Nest site characteristics of **Hooded Warblers** at the northern edge of their breeding range

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Introduction

The northern limit of the breeding range of the Hooded Warbler (*Setophaga citrina*) extends from southeastern Nebraska to the southern Great Lakes Region and includes Wisconsin, Michigan, southern Ontario and New York (Chiver *et al.* 2011). The southern limit of the Hooded Warbler's breeding range extends from Florida to eastern Texas, although breeding in California has been documented (Chiver *et al.* 2011). Hooded Warblers have been undergoing a population and range expansion in the northeastern portion of their range (Gartshore 1988, Badzinski 2007, Hitch and Leberg 2007, Melles *et al.* 2011). For example, between the first (1981 – 1985) and second (2001 – 2005) Ontario Breeding Bird Atlas, Hooded Warblers were found in 68 new 10 km x 10 km atlas squares, and 12 of the same squares, while the species became absent in eight squares (Cadman *et al.* 2007). The expansion has generally been attributed to climate change (Hitch and Leberg 2007, Melles *et al.* 2011), but may also be a result of increases in suitable forested habitat within portions of its range (Badzinski 2007).

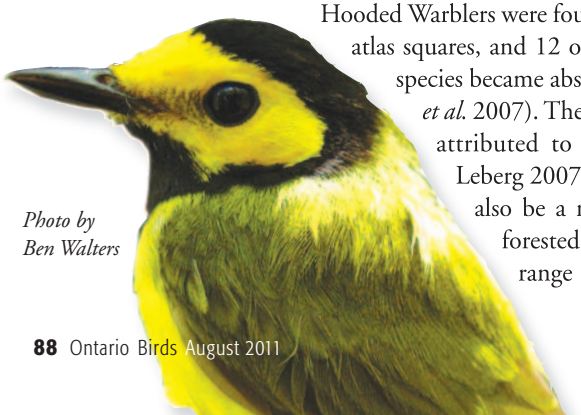

Photo by Ben Walters

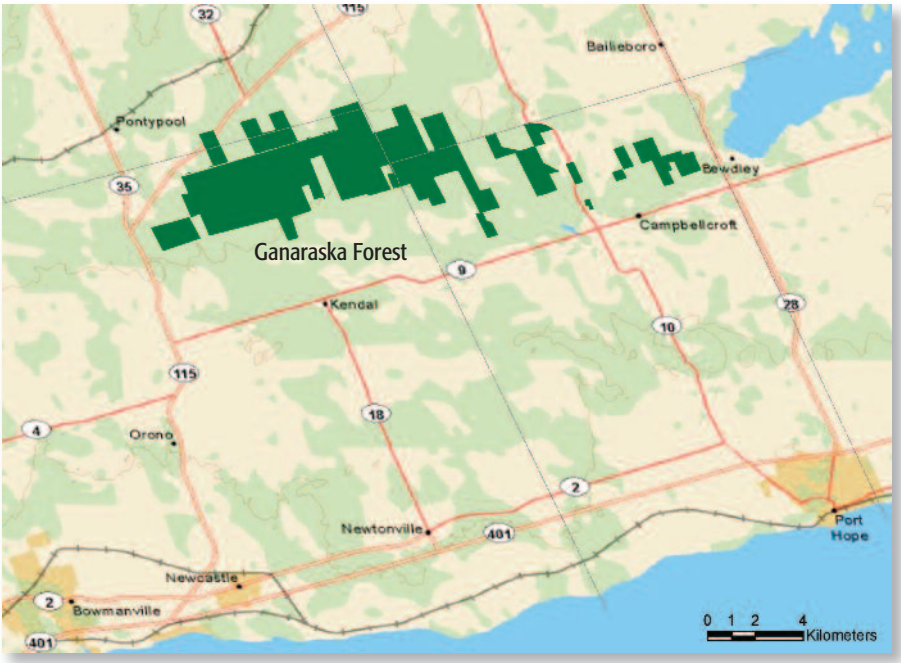

Figure 1. Location of the Ganaraska Forest owned by the Ganaraska Region Conservation Authority.

