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GOSHAWKS IN CANADA: POPULATION RESPONSES TO HARVESTING AND THE APPROPRIATENESS OF USING STANDARD BIRD MONITORING TECHNIQUES TO ASSESS THEIR STATUS

Frank I. Doyle

Abstract. In this paper, I use the results from current research and from established bird monitoring techniques to highlight the inability of current techniques to establish the status of Northern Goshawk (*Accipiter gentilis atricapillus* and *A. g. laingi*) across Canada. At a national-scale monitoring of goshawks relies upon opportunistic goshawk sightings made during Breeding Bird Surveys (BBS), Christmas Bird Counts (CBC), or during migration counts. These sources indicate that the population trend is either stable (BBS and CBC), or possibly declining (migration counts over last 20–30 yr). However, recent goshawk population studies in western Canada have shown that individual subpopulations respond differently to harvesting of mature forest, with some showing a negative impact, while others appear to be thriving at the same rate of harvest. Work in the undisturbed boreal forests of the Yukon has linked goshawk density and productivity to prey abundance. Differences in the response of goshawk populations to timber harvest may therefore be primarily dependent on the prey available and the habitat used by the prey. Goshawks that are more reliant on prey associated with mature forests showed the greatest impact from harvesting. Across Canada, therefore, population responses to harvesting at the ecosystem level may vary, with the possibility that at the regional or local scale goshawk populations could be lost without this loss being detected by the present non-target monitoring techniques (CBC, BBS, and migration counts). Broad assessment of prey and prey habitat use will help managers to assess the risk to population persistence at regional and local scale.

Key Words: *Accipiter gentilis, laingi*, Canada, harvest, habitat, prey, status, threshold.

GAVILANES EN CANADÁ: RESPUESTAS POBLACIONALES AL APROVECHAMIENTO Y LO APROPIADO DEL USO DE TÉCNICAS ESTANDARIZADAS DE MONITOREO DE AVES PARA EVALUAR SU ESTADO.

Resumen. En este artículo utilizo los resultados de investigación actual, así como técnicas establecidas de monitoreo de aves, para resaltar la inhabilidad de las actuales técnicas para establecer el estado del Gavilán Azor (*Accipiter gentilis atricapillus* y *A. g. laingi*) en Canadá. A escala nacional, el monitoreo de los gavilanes reside en los avistamientos oportunos del gavilán, realizados durante Estudios de Aves Reproductoras (BBS), Conteos de Aves en Navidad (CBC) o durante los conteos de migración. Estos recursos indican que la tendencia de la población, es ya sea estable (BBS y CBC), o posiblemente decadente (conteos de migración durante los últimos 20–30 años). Sin embargo, estudios poblacionales recientes del gavilán en el oeste de Canadá, han mostrado que subpoblaciones individuales responden de forma distinta al cultivo del bosque maduro, algunas mostrando impacto negativo, mientras que otras parecen prosperar durante el cultivo. Trabajo realizado en el bosque boreal no perturbado del Yokon, ha vinculado la densidad y productividad del gavilán a la abundancia de la presa. Diferencias en la respuesta de las poblaciones del gavilán al aprovechamiento de la madera quizás se deban principalmente a la disponibilidad de la presa y al hábitat utilizado por la presa. Gavilanes que dependen más en presas asociadas con el bosque maduro, mostraron el gran impacto que causa el aprovechamiento. Es por esto que en Canadá, las respuestas al aprovechamiento a nivel de ecosistema quizás varíen, con la posibilidad de que las poblaciones de gavilán a escala regional o local se pierdan sin poder detectar dicha pérdida a través de las técnicas de monitoreo actuales de no-blanco (CBC, BBS y conteos de migración). Mayor valoración de la presa, así como de la utilización del hábitat por la presa, ayudarán a los administradores a evaluar el riesgo de la permanencia de la población a escala regional y local.

