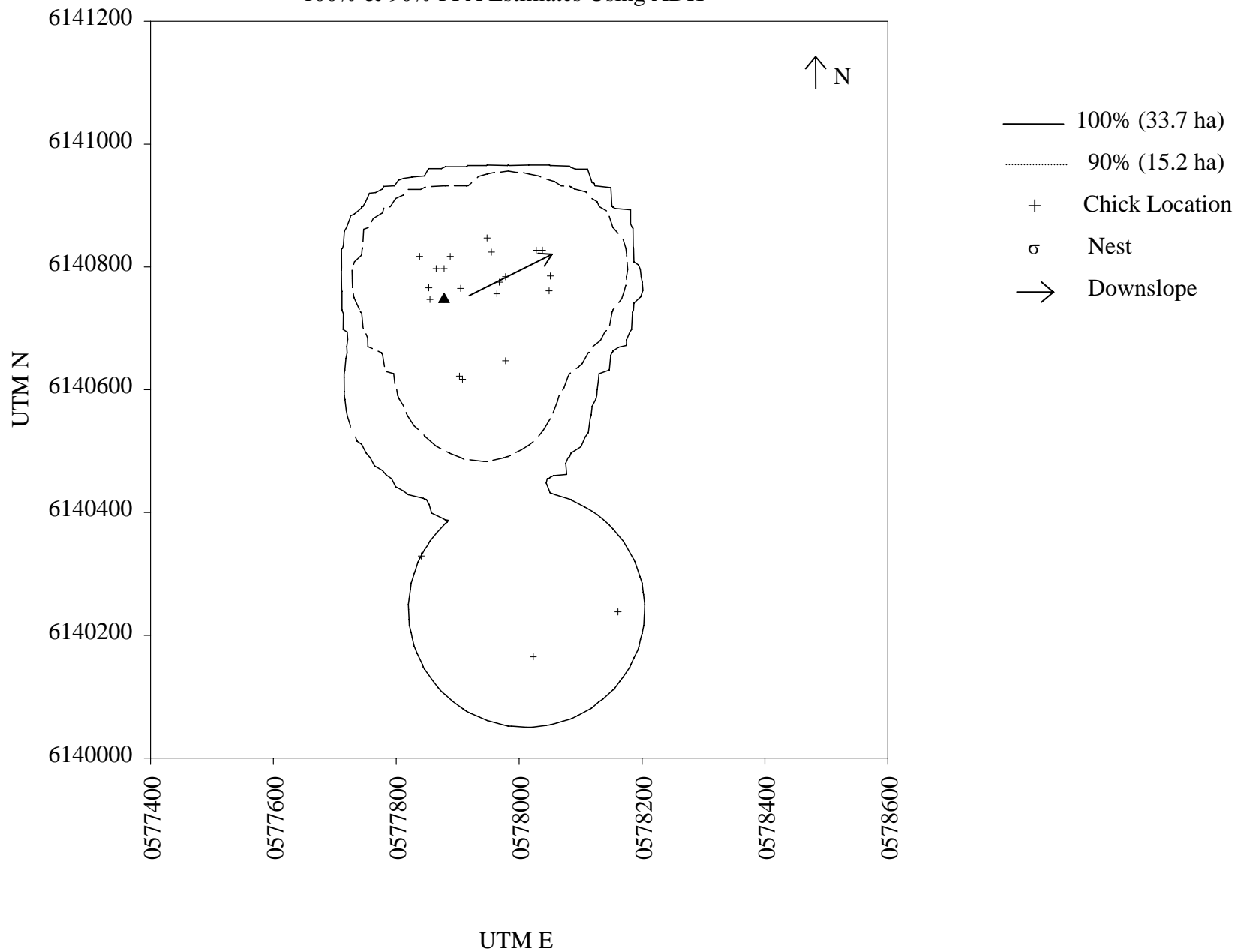
APPENDIX 6. Measurements of trapped goshawks. (all measurements in mm) HY = Hatching Year (all measurements from late (>25 days) in PF period, but prior to dispersal). ASY = After second year.

| SPECIES | AGE | SEX | DATE | WING CHORD | TAIL | CULMEN | CULMEN +CERE | TARSUS (Width) | NET WEIGHT |
|---------|-----|-----|----------|---------------|------|--------|-----------------|-------------------|---------------|
| NOGO | HY | F | 14/08/97 | 347 | n/a | n/a | n/a | 7.5 | 805 |
| NOGO | ASY | F | 24/06/98 | 345 | 254 | 23.9 | n/a | 7.5 | 935 |
| NOGO | ASY | F | 28/06/98 | 350 | 253 | 25.3 | 33.5 | 7.5 | 938 |
| NOGO | ASY | F | 05/07/98 | 360 | 262 | 23.3 | 31.6 | 7.4 | 980 |
| NOGO | HY | F | 07/08/98 | 347 | 241 | 22.7 | 31.8 | 6.8 | 820 |
| NOGO | HY | M | 06/08/98 | 327 | 230 | 20.5 | 28.0 | 6.0 | 728 |
| NOGO | HY | M | 21/08/98 | 320 | 230 | 21.7 | 26.6 | 5.7 | 733 |
| NOGO | ASY | F | 04/06/99 | 350 | 250 | 25.5 | 36.9 | 6.8 | 1040 |
| NOGO | HY | F | 19/07/99 | 368 | 281 | 23.6 | 33.8 | 7.0 | 1080 |
| NOGO | HY | F | 24/07/99 | 347 | 274 | 22.6 | 34.2 | 7.2 | 950 |
| NOGO | HY | M | 28/07/99 | 332 | 240 | 21.0 | 29.8 | 5.9 | 585 |
| NOGO | HY | F | 05/08/99 | 357 | 286 | 24.0 | 35.3 | 7.0 | 990 |

APPENDIX 7. Post-fledging area range maps.