The Hooded Warbler is listed as a "threatened" species in the federal *Species at Risk Act*, and a "special concern" species in *Ontario's Endangered Species Act*, 2007. Less than 1% of the Hooded Warbler's breeding range is in Canada (Environment Canada 2011) and all of that is in southern Ontario (Badzinski 2007). The first documented occurrence of the Hooded Warbler at the northern extent of its range in Ontario was in 1878 and nesting was first documented in 1949 (Peck and James 1987). The northern extent of the Canadian Hooded Warbler population was considered to inhabit primarily Carolinian Forests in southwestern Ontario (Bisson and Stutchbury 2000, Friesen *et al.* 2000, Whittam *et al.* 2002, Badzinski 2003).

Some breeding evidence north of this range, such as a male feeding young east of Peterborough, Ontario, in 1963 (Sadler 1968), has been reported, but a breeding population was not discovered. Evidence now suggests that Hooded Warblers may breed as far north as the Bruce Peninsula, Lake Simcoe-Rideau and the southern Canadian Shield regions (Badzinski 2007). For example, an unsuccessful breeding attempt was documented at Awenda Provincial Park in 1989 (Weir 1989) and a pair with fledged young was observed there in 2010 (Friends of Awenda Park 2011).

Hooded Warblers mainly breed in mid- to late-successional mixed deciduous forests. At the northern extent of their range, such as in Ontario, Pennsylvania, Ohio, and Missouri, they breed in beech-maple and oak-hickory dominated forests (Horn and Benninger-Truax 1997, Friesen *et al.* 2000, Howlett and Stutchbury 2003, Wallendorf *et al.* 2007, Chiver *et al.* 2011). At the southern edge of their range they breed in wet lowlands such as cypress-gum swamps (Heltzel and Leberg 2006). Hooded Warblers will also inhabit forests with coniferous components such as oak-pine in south-central Missouri (Wallendorf *et al.* 2007), mature pine forests in North (Greenberg and Lanham 2001) and South Carolina (Sargent *et al.* 1997) and coniferous plantations in southwestern (Badzinski 2003) and south-central Ontario (*this study*).

Hooded Warblers prefer mature forests with a high canopy (Whittam and McCracken 1999), dense understory, and canopy gaps for nest sites and territories (Gartshore 1988, Whittam and McCracken 1999, Bisson and Stutchbury 2000, Friesen *et al.* 2000, Pasher *et al.* 2007). Hooded Warbler nest sites would naturally be found in tree-fall gaps (Chiver *et al.* 2011), but because of a lack of mature forest throughout their range, they are typically found in sites that are selectively logged (Tarof and Stutchbury 1996, Whittam and McCracken 1999, Greenberg and Lanham 2001). Hooded Warblers appear to be more abundant at sites within 12 to 18 years after harvest (Gartshore 1988, Heltzel and Leberg 2006) and in hurricane created gaps after two and three years (Greenberg and Lanham 2001) rather than in control stands without gaps. In some regions, Hooded Warblers are observed only in sites that have undergone forest harvesting (Wallendorf *et al.* 2007, *this study*). As well, because of their preference for dense understory, nesting can occur close to skidder trails, old logging roads and roads (Gartshore 1988, Howlett and Stutchbury 1996).