Goshawks in Canada are distributed throughout the entire forested portion of the landscape, from the US border to tree line in the Arctic, and thus potentially a large portion of the North American goshawk population is resident in Canada. My objective is to determine the status of goshawks across Canada based on all the available information on goshawk populations. In Canada, as in the US, large-scale harvesting of mature forests has taken place throughout the past century and up-to-date information on the present status of the goshawk is required to determine if this identified threat is influencing the status of goshawk population. However, recent long-term goshawk research in the west of Canada

has highlighted how inappropriate the standard bird monitoring tools may be in establishing the population status of goshawks across Canada. In this paper I set out the problems associated with the present methodology, and focus on the differing responses of goshawk subpopulations to harvesting. Harvesting and its impact on prey, versus impacts at a nest stand or other factors such as depredation or climate, being identified by the Canadian research studies as likely to be the most critical factor influencing the status of goshawks in Canada. This impact on prey and the differences seen in the scale and type of this impact between forest types indicates that specific monitoring of goshawk populations may be the only accurate method for determining the overall status of this species.

In Canada raptor populations have been monitored by the Canadian Wildlife Service using trend information from breeding bird surveys (BBS), Christmas Bird Counts (CBC) and from migration counts (Hyslop 1995, Kirk and Hyslop 1998, Kennedy 2003). These counts indicate a range in Northern Goshawk (*Accipiter gentilis atricapillus* and *A. g. laingi*) population trends depending on the source with BBS and CBC indicating a relatively stable population, whereas the migration counts have shown a decreasing trend in the numbers of goshawks, which is significant at three of the eight migration stations. No discernible geographic trend was observed.

In contrast to this opportunistic count of goshawks, the last decade has seen several intensive long-term goshawk population studies (Table 1; Fig. 1) taking place in the Yukon, and in British Columbia (BC) (Doyle and Mahon 2001, Doyle 2003, McClaren 2003, Mahon and Doyle 2003a). These studies were designed to quantify the possible impacts to this raptor of harvesting mature forests and have show that goshawk populations react differently to that impact on an ecosystem specific basis. This variation in impacts could potentially result in the loss of goshawks at a local or regional level, an impact that may be unnoticed at a national level if relying on the opportunistic BBS, CBC, and migration counts to monitor population trends. This can occur because the negative responses by goshawks to harvesting in one forest type may be balanced by a positive response in another, such that the coarse opportunistic monitoring fails to detect any significant change. Consequently the habitat thresholds that may negatively impact goshawks may be exceeded in some landscapes, such that the goshawk population is lost without being noticed.

The work showing the potential weakness in relying of non-target species monitoring techniques to monitor goshawk populations has all taken place in western Canada over the past decade. No comparable studies have been conducted elsewhere in Canada. In BC this has included work on two island populations of the threatened goshawk sub-species, the Queen Charlotte goshawk (*A. g. laingi*), while those on mainland BC and in the Yukon are working with the larger *A. g. atricapillus*. The Yukon study took place within an undisturbed northern boreal forest

Table 1. Long-term goshawk study area in British Columbia and Yukon, Canada.

Location	Number of goshawk nest areas located	Length of study	Forest type	Nest area spacing (km)
Haida Gwaii-Queen Charlotte islands [a]	9	1995–present	Rain-forest coastal western hemlock	9–15
Vancouver Island [b]	66	1995–present	Rain-forest coastal western hemlock	6–8
Interior BC (Lakes and Morice Forest Districts) [c]	40	1997–present	Sub-boreal spruce and pine	4–5
Interior BC (Kispiox Forest District) [d]	33	1995–present	Interior cedar hemlock	4–5
Yukon [e]	13	1986–1996	White spruce	3 (P)[f] 12 (L)[g]

[a] Doyle 2003.
[b] McClaren 2003.
[d] Mahon and Doyle 2003a, Doyle and Mahon 2001.
[c] Doyle and Smith 1994, Doyle 2000.
[f] P = Years with a peak in prey abundance,
[g] L = Years with low prey abundance.

