MOUNTAIN BIRDWATCH

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2001 FINAL REPORT
TO THE UNITED STATES FISH AND WILDLIFE SERVICE

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ABSTRACT

Mountain Birdwatch is a long-term monitoring program for songbirds that breed in high-elevation forests of the Northeast. Skilled volunteers conduct annual surveys along 1-km routes that are located on mountains in New York, Vermont, New Hampshire, and Maine. Primary emphasis is placed on Bicknell's Thrush, the region's only endemic bird species, and a montane fir specialist that is vulnerable to ongoing and projected habitat loss. Other focal species include Swainson's Thrush, Blackpoll Warbler, White-throated Sparrow, and Winter Wren. In 2001, we gathered observations from 141 locations, with point count surveys completed under suitable weather conditions on 112 routes. White-throated Sparrow and Blackpoll Warbler were the most widespread and abundant of the focal species, averaging about one individual per point. They were followed by Swainson's Thrush and Winter Wren, which were also common (0.55 and 0.54 per point, respectively). Bicknell's Thrush was detected during fewer than half of the point counts and in relatively low numbers (0.24 per point). Chance encounters and audioplayback techniques doubled the frequency of Bicknell's Thrush detections on survey routes, raising it from to 45% to 88%. An analysis of survey protocols confirmed that the point count duration (5 min) and sampling window (4:30 a.m. to 6:30 a.m.) are appropriate for achieving the program's objectives. In addition to establishing a baseline for future monitoring, we investigated the influence of landscape structure on montane forest birds. Multiple regression analysis of landscape attributes suggests that neither landscape composition nor landscape configuration underlie patterns of Bicknell's Thrush abundance. This finding supports earlier evidence of high dispersal capability in this species. Continued study will focus on stand-level habitat characteristics, including those that might be remotely sensed with improving satellite technology.

BACKGROUND AND RATIONALE

Bicknell's Thrush (*Catharus bicknelli*), once considered a subspecies of Gray-cheeked Thrush (*C. minimus*), gained full species status in 1995. Since then, it has been recognized as one of the most at-risk passerines in eastern North America. Partners in Flight ranks Bicknell's Thrush as the top conservation priority among Neotropical migrants in the Northeast (Pashley et al. 2000), while the International Union for the Conservation of Nature classifies the songbird as "vulnerable" on its list of threatened species (BirdLife International 2000).

A number of factors contribute to the vulnerability of Bicknell's Thrush, including its limited breeding range. In the United States, Bicknell's Thrush breeds in montane fir forests of New York and northern New England (Atwood et al. 1996) and is often associated with recently disturbed areas characterized by vigorous regrowth (Wallace 1939, Rimmer et al. 2001). In southeastern Canada, it inhabits montane fir (Ouellet 1993), maritime spruce-fir (Erskine 1992), and regenerating mixed forest (Nixon 1996). The species is similarly restricted in its wintering distribution, occurring primarily in wet, broadleaf forests of the Dominican Republic. These forests have been reduced to less than 10% of their historic extent in the last 30 years (Stattersfield et al. 1998).

Loss of the Northeast's montane fir habitat may also threaten Bicknell's Thrush. Expansion of recreation areas, cell tower construction, and wind power development have received the most regulatory attention, as each results in highly visible forest loss. Effects of airborne pollutants on Bicknell's Thrush are unclear, but potential threats include forest decline from acid deposition (Johnson et al. 1992) and heavy metal toxicity (Gawel et al. 1996), mercury poisoning by uptake in the food chain, and egg-laying irregularities associated with calcium limitation, a possible consequence of acidified soils (Graveland et al. 1994). Climate change represents the most far-reaching, long-term threat to the species. A warming climate is expected to cause incremental, but widespread changes in the composition and structure of high-elevation forests. Forest ecologists predict that balsam fir (*Abies balsamea*) will be substantially diminished, if not lost from the Northeast if atmospheric concentrations of CO_2 double, as expected within the next century (Iverson et al. 1999).

In the past fifty years, extirpations of Bicknell's Thrush may have occurred at isolated summits in southern New Hampshire (Mount Monadnock and Mount Sunapee), southern Vermont (Mount Aeolus, Mount Ascutney, Mount Carmel, Mount Glebe, Molly Stark Mountain), and western Massachusetts (Mount Greylock, Saddleball Mountain) (Atwood et al. 1996, VINS unpubl. data). To monitor changes in the status of Bicknell's Thrush and other songbirds that breed in mountain forests, the Vermont Institute of Natural Science (VINS) added high-elevation survey routes to the Vermont Forest Bird Monitoring Program (FBMP) in 1993. Highly skilled FBMP volunteers conduct two surveys each June, recording the number of all bird species seen and heard during five 10-minute point counts. In the spring of 2000, we launched Mountain Birdwatch as a simplified and complementary monitoring program. Mountain Birdwatchers conduct 5-minute counts and focus on a small group of species, consisting of: Bicknell's Thrush, Swainson's Thrush (*Catharus ustulatus*), Blackpoll Warbler (*Dendroica striata*), White-throated Sparrow (*Zonotrichia albicollis*), and Winter Wren (*Troglodytes troglodytes*). Novice and intermediate birdwatchers receive training in the identification of these species, which have distinct plumages and vocalizations.

Mountain Birdwatch increases the opportunity for volunteer participation, adds substantially to the number of sampled habitat units, and expands the geographic scope of high-elevation bird study in the Northeast. Consequently, the program boosts the statistical power to detect population change and increases the capacity to record changes in breeding distribution that may result from growing or declining numbers. Furthermore, Mountain Birdwatch avoids duplication of effort since its design allows data to be pooled with subsampled results from the Forest Bird Monitoring Program.

During Mountain Birdwatch's 2000 pilot season, we tested and refined training materials, sampling protocols, and route selection standards on 44 survey routes in Vermont (Lambert et al. 2001). Using the computer program Monitor (Gibbs 1995), we determined that at least 100 routes would be required to achieve > 90% power to detect a 5% annual decline in Bicknell's Thrush within five years. Annual surveys of 100 routes would enable detection of a 2% annual decline within a decade. The program's capacity to detect declines in Swainson's Thrush and Winter Wren populations is somewhat greater. It is highest for the most abundant species, Blackpoll Warbler and White-throated Sparrow. As few as 7 years may be required to detect 2% annual declines in these two populations. On the basis of this power analysis, we aimed to expand our high-elevation monitoring network to at least 100 sites across New York, Vermont, New Hampshire, and Maine in 2001.

Extensive survey coverage allowed us to address the following questions. Does landscape structure underlie patterns of Bicknell's Thrush abundance? If so, do these patterns reflect landscape configuration (the distribution and spatial character of habitat patches), landscape composition (the make-up of habitat patches), or both?

