POPULATION DENSITY AND DEMOGRAPHIC STUDIES OF BICKNELL'S THRUSH ON MT. MANSFIELD, VERMONT AND OTHER NORTHEASTERN UNITED STATES PEAKS

Progress Report 1995

Christopher C. Rimmer and Kent P. McFarland
Vermont Institute of Natural Science
RR 2, Box 532
Woodstock, VT 05091

Abstract: Research on the population ecology of Bicknell's Thrush *(Catharus bicknelli)* was expanded on Mt. Mansfield and 11 other northeastern U.S. peaks in 1995. On Mt. Mansfield, spot mapping of territorial males on an 8.8 ha ridgeline study plot yielded a density estimate of 45-53 pairs/40 ha, while estimates of 20-21.5 and 4-9 pairs /40 ha were obtained from two plots at lower elevations. Efforts to capture and band thrushes on ten study plots resulted in a total of 147 birds (75 males, 34 females, 38 juveniles) being uniquely color-banded in 1992-95, 103 of these on Mt. Mansfield. Band returns of adults indicated high survivorship and site fidelity. None of the juveniles banded on Mt. Mansfield in 1992-94 were recaptured in a subsequent year. Of 11 active nests located in 1992-95, only 3 (27%) were successful in fledging any young. Most nests failed due to predation, apparently by red squirrels (*Tamiasciurus hudsonicus)*. Analysis of vegetation data at nest sites (n=13) and non-use (n=13) sites failed to detect expected differences in stem densities, but did reveal significantly higher ground and fern cover on non-use sites.

Introduction

The Bicknell's Thrush (*Catharus bicknelli),* recognized as a subspecies of the Gray-cheeked Thrush (*Catharus minimus*) since its discovery in 1881 on Slide Mountain in the Catskills of New York, has recently been given full species status (AOU 1995). Significant differences between the two taxa in morphology, vocalizations, biochemistry, and breeding and wintering distributions contributed to this designation (Ouellet 1993). With this classification Bicknell's Thrush has become recognized as one of the most at-risk passerine species in the eastern United States. Rosenberg and Wells (1995) ranked Bicknell's Thrush as number one on a conservation priority list of Neotropical migrant birds in the Northeast. The species has been proposed for "threatened" status in Canada (Nixon 1995).

The breeding range of Bicknell's Thrush in the United States is limited to subalpine spruce-fir forests of New England and New York (Atwood et al. in press). In Canada it is found in highland spruce-fir forests in Quebec, Nova Scotia and New Brunswick (Erskine 1992, Ouellet 1993, Gauthier and Aubry 1995). It has also been found in mixed second-growth forest following clear cutting or burning in Quebec (Ouellet 1993) and New Brunswick (Nixon pers. comm.). As the only breeding songbird endemic to high altitude and maritime spruce-fir forests of the northeastern United States and adjacent Canada, Bicknell's Thrush qualifies as a potentially valuable indicator of the health of subalpine avian populations and their associated forest habitat. Surveys aimed at clarifying the distribution and population status of Bicknell's Thrush in the Northeast were conducted from 1992-95 (Atwood et al. in press, Rimmer et al. in press) and are in progress in New Brunswick, Canada (D. Busby, pers. comm.).

Many important questions about the ecology and stability of Bicknell's Thrush breeding populations require intensive monitoring of discrete habitat units and studies of known-identity individuals. Baseline data on population densities, territory size, movements, productivity, site fidelity, survivorship, and habitat use are needed to evaluate the conservation status of the species across its fragmented high elevation breeding range. Studies conducted since 1992 on Vermont's Mt. Mansfield, the site of a large, dense breeding population, have established a solid foundation for future long and short-term research.

In 1995 research was expanded on Mt. Mansfield and on 11 additional peaks in the Northeast, using a variety of methods (Table 1). Primary research objectives in 1995 were: 1) to uniquely color-band all known breeding pairs of Bicknell's Thrushes on 10 study plots, for demographic investigations ; 2) to obtain estimates of population density on 3 Mt. Mansfield study plots by spot-mapping and tracking movements of known identity individuals; 3) to examine site fidelity, territorial turnover, survivorship, and population stability on 6 established plots by searching for previously color-banded thrushes; 4) to obtain productivity data by locating and monitoring nests on 7 study plots, and through combined mist-netting and observations of banded family groups; and 5) to establish point count stations on additional peaks and to complete censuses on as many of these sites as possible.

