Canada Warbler

Population Status, Habitat Use, and Stewardship Guidelines for Northeastern Forests

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SUMMARY

Canada Warblers are declining throughout the Northeast at rates of 4% to 7% per year. The causes of the declines are unknown, but loss and degradation of breeding habitat appear to be contributing factors. In this report, we review available information on Canada Warbler habitat use and introduce new findings that relate habitat characteristics to reproductive success. Canada Warbler densities are naturally highest in swamps and riparian forests with a well-developed shrub layer. Moderate numbers occur in old upland forests, especially in association with canopy gaps. Small openings created by timber harvest may enhance Canada Warbler habitat, but more research is needed to identify a minimum gap size. Even-aged forests between 20 and 75 years old seem to be of low value to this species. Intensive harvest of upland forest may reduce Canada Warbler abundance in the short term. However, high densities occur 5-20 years following harvest operations, especially in areas where some overstory trees are retained. A similar, though somewhat muted, response is observed in areas that are completely clearcut. Saplings in the 2-6 m height class are a key habitat feature in timber cuts and in natural settings, therefore removal of shrubs and saplings by thinning or deer browse reduces habitat value. Canada Warblers inhabit deciduous and coniferous forests, but tend to be more abundant in mixed forests than in pure stands. The species requires large forested tracts for breeding in settled landscapes, but is not area-sensitive in forest-dominated regions.

A recent study indicated that Canada Warblers nesting in regenerating harvest zones achieve levels of pairing and fledging success similar to those breeding in forested wetlands. The wet forest was more productive overall, because small and overlapping territories enabled the species to breed in relatively high densities. The small size and packed configuration of wetland territories could indicate higher resource availability in some wet forests, compared to upland timber cuts.

Natural resource professionals can use a variety of land protection and forest management strategies to help stabilize declining Canada Warbler populations. Land protection efforts aimed at conserving Canada Warbler habitat should focus on large areas of moist, mixed forest that feature a semi-open canopy and dense undergrowth. Stewards of managed forests could employ a variety of strategies to support this species, including efforts to maintain understory and forest-floor structure, riparian and wetland buffers, mixed forest cover, and large forest reserves in which treefall gaps naturally occur. Upland clearcutting with residual tree retention seems to improve Canada Warbler habitat during a 15-year period beginning about 5 years after harvest. Partial cuts, like those used in a shelterwood system, also appear to benefit the species. We suggest that future investigations collect standardized density and demographic data to: 1) compare the quality of natural and human-created habitats; and 2) specifically evaluate effects of small-scale harvests on Canada Warbler populations.

INTRODUCTION

Distribution and Population Status

The Canada Warbler (*Wilsonia canadensis*) is a Neotropical migratory songbird that breeds in forests of boreal Canada, the northeastern United States, and south along the Appalachian Mountains to Tennessee. It winters in wooded, semi-open, and forest edge habitats of northern South America, with greatest numbers observed in and east of the Andes (Conway 1999).

Results from the North American Breeding Bird Survey indicate nearly four decades of Canada Warbler decline throughout the northeastern portion of its summer range (Table 1). Estimates of annual population change since 1980 range between -3.8% and -7.3% (Sauer et al. 2005). The reasons for the declines are unknown, however loss of breeding habitat may be a contributing factor (Conway 1999).

Conservation Rank

The North American Bird Conservation Initiative designated the Canada Warbler as a Highest Priority Landbird in Bird Conservation Region 14 (Atlantic Northern Forest), citing significant population decline and high regional responsibility (Dettmers 2003). The Partners In Flight North American Landbird Conservation Plan lists Canada Warbler as a species of high conservation concern in the Northern Forest region (Rich et al. 2004). The Northeast Endangered Species and Wildlife Diversity Technical Committee also recognizes Canada Warbler as one of the region's highest priorities for conservation and research (Therres 1999).

Table 1. Canada Warbler population trends in different states and regions, estimated by the North American Breeding Bird Survey (Sauer et al. 2005).

	|-----1966-2004----|			|---1966-1979----|		|---1980-2004----|		
Region	Trend	P	N	Trend	P	N	Trend	P	N
Connecticut	-3.5	0.49	10	5.0	0.53	8	-6.9	0.28	8
Maine	-2.2	0.15	57	+5.6	0.18	19	-3.8	0.03	55
Massachusetts	-4.6	0.29	12	-7.4	0.33	9	-5.7	0.05	10
New Brunswick	-3.0	0.00	32	+6.3	0.04	25	-7.3	0.00	27
New Hampshire	-4.6	0.03	24	-10.1	0.00	22	-5.9	0.12	19
New York	-4.7	0.00	54	-8.3	0.00	39	-5.0	0.00	42
Nova Scotia	-1.9	0.28	24	+6.1	0.11	14	-7.0	0.00	19
Quebec	-3.0	0.14	65	-4.2	0.35	18	-5.5	0.04	58
Rhode Island	-3.2	0.84	2	-1.9	0.90	2	--	--	--
Vermont	-3.1	0.08	19	+0.4	0.91	10	-5.4	0.12	19
So. New England	-4.8	0.17	22	-0.1	0.99	18	-8.0	0.06	14
Adirondack Mtns.	-4.9	0.00	23	-8.0	0.06	19	-5.0	0.02	18
No. New England	-2.6	0.14	51	-3.0	0.41	30	-6.2	0.00	47
N. Spr.-Hardwoods	-2.4	0.03	246	-2.4	0.41	116	-3.9	0.00	220
Eastern BBS Region	-2.0	0.02	494	-3.3	0.18	247	-3.4	0.00	422
FWS Region 5	-2.4	0.01	228	-7.8	0.00	129	-2.0	0.12	195
United States	-1.7	0.01	301	-5.1	0.00	158	-1.7	0.06	261
Canada	-2.2	0.06	201	-2.6	0.44	89	-4.0	0.00	169
Survey-wide	-2.0	0.02	502	-3.3	0.17	247	-3.4	0.00	430

