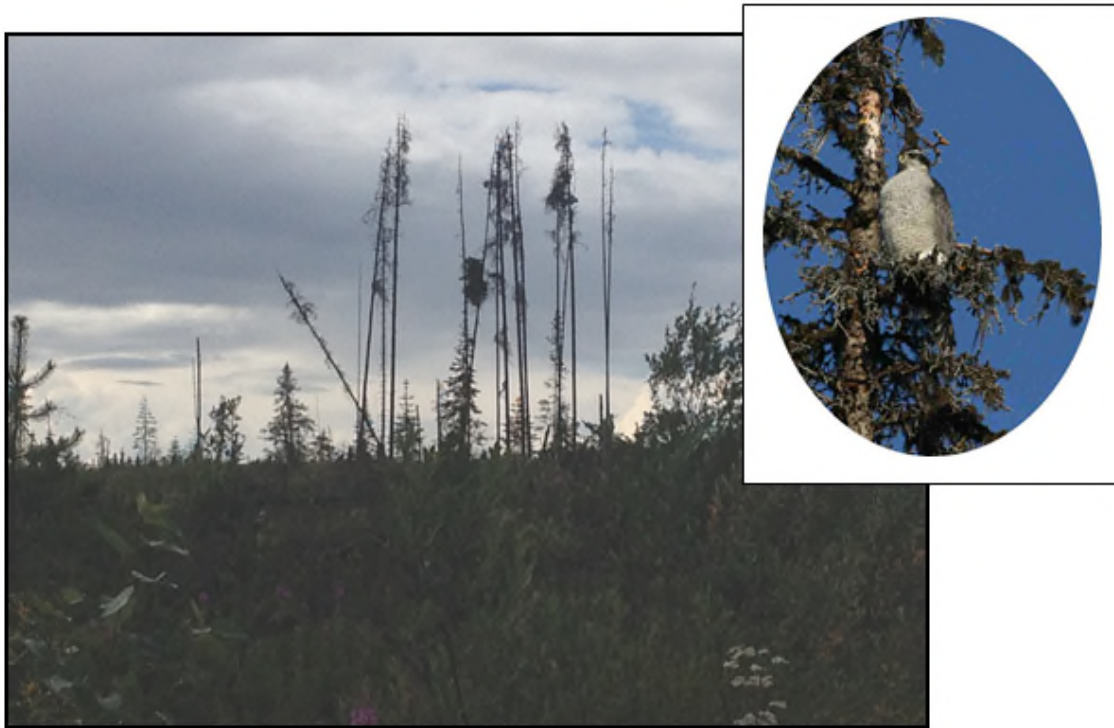


Occupancy and Status of Northern Goshawk Breeding Areas in the Coast Mountains (Kalum), Nadina and Skeena Stikine Resource Districts

- **Harvesting**
- **Climate Change: Mountain Pine Beetle & Black flies**



Picture 1. Goshawk Breeding Area: 26km Augier August 2015.

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Executive Summary

Goshawks are a forest raptor associated with mature-old forests for both foraging and breeding. In our area it is now identified at a National Level as a Priority Species of Conservation Concern and Stewardship focus with a goal of increasing populations by 50% (Environment Canada 2013).

Within central-northwestern BC, we initiated research in 1996 to identify and manage for this species' requirements within the harvested landscape. This initiative was driven at its outset with the idea that, as a generalist forest predator, we could use goshawks as an indicator umbrella species: "if we can maintain viable goshawk territories across the landscape, we are also successfully managing for the mature-old forest species on which they depend."

After several years' hiatus in the monitoring of known goshawk breeding areas, we re-surveyed 33 known breeding areas in the Nadina Resource District in 2014. These surveys were undertaken during what we know to be a peak in prey numbers (hare cycle peak); nevertheless, only 12% (4 of 33) of breeding areas were occupied. All areas were found to be heavily impacted by mountain pine beetle (MPB), and all areas <40ha in size (42% of the sample) appeared to be abandoned.

The 2014 surveys sparked several concerns and questions:

- smaller breeding areas were being abandoned,
- known breeding areas may no longer be of sufficient size (i.e. may not meet the recently published (2012) Best Management Practices (BMP) guidelines),
- high MPB-driven tree mortality was making known breeding areas unsuitable,
- a previously identified potential link between climate change and black fly abundance could be killing nestling goshawks. (Why are so many breeding areas abandoned during an apparent peak in prey abundance?)

In 2015, we received funding support from Canfor Ltd. Houston (CANFOR) and the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) to resurvey all of the breeding areas visited in 2014, and additional breeding areas distributed across all three Resource Districts (Kalum, Nadina and Skeena Stikine). A total of 72 breeding areas were monitored (5 - Kalum, 45 - Nadina & 22 - Skeena Stikine) for evidence of breeding area occupancy and breeding success.

Of the 72 areas monitored, only 2 (3%) were occupied (both were found to have successfully fledged young)—a re-occupancy rate far lower than that observed in other monitored populations during a time of high prey abundance.

Looking at the suitability of these known breeding areas in relation to the science-driven BMP (2012) guidelines, 83% of all breeding areas were smaller than the recommended 100 ha, and 66% had harvest closer than the recommended >200 m from known nests.