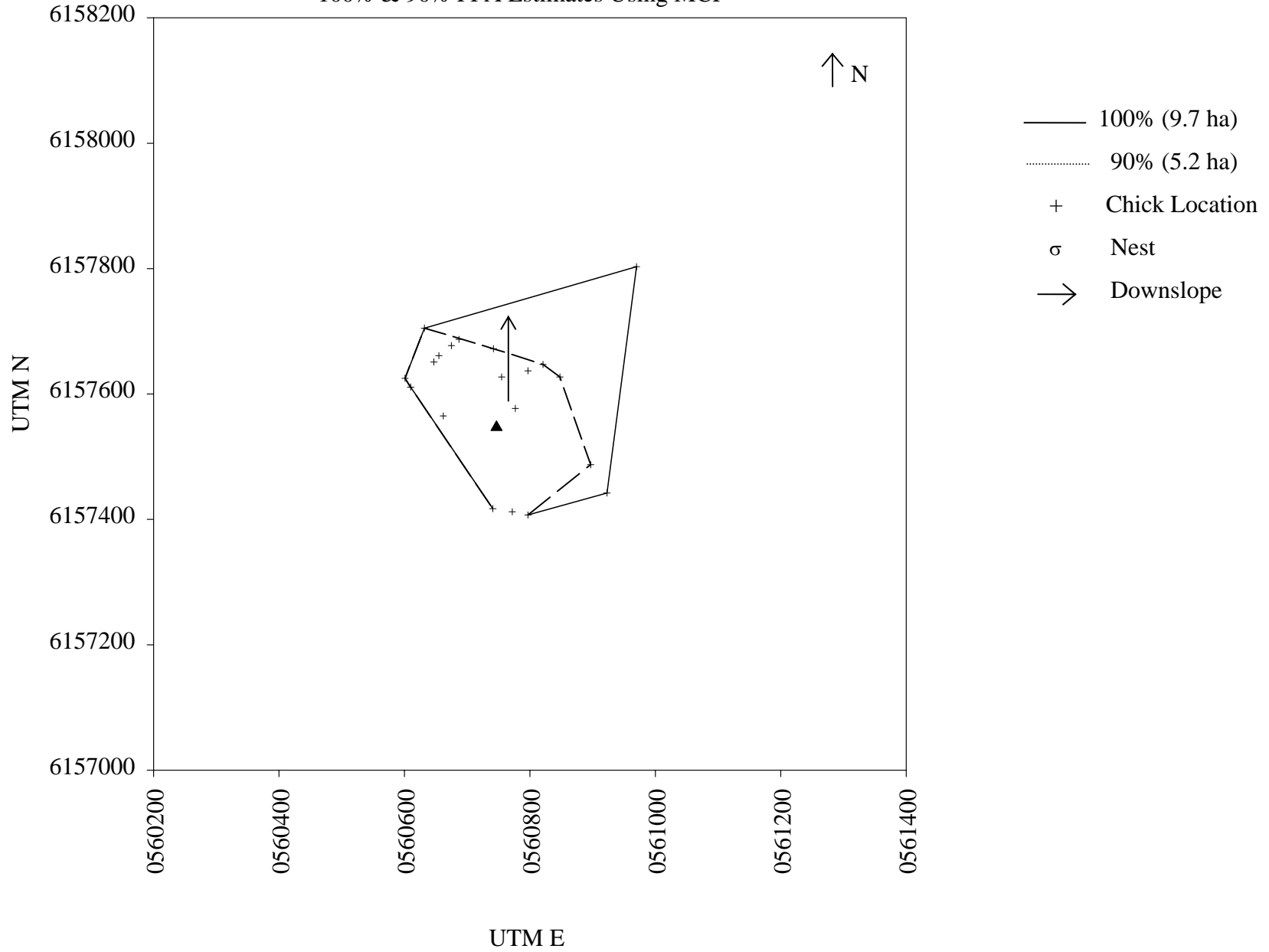
Date 1999 (N=24)

100% & 90% PFA Estimates Using ADK



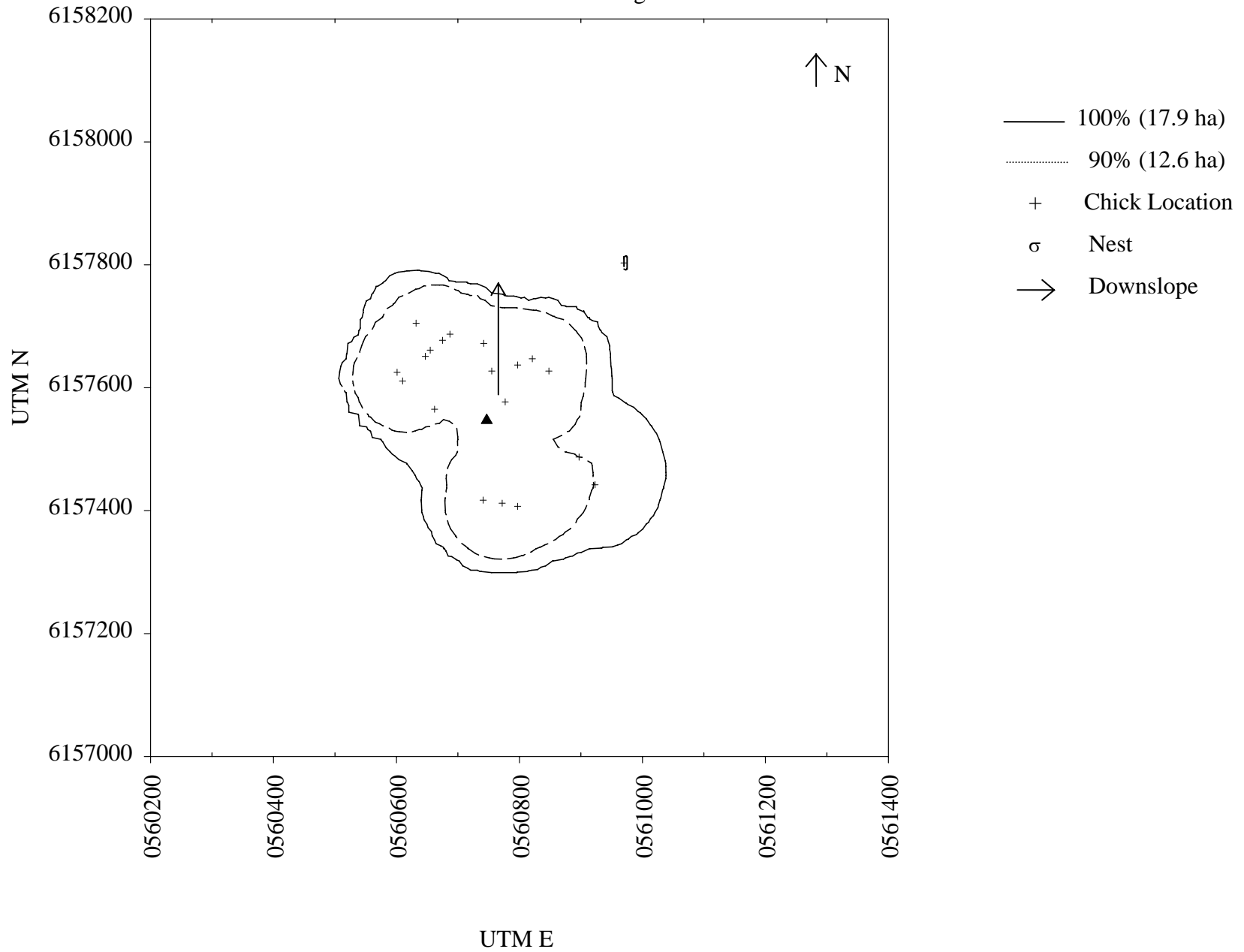
Helen Lk. 1999 (N=20)

