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DISTRIBUTION OF BICKNELL'S THRUSH IN NEW ENGLAND AND NEW YORK

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ABSTRACT.—We conducted presence-absence surveys for Bicknell's Thrush (*Catharus bicknelli*) in Marine, Massachusetts, New Hampshire, New York, and Vermont during the 1992–1995 breeding seasons. The species was found at 234 sites, of which 225 (96%) were dominated by varying mixtures of balsam fir (*Abies balsamea*) and red spruce (*Picea rubens*). Ninety-one percent of the occupied sites were ≥915 m (3000 ft) in elevation. Size of occupied habitat patches was generally small; 73% of occupied areas delimited by the 915 m elevation contour were less than 1000 ha in extent. A logistic regression model using independent variables describing vegetation, elevation, land area ≥915 m located within 1 km of a site, and latitude successfully predicted thrush presence. There was no conclusive evidence of widespread population declines of Bicknell's Thrush in the United States; we found the species at 63 of 73 sites (86%) known to have been occupied prior to 1992. However, the restricted breeding distribution and narrow habitat requirements of Bicknell's Thrush in the United States suggest that it is vulnerable to habitat loss and degradation, and that continued efforts to document the species' status and ecology are warranted. *Received 26 Jan. 1996, accepted 18 May 1996.*

Bicknell's Thrush (*Catharus bicknelli*), until recently considered a subspecies of the Gray-cheeked Thrush (*Catharus minimus*) (Ouellet 1993, American Ornithologists' Union 1995), breeds from southern Quebec and the Maritime Provinces south to the higher elevations of New England and New York (Wallace 1939, Ouellet 1993). Suitable nesting habitat of this species in the United States has been described as dense forests of balsam fir (*Abies balsamea*) and red spruce (*Picea rubens*) occurring near tree-line (Wallace 1939). In Canada, the species also occurs at lower elevations, and has been documented in regenerating clearcuts and coastal areas where structure of the spruce-fir habitat approximates that found in the United States at higher elevations (Ouellet 1993; E. Nixon, unpubl. data).

Concern recently has been raised that Bicknell's Thrush has disappeared from portions of its historic range, especially in Canada (J. T. Marshall, pers comm.; E. Nixon, unpubl. data), and various factors seem to pose likely threats to the species. In its breeding range, habitat degradation caused by acid precipitation (Vogelmann 1982, Schreiber and Newman 1988), replacement of high elevation coniferous forests by de-

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ciduous tree species as a result of global warming (Davis and Botkin 1985, Rodenhouse 1991), or habitat loss caused by development of ski resorts or communications facilities could conceivably impact it. On its wintering range, apparently restricted to the Greater Antilles (Wallace 1939, Ouellet 1993), Bicknell's Thrush may be threatened by deforestation (Arendt 1992; Wunderle and Waide 1993; Rimmer and McFarland, unpubl. data).

The Committee on the Status of Endangered Wildlife in Canada currently is considering a proposal to designate the bird as "threatened" in Canada (E. Nixon, unpubl. ms), and in the United States Bicknell's Thrush was listed as a Category 2 candidate species under the Endangered Species Act in 1994 (U.S. Fish and Wildlife Service 1994). Rosenberg and Wells (1995) identified Bicknell's Thrush as the top priority for conservation concern among neotropical migrant birds in the northeastern United States.

Few empirical data exist by which to evaluate the current status of Bicknell's Thrush, and various aspects of the species' life history have caused it to be exceptionally difficult to study (Rimmer et al. 1996). In this paper we present the results of surveys for Bicknell's Thrush conducted in Maine, Massachusetts, New Hampshire, New York, and Vermont from 1992–1995. Where possible, we compare these data with historic distributional information. Finally, we present a preliminary quantitative model for assessing the probability of occurrence of Bicknell's Thrush in the United States portion of its breeding range.

