Bicknell's Thrush *(Catharus bicknelli)* Conservation Strategy

for the Green Mountain National Forest

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Executive Summary

Bicknell's Thrush is one of eastern North America's most rare, at-risk migratory songbirds, believed to number no more than 50,000 individuals across its restricted and highly fragmented breeding range. The species is a habitat specialist, nesting in the U.S. only in fir-dominated montane forests generally above 900 m in elevation. These forests face numerous threats that include global climate change, atmospheric deposition of acidic ions and mercury, recreational ski area development, telecommunications tower construction, and wind turbine development. On its Greater Antillean wintering grounds, Bicknell's Thrush is largely restricted to moist, primary broadleaf forests, many of which have been severely reduced in extent and are poorly protected. The species is inadequately monitored by traditional sampling methods such as the Breeding Bird Survey, and estimates of breeding or wintering densities are unreliable at best. An elevation-based model of Bicknell's Thrush habitat in the U.S. indicates 136,250 ha of potentially suitable conifer-dominated montane forest habitat. Of this, a total of 3,151 ha of potential Bicknell's Thrush habitat occurs in the Green Mountain National Forest (GMNF), representing 27.2% of all potential habitat within Vermont (11,580 ha) and 2.3% of the species' U.S. habitat. Analysis of 47 mountaintop survey routes censused annually from 2001 to 2004 shows Bicknell's Thrush in a four-year decline, averaging -9.0% per year.

Because few timber harvesting operations occur in the montane fir-dominated forests preferred by Bicknell's Thrush, the most promising opportunities on the GMNF for active management exist in areas of habitat that are currently developed for recreation, telecommunications, or wind power facilities. Measures to minimize or mitigate possible impacts of activities that may alter Bicknell's Thrush habitat include: 1) restricting timing of activities to before 15 May or after 1 August; 2) avoiding areas where natural disturbance, either chronic or random, could maintain suitable habitat; 3) striving for a "no net loss" habitat mitigation process; 4) consolidating small, adjacent habitat fragments into single, larger blocks on developed peaks; and 5) conducting vegetation management on ski areas or other managed sites to maintain and enhance appropriate habitat for Bicknell's Thrush.

A coordinated Conservation Strategy for Bicknell's Thrush should include 1) continuation of standardized, long-term population monitoring and demographic research; 2) development of a spatially explicit Population Viability Assessment; 3) development of spatially explicit density estimates from the GMNF and the species' entire breeding range, to enable accurate calculations of total population size; 4) small-scale experimental manipulations of forest stands above 2500' in the GMNF for the purpose of developing habitat improvement techniques for Bicknell's Thrush; 5) formation of a species management team to oversee and guide conservation planning for Bicknell's Thrush on the GMNF, and throughout its breeding range; 6) formalization of an international consortium that includes GMNF, VINS, and other U.S. and Hispaniolan partners, to plan Hispaniolan conservation projects that target Bicknell's Thrush; and 7) collaborative development of informational materials on the GMNF and elsewhere that showcase Bicknell's Thrush habitat management efforts and educate the public about montane forest ecology and conservation.

Introduction

Bicknell's Thrush (*Catharus bicknelli*), once considered a subspecies of Gray-cheeked Thrush (*C. minimus*), gained full species status in 1995 (American Ornithologists' Union 1995). It has since been considered one of the passerines most at risk of extinction in eastern North America. The North American Bird Conservation Initiative identifies Bicknell's Thrush among the Highest Priority Landbirds in the Northern Atlantic Forest (Dettmers 2003), while Partners in Flight has placed the species on its Continental Watch List, citing multiple causes for concern (Pashley et al. 2000, Rich et al. 2004). The International Union for the Conservation of Nature (BirdLife International 2000) classifies Bicknell's Thrush as "vulnerable" on its list of globally threatened species. Although there is no conclusive evidence of rangewide population declines, reports of regional declines (Rompré et al. 1997; Rimmer et al. 2001a, Lambert 2005, Lambert et al. 2005a) and local extinctions (Christie 1993, Atwood et al. 1996, Nixon 1999) have elevated concern for this rare species. In Vermont, Bicknell's Thrush is listed as a Species of Special Concern, with a Natural Heritage rank of S3B (Vermont Nongame and Natural Heritage Program 2005). On the Green Mountain National Forest (GMNF), Bicknell's Thrush is designated as a Regional Forester Sensitive Species (USDA Forest Service 2000).

A 2001 Conservation Assessment for the GMNF and White Mountain National Forest (WMNF) (Rimmer et al. 2001b) provided an overview of the current state of knowledge on Bicknell's Thrush, including primary threats facing the species and priorities for future research and monitoring. This Conservation Strategy synthesizes and updates that information to (1) develop explicit objectives for the management of Bicknell's Thrush populations and habitats on the GMNF, (2) recommend specific actions by which to accomplish those objectives, and (3) refine research and monitoring needs for Bicknell's Thrush. The Conservation Strategy, while focused on the GMNF, has broad applications that extend throughout the species' northeastern U.S. breeding range.

Distribution and Status

Breeding range. Bicknell's Thrush occupies a restricted and highly fragmented breeding range (Figure 1 and 2). Breeding is documented north to southwestern Quebec in Réserve La Verendrye, southeastern Quebec along the north shore of the St. Lawrence River and Gaspé Peninsula (Ouellet 1993, 1996), northwestern and north-central New Brunswick (Erskine 1992, Nixon 1996), and Cape Breton Island, Nova Scotia, including the small, outlying St. Paul and Scaterie islands (Erskine 1992, D. Busby pers. comm.). Southern breeding limits are reached in the Catskill Mountains of New York (Atwood et al. 1996, Peterson 1988), the Green Mountains of southern Vermont (Atwood et al. 1996, Kibbe 1985), the White Mountains of central New Hampshire (Atwood et al. 1996, Richards 1994), the mountains of western and central Maine (Adamus 1987, Atwood et al. 1996), south-coastal New Brunswick (possibly extirpated; Erskine 1992, Christie 1993), and southwest-coastal Nova Scotia (probably extirpated; Erskine 1992, D. Busby pers. comm.). Possible but unconfirmed local and sporadic breeding has been documented in north-coastal Maine (Atwood et al. 1996, Rimmer and McFarland 1996).

Bicknell's Thrush is widespread at high elevations in the GMNF, where surveys conducted between 1992-2003 confirmed the species' presence on 42 mountains (Table 1, Figure 2). Occupied peaks were distributed from Searsburg Ridge in the south to Mt. Ellen in the north. A recently-constructed model of Bicknell's Thrush distribution in the northeastern U.S., using elevation, latitude, and forest type as co-variables, predicts the species to be present in conifer-

dominated forests above an elevation threshold that descends with an increase in latitude (Lambert et al. 2005b). The slope of the threshold (-81.63 m/1° latitude) reflects climatic effects on forest composition and structure. At the southern edge of GMNF, the model predicts Bicknell's Thrush occurrence above 985 m elevation, while the lower limit of the species' occurrence at GMNF's northern extent is 870 m. The model further predicts that a total of 3,151 ha of potential Bicknell's Thrush habitat occurs in the GMNF (Figure 3); this represents 27.2% of all potential habitat within Vermont (11,580 ha) and 2.3% of the species' U.S. habitat (136,250 ha; Lambert et al. 2005b).

Winter range. The known wintering distribution of Bicknell's Thrush is confined to the Greater Antilles (Figure 1). Specimen and field survey data indicate that the majority of wintering birds occur in the Dominican Republic (Wetmore and Swales 1931, Ouellet 1993, Rimmer et al. 1997, 1999), where the species is widely distributed and locally common from sea level to 2220 m (Rimmer et al. 1999, 2001a). Few records exist from Haiti, where it is restricted to higher elevations, mainly in the southwest (Massif de la Hotte) and east (Massif La Visite; Wetmore and Swales 1931, Woods and Ottenwalder 1983, 1986). Surveys conducted by VINS in Massif de la Hotte during February of 2004 confirmed Bicknell's Thrush to be fairly common in mesic karst broadleaf forest at 1175-1250 m elevation and in the wet montane broadleaf forest at 1825-1915 m elevation (Rimmer et al. 2004). In the Massif de la Selle, VINS found the species in small patches of remnant, highly threatened wet broadleaf forest at 1175-2060 m elevation during January of 2005 (Rimmer et al. 2005). Bicknell's Thrush is uncommon and local in Jamaica, mainly in the Blue Mts. from 1200–2225 m elevation (R. and A. Sutton, unpubl.data; VINS, unpubl. data). The species is a rare winter resident in eastern and southeastern Puerto Rico, known only from the Luquillo Mts. at 450-720 m elevation and Sierra de Cayey at 720 m (Arendt 1992; J. Wunderle unpubl.). Bicknell's Thrush has recently been recorded in eastern Cuba at 1600-1960 m in Sierra Maestra (Rompré et al. 2000, Y Aubry and G. Rompré pers. comm.); two October specimens from western Cuba (Havana) in the 1960s (Garrido and Garcia Montaña 1975) probably represent transients. There are no confirmed winter records elsewhere.