Methods

Spot mapping. Territory mapping was conducted from 1992-95 on the MANS plot and in 1995 on the RABR and NDPO plots (Table 1). For each bird seen or heard a compass bearing and distance estimate were recorded from marked vantage points (MANS) or following a 25m grid system marked with blue survey flagging and metal tree tags (RABR, NDPO). Data were plotted on a base map of each study area. Simultaneous registration of two or more vocalizing birds was used as the primary means of discriminating between adjacent territories (Robbins 1970). Sightings of color banded birds were recorded and mapped in an attempt to match each territory with a known identity bird.

Surveys were conducted on 12 dates in 1992 (11-18 June, 27-30 June), 8 dates in 1993 (8-10 June, 16,17,23,24,29 June), 14 dates in 1994 (5-9 June, 14-17 June, 20,22,23,29,30 June) and 16 dates in 1995 (1, 5-8, 12-14, 16, 19, 20, 22, 23, 27 June). We determined the density of Bicknell's Thrush territories in several ways. Maximum density values were obtained by including percentages of territories estimated to be located within the boundaries of the study plot. Minimum density values were calculated by excluding all "partial" territories from consideration. Data from the MANS plot were independently evaluated by an individual experienced in spot mapping but unfamiliar with the study plot. Finally, we calculated the number of territories on each study plot using the international spot mapping standards (Robbins 1970), where each territory that is at least 50% within the plot boundaries is counted as a full territory on the plot. We applied a simple linear regression to each territory calculation method to compare the trends shown by each.

Color Banding. On 10 study plots we used strategically placed mist nets in combination with tape recorded playbacks of Bicknell's Thrush vocalizations and a life-like wooden decoy to attempt to capture and color band all known Bicknell's Thrushes on the study areas. Up to 10 mist nets were used simultaneously to passively capture thrushes as a complement to the use of vocal and visual lures. This facilitated the capture of females, which are not readily lured into nets. Detailed mensural (e.g., wing chord, weight) and body condition (e.g., subcutaneous fat, molt, feather wear) data were recorded for all captured birds. Capture locations were marked on study plot base maps. On plots where spot mapping was conducted we attempted to identify the color banded adults on each known territory. Concerted efforts were made to locate color banded birds throughout the season.

Nest Monitoring. From early June through mid-July, 7 study plots were systematically searched to locate active and recently-used nests. Each nest location was marked on a study plot base map. The chronology and success of all active nests were monitored, and nestlings were banded. Nest monitoring was conducted according to guidelines established by the Breeding Biology Research and Monitoring Database Program (BBIRD) (Martin and Conway 1994). After fledging, nest site and microhabitat data were collected in accordance with BBIRD protocols.

Univariate comparisons were made between Bicknell's Thrush nest sites and non-use sites. Ocular estimate variables (i.e., ground cover parameters) were placed in 5 classes (Table 11) (Barbour et al. 1987). These indices were compared with a Wilcoxon rank-sum test. All other comparisons were made with two-sample *t*-tests. We were unable to compare successful nest sites and unsuccessful sites due to the small sample size (n=13 nests). At least 20 nests are needed to give a reliable estimate of nest success (Hensler and Nichols 1981). Nearly all nests were found after the onset of incubation, so nest success, mortality and initiation dates were calculated using the Mayfield method (Mayfield 1961, 1975) as modified by Johnson (1979) and Hensler and Nichols (1981). Initiation date is the day on which the first egg was laid. To calculate this date we assumed laying intervals of one day and incubation and nestling periods of 14 days each. The small sample size should be kept in perspective when reviewing these results.

Point Count Surveys. Point count surveys have been conducted since 1991 on MANS and Camel's Hump, Vermont (CAME) and were initiated on 9 other peaks in 1995. We used the Forest Bird Monitoring Program protocol of the Canadian Wildlife Service, Ontario Region (Welsh 1995). Five point count stations are located at each site ecept WHIT and PLAT which contain ten stations. Stations are separated by at least 250m. Counts begin as soon as possible after observers arrive at the station. All birds seen or heard during a 10 minute period are recorded. All data are mapped on sheets to minimize duplicate records. All counts are conducted from dawn to approximately 4 hours after sunrise on the same morning. Surveys are conducted only in weather that is unlikely to reduce count numbers (i.e., avoidance of strong winds, moderate or heavy rain, extreme cold). Each site is sampled twice during the breeding season: once in early to mid-June and once in late June to early July. Singing males, observed pairs, occupied nests, or observed family group are assumed to represent breeding pairs. All other individuals seen or heard calling are counted as single birds. The higher count for each species from the two survey dates is used as the annual station abundance estimate. Station values can be summed to obtain site values.