METHODS

We solicited survey volunteers from various sources. Cooperators were instructed to collect data in a standardized manner. Each cooperator was provided with a tape recording of Bicknell's Thrush songs and call notes obtained from the Cornell Laboratory of Ornithology's Library of Natural Sounds. We emphasized censusing at locations where the bird was previously recorded and at areas located above 915 m elevation. Three hundred eighty localities were visited during June and early July 1992–1995, usually within 3 h of sunrise or sunset. Bicknell's Thrush was determined to be present on the basis of clearly identified vocalizations or observation of a territorial bird responding to broadcast tape recordings. Dominant habitat at each site [VEG] was subjectively categorized as (1) spruce-fir forest, (2) mixed hardwood-coniferous forest, or (3) northern hardwood forest. Elevation above sea level at each survey location [ELEV] was approximated to the nearest 100 ft.

Given the limited nature of these surveys and the variable levels of expertise among observers, we cannot certainly conclude that Bicknell's Thrushes were absent from locations where we failed to encounter them, especially at areas that were visited only on a single date (N = 80). However, during 213 visits to sites where Bicknell's Thrushes were known to occur and which were surveyed on two or more dates, the species was missed in only 20 instances (9%), suggesting that when appropriate sampling protocols are used (Rimmer et al. 1996), even single visits are likely to detect the species when it is present.

In addition to these surveys, we also incorporated relevant data collected from 1992–

1995 as part of more intensive studies of bird populations and forest habitats in Maine (35 sites; J. M. Hagan, unpubl. data) and Vermont (15 sites; C. C. Rimmer, unpubl. data). Although these projects did not use playbacks of Bicknell's Thrush vocalizations, nonetheless we believe that the multiple visits made to each site by trained observers familiar with the songs and calls of all local breeding species warrant inclusion of these data in our analysis.

All surveyed localities were manually digitized from 1:24,000 USGS topographic maps using ArcInfo GIS software, as were all 915 m (3000 ft) contour lines in the study region. For each point in the resulting data set, we calculated an index of latitude [LAT], the amount of high elevation land (≥915 m) occurring in a 1-km diameter circle centered on the survey point [KM1], and the amount of high elevation land occurring in a 10 km diameter circle centered on the survey point [KM10]. KM1 was considered to reflect habitat availability in the immediate vicinity of the survey point, while KM10 provided a representation of the survey point's location relative to the regional distribution of high elevation land. Additionally, ArcInfo was used to calculate the area of high elevation polygons, as delineated by the 915 m elevation contour, that were occupied by Bicknell's Thrushes. Area estimates were not corrected for topography.

Using the SAS procedure LOGISTIC, we performed a stepwise logistic regression (Mills et al. 1993, Akçakaya et al. 1995) with the response variable defined as thrush presence (1) or absence (0). Independent variables (VEG, ELEV, LAT, KM1, and KM10) were added and removed at a significance level of $P = 0.05$. A total of 392 sites for which complete and unambiguous data were available were used in this analysis.

We also conducted road-based surveys from 18–21 June 1993 in the north Maine woods from T. 11 R. 17 east to Garfield Township, from T. 11 R. 13 southeast to T. 7 R. 11, and from Garfield Township southwest to T. 9 R. 8. These surveys consisted of 294 5-min stops spaced at intervals of approximately 1 km. Recordings of Bicknell's Thrush vocalizations were broadcast at each point to elicit responses from any birds that might be present. All road-based point surveys were conducted prior to 11:00 under good weather conditions; lakes and recent clear cuts were excluded. However, because data from these surveys were not recorded in a geographically explicit format, we did not include these results in calculating the quantitative habitat suitability function described above.

RESULTS

A total of 430 localities (251 sites >915 m elevation, 87 sites from 610–915 m, 10 sites from 305–610 m, and 82 sites ≤305 m), were surveyed for Bicknell's Thrushes. The species was found at 234 of these sites (Fig. 1). A detailed list of documented sites of its occurrence (through 1995) is available on request from the senior author. The species was found at 234 sites, of which 225 (96%) were dominated by varying mixtures of balsam fir and red spruce. Ninety-one percent of the occupied sites were ≥915 m (3000 ft) in elevation. Road-based surveys in the north Maine woods failed to encounter *bicknelli* at any of 294 point localities.