100% & 90% PFA Estimates Using MCP



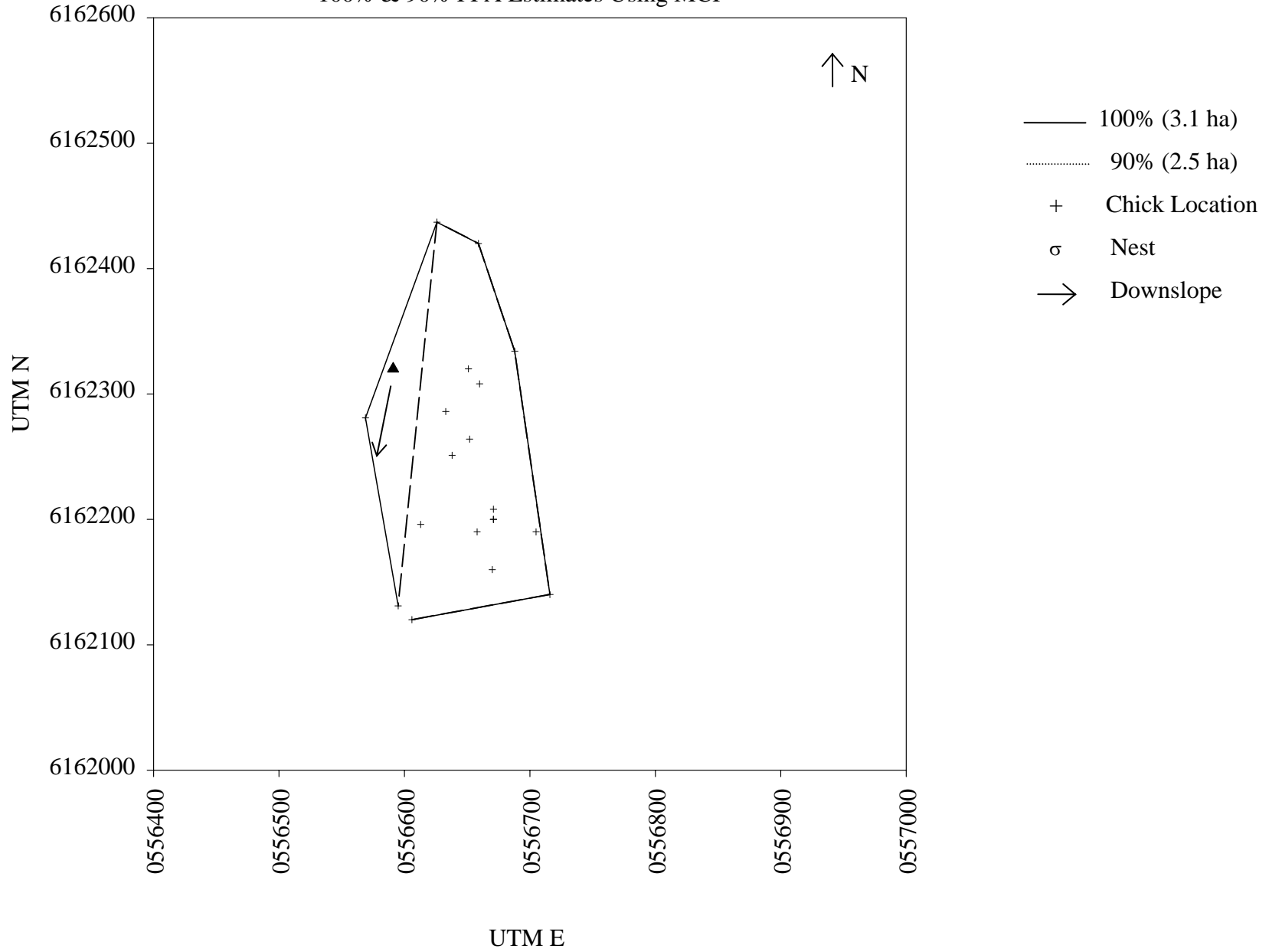
Helen Lk. 1999 (N=20)