Beginning in 1994 habitat parameters were monitored at each site using the BBIRD protocol. These will be repeated at 3-year intervals, sooner in the event of obvious habitat changes at a given site (e.g., fire, wind throw, human induced changes). As of 1995, habitat monitoring has been completed on MANS, BELV, PLAT, and EQUI.

Constant Effort Mist Netting. Using the Monitoring Avian Productivity and Survivorship Program (MAPS) protocol (Desante and Burton 1994), an array of six 12m mist nets were used on MANS in 1994. In 1995 we increased the number of nets on this site to ten. On RABR, BELV, EQUI, and PLAT we established arrays of ten 12m mist nets in 1995. Mist nets were operated for six hours on one morning in each of nine different ten-day periods (May 31-Jun 9, Jun 10-19, Jun 20-29, Jun 30-Jul 9, Jul 10-19, Jul 20-29, Jul 30-Aug 8, Aug 9-18, Aug 19-28). During the breeding season MAPS mist net locations were not used for any other mist-netting, and no tapes or decoys were used at these sites.

Results

Density estimates. Spot mapping of vocalizing males on the MANS plot yielded density estimates for Bicknell's Thrush of 36-52 pairs/40 ha in 1992, 50-59 pairs/40 ha in 1993, 55-65 pairs/40 ha in 1994 and 45-53 pairs/40 ha in 1995 (Fig. 1). The territories of 8, 11, 12, and 10 pairs were located entirely within the borders of the study plot in 1992-95, respectively. The total number of territories on the plot was estimated at 11.5 in 1992, 13.0 in 1993, 14.25 in 1994 and 11.75 in 1995. Independent evaluation of our data by an individual experienced in spot mapping but unfamiliar with the plot yielded estimated totals of 11.75 territories in 1992, 13.25 territories in 1993, 12.5 territories in 1994, and 10.0 territories in 1995 (Fig. 2). Spot mapping on RABR and NDPO yielded considerably lower densities than on MANS (Table 2). Densities calculated from MANS point counts showed little agreement with density estimates obtained by spot mapping (Table 2).

Point count totals from 12 sites in 1995 suggest that size of contiguous habitat area may influence Bicknell's Thrush densities (Table 3). Of two point count sites (MANS and CAME; n = 10 point counts) that were censused for 5 years (1991-95), CAME consistently had fewer Bicknell's Thushes than MANS. However, both sites showed similar population trends (Fig 3).

Mist Netting. We have banded a total of 137 AHY (after hatching year) and 24 HY (hatch year) Bicknell's Thrush since 1992 on 10 different plots. On our two longest term (1992-95) banding sites (MANS and OCTA) we banded 39 birds and recaptured 9 previously banded birds in 1995, 33 banded and 10 recaptured birds in 1994, 26 banded and 4 recaptured birds in 1993, and 11 banded adults in 1992. Total return rate for AHY birds, based on percent of banded birds recaptured or resighted in subsequent years, was 45.2% for MANS and 23.1% for OCTA (Table 4). We have never recaptured a HY bird (n=15, 1992-94) in a subsequent breeding season. We banded 30 adults on five smaller, more isolated mountains in 1994 and 1995 (Table 5). Fifty percent of the 18 birds banded in 1994 were confirmed to return in 1995 (Table 5).

We captured 11 adult males, 9 adult females and 3 adults of unknown sex on MANS in 1995, 12 males, 5 females and 1 unknown sex bird in 1994, 14 males and 5 females in 1993, and 3 males and 3 females in 1992 (Table 6). One female banded as an AHY on MANS in 1992 was recaptured in 1995. To our knowledge this represents a longevity record for the species. The oldest known males are three 4-year old males on MANS and one on OCTA, all banded in 1993 and recaptured in 1995 (Table 6).

Constant effort mist netting in 1995 yielded 25.5 Bicknell's Thrushes per 1,000 net hrs on MANS, 13.0 on PLAT, 11.0 on RABR, 8.5 on BELV and 4.0 on EQUI. Constant effort mist netting conducted on MANS in 1994 resulted in 12.2 Bicknell's Thrushes per 1,000 net hrs. However, we used fewer nets in 1994, a pilot year.