Ninety-nine high elevation polygons, arbitrarily defined as areas demarcated by the 915 m elevation contour, were occupied by Bicknell's Thrushes. Of these, 73 (74%) were relatively small in size, being characterized by <1000 ha of land ≥915 m elevation (Fig. 2). The mean area of distinct high elevation polygons occupied by *bicknelli* was 1046 ha

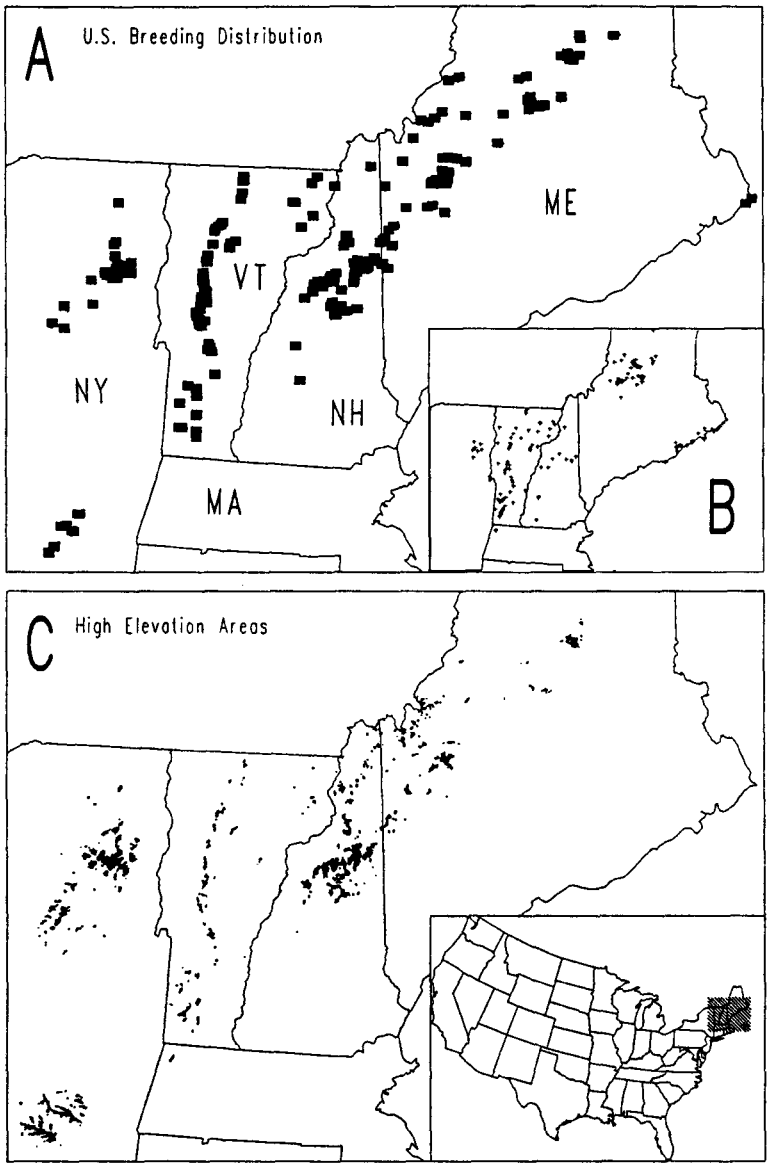

FIG. 1. (A) Documented occurrence of Bicknell's Thrush within its United States breeding range. (B, inset): Sample localities where Bicknell's Thrush was not encountered. (C) Location of high elevation (>approximately 900 m) land in New England and New York.