Three previous studies have used categorical data (presence and presumed absence) to describe Bicknell's Thrush distribution. Pierce-Berrin (2001) found percent cover of balsam fir in the subcanopy to be the best predictor of the species' presence in the Catskill Mountains. She found no effect of stem density, canopy composition, or habitat area. A 1992-1995 regional survey of Bicknell's Thrush produced a model that predicted thrush presence based on vegetation type, elevation, latitude, and land area above 915 m and within 1 km of a site. The influence of high-elevation land area did not extend to a 10-km distance category (Atwood et al. 1996). Finally, a geographic information systems (GIS) model, incorporating elevation and latitude alone, properly classified the status of Bicknell's Thrush at 86% of Vermont sites surveyed by Mountain

Birdwatchers in 2000 (Lambert et al. 2001). Point count data gathered across the Northeast in 2001 provided the first opportunity to measure the influence of elevation and latitude and assess the effect of landscape structure on the abundance of Bicknell's Thrush.

We hypothesized that landscape structure influences Bicknell's Thrush abundance, primarily through landscape composition. We predicted that Bicknell's Thrush numbers would be positively associated with conifer dominance, but unrelated to measures of landscape configuration (e.g. area and isolation).

Mountain Birdwatch fulfills the longstanding need for an efficient, statistically powerful program to monitor high-elevation birds at a regional scale. At the same time, it promises to advance our understanding of how landscape attributes influence the distribution and abundance of the region's only endemic songbird, Bicknell's Thrush. Mountain Birdwatch accomplishes both of these aims while providing a learning opportunity to the hikers, birdwatchers, trail monitors, and families that participate.

METHODS

Volunteer recruitment and training

We announced the opportunity to volunteer for Mountain Birdwatch on our web site (www.vinsweb.org/conservation/citizenscience/mtnbirdwatch.html) and in VINS newsletters, flyers, and press releases. Local and regional hiking, natural history, and conservation organizations circulated announcements in their publications and on email list serves, generating dozens of new volunteers. The Appalachian Mountain Club and the Adirondack Mountain Club sponsored presentations and volunteer training sessions attended by approximately 150 individuals. In all, about 175 people participated in the survey, including FBMP volunteers and those who assisted as companions of the primary route monitors. When route assignments were made, Mountain Birdwatchers received maps, survey instructions, an identification guide to high-elevation songbirds, and a training tape with an auditory identification quiz. A perfect score on the quiz was a prerequisite for participation.

Site selection, route placement and coverage

Site selection was based on a geographic information systems (GIS) model of potential Bicknell's Thrush (BITH) habitat that incorporates elevation, latitude, and forest type (Figure 1). Developed with recent BITH location data, the model depicts conifer-dominated forests above an elevation threshold that drops 84 m for every one-degree increase in latitude (-84 m/1º latitude). The threshold's slope corresponds closely with the latitude-elevation relationship for treeline in the Appalachian Mountain chain, which is -83 m/1º latitude (Cogbill and White 1991). Our choice of sites was constrained by the availability of volunteers and the location of existing trails.

When placing routes, we favored upper elevations, extensive conifer stands, and distinct starting points (e.g. trail junction or summit). Volunteers establishing a route for the first time placed up to four additional points at 325-step (250± m) intervals along a mapped course. The number of points depended on the length of trail passing through modeled habitat. Upon completion, monitors submitted a detailed description of each station in order to facilitate its location in future years.

Mountain Birdwatchers and high-elevation FBMP volunteers conducted 116 surveys on routes scattered throughout New York (29), Vermont (44), New Hampshire (28), and Maine (15). Massachusetts contained a single route on Mount Greylock, a historic site for Bicknell's Thrush. Of the 117 routes, 112 were located in forest modeled as potential BITH habitat, with 5 located on mountains falling below the elevation threshold. We gathered Bicknell's Thrush observations from 24 additional peaks, for a total of 141 locations (Figure 2).