Habitat

Breeding range. In the United States, Bicknell's Thrush is a habitat specialist restricted to montane forests dominated by balsam fir *(Abies balsamea)*, with lesser amounts of spruce *(Picea rubra* and *P. mariana)*, white birch *(Betula papyrifera* var. *cordifolia)*, mountain ash *(Sorbus* sp.*)*, and other hardwood species. At the southern extent of its range in the Catskill Mountains, Bicknell's Thrush generally breeds above 1100 m elevation, with birds recorded as low as 750 m on several Maine peaks (Lambert et al. 2005b). The lowest nest in Vermont was documented at 1006 m, although the species is regularly found at elevations below 900 m (Rimmer et al. 2001a). Bicknell's Thrush is often associated with recently-disturbed areas undergoing vigorous succession, characterized by standing dead conifers and dense regrowth of balsam fir (Wallace 1939, Rimmer et al. 2001a). Highest densities are typically found in chronically-disturbed (high winds, heavy winter ice accumulation) stands of dense, stunted fir on exposed ridgelines or along edges of human-created openings (e.g. ski trails), or in regenerating "fir waves" (cf. Sprugel 1976, Marchand 1984; Rimmer et al. 2001a, 2004). In the White Mountains of New Hampshire, Sabo (1980) found Bicknell's Thrush at a mean elevation of 1290 m in exposed mid to upper slopes dominated by conifers (75% of foliage volume) with a mean canopy height of 4.8 m.

In Canada, Bicknell's Thrush occupies montane fir forests in southern Quebec and New Brunswick up to 1178 m elevation (Ouellet 1993, Rompré et al. 1997, Connolly 2000, Nixon et al. 2001; D. Busby pers. comm.), coastal maritime spruce-fir forests in New Brunswick and Nova Scotia (Erskine 1992, D. Busby pers. comm.), and regenerating stands of mixed forest following forest fires or clear cutting in Quebec and New Brunswick, generally above 450 m (Ouellet 1993, Nixon 1996, Nixon et al. 2001).

Winter range. The current preferred winter habitat of Bicknell's Thrush is mesic to wet broadleaf montane forests in the Dominican Republic (Rimmer et al. 1999), Haiti (Wetmore and Swales 1931, Woods and Ottenwalder 1983, 1986; Rimmer et al. 2004), Cuba (Rompré et al. 2000, Aubry and Rompré pers. comm.), Jamaica (R. and A. Sutton, pers. comm., VINS), and Puerto Rico (J. Wunderle unpubl.). In the Dominican Republic, the species is found at all elevations from sea level to 2200 m, although 62% of occupied sites were in forests > 1000 m elevation (Rimmer et al. 1999). The majority (75%) of occupied sites (n = 24) were in broadleaf-dominated forests ("cloud/montane broadleaf forest" and "submontane broadleaf rainforest"; Tolentino and Peña 1998) at all elevations, 19% were in mixed broadleaf-pine forests, and 6% occurred in pine-dominated forests. Primary, wet and/or mesic forests constituted 78% of all occupied sites; only 6% of occupied sites were in predominantly dry forests (Rimmer et al. 1999). The use of regenerating secondary forests (22% of occupied sites) in the Dominican Republic may indicate winter habitat flexibility or a recent shift from preferred primary broadleaf forest habitat, much of which has been lost or degraded.

In the Dominican Republic, some evidence exists for sexual macro- or micro-habitat segregation, or segregation of sexes by geographic area (Rimmer and Goetz 2001, Rimmer et al. 2001a; Rimmer and Townsend unpubl. data). In Sierra de Bahoruco on the Haitian border, in predominantly undisturbed broadleaf montane forests, 70 of 86 (81%) of known-sex birds mist-netted from 1998-2003 were male. At a smaller, mid-elevation, moderately disturbed wet forest site in the Cordillera Septentrional, 27 of 52 (52%) of known-sex birds were female. These results, while still preliminary, suggest that females may be limited by availability of high quality winter habitat; they warrant more intensive investigation.

Life history

The life history, demography, and ecology of Bicknell's Thrush are described in detail in Rimmer et al. (2001a). Only those aspects most relevant to the species' conservation status and management on the GMNF are presented here.

Mating system and sex ratio. The mating system of Bicknell's Thrush is unusual and not easily categorized; it may be most similar to that of Smith's Longspur (*Calcarius pictus*), which has been termed "female-defense polygynandry" (Briskie 1993), in that both males and females mate with multiple partners, multiple paternity is common, and > 1 male often feeds nestlings (Goetz et al. 2003). In Vermont, > 75% of broods are sired by multiple males; some males have offspring in two nests in the same breeding season. Of 13 broods in 1998 and 1999, 10 had 2 or more sires, 3 a single father (Goetz et al. 2003). This unusual mating system, combined with the species' unpredictable spacing patterns, make estimation of breeding densities unreliable at best.

The overall 4-yr mean male:female ratio on 3 Vermont study plots was 1.8:1.0 (annual range = 1.4-2.8:1.0; Rimmer et al. 2001a). The cause of a male-biased sex ratio is not known, but may relate to the ratio at hatching, differential natal dispersal patterns, differential survival of first-year birds, or events on the wintering grounds (e.g., differential male and female survival due to winter habitat segregation).

Breeding phenology. The earliest known arrival date of a breeding male in Vermont is 15 May, of a female 23 May. Males arrive significantly earlier than females (mean difference = 1.7 days, 95% CI = 3.2 – 0.3). Mating activities probably begin shortly after female arrival, as evidenced by frequent singing and calling throughout the day in late May and early June (Rimmer et al. 1996). Mating associations are dynamic and probably tied to the stage of individual females' fertile periods, and are likely influenced by the availability of other mating opportunities and chick feeding by males.

The earliest confirmed nest construction date in Vermont is 1 June, with other extrapolated nest initiation dates of 2-4 June (Wallace 1939, Rimmer et al. 2001a). In Vermont, 71% (n = 89) of clutches are initiated in the first 3 weeks of June. Later clutches probably represent renesting attempts. Clutch initiation dates in Vermont range from 7 June-14 July (n = 89), and in New Hampshire 21 June-14 July (n = 5; Wallace 1939, Richards 1994). Known hatching dates range from 23 June-29 July (70% by 6 July) in Vermont (n = 68; Wallace 1939, Rimmer et al. 2001a). Known Vermont fledging dates range from 3 July-3 August (70% by 14 July, n = 53; Wallace 1939; Rimmer et al. 2001a). Young stay in the nest 9-13 days (average 11.4 ± 1.3, n = 17; Wallace 1939, Rimmer et al. 2001a).

Second broods are rare, with only one confirmed instance in Vermont. A female that fledged 2 chicks on 2 July initiated a second clutch 5 days later, building her nest while feeding fledglings and continuing to feed her first brood during egg laying (Rimmer et al. 2001a). Renesting attempts after early-season failures are common. The mean interval between loss of a first nest and initiation of a second clutch in Vermont is 6.8 days (range 5-12, n = 5). One female renested successfully on her third attempt, requiring only 2 days from loss of her second clutch to initiation of her third (Rimmer et al. 2001a).

Nest characteristics and microhabitat. Nests are usually located in dense stands of young to mid-successional fir or "krummholz", uncommonly in more mature, open forests (Wallace 1939, Rimmer et al. 2001a), and are often found in dense regrowth along natural or artificially created edges. On 2 ski areas (Mt. Mansfield and Stratton Mountain) in the Green Mountains, 57% of all nests were within 10 m of a ski trail edge (Table 2), and 45% of these were $\leq$ 2 m from the edge (Rimmer et al. 2004). Of 118 Vermont nests, the mean height above ground was 2.05 m $\pm$ 1.18 SD (range = 0.46-10 m; Wallace 1939, Rimmer et al. 2001a). Most nests (103 of 118; 87%) are built in balsam fir, but also in red spruce (n = 10), paper birch (n = 3), and dead standing fir (n = 2; Wallace 1939, Rimmer et al. 2001a). Average nest tree height was 3.2 m ±1.55 SD (range 0 – 11m, n = 102) and mean DBH was 5.7 cm ± 5.24 SD (range 1-31.5 cm, n = 102).

Incubation and care of nestling and fledglings. In Vermont, the incubation period is 9-14 days (mean 12 ± 1.6, n = 8; Wallace 1939, Rimmer et al. 2001a). Chicks generally hatch within 24 hours of each other. Only females brood, but both sexes feed chicks. Nestlings fledge 9-13

days after hatching (mean 11.4 ±1.3, *n* = 17 known to the exact day; Wallace 1939, Rimmer et al. 2001a). Fledglings may remain with adults up to 14 days after leaving the nest. Adults often split broods, although one known case exists of 2 males splitting a brood, apparently emancipating the female. In another case, a female and one of 2 male feeders split the brood, while the second male continued to feed nestlings in another nest. Movements of family groups are not well documented, but adults with dependent fledglings have been found up to 280 m away from known nest sites. (Rimmer et al. 2001a)

Movements and habitat use of both adults and fledglings during the post-fledging period are poorly known. Of 11 Mansfield fledglings radio-tagged in 2000, 7 were known to have been depredated (mean survival 8.1 $\pm$ 6.6 days after fledging, range 1-19), 2 disappeared after 8 and 19 days, respectively, and 2 survived until their transmitter batteries expired (40 and 31 days, respectively). Of these latter 2 birds, one remained within 275 m of its natal nest site in montane fir forest, while the other moved nearly 1 km downslope after about 10 days to hardwood-dominated forest at elevations of 700-900 m and remained there. One free-flying juvenile banded on 25 July stayed within a 100-m radius of its banding location in stunted fir forest at 1150-1175 m elevation until 22 August, then disappeared. (Rimmer et al. 2001a).