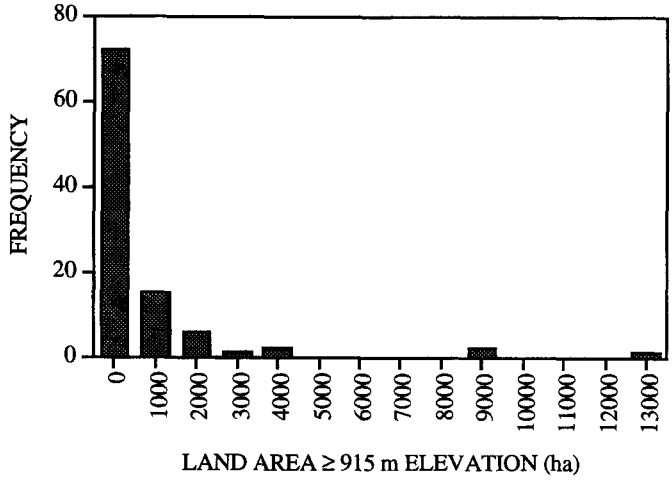

FIG. 2. Frequency distribution of area estimates of high elevation land occupied by Bicknell's Thrush in the United States.

(SD = 2006; range 1.5 ha (Little Bigelow Mtn., Maine)–130,020.1 ha (Mt. Washington, New Hampshire).

Approximately 155,295 ha of land ≥915 m elevation were identified in New England and New York; areas ≥793 m (2600 ft) that were categorized by Miller-Weeks and Smoronk (1993) in vegetation classes likely to be occupied by Bicknell's Thrushes totalled 99,188 ha in western Maine, the Adirondack region of New York, New Hampshire, and Vermont (Table 1). Neither of these values should be construed as actual measurements of the extent of Bicknell's Thrush habitat. Nonetheless, these results do suggest that the maximum land area potentially occupied by the species in the United States is probably in the range of 100,000–150,000 ha.

Stepwise logistic regression yielded the following index of habitat suitablity:

$$P = 1/(1 + \exp(-\beta_0 - (\beta_1 \cdot \mathrm{VEG}) - (\beta_2 \cdot \mathrm{ELEV}) - (\beta_3 \cdot \mathrm{KM1}) - (\beta_4 \cdot \mathrm{LAT}))),$$

where P is the probability of occurrence, VEG, ELEV, KM1, and LAT are the data values from each site, and β_X are the associated regression coefficients (Table 2). Based on the goodness of fit statistics (Chi-square for covariates: log likelihood statistic = 289.8 with 4 df, $P = 0.0001$; score statistic = 221.8 with 4 df, $P = 0.0001$), the model is highly significant. Sites occupied by Bicknell's Thrushes had a mean habitat suit-

TABLE 1

ESTIMATES OF APPROXIMATE MAXIMUM EXTENT OF BICKNELL'S THRUSH HABITAT IN NEW ENGLAND AND NEW YORK

	Area ≥ 915 m (ha)[a]			Area ≥ 793 m (ha)[b]	
	Total	Mean	SD	Spruce-fir	Total sample
Maine					
Western Maine	18,332	168	498	32,366	45,458
Other	6471	196	639	na	0
Massachusetts	302	151	180	na	0
New Hampshire	54,480	436	1572	34,154	88,632
New York					
Catskills	17,305	247	530	na	0
Adirondacks	41,674	344	1050	28,393	79,205
Vermont	16,731	164	359	4275	45,858

[a] Estimates of land area (uncorrected for topography) ≥915 m (3000 ft) elevation.
[b] Estimates of land area ≥793 m (2600 ft) elevation. Spruce-fir estimates based on values for "Spruce-Fir Slope" and "Balsam Fir" categories provided by Miller-Weeks and Smoronk (1993). "Total Sample" = total amount of photographed land area included in analysis by Miller-Weeks and Smoronk. na = data not available.

ability value of 0.831 (SD = 0.19); sites where we failed to document the species had a mean value of 0.221 (SD = 0.29).