Within Resource Districts, the harvest of breeding areas was highest **in the Nadina with 35.6% (16 of 45) of the monitored breeding areas harvested.** Harvest pressure was lowest in the Skeena Stikine, with only 9% of breeding areas harvested, but still 70% of field assessed areas were <100ha. Irrespective of the impact that harvest may have had on breeding area re-occupancy, the near total collapse of the breeding population across the region may far exceed the potential impact of this single factor.

Unfortunately, a previously identified link between nestling mortality and high black fly abundance, may now through a predictable link with a climate change, be contributing to a crash in of the goshawk population. (Think climate driven MPB and the subsequent devastating impacts on our forests). Black flies are known to kill nestling hawks and owls through blood loss, trauma, and also as a vector for a blood parasite that kills the nestlings.

Within this rapidly changing environment (climate, MPB and harvest) one of the few tools available to landscape managers to allow for the potential that goshawk population can adapt and survive, is to ensure that we manage for a large number of viable territories across the landscape. This action will allow for the opportunity that sufficient individuals are present such that through natural selection (phenotypic plasticity), some goshawks may be selected for that can breed and thrive within this new environment.

If we are to maximize this potential we need to manage not only for the known territories, but also for the estimated >90% of territories that are not located (as observed after 10 yrs. of reporting/monitoring in the Nadina Resource District). Within the three Resource Districts goshawk territories are (were) distributed regularly (~ 4-5km) within suitable habitat, and following the BMP guidelines we should manage each territory (~2,400 ha) such that at its core we have a suitable ~100 ha breeding areas, which is then surrounded by >30% and preferably ~ 50% mature forest.

In addition, to highlight the concern about the status of the goshawks it is recommended that goshawks are assessed for Provincial CDC listing, and under FRPA as a focal species within the Identified Wildlife Management Strategy, and/or as a Regionally Important Wildlife species. This would highlight our concern that goshawks are under threat from harvest/landscape change; support systematic surveys for active nests, and would ensure any active breeding areas are reported and managed.

Goshawks through this region typically breed in structurally mature forest >120 years of age. **None of the 115 known Breeding Areas are protected,** 29% have been harvested, and only 25% were in suitable condition (primarily in the Skeena Stikine) to support breeding. In addition, under current legislation only active nests (with eggs or young) are protected, therefore breeding areas can be/and are harvested.

If, as appears, we have lost a large number of breeding goshawks (possibly up to 600 pairs in the Nadina Resource District alone), and potentially other species that are reportedly vulnerable to attacks by black flies (including owls, other raptors, birds and mammals), then this may result in rapid and largely unknown impacts on our ecosystem

function and integrity. This may also result in potential long-term negative economic impacts. For example the loss of avian predators, will predictably result in an increase in small mammal and snowshoe populations, and a subsequent increase in browse damage and loss of seedling trees.

To allow us understand and manage for these potential impacts—specifically around a possible tipping point in ecosystem function—further work is required to confirm the strength of the linkage between black flies and the loss of goshawks, and to determine the magnitude of other potential related ecosystem impacts.

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Introduction

The goshawk is a generalist forest predator, which requires a large territory, and is dependent on mature forest for both prey and breeding requirements (Stuart-Smith et al. 2012). It is not a listed species in BC, but has been identified in our area at a National Level as a Priority Species of Conservation Concern and Stewardship focus with a goal of increasing population in our region by 50% (Environment Canada 2013).

Since 1995 in British Columbia, the maintenance of goshawks across the landscape has been seen as an indicator of the effectiveness of a “coarse filter” management strategy in maintaining ecosystem integrity. In response to this landscape managers and forest harvest companies have actively surveyed for and set aside from harvesting goshawk breeding areas. In addition, an adaptive management trial was initiated across northwestern BC to monitor the re-occupancy in breeding areas in response to forest harvest development. This work resulted in a unique ecological resource, with over 100 goshawk breeding areas identified in the Coast Mountains (Kalum), Nadina, and Skeena Stikine Resource Districts.

The monitoring of these breeding areas, and companion monitoring work of a similar number of breeding areas in the south – southeast of the Province (Harrower et al. 2007), provided for the opportunity to determine the breeding area requirements that resulted in long-term breeding area re-occupancy, which subsequently resulted in a Best Management Practices (BMP) document for goshawk breeding areas (Stuart-Smith et al. 2012). Focal to this analysis it was determined that breeding areas need to be $\geq 100\text{ha}$ to maintain occupancy equivalent to controls, $<25\text{ ha}$ breeding areas are abandoned and that harvest should be $>200\text{m}$ from the nearest nest.