Population Biology and Viability

Age at first breeding; intervals between breeding. Bicknell's Thrushes breed at approximately 1 year and annually thereafter. Of known-age female breeders at 85 Vermont nests in 1994-1999, ASY (after second-year) females outnumbered SY (second-year) females 73 to 12 (85.9% to 14.1%). Of 25 Vermont males with known paternity at 1998 and 1999 nests, only 2 (8%) were SY birds, while the SY age class comprised about 25% of entire male study population (Goetz et al. 2003). Highly irregular settlement patterns further suggest that some SY males may fail to achieve fertilizations. (Rimmer et al. 2001a).

Annual and lifetime reproductive success. In Vermont, annual reproductive success among males is skewed but generally low. Paternity data from 12 broods monitored in 1998 and 1999 suggest considerable reproductive skew. Of 19 males with known paternity, 12 (63%) males sired 1 young, 2 (11%) sired 2 young, 4 (21%) sired 3 young, and 1 (5%) sired 4 young; these are minimum estimates (Goetz et al. 2003).

The annual Mayfield daily survival rate of nests (probability of nest surviving 1 day without failure) on Stratton Mtn. was 0.98 $\pm$ 0.014 SE (*n* = 39 nests), and on Mt. Mansfield 0.96 $\pm$ 0.007 SE (*n* = 56 nests). Daily survival rates of Vermont nests are strikingly biennial in response to balsam fir cone production and red squirrel population cycles. From 1994-2000, fall cone crops were very high in even-numbered years, resulting in high red squirrel populations during the following springs and summers, with consequent low productivity for Bicknell's Thrush due to nest depredation. In odd-numbered years, fall cone production was invariably lower, spring and summer squirrel populations reduced, and thrush nesting success markedly higher (Rimmer et al. 2001a). The average number of young fledged/nest in Vermont was 2.1 ± 1.37 SD (range = 0-4, *n* = 30) on Stratton Mtn. and 1.5 ± 1.59 SD (range = 0-4, *n* = 46) on Mt. Mansfield (Rimmer et al. 2001a).

Life span and survivorship. The longevity record for both male and female Bicknell's Thrush, based on band returns, is 9 years. The annual survival rate of ASY birds captured on Vermont breeding grounds, based on a Cormack-Jolly-Seber model (Cooch and White 1998,

White and Burnham 1999), was not dependent on time or sex on four study plots. To account for uncertainty in model selection, the range of mean parameter estimates was averaged over all 16 models in the candidate set for each study plot, weighted by Akaike model weights, and the most parsimonious model was used (Bertram et al. 2000, Burnham and Anderson 2002). Survivorship on the Mt. Mansfield ridgeline in 1992-1999 was 54.7% ± 6.5% SE with mean parameter estimates for all models ranging from 54% - 55.8%; on Mt. Mansfield's east slope in 1995-1999, 74.8% ± 8.6% SE, mean estimates 71.9% – 79.1%; on VINS' Stratton Mtn. ski area plot in 1997-1999, 73.9% ± 10.1% SE, mean estimates 75.6% - 88.3%; and on VINS' Stratton Mtn. natural plot in 1997-1999, 94.6% ± 28.4% SE, mean estimates 86.1% - 94%. A more detailed analysis of 1994-2003 adult survivorship data from Mansfield and Stratton showed no significant difference in survivorship between birds on ski area and natural area plots (Rimmer et al. 2004).

Survival rates of juveniles are poorly known due to apparent natal dispersal; only 9 of 157 (5.7 %) fledglings and 3 of 16 (18.8 %) independent juveniles banded in Vermont from 1992-2004 were documented to return to their natal mountain. Two nestlings that returned to Stratton Mountain were females from the same nest. On Mt. Mansfield in 2000, only 2 of 11 (18.2%) radio tagged fledglings were known to have survived beyond 30 days. The annual survival rate of wintering individuals captured at a montane broadleaf forest site in Sierra de Bahoruco, Dominican Republic, based on Cormack-Jolly-Seber model estimates, was not time dependent in 1994-1999: 72.9% ±14.3% SE, with mean parameter estimates for all models ranging from 68.4% - 79.7% (Rimmer et al. 2001a). Return rates differ significantly for thrushes banded in Vermont (64.7%: 225 of 348 birds) and the Dominican Republic (28.3%: 25 of 99 birds). However, return rates of age classes are similar within each area: 61.5% (112 of 182 birds) for yearlings and 68% (113 of 166 birds) for older individuals in Vermont; 22% (12 of 55 birds) for yearlings and 29.6% (16 of 54 birds) for older individuals in the Dominican Republic.

Relationship to Land Management and Human Activity

Of the 3,151 ha of potential BITH habitat in the Green Mountain National Forest, 75% occurs in areas where timber harvesting is restricted. Of the remaining 25%, (1) 11.8% occurs in areas where "Wildlife and timber management activities are selected, scheduled, and located to ensure that backcountry recreation is protected."; (2) 7.8% occurs on newly acquired lands where "management options will be kept open until inventories can be done."; and (3) 5.7% occurs on lands where recreation benefits are emphasized, including 46 ha on Mount Snow designated as potential ski area expansion.

Adjacent lands contain hundreds of additional unconserved hectares, including 313 ha on Stark Mountain, 178 ha on Mount Equinox and Little Equinox, and 79 ha on the northeast slope of Stratton Mountain.

Population Viability Goals

Because a comprehensive Population Viability Analysis (PVA) for Bicknell's Thrush is lacking, and because population estimates remain imprecise, it is not currently feasible to establish quantifiable goals to maintain or enhance Bicknell's Thrush populations. The species is believed to number fewer than 50,000 breeding individuals rangewide (Rimmer et al, 2001a, Rich et al. 2004), and recent estimates suggest a global population of fewer than 20,000 birds (Hale 2006, Lambert et al. 2006a). These figures represent coarse approximations at best, based on a number of assumptions (Rimmer et al. 2001b). Few reliable population trend data are

available from any part of the breeding range. Bicknell's Thrush is inadequately monitored by the North American Breeding Bird Survey of the USGS Patuxent Wildlife Research Center. Since 2000, a regionwide (New York to Maine), long-term population monitoring program, Mountain Birdwatch, has used trained volunteers to conduct standardized point counts on >100 mountains annually (Lambert 2005). Analysis of 47 routes surveyed annually from 2001 to 2004 shows Bicknell's Thrush in a four-year decline, averaging -9.0% per year ($P = 0.07$; Figure 4 and 5; Lambert 2005).

Lambert et al. (2005a) recently completed an analysis of existing Bicknell's Thrush census data from New Hampshire and Vermont. The study integrated and analyzed survey data gathered from the GMNF by the University of Vermont (1991-2000), from elsewhere in Vermont by VINS (1992-2000), and from the WMNF by Forest Service personnel and the Audubon Society of New Hampshire (1993-2003. Results provided the first evidence of a sustained decline in a major population of Bicknell's Thrush. Counts on the WMNF significantly declined by an average of 7.0% per year ($P < 0.1$), while Vermont counts did not significantly change, declining annually by an average of 1% ($P = 0.71$; Lambert et al. 2005a). On GMNF survey routes (n = 4), Bicknell's Thrush exhibited a nonsignificant, annual decline of 6.2% ($P = 0.27$). The apparent disparity in the magnitude of population declines between New Hampshire and Vermont may be due to sampling error, as Vermont surveys were conducted on only six routes, while 39 routes contributed data from New Hampshire. However, data from the North American Breeding Bird Survey indicate that population trends from New Hampshire and Vermont differ in direction for nearly half of the bird species that typically occur in montane forests (King et al. 2005), suggesting that the difference in Bicknell's Thrush trends between the two states may be real. Factors that might account for such a difference include potentially higher levels of atmospheric pollutants in the White Mountains, or geographic separation and differential mortality of populations on the species' wintering grounds. There is no solid evidence for either possibility, however, and expanded, long-term monitoring will be necessary to elucidate regional trends.

In the absence of robust data on population size or trends, only general population viability targets can be proposed. Partners in Flight goals advocate the "…protection of 100% of sites that support Bicknell's Thrush populations large enough to be considered source populations for other sites, and as many additional high-elevation habitat patches with smaller populations as possible" (Hodgman and Rosenberg 2000). Although statewide Partners in Flight population objectives for Vermont and New Hampshire are unavailable (Rosenberg 2004), due to the paucity of data on Bicknell's Thrush, a minimum goal should be maintenance of current numbers. Given the extremely high priority of this species in the Partners in Flight conservation ranking scheme, eventual objectives will almost certainly recommend increasing statewide populations of Bicknell's Thrush. If the current population decline indicated by Mountain Birdwatch data continues, population increases of 50-100% over 30 years will likely be proposed as targets (Rosenberg 2004).