However, because these data were used to calculate the habitat function, they cannot be considered an independent validation of the model's predictive power. To validate use of this approach to predict occupancy of a site by Bicknell's Thrushes we randomly subdivided the overall data set into two equal parts (N = 196), recalculated a new habitat suitability function based on one part (A) and then applied the resultant model to the second part (B) of the data. Using this smaller sample size, the variables KM1 and KM10 both failed to meet the stepwise selection criterion,

TABLE 2

RESULTS OF STEPWISE LOGISTIC REGRESSION PREDICTING BICKNELL'S THRUSH PRESENCE IN NEW ENGLAND AND NEW YORK[a]

Variable	Regression coefficient	Standard error	Wald Chi-square	Probability
INTERCEPT	−36.6017	9.4148	15.11	0.0001
ELEV	0.00151	0.000325	21.59	0.0001
VEG	−1.9502	0.4069	22.97	0.0001
LAT	0.00000691	0.00000185	14.16	0.0002
KM1	0.0200	0.00678	8.72	0.0031

[a] Variables listed in order of entry into model. 10KM failed to meet the 0.05 significance level for inclusion.

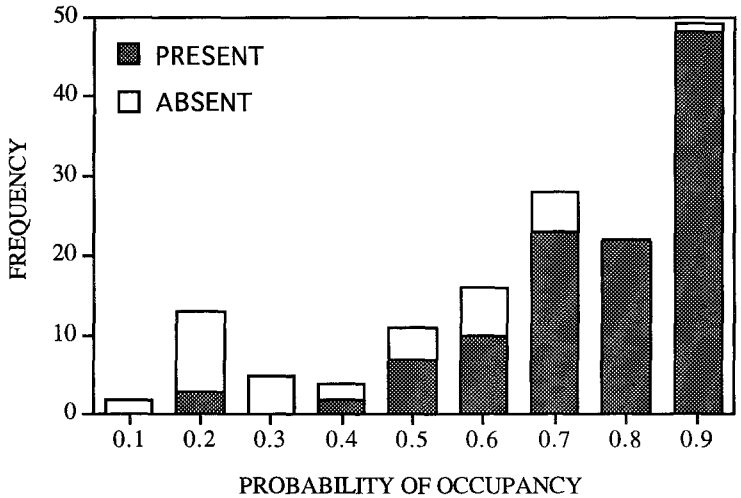

FIG. 3. Frequency distribution of habitat suitability values (probability of occurrence) among subset (N = 196) of total dataset, based on logistic regression model derived from a different data subset (N = 196). Habitat suitability index varies from 0 (no probability of occurrence) to 1 (certain probability of occurrence).

so the model included only ELEV, VEG, and LAT as independent variables. Eighty-nine percent of sites in subset B where Bicknell's Thrushes were observed had predicted occupancy values ≥0.60 based on the model derived from data subset A, and 85% of unoccupied sites had values <0.60 (Fig. 3).

Two sites (Quoddy Head State Park and Boot Head, Maine) where Bicknell's Thrushes were reported were poorly accounted for by the overall regression model (Pearson residuals = 7.50 and 7.38, respectively). Both areas are located coastally near sea level and represent the only low elevation sites in the United States where the species was documented during 1992–1995. The sighting from Quoddy Head State Park occurred on 4 Jul 1993; the species was not subsequently seen at this site during multiple visits from 1993–1995. At Boot Head, Bicknell's Thrush was reported on 12 Jun 1993, but later surveys during 1993, as well as multiple visits in 1994 and 1995, failed to locate the species. If correctly identified, the two 1993 records may involve transient rather than breeding individuals.

We found 98 historic (pre-1992) breeding sites for Bicknell's Thrush in Maine, Massachusetts, New Hampshire, New York, and Vermont through literature review and correspondence with active field ornithologists. Seventy-three of these localities were surveyed from 1992–1995;

TABLE 3
SUMMARY OF 1992–1995 BICKNELL'S THRUSH SURVEYS AT HISTORIC (PRE-1992) SITES IN NEW ENGLAND AND NEW YORK

State	Historic sites (total)	Historic sites visited	Present	Absent
Maine	5	5	5	0
Massachusetts	2	2	0	2
New Hampshire	26	20	16	4
New York	33	16	16	0
Vermont	32	30	26	4
TOTAL	98	73	63	10