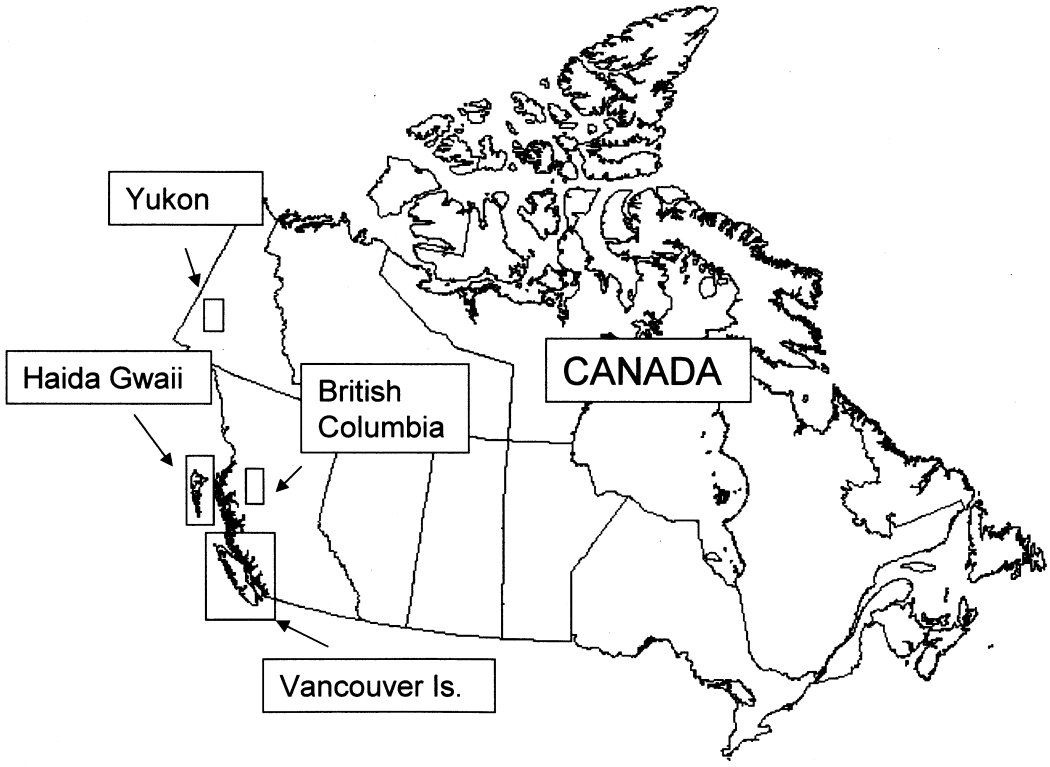

FIGURE 1. Location of the long-term goshawk study areas in Canada.

ecosystem, while those in BC are all taking place within forest types associated with the southern boreal and coastal rain forest ecosystems that have all seen 30–40% of the mature forest harvested in the last 20–30 yr (Doyle 2003, McClaren and Pendergast 2003, Mahon et al. 2003). These BC studies show very different population responses to harvesting; the rain forest *laingi* may be possibly under threat with declining populations and reduced productivity while *atricapillus,* found in the drier mainland forests, may be benefiting from harvesting, at least in the short-term.