In 2006, a small nesting population of Hooded Warbler was observed in the Ganaraska Forest in south-central Ontario, approximately 200 km north of the previously documented northern range (Friesen *et al.* 2000) (Fig. 1). Unlike the southwestern Ontario population in the Carolinian Forest Zone, this south-central Ontario population inhabits the Great Lakes-St. Lawrence Forest Zone. Similarly, however, the Ganaraska Forest is mainly underlain by sandy soils as is much of this species' distribution in Ontario's Carolinian Forest (Gartshore 1988). The Ganaraska Forest is composed of beech-maple and oak-maple forest with some mixed pine-oak forest and coniferous plantations. Some trees and shrubs such as tulip-tree (*Liriodendron tulipifera*), sassafras (*Sassafras albidum*) and spicebush (*Lindera benzoin*), that are present in the Hooded Warbler's southwestern Ontario breeding habitat, are absent from the Ganaraska Forest. Therefore, differences in forest structure such as tree spacing, canopy height and closure, and shrub layer density, between

Figure 2. Deciduous habitat used by nesting Hooded Warblers in the Ganaraska Forest. *Photo by Ben Walters*

the Carolinian Forest Zone and the Ganaraska Forest could result in differences in habitat selection. Our objective was to determine whether the structure of nesting habitat in the Ganaraska Forest was similar to that in other areas of this species' range, particularly in southwestern Ontario. Determining the similarity in nest-site habitat requirements among forest types would be useful for understanding what forest management practices are most beneficial to Hooded Warblers and whether they could be the same across this species' Canadian range. Furthermore, identifying the similarities or differences in structural characteristics would help in future assessments of potential breeding habitat availability in the Great Lakes-St. Lawrence Forest Zone. We expected that Hooded Warblers would use nest-sites with the same structural characteristics as as individuals to the south, despite a difference in forest type. We expected that, because Hooded Warblers are a gap-dependent

species (Bisson and Stutchbury 2000, Shifley *et al.* 2006), nesting habitat would be structurally similar to areas to the south with dense undergrowth and an open canopy.

Methods

Study area

The Ganaraska Forest (N44° 5.8' W78° 30.5'), owned by the Ganaraska Region Conservation Authority, is a 4,228 ha forest on the Oak Ridges Moraine (Figure 1). The boundaries of the Ganaraska Forest are within Durham Regional Municipality, and Peterborough and Northumberland counties. Forest soils are dominated by Pontypool series gravely sand, Dundonald sandy loam, Bridgman sand and Pontypool sandy loam underlain by Black River Trenton group limestone. Forest elevations range from 200 m to 408 m above sea level (Tedford 1978).

In the early 1900s, reforestation of the Ganaraska Forest was necessary to stabilize the soils that began to erode after they were cleared for farmland. The forest is approximately equally comprised of coniferous plantation and mixed hardwoods. The coniferous plantations consist of red pine (*Pinus resinosa*) with smaller areas of scots pine (*Pinus sylvestris*), jack pine (*Pinus banksiana*), white spruce (*Picea glauca*), European larch (*Larix deciduas*) and American larch (*Larix laricina*). The mixed hardwoods are dominated by red oak (*Quercus rubra*), sugar maple (*Acer saccharum*) and poplar (*Populus spp.*) (Tedford 1978). The surrounding land use is largely agricultural. Pasture lands for horse and cattle production dominate with some hay fields and few row crops. Similar to the St. Williams forest where a large percentage of Canada's Hooded Warblers breed (Whittam *et al.* 2002), tree harvesting in the Ganaraska Forest is performed by either single-tree selection in mixed deciduous forest or row-thinning in pine plantations.

Nest site vegetation characteristics

Hooded Warbler nest sites were located in 2006 (n = 4) and 2007 (n = 8) through intensive foot searches near singing males and agitated females. Vegetation characteristics were measured at eight of the 12 sites in 2007.

We measured the habitat characteristics at nest sites within a 5m x 10m area centered on the nest. The habitat variables measured included percent cover of overstory canopy cover, stem density of saplings and trees, ground cover and vegetation stratification (Kilgo *et al.* 1996). We then compared the vegetation characteristics from the nest patch to the vegetation characteristics at randomly chosen unused sites (Kilgo *et al.* 1996, Bisson and Stutchbury 2000). To test nest-site selection, we pooled nests from 2006 and 2007 because of small sample sizes (Whittam *et al.* 2002).