Filling the Information Gap

Despite its prominence among species of conservation concern, the Canada Warbler has received little attention from avian ecologists. It is possible to glean habitat use data from community-level investigations, but until recently no effort had been made to identify correlates of reproductive success. Focused study of marked populations is necessary to determine stewardship practices that promote conservation of this vulnerable species. In this report, we review available information on Canada Warbler habitat use, and summarize preliminary results of ongoing research. We also assess the potential of various land-use practices to support breeding populations of Canada Warblers.

CANADA WARBLER BREEDING HABITAT

In the Atlantic Northern Forest (Fig. 1), Canada Warbler inhabits several lowland and upland habitats, including swamps, streamside thickets, brushy ravines, moist forests, and regenerating timber cuts (Ellison 1984, Smith 1994, Conway 1999). It also occurs on reforested talus slopes and in subalpine forests with adequate deciduous undergrowth (Sabo 1980). Canada Warblers forage among shrubs and primarily nest on the ground. Therefore, they typically inhabit areas with a well-developed shrub layer and a structurally complex forest floor. Nests are often concealed beneath or within root masses, rotting stumps, and mossy hummocks, but may also be tucked in close to logs, rocks, or overhanging banks (Conway 1999).

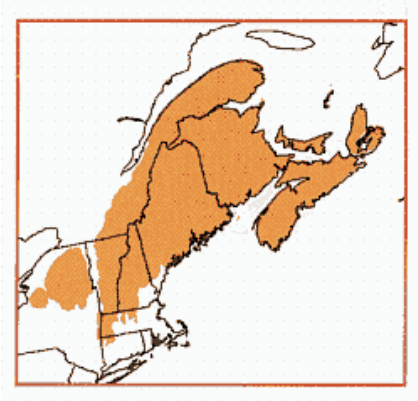

Figure 1. The Atlantic Northern Forest or the North American Bird Conservation Initiative's Bird Conservation Region 14 (abcbirds.org/nabci).

Previous Studies

Although we found no published studies that focused solely on Canada Warbler ecology, several community-level investigations have produced habitat information for this species. Though sometimes contradictory, these studies indicate that Canada Warblers occur at varying densities in several habitats. Highest natural densities occur in swamps and riparian forests, where wet conditions limit canopy closure and favor shrub growth. In the uplands, Canada Warblers appear to be disturbance specialists, moving into regenerating forest patches following wind-throw, ice damage, fire, or timber removal. The species is relatively abundant in logged areas, especially where some residual trees remain 5-20 years following harvest. Mixed forests appear to suit Canada Warblers better than hardwood or conifer stands, although the species can be found in all three cover types. In settled landscapes, Canada Warblers are sensitive to habitat area, with lowest densities occurring in small forest fragments.

Wet Forests

In the mid-Atlantic forest, Canada Warblers concentrate in moist areas, such as floodplains and swamps (Robbins et al. 1989). It is among the most abundant birds in red maple swamps in Massachusetts (Swift et al. 1984) and Rhode Island (Golet et al. 2001), where it is restricted to forested wetlands (Miller 1999). In Quebec, Canada Warbler densities are two times higher in riparian stands than in upland locations (Larue et al. 1995). Several qualitative descriptions of Canada Warbler habitat also emphasize a primary association with damp forests (e.g. Ellison 1985, Smith 1994). One observer noted a preference for "hurricane wrecked maple swamps or cedar bogs" (Sprunt 1957).

Wet forests feature four main attributes that could be attractive to Canada Warblers: exposed song perches, a well developed shrub layer, an abundance of flying insects, and a structurally complex forest floor. Wet forest canopies are frequently broken by windthrow of shallow-rooted trees and/or by beaver activity. Anaerobic conditions maintained by saturated soils or standing water also inhibit tree growth and canopy closure. Gaps in the canopy expose elevated perches from which Canada Warblers vocalize (Kendeigh 1945, Lambert and Faccio unpubl. data).

Hydrophilic willows, alders, and other wetland shrubs typically thrive in canopy gaps, providing cover and favorable foraging structure. Two studies of warbler foraging behavior, conducted in upland forests of New Hampshire and in Wisconsin, found that Canada Warblers concentrate their feeding effort in shrubs and low tree branches at heights of 3 – 5 m (Sabo and Holmes 1983, Sodhi and Paszkowski 1995). This range corresponds with the leafy stratum often formed by wetland shrubs. Foliage cover in the 2 – 4 m stratum was high in areas of Rhode Island swamps used by Canada Warblers (Miller 1999).