Management Recommendations/Standards and Guides

Because most Bicknell's Thrush habitat in the U.S. lies above the elevational limit of conventional land management activities, the species affords relatively few opportunities for active management. Few timber harvesting operations occur in the montane fir-dominated

forests preferred by Bicknell's Thrush due to logistical constraints of accessing or operating in high elevation terrain and relatively low commercial value of the lumber. On the GMNF, very little timber harvesting has occurred in forested stands that extend above the lower elevation threshold of Bicknell's Thrush occupancy (R. Hoelscher, pers. comm.), such that current or future harvesting activities pose a negligible risk to the species' conservation status on the GMNF.

The most promising opportunities for active management exist in areas of habitat that are currently developed for recreation, telecommunications, or wind power facilities. These typically afford accessibility via work roads, and they are often characterized by disturbance regimes that can be maintained to varying degrees by targeted management. Undeveloped habitats, on the other hand, are typically difficult to access and are characterized by natural disturbance regimes that may be problematic to maintain or enhance. Bicknell's Thrushes occupy habitats that are extremely dynamic and often ephemeral in nature (Reiners and Lang 1979). Habitat suitability for the species tends to be patchy within a given area of montane forest, and often changes over time, as birds shift their local distribution in accordance with changes in forest composition and structure. Whether natural disturbance processes (e.g., weather events, fir waves) can be effectively mimicked in currently undisturbed areas is unknown, but raises complex issues of ecological effects, practicality, cost effectiveness, aesthetics, public relations, and ethics. A small number of carefully controlled, experimental manipulations might yield valuable information.

A. Minimization and Mitigation of Management Impacts. – In general, we recommend several measures to minimize or mitigate possible impacts of activities that may alter Bicknell's Thrush habitat. These include:

1) Timing of activities. Field observations suggest that the most critical time for Bicknell's Thrush in regards to noise and human disturbance is during female nest site selection, nest building, mating, egg laying, and through at least the first half of the incubation period. Thrushes generally do not return to breeding sites before 15 May. Spring management activities can therefore safely be conducted as late as this date. Actual habitat removal, however, may adversely impact thrushes during any point in the active nesting cycle. Of 142 nests with known termination dates on Stratton and Mansfield, 25 (17.6%) were terminated on or after 20 July, while 89 (62.7%) had termination dates between 29 June and 19 July. Only 7% of all nests were still active after 26 July. Among the 65 nests that fledged at least one chick, only 6% were active after 26 July. All late nests were those of individual females that renested after failing to complete earlier nesting attempts (mostly due to natural depredation events). Overall fledging dates on Mansfield and Stratton ranged from 2 July to 2 August. Fledglings remain with adults for up to 2 weeks after leaving the nest (Rimmer et al. 2001a) and show relatively little mobility during the first 4-5 days after fledging (personal observation). To minimize impacts to late-season nests and family groups with recent fledglings, management activities (e.g., cutting, thinning, mowing, construction) should be delayed until 1 August. This date can be earlier in a given area, provided that monitoring has been sufficient to determine that all known active nests are terminated. We believe that a

1 August cut-off date, which poses a risk to less than 5% of thrush nests in an average year, is acceptable.

2) Habitat alterations should be avoided in areas where natural disturbance, either chronic or random, could maintain suitable habitat for Bicknell's Thrushes. Such areas include west-facing slopes, ridgelines, fir waves, and areas adjacent to fir waves. Management activities or other habitat alterations should be limited to sheltered areas, where natural disturbances tend to be minimal, and especially where mature hardwood species comprise greater than 1/3 of the forest canopy. These are areas least likely to provide suitable habitat for Bicknell's Thrushes.
3) In instances of habitat removal or alteration (i.e., ski trail establishment or expansion) in fir-dominated montane forests, a "no net loss" mitigation process is warranted, such that an area of currently developed habitat equal to (or greater than) that to be altered will be actively restored or passively allowed to recover to conditions suitable for Bicknell's Thrush occupancy. Any impacted areas selected for mitigation (e.g., packed gravel work roads) that are not currently favorable for plant growth may require careful site preparation to promote regeneration (see below). A "no net loss" policy should be a primary habitat mitigation tool at montane forest sites where the Forest Service or other landowners have both the necessary control and capacity to achieve mitigation.
4) Measures to accomplish habitat mitigation primarily involve restoration of montane forest areas that currently provide unsuitable habitat for Bicknell's Thrush. These may include existing ski trails dominated by herbaceous or low shrubby vegetation, gravel or other packed surfaces, ski lift openings that may be closed for skiing but maintained in an early successional state, or any other human-altered habitats that do not provide the dense fir-dominated cover favored by Bicknell's Thrush. Areas that are selected for restoration should be near or adjacent to currently occupied habitat and should, to the extent possible, be subject to natural disturbance from wind and ice (e.g., west-facing slopes and forested ridgelines). Habitat restoration should generally take one of two forms: a) active revegetation of bare or herbaceous ground, via planting of native vegetation, or b) passive revegetation through natural succession. In either case, it is important to realize that forest regeneration occurs slowly at high elevations. A timeframe of 8-10 years is a likely minimum before regular occupancy by Bicknell's Thrushes can be expected.
5) For restoration efforts involving active revegetation, balsam fir seedlings or saplings should be planted. If possible, these should be transplanted from nearby forest stands to ensure genetic compatibility, provided that minimal alteration of these stock habitats will occur. If transplanting can not be accomplished without unacceptable loss from, or damage to, adjacent habitats, balsam fir seeds may be planted. In either case, soil may need to be prepared in advance, and possibly augmented in thin areas overlying bedrock, to accelerate the growth of fir seedlings or germination of seeds. Prior to and during any active revegetation efforts, activities should be assessed by a certified forester on private lands, and by an agency forester in the case of public land. Restoration via natural succession may be especially warranted where succession by balsam fir and/or red spruce has already begun. In such cases, advance site preparation may not be needed. Active revegetation of montane forest sites has not previously been attempted, and this method should be considered experimental, possibly requiring a "trial and error" approach.
6) Consolidation of habitat islands in mitigation plans, especially on ski areas, should be given high priority. Consolidation of small, adjacent habitat fragments (< 0.1 ha) into

single, larger blocks will enhance overall habitat suitability for Bicknell's Thrush in a given area. Most islands smaller than 0.1 ha are not regularly used by thrushes, other than as a waypoint during trail crossings. Decreasing the amount of overall edge through creation of larger, contiguous habitat blocks promotes microclimate and microhabitat features that enhance the likelihood of breeding by thrushes and other montane forest bird species.

7) For any mitigation sites, especially on ski areas, that are planned for forest regeneration, some type of barrier should be erected to block these sites from human traffic, in order to minimize disturbance to young trees that will eventually protrude above the winter snowpack, exposing new growth to potential damage. Barriers should include conspicuous signage to inform potential users about the closure and to educate them about its benefits.
8) Any habitat restoration efforts will need to be guided by standards to evaluate their success. Development of specific objectives for restoration, including a timeline, and measures to objectively determine success are recommended. Field surveys to monitor progress should be conducted over a timeframe of at least 15-20 years, by an agency or certified forester or by other individual(s) knowledgeable about montane forest ecology. There should be a specific contingency plan in place to compensate for the possible failure of initial restoration efforts. Careful, sustained monitoring is necessary not only to gauge the success of site-specific restoration attempts, and to apply corrective measures as warranted, but to document the feasibility of montane forest restoration. There are currently no standards or specific protocols to guide restoration of montane forest habitat, and these are needed.
9) Conservation research and monitoring since 1994 on the Hispaniolan wintering grounds of Bicknell's Thrush leave few doubts that winter habitat loss and degradation pose the greatest single threat to the species' long-term survival (e.g., Rimmer et al. 2001a, 2003, 2005). Remaining forest cover in the Dominican Republic is estimated at <10%, while fewer than 1.5% of Haiti's original forests are intact (Stattersfield et al. 1998). Despite chronic deforestation and a poor protected lands system in both countries, tangible opportunities exist to conserve mesic and wet broadleaf forests on Hispaniola. We propose the formalization of an international consortium that includes GMNF, VINS, and other U.S. and Hispaniolan conservation partners, to plan and implement Hispaniolan conservation projects that target Bicknell's Thrush. One viable and far-reaching mitigation measure that this consortium might promote is a designated fund for the protection, restoration and management of Bicknell's Thrush habitat in the Dominican Republic and Haiti. A source of revenue for such a fund, which would be administered by a Steering Committee, would be contributions from ski areas and other entities that alter or remove montane forest vegetation in North America. For every hectare of habitat converted from its natural state to one used for skiing or other development, a contribution would be set aside to enable the purchase or restoration of thrush wintering habitat. Specific conversion metrics would need to be resolved for such an innovative program, but the concept has met with enthusiasm from habitat conservationists at both ends of the species' range.

