

Hooded Warbler research in St. Williams Forest, Ontario:

An investigation of nest productivity, nest concealment, territory size and species associations



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INTRODUCTION

Nest predation is usually the most significant factor affecting nest success of cup-nesting passerines, and may be the predominant factor regulating populations (George 1987). Landscape characteristics such as forest fragmentation, forest structure and distance from edge and nest site characteristics such as nest height, density of surrounding vegetation and nest concealment have been shown to influence nest predation rates. High rates of nest predation have been reported for forest birds in fragments that are surrounded by agricultural fields because of the higher diversity and abundance of predators in the landscape (Vander Haegen et al. 2002, Robinson et al. 1995). In addition to increased predation rates, birds nesting in highly fragmented landscapes often suffer from increased incidence of brood parasitism by cowbirds. Parasitized nests usually fledge less host young and nests may also suffer higher rates of nest predation than do unparasitized nests (Dearborn 1999). For these reasons, there is concern about the health and long-term stability of forest songbirds, particularly forest interior and/or area sensitive species.

The Hooded Warbler (*Wilsonia citrina*) is considered area sensitive, preferring to nest in large tracts of mature forest in areas with high regional forest cover (Evans Ogden and Stuchbury 1994, Friesen et al. 2000). It is listed as a threatened species in Canada because the small Canadian population is almost exclusively limited to the highly fragmented Carolinian Forest Zone of southwestern Ontario. To address concerns about the long-term viability of the Canadian Hooded Warbler population, Bird Studies Canada in partnership with the National Acadian Flycatcher/Hooded Warbler Recovery Team (Friesen et al. 2000), began intensive annual monitoring of the Hooded Warbler population in St. William's Forest in 1999. St. William's Forest is one of the largest woodlots within the Carolinian Zone and supports more than 20% of the Canadian Hooded Warbler population. This makes it an ideal site to investigate Hooded Warbler population dynamics and identify factors affecting productivity and survival rates.

The long-term objectives of the St. Williams Hooded Warbler research project are to monitor annual productivity, predation rates, parasitism rates, and return rates of banded birds, and to collect information on nest site characteristics and habitat selection. By collecting this information, Bird Studies Canada and the recovery team hopes to further our understanding of the factors affecting Hooded Warbler productivity and survival rates, which will assist in the conservation and protection of Hooded Warblers in Canada. The specific objectives of the 2002 field season were:

- (1) Monitor Hooded Warbler population size and nest productivity.

- (2) Collect basic information on nest site characteristics and calculate an index of concealment at each nest site to test the hypothesis that successful nests are more concealed than are unsuccessful nests.
- (3) Carefully check all Hooded Warblers for the presence of colour bands, and colour band as many adults and nestlings as possible.
- (4) Using playback of conspecifics song, determine the size of a representative sample of Hooded Warbler territories in St. Williams.
- (5) Identify other passerine species that are closely associated with Hooded Warblers (i.e. are found within Hooded Warbler territories) in both St. Williams and throughout the species Canadian range by doing point counts at Hooded Warbler territories.

METHODS

STUDY AREA

St. Williams Forest (N 42° 42.0', W 80° 28.1') is part of the Norfolk County sand plains, and historically was dominated by an oak savannah-prairie grass ecosystem. The nursery tract of the St. Williams Forestry Station is owned and managed by the Ontario Ministry of Natural Resources (OMNR). The 1213 ha forest is the largest continuous block of forested habitat in Carolinian Canada and is recognized by the OMNR as an Area of Natural and Scientific Interest. In addition, the province of Ontario declared the St. Williams Crown Lands a new signature site under *Ontario's Living Legacy* in 2002.

St. Williams Forest is dominated by well-drained Plainfield soils, and consists mainly of dry sand ridges intergrading with low, wet plains (Gartshore et al. 1987). The current nursery tract consists primarily of White Pine (*Pinus strobes*, natural stands and plantations), Red Pine (*Pinus resinosa*, managed for pole production), and several stands of Scots and Jack Pine (*Pinus sylvestris* and *Pinus banksiana*) (Wynia 1990). The site also contains many species of commercially valuable deciduous trees, some of which are unique in Canada.

Beginning in 1800, settlement of the area led to a rapid clearing of the forest for farmland, followed by reforestation of marginal farmlands in 1908 (Wynia 1990). In 1990, a resource management plan was developed to guide timber production and sales, while preserving natural flora and fauna, water quality, and tourism and educational values of the property. Logging activities in St. Williams have consisted of thinning Red Pine plantations (i.e. selective removal of trees based on prescriptions), and some removal of White Pine, generally for log home construction, and other species (e.g. larch, spruce) for fuel wood and pulp. No logging activity has occurred in the forest since 1996.