Canada Warblers capture invertebrate prey by foliage gleaning, hover gleaning, and hawking (Sabo and Holmes 1983, Sodhi and Paszkowski 1995). Mosquitoes and flies make up a significant part of their diet (Bent 1953, Krause 1965). Wet forests teem with flying insects during the breeding season, and thus ensure a reliable food supply for adults and their growing young.

Feeding of nestlings and fledglings occurs at the ground level, which is structurally complex in most wet forests. Hollows, mossy hummocks, woody debris, and clumps of fern and sedge create countless niches for concealing nests and weak-flying young. Several observers have noted the importance of an uneven forest floor (Ellison 1985, Peck and James 1987, Smith 1994). Robbins et al. (1989) found a positive relationship between Canada Warbler abundance and foliage density between 0.3 m and 1 m. The same study identified a positive relationship between tree basal area and Canada Warbler abundance, evidence that late-successional forests can be important to this species.

Old and Naturally Disturbed Forests

Two Canadian studies have underscored the association of Canada Warblers with late-successional, upland forests, especially those structured by natural disturbance. Schieck and Nietfeld (1995), comparing three seral stages of Alberta's aspen and mixed-wood forests, found that Canada Warblers were most abundant in old forests (≥ 120 years), uncommon in stands 50-65 years old, and absent from forests in the 20-30 year age class. They also showed a significant, positive association with birch density and snag density > 20 cm dbh, but found no relationship with shrub/sapling density, a variable that other studies have found to be an important predictor of

Canada Warbler habitat (Titterington et al. 1979). In Quebec, Drapeau et al. (2000) found Canada Warblers at 43% of survey stations in a boreal mixed-wood forest characterized by natural disturbance, compared to 21% of stations in adjacent industrial timberland. Canada Warbler is one of several species that have shown a positive, numerical response to outbreaks of spruce budworm (Crawford and Jennings 1989).

DeGraaf (1985) did not detect Canada Warblers among even-aged sawlogs in New Hampshire northern hardwoods, but encountered low numbers in "over-mature" and uneven-aged stands. King and DeGraaf (2000) observed a positive relationship between Canada Warbler abundance and basal area of dead trees. Hagan and Meehan (2002) reported that Canada Warbler presence was positively correlated with dead tree basal area and understory stem density (4-6 m tall).

The value of mature forests to Canada Warbler is diminished by thinning and heavy deer browse. In a survey of Massachusetts oak forests, Canada Warblers were more common in stands with a natural understory than in those where understory trees had been removed. An even greater contrast occurred between stands with few deer, where Canada Warbler was abundant, and stands with many deer, where the species was nearly absent (DeGraaf et al. 1991).

Hagan frequently encountered Canada Warblers in small treefall gaps deep within large blocks of mature forest in Maine (Hagan and Grove 1999). Sprunt (1957) also noted an association with natural forest openings in the northern portion of the species' range. Canada Warblers inhabiting Ohio hemlock ravines occurred in forest gaps with low tree basal area (Mitchell 1999). In red spruce-northern hardwoods of West Virginia, Canada Warbler numbers increased for at least five years beneath wind-created canopy breaks, but returned to previous levels as the canopy closed (Hall 1984). During three years following a Vermont ice storm, Faccio (2003) found Canada Warblers in small (0.1-0.2 ha) canopy gaps within an extensively forested landscape. However, these gaps did not increase Canada Warbler abundance within the forest as a whole.

Two other Vermont studies have examined effects of patch cuts on forest songbirds (Lent and Capen 1995, Buford and Capen 1999). Both found higher numbers of Canada Warbler in unharvested stands, compared to similar areas where tree removal had created small gaps in the canopy. In each study, the sample size was low and the difference statistically insignificant. A West Virginia bird census revealed an opposite pattern: no Canada Warblers in an unharvested 65- to 75-year-old forest, but small numbers in an area from which individual trees were cut 10 years before the study (Maurer et al. 1981).

Additional research is necessary to assess the potential for small-scale timber harvests to create Canada Warbler habitat. If Canada Warblers utilize natural canopy gaps, can single-tree, group-selection, and/or patch-cut practices improve conditions for this species? Although previous studies do not adequately address this question, they clearly demonstrate a positive effect of intensive harvest methods on Canada Warbler abundance.

Regenerating Forests

Several studies have documented relatively high densities of Canada Warbler in regenerating harvest zones located within forested landscapes. Working in the industrial forests of Maine, Hagan et al. (1997) found the species was most abundant in young, scrubby re-growth 6-20 years following both partial-cuts (0.38 birds/point) and clearcuts (0.26 birds/point), particularly

when some unharvested trees remained. Density of understory stems (4-6 m tall) was an important predictor of the species' presence (Hagan and Meehan 2002). This finding mirrored results from a previous study of bird-habitat relations in Maine timberlands, in which Canada Warblers were found only in regenerating stands dominated by stems < 10 cm dbh and > 2 m in height. Highest counts occurred in areas where saplings exceeded 4.5 m and where loggers had left some trees in the overstory (Titterington et al. 1979). In the early study, Canada Warblers were absent from mature spruce-fir plots. In the later study, they were uncommon in mature spruce-fir (0.17 birds per point), rare in mature mixed-woods (0.07 birds per point) and absent from mature hardwoods (Hagan et al. 1997).