B. Post-management Habitat Maintenance. – Bicknell's Thrush nest mainly in low, dense fir-spruce on high exposed ridges, in blow-downs, or in fir-wave areas. Small numbers have also

been found in mixed forests, particularly in the presence of a well developed conifer sapling layer. Areas along ski trails or other human-created openings often mimic these naturally disturbed forest types, and development of suitable habitat structure often is greatly accelerated because of increased exposure. In the Adirondack Mountains and New England, Bicknell's Thrush nest mainly above 900 m in elevation and occasionally lower if the habitat is appropriate. Furthermore, it appears that birds regularly descend below 900 m for foraging, especially early in the breeding season (Rimmer et al. 2001a). It should be noted that there are few data on fledgling or post-breeding dispersal in fall, but that both juvenile and adult thrushes have been documented to use lower elevation forests at this time.

VINS' recent research has determined that leaving fir-spruce cover along ski trail edges can maintain habitat for Bicknell's Thrush by providing suitable structure and a buffer (Rimmer et al. 2004). Bicknell's Thrush will use these areas for foraging, perching, and for cover when moving along and crossing trails. VINS has also documented regular nesting in narrow buffers covered with low, dense fir-spruce along ski trails.

The following specific measures could maintain and enhance appropriate habitat on ski areas or other managed sites for Bicknell's Thrush.

1) Vegetation management is warranted mainly in areas where the adjacent forest is fir-spruce dominated and characterized by a high stem density in the understory, often forming a dense thicket. Taller (>5 m) trees may be present, but these are often damaged by wind and/or insects and do not form a complete canopy, thus promoting understory growth. In these areas, which may include only one (usually the wind-exposed) side of a ski trail, low fir-spruce should be allowed to extend along the edge outward for 3-6 m (or wider) at heights of 0.5-2.0 m (or higher). An attempt should be made to "feather" such vegetation at the edge of ski trails or other permanent openings, i.e., gradually decreasing tree height from the forest to the grassy trail edge. When these areas are cut back, there should be an attempt to maintain woody vegetation at heights of 0.5 m or more. Also, regeneration cuts should be made as infrequently as possible to maximize habitat availability and continuity.
2) Management of gladed skiing trails for Bicknell's Thrush is important to maintain habitat integrity within ski areas. Although the effects of glading have not been studied, any removal of understory montane forest vegetation is likely to reduce habitat suitability for Bicknell's Thrush. To minimize adverse impacts, existing gladed trails in suitable habitat should be kept as narrow as possible, and remaining patches of low, dense fir-spruce should be left intact or minimally altered. In general, new glading should be restricted to hardwood forest stands. In any habitat type, new glading should stringently minimize understory removal. Annual maintenance should ensure that some tree saplings are retained, so there is continual recruitment to older age classes. This will help to prevent tree mortality events that could cause the longer-term conversion of gladed trails to completely open trails. Altering the spatial arrangement of maintenance cutting in established glades, to allow for areas that are continually regenerating, might help promote habitat suitability for Bicknell's Thrush.
3) Concerted efforts should be made to prohibit any unauthorized gladed trail establishment or maintenance, or unauthorized habitat alteration (i.e., cutting) of any kind. The

proliferation of trails illicitly cut by recreational, off-trail skiers has been recently documented by VINS on some Vermont ski areas and should be actively discouraged.

4) Another potential habitat enhancement for Bicknell's Thrush involves islands of trees in ski trails. Islands often have a low, dense fir-spruce component and provide crossing points for Bicknell's Thrushes, which tend to avoid wide crossings of open ski trails. Maximizing the size of islands between ski trails will benefit movements of Bicknell's Thrush between patches of suitable habitat and may provide increased nesting opportunities. In situations where one or more small (generally $\leq$ 0.5 ha) islands can be combined into a single, larger island, Bicknell's Thrush habitat will be improved.
5) The timing of vegetation management in areas of Bicknell's Thrush breeding habitat is important and should be delayed until August 1, when the majority of nesting activities are complete (see above).
6) Trail areas that are appropriate for thrush habitat management should be explicitly identified in individual ski area management plans, subject to input and regular review by GMNF staff and regional experts in Bicknell's Thrush ecology. Each management plan and its accompanying map should be reviewed annually by the GMNF, appropriate ski area staff, and other concerned agencies. Specific management actions should be identified, progress on previously-identified actions should be assessed, and measures should be taken to ensure compliance/accountability by each ski area.

Collaborative Potential

Increased public awareness of the uniqueness and vulnerability of montane forest habitats in the Northeast will be necessary for full and successful implementation of any conservation plan. This can be best accomplished by the synergistic efforts of public agencies (National Forests, state agencies), non-governmental organizations (e.g., VINS, Audubon Vermont), private landowners (e.g., ski areas, timber companies, wind power companies, telecommunications companies), and citizens' groups. These groups have unique individual and collective opportunities to showcase Bicknell's Thrush habitat management efforts and to educate the public about montane forest ecology and conservation. Educational efforts could take many forms, including, but not limited to: (1) development of informational displays at ski areas, National Forest or State-owned facilities, and private lands on or near montane forest habitats; (2) offering public programs on various topics relating to montane forest ecology, including Bicknell's Thrush; (3) sponsorship of summer field trips at ski areas or other sites to learn about Bicknell's Thrush and other aspects of montane forest ecology; (4) development of booklets or brochures for the GMNF, ski areas, and other publicly-visited facilities summarizing montane forest ecology, with a focus on Bicknell's Thrush; and (5) development of simple or annotated checklists to the birds of the GMNF, to individual ski areas, and to other montane forest sites visited by the public. Efforts should be made to educate visitors at all times of year.

Efforts should be made to increase collaborative support for and participation in monitoring and research programs that focus on Bicknell's Thrush on the GMNF, such as VINS' Mountain Birdwatch program and long-term research program on Stratton Mountain. To ensure the perpetuation of these and other important programs, ongoing commitments of financial, logistic, and human resources will be necessary, both on the GMNF and throughout the breeding range of Bicknell's Thrush.

Expanded collaboration between GMNF, the USDA Forest Service International Program (USFSIP), VINS, other U.S. partners, and conservation partners on Hispaniola should be promoted. The beginnings of a working partnership have been established among USFSIP, VINS, GMNF, and The Nature Conservancy, following a successful February, 2002 field trip to the Dominican Republic. This international consortium should be diversified and strengthened to assist in planning and implementing Hispaniolan conservation programs that target Bicknell's Thrush.

A management team should be formed to oversee and guide conservation planning for Bicknell's Thrush on the GMNF, and throughout its breeding range. This should include representatives from groups most closely involved in research, monitoring, management, and regulatory issues related to Bicknell's Thrush. The team would identify research and monitoring needs, review and revise as necessary adaptive management practices, craft conservation and regulatory recommendations, develop educational approaches, and critically assess the species' conservation status.

Research and Monitoring Needs

Many aspects of the breeding and wintering ecology, demography, and behavior of Bicknell's Thrush remain poorly known. Lack of baseline population data and logistical difficulties hinder attempts to clarify the species' conservation status. The regionwide Mountain Birdwatch program has been established to determine breeding population trends and distributional changes. Similar efforts are warranted on the wintering grounds, where limiting factors may be most severe. Until the interactions of limiting factors throughout the annual cycle of Bicknell's Thrush are better understood, it will not be possible to prescribe fully meaningful management and conservation measures. While the Forest Service is not expected to play a major role in research and monitoring efforts, collaboration by GMNF staff via a regional management team or international consortium, could prove valuable in achieving the following goals:

1. Development of accurate methods to census populations and estimate densities are needed in both areas. Accurate calculations of total population size, based on GIS projections of occupied habitats and spatially-explicit density estimates, are needed throughout the breeding range.
2. Development of a Habitat Suitability Index and its incorporation in a spatially explicit Population Viabilty Analysis (PVA) would be a critical step in developing ecological risk assessments and sound conservation planning for Bicknell's Thrush. A spatially explicit PVA is necessary to better understand how local (development projects at single sites), regional (atmospheric depositions, forest disturbance), and continental (global climate change) perturbations will interact to limit the species' population. Parameterizing a spatially explicit model with long-term data on demographic parameters (density, birth rates, survival rates, and dispersal rates) would enable a better assessment of the severity of anthropogenic threats, and would guide development of management practices. This would be of particular importance in planning how best to use limited resources of time and funds for conservation and management. A spatially explicit PVA model could be used to assess risks to other high elevation species such as Blackpoll Warbler (*Dendroica*

striata) and might be applicable to mammals (e.g., northern bog lemming; *Synaptomys borealis*), insects such as carabid beetles (Strong et al. 2002), and plants.