NEST MONITORING

Beginning in mid-May, Hooded Warblers territories were located (by the presence of a singing male), flagged, mapped, and georeferenced with a GPS. All Hooded Warbler territories were subsequently searched for the presence of a Hooded Warbler female, nest, and/or fledged young. For territories where nests were not found, the highest level of breeding evidence was documented so that we could conclude whether singing males were a) mated, and b) successfully produced young. When nests were located, they were georeferenced and discretely flagged to avoid attraction of predators.

After their discovery, nests were monitored at least every three days to determine nest fate, hatching date, nest survival rate, predation rate and productivity (i.e. number of young fledged per nest). To reduce disturbance of incubating females, nest contents were checked only if the female was away from the nest. Nests were considered to have hatched successfully if at least one Hooded Warbler egg hatched, and to have fledged successfully if at least one Hooded Warbler nestling survived to five days old. At each nest the number of Hooded Warbler eggs, number of Brown-headed Cowbird (*Molothrus ater*) eggs, number of Hooded Warbler and cowbird chicks hatched, and number of Hooded Warbler and cowbird chicks fledged were recorded. Although Hooded Warblers normally fledge at 8 days of age (Evans Ogden and Stutchbury 1994), in this study a chick was considered to have successfully fledged if it survived until its fifth day because this is when chicks were banded.

COLOUR BANDING AND RESIGHTING

When a Hooded Warbler territory was located, observers checked the birds for the presence of colour bands and then observed the bird through binoculars until the colour combination was confirmed. Two methods were used to trap and band adult Hooded Warblers. First, early season banding (mid-late May) involved the use of conspecific playback and a model of a male Hooded Warbler to lure males into the mist net and subsequently band them. The second method was nest site banding in which mist nets were set up at nests containing young that were 5 days old so that adults could be trapped when they returned to feed the young. After the adults were trapped and banded, they were placed in cloth bags in the shade while the nestlings were banded. Once the young were banded and returned to the nest, the adults were released. If the adults failed to return to the nest within one hour, the mist net was taken down and the young were banded.

NEST CHARACTERISTICS

Measurements taken at each nest site included support species, nest height, distance from trail and nest concealment. Nest concealment was determined by standing 1 meter from the nest and estimating the percent of nest obstructed by vegetation at, above, and below

nest level (0=0% concealed; 1=1-25% concealed; 2=26-50% concealed; 3=51-75% concealed; 4=76-100% concealed) for all four cardinal directions (Moorman et al. 2002). To calculate an index of concealment, the four cardinal directions were averaged to create an above nest index, a nest level index and a below nest index.

TERRITORY MAPPING

Playback of conspecific song was used to provoke territorial Hooded Warbler males into active defense and attempt to draw them to the boundaries of their territory. Observers started playback in the estimated centre of the territory and as soon as the bird approached the tape, the observer moved farther away (in the same direction) and repeated the playback. Playback was repeated until the point was reached where the bird no longer approached the tape player. This point was considered to be the territory boundary. This process was repeated at the four cardinal directions so that the corners of the territory could be identified. Once the boundaries were located, they were marked with flagging tape and georeferenced. To calculate territory size, the coordinates of territory boundaries were overlain on a base map of St. Williams Forest in a Geographic Information System (ArcView) and the area of the polygon was calculated.

SPECIES ASSOCIATIONS

To identify passerine species that were associated with Hooded Warblers, 5-minute point counts were conducted at all Hooded Warbler territories. To broaden the scope of the study (beyond St. Williams Forest), observers participating in the 2002 Hooded Warbler/Acadian Flycatcher Survey also performed point counts at Hooded Warbler territories. To standardize data collection, observers were asked to do point counts from 6-9 am within the month of June. Observers recorded all birds that were seen or heard during the five minutes, and were asked to specify whether the birds were within 50 meters or 50-100 meters.

STATISTICAL ANALYSES

To estimate productivity of Hooded Warblers in St. Williams, daily nest survival rates were calculated based on Mayfield's (1975) method over the incubation and chick rearing stages combined, with standard errors calculated following Hensler and Nichols (1981). Daily mortality across the nesting cycle was calculated as the total number of failures divided by the total number of observation days pooled across all nests. Daily survival was calculated as: 1-daily mortality. Nest success, or the probability that a nest will survive to fledge at least one young, was based on the estimate of daily survival raised to the exponent that reflects the average length of the nest period under study. Nest success was calculated from the first day of incubation to the date when chicks reached 5 days of age (17 days total). Nests that were found after the young reached 5 days were not

included in the Mayfield calculations, but were included in calculations of fledging success.