Three studies conducted in New Hampshire's White Mountain National Forest also point toward an association with young forests. DeGraaf estimated 3-12 pairs per 100 acres in 5- to 10-year-old regenerating hardwoods, increasing to 42 pairs per 100 acres in 15-year-old saplings (1985). Canada Warbler was absent from 0-4 year-old stands, pole stands, and sawlog stands. Welsh and Healy (1993) also found Canada Warblers concentrated in saplings within six managed forests. Although they counted only 6 individuals in all, none was observed in nearby forest reserves. The third New Hampshire study counted birds at 10 stations in mature hardwoods, 10 stations in 3-5 year-old clearcuts, and 20 stations in 3-5 year-old shelterwood cuts. Canada Warbler did not occur in the mature forest, but was moderately abundant in both treatment types (King and DeGraaf 2000).

In northern hardwood stands in New York's Adirondack Mountains, Webb et al. (1977) found that Canada Warblers were twice as abundant in stands 5-15 years after 100% of the merchantable timber was removed, compared to an uncut control site and treatments in which 25%, 50%, and 75% of merchantable timber was removed. However, during 10 years of point count surveys, a significant decline in Canada Warbler abundance was detected within the 100% treatment (attributable to maturation), while Canada Warbler numbers remained relatively stable in the control site and in the 25%, 50% and 75% treatments.

In northern Minnesota, Canada Warblers were more abundant in pole-sized aspen stands 7-10 years after mechanical strip-thinning than in similar stands that had not been thinned (Christian et al. 1996). The difference was attributed to vigorous shrub development between the remnant strips. A second study in the same region found greater abundance in 3- to 9-year-old aspen clearcuts with residual tree clumps, compared to clearcuts with no trees retained (Merrill et al. 1998).

Canada Warbler habitat that is created by logging is ephemeral at the stand level, but could be maintained at the landscape level by a rotation of partial and/or clearcut harvests. Because extensive clearing can degrade forest ecosystems, future studies should seek to identify a minimum cut size for Canada Warblers. Canada Warblers established territories in natural gaps as small as 0.1-0.2 ha in one Vermont study (Faccio 2003).

Timber management that aims to increase Canada Warbler numbers should account for a lag time in response. Researchers in Alberta found that Canada Warblers disappeared from clearcut sites for at least three years following harvest of mature boreal mixed-wood (Tittler et al. 2001). Partially cut sites retained only a few birds in the first post-harvest year (Norton and Hannon 1997). Evidence from the Northeast indicates that regenerating forests are most suitably structured 6-20 years after harvest (Webb et al. 1977, Titterington et al. 1979, DeGraaf 1985, Hagan et al. 1997). As

the understory grows above 6 m a stand's suitability for Canada Warbler appears to decline (Hagan and Meehan 2002).

The lag time in Canada Warbler response to canopy removal could be greater in the boreal mixed-wood of western Canada. A study of harvested and burned stands in Alberta found significantly higher densities in 22-28 year-old stands, compared to 1 and 13-15 year-old stands (Hobson and Schieck 1999). The relevance of these findings to harvest planning is obscured by the grouping of disturbance types in the age-class comparison. Overall, densities of Canada Warbler were significantly higher in harvested areas than in burned areas, with the difference most pronounced in the younger forest age classes.

Forest Type

Canada Warblers inhabit deciduous, coniferous, and mixed forests. In the Northeast, they are more common in mixed forests than in pure stands. Researchers in Maine found higher numbers in medium-aged mixed-woods (20-60 years old) than in any other mid- to late-successional forest type. The study's lowest counts were in medium-aged and mature hardwoods (60-100+ years old; Hagan et al. 1997). Canada Warbler presence was positively correlated with landscape contrast for forest type (Hagan and Meehan 2002). Surveys conducted in mature forests of northern Vermont produced similar results. Canada Warblers were common in red spruce-northern hardwood forests, especially near natural or created ecotones, but absent from hardwood forests. Low numbers were detected in lowland conifer swamps (Lambert 2000). In Canada's Great Lakes-St. Lawrence region, Canada Warblers are most often found in canopy breaks within dense, mixed forests, where northern hardwoods intersperse with the dominant species Eastern Hemlock and White Pine (Clement and Gunn 1957).

Canada Warblers preferentially select conifers for foraging (Sodhi and Paszkowski 1995) and reach maximum abundance where hardwoods form a low (2-6 m), dense layer (Titterington et al. 1979, Hagan and Meehan 2002). Outside of regenerating timber cuts, mixed forests are most likely to provide this combination of features. Therefore, forest managers in the Northeast should avoid homogenizing forests that include hardwood and softwood components. Long rotations and conifer retention will help maintain a mix favorable to Canada Warbler.

The Canada Warbler's link to mixed forest may be weaker in western Canada. In Alberta, Schieck and Nietfeld (1995) found similar levels of abundance in deciduous stands and in mixed-woods dominated by white spruce. In a Saskatchewan study of mixed, conifer and hardwood stands, Hobson and Bayne (2000) found Canada Warbler almost exclusively in pure aspen. Although mixed stands proved unimportant to Canada Warbler in this study, they ranked highest in measures of overall avian diversity and abundance.