In the Yukon, the Northern Goshawk population was studied intensively at Kluane Lake as part of a long-term boreal forest ecosystem study (Krebs et al. 2001) in which all raptors, their prey, and the environment in which they lived were monitored to establish if and how these ecosystem components were linked together. This study established that goshawks were largely resident and that the number of nests and production of young (Fig. 2) was significantly linked to the abundance of their main prey the snowshoe hare (*Lepus americanus*) and possibly also to grouse, their secondary winter and early breeding season prey. Rainfall and other factors such as nest depredation by wolverines (*Gulo gulo*; Doyle 1995) and Great Horned Owls (*Bubo virginianus*; Doyle 2000) influenced the breeding success of individual pairs; however, these impacts were insignificant compared to the density of snowshoe hares in winter. In addition, human impacts have also been cited in the past as possibly reducing breeding success at the nest stand level (Squires and Reynolds 1997), and certainly disturbance of any breeding birds can cause breeding attempts to fail. However, an ongoing long-term, adaptive-management experiment at the mainland study sites in BC (Mahon et al. 2003), has to date (3–5 yr post harvest, 73 nest areas) shown no significant impacts, with goshawks continuing to breed successfully even in highly fragmented nest stands. This does not mean a threshold fragmentation or disturbance threshold for some individuals at the nest-stand level does not exist, but it does indicate that this impact is not driving changes in population trends at this stage.

The critical role of prey in the breeding success and the subsequent status of individual goshawk populations may in part be explained by the fact

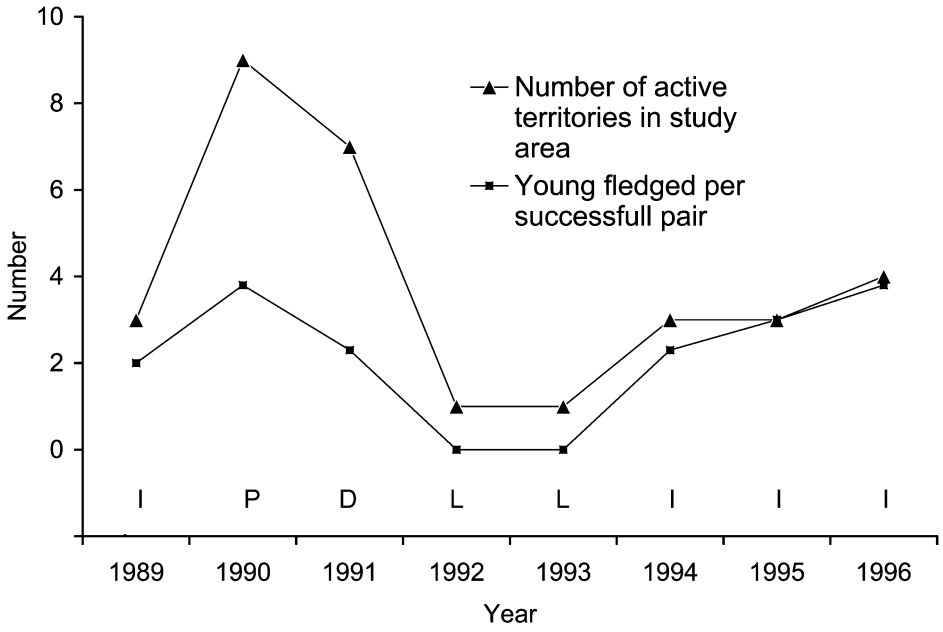

FIGURE 2. Number and productivity of successful goshawk nests in relation to the cyclic phases of the hare and grouse population at Kluane Lake, Yukon. (Doyle 2000). Phases in the abundance of hares and grouse over the period of the 10-yr snowshoe hare cycle: I = Increase, P = Peak, D = Decrease, L = Low.

that in BC as in the Yukon, populations appear to be largely resident. Birds' radio-tagged as breeding adults, and independent goshawk sightings indicate that some, and possibly all, adults and juveniles are resident in the breeding habitat during the winter months. Independent of these observations, birds in all the study locations began to breed in late winter (February–March; Doyle 2000, Mahon et al. 2003), 1–2 mo before spring or summer prey (migrant passerines, young prey or hibernating prey) were available. All birds, independent of their winter movements therefore appear to be largely dependent on the abundance and availability of winter prey to ensure their survival, body condition and subsequent ability to breed, if territories become vacant.