A one-tailed t-test was done to determine whether successful nests (i.e. nests that fledged at least one Hooded Warbler chick) were more concealed than were failed nests for each of the three nest concealment measures (above nest level, at nest level, below nest level). To further investigate the effect of nest concealment, nests were classified into four categories based their success and whether they were parasitized. The categories were: failed and parasitized, failed and not parasitized, successful and not parasitized, successful and parasitized. To determine whether these four categories of nests differed in nest concealment, the four nest concealment indices were compared using a General Linear Model (proc GLM, SAS Institute). All statistical tests were performed in SAS and were considered statistically significant at $P < 0.05$.

RESULTS

POPULATION MONITORING

The Hooded Warbler population in St. Williams Forest has been increasing since it was first colonized by this species in the early 1990s. In 1995, 6 pairs were recorded at the site and the population has since increased to 52 territorial males in 2002 (Figure 1). The distribution of Hooded Warbler nests in St. Williams has not changed considerably from 1999-2002, although there were fewer nests in the southwest section of the forest in 2002 (Figure 2). Hooded Warblers were not uniformly distributed throughout the forest, but instead were concentrated in several distinct sections; highest nesting densities were in the northwest forest block.

NEST PRODUCTIVITY

In 2002, there were 52 Hooded Warbler territories in St. Williams Forest, and 38 nests were located. Of the 38 nests, 13 were first nesting attempts, 9 were renests, 4 were second nests and one was abandoned during nest construction. There were sufficient data (i.e., multiple visits to a nest) to calculate Mayfield nest success for 33 nests (Table 1).

Predation was the most common cause of nest failure. In 2002, 9 (24%) nests were predated at the egg stage, while predation at the young stage occurred at 5 (13%) of the nests. For one nest, it was unknown whether there were eggs or young in the nest at the time that it was depredated. In addition to predation, one nest was destroyed because of weather, one was abandoned during construction, and two failed to produce Hooded Warbler young but fledged at least one cowbird. In 2002, 11 Hooded Warbler nests (18%) were parasitized by Brown-headed Cowbirds, and a mean of 1.27 cowbird eggs were laid in the parasitized nests. Six Brown-headed Cowbird chicks were fledged from

Hooded Warbler nests and only 4 of the 11 parasitized nests successfully fledged Hooded Warblers.

Hooded Warbler hatching success (chicks hatched/nest) was lower in 2002 than in all other years, but fledging success and Mayfield nest success were higher than in 1999 and 2000 (Table 1). On average in 2002, 1.4 chicks were fledged from each Hooded Warbler nest and overall Mayfield nest success was 39%.

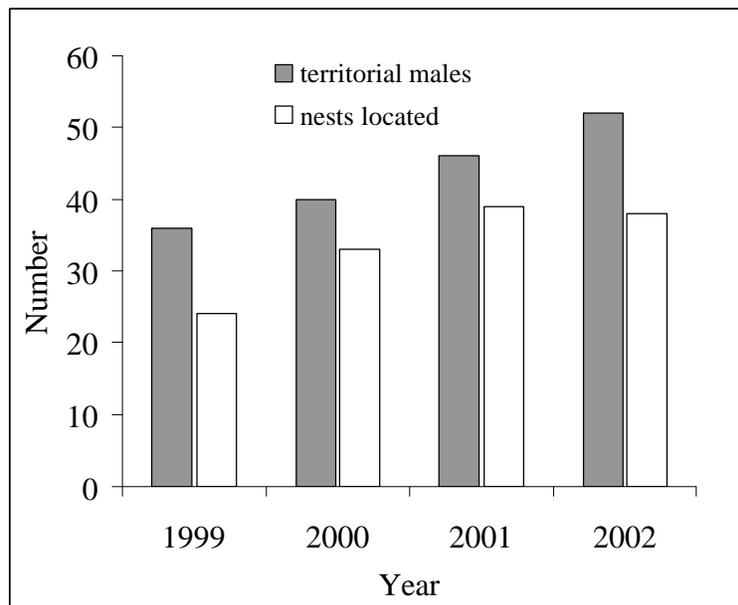


Figure 1 –Size (number of territorial males, number of nests) of Hooded Warbler population breeding at St. Williams Forest in Norfolk County, Ontario from 1999-2002.

Table 1 - Hooded Warbler nest success, predation and parasitism rates in St. Williams Forest from 1999-2002. Values shown are means \pm standard error with sample sizes given in parentheses.