Area Sensitivity

Canada Warblers appear to be area-sensitive in settled landscapes, but not in forest-dominated regions. A study conducted in mid-Atlantic forests found Canada Warbler density positively correlated with forest extent (Robbins et al. 1989). In Rhode Island, the incidence of Canada Warbler was greatest in large (> 6 ha) swamps and where forest covered > 50% of the land within 2 km. They were less common in agricultural or suburban areas, especially within 300 m of a paved road (Miller 1999). In Quebec, Canada Warblers were encountered over three times more frequently in natural forests (43% of survey stations) than in areas dominated by human settlement, farms, and woodlots (13% of survey stations; Drapeau et al. 2000). Surveys conducted on logging roads in

northern Vermont detected Canada Warblers at a level similar to that observed in forest interiors (Lambert 2001). Hagan et al. (1997) found no relationship between Canada Warbler abundance and stand area. Canada Warbler was likewise unaffected by the extent of clearcut, young, medium-aged, or mature forest in the surrounding timberland.

Density May Not Indicate Habitat Quality

Birds typically select breeding sites based on structural features to which they are adapted. In altered landscapes, these gross cues may belie factors that impair reproductive success, such as elevated risk of predation (Gates and Gysel 1978). Therefore, density can be a misleading indicator of habitat quality (van Horne 1983, Vickery et al. 1992). Studies that combine density estimates with measures and reproductive success are preferred, but unavailable for Canada Warbler. The preceding description of Canada Warbler habitat is limited by reliance on community-level abundance studies. Population-level research is necessary to identify predictors of abundance *and* reproductive success. Our current research addresses this need.

Current Research

Since 2001, we have collaborated with Dr. Jameson Chace (Salve Regina University) and Dr. Leonard Reitsma (Plymouth State University) on a study of Canada Warbler breeding ecology. Study areas include: 36 mature forests surveyed by the Vermont Forest Bird Monitoring Program (primarily northern hardwoods), a red spruce-balsam fir swamp at the Center for Northern Studies (Wolcott, VT), a variety of managed forest types in the Nulhegan Basin Division of the Silvio O. Conte National Fish and Wildlife Refuge (Lewis, VT), and two plots in the Bear Pond Natural Area (Canaan, NH), a red maple-balsam fir-red spruce swamp, and a regenerating, upland mixed-wood with remnant patches of mature trees.

We have conducted point counts, delineated male territories, and assessed the reproductive status of Canada Warblers at these locations. Results of this work appear in six separate studies, detailed in Appendix 1. The first two studies (Ueland 2004 and Chace et al. 2005) confirmed the importance of high shrub density in habitat use and also introduced ground cover (especially ferns) as a vegetative correlate of patch occupancy. The next two studies, which compared vegetation characteristics between territories of paired and unpaired males, produced inconsistent results. Chace (2005) found no structural difference between the two groups, but Anderson (2005) determined that territories of paired males contained more small shrubs and fewer large shrubs than unpaired males. This suggests that females evaluate shrub structure when choosing mates. Territory size did not differ between paired and unpaired males in Vermont (Chace and Bauerle 2005), but territories placed in cutover uplands in New Hampshire were 1.5 to 2 times larger than those located in a nearby swamp (Hallworth 2005). In this case, territory size had no bearing on pairing status. Upland and wetland birds both exhibited high rates of pairing and fledging success (86-92%). Territory density was greater in the swamp, however, where small and overlapping territories suggested an ample resource supply. If reproductive rates are comparable in managed and natural habitats, then density could, in fact, be an appropriate gauge of habitat quality for these warblers.

STEWARDSHIP GUIDELINES FOR CANADA WARBLER BREEDING HABITAT

Although much remains to be learned about Canada Warbler breeding ecology, our recent research has begun to fill the information gaps. The rate of population decline demands that we use the best available information to develop conservation strategies, monitor effects of different silvicultural approaches, and adapt as new information emerges. We present a variety of techniques to maintain or create Canada Warbler habitat in the face of threats from wetland loss, forest fragmentation, and age-class conversion. We suggest that land trusts, private landowners, foresters, and natural resource agencies adopt these methods to help conserve the Northeast's vulnerable Canada Warbler population. Achieving population stability will require a combination of land protection and habitat management. Below, we address these areas separately, but recognize that some protected lands will be managed for multiple values, including timber production.

Land Protection Strategies

A variety of land protection strategies could be employed to help stabilize the Canada Warbler population.