3. Many landscape-level questions about the ecology and population dynamics of Bicknell's Thrush require focused research. Information is needed on reproductive success, demographics, and site persistence in habitat patches of different size and isolation; on the possible existence of source/sink population dynamics; on levels of population interchange among habitat patches. The apparent male-biased breeding sex ratio requires rangewide investigation; its causes and demographic/ecological correlates must be determined. Accurate estimates of breeding population density in different habitat types across the species' range are needed. The species' breeding status and ecology in regenerating clearcuts in both montane and low elevation forests of Maine and Maritime Canada should be more closely investigated.
4. Natal dispersal and migratory connectivity should be investigated through (a) determination of biogeochemical signatures in natal feathers of Bicknell's Thrush from each major breeding region and subsequent matching with feathers of yearling birds captured at breeding sites; and (b) determination of biogeochemical signatures in adult thrush feathers from each major breeding region, and subsequent determination of the breeding origin of individuals captured on their Greater Antillean wintering grounds. Documenting dispersal movements and geographic linkages at local, regional and hemispheric levels will provide crucial life history data and should promote collaborative, international commitments for the conservation of Bicknell's Thrush.
5. Expanded research is warranted on the demographic effects of mercury body burdens in Bicknell's Thrush and possible interactions with calcium depletion and other potential stressors. Recent studies have shown that thrushes throughout the breeding range exhibit elevated mercury concentrations in their blood and feathers (Rimmer et al. 2005). Additional studies are needed to examine whether atmospheric deposition of acid ions and mercury interact synergistically to negatively affect thrush populations. Long-term monitoring of both mercury burdens and thrush demography stands to contribute ground-breaking scientific and conservation data. Studies of mercury burdens are also needed on the species' wintering grounds, where preliminary data show blood concentrations to be up to three times higher than in the Northeast (Rimmer et al. 2005).
6. Research is needed on potential effects of food availability and its temporal-spatial variability on breeding system structure and reproductive success; diets of adults, nestlings and fledglings; post-fledging dispersal and habitat use; post-breeding movements and habitat use of adults;
7. Site-specific research is needed on effects of human activities (e.g. recreational development, telecommunications towers, wind turbines) on behavior, spacing patterns, reproductive success, and population persistence over time. Such studies should include both pre- and post-construction phases, and ideally should be replicated in space and time.
8. The influence of hikers on breeding Bicknell's Thrush activity needs more focused study. Use of foot paths by day hikers and backpackers has steadily increased on both the GMNF and WMNF (Stokowski et al. 2005, USDA Forest Service 2005). Yet, the impact of hikers on Bicknell's Thrush behavior or breeding success has received little attention. Anecdotal evidence from Stratton Mountain and Mt. Mansfield suggests that incubating or brooding females become habituated to nearby foot traffic, and that male and female

movements are unaffected by narrow openings (Rimmer and McFarland, unpubl. data). Studies of other avian species, however, have shown that recreational activities may reduce singing activity (Gutzwiller et al. 1994), nest placement (Knight and Fitzner 1985) nesting success and survival (Knight and Gutzwiller 1995), and population size (Yalden 1992). These findings underscore the need for investigations of hiker effects on Bicknell's Thrush and other songbirds breeding in montane forests.

9. Experimental research should be carefully considered to determine whether it is possible to enhance Bicknell's Thrush habitat in a manner that mimics the types of natural disturbance to which the species is adapted. Bicknell's Thrush occurs in regenerating forest stands following timber harvest at middle elevations in New Brunswick and Nova Scotia and at upper elevations in Maine and southern Quebec. However, the value of these areas as breeding habitat is unknown. A rigorous investigation would require replicated habitat treatments in a region where Bicknell's Thrushes are sufficiently abundant to provide adequate sample sizes. The larger habitat units of the GMNF are well suited for such an investigation. If techniques can be developed to improve Bicknell's Thrush habitat, they could potentially offset effects of habitat loss due to ski area expansion and telecommunications or wind power development. However, it is important to emphasize that such habitat manipulations should not substitute for maintaining the natural integrity of montane forests, whose dynamics provide a continually shifting, but unpredictable, mosaic of suitable thrush habitat.
10. In winter, distribution and habitat use of Bicknell's Thrush in Cuba and Haiti, and to a lesser extent Jamaica, need to be better understood. The protected status of core wintering areas must be carefully assessed, and needs for further protection specifically identified. Occupancy of primary vs. second-growth winter habitats needs study, as does existence of possible habitat segregation by sex and/or age. Demographic and ecological studies are needed to investigate microhabitat use, overwinter survival and site persistence by age and sex, between-winter site fidelity and survivorship. Spacing patterns and movements of age and sex classes throughout winter need further study, as do possible seasonal shifts in diet and body condition. The possibility of restoring degraded winter habitats holds promise but needs careful study.

Action Plan

While long-term conservation of Bicknell's Thrush and its breeding habitats may ultimately depend on a multilateral, international effort to halt or reverse the effects of acid precipitation and global climate change in the Northeast, a short-term strategy is needed to monitor the species' status and minimize the risk of its becoming imperiled. The following proposed actions, while not exhaustive, apply to both the GMNF and the full breeding range of Bicknell's Thrush, and are minimal components of such a strategy. Most follow from the needs and recommendations identified above. Those recommendations most specific to the GMNF are listed first, followed by those in which GMNF's role would likely be more collaborative than principal.

1. A species management team should be formed to oversee and guide conservation planning for Bicknell's Thrush on the GMNF, and throughout its breeding range.
2. Each ski area on the GMNF should develop a management plan targeted towards Bicknell's Thrush habitat. This should include spatially explicit identification of existing

habitat and its occupancy by Bicknell's Thrush, a prioritized list of opportunities for habitat enhancement, and an annual agenda of specific management activities. Each plan should be annually reviewed by a GMNF Bicknell's Thrush management team, and its outcomes carefully evaluated.

3. The Mountain Birdwatch program should be expanded, both within the GMNF and throughout the northeastern U.S. breeding range of Bicknell's Thrush, and annual trend analyses should be conducted.
4. Spatially explicit density estimates should be obtained throughout the GMNF and entire breeding range of Bicknell's Thrush. These should be correlated with quantifiable habitat variables and used to construct a GIS model that will enable reasonable estimates of total population size at different spatial scales, following a model recently developed for the WMNF (Hale 2006).
5. Small-scale experimental manipulation of forest stands above 2500' should be considered in designated areas for the purpose of developing habitat improvement techniques for Bicknell's Thrush. Such manipulation should strive to mimic natural disturbance and be limited to hand-felling or girdling of mature trees to encourage softwood regeneration. Soil disturbance and removal of trees or debris would be avoided by this method.
6. Long-term demographic and ecological research and monitoring at VINS' Stratton Mountain study site, part of which lies within GMNF boundaries, should be continued. This is the only intensive, long-term Bicknell's Thrush study site within the species' U.S. breeding range. Maintenance of a core research program on Stratton will be critical to understanding the long-term population dynamics of Bicknell's Thrush.
7. Collaborative efforts should be made to develop informational materials on the GMNF and elsewhere that showcase Bicknell's Thrush habitat management efforts and educate the public about montane forest ecology and conservation.
8. An international consortium of GMNF, USFSIP, VINS, The Nature Conservancy, and conservation partners on Hispaniola should be formalized and diversified. This group should identify, prioritize, and plan Hispaniolan conservation projects that target Bicknell's Thrush.
9. A spatially explicit PVA should be conducted and parameterized with long-term demographic data that can be annually updated. Periodic sensitivity analyses should be conducted to guide further research.

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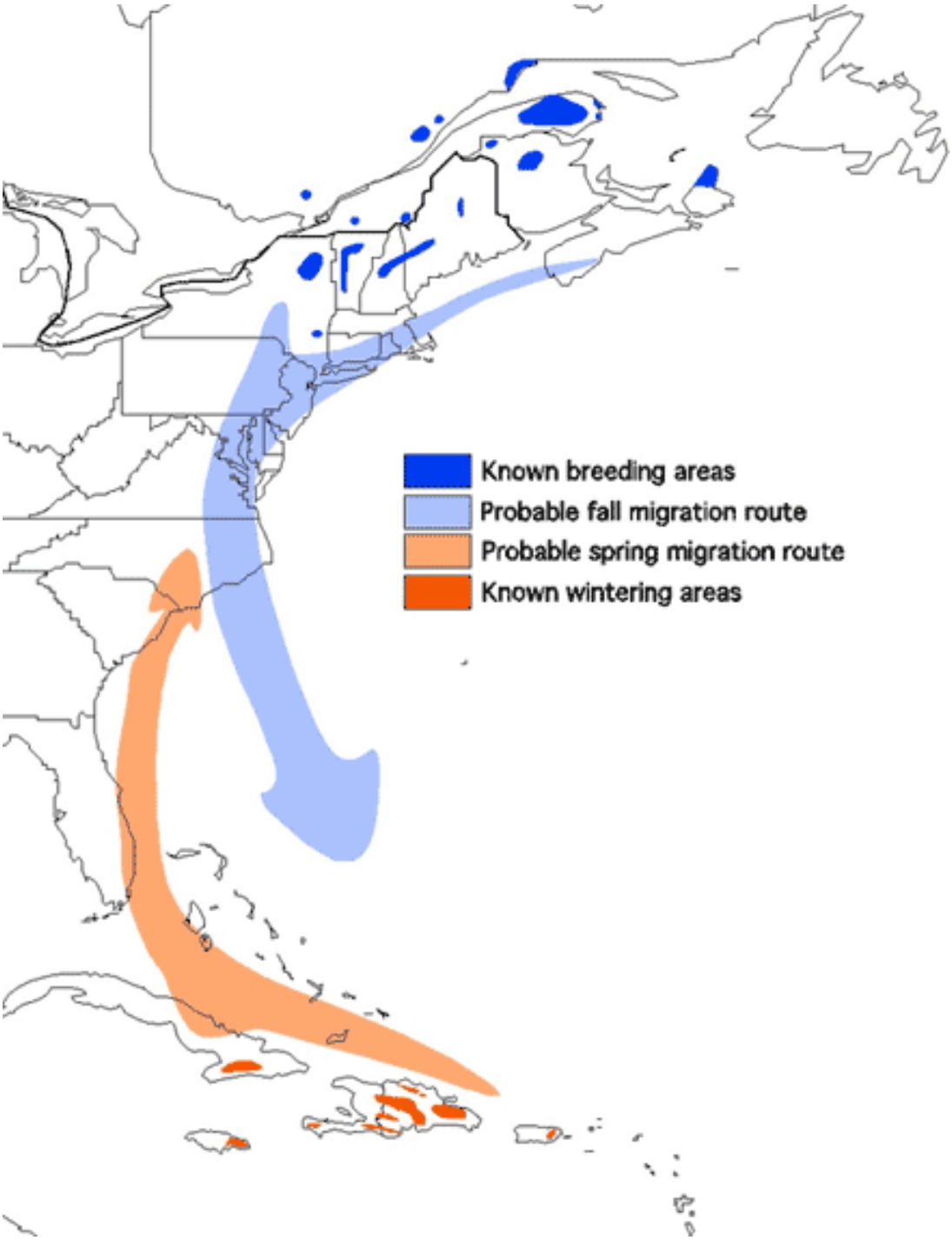