All statistical analyses were performed using STATISTICA (Statsoft 2004). Normality was tested using the Kolmorogov-Smirnov test and homogeneity of variances was tested using

the Levene's test. Variables that were normally distributed, or normalized using a transformation, were tested for their difference between nest sites and non-use sites using independent t-tests. Data that were not normally distributed were transformed using log(k) or log(k+1) to meet the assumptions of parametric testing. If data could not be normalized, the difference between nest sites and non-use sites was tested using a Mann-Whitney U test.

To assess percent cover within the nest and random unused sites, vegetation was vertically stratified as follows: Ground cover = <0.5 m; Regeneration = >0.5 m and <1.3 m; Saplings = >1.3 m <2.5 m; Understory = >2.5 m and <10 m; Sub-canopy = >10 m and < 20 m; Canopy = >20 m. Percent cover estimates were categorized as follows: 0% = 1; 1 – 25% = 2; 26 – 50% = 3; 51 – 75% = 4; 76 – 100% = 5 Kilgo *et al.* 1996, Moorman *et al.* 2002. Because of the high degree of correlation within the percent cover classes, one variable was removed from each correlated pair (Moorman *et al.* 2002). Within the percent cover classes, the uncorrelated variables analyzed were regeneration and understory. All trees (>25 cm circumference), saplings (>1.3 m high and <7.8 cm circumference) and shrubs within the plot were counted and classed as either dead or alive. The vegetation plot rectangle was quartered into quadrats by assigning boundaries along each cardinal direction. The distance to the nearest tree and the nearest sapling in each of the quadrats was measured. Distances were then pooled into a mean distance. Litter depth was measured at the edge of the plot in all cardinal directions and at the centre point of the plot. Measurements at each site were pooled to create a mean depth for each site.

Coarse woody debris (CWD) was counted along a 10 m transect which was defined as 1 m on either side of the eastern boundary of the vegetation plot (20 m^2). CWD was classified as small CWD (<2.5 cm circumference), medium CWD (2.6 – 8 cm circumference), and large CWD (>8 cm circumference). Lastly, all classes at each site were pooled to create a total abundance of CWD for each site. For testing of the pooled CWD, one site was removed from the non-use sites as it had no CWD and was a severe outlier affecting normality.

Basal area, the area of land that is covered by the cross-sections of woody stems (m^2/ha), was measured using a 2X prism centred on the nest or at the centre of the plots in the non-use sites. From the non-use sites, two sites that were measured in large openings such as on roads at logging landings were not used as they severely affected normality. Once these outliers were removed, parametric tests could be used without transformation.

Canopy cover was measured using a spherical densiometer. Four measurements were taken by standing at the centre point and extending the densiometer in each cardinal direction. The measurements from each direction were multiplied by 1.04 as required by the instructions for the instrument to approximate 100% coverage, and the results were averaged.

Table 1. Comparisons of the percent cover in the regeneration layer between Hooded Warbler nest sites and randomly chosen non-use sites in the Ganaraska Forest, Ontario, 2006 – 2007.

Class	Nest sites (n = 4)	Non-use sites (n = 62)
1 (0%)	0 (0%)	3 (5%)
2 (1 – 25%)	0 (0%)	44 (71%)
3 (26 – 50%)	3 (75%)	12 (19%)
4 (51 – 75%)	1 (25%)	3 (5%)
5 (76 – 100%)	0 (0%)	0 (0%)

Table 2. Comparisons of the percent cover in the understory layer between Hooded Warbler nest sites and randomly-chosen non-use sites in the Ganaraska Forest, Ontario, 2006 – 2007.