1. Identify Canada Warbler population centers with assistance of the local birding community, state bird atlases, and the North American Breeding Bird Survey (www.mbr-pwrc.usgs.gov/bbs).
2. Focus preservation efforts on natural habitats with high Canada Warbler densities.
3. In the absence of Canada Warbler location and abundance data, identify parcels that feature one or more of the following habitats:
   - forested wetland;
   - riparian forest;
   - moist forest;
   - old forest subject to canopy breakup (by wind, ice-storm, or insect damage).
4. Target areas characterized by the following attributes, listed in presumed order of importance:
   - high shrub density (woody stems measuring 2-6 m in height, < 8cm dbh);
   - high volume of understory foliage (including ferns);
   - low level or threat of deer/moose browse;
   - low or semi-open canopy;
   - emergent trees or tree clumps used for territorial display;
   - structurally complex forest floor (hummocks, root masses, logs, etc.);
   - extensive forest cover (especially important in developed landscapes);
   - connectivity to other forested areas;
   - proximity to a continuous supply of 5- to 20-year-old stands that provide additional nesting and post-fledging cover;
   - a compact configuration (e.g. circle or square) to reduce the amount of interior forest susceptible to negative edge effects.
5. To locate potentially suitable habitat, refer to National Wetlands Inventory maps (wetlands.fws.gov), Natural Resource Conservation Service soil maps (websoilsurvey.nrcs.usda.gov/app/), topographic maps (topozone.com), aerial photos (terraserver.microsoft.com), and state map and aerial photo resources (gisuser.com/content/view/2379 or www.gap.uidaho.edu/Projects/States). For additional assistance, contact a county forester or regional planning commission.
6. To access knowledge of local habitats, consult a land surveyor, forester, or sporting club active in the area of interest.

Land Protection Strategies (cont.)

7. Work with local government to support land use regulations that:
   - curb sprawl (e.g. return abandoned public highways to private ownership);
   - concentrate growth (e.g. establish commercial and residential zones);
   - protect wetland and riparian habitat (e.g. require adequate buffers);
   - maintain natural forest hydrology (e.g. best engineering and construction practice);
   - conserve forest lands (e.g. current use taxation for managed and natural areas);
   - control deer numbers (e.g. permit hunting on town lands).
8. Protect large tracts of working forest with intent to pursue one or more of the management strategies described below.

Forest Management Strategies

Nearly 70% of the total land area of New York, Vermont, New Hampshire, and Maine meet the U.S. Forest Service's definition of timberland: productive forest land on which harvesting is not prohibited (North East State Foresters Association 2004). This area represents 6,650 square miles. Timberlands can play a significant role in the recovery of Canada Warbler populations because: 1) they reduce the threat of habitat loss and fragmentation by keeping the landscape forested; and 2) they present an opportunity to create habitat where it does not currently exist. Of the following recommended practices, several apply to conserved properties that permit or restrict timber harvest.

1. Ensure continuous supply of old, uneven-aged, and/or regenerating stands. Even-aged forests 20-75 years old appear to be of low value to Canada Warblers.
2. Maintain large, contiguous areas of unmanaged forest. Such areas are more likely than age-class mosaics to experience large natural disturbance that could benefit Canada Warbler. These areas also harbor unique biological communities and serve as valuable benchmarks for assessing forest management effects.
3. Plan for and tolerate natural disturbances that create gaps in the canopy and/or increase invertebrate food supply, such as: spruce budworm outbreaks, hurricanes, and beaver activity. For example, lay out roads where they are unlikely to be flooded by construction of a new beaver dam.
4. Maintain or restore mixed forest cover at the stand level.
   To maintain/restore conifers in hardwood dominated sites:
   - plant conifer among regenerating hardwoods;
   - use long rotations that favor slow-growing, shade-tolerant conifers (e.g. balsam fir, hemlock, red spruce);
   - retain young and mature conifers well dispersed throughout the harvest zone (preferably in clumps);
   - take extra care to retain conifer seed trees;
   - control exotic pests (e.g. hemlock woolly adelgid).

   To retain/restore hardwoods in conifer-dominated sites:
   - avoid management practices, such as herbicide and thinning, that reduce broad-leafed component of regenerating softwoods;
   - retain young and mature hardwoods well dispersed throughout the harvest zone (preferably in clumps);
   - take extra care to retain hardwood seed trees.
5. Maintain or restore mix of forest types at landscape level.
6. Promote reforestation of isolated forest tracts. This can be achieved by replanting or through natural succession.

Forest Management Strategies (cont.)

7. Maintain a well-developed woody and herbaceous understory by observing the following practices:
   - retain/encourage vigorous understory growth including herbaceous plants (especially ferns) and shrubs/saplings (2-6 m tall, < 8 cm dbh);
   - if thinning can not be avoided, delay it until the stand reaches a mid-successional stage (> 6 m high);
   - restrict use of all-terrain vehicles;
   - limit removal of understory vegetation when creating ski glades in mountain forests;
   - limit removal of understory vegetation when maintaining sugar bushes;
   - avoid damage to understory during harvest and skidding operations;
   - control browsing by ungulates. White-tailed deer pose the greatest threat to birds that dwell in the understory, however grazing by moose and livestock can also have severe local impacts.

8. Maintain or enhance forest floor structure for Canada Warbler nests:
   - harvest in winter to avoid compaction of hummocks, root masses, rotting logs and stumps, which add structure to the forest floor;
   - avoid moist areas where ferns and moss offer suitable nesting cover;
   - leave woody debris on site.

9. Apply silvicultural treatments known to provide nesting habitat. Clearcuts with residual tree retention (a.k.a. wildlife clearcuts) and open shelterwood cuts appear to have the greatest potential to create temporary habitat. The response of Canada Warblers will lag five or more years behind the treatment, during a period of sapling development. Peak abundance is typically achieved between 5 and 20 years post-harvest, when dense regeneration provides cover for nesting and foraging. Clearcutting without residual tree retention fails to provide song perches for territorial display and elevates the risk of converting a mixed forest to a pure stand.