Reproductive parameter	1999	2000	2001	2002
Eggs laid/nest	2.81 \pm 0.23 (21)	3.47 \pm 0.14 (32)	3.69 \pm 0.12 (33)	3.29 \pm 0.15 (28)
Hatching success	2.10 \pm 0.34 (21)	1.97 \pm 0.32 (32)	2.62 \pm 0.27 (34)	1.87 \pm 0.28 (32)
Fledging success	1.29 \pm 0.34 (21)	1.27 \pm 0.28 (33)	2.23 \pm 0.29 (34)	1.40 \pm 0.27 (37)
Parasitism rate	52%	39%	18%	29%
Predation rate	33%	39%	26%	39%
Mayfield daily survival rate	0.936 \pm 0.019 (17)	0.944 \pm 0.014 (29)	0.974 \pm 0.009 (33)	0.946 \pm 0.013 (33)
Mayfield nest success	0.325 (17)	0.376 (29)	0.636 (33)	0.391 (33)

NEST CHARACTERISTICS

Hooded Warblers used 10 different species of plants to support nests: Raspberry (*Rubus* spp.; 18 nests), Elderberry (*Sambucus canadensis*; 4 nests), Hazel (*Corylus* spp., 2 nests), Hawthorn (2 nests), Cherry (*Prunus* spp.; 2 nest), Red Maple (*Acer rubrum*; 2 nests), White Pine (*Pinus strobes*), Maple-leaved Viburnum (*Viburnum acerfolium*; 1 nest), Garlic Mustard (*Alliaria petiolata*; 1 nest), and Royal Fern (*Osmunda regalis*; 1 nest). Two additional species: Wild Grape (*Vitis* spp.; 1 nest) and Blueberry (*Vaccinium* spp.; 1 nest) were secondary nest support species. Mean nest height was 48 cm ($N=31$, range: 22-83 cm) and nests were located an average of 28 meters from the nearest trail ($N=33$, range: 1-80 m).

There was no statistical difference between successful and failed nests for above ($t(25)=1.08$, $p=0.29$) below ($t(25)=0.24$, $P=0.81$) or nest level ($t(25)=0.26$, $P=0.80$) concealment indices, although mean concealment values were slightly higher for successful nests (Figure 3). When nests were further divided into four categories (failed and parasitized, failed, successful and parasitized, successful), there was once again no difference in the above or below nest concealment (above: $F(3,24)=1.9$, $P=0.16$; below: $F(3,24)=0.76$, $P=0.52$) but there was a difference in nest level concealment ($F(3,24)=3.3$, $P=0.04$) (Figure 4).



Figure 2 – Distribution of Hooded Warbler nests in St. Williams Forest from 1999-2002.

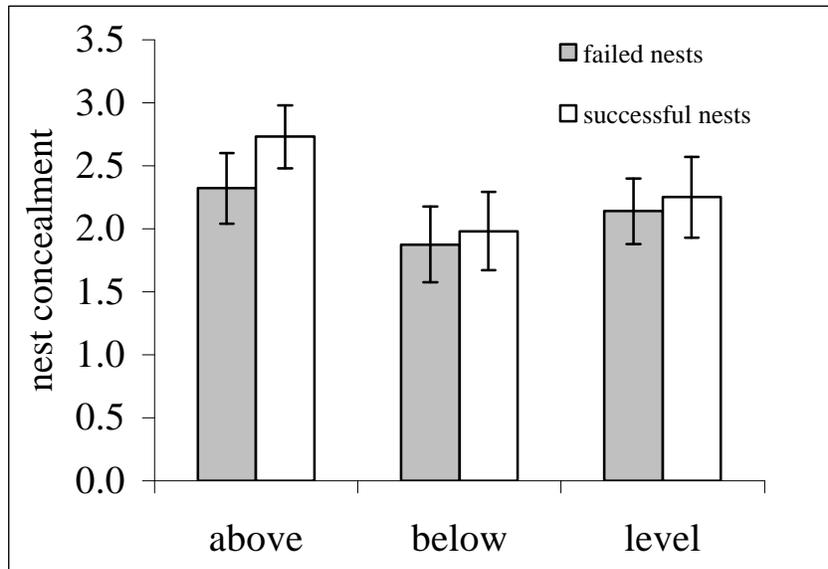


Figure 3 – Above, below and nest level concealment values for failed and successful Hooded Warbler nests in St. Williams Forest in southern Ontario. Data were collected from May to August 2002.