This likely dependence on winter prey has been identified as a possible driving factor in the observed differences in the resilience of goshawk subpopulations to habitat change (Doyle 2003). Within these same study areas in the winter months we see pronounced ecosystem differences in the species, abundance and habitat associations of the available prey (Fig. 3). In BC, two of the four long-term goshawk studies are being conducted on large islands (Haida Gwaii and Vancouver islands) off the west coast. On these islands the winter diet appears as though it may be dominated by red squirrels (*Tamiasciurus hudsonicus*) and forest grouse, while the dominant winter prey on the mainland, the snowshoe hare, is absent, and other common mainland prey, ptarmigan and grouse, are at relatively low densities. When we then look at where these prey types are found within a landscape we can see clear differences in broad habitat types. Snowshoe hares, grouse, and ptarmigan are typically associated with openings of shrub-young forest (pole sapling), while red squirrels (Mahon and Doyle 2003b), and the island's forest grouse (Zwickle 1992) are most abundant in mature coniferous forest that once dominated the entire landscape (Canning and Canning 1996). Harvesting of the mature forests that dominate these landscapes will therefore likely have very different impacts on the resident goshawk population, depending on the habitat association of their prey in that ecosystem. On the mainland the harvested openings result in habitat (after a shrub layer has formed) in which snowshoe hare and grouse densities are higher than compared to the surrounding mature forest (Mahon and Doyle 2003b). In contrast, these same harvested habitats on Vancouver Island (Ethier 1999, McClaren 2003) and on Haida Gwaii (Doyle 2003) have few prey associated with them in winter and early in the breeding season.

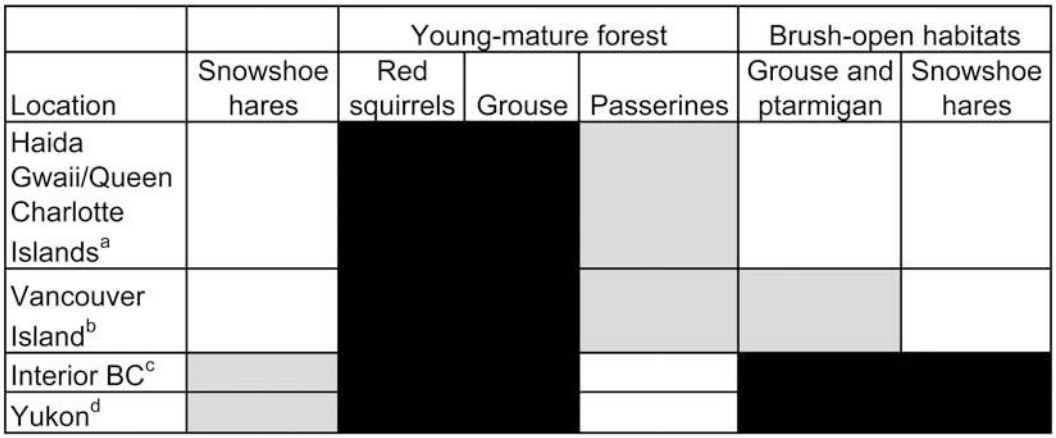

FIGURE 3. Relationship between the location (ecosystem type), and the association of habitat and the main goshawk prey in late winter. Black = species abundant; gray = species occurs but less abundant; white = species absent.

In mainland versus island we also see different patterns in goshawk productivity and territory spacing which supports this observed link between habitat and prey (Table 1). The mainland territories are at around twice the density of their island counterparts and the annual productivity (both reoccupancy rates and young fledged per breeding attempt) is higher (Doyle 2003). In addition, at the territory scale, harvesting on the mainland has not been seen to reduce breeding success (Mahon et al. 2003), but on Haida Gwaii, in areas with >30% harvesting, no active nests have been located, and on Vancouver Island (McClaren and Pendergast 2003) landscapes with the highest rates of harvesting have significantly lower reoccupancy rates.