Nest Monitoring. Despite many hours of observations and systematic searches we found only 14 active or recently active nests in 1992-95 (7 MANS, 3 OCTA, 3 RABR, 1 NDPO). Of these 14 nests, 3 were successful (fledging at least one), 4 were depredated, 2 failed due to nest abandonment, 2 failed due to unknown circumstances, and 4 were of unknown status because they were never occupied during observation (Table 8). It remains unclear why the two 1994 MANS nests were abandoned. Of the 11 active nests that we monitored, 3 fledged 5 young. Wallace (1939) reported that only 4 of 15 nests monitored during his study on Mt. Mansfield fledged young. One nest with eggs was abandoned and the remaining 10 were depredated.

Clutch sizes ranged from 3-4 eggs (n = 7 nests, x = 3.4, SD = 0.53) (Table 8). Wallace (1939) recorded the same clutch size range (n = 13 nests, x = 3.46, SD = 0.56). Initiation dates ranged from 10 June to 6 July (n = 10 nests, x = 20 June, SD = 8.8 days). The latest date represents a probable second attempt by a pair that failed during the egg laying period. Wallace (1939) reported clutch initiation dates from 9 June to 10 July (n = 11 nests, x = 18 June, SD = 8.9 days). His latest nest also represented a second attempt. It is unclear how he calculated these initiation dates.

Twelve of 14 nest trees were balsam fir (*Abies balsamea*). One nest was located in a red spruce (*Picea rubens*), and one was situated in the junction of a balsam fir leaning on a white birch (*Betula papyrifera* var. *cordifolia*). Wallace (1939) found 7 nests in balsam fir, 5 in red spruce and 1 in a white birch. Nest trees were small (1.8-3.39 m tall and 1 -7.9 cm DBH), and nests were located between 1 and 2.85 m above ground (Table 10). Wallace (1939) found nests to be 0.9 - 3.7 m above the ground (Table 10). Nests were supported by 1 to 4 small branches (0.3-1.5 cm diameter) and were placed abutting the trunk of a tree or very close to the trunk. Nests were most often on the eastern side of the nest tree (n = 13, x^2 = 13.51, DF = 4, $P < 0.025$). The amount of vegetation obscuring the nest in each cardinal direction in a 25 cm radius circle centered at the nest was higher on the north side and from above (Table 10). Nests were invariably found in a live portion of the tree and in healthy trees, except in one case where nest tree's top quarter was gnarled and dead.

We compared vegetation surrounding nest sites (n = 13) with randomly selected non-use (no nest) sites (n = 13) (Table 11). Shrub stem densities were measured on 5-m radius plots (shrubs were defined as woody plants > 0.5 m high with a DBH <8 cm). Similarly, tree densities were examined on 11.3-m plots around the nests and in randomly chosen non-use sites. We found no differences in the density of stems in any size classes. Ocular estimates of ground cover yielded some patterns. Both total green cover (< 50cm tall) and fern cover were significantly higher on non-use sites than on nest sites (Table 11).

Discussion

Spot mapping data showed an increase of 4 territories located entirely within the MANS plot from 1992-94, followed by a decrease of 2 territories in 1995. We believe that our data, from which two independent observers calculated similar numbers of territories in each year, closely approximated actual Bicknell's Thrush densities on the study plot. On 11 July 1994 we observed a color banded bird counter calling five times with other birds. The location of this bird coincided closely with a territory plotted from mapping data. These observations appear to support the accuracy of our spot mapping data. We analyzed these data using several methods to explore possible errors in determining edge territories on the study plot boundaries. Each technique yielded similar densities and population trends (Fig. 2).

Some birds wandered over a large area. These individuals were typically identified only through mist net captures and were rarely observed singing or calling. Most documented nomadic behavior occurred early (territory establishment phase) and late (post-breeding dispersal) in the breeding season, suggesting that territorial boundaries "relax" or break down outside of breeding activities. It is possible that some individuals were non-breeders, or "floaters", and simply wandered over the area throughout the summer. In 1995 we documented repeated movements (through mist net captures and color band observations) of a second year (SY) male over a 5 ha area on MANS between 5 June and 29 September. We captured another SY male on the MANS plot in early June and documented its occupancy of a territory on the NDPO plot later in the month.

A comparison of Bicknell's Thrush density estimates from spot mapping and point count surveys on MANS yielded conflicting results (Table 2). Bicknell's Thrush vocalizations tend to be sporadic and concentrated in brief temporal windows at dawn and dusk (Rimmer et al. in press). We believe that density estimates obtained by point counts alone are unreliable. We suggest the use of recorded vocal playbacks to determine the density of thrushes on point counts. In the future we will follow our current 10-min counts with an additional 2 min of playbacks of Bicknell's Thrush calls and songs and 3 min of silent observation for a total of 15 min. We believe that this will yield improved estimates of both density and relative abundance.