100% & 90% PFA Estimates Using ADK



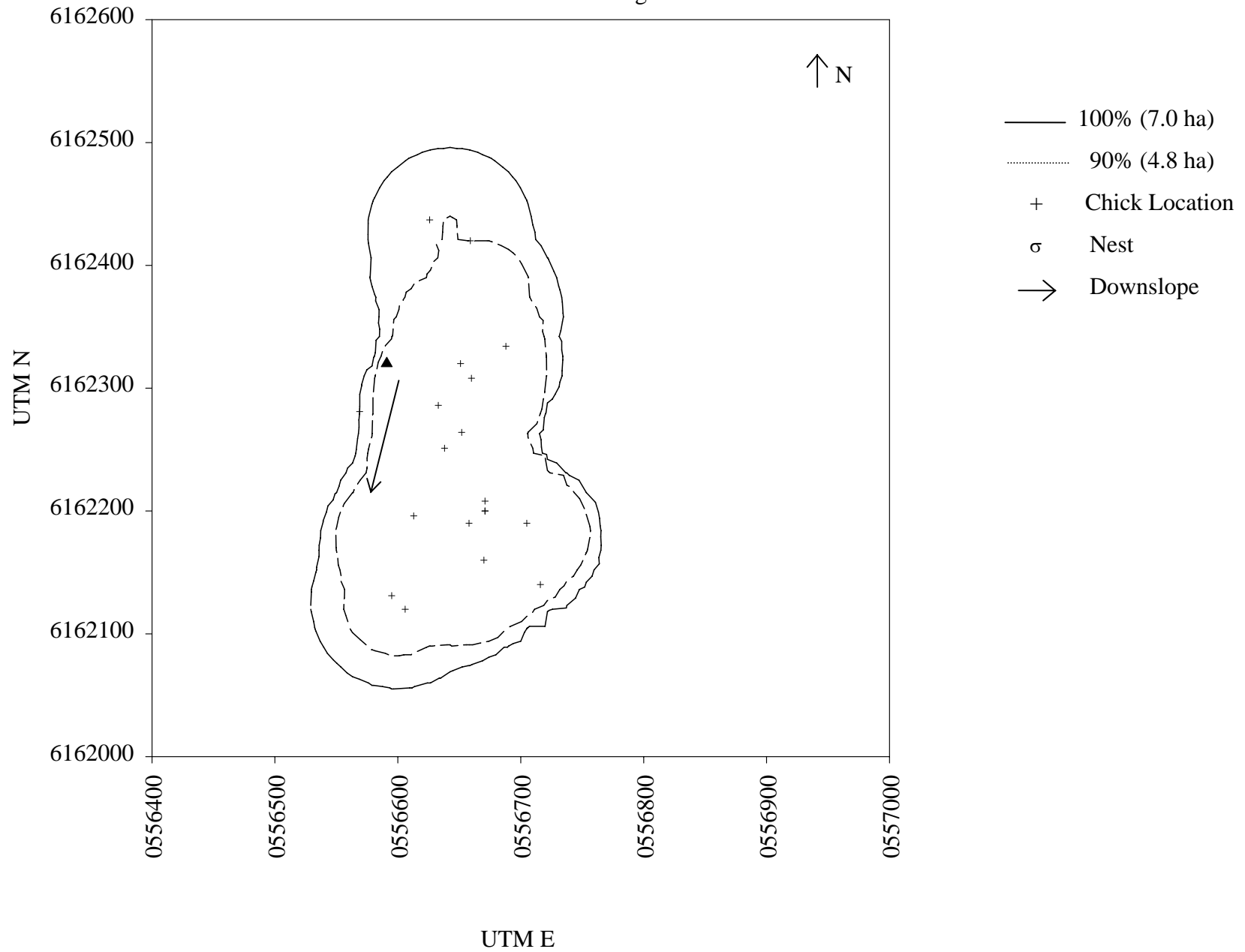
Ironside 1999 (N=19)

100% & 90% PFA Estimates Using MCP



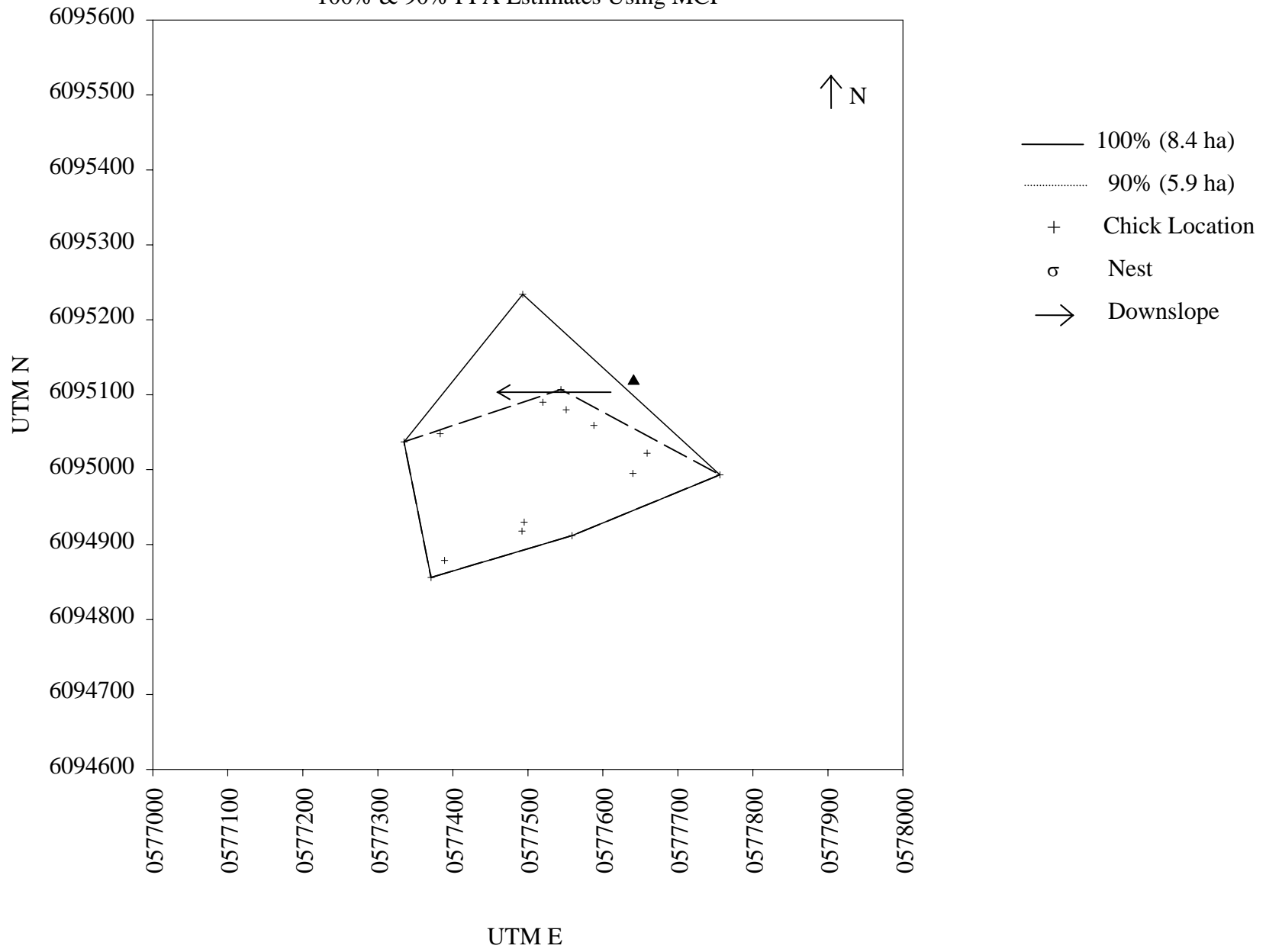
Ironside 1999 (N=19)