How these observed differences in available prey, habitat, and goshawk productivity vary across Canada have not been explored, but they provide the possibility that harvesting combined with individual ecosystem differences could lead to the loss of certain goshawk populations while other populations may remain stable or indeed increase in density. However, this does not mean that we can be complacent even for those populations that appear to be relatively robust. As was seen in the Yukon hare population, which predictably peaks and then crashes cyclically, we have to ensure that enough diversity of habitat types and their associated prey remains to support goshawk population through the low in hare numbers. In particular, sufficient areas of mature forest supporting populations of red squirrels or forest grouse may be critical to the long-term persistence of goshawks and other predators. Both the Yukon study on goshawks and on another winter resident, the lynx (*Lynx canadensis*), showed a switch to prey typically associated with mature forests (red squirrels and forest grouse) during the low in hare numbers (Krebs et al. 2001). At present, the critical habitat and the threshold in habitat area required to maintain goshawk populations in landscapes in which they largely depend on cyclic prey is unknown. As we have seen the rate of timber harvesting in the goshawk study areas in BC has resulted in 30–40% of the mature forest being cut in the last 20–30 yr. In addition, this harvest has recently been spread across the landscape, such that out of the 73 or more goshawk territories located to date, none have no harvesting at a territory scale, if we assume that nest-area spacing in a landscape (Table 1) indicates the foraging area required by the birds in that landscape. If this rate and spatial arrangement of harvesting is taking place throughout the rest of the province or across large areas of Canada and a threshold in critical habitats does exist, will it allow for the retention of enough critical habitats to ensure the long-term persistence of goshawk populations across much of their range?

Finally, the possibility exists that this could all take place while information from migration stations fails to detect a notable population change at a time when action should be taking place to protect threatened populations at a regional or on a listed sub-species basis. This could occur because declines

in goshawk populations in any one area may be masked by increasing populations elsewhere. As an example, large numbers of goshawks sightings at some migration stations are thought to be influenced by the abundance and subsequent population crash of snowshoe hares in the northern boreal forests, a prey species that we know is cyclic (9–11 yr cycle) (Doyle 2000), and which also exhibits a variation in the amplitude of the density between cycles. This large number of goshawks from the northern boreal forest may therefore effectively mask declines brought about by human influences on goshawk carrying capacity of landscapes.

Other broad-scale land-bird surveys methods such as BBS and CBC are likely to be inappropriate goshawk survey methods. BBSs are focused on detection of calling by songbirds, while CBCs are not stratified across regions or habitat types, because they are centered on communities. Most communities, and therefore count sites, are located in southern Canada. In addition they do not specifically target habitat types (forested landscapes in Canada) in which we may expect to locate goshawks in the winter months. As a consequence, the present survey methods may fail to detect any significant population change.

Therefore, we do not know the long-term resilience of individual goshawk populations to habitat change and changes in prey availability outside of few local studies conducted to date in western Canada. Furthermore, a possibility exists that the broad-scale monitoring methods that are being used to monitor goshawk populations across Canada may fail to detect local or regional population declines. Additionally, it may be too late by the time these broad-scale survey methods do detect a decline. If, for example, goshawk a population increases with timber harvesting until a critical threshold is reached and then that population (genetically or regionally) declines sharply, becoming extinct in the worst case scenario. In Canada, as in other areas of North America, standardized broadcast surveys using localized detection probability functions and area occupied methods (McLeod and Andersen 1998, McClaren et al. 2003) could be used to detect changes in breeding populations. However, the challenges associated with setting up such a comprehensive monitoring system in Canada, i.e., training, money, low-detection rates in coastal forests, and cyclic goshawk populations, will likely prevent such a strategic plan being put in place until it is too late. If this is the likely outcome, research that identifies broad landscape thresholds for goshawks within individual ecosystem types based on the habitat and available prey may be necessary. Although necessarily coarse in its assessment this will at least allow landscape managers to assess the risk of their actions to the goshawks population, both at a local and regional scale.

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