Since the end of annual systematic monitoring trials of all known breeding areas within our region 2007, large areas of our forest landscape has undergone dramatic regional change as a result of the MPB (Mountain Pine Beetle) outbreak, and our response to this through an increase in the annual harvest. In 2014, we conducted an assessment of the status and re-occupancy of 33 known breeding areas in the heavily MPB impacted landscape within the Nadina Resource District (Doyle 2014). This work was conducted on behalf of CANFOR, and MFLNRO, who were interested to know which of the known goshawk breeding areas were still supporting breeding. This assessment determined that only 12% (4 of 33) of known breeding areas were occupied. All breeding areas (location of long-term annual nesting sites) were heavily impacted by harvesting and the loss of trees through the MPB. No sites were occupied if the remaining patch of suitable nesting habitat $<42\text{ha}$, and only areas $>78\text{ha}$ were consistently occupied, results which were consistent with the 2012 Best Management Practices for goshawk breeding areas.

To determine if these observations from 2014 are robust; Canfor and MFLNRO supported a second year of goshawk breeding area monitoring (2015) to confirm which breeding areas are still supporting breeding, and to increase our sample of surveyed breeding areas.

- From a forest harvest perspective the question now being asked is: Before they lose their timber value should we be harvesting heavily impacted MPB breeding areas if they are no longer being used by goshawks?
- Which areas are still being used by goshawks, and what can we learn from the attributes of these areas, such that we can successfully manage for these requirements across the landscape?
- Do areas occupied by goshawks support the BMP guidelines for managing known breeding areas?

Separate from the above assessment, in 2014 work was initiated by BCTS Kispiox to manage for the known goshawk breeding area requirements following the updated BMP. During occupancy assessment of six known breeding areas in spring 2015, it was observed that no areas successfully fledged young, and there was no evidence of recent activity in five of the six areas. Given that this area (CWH/ICH Biogeoclimatic Zone) is not heavily impacted by MPB, and the total area of harvest and harvesting around breeding areas is not as high as observed within the Nadina Resource District, we were concerned that in addition to harvest and MPB, that another potentially climate related impact, black flies, may be killing nestlings. High numbers of black flies were observed on nestling goshawks in nests that subsequently failed in the Nadina (Doyle pers. obs. 2008), and black flies are known to cause high mortality of nestlings (Doyle 2000, Smith et al. 1998) and Great -horned Owls (Hunter et al. 1997). As hatch date of black flies is driven by spring temperature, we speculated in 2005 that we may see high mortality of nesting goshawks as a result of early warm spring weather – if this coincided with the goshawk early nestling phase (1-3 weeks of age).

With this concern in mind, in addition to the observed low rates of breeding area re-occupancy and breeding success, the breeding area assessment project expanded to a sample of all known breeding areas across the region.

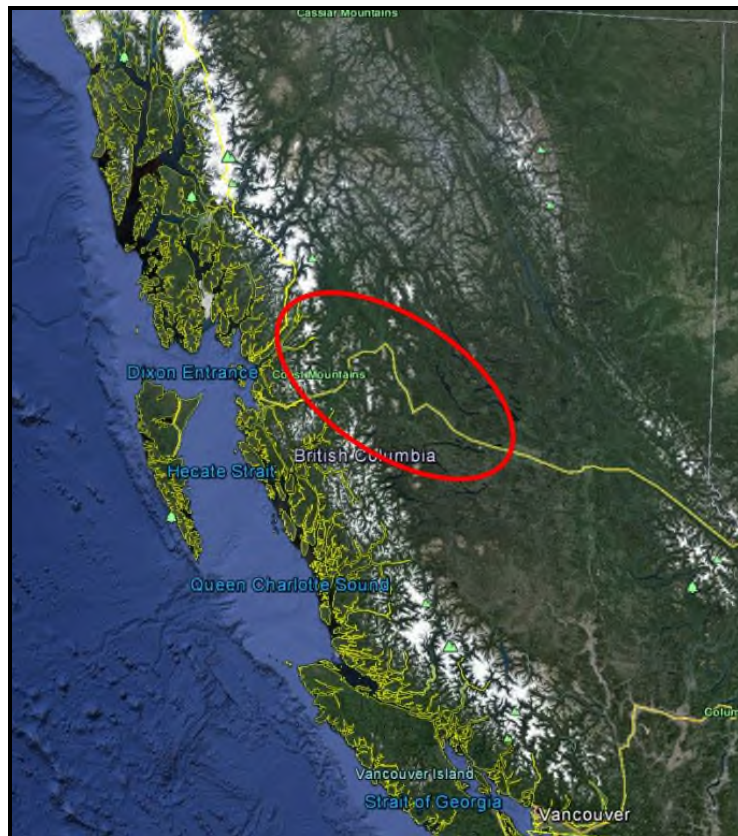
- In addition to the questions above, we were therefore also looking to determine if there are landscape attributes: geographic, topographic and biogeoclimatic (all of which may be associated with differences in black fly abundance), associated with occupied and successful sites?

Methods

In late spring-early summer, known goshawk breeding areas in the Kalum, Nadina and Skeena Stikine Resource District (Study area Map 1) were visited to determine occupancy and breeding success (young fledged). This survey included an inspection of known nests to determine current use, an intensive ground search for goshawk sign, and—if no sign was detected—call playback surveys (Kennedy and Stahlecker 1993, RISC 1997) to assist in the detection of breeding birds. All work was conducted by a goshawk biologist, and covered the core identified breeding area (based on the previous

multiple years of monitoring of the individual sites) (Mahon et al. 2003, Mahon 2009, Doyle 2014).