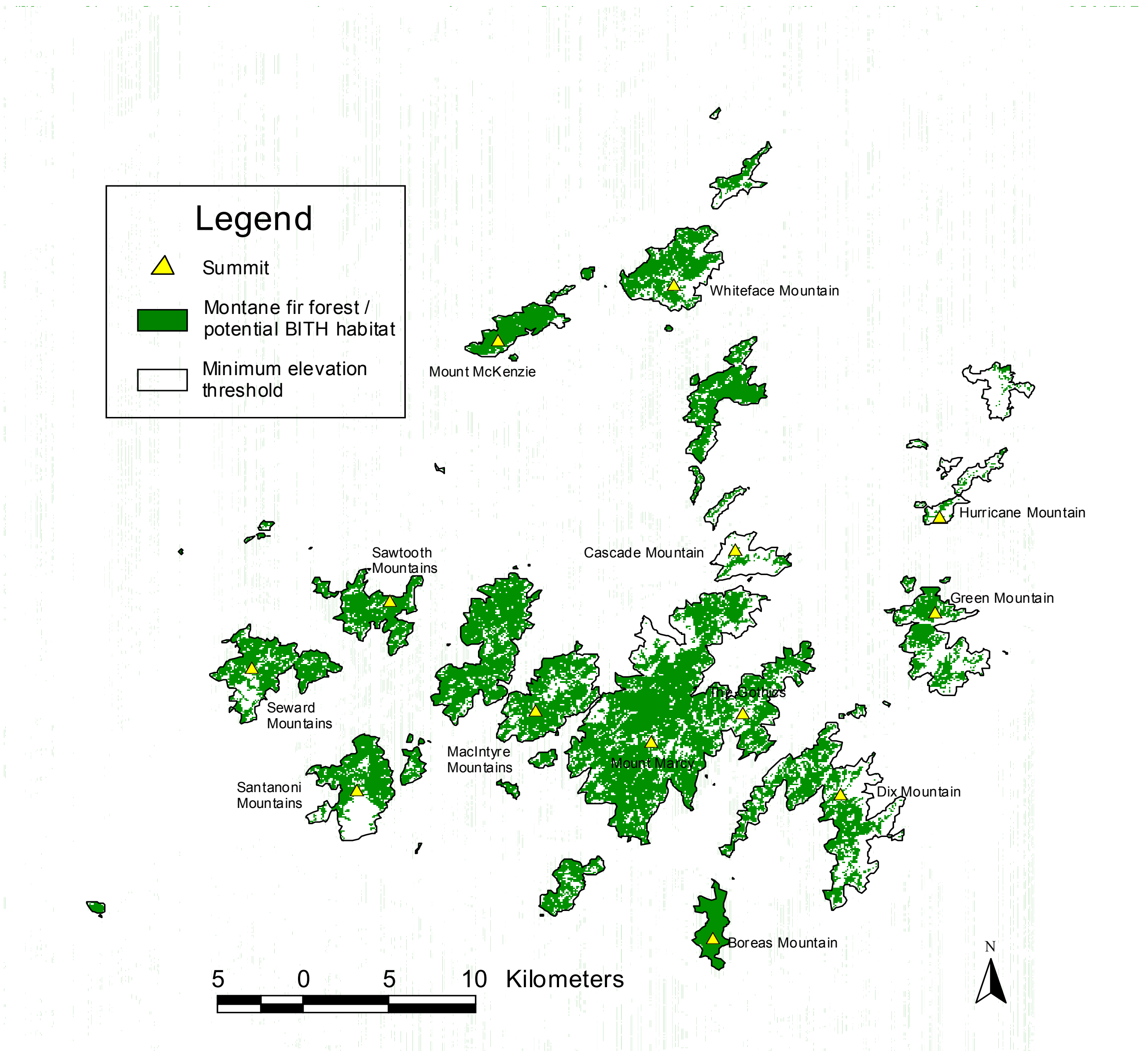


Figure 1. Potential Bicknell's Thrush habitat in the High Peaks region of the Adirondack Mountains. Forest cover data from the USGS National Land Cover Dataset. Minimum-elevation polygons created in ArcView GIS by laying a sloping elevation mask over a digital elevation model (Lambert et al. 2001).

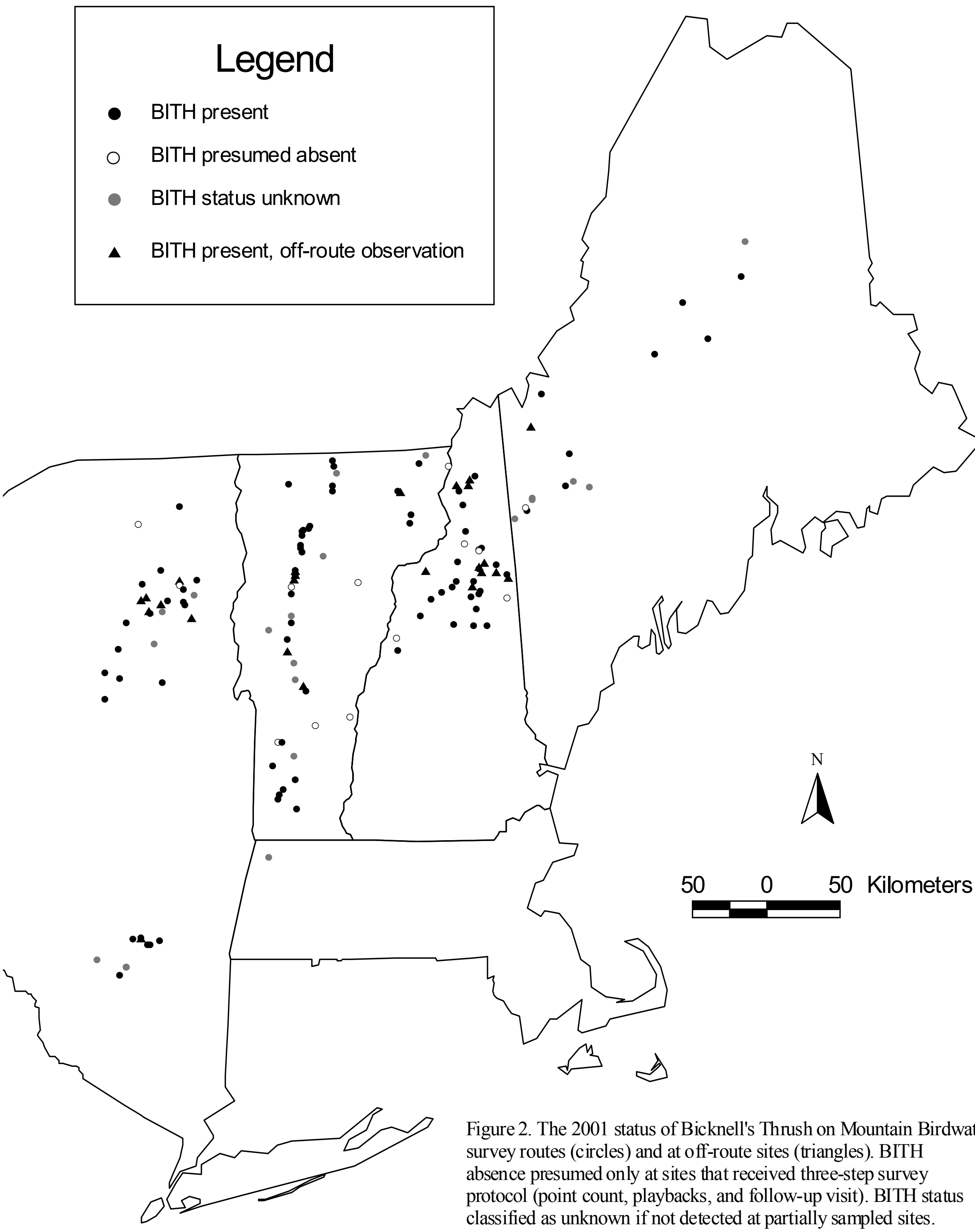


Figure 2. The 2001 status of Bicknell's Thrush on Mountain Birdwatch survey routes (circles) and at off-route sites (triangles). BITH absence presumed only at sites that received three-step survey protocol (point count, playbacks, and follow-up visit). BITH status classified as unknown if not detected at partially sampled sites.

Field Methods

Surveys were conducted under acceptable weather conditions between 4:00 a.m. and 8:00 a.m., on dates ranging from 1 to 21 June. Observers listened quietly for five minutes at up to five stations. They recorded the number of each focal species seen or heard at each station, noting Bicknell's Thrush observations between points, as well. If Bicknell's Thrush was not detected during or between point counts, surveyors returned to each point and broadcast a three-minute recording of the bird's vocalizations in order to elicit a response from present, but silent birds. Audioplaybacks were discontinued upon detection of one or more individuals. If no Bicknell's Thrushes responded to the broadcasts, the status of the species was classified as unknown.

Monitors who completed their surveys without encountering Bicknell's Thrush were asked to conduct follow-up, audioplayback surveys at dusk or dawn before 15 July (after Atwood et al. 1996). In many cases, VINS staff substituted for volunteers who were unable to complete follow-up surveys. If no observations of Bicknell's Thrush were made during the second visit, the species was presumed to be absent from that site.

Data analysis: distribution and abundance

To include FBMP data in our analyses, we subsampled the first five minutes of each ten-minute count. Where two point count series were conducted, we used results from the first survey only. We mapped the distribution of Bicknell's Thrush sightings and measured frequency of occurrence and relative abundance for each of the focal species. For frequency of occurrence, we divided the number of routes on which a species was detected during point counts by the total number of routes surveyed by point count. To produce a more informative frequency measure for Bicknell's Thrush, we also calculated the proportion of survey routes on which the species was detected by any means (point count, chance, playback, or follow-up).