100% & 90% PFA Estimates Using ADK



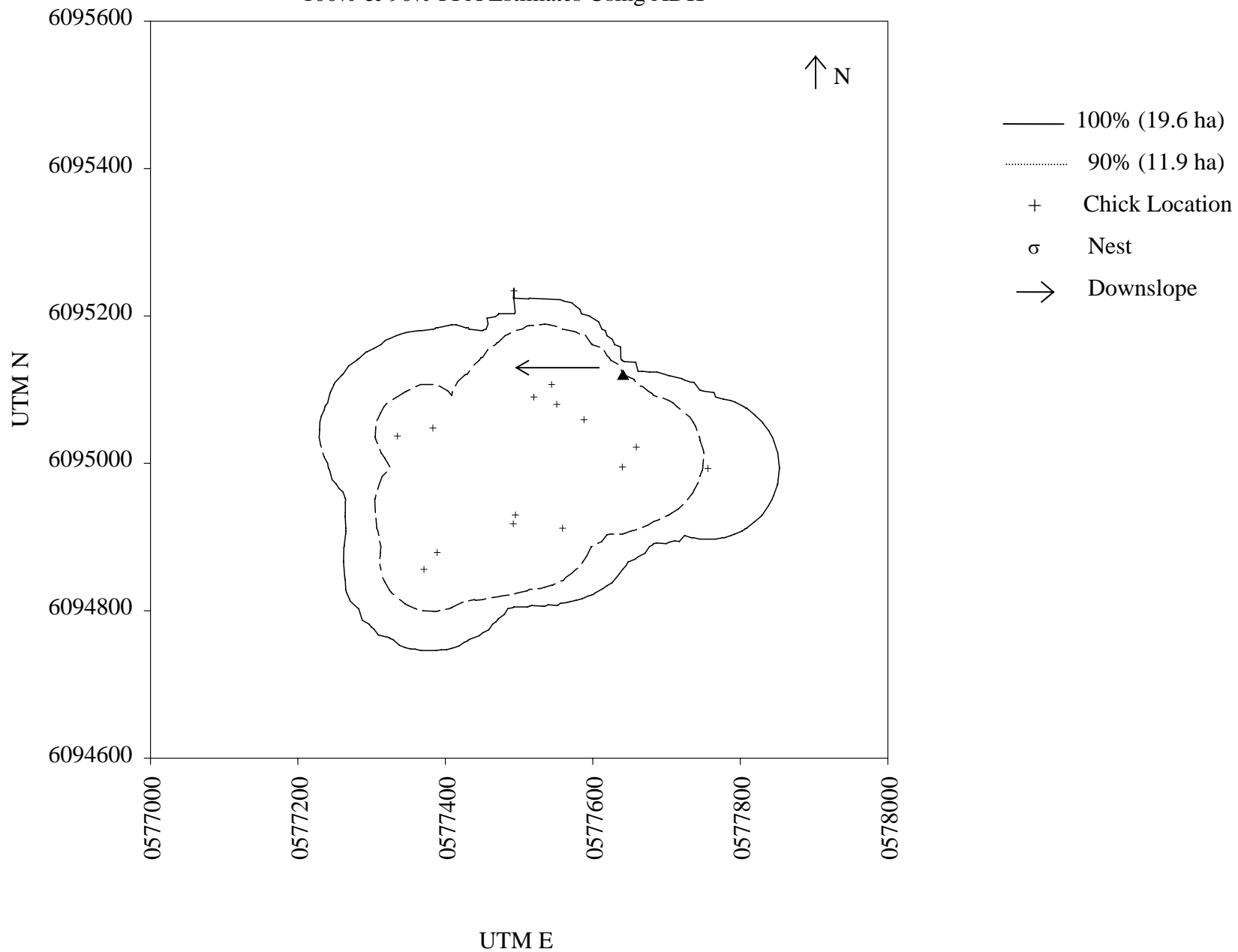
Kitsuns 1999 (N=15)