Class	Nest sites (*n* = 4)	Non-use sites (*n* = 62)
1 (0%)	0 (0%)	7 (11%)
2 (1 – 25%)	1 (25%)	29 (47%)
3 (26 – 50%)	2 (50%)	16 (15%)
4 (51 – 75%)	1 (25%)	9 (15%)
5 (76 – 100%)	0 (0%)	1 (2%)

Results

We observed four nests (probably of three nesting pairs) and five males (two unpaired) in 2006, and eight nests in 2007 (probably of seven nesting pairs) and 14 males (seven unpaired). Search effort was similar in the two years so the local breeding population appears to have increased between 2006 and 2007. By colour-banding males with individually identifiable patterns in 2007, we were able to determine that two nests with nestlings were being attended by the same male.

All but one Hooded Warbler nest found in the Ganaraska Forest were placed in gaps created by silvicultural wood removal. Hooded Warblers chose four different nest substrates: elderberry (*Sambucus sp.*), 3 (25%); sugar maple (*Acer saccharum*), 6 (50%); raspberry (*Rubus sp.*), 2 (17%), and beaked hazel (*Corylus cornuta)*, 1 (8%). The average nest height was 0.56 m ± 0.10 (mean ± standard error). Most nests were placed in the crotch of nest substrates or on a platform created by branches. One nest however, was placed where a dead branch touched the stem of a sapling and the edges of the nest on two sides were attached to the substrate at the top of the nest cup. The nest was very flimsy and had begun to disintegrate by the time of fledging. This nest was also different because it was found in a medium-aged patch of forest approximately 10 m from the nearest typical gap nesting habitat.

Because we had percent cover estimates for a few sites only ($n = 4$), we did not analyze them statistically. Hooded Warbler nest sites were found in areas with a high percent cover (between 26 – 75% cover) in the regeneration layer

Table 3. Comparison of vegetation characteristics between Hooded Warbler nest sites and randomly chosen non-use sites in the Ganaraska Forest, Ontario, 2006 – 2007.

Parameter	Nest Site[h]	Non-use Site[h]	P[i]
Live tree density (# of trees/50 m^2)[b]	2.6 ± 0.7	3.1 ± 0.3	0.74
Dead tree density (# of trees/50 m^2)[a,b]	0 (range 0 – 3)	0 (range 0 – 5)	0.66
Live sapling density (# of saplings/50 m^2)[b]	27.9 ± 7.8	9.3 ± 1.0	**<0.0001**
Dead sapling density (# of saplings/50 m^2)[b]	0.8 ± 0.5	1.3 ± 0.3	**0.005**
Shrub density (# of shrubs/50 m^2)[a,d]	43 (range 7 – 66)	3 (range 0 – 125)	**0.02**
Mean distance to trees (cm)[c]	510.0 ± 42.2	438.1 ± 39.1	0.25
Mean distance to saplings (cm)[c]	184.3 ± 48.7	414.4 ± 41.9	**0.007**
Distance to nearest tree (cm)[c]	249.9 ± 22.0	272.6 ± 38.3	0.45
Distance to nearest sapling (cm)[c]	64.4 ± 14.9	191.8 ± 30.9	0.058
Litter depth (cm)[e]	3.6 ± 1.2	3.3 ± 0.2	0.7
CWD small (# of pieces/20 m^2)[d]	43.5 ± 9.8	42.1 ± 4.0	0.93
CWD medium (# of pieces/20 m^2)[d]	9.3 ± 1.7	5.2 ± 0.6	0.06
CWD large (# of pieces/20 m^2)[d]	1.5 ± 0.5	2.3 ± 0.5	0.86
CWD total (# of pieces/20 m^2)[d]	54.3 ± 10.0	49.6 ± 4.4	0.51
Basal Area (m^2/ha)[f]	18.8 ± 1.3	23.5 ± 1.1	0.12
Canopy cover (#/100 units)[g]	27.6 ± 3.8	31.8 ± 4.7	0.98

a Mann-Whitney U test
b Nest site ($n = 8$); Non-use site ($n = 62$)
c Nest site ($n = 7$); Non-use site ($n = 62$)
d Nest site ($n = 4$); Non-use site ($n = 62$) CWD: Coarse woody debris
e Nest site ($n = 3$); Non-use site ($n = 61$)
f Nest site ($n = 8$); Non-use site ($n = 60$)
g Nest site ($n = 4$); Non-use site ($n = 22$)
i Mean ± standard error
h Significant results ($P<0.05$) are bolded.