For each species and route, we calculated the average number of individuals per point. We used the grand mean of the resulting figures as the regional index of relative abundance. Because of interspecific differences in detectability, caution should be exercised when comparing frequency of occurrence and relative abundance measures among species. The data are best suited for quantifying changes in species distribution and abundance over time.

GIS model performance

We used results from thoroughly surveyed sites to evaluate the performance of our preliminary Bicknell's Thrush habitat model. The percentage of potential habitat units with confirmed occupancy by Bicknell's Thrush served as one measure of accuracy in classification. As a complementary measure, we calculated the percentage of sites excluded from the model that were occupied by Bicknell's Thrush. Finally, we examined the 24 additional BITH sightings to determine what percentage occurred within modeled habitat units.

Landscape analysis

We measured a variety of landscape attributes for each habitat unit occurring above the minimum elevation threshold (Table 1). Simple linear regression was used to identify variables significantly ($p<0.05$) associated with BITH abundance (BITHppt). Each significant independent variable was then included in a multiple regression analysis. Interaction terms were examined and significant interaction terms were included in the multiple regression. Predictor variables with $p>0.10$ were then culled from the multiple regression, yielding a final model. Spatial autocorrelation was examined using Moran's I spatial autocorrelation coefficient and the corresponding correlogram. All analyses were conducted using Stata 7.0 (College Station, TX).

Table 1. Variables measured for each habitat unit (polygon) in landscape analysis.

Variable Name	Measurement
LOG_POLYCON	Area of conifer-dominated forest, log-transformed for normality
MAXPOLYELEV	Maximum elevation
CONIFERDOM	Proportion of polygon in conifer-dominated cover
NEARNBR	Distance to nearest polygon with $\geq$ 5 ha of conifer-dominated forest
HICON1K	Area of high-elevation, conifer forest $\leq$ 1 km of polygon boundary
HICON10K	Area of high-elevation, conifer forest $\leq$ 10 km of polygon boundary
HICON50K	Area of high-elevation, conifer forest $\leq$ 50 km of polygon boundary
HICON100K	Area of high-elevation, conifer forest $\leq$ 100 km of polygon boundary
Y_DECDEG	Latitude, measured in decimal degrees
POLYLCD	Landcover diversity, measured with Shannon's Diversity Index

Survey timing

To evaluate the influence of time of morning on survey results, we pooled all 2001 routes and calculated the number of Bicknell's Thrushes observed per minute in eight half-hour intervals between 4:00 a.m. and 8:00 a.m. To assess the merits of extending the standard point count period from five minutes to ten minutes, we analyzed nine years of data from high-elevation FBMP routes (1993-2001). First, we calculated the percentage of all Bicknell's Thrush observations that occurred during the first half of the ten-minute count. Then, we calculated the percentage of high-elevation surveys on which the *only* BITH observations occurred within the second half of the sampling interval.

RESULTS

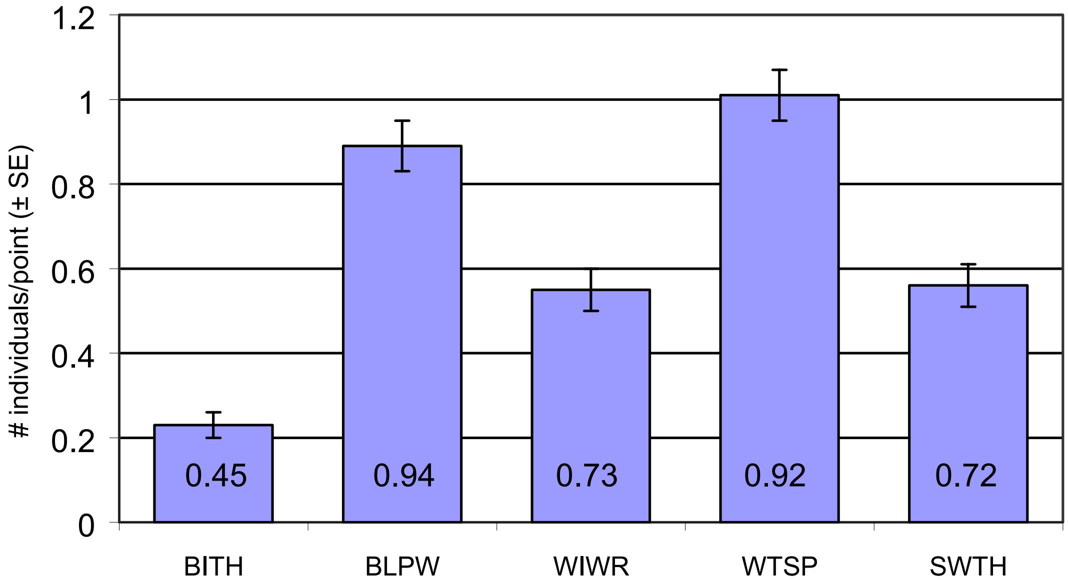
GIS model performance

Mountain Birdwatchers completed the full survey sequence (point count, playback, and follow-up, as needed) on 94 of the 112 survey routes that were located in potential Bicknell's Thrush habitat. The presence of Bicknell's Thrush was confirmed on 83 (88%) of these 94 routes. The species was presumed absent from the remaining 11 (12%). Of the five surveyed mountains that were too low to be included in the model, volunteers conducted the full sampling sequence on three. Bicknell's Thrush appeared on none (0%) of the five routes. In addition to standardized survey data, we gathered breeding season observations of Bicknell's Thrush from 24 mountains without survey routes (Appendix 1). All 24 observations (100%) were made within polygons generated by the preliminary model of Bicknell's Thrush habitat.

Distribution and abundance

Blackpoll Warbler (BLPW) and White-throated Sparrow (WTSP) were the most prominent of the focal species, surpassing the other three in measures of occurrence frequency and relative abundance (Figure 3, Appendix 2 for route data). Blackpolls and White-throats were observed in over 90% of the point count surveys at average levels of 0.91 and 1.01 individuals per point, respectively. Winter Wren (WIWR) and Swainson's Thrush (SWTH) occupied a distinct second tier, with nearly identical frequency and abundance levels (0.54 and 0.55 individuals per point, respectively). Mountain Birdwatch's flagship species, Bicknell's Thrush, was detected during fewer than half of the point counts and in relatively low numbers (0.24 per point). Incidental and audioplayback encounters doubled the frequency of Bicknell's Thrush detections on survey routes, raising it from to 45% to 88%. Records of Bicknell's Thrush in 2001 were widely distributed throughout the survey region (Figure 2).

Figure 3. Relative abundance of five songbirds surveyed along 112 high-elevation routes. Frequency of occurrence values appear as column numbers and refer to the proportion of routes on which a given species was detected by point count. Relative abundance values represent the average number of individuals per point ± SE.