100% & 90% PFA Estimates Using MCP



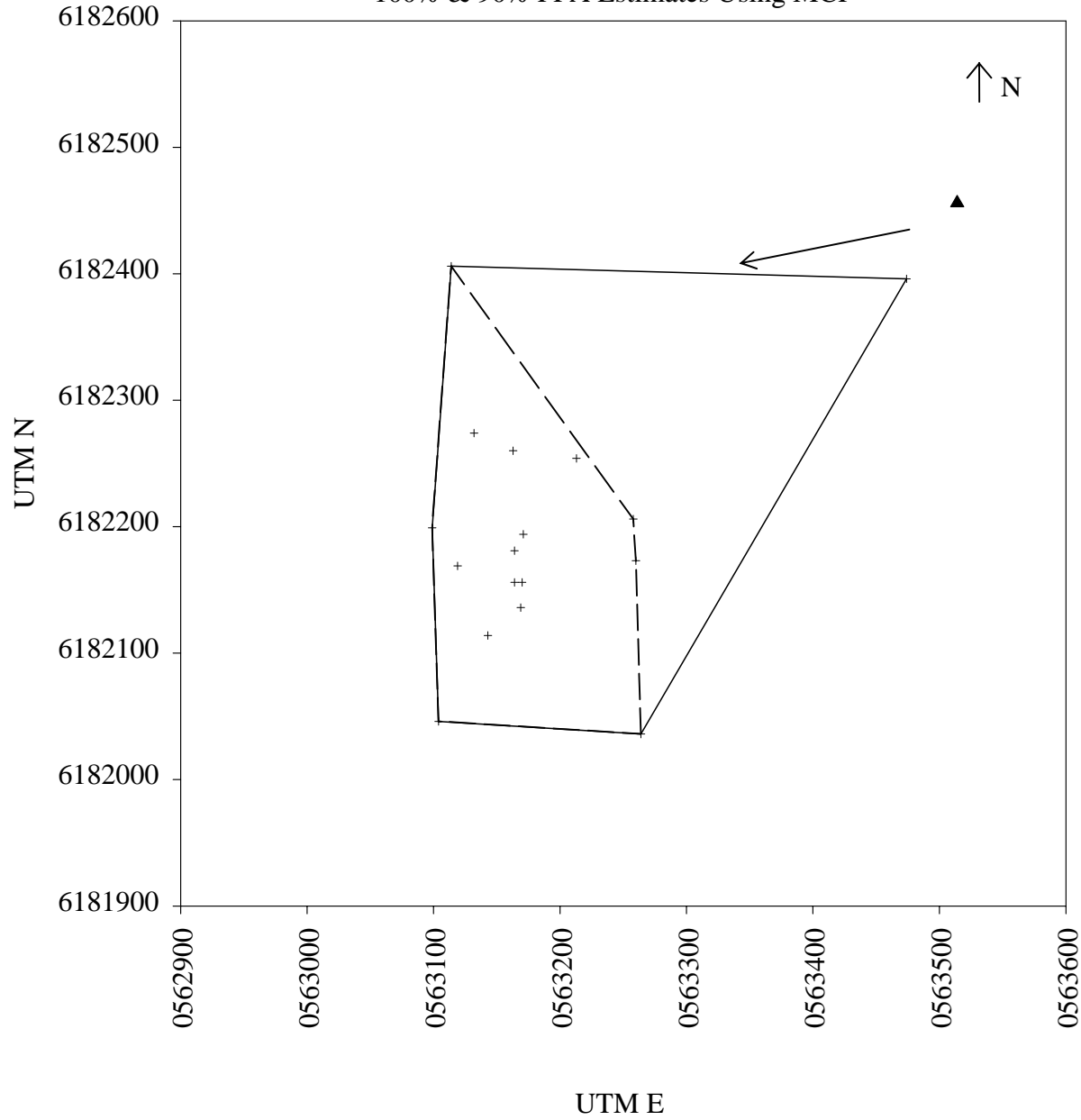
Kitsuns 1999 (N=15)

100% & 90% PFA Estimates Using ADK



Kuldo 1999 (N=17)