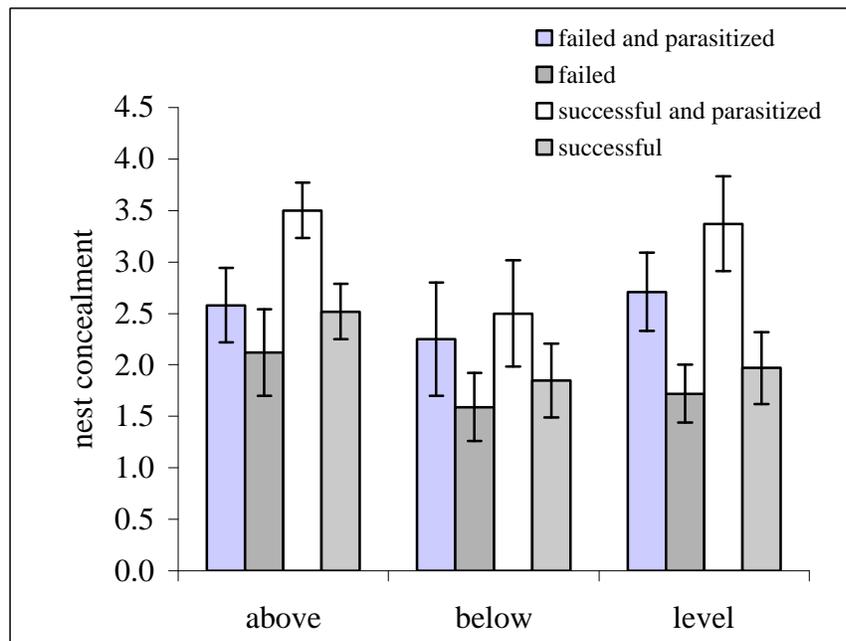


Figure 4 – Above, below, and nest level concealment values for Hooded Warbler nests that: (1) failed and were parasitized, (2) failed but were not parasitized, (3) successful and were parasitized, (4) successful and were not parasitized. Data were collected from May-August 2002 in St. Williams Forest in southern Ontario.

COLOUR BANDING AND RESIGHTING

Only three males were banded using conspecific playback early in the season because a cold spell in late May precluded continuation of banding. An additional 10 adult males, 9 adult females, and 47 young were banded at nest sites. In 2002, a lot of effort was invested into resighting colour banded adults. As a result 11 adults (3 females, 8 males) were identified based on their colour band combination (Table 2).

Table 2 – Summary of Hooded Warbler colour band resightings from the 2002 breeding season at St. Williams Forest.

Nest ID	Sex	Band Number	Year banded and age at banding ¹	Age in 2002 (min.) ²
NW15	F	2120-36987	1999 (SY)	4
SE4	F	2170-87357	2000 (ASY)	4
SE6	F	2170-87317	2000 (HY)	2
NE9	M	2170-87349	2000 (SY)	3
NW16	M	2170-87311	2000 (HY)	2
NW19	M	2120-36991	1999 (HY)	3
NW2	M	2170-87327	2000 (ASY)	4
NW6	M	2170-87352	2000 (ASY)	4
SE1	M	2170-87321	2000 (ASY)	4
SW1	M	2170-87309	2000 (AHY)	4
SW2	M	2170-87307	2000 (SY)	3

1. SY= second year bird (i.e. hatched the previous year), ASY=after second year bird, HY=hatch year bird (banded as a nestling), AHY=after hatch year bird (i.e. could not determine whether bird was a SY or ASY).

2. Ages of birds banded as ASY and AHY are considered minimum ages but exact age at banding was unknown.

TERRITORY MAPPING

The north, south, east and west boundaries of 15 Hooded Warbler territories were mapped in 2002. Mean Hooded Warbler territory size was 6.54 ± 1.51 ha, but there was large variation in size. The smallest territory was 0.4 ha and the largest was approximately 24 ha (Table 3). The locations of mapped territories and the distribution of Hooded Warbler nests in the study area are shown in Figure 5.



Figure 5 – Hooded Warbler territory boundaries that were measured in St. Williams Forest in 2002. Dark grey areas represent territories that were mapped and closed circles are nest sites.

Table 3 – Territory size and breeding evidence for 15 Hooded Warbler territories in St. Williams Forest in 2002. Territory boundaries were determined through playback of male Hooded Warbler song.

Territory ID	Breeding Evidence	Size (ha)
NW5	pair	0.40
SE1	nest	0.83
NW15	nest	1.04
SE2	nest	2.65
NW2	nest	2.93
NW4	territory	3.74
SW2	territory	4.49
SW5	pair	6.44
NW11	pair	7.46
NE9	nest	7.68
NW9	fledglings	7.75
NW16	territory	8.53
NW10	nest	9.66
NW8	nest	10.60
SW11	pair	24.04

SPECIES ASSOCIATIONS

Between 30 May and 24 July 2002, 18 observers completed 186 5-minute point counts at Hooded Warbler territories. Point counts were completed at 42 different woodlots in 10 different counties throughout southern Ontario (Figure 6). The largest number of point counts was completed in St. Williams Forest in Norfolk County (41), followed by South Walsingham Forest in Norfolk County (20), Skunk's Misery in Middlesex County (12) and Dundas Valley in Hamilton-Wentworth County (12). Together, these five sites support most of the Canadian Hooded Warbler population.