Landscape analysis

Variables found to be significantly associated with BITH abundance under simple linear regression included LOG_POLYCON and MAXPOLYELEV (Table 2). Borderline significance was observed for NEARNBR (p=0.062) and HICON1K (p=0.051). Significant interaction was observed between MAXPOLYELEV and Y_DECDEG, and therefore both Y_DECDEG and MAXPOLYELEV*Y_DECDEG were included in the full multiple regression model. The only variables that maintained significance in the multiple regression model were MAXPOLYELEV, Y_DECDEG and MAXPOLYELEV*Y_DECDEG (Table 3). No significant spatial autocorrelation was observed (Table 4), and the final estimated prediction equation for BITH abundance was:

BITHppt = -39.18 + 0.035*MAXPOLYELEV + 0.87*Y_DECDEG – 0.00077*(MAXPOLYELEV*Y_DECDEG)

As expected both elevation and latitude are positively associated with BITH abundance (positive regression coefficients.) A negative interaction term confirms the *a priori* assumption that lower elevation settings at higher latitudes should provide similar habitat to higher elevations at lower latitude.

Table 2. Univariate regression results (dependent variable BITHppt)

Variable Name	Estimated Regression Coefficient (β)	Standard Error	P-Value	R-Squared
LOG_POLYCON	0.047	0.016	0.003	0.086
MAXPOLYELEV	0.0028	0.00087	0.002	0.097
CONIFERDOM	0.0077	0.16	0.96	0.000
NEARNBR	-0.000013	7.11e-06	0.062	0.035
HICON1K	2.49e-07	1.26e-07	0.051	0.038
HICON10K	1.77e-09	1.40e-09	0.21	0.016
HICON50K	-7.25e-11	2.34e-10	0.76	0.0010
HICON100K	-1.78e-10	1.51e-10	0.24	0.014
Y_DECDEG	-0.026	0. 038	0.49	0.0048
POLYLCD	0.017	0.11	0.88	0.0002

Table 3. Multiple regression analysis results (dependent variable = BITHppt, R-Squared=0.16)

Variable Name	Estimated Regression Coefficient (β)	Standard Error	P-Value
MAXPOLYELEV	0.035	0.012	0.006
Y_DECDEG	0.87	0.32	0.008
MAXPOLYELEV*Y_DECDEG	-0.00077	0.00029	0.007
INTERCEPT	-39.17	14.4	0.008

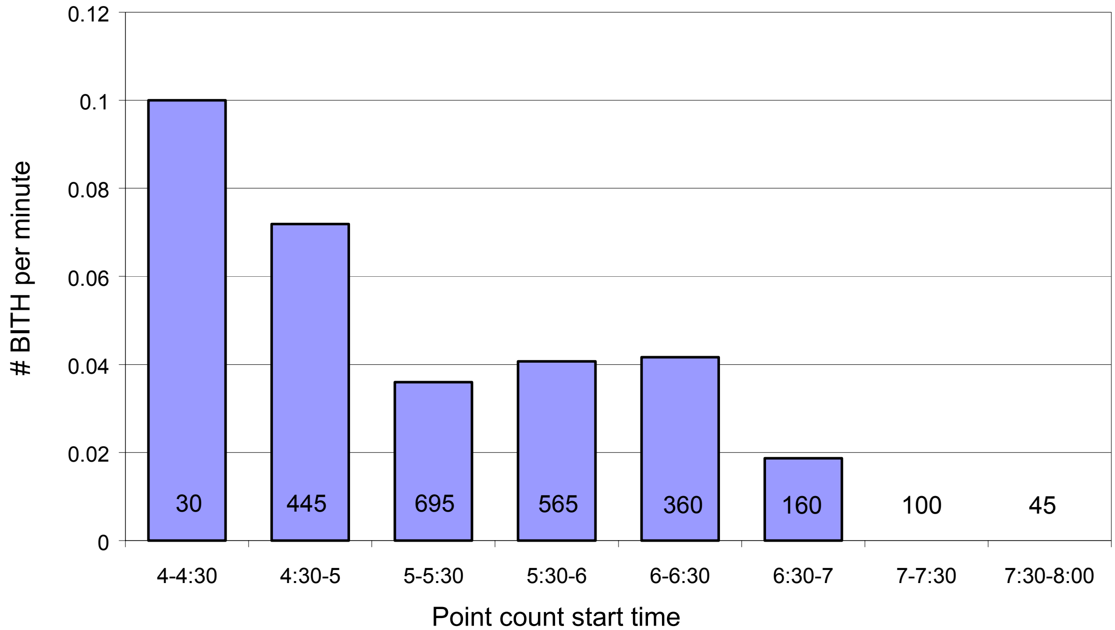
Table 4 . Spatial autocorrelation results

Distance Bands (decimal degrees)	Morans I	Standard Deviation	P-Value
(0.0-0.05]	-0.15	0.23	0.27
(0.05-0.1]	-0.42	0.18	0.42
(0.1-0.15]	0.13	0.16	0.18
(0.15-0.2]	-0.034	0.15	0.44

Survey timing

In 2001, volunteers conducted 480 point counts between 4:00 a.m. and 8:00 a.m. The vast majority of these (86%) occurred during the recommended timeframe of 4:30 a.m. and 6:30 a.m. The number of Bicknell's Thrushes detected per minute showed an overall decline over eight half-hour intervals between 4:00 a.m. and 8:00 a.m. The data indicate a period of peak vocal activity between 4:00 and 5:00 a.m. (> 0.07 individuals per minute), followed by 90 minutes of consistent vocalizing at a more moderate level of approximately 0.04 individuals per minute. Detections of Bicknell's Thrush were rare after 6:30 a.m. and did not occur at all during 29 point counts conducted between 7:00 a.m. and 8:00 a.m.

Figure 4. Time of morning effects on detections of Bicknell's Thrush by five-minute point count, based on 2001 survey data. Column numbers represent the total number of minutes surveyed in the given time interval. Note that the first and final time intervals are represented by just 6 and 9 point counts, respectively.



In our review of high-elevation FBMP surveys conducted since 1993, we found 456 Bicknell's Thrush records. Over half of these observations (235 or 52%) were made during the first three minutes, and the majority (305 or 67%) were made in the first five minutes. Bicknell's Thrush was detected during the second five-minute interval without being detected in the first on 68 occasions. The second five-minute interval produced the lone Bicknell's Thrush record for 16% of the five-point surveys in which the species was observed (20 of 126) and for 10% of all surveys (20 of 201).

DISCUSSION

Distribution and abundance

In many respects, the data gathered from five states in 2001 are largely consistent with findings of the Vermont pilot study. In both surveys, Blackpoll Warbler and White-throated Sparrow were the most abundant focal species. In each year, monitors counted them on >90% of the survey routes. As in 2000, Swainson's Thrush was less abundant than these two, but more abundant that Bicknell's Thrush. The occurrence frequency of Swainson's Thrush also remained constant, measuring 0.72 in 2000 and 0.74 in 2001.