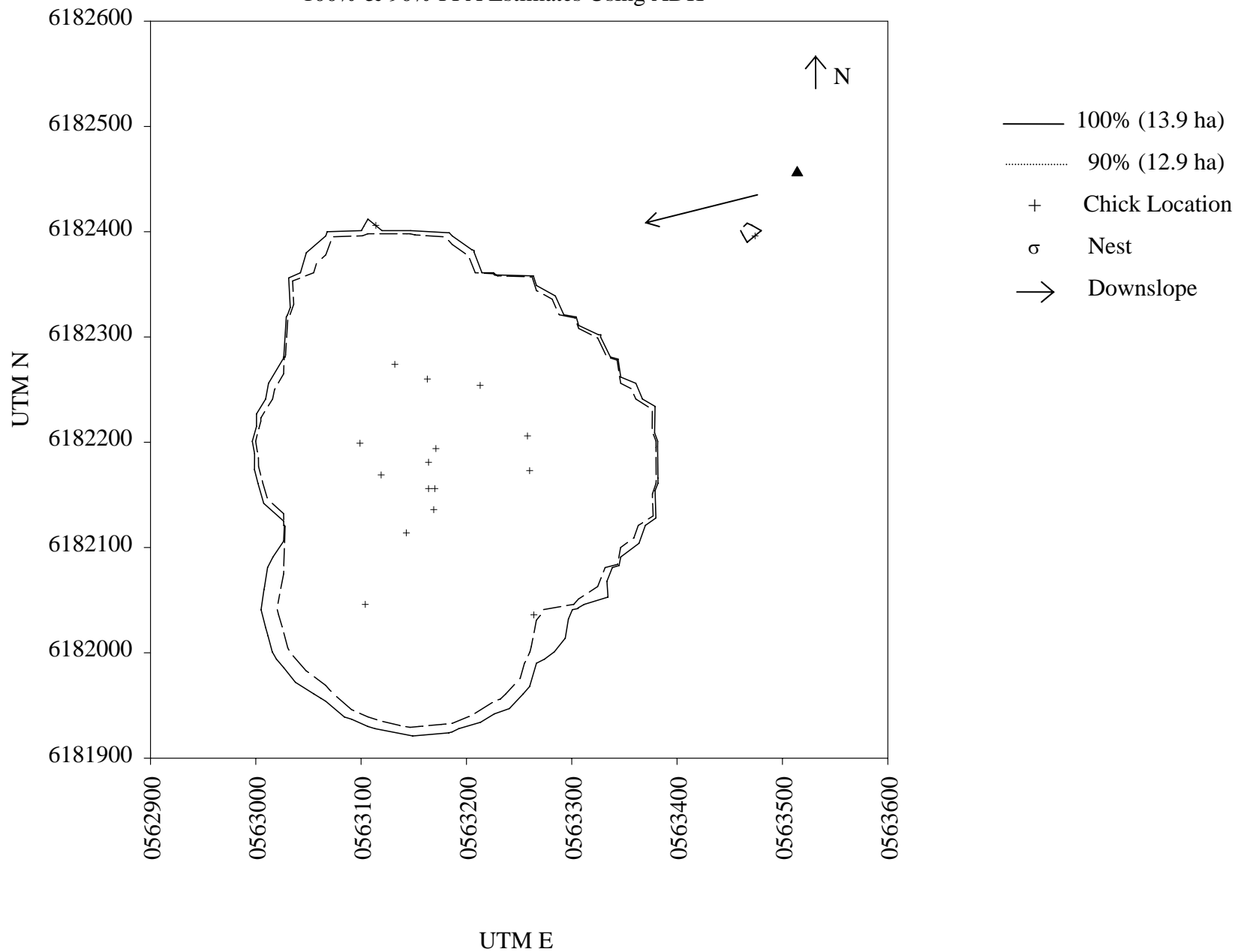
100% & 90% PFA Estimates Using MCP



- 100% (9.6 ha)
- - - 90% (4.2 ha)
- + Chick Location
- σ Nest
- Downslope

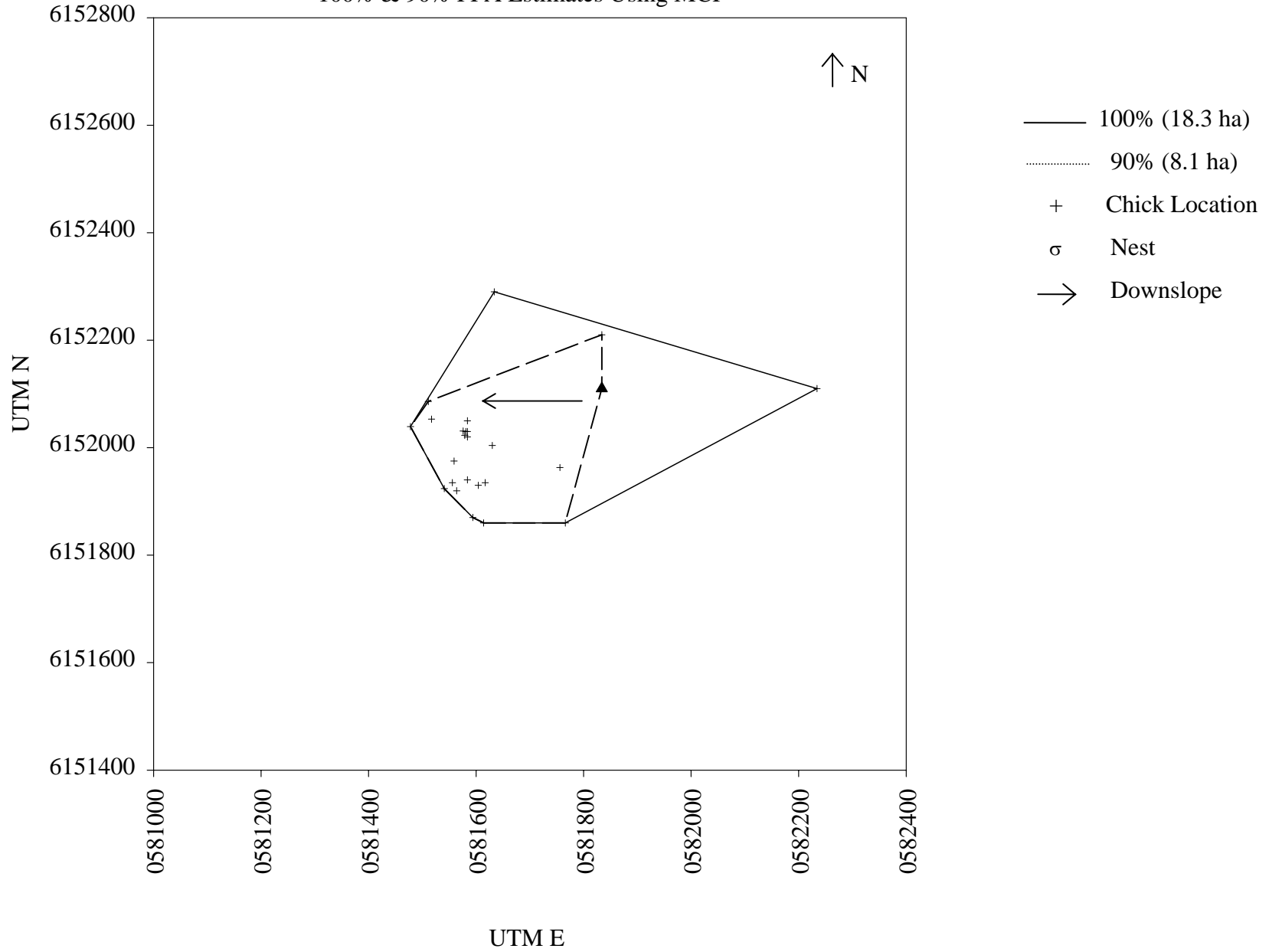
Kuldo 1999 (N=17)