Following these surveys, a breeding area habitat analysis using was conducted to determine if the breeding areas met the current goshawk breeding area best management habitat requirements, of ≥ 100 ha mature forest and harvest edge ≥ 200 m from known nests (Stuart-Smith et al. 2012). This analysis used a combination of in field observations, Google Earth imagery, Landsat Ortho imagery and a more detailed habitat analysis conducted in the Nadina Resource District by Canadian Forest Products (Houston) using VRI data (Doyle 2014). (In this landscape harvest edges are typically defined as <40 years.)



Map 1. Long-term goshawk study area (red polygon).

Results

Breeding Areas Occupancy and Breeding Success

In 2015, 72 known goshawk breeding areas were monitored in the Kalum, Nadina and Skeena Stikine Resource Districts. Only two (3%) of breeding areas were occupied, and both successfully fledged young.

Since monitoring began in 1999, we have seen an overall downward trend in breeding area occupancy. (However, since 2010 annual monitoring has not been consistent across Resource Districts, see Figure 1) In 2002 & 2003, we saw an increase in occupancy which predictably coincided with an increase and subsequent decrease (2004 onwards) in prey with the snowshoe hare cycle (Doyle 2011). Snowshoe hare numbers substantially increased across the region in 2013 (as predicted in Doyle 2011), and numbers have been high since then (pers. obs. and as reported by field crews across the region), yet no corresponding increase in occupancy or breeding success in breeding areas has been observed.

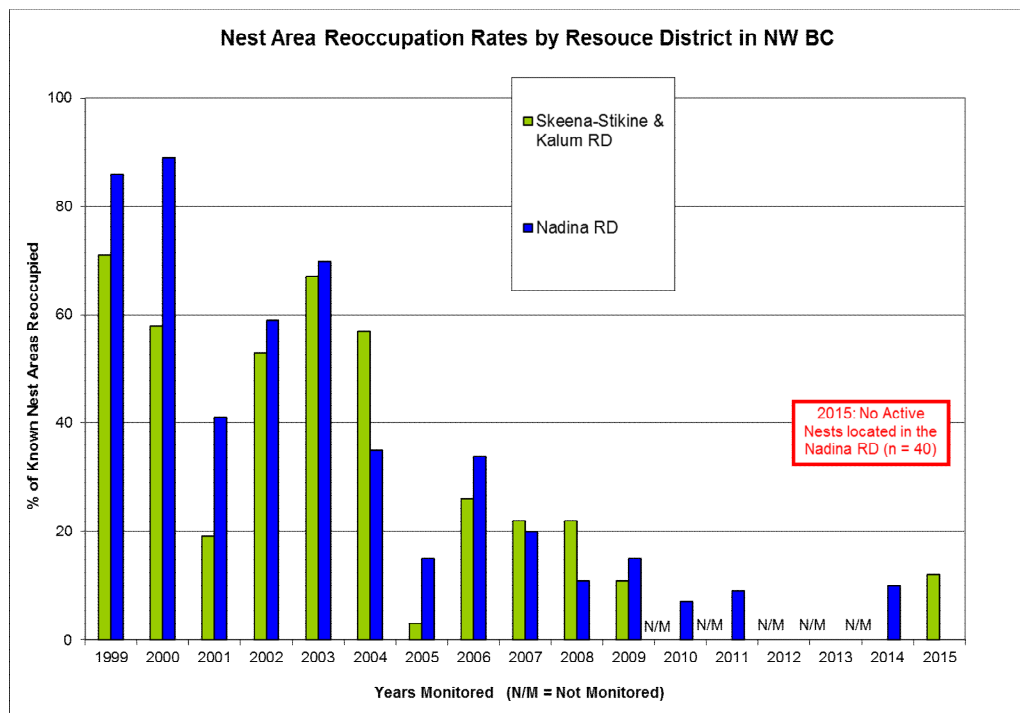


Figure 1. Occupancy of known Breeding Areas 1999 – 2015.

Forty-five known goshawk breeding areas were monitored in the SBS dominated Nadina Resource District, but there was no evidence of breeding, or occupancy (Figure 2) (Table 1). In the ICH/CWH dominated Skeena Stikine 22 known breeding areas were also surveyed and birds were located in 2 breeding areas, and both had fledged young (Table 1). At a third site evidence (feathers and prey remains) suggests that birds may have been present early in the breeding season, but when the area was visited in early June a portion of the Breeding Area was being harvested, and no birds were present. In the CWH dominated Kalum Resource District, only 5 breeding areas were accessible, and there was no evidence of birds or breeding at any site.

Table 1. Occupancy and fledging success of known Breeding Areas in each Resource District.

Resource Districts	Total Number Monitored	Number Occupied	Number Fledging young
Nadina	45	0	0
Skeena Stikine	22	3*	2
Kalum	5	0	0
	72	3*	2 (3%)

*2 confirmed and 1 possible

In addition to the known breeding areas, one new confirmed breeding area was located in the Nadina Resource District (Table 2), by a CANFOR forest layout crew. This area was in a relatively young mature open pine, spruce, aspen stand (Picture 2). Unfortunately the young died at around 2 weeks of age, with a dead chick found on the forest floor some 30 meters from the nest.