Results were less consistent for Winter Wren and Bicknell's Thrush. The proportion of routes on which Winter Wrens were detected by point count dropped sharply from 0.92 to 0.73, while the same value increased from 0.28 to 0.45 for Bicknell's Thrush. These differences are attributable to an adjustment in site selection standards made in 2001. Polygons surveyed in the pilot year were delineated by the 823-m contour line. The use of this conservative threshold resulted in the inclusion of several low mountains topped by mature mixed-wood and conifer stands, forest types that support unusually high densities of Winter Wren in Appalachian highlands (Haney et al. 1999).

Many of these sites lacked sizable patches of the young, dense conifer frequently selected by Bicknell's Thrush (Rimmer et al. 2001). The sloping elevation mask used in the selection of 2001 sites eliminated most mountains that experience low disturbance and therefore contain predominantly mature forest cover.

The preliminary GIS model of Bicknell's Thrush habitat performed well in 2001, successfully predicting the status of Bicknell's Thrush at 89% of the sites sampled with the full survey sequence. Errors of commission (misclassification of unoccupied sites as occupied) occurred at a low rate (12%). Such a rate is desirable for habitat models of vulnerable species, particularly vagile organisms capable of recolonizing habitat patches that periodically "blink out". A low rate of commission error guards against overestimating the extent of Bicknell's Thrush habitat, while ensuring that some marginal sites are retained in the model. These sites may be irregularly occupied or may one day develop the characteristics of consistently occupied sites. Of the 11 "presumed absent" sites, four have contained one or more individuals in recent years. Errors of omission (misclassification of an occupied site as unoccupied) did not occur, even when off-route observations were included in the analysis. All 24 off-route sightings were within modeled habitat units, further demonstrating the strength of current model parameters.

Nonetheless, a presence/absence model is of limited conservation value since it provides only a crude basis on which to evaluate the importance of mountain forests to Bicknell's Thrush. Fine-tuning is required to produce a more useful model, one that ranks habitat units based on features that directly affect the species. If it were possible to construct a robust model with remotely sensed landscape data, the entire U.S. range of Bicknell's Thrush could be efficiently and cost-effectively mapped.

Landscape analysis

Results of univariate regression analysis ran opposite of our predictions. Measures of landscape composition (CONIFERDOM and POLYLCD) had no effect on BITH abundance, whereas measures of configuration achieved high (LOG-POLYCON) or marginal (NEARNBR, HICON1K) levels of significance. Together, these tests suggested a possible, though unexpected role of landscape structure in shaping patterns of Bicknell's Thrush abundance. However, multiple regression analysis failed to support this possibility, as no landscape attribute maintained its significance in the multivariate model. Because Bicknell's Thrush has evolved in a naturally fragmented and dynamic habitat, it may possess high dispersal capability (Hobson et al. 2001). The ability to disperse to small and distant patches would diminish the importance of landscape composition and configuration, factors that structure forest bird communities in landscapes fragmented by agriculture and human development (Villard et al. 1999).

Previous investigations have demonstrated the influence of elevation and latitude on the presence of Bicknell's Thrush (Atwood et al. 1996, Lambert et al. 2001). Our findings indicate that these factors also affect the abundance of the species at a given location. Both variables and their interaction term emerged as highly significant factors in the final model. Still, the low R-squared value (0.16) indicates ample room for model improvement. In 2002, we will begin to collect information on habitat features measured at the stand level. These features, which reflect the harsh conditions associated with high latitude and elevation, should be useful in future iterations of our Bicknell's Thrush habitat model. Earlier efforts to relate Bicknell's Thrush abundance to habitat characteristics have found the following variables to be important: percent cover of balsam fir in the subcanopy (Pierce-Berrin 2001), dominant vegetation height, and distance to nearest fir-sapling cover type (Hale 2000). If such factors figure prominently in our regional habitat assessment, it may yet be possible to use remotely sensed landcover data to refine the habitat model. Hale (2000) has already used spectral features of satellite imagery to model and map the distribution of Bicknell's Thrush in the White Mountain National Forest. VINS plans to collaborate with Hale on future modeling efforts.

Survey timing

We found Bicknell's Thrush to be most vocal at dawn, with a period of consistent, but reduced vocal activity continuing until 6:30 a.m. Few Bicknell's Thrushes were detected after 6:30 a.m. and none were recorded after 7:00 a.m. Continuous song and call counts conducted in Quebec's Chic Choc Mountains showed the same pattern of vocal behavior in the early morning (Ball 2000). However, vocalizations persisted at a reduced level throughout the day. Similar work at Mount Mansfield in Vermont found vocal activity continuing into the early afternoon (Rimmer et al. 1996). Methodological differences (vocalization counts vs. point counts) may explain some of the discrepancies between previous studies of vocal behavior and our analysis of point count protocols. However, differences in geographic scope may be more significant. Each of the earlier studies was conducted in a single, densely occupied patch of Bicknell's Thrush habitat. Persistent vocal activity may have resulted from heightened competitive interactions, characteristic of crowded areas. In contrast, Mountain Birdwatch point counts were conducted at hundreds of locations, many in sparsely occupied or unoccupied habitat. Regardless of cause, the decrease in observability of Bicknell's Thrush on Mountain Birdwatch routes after 6:30 a.m. confirms this time as an appropriate goal for survey completion.

Our analysis of point count duration indicates that the second half of a ten-minute count adds a small amount of information about the distribution and abundance of Bicknell's Thrush. On the other hand, extending the survey period with longer counts elevates the risk of detection failure at the end of the survey route. Considering the tradeoffs, we determined that the current sampling strategy strikes an appropriate balance, combining the efficiency of five-minute counts of the focal species, with the thoroughness of ten-minute, FBMP counts of the full bird community. The overarching goal is to survey each route the same way every year in order to obtain credible trend information.

Conclusion

In its first year as a regional survey, Mountain Birdwatch surpassed the goal of 100 survey routes and established a strong baseline for future monitoring. Results from 2001 also validated our preliminary model of Bicknell's Thrush habitat and survey protocols. We found no evidence for an effect of landscape structure on Bicknell's Thrush abundance. Therefore, we propose that the influence of elevation and latitude is mediated by stand-level characteristics. In 2002, we will GPS approximately 40% of the active survey routes and collect detailed vegetation data at route stations. The information will be used to further describe factors that structure high-elevation songbird communities.

Understanding the ecology and status of high-elevation songbirds will enable stewards of mountain habitat to support vulnerable populations with informed management decisions. Mountain Birdwatch data have already been used to delineate a Bird Conservation Area in the Adirondacks, identify Important Bird Areas in Vermont, inform National Forest policy in Vermont and New Hampshire, and evaluate potential impacts of wind power development in Maine. There will be more opportunities to apply our findings as monitoring continues and the scope of habitat modeling expands to include more species.