100% & 90% PFA Estimates Using ADK



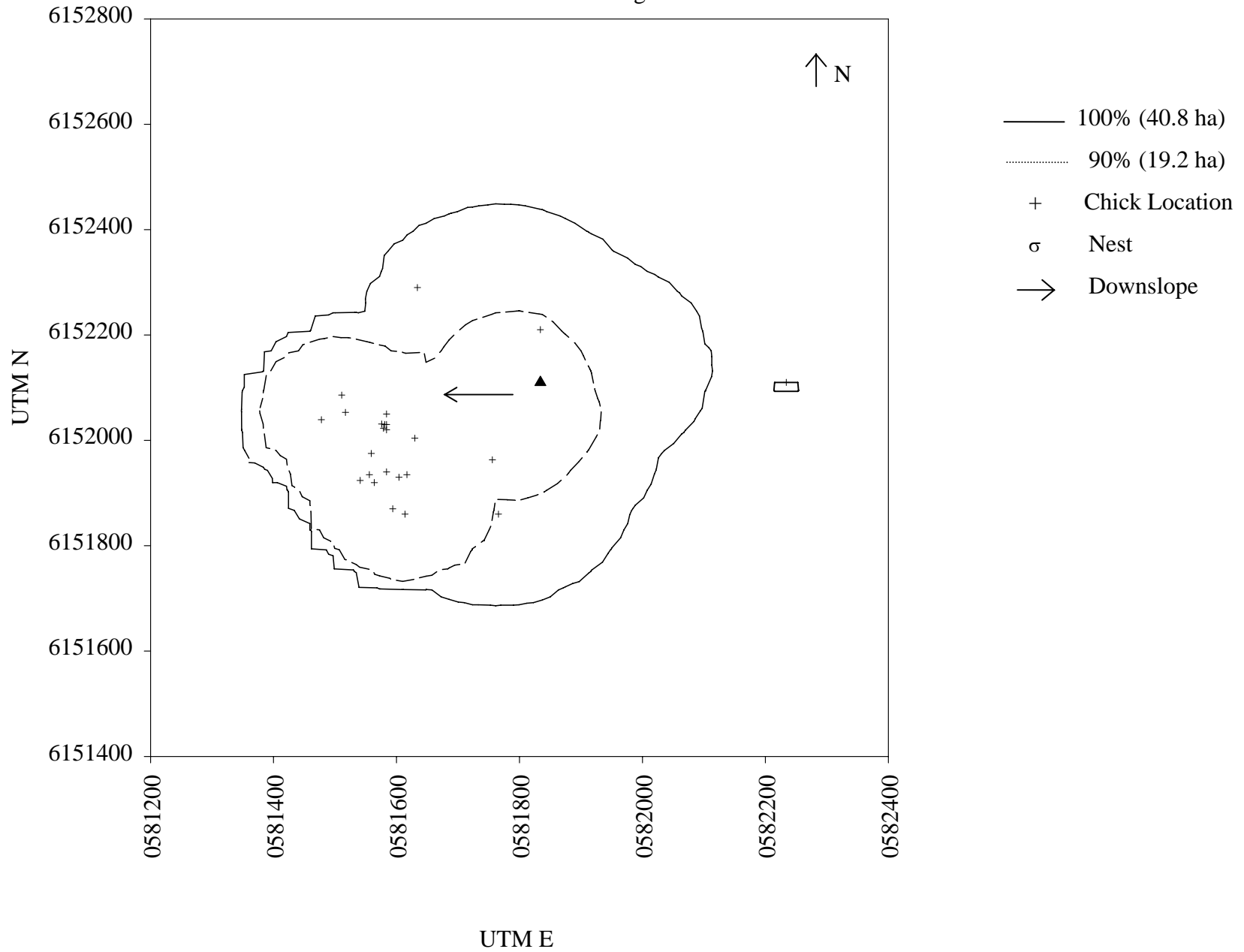
Muldoe 1999 (N=25)

100% & 90% PFA Estimates Using MCP



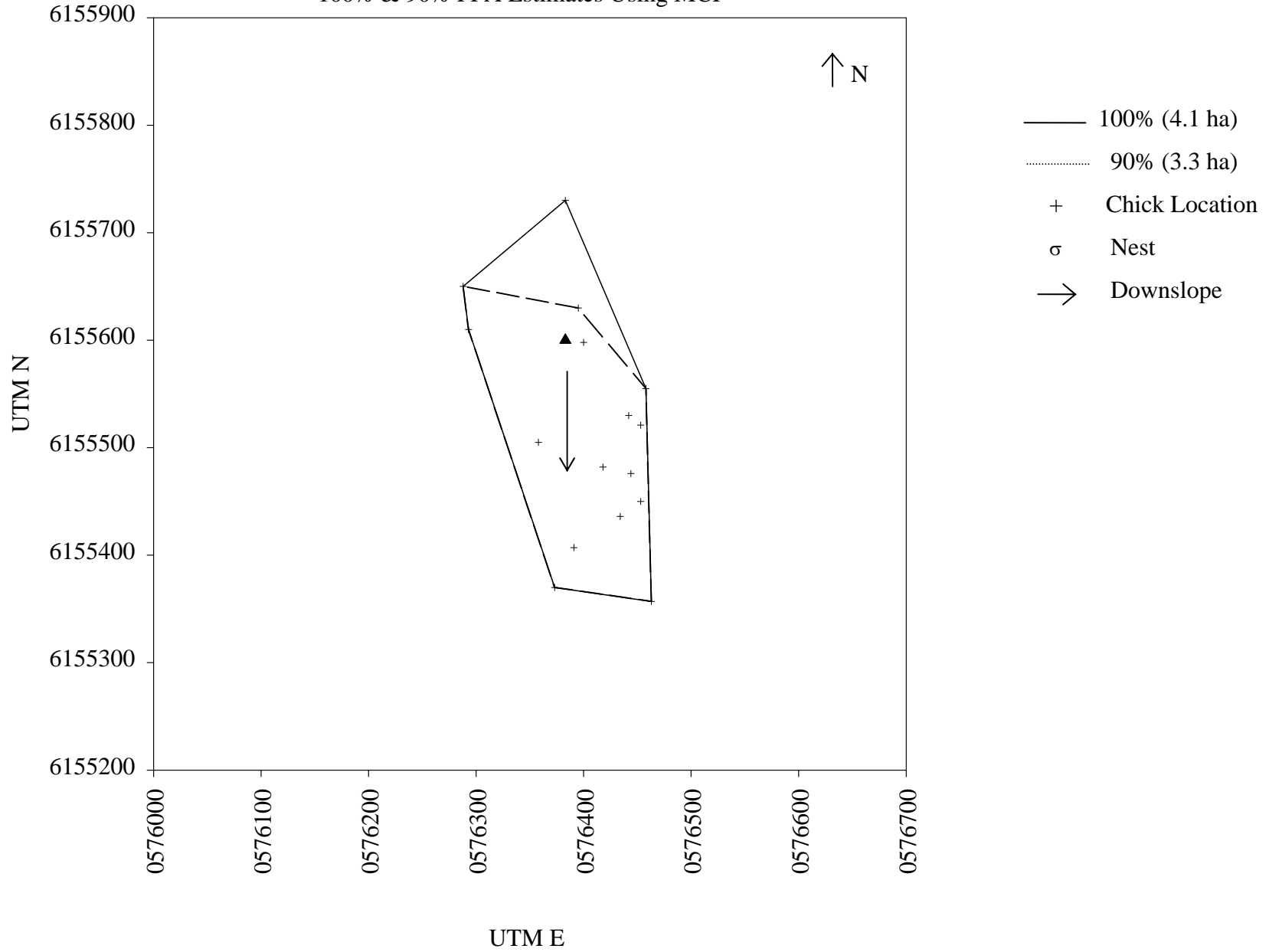
Muldoe 1999 (N=25)

100% & 90% PFA Estimates Using ADK



Pope 1999 (N=17)

100% & 90% PFA Estimates Using MCP



Pope 1999 (N=17)

100% & 90% PFA Estimates Using ADK