Table 2. New goshawk Breeding Areas located in 2015.

Resource Districts	Total # New Areas Located	Number Fledging young
Nadina	1	0
Skeena Stikine	0	0
Kalum	0	0
	1	0



Picture 2. New Goshawk Breeding Area on the Kivi (Nadina FD).
With remains of dead nestling.

Status of known Breeding Areas in relation to the recommended BMP

Overall, 19 (26%) of 72 known breeding areas (100 ha centered on the centroid of the breeding areas) had been harvested (e.g. Picture 1, 26km Augier and Picture 3 Anders, both in the Nadina Resource District), with the highest percentage (35.6%) harvested within the MPB impacted Nadina Resource District (Table 3).

Looking at the two recommended aspects of harvesting that should **be avoided** in relation to known Breeding Areas (Table 3, Stuart Smith et al. 2012), **harvesting <200m from known nests sites, and retention of <100ha suitable habitat**, 51 (66%) of Breeding Areas had harvesting <200m from nest sites, and 64 (83%) of Breeding Areas were comprised of <100ha of suitable habitat.

On a Resource District basis, 89% of all known Breeding Areas in the Nadina were <100ha and 77% had harvesting <200m from known nests sites. In the Skeena Stikine 70% of all known Breeding Areas were <100ha and 39% had harvesting <200m from known nests sites, and in the Kalum 86% of all known Breeding Areas were <100ha and 86% had harvesting <200m from known nests sites, although in the Kalum only a small

sample of 5 known Breeding Areas were accessible and surveyed. Overall therefore there was only a weak geographic or biogeoclimatic linkage between breeding area occupancy and success, with the two successful areas in the more coastal ICH/CWH biogeoclimatic zone.

Table 3. Status of known goshawk Breeding Areas in relation to the current recommended BMP.

Resource Districts	Total	Number Harvested	Harvest <200m of nests, recommended to be <u>avoided</u> in BMP (Stuart-Smith et al. 2012)	Less than the recommended >100ha of suitable Nesting Habitat (centered on the known breeding area) as per the BMP (Stuart-Smith et al. 2012)
Nadina	45	16 (35.6%)	36 (77%)	42 (89%)
Skeena Stikine	22	2 (9%)	9 (39%)	16 (70%)
Kalum	5	1 (14%)	6 (86%)	6 (86%)
Total	72	19 (26%)	51 (66%)	64 (83%)



Picture 3. Goshawk Breeding Area harvested (Anders) 2015 (Insert: Prior to harvest in 2014 fledged 2 young).

Looking at all the known breeding areas across all three Resource Districts (Table 4), 115 Breeding Areas are known. Currently only 25% of these areas meet the recommended

Breeding Area requirements (Stuart-Smith et al. 2012), 29% have been harvested and none of the remaining areas are in protected habitats (OGMA's, Park, etc.).

Table 4. Analysis of the Current Status of Breeding Areas.

Resource District	Total Number of Known Breeding Areas	Number of Breeding Areas that are Currently Suitable (Based on BMP: Stuart Smith et al. 2012)	% of Breeding Areas that are Currently Suitable (Based on BMP: Stuart Smith et al. 2012)	% of Nests in Protected Areas	% Logged	% of Breeding Areas with Moderate - High MPB
Kalum	10	2	20	0	30	0
Nadina	64	6	9	0	38	59
Skeena Stikine	41	21	51	0	15	17
Total	115	29	25	0	29	33

Discussion

From a goshawk management perspective, we are therefore left with the conclusion that a potential landscape tipping point has been reached, or an equivalent environmental change that has resulted in the near total collapse of the goshawk breeding population. In 2014, at a time of a potential peak in goshawk prey, we observed a breeding areas re-occupancy rate of only 12% (4 of 33: Nadina Resource District, Doyle 2014), indicating very few breeding areas were supporting breeding, at a time of a peak in prey abundance (Doyle 2011). One year later the situation appears to be even worse, with only 2 known successful breeding areas of 72 surveyed across three Resource Districts, and none of the 6 areas occupied last year fledged young (2 areas were largely harvested) or even showed evidence of occupancy this year.