Figure 1. Generalized breeding and wintering distribution of Bicknell's Thrush, with probable migration routes.

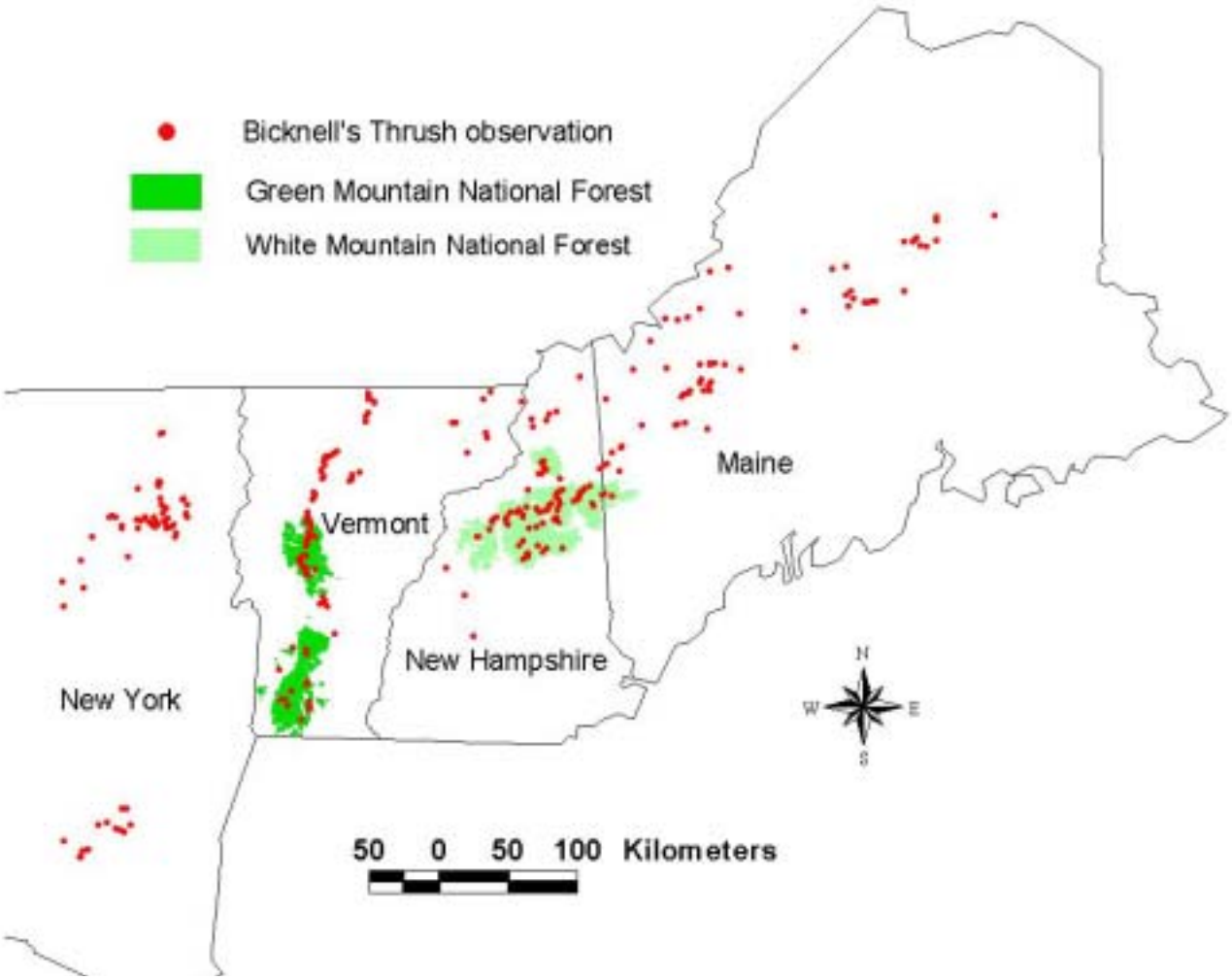

Figure 2. Documented Bicknell's Thrush occurrences in the U.S., 1992-2004.

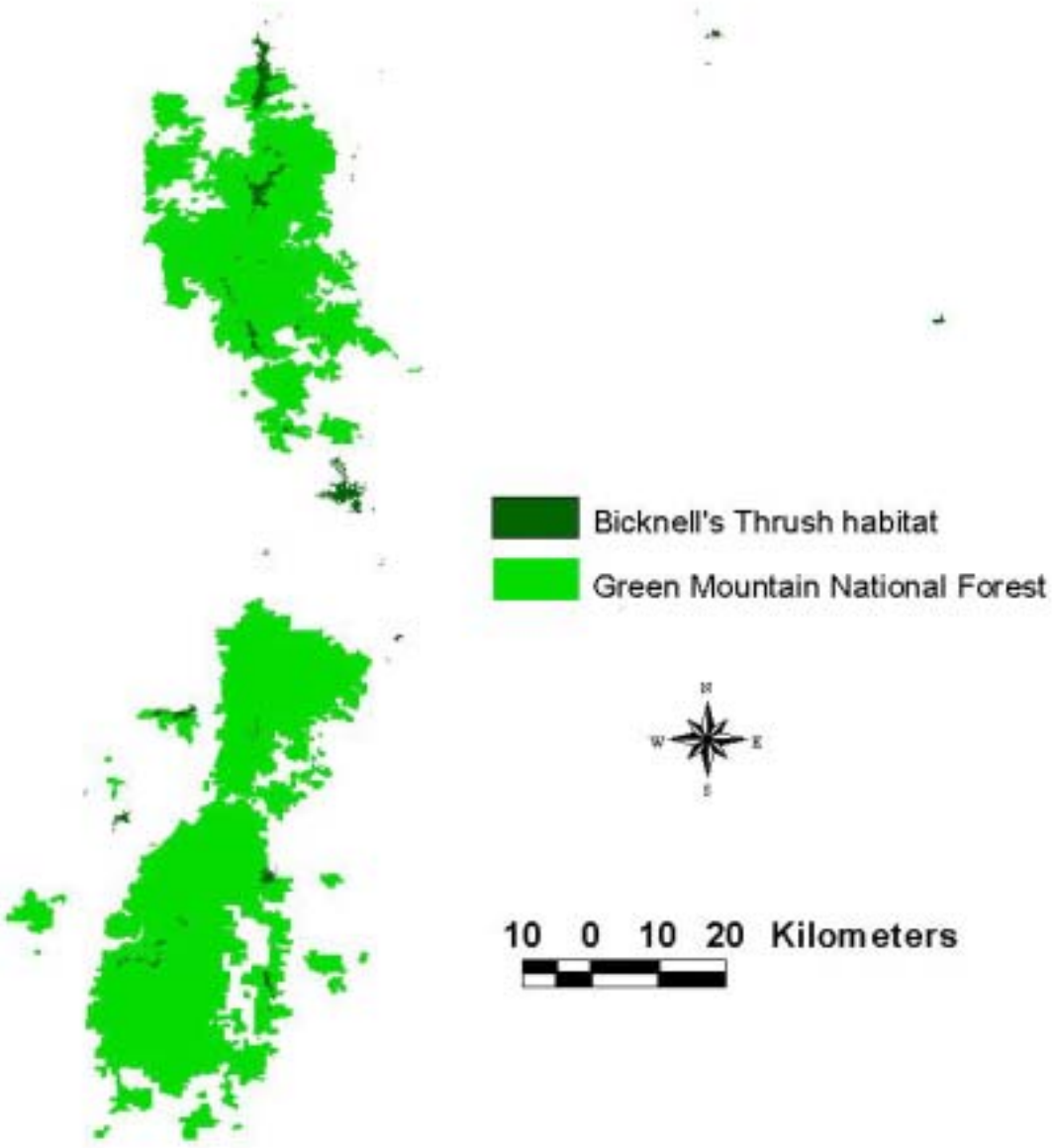

Figure 3. Bicknell's Thrush habitat on the Green Mountain National Forest.