Bicknell's Thrushes were documented at 63 sites (86%) (Table 3). Historic sites where we failed to find *bicknelli* included: *Massachusetts*—Mt. Greylock (3 visits), Saddleball Mtn. (3 visits); *New Hampshire*—Mt. Pemigewasset (1 visit), Mt. Monadnock (1 visit), Mt. Sunapee (1 visit), and North Moat Mtn. (1 visit); *Vermont*—Glebe Mtn. (Magic Mtn.) (1 visit), Green Peak (Mt. Aelous) (3 visits), Mt. Ascutney (2 visits), and Molly Stark Mtn. (3 visits). At Mt. Greylock, the only historic locality where Bicknell's Thrush numbers have been recorded over an extended period of time (29 years between 1938–1993), population estimates suggest a gradual, long-term decline that culminated in the species' disappearance from the site in 1973 (Fig. 4; Veit and Petersen 1993).

DISCUSSION

In the United States, Bicknell's Thrush regularly breeds only at the higher elevations of Maine (730–1280 m, but see below), New Hampshire (850–1460 m), New York (880–1430 m), and Vermont (820–1250 m). Because its obligate habitat, subalpine spruce-fir forest (Wallace 1939, Rimmer et al. 1996), is generally restricted to mountaintops surrounded by large areas of northern hardwoods or mixed hardwood–conifer stands, the distribution of *bicknelli* in the United States is extremely patchy at the landscape level. Furthermore, of high elevation (≥915 m) regions known to be occupied by the species, few exceed 1000 ha in area, suggesting that much of the range of Bicknell's Thrush in the United States is limited to relatively small fragments of suitable habitat. We did not encounter the species in low elevation, regenerating clearcuts as has been reported in Canada (Ouellet 1993; E. Nixon, unpubl. ms).

The status of Bicknell's Thrush in coastal Maine is problematical. The species has been documented at various low elevation, coastal areas of Quebec (Ouellet 1993, Gauthier and Aubry 1995), New Brunswick (Er-

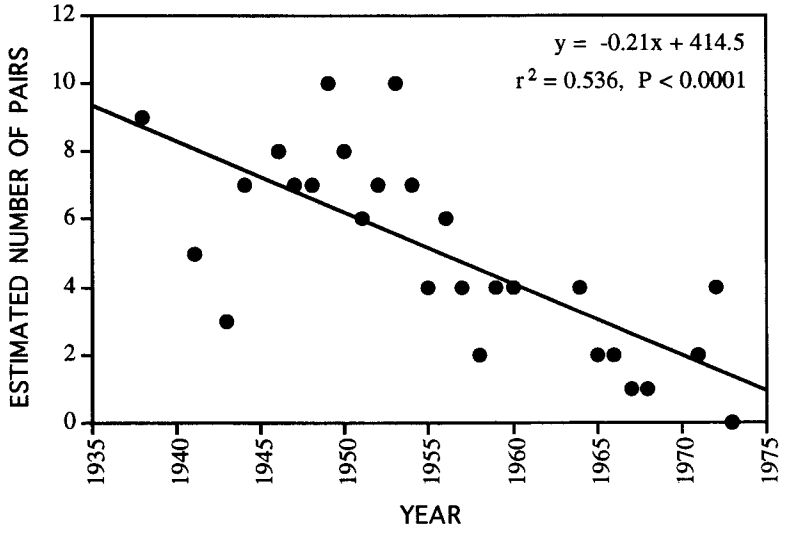

FIG. 4. Decline and local extinction of Bicknell's Thrush on Mt. Greylock, Massachusetts.

skine 1992), Nova Scotia (Allen 1916, Erskine 1992, Wallace 1939), and Prince Edward Island (Erskine 1992), lending credence to the possibility of its breeding in coastal Maine. However, we obtained only two coastal records during our study, and both were at sites where the species could not be confirmed during multiple subsequent visits by experienced observers. Wallace (1939) reported that Gross, Pettingill, and other ornithologists never detected Bicknell's Thrush during their intensive studies of the avifauna of coastal Maine. At the present time, we do not feel that available data warrant inclusion of coastal Maine within the breeding range of Bicknell's Thrush, although more field work in this area is certainly desirable.