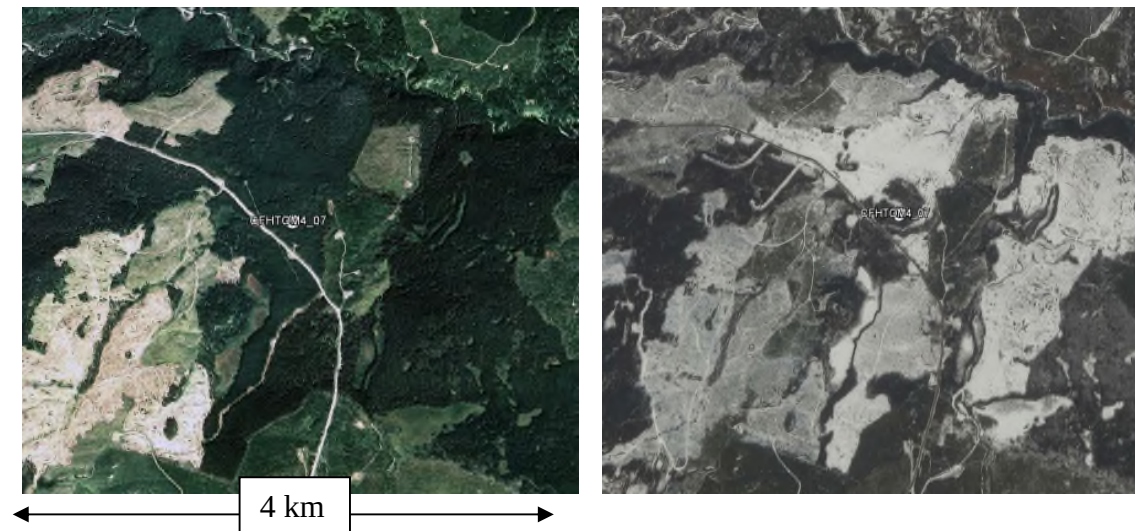
Compared to other long-term monitoring studies, there are no similar patterns in low re-occupancy rates or low breeding success, specifically at a time of a peak in prey and the warm dry breeding conditions as observed in 2015. In contrast under such conditions, we should be experiencing a high in breeding area re-occupancy rates and breeding success, with many areas occupied and fledging young (Bloxtton 2002, Doyle and Smith 1994, Kenward 1996, Squires and Reynolds 1997).

Trying to understand what is driving the observed low rates of occupancy, in 2014 we did observe that those areas supporting breeding primarily (5 of 6) consisted of areas >78ha of suitable mature forest centered on the breeding area. This observation was consistent with the recently released scientifically driven BMP for Breeding Areas (Stuart-Smith et al. 2012) that indicated that large intact breeding areas were required to maintain breeding area occupancy over several years, however none of those areas that supported breeding last year were occupied in 2015. On the positive side the two areas that supported breeding in 2015 both were consistent with the BMP as both were >100ha, and nests sites were >200m from harvest edges. This shows that the earlier BMP patch – occupancy analysis of breeding areas indicating that large patches are required, is supported even when few birds are breeding in the landscape.

Certainly both the required patch size of suitable breeding habitat at the breeding area scale (>100ha), and the recommended required foraging habitat of >30% - 50% mature-old growth at the territory scale are under threat in the Nadina Resource District, with both MPB (Picture 4) and an uplift in harvest resulting in smaller patches of suitable habitat in a highly fragmented landscape (Picture 5). However, this same change in seral and patch distribution has not been seen in the Skeena Stikine Resource District, where relative large patches of suitable breeding habitat (>30% of all known field checked areas >100ha) are still available to goshawks.



Picture 4. Mountain Pine Beetle, patches and change in seral stage in the Nadina Resource District.



Picture 5. Landscape example of goshawk Breeding Area (center of landscape) pre-MPB (left 2003), and post MPB and harvest (right 2013).

However, this use of only the larger breeding areas does not explain why so many of the larger (>25ha) breeding areas are not supporting breeding at a time of a peak in prey, both in the heavily impacted MPB – harvest landscape, but also in the more intact Kalum and Skeena Stikine Resource Districts (Picture 6).



Picture 6. Google Earth Image of forested habitat in the Kispiox Valley, Skeena Stikine Resource District.

One plausible explanation is the impact of climate change on the timing in the peak of black fly populations. In both the Nadina and Skeena Stikine nestling goshawks have been observed being attacked by large numbers of black flies and these nests subsequently failed at the young nestling phase (Doyle pers. obs. *In: Doyle 2008*). These observations were consistent with earlier work in the Yukon, where in years with a high in early spring temperatures both nestling Red-tailed Hawks (Picture 7) and fledged Great Horned Owls died as a result of attacks by black flies (Rohner and Hunter 1996, Doyle 2000, Rohner et al. 2000). Unfortunately for the nestlings, black flies have been seen to kill the nestlings through blood loss, falling from the nest during an attack and through the transmission of a blood parasite (leucocytozoon) (Smith et al. 1998). Consistent with many of these deaths (F. Doyle pers. obs), at the one new active goshawk nest in 2015, we found a dead 2-3 week old nestling on the forest floor beneath the nest (Picture 2) and the breeding attempt failed.



Picture 7. Red-tailed Hawk nestling attacked by black flies.

Crucially growth of black fly lava and hatch of adults is driven by water availability and temperature (Bernotiene and Bartkeviciene 2013) and from weather data readily available from local meteorological stations, we are seeing increasing-earlier spring temperatures (e.g. Figure 2, Smithers Airport), and higher precipitation (Figure 3, Smithers Airport: from Doyle 2008).