(between 0.5 m and 1.3 m from the ground) of the Ganaraska Forest (Table 1). Although the sample size was small, this observation was disproportionate to the non-use sites which had a higher distribution in the lower regeneration class of 1 – 25% cover.

Similarly, although not analysed statistically, nest sites were found at locations with proportionally more cover in the understory layer (between 2.5 m and 10 m from the ground) than non-use sites (Table 2). While non-use sites were found to occur within each

Figure 3. Hooded Warbler nest containing four eggs in a sugar maple sapling, the most often used nesting substrate in the Ganaraska Forest. *Photo by Ben Walters*

percent cover class, they were distributed around class 2 (1 – 25%). Nest sites were distributed around class 3 (26 – 50%), suggesting that Hooded Warblers in the Ganaraska Forest choose a denser understory. The variables that were significantly different between nest sites and non-use sites were: (1) live sapling abundance; (2) dead sapling abundance; (3) shrub density, and (4) mean distance to saplings. There were significantly more living and fewer dead saplings at nest sites that at non-use sites (Table 3). As well, there were significantly more shrubs at nest sites than at non-use sites (Table 3). In addition, the mean distance to saplings, measured from the nearest sapling to the northwest, northeast, southwest, and southeast was significantly lower at nest sites than non-use sites.

Figure 4. Female Hooded Warbler incubating eggs that included the first observed case of Brown-headed Cowbird parasitism in the Ganaraska Forest. *Photo by Ben Walters*

Discussion

Hooded Warbler nest sites in the Ganaraska Forest were mostly in deciduous dominated forest (Figure 2), although two of the 12 nests were in managed conifer plantations that were regenerating to mixed forest. The preference of Hooded Warblers nests to be in forest gaps with dense vegetation in the lower regeneration layer in the Ganaraska Forest was similar to the preferences reported elsewhere (*e.g.,* Gartshore 1988, Whittam and McCracken 1999, Bisson and Stutchbury 2000, Pasher *et al.* 2007). Proportionally more often, Hooded Warblers in the Ganaraska Forest used sugar maple as the nesting substrate compared to other substrates (Figure 3), although the sample size of nests was small. Higher proportional use of sugar maple as nest substrate had not been reported in other studies, however two of our nests were in raspberry brambles,

Due to the success of the populations to the south, Hooded Warbler individuals appear to have emigrated north to suitable habitat

the preferred substrate of nests in southwestern Ontario (Badzinski 2003). Nest heights in the Ganaraska Forest (mean = 0.56 m) were similar to the heights observed in the southwestern Ontario (*e.g.*, mean = 0.48 m: Badzinski 2003), Pennsylvania (mean = 0.54 m: Howlett and Stutchbury 1996, mean = 0.51 m: Howlett and Stutchbury 1997) and slightly lower than in South Carolina (mean = 0.98 m: Kilgo *et al.* 1996; mean = 0.9 m <100 m from edge, and mean = 0.8 m>100 m from edge: Moorman *et al.* 2002).