10. Evaluate Canada Warbler response to lighter prescriptions (dense wildlife shelterwood, single-tree, and small-group selection cuts) in order to ascertain their value to this species.

11. When logging, control damage to the understory by:
   - directional felling;
   - winching instead of skidding from each stump;
   - using a feller-buncher with a boom, restricted to a designated trail;
   - working around shrubby pockets;
   - harvesting when a heavy snow pack is present.

12. Conserve riparian buffers and avoid logging wooded ravines. For buffers, a 100 m distance from shoreline or wetland edge is adequate to encompass a typical Canada Warbler territory (Lambert unpubl. data). A 200 m buffer is advisable to avoid crowding or loss of forest interior species (Lambert and Hannon 2000, Hannon et al. 2002).

13. Restrict tree removal between the dates of Canada Warbler territory establishment (May 20) and fledging (July 31).

14. Employ best management practices in timber cutting and road construction to safeguard water quality, maintain natural hydrological regime, and protect the structural and nutritional integrity of the soil.

15. Think big. Take a landscape perspective when managing songbird habitat. Consider the availability and configuration of habitat both within the management unit and beyond its boundaries.

16. Think long. Plan for the long term in order to build on gains made in the short term.

17. Balance goal of providing Canada Warbler habitat with other ecological considerations, including the needs of songbirds that require large tracts of mature forest.

Perils of Migration

Canada Warblers that migrate through the Northeast face the risk of collision with television towers, tall buildings, power lines, and other stationary structures. A chimney in Kingston, Ontario killed 325 Canada Warblers over 10 years, including 131 individuals in a single night (Weir 1989). The risk of bird collisions can be reduced by proper lighting and careful site selection. Since migration risk is beyond the scope of this document, we refer the reader to The Fatal Light Awareness Program (flap.org), Towerkill.com, and the U.S. Fish and Wildlife Service's Guidance on the Siting, Construction, Operation and Decommissioning of Communications Towers, available from the Division of Migratory Bird Management (fws.gov/migratorybirds).

PRIORITIES FOR FUTURE BREEDING-GROUND RESEARCH

Studies are urgently needed to determine the causes of Canada Warbler population declines. While some work must be conducted on the species' wintering grounds, limiting factors on the breeding grounds could be equally important. Forest maturation, wetland habitat loss, and environmental contaminants (e.g., mercury) warrant special attention as potential contributors to declines. Standardized density and demographic data are required from young, old, and wet forests to assess their value during different phases of the breeding cycle. In particular, we need "estimates of adult and brood survival, nesting success, frequency of renesting following failure, site fidelity, and recruitment" (Conway 1999). We also lack basic information on timing and duration of different phases of breeding: nest construction, egg-laying, incubation, and nestling development.

Advances are needed in two additional fields of inquiry: area requirements in settled landscapes (suburban and agricultural) and the habitat improvement potential of single-tree and group-selection cuts. More knowledge in these areas would help guide decisions that affect this vulnerable species.

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Appendix 1. Abstracts from recent Canada Warbler research conducted in Vermont and New Hampshire.

Canada Warbler Habitat Use in Vermont: Influence of Forest Community Type, Canopy structure and Understory Density
Jameson F. Chace, Steven D. Faccio, and Abraham Chacko

Canada Warblers were detected within 50 m of 31 of the 134 census points of the Forest Bird Monitoring Project coordinated by the Vermont Institute of Natural Science. Based on the measurements of 25 vegetative characteristics from four 11.3 m radius plots around each bird census point, we found that Canada Warblers occupy sites that have lower average canopy height and higher coverage of ground cover, principally shrubs and ferns in the understory. The lower canopy height perhaps permits greater sunlight penetration of the forest floor, which promotes a higher density of shrubs, saplings and ferns in the understory. These results are limited to determining the vegetative correlates of patch occupancy; they do not provide any information on whether the birds inhabiting these patches were breeders or nonbreeders, or if they were successful in fledging any young. These results do suggest that Canada Warblers in Vermont are dependent on small canopy disturbances that allow greater sunlight penetration to the forest floor. All of these data were collected from sites where such disturbances are natural events. To determine the response of warblers to small canopy removal by harvesting would require further study and evaluation.

Habitat Selection of Canada Warblers in a Forested Wetland in Canaan, NH
Amy Ueland

Canada Warblers (*Canadensis wilsonia*) are known to be associated with cool, moist areas that contain a layer of shrubby undergrowth. To determine any habitat selection patterns in Canada Warblers, fifteen vegetation variables were measured in 99 0.04-ha circular plots in a forested wetland in Canaan, New Hampshire. Prior to vegetation analysis, the warblers were mist-netted, banded, and observed in three fifteen-day intervals. Vegetation in 81 0.04-ha circular plots was measured in Canada Warbler breeding territories and compared to vegetation in 18 randomly generated, nonterritory plots. Univariate analysis indicated a difference between 4 of the 15 vegetation variables (shrubs and saplings < 2.5 cm dbh, shrubs and saplings > 2.5cm dbh, grasses and sedges, and ferns). A principal components analysis was computed on all vegetation variables and indicated that shrubs and saplings < 8 cm dbh are a key descriptor in habitat used by the warblers.