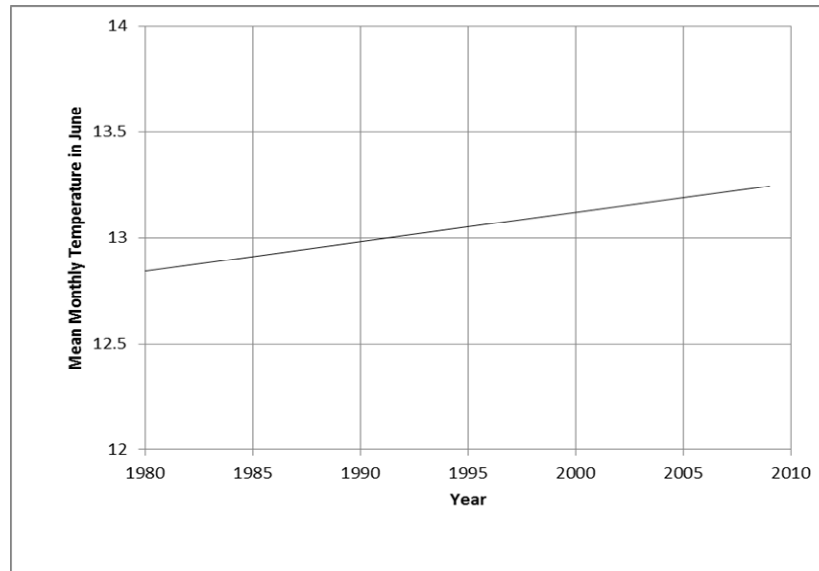


Figure 2. Trend line for the Mean Monthly temperature in June (Smithers Airport: http://climate.weather.gc.ca/climateData/monthlydata_e.html. Oct. 2015)

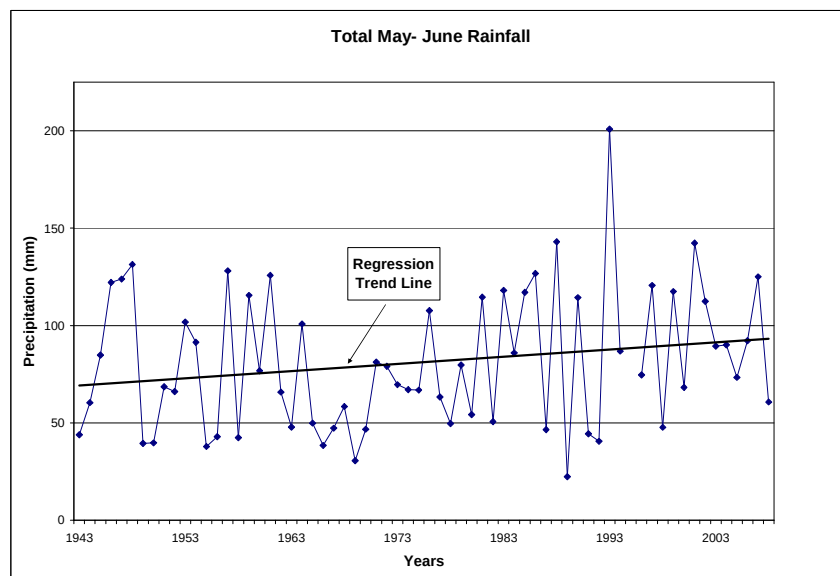


Figure 3. Total monthly May – June rainfall at Smithers Airport 1943-2008. (From Doyle 2008) http://www.climate.weatheroffice.ec.gc.ca/climateData/monthlydata_e.html

Within central-northwest B.C. the argument that black flies may ultimately be driving the reduction in goshawk breeding as a result of changing climate change, is perhaps more plausible if we consider that we never thought that MPB could kill the majority of pine trees across large areas of western North America. It is now accepted that a changing climate pushed us past a tipping point such that the MPB thrived and through a secondary host killed the trees (Carroll et al. 2004). Similarly due to increases in environmental temperature black flies may now have an extended breeding/hatch period at a time when young hawks, owls and perhaps other birds and mammals (see Caribou *In*: Dybas 2012,

Witter et al. 2012) are vulnerable to attacks by the flies, attacks that we know can kill nestling and fledged young (Hunter et al. 1997).

As appears probable a changing climate through black flies is causing the widespread death of goshawk nestlings (and possibly other forest raptors and birds), then a thriving-healthy population with ample prey, and a large number of viable territories across the landscape, maybe the only mechanisms by which the birds can counteract this impact. In this environment nestlings may be expected to receive sufficient food such that they are less vulnerable to mortality as a result of the blood parasites carried by the black flies. In addition, with a large number of viable territories, it may, through natural selection – via phenotypic plasticity, allow for enough individuals to breed successfully (e.g. resistant to the blood parasites, and/or breed early or late and thus miss the peak in black flies), such that through their genes their offspring are also successful.

To allow for the possibility that these two mechanisms above can function any other environmental impacts that reduce the overall habitat quality (breeding and foraging), will predictably reduce the ability of the landscape to support goshawks. If we are to maintain the possibility of a viable goshawk population then we need to ensure we apply the BMP breeding area and territory scale recommendation (Stuart-Smith et al. 2012).