Acknowledgments

We gratefully acknowledge the scores of volunteers who participate in Mountain Birdwatch and the Forest Bird Monitoring Program. This dedicated group was recruited with assistance from the Adirondack Mountain Club, the Appalachian Mountain Club, the Appalachian Trail Conference, the Audubon Society of New Hampshire, the Green Mountain Club, the Maine Audubon Society, the Maine Department of Inland Fisheries and Wildlife, the National Audubon Society of New York State, the National Wildlife Federation, The Nature Conservancy, the New York-New Jersey Trail Conference, the New York State Department of Environmental Conservation, Northeast Kingdom Audubon, *The Northern Forest Forum*, the Olive Natural Heritage Society, and the Wonalancet Outdoor Club. The Appalachian Mountain Club, the Adirondack Mountain Club, and the Wildlife Conservation Society offered extra support as sponsors of volunteer training workshops. Thanks to Heidi Kretser, Jen Kretser, Stacey Low, Brian McAllister, Richard MacDonald, Allison Nelson, and Nancy Ritger for making these workshops possible. We are very grateful for permission to conduct surveys on lands owned and/or managed by: the American Ski Corporation, the Carthusian Monastery, Essex Timber Company, LLC, the Green Mountain Club, the Maine Department of Inland Fisheries and Wildlife, the National Park Service, the New York State Department of Environmental Conservation, the U.S. Forest Service, and the Vermont Agency of Natural Resources. We thank Kimberley Corwin Hunsinger of the New York State Breeding Bird Atlas and the atlas volunteers who shared their recent observations of Bicknell's Thrush. We also thank Andrew Toepfer for providing patient GIS support, Joel Schlagel for introducing latitude-sensitivity to our habitat model, and Derek Burkins for producing the Mountain Birdwatch training tape. Mountain Birdwatch is funded by the U.S. Fish and Wildlife Service. We extend special thanks to Randy Dettmers, Region 5 Assistant Nongame Bird Coordinator, for supporting this work.

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APPENDIX 1

Locations of 24 off-route Bicknell's Thrush observations reported in 2001

State	Mountain
ME	Gulf Hagas Mountain
ME	West Kennebago Mountain
NH	Baldhead Mountain
NH	Bunnell Mountain
NH	Carter Dome
NH	Mount Jefferson
NH	Mount Madison
NH	Mount Washington
NH	Mount Webster
NH	Muise Mountain
NH	South Baldface
NH	South Carter Mountain
NY	Giant Mountain
NY	Green Mountain
NY	Macomb Mountain
NY	Panther Peak
NY	Seward Mountain
NY	Slide Mountain
NY	Wallface Mountain
VT	Burnt Rock Mountain
VT	Jay Peak
VT	Mount Ethan Allen
VT	Mount Horrid
VT	Pico Peak

APPENDIX 2

2001 Mountain Birdwatch results summarized by route

State	Mountain	BITH status*	BITH	BLPW	WIWR	WTSP	SWTH
			Relative abundance (individuals per point count)				
MA	Mount Greylock	3	0.00	0.20	0.00	0.40	0.00
ME	Baldpate Mountain	1	0.60	1.60	0.60	0.40	0.00
ME	Big Spencer Mountain	1	0.80	1.60	0.80	1.20	1.80
ME	Big Squaw Mountain	2	0.00	1.20	1.20	0.80	1.40
ME	Blueberry Mountain	3	0.00	1.50	0.00	2.00	0.00
ME	Mount Blue	4	0.00	3.00	0.00	1.00	1.00
ME	Mount Katahdin	2	0.00	2.00	1.80	1.40	1.00
ME	North Traveler Mountain	3	0.00	0.20	0.00	2.00	0.00
ME	Old Speck Mountain	3	0.00	0.80	0.20	0.20	0.00
ME	Saddleback Mountain	2	point count data discarded due to high winds; route relocated				
ME	Snow Mountain	1	1.40	0.60	0.40	0.80	2.20
ME	Surplus Mountain	5	0.00	0.00	1.00	1.00	0.00
ME	Tumbledown Mountain	1	0.25	1.25	0.50	2.00	0.25
ME	White Cap Mountain	1	0.20	0.40	0.40	1.60	0.20
ME	Wyman Mountain (North Peak)	4	0.00	0.50	0.00	1.00	1.00
ME	Wyman Mountain (South Peak)	4	0.00	1.25	0.75	1.00	0.50
NH	Crescent Ridge	5	0.00	0.33	1.00	0.33	0.67
NH	Dixville Peak	1	0.40	1.00	1.00	1.00	0.00
NH	Kearsarge North	5	0.00	0.00	0.00	2.33	0.67
NH	Kinsman Mountain (North Peak)	2	0.00	1.00	1.20	1.20	0.00
NH	Middle Carter Mountain	2	0.00	1.00	0.20	0.20	0.00
NH	Mount Cabot	2	no point count; BITH detected by audioplayback survey				
NH	Mount Chocorua	2	0.00	0.20	0.00	0.60	0.20
NH	Mount Clay	1	0.80	0.80	0.20	0.60	0.60
NH	Mount Crawford	1	0.40	0.80	0.20	1.80	0.80
NH	Mount Crescent	1	0.40	0.80	0.00	0.40	0.00
NH	Mount Cube	5	0.00	0.60	0.40	1.20	1.40
NH	Mount Hale	2	0.00	0.40	0.60	1.20	1.40
NH	Mount Lafayette	1	0.40	0.60	0.20	1.80	0.00
NH	Mount Martha	1	0.00	0.40	0.80	0.40	0.60
NH	Mount Moosilauke	1	0.20	0.60	0.00	1.00	0.40
NH	Mount Nancy	1	0.20	0.40	0.20	1.80	0.20
NH	Mount Passaconaway	1	0.20	0.40	0.60	0.80	0.20
NH	Mount Pierce	1	1.00	1.20	0.00	2.00	0.40
NH	Mount Randolph	5	0.00	2.00	2.00	0.00	0.00
NH	Mount Starr King	5	0.00	0.20	0.00	1.00	0.00
NH	Mount Tecumseh	1	1.00	0.60	0.00	0.80	1.20
NH	Mount Tremont	2	0.00	1.20	0.00	0.60	0.60
NH	North Baldface	1	0.20	0.80	0.00	1.40	0.00
NH	Percy Peak	2	0.00	0.50	0.00	0.50	0.00
NH	Smarts Mountain	2	0.00	0.25	0.00	0.50	0.50
NH	South Twin Mountain	1	0.60	1.40	0.00	1.40	0.20
NH	Stairs Mountain	1	1.00	1.20	1.00	0.60	0.60
NH	Sugarloaf	2	0.00	0.20	0.00	0.00	1.00
NY	Ampersand Mountain	2	0.00	1.00	0.00	1.33	1.00