Bird species diversity on Hooded Warbler point counts ranged from 2 to 17 species; mean bird species diversity was 7.6 species/territory (Table 4). The distribution of bird species diversity at Hooded Warbler territories is shown in Figure 7. A total of 72 species was recorded at Hooded Warbler territories, most territories had 7-8 bird species. Red-eyed Vireo (*Vireo olivaceus*) was the most frequently recorded bird species on Hooded Warbler point counts; 198 individuals were observed on 73% of the point counts (Table 4). Ovenbird (*Seiurus aurocapillus*), Eastern Wood-pewee (*Contopus virens*), Rose-breasted Grosbeak (*Pheucticus ludovicianus*) and Veery (*Catharus fuscenscens*) were the next most common bird species recorded on point counts. Blue Jay (*Cyanocitta cristata*), a common predator of eggs and nestlings, was recorded at 31% of Hooded Warbler territories, while the Brown-headed Cowbird, a parasitic egg layer was recorded at 19% of the territories.



Figure 6 – Geographic distribution of point counts that were done to identify bird species that are associated with Hooded Warblers in southern Ontario.

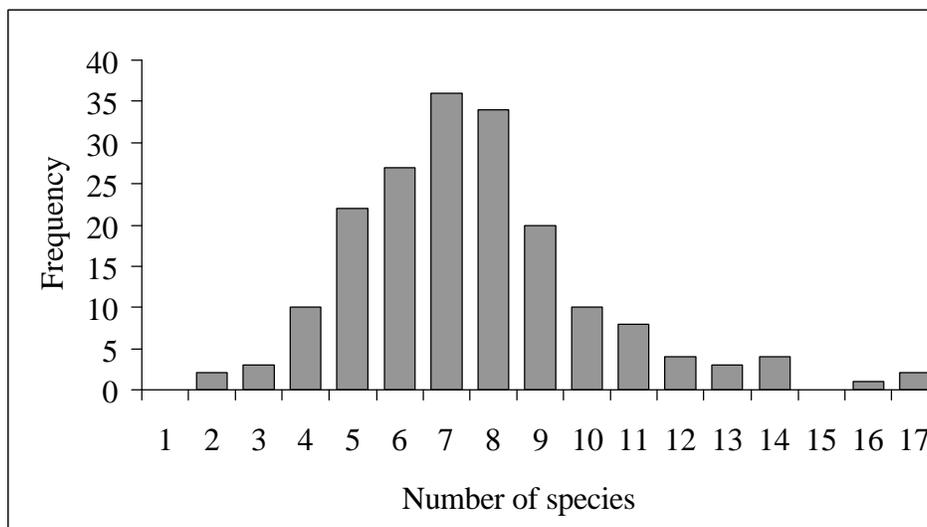


Figure 7 – Distribution of avian species diversity on Hooded Warbler territories in southern Ontario.

Table 4 – Species associations of Hooded Warblers based on data collected during 186 point counts from May-July 2002 in southern Ontario. This table shows the number of counts that recorded each species, the total number of individuals recorded, and the percentage of counts that recorded each species. Species are sorted in descending order based on number of counts.

Species	Number of Birds	Number of Counts	Percentage of counts
Red-eyed Vireo	198	136	73
Ovenbird	108	80	43
Eastern Wood-pewee	81	76	41
Rose-breasted Grosbeak	86	71	38
Veery	75	62	33
Blue Jay	67	58	31
Scarlet Tanager	67	58	31
Wood Thrush	59	51	27
American Robin	57	51	27
American Crow	82	45	24
Northern Cardinal	43	39	21
Indigo Bunting	42	38	20
Black-capped Chickadee	51	37	20
Brown-headed Cowbird	37	36	19
Chestnut-sided Warbler	42	35	19
Chipping Sparrow	43	34	18
Great Crested Flycatcher	36	34	18
Pine Warbler	38	32	17
Cedar Waxwing	27	24	13
Gray Catbird	24	22	12
Baltimore Oriole	22	22	12
Eastern Towhee	19	18	10
American Redstart	18	17	9
Common Yellowthroat	18	16	9
Black-throated Green Warbler	18	15	8
American Goldfinch	16	14	7
Common Grackle	14	14	7
Song Sparrow	15	13	7
Downy Woodpecker	13	12	6
Blackburnian Warbler	11	11	6
White-breasted Nuthatch	11	10	5
Mourning Warbler	10	10	5
Yellow Warbler	10	10	5
House Wren	10	9	5
Red-bellied Woodpecker	9	9	5
Blue-headed Vireo	8	8	4
Northern Flicker	7	7	4
Yellow-throated Vireo	7	7	4
Hairy Woodpecker	7	6	3