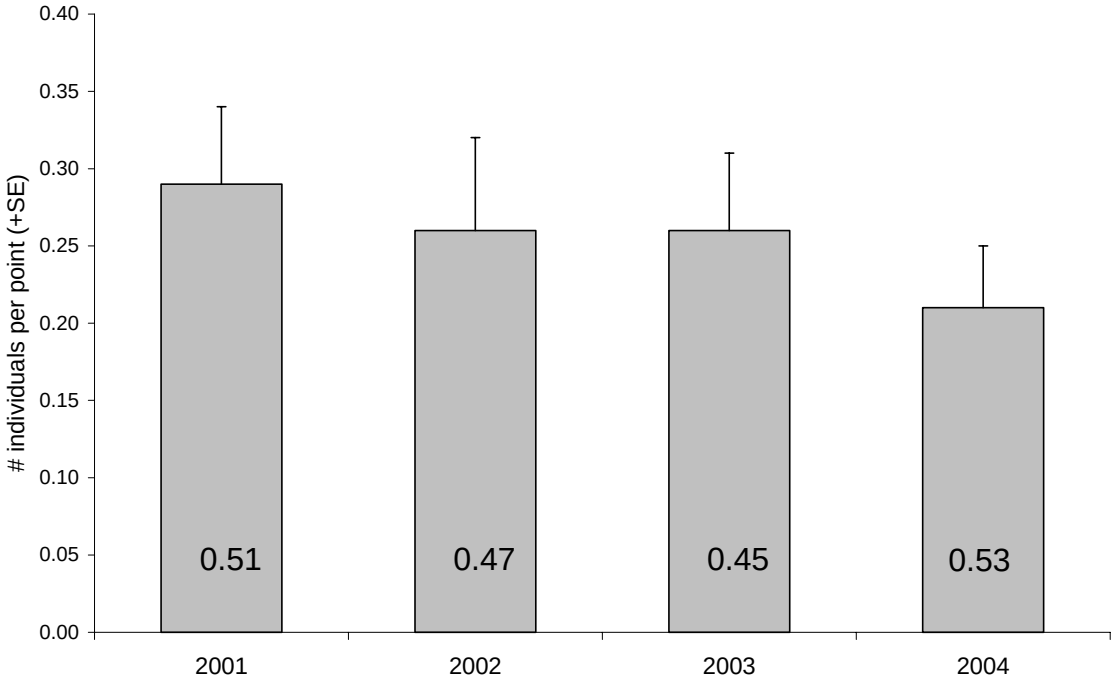

Figure 4. Relative abundance of Bicknell's Thrush on 47 Mountain Birdwatch survey routes monitored each year between 2001 and 2004. Column numbers represent proportion of survey routes on which Bicknell's Thrush was detected by 5-minute point count in each year.

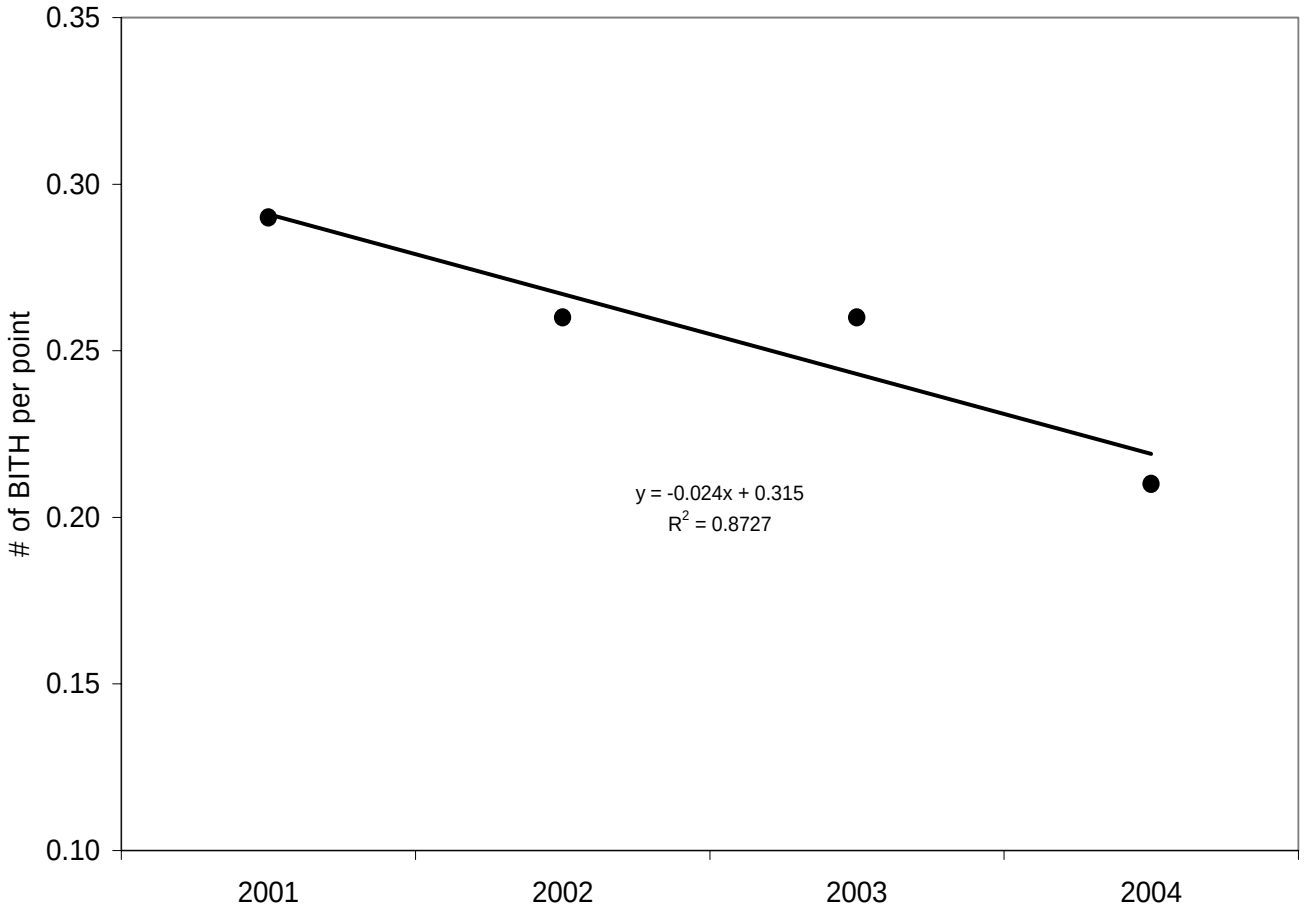

Figure 5. Relative abundance of Bicknell's Thrush on 47 Mountain Birdwatch survey routes monitored each year between 2001 and 2004. Slope of regression line corresponds with an annual decline of 9.0% ($t = 3.703$, $P = 0.066$, $R^2 = 0.873$).

Table 1. Green Mountain National Forest peaks with confirmed detections of Bicknell's Thrush, 1992–2003.

Abraham, Mount
Battell Mountain
Bloodroot Mountain
Boyce Mountain
Bread Loaf Mountain
Cape Lookoff Mountain
Cleveland, Mount
Cutts Peak
Deerfield Ridge
Dorset Peak
Ellen, Mount
Farr Peak
Gillespie Peak
Glastenbury Mountain
Grant, Mount
Haystack Mountain
Horrid, Mount
Lincoln Peak
Monastery Mountain
Nancy Hanks Peak
Peru Peak
Romance Mountain
Roosevelt, Mount
Round Mountain
Searsburg Ridge (or Unnamed ridge 8.8 km SW of Haystack Mountain)
Snow, Mount
Stratton Mountain
Styles Peak
Unnamed peak 0.5 km S of Gillespie Peak
Unnamed peak 0.9 km N of Styles Peak
Unnamed peak 0.9 km S of Lincoln Gap
Unnamed peak 0.9 km S of Mount Abraham
Unnamed peak 1.0 km NW of Farr Peak
Unnamed peak 1.4 km NE of Mt. Roosevelt
Unnamed peak 1.5 km SW of Stratton Mtn.
Unnamed peak 2.0 km NW of Farr Peak
Unnamed peak 2.7 km E of Goshen Mtn.
Unnamed peak 3.2 km W of Glastenbury Mtn.
Unnamed peak 4.6 km S of Glastenbury Mtn.
Unnamed peak 6.4 km NE of Glastenbury Mtn
Wilson, Mount
Worth Mountain