Vegetation correlates of reproductive success of the Canada Warbler in the Nulhegan Basin, VT
Jameson F. Chace

I measured the habitat characteristics of 31 Canada Warbler territories (21 paired and 10 unpaired) and 20 random points near those territories in the same habitat type at three locations in the Nulhegan Basin of the Silvio O. Conte Fish and Wildife Refuge in northeastern Vermont. Clearly, Canada Warbler males choose territories with a greater density of large shrubs and saplings (> 2.5 cm diameter at boot height) and a greater percent ground cover of moss than the unoccupied “random” sites. Females, however, showed no preference for male territories by any of the 25 vegetative characteristics. Females probably choose males on these sites by more

subtle habitat cues combined with behavioral and morphological characteristics of the males themselves; all of which are beyond the scope of this work to date. For the refuge manager, the protection or creation of areas of high stem density in lowland forested wetlands might maintain or create more opportunities for these semi-colonial warbler subpopulations to persist in the refuge.

Habitat characteristics of paired and unpaired male Canada Warblers (*Wilsonia canadensis*) in a forested wetland in Canaan, NH

Erik A. Anderson

Canada Warblers (*Wilsonia canadensis)* were studied to determine if any habitat differences occurred between territories of males that successfully paired and males that did not successfully pair. Multiple vegetation variables were measured in 100 vegetation plots within 26 paired male territories and 30 vegetation plots within 8 unpaired male territories in a forested wetland in Canaan, New Hampshire. Before vegetation analysis, territorial males were mist netted, banded, and observed for six continuous 30-min observation periods in three fifteen-day intervals from the beginning to the post-fledgling stage of the breeding cycle. Each vegetation plot was a 0.04-ha circular plot. Univariate analyses indicated a difference between ten of the vegetation variables. Paired male territories contained greater stem densities of Red Spruce (*Picea rubens)* < 23 cm dbh and Red Maple (*Acer rubrum*) shrubs < 2.5 cm dbh. Unpaired male territories contained greater stem densities of dead trees 8-23 cm dbh, Balsam Fir trees (*Abies balsamea*) 2.5-38 cm dbh, Red Maple trees 8-23 cm dbh, and Yellow Birch trees (*Betula alleghaniensis*) 8-23 cm dbh. A principal components analysis and a discriminant function analysis were computed on vegetation components for all but plant species specific measurements. This analysis indicated that shrubs < 2.5 cm dbh might be a key descriptor in habitats of males that find a female mate, and shrubs 2.5-8 cm dbh and trees 8-23 cm dbh are key descriptors in habitats of males that did not find a female mate. While it is known that Canada Warblers prefer thick, shrub-infested habitat, this study may indicate that breeding success is significantly correlated with territories of males containing high densities of small shrubs. Knowing the preferences of females may influence habitat management practices that are aimed at the conservation of this species. More data are needed concerning other male qualities that females may use to select males such as voice, displays, plumage, and territory size.

Canada Warbler Home Range, Territory Size and Breeding Behavior in the Nulhegan Basin, VT

Jameson F. Chace and Sarah Bauerle

Canada Warblers establish breeding territories in late May in Vermont. By early June females have paired with some males, but not others. We explored the differences in territory size and breeding behavior among 20 paired and 9 unpaired males using territorial observations in 30-min focal periods within 3 h of sunrise. Using radio telemetry we measured the home range of paired and unpaired males. We found no difference in territory size between paired and unpaired males (mean size 0.38 ha), although males appear to have much larger home ranges (2 ha) than defended territories. Some, unpaired, floater, males were found to range widely (7 ha) over the course of a day. Males that return between years return to the same territory, even when pairing was unsuccessful the year before. Given the high site fidelity and rather large home ranges, conservation of this species in the Nulhegan Basin rests on identifying and conserving the habitat of productive subpopulations.

Canada Warbler Reproductive Success and Territory Size in a Natural Wetland and Managed Forest in Canaan, NH

Michael Hallworth and Len Reitsma

During the summer of 2005, we tracked and mapped 14 male Canada Warblers in a red maple-balsam fir-red spruce swamp, plus another 10 in a nearby, regenerating mixed forest with residual tree retention. Inhabitants of the natural wetland exhibited high pairing and fledging success (93% and 92%, respectively). Males occupying the cutover forest were also successful in finding mates (90%) and fledging young (86%). Kernel home range (KHR) estimates of territory size showed that territories in the harvest zone were 1.5 to 2 times larger than those in the wetland. The 95% KHR estimate was 1.46 ha in the managed forest, compared to 0.97 ha in the swamp. The 50% KHR estimate measured 0.27 in the harvest zone, and just 0.13 in the swamp. Smaller and overlapping territories in the wetland resulted in a higher overall density of Canada Warblers in this habitat, compared to the adjacent upland. Differences in the size and configuration of territories between the wetland and upland forests suggest that key resources (e.g. prey, nest sites, song perches), may be limited in the upland harvest zone. This study shows that Canada Warblers can achieve natural levels of nesting success in managed forests. However, more densely settled wetlands could be more productive overall.