Table X continued

Species	Number of Birds	Number of Counts	Percentage of counts
Mourning Dove	6	6	3
Field Sparrow	6	5	3
Black-throated Blue Warbler	5	5	3
Pileated Woodpecker	4	4	2
Red-tailed Hawk	4	4	2
Tufted Titmouse	4	4	2
Brown Creeper	3	3	2
Blue-winged Warbler	3	3	2
Carolina Wren	3	3	2
Cerulean Warbler	3	3	2
Winter Wren	3	3	2
Red-winged Blackbird	3	3	2
Ruffed Grouse	8	2	1
Northern Waterthrush	2	2	1
Red-breasted Nuthatch	2	2	1
Ruby-throated Hummingbird	2	2	1
Yellow-billed Cuckoo	2	2	1
Canada Goose	30	1	0.5
Yellow-bellied Sapsucker	2	1	0.5
Acadian Flycatcher	1	1	0.5
Blue-gray Gnatcatcher	1	1	0.5
Broad-winged Hawk	1	1	0.5
Canada Warbler	1	1	0.5
Golden-crowned Kinglet	1	1	0.5
Louisiana Waterthrush	1	1	0.5
Magnolia Warbler	1	1	0.5
Red-headed Woodpecker	1	1	0.5
Vesper Sparrow	1	1	0.5
Wild Turkey	1	1	0.5
Wood Duck	1	1	0.5
Whip-poor-will	1	1	0.5

DISCUSSION

POPULATION MONITORING

The Hooded Warbler population in St. Williams Forest has increased from 6 pairs in 1995 to 52 territorial males in 2002. Concurrent with the increase in St. Williams Forest, there has been an increase in the Canadian Hooded Warbler population throughout Ontario. From May-July 2002, Bird Studies Canada coordinated an intensive survey of Hooded Warblers and Acadian Flycatchers throughout southern Ontario. Results of the survey showed that over the last 5 years, Hooded Warblers increased by 150% and expanded their range in Ontario.

The expansion and growth of the Canadian Hooded Warbler population is likely partly due to this species' ability to colonize forests that have been selectively logged. Group selection logging for example, creates gaps in the forest, which results in the proliferation of dense understory species (e.g., raspberry) that Hooded Warblers use for nesting. Even within St. Williams Forest, most Hooded Warblers are found in pine plantations that have been thinned through selective logging (Whittam et al. 2002). In 2002, Hooded Warbler density declined in the southwest block of the forest and many Hooded Warblers were unpaired. It appears that the understory vegetation in this section of the forest is becoming too high for Hooded Warblers, so the birds are dispersing to other parts of the forest.

NEST PRODUCTIVITY AND NEST CHARACTERISTICS

Nest productivity varied annually from 1999-2002 in response to fluctuations in predation and parasitism rates. Between 2001 and 2002, nest predation rates increased from 18% to 39%. Although this was a large annual increase, 2002 predation rates were equal to those documented in 1999 and 2000 and are comparable to rates recorded for other songbird populations. Nest success (eggs hatched/nest) in 2002 was the lowest recorded at St. Williams since monitoring began, but fledging success and Mayfield nest success were higher than in 1999 and 2000.

Factors affecting Hooded Warbler nest success are not yet well understood, partly because the important nest predators have not been identified. Hooded Warblers consistently choose nest sites with dense vegetation, especially within one meter of the ground (Whittam et al. 2002). It seems likely that Hooded Warblers nest in dense vegetation to avoid predation because the density and diversity of forest understory vegetation may affect the ability of predators to locate nests of forest birds (Martin and Roper 1988, Yahner and Morell 1991). However, the effects of nest characteristics, including nest concealment on Hooded Warbler nest success have been equivocal.

In Pennsylvania, researchers experimentally removed vegetation from Hooded Warbler nests, but found no difference in nest success between nests and control sites (Howlett

and Stuchbury 1996). Similarly, successful nests in St. Williams Forest did not differ from unsuccessful nests for 17 different habitat and nest site variables (Whittam et al 2002) and nest success appears to be unrelated to nest concealment (this study). Nest level concealment differed among the four nest categories in this study, but this could be a spurious result because of small sample size; further research is needed. A study of Hooded Warbler nest success in South Carolina found that successful Hooded Warbler nests were more concealed from below and were located in patches with a greater abundance of Switchcane (*Arundinaria gigantea*) stems than were unsuccessful nests (Moorman et al. 2002).

It is difficult to compare results of the South Carolina study with results from Pennsylvania or Ontario, because the landscape, forest structure and plant species composition and diversity and abundance of prey species differ considerably among these geographic locations. Overall, nests in St. Williams forest were more concealed, located closer to the ground and density of vegetation surrounding the nest is greater than were nests in South Carolina (Moorman et al. 2002, Whittam et al 2002). Hooded Warblers in Ontario usually nest in dense patches of Raspberry brambles, which is very different from patches of Switchcane that Hooded Warblers in South Carolina prefer. Furthermore, below nest level concealment, the only concealment measure that affected nest success in South Carolina, was twice as high in Ontario.