In addition, if as observed in Table 3, the large majority of known breeding areas are no longer suitable, then through landscape forest stewardship planning we should ensure at the very minimum that suitable patches of breeding area habitat (>100ha), are available across the landscape (ideally at the previously observed 4-5km spacing (Mahon 2009), such that if and when goshawks attain breeding condition they have somewhere to breed. The need for this new landscape approach is further heightened by the knowledge that all but one known breeding area in the Nadina has lost trees as a result of MPB attack, and in 63% of cases >75% of trees were dead. This means that with the rot and fall of these trees these areas will not be suitable as goshawk breeding areas in the near future, and other goshawk breeding areas (or suitable habitat patches) need to be identified and managed to meet goshawk breeding area requirements (Doyle 2014).

Support by **Land Managers** is needed for any actions that help mitigate impacts (harvest, MPB, black flies) on the viability of goshawks at either the individual territory or the population scales. The main tool to ensure this link is listing by the **CDC and the Identified Wildlife Management Strategy under FRPA**. Right now, goshawks are not listed and thus there is **no legal** requirement for managers to survey for and manage for this species' requirements, and none of the known goshawk breeding areas (n = 115) are in protected areas. At a **minimum, Regionally Important Wildlife status** for this species would highlight our concern that goshawks are under threat from harvest/landscape change and would ensure any active breeding areas are reported. To determine the extent of this threat we need to more fully understand the current distribution and condition of goshawk territories, both in the central-northwest and across the province of BC. (Are there regional differences in relative abundance that can help drive/structure management direction for this species?).

Finally, in addition to the stewardship concerns around maintaining ecosystem function and integrity - an economic rationale for maintaining raptor and owl populations is the role they play in controlling – reducing small mammal and snowshoe hare populations. Both of these species groups have historically had a large economic impact through the browsing damage and loss of seedling trees (Sullivan and Sullivan 1982, Sullivan 1984), and as a natural control goshawks and Great-horned Owls alone accounted for 30% of adult hare mortalities in the Yukon (Krebs et al. 2001).

The scale, and subsequent ecological impact on our ecosystem, of this population crash is hard to grasp, but we do know that prior to 2010 in the Nadina Resource District that there was an estimated ~600 goshawk territories in the (D. Steventon: Draft unpub. report MFLNRO 2010). Of these territories, only 61 (10%) have been located, and in our sub-sample of 45 none were occupied. If this represents loss of breeding pairs across the landscape, and this pattern is repeated across the Resource District, then we could be looking at the loss of nearly 600 pairs of birds, and the ecological role they play across the ecosystem.

Summary: Recommended Management Actions

- Manage for as large a population as possible to allow survival and climate change adaptation (e.g. change in timing of breeding, blood parasite tolerance)
 - Follow BMP's for known goshawk Breeding Areas (Stuart-Smith *et al.* 2012).
 - Breeding Habitat: >100 ha patch of suitable mature-old forest.
 - Foraging Habitat: >30% mature-old growth (i.e. of each ~2,400ha territory) surrounding Breeding Habitat.
- Above all manage for high suitability territories where both the Breeding Area and associated Foraging Habitat may be expected to support goshawks, by protecting Breeding Areas, and provide for long term foraging habitat requirements through harvest rotation and other silvicultural management strategies.
- Update Conservation Data Centre Risk Assessment Ranking.
- Consider adding interior goshawk to IWMS, requiring that all active breeding areas be reported and managed.
- Where intact Breeding Areas no longer exist, identify and manage for future Breeding and associated foraging habitat requirements.
- Maximize functionality of areas by co-locating with other retained or managed areas (e.g. for other identified species, protected areas or retention requirements from Land & Resource Management Plans).

- Proactive, long-term forest management for this focal umbrella species will enable persistence of goshawks and will support species/ecosystem resilience and function.
- Recognize and support good stewardship by the resource community. The above actions will have direct \$\$ impacts on harvesting.

Management Knowledge Gaps (Future Research)

Establish conclusively the link between black flies and goshawk breeding and breeding success. And determine if there is a geographic pattern (e.g. across Resource Districts) in the severity of attacks that may help direct regional landscape management focus of our raptors, owls and other potentially vulnerable species (e.g, Caribou? Dybas 2012, Witter et al. 2012. Moose? BBC 2008)

“Potentially in collaboration with academic institutions” establish when the peak in black flies occurs in the Kalum, Nadina and Skeena Stikine Resource Districts to determine:

- Are the black flies carrying the blood parasite?
- What is the impact of black flies attack and/or leucocytozoon on a health bird?
- If the peak in black flies is occurring at a time that nestlings raptors are vulnerable to attacks by the flies? (Is the timing in the peak of black flies synchronous across Resource Districts?
- If the abundance (and earlier peak) of black flies is killing young across all three Resource Districts?
 - Is there a geographic or biogeoclimatic pattern to black fly abundance that we can use to help direct landscape management for raptors, owls, etc?
 - Is there a harvest – seral stage landscape pattern associated with higher densities of black flies?
- How many goshawk territories do we need to manage for to maintain the potential for a fully functional population (across the ecosystem as a whole) across the landscape?
- What other bird and mammal species may be vulnerable to any changes in the abundance and peak in numbers of black flies?
- Is there a landscape pattern in habitat distribution and seral stage that makes species vulnerable to attacks by black flies less vulnerable to these attacks?

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