			Relative abundance (individuals per point count)				
State	**Mountain**	**BITH status***	**BITH**	**BLPW**	**WIWR**	**WTSP**	**SWTH**
NY	Balsam Lake Mountain	4	0.00	1.00	0.00	0.00	1.25
NY	Blue Mountain	2	point count data discarded due to cold temperature				
NY	Cornell Mountain	1	0.67	1.00	1.00	1.00	0.00
NY	Debar Mountain	5	0.00	0.60	0.80	0.80	0.40
NY	Gore Mountain	2	0.00	0.40	0.40	1.20	0.00
NY	High Peak	1	0.50	0.50	1.00	0.00	0.50
NY	Hopkins Mountain	3	0.00	0.00	0.50	1.50	1.50
NY	Hunter Mountain	1	0.60	0.20	0.00	0.60	0.60
NY	Kempshall Mountain	1	0.50	0.75	0.00	0.50	1.00
NY	Lyon Mountain	1	0.40	0.80	0.20	0.20	0.60
NY	McKenzie Mountain	2	0.00	0.80	0.40	0.80	0.80
NY	Mount Adams	3	0.00	0.20	1.00	0.20	0.20
NY	Noonmark Mountain	1	0.25	0.00	0.25	0.75	0.50
NY	Pillsbury Mountain	2	0.00	0.75	0.00	0.25	0.25
NY	Pitchoff Mountain	5	0.00	1.20	1.60	1.20	0.60
NY	Plateau Mountain	1	1.20	1.60	1.00	0.60	1.00
NY	Porter Mountain	1	0.20	1.60	0.60	1.20	0.00
NY	Santanoni Peak	2	0.00	1.40	0.80	1.00	1.20
NY	Snowy Mountain	1	0.60	0.20	0.60	1.20	0.60
NY	Soda Range	1	0.20	0.40	1.20	0.60	0.60
NY	Sugarloaf Mountain	2	0.00	0.60	0.40	0.40	0.00
NY	Table Mountain	2	0.00	0.60	0.60	1.00	0.80
NY	Upper Wolfjaw Mountain	1	0.40	0.40	0.60	0.20	0.00
NY	Vanderwhacker Mountain	3	0.00	0.00	0.20	0.00	0.20
NY	Wakely Mountain	1	0.00	0.67	0.67	0.67	0.00
NY	West Kill Mountain	2	0.00	0.80	0.60	0.20	0.40
NY	Wittenberg Mountain	3	0.00	1.67	0.33	0.00	0.00
NY	Wright Peak	1	0.40	1.20	0.80	1.00	0.60
VT	Bald Mountain	2	0.00	1.00	1.00	1.50	1.25
VT	Bear Head	1	0.80	1.20	0.40	3.20	0.60
VT	Belvidere Mountain	1	0.40	0.80	0.40	1.60	0.00
VT	Big Jay	2	point count data discarded due to 5" snowfall				
VT	Blue Ridge Mountain	4	0.00	0.00	0.00	0.00	0.00
VT	Bolton Mountain	1	0.60	1.20	0.80	1.00	1.60
VT	Bromley Mountain	3	0.00	0.60	0.40	0.60	0.20
VT	Brousseau Mountain	4	0.00	1.00	1.50	0.50	1.00
VT	Buchanan Mountain	4	0.00	1.00	0.00	2.00	0.00
VT	Burke Mountain	1	0.20	2.20	0.80	1.80	0.20
VT	Camels Hump	2	0.00	1.80	1.60	1.60	0.60
VT	Deerlick	2	0.00	1.67	0.33	0.00	1.00
VT	Dorset Mountain	5	0.00	0.60	0.40	0.20	0.20
VT	Dorset Peak	2	0.00	0.00	0.00	0.00	0.00
VT	East Haven Mountain	1	0.20	0.40	1.40	0.40	1.80
VT	Glastenbury Mountain	1	0.40	0.60	0.40	1.00	1.00
VT	Gore Mountain	1	0.20	0.40	0.40	2.60	0.80
VT	Haystack Mountain	1	0.80	1.60	1.00	2.40	0.00
VT	Haystack Mountain	1	0.40	1.00	0.40	0.60	1.00
VT	Killington Peak	1	1.00	1.20	0.00	1.20	0.60

			Relative abundance (individuals per point count)				
State	**Mountain**	**BITH status***	**BITH**	**BLPW**	**WIWR**	**WTSP**	**SWTH**
VT	Ludlow Mountain	5	0.00	1.00	1.50	1.50	0.50
VT	Madonna Peak	1	1.00	2.00	0.40	1.60	1.80
VT	Molly Stark Mountain	5	0.00	1.20	0.60	1.00	0.40
VT	Monadnock Mountain	5	0.00	0.67	1.67	1.00	1.33
VT	Morse Mountain	1	0.20	0.80	1.00	1.20	0.60
VT	Mount Ascutney	5	0.00	0.00	0.80	0.80	0.20
VT	Mount Carmel	6	no point count; BITH not detected by audioplayback survey				
VT	Mount Equinox	1	0.40	1.60	0.80	1.00	0.60
VT	Mount Grant	4	0.00	1.80	0.80	1.40	1.40
VT	Mount Hunger	3	0.00	0.40	0.20	1.60	0.20
VT	Mount Ira Allen	1	0.60	1.40	1.20	1.60	1.00
VT	Mount Mansfield	1	1.00	1.60	0.60	3.20	0.20
VT	Mount Mansfield (The Forehead)	2	0.00	1.20	0.80	1.20	1.60
VT	Mount Mayo	1	0.33	1.67	0.00	1.00	0.00
VT	Mount Wilson	1	0.60	0.80	0.40	1.00	0.40
VT	North Glastenbury	2	0.00	0.33	0.00	0.00	0.00
VT	North Jay Peak	1	0.20	0.80	0.60	1.00	0.00
VT	Ricker Mountain	1	0.40	1.40	1.00	1.20	1.80
VT	Spruce Mountain	5	0.00	0.50	0.75	0.50	0.25
VT	Stark Mountain	2	0.00	2.20	0.60	2.00	0.60
VT	Stratton Mountain	2	0.00	1.20	0.00	1.60	0.40
VT	Tillotson Peak	2	0.00	1.00	1.67	1.67	0.00
VT	West Ridge of Glastenbury	3	0.00	0.40	0.00	1.20	1.20
VT	Worth Mountain	1	0.00	0.60	1.00	0.60	0.00

1 = present, detected by point count

2 = present, detected incidentally, during playbacks, or on follow-up survey

3 = not detected during point counts, no playbacks or follow-up

4 = not detected during point counts or playbacks, no follow-up

5 = presumed absent, not detected by point count, playback, or follow-up

6 = not detected by single audioplayback survey