There are several reasons why there was no relationship between nest success and concealment in this study. First, in environments with high predator diversity and abundance, the high incidence of nest predation and the diversity of nest searching tactics used by those predators may preclude the existence of predictably safe nest sites (Filliater et al. 1994). Potential nest predators in St. Williams Forest include Blue Jay, American Crows, hawks, squirrels, chipmunks and mice; squirrels and chipmunks are very abundant in the forest and thus could be the primary source of predation. Second, mammalian predators locate nests by olfactory rather than visual cues. Hence, concealment measures are not likely to provide adequate information in areas where mammalian or reptilian predation rates are high. Third, there are several other bird species nesting in St. Williams Forest that occupy a similar niche, and nest in close proximity to the Hooded Warbler (e.g., Chestnut-sided Warbler (*Dendroica pensylvanica*), Veery (*Catharus fuscescens*), Indigo Bunting (*Passerina cyanea*)). Presence and abundance of these species' nests in similar habitats may 'dilute' chances of predation. An examination of interspecific differences in nesting success and nest site characteristics of nesting passerines in St. Williams Forest would be needed to test this hypothesis. Third, sample size may have been too small to detect a difference and/or methodology used may have been inappropriate. A recent study found that concealment data collected through observer estimates were inconsistent between individuals (Ortega et al. 2002). The study recommended a new method of quantifying nest concealment,

which involved taking digital photographs of nests and then determining the percent concealment by using photographic software. This new method provides a more accurate assessment on nest concealment and is not affected by observer biases (Ortega et al. 2002).

COLOUR BANDING AND RESIGHTING

The banding and resighting of colour banded birds provides critical information on dispersal rates, and survival rates and allows researchers to track reproductive success over an individual's lifetime. Colour banding also assists with the delineation of territory boundaries and allows movements of individual birds throughout the forest to be tracked. Because it would be impossible to collect this information using any other method, I strongly recommend that colour banding and resighting efforts continue for as long as possible. In 2002, 11 adults were resighted in the study area, which is a large number considering that no birds were colour banded in 2000. In 2003, more effort will need to be invested into resighting colour banded individuals because a larger proportion of the population will be banded.

TERRITORY MAPPING

Fifteen Hooded Warbler territories were mapped in 2002 using playback of conspecific song. The response of male Hooded Warblers to playback varied among individuals and among days. Some males responded immediately and aggressively to playback by singing and displaying near the tape recorder, while others showed little or even no response. For males that responded to playback, playing the Hooded Warbler song sometimes provoked territorial disputes between neighbouring Hooded Warblers. This helped define the boundaries. Interestingly, there are some Hooded Warbler territories in St. Williams Forest for which singing males have been only rarely observed defending territories. Similarly, nests or females with fledglings have been observed in locations where singing males have never been recorded.

There was large variation in territory size, and on average, Hooded Warbler territories at St. Williams were much larger than has previously been recorded for Hooded Warblers in other locations. Evans Ogden and Stuchbury (1994) report that breeding territories range from 0.5-0.75 ha, whereas this study found mean territory size was 6.5 ha and only one territory was within the range 0.5-0.75 ha. Some Hooded Warbler territories were quite extensive, covering a large proportion of the forest block. Territory size can be influenced by many factors including date, breeding density, habitat availability and quality (e.g. gap size), age of male, and breeding status (single male vs. pair). In St. Williams, it appears that territories were smaller in areas with high breeding densities. Further research into the factors affecting Hooded Warbler territory size is needed.

SPECIES ASSOCIATIONS

Red-eyed Vireo, Ovenbird, Eastern Wood-pewee, Rose-breasted Grosbeak, and Veery were the five species that were most frequently recorded at Hooded Warbler territories. Red-eyed Vireos and Eastern Wood-pewees are the most common forest bird species in this area, and their tendency to vocalize frequently makes them very likely to be recorded on point counts. Although the Ovenbird is a ground-nesting species, like the Hooded Warbler, it prefers large mature forests for breeding (Burke and Nol 1998), which explains why this species was often recorded at Hooded Warbler territories. Veery and Rose-breasted Grosbeak, on the other hand, have similar preferences for disturbed areas within large forests, same as Hooded Warblers (D. Burke pers. comm.). In order to determine which species are closely associated with Hooded Warblers, it is necessary to do point counts at random locations outside of Hooded Warbler territories and compare results with counts done at Hooded Warbler territories.

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