Lack of detailed historic data makes it difficult to evaluate whether populations of *bicknelli* in the United States have declined in recent years. The species has disappeared from its principal site of historic occurrence in Massachusetts (Mt. Greylock), where the population numbered approximately 5–10 pairs in the early 1900s. Based solely on presence-absence determinations, we found no clear evidence that Bicknell's Thrush has declined in Maine, New Hampshire, New York, or Vermont.

However, although these data do not substantiate recent concerns that Bicknell's Thrushes may be showing serious rangewide declines in the United States, neither have we refuted this possibility. We believe that the distribution and ecology of the species places it in a precarious po-

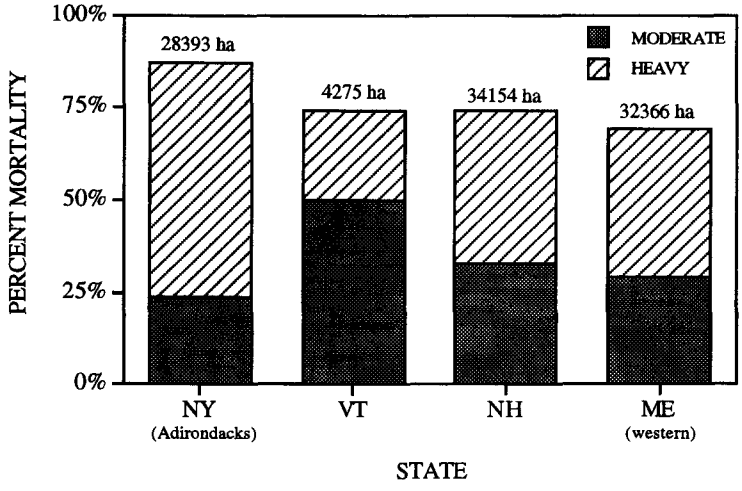

FIG. 5. Condition of high elevation (≥793 m) spruce-fir forests occurring in New York's Adirondack region, Vermont, New Hampshire, and western Maine. Based on data presented by Miller-Weeks and Smoronk (1993). Mortality classifications: Moderate = 11–30% standing dead trees; Heavy = >30% standing dead trees. Total area of "Spruce-Fir Slope" and "Balsam Fir" cover types occurring at elevations ≥793 m (2600 ft) provided above each bar (Miller-Weeks and Smoronk 1993).

sition that warrants further monitoring efforts. Acid precipitation, global warming, and other complex biotic and abiotic factors have been postulated as potentially impacting the geographically limited, high elevation spruce-fir ecosystem (Weiss and Millers 1988) that is required by Bicknell's Thrushes breeding in the United States. In fact, Miller-Weeks and Smoronk (1993) found, based on data collected 1985–1986, that most areas of high elevation spruce-fir habitat in New England and the Adirondack region of New York showed extensive levels of tree mortality (Fig. 5). The causes of this spruce-fir mortality are uncertain, and no information is available concerning its possible impacts on the biology of Bicknell's Thrushes or other birds that breed at high elevations. Finally, if the species' poorly-known wintering grounds are, in fact, restricted to the Carribean (Wallace 1939, Ouellet 1993), then the extensive deforestation that has occurred in this region (Arendt 1992; Rimmer and McFarland, unpubl. data) would also be expected to adversely impact the population.

Based on these reasonably postulated threats, Bicknell's Thrush should be ranked as one of the most potentially threatened species of Neotropical migrant songbirds in the United States (Reed 1989, Rosenberg and Wells 1995). Further research should attempt to clarify details of its current

breeding and wintering distribution, calculate population sizes based on remote sensing data combined with regionally-explicit density estimates, evaluate levels of population interchange among birds breeding on isolated mountain peaks, and assess the impacts of differences in habitat quality on Bicknell's Thrush occupancy and reproductive success.

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