Although Hooded Warblers in the Ganaraska chose nest sites in openings created by forest harvesting, we did not observe a significant difference between the canopy cover at nest sites and non-use sites. On average, canopy cover at nest sites was lower, but the difference was not statistically significant. Nest sites in South Carolina also did not have significantly different canopy cover at nest sites (Kilgo *et al.* 1996); however, other studies have found significantly reduced canopy cover at nest sites (Whittam *et al.* 2002, Pasher *et al.* 2007). A potential reason for our results differing from other studies is that we used a spherical densiometer to measure canopy cover. Due to its concave mirror, we may have sampled forest canopy cover further outside the nest patch than other studies. The increased coverage outside the nest patch would have decreased the overall coverage by the opening. Because there were no apparent differences among the nest sites at our study site in the Great Lakes-St. Lawrence Forest Zone and the nest sites to the south such as in the Carolinian Forest Zone, we suggest that this new nesting population of Hooded Warblers is part of a range expansion rather than attraction to a novel habitat feature.

Due to the success of the populations to the south, Hooded Warbler individuals appear to have emigrated north to suitable habitat, possibly as a result of a warming climate (Melles *et al.* 2011). Forest harvesting practices in the Ganaraska Forest are similar to those in southwestern Ontario (*e.g.*, South Walsingham and St. Williams Forest) and their populations have continued to grow in those forests when suitable habitat is created by logging practices (Whittam and McCracken 1999). We expect that unless a stochastic event occurs to

Figure 5. An after second year male Hooded Warbler banded as part of research in the Ganaraska Forest. *Photo by Ben Walters*

adversely affect nest productivity or the interannual survival of individuals of this new population, continued population growth and expansion will occur in this Great Lakes-St. Lawrence Forest Zone population.

Interestingly, following the intensive surveys for Hooded Warblers in 2007, the population has appeared to remain (as of July 2011) at approximately five pairs and nesting as far north as Peterborough County in 2008 has not been re-observed (BJW, pers. obs.). A major problem for more southern populations is a high incidence of nest parasitism by Brown-headed Cowbirds (*Molothrus ater*).

However, until a nest containing a Brown-headed Cowbird egg was found in 2010 in the Ganaraska Forest (Figure 4), no previous incidences of parasitism had been detected. Therefore it is unlikely that nest parasitism is a cause of slow population growth. In fact, we

could speculate that the novelty of Hooded Warbler nesting allowed them to go undetected until the local Brown-headed Cowbirds became accustomed to Hooded Warbler nesting behavior. The stability, rather than growth of this population may be an effect of the small number of annual recruits being offset by interannual mortality and territorial abandonment by unpaired adults. In 2009, two years after banding many fledglings and adults (Figure 5), we only re-encountered a single banded male despite nesting occurring at similar territories. The difficulty of finding mates in a small population was exemplified in 2008 when a male was observed mating with a female offspring from the previous year. While geographic expansion of the Hooded Warbler populations provides a promising outlook for a stable Ontario population, population growth at the northern limit appears slow.

Summary

The population and range of the Hooded Warbler has been expanding in Ontario. Once considered a species of the Carolinian Forest Zone, Hooded Warblers have continued to expand northward. In 2006, we found a previously unreported, small breeding population of Hooded Warblers in the Ganaraska Forest, south of Peterborough, Ontario. This population represented a shift from being restricted to the Carolinian Forest Zone in Canada to inhabiting the Great Lakes-St. Lawrence Forest Zone. In 2007, we sought to assess the habitat characteristics of Hooded Warbler nest sites in the Ganaraska Forest to determine if the habitat structure was similar to the more southern breeding population. We found that Hooded Warblers were choosing to nest in forest gaps. The nest sites in the gaps had higher vegetation density in the regeneration (>0.5 m and <2.3 m) and understory (>2.5 m and <10 m) layers than random locations. For example, most nest sites had 26–50% cover in the regeneration layer while most random locations had 1–25% cover. Similarly the greatest number of nest sites had 26–50% cover in the understory layer while most random locations had 1–25% cover. Nest sites had significantly higher sapling and shrub densities than random locations. As we expected, Hooded Warblers appear to be choosing structural characteristics in the Ganaraska Forest that are similar to those in more southern forest types. We detected only one case of Brown-headed Cowbird parasitism in Hooded Warbler nests since 2006.

Acknowledgments

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