Wallace (1939) reported that Bicknell's Thrush territories on Mt. Mansfield "may apparently cover an acre or more." Assuming densely packed territories of about 0.6 ha (1.5 ac) in size, Wallace's suggestion would yield density estimates of approximately 65 pairs/40 ha. This is similar to our maximum estimates from spot mapping data on MANS and may reflect unusually high densities on Mt. Mansfield, which we believe may support over 250 pairs.

Spot mapping of Bicknell's Thrush on RABR and NDPO in 1995 yielded much lower densities than on MANS. This may reflect differences in thrush habitat selection. Bicknell's Thrush appears to prefer stunted, dense spruce-fir growth punctuated by standing dead snags and small openings. This habitat type characterizes the MANS plot, while the lower elevation plots, particularly NDPO, contain more continuous-canopy forests of taller stature and mixed species composition. Alternatively, there may be interspecific competitive interactions between Bicknell's Thrushes and Swainson's Thrushes at lower elevations. We have not documented breeding by Swainson's Thrushes on the MANS plot during our studies. However, at lower elevations the species is found breeding in densities comparable to or higher than Bicknell's Thrush. In 1995 we recorded Swainson's Thrush densities of 33 pairs/40 Ha on RABR and 11 pairs/40 Ha on NDPO. We witnessed several instances of Swainson's Thrushes reacting aggressively to recorded playbacks of Bicknell's Thrush calls and songs.

A significant, but still preliminary, finding is that the return rates and site fidelity of adult Bicknell's Thrushes appear to be high. Our estimates are undoubtedly low because of the difficulty in recapturing birds and sighting color bands in the dense habitat. We have not documented the return of a banded HY (juvenile) bird in a successive year. Despite capturing 13 HY birds on Mt. Mansfield in 1994 we failed to document any returns in 1995. However, we did capture 7 unbanded SY birds (juveniles from 1994) on MANS, suggesting that recruitment from other breeding areas may be occurring.

Similar breeding densities in 1992-95, coupled with apparent high adult site fidelity and return rates, suggest that Mt. Mansfield's breeding population may be relatively stable. However, the demographics of this relatively large population may not reflect those on the many smaller, more isolated peaks occupied by this species. We will continue to compare Bicknell's Thrush demographics and population stability on peaks with both extensive and limited subalpine spruce-fir habitat as part of our overall research on the status of this species.

Obtaining productivity data from nest monitoring has proven to be difficult because of the rough terrain and dense vegetation on our study plots. Two nests abandoned on MANS in 1994 during incubation were believed to have been caused by either excessive foot traffic on nearby hiking trails (both nests located < 5m from trails), observer disturbance, or predation of the females. We do not believe that our limited visits to the nests caused their abandonment. During 1994 five Blackpoll Warbler (*Dendroica striata*)nests, 1 Myrtle Warbler (*Dendroica coronata*) nest and a Purple Finch (*Carpodacus purpureus*) nest were discovered on MANS and monitored in a similar manner, yet all 7 nests fledged young. We failed to recapture either female associated with the two abandoned 1994 nests in 1995. We did not document any nest abandonment in 1995.

Possible nest predators of adults or nests observed from 1992-1995 on Mt. Mansfield included: Blue Jay (*Cynocitta cristata*), Northern Raven (*Corvus corax*), *Accipiter* species, red squirrel (*Tamiasciurus hudsonicus*), eastern chipmunk (*Tamias striatus*; observed only on RABR), raccoon (*Procyon lotor*), and weasel (*Mustela* species). Wallace (1939) reported that red squirrels and a Blue Jay preyed on Bicknell's Thrush nests on Mt. Mansfield. We strongly suspect red squirrels to be the major nest predator. We began to map red squirrel territories in 1995 to obtain yearly population indices and found 10 squirrel territories on RABR and 5 territories on NDPO. We believe that extremely high cone production in 1994 may have resulted in unusually high numbers of red squirrels on Mt. Mansfield in 1995. Cone production in 1995 was relatively low. Future indices of red squirrel populations and their correlation with annual nest predation rates may reveal the influence of this species on Bicknell's Thrush productivity.

Despite our small sample size (n = 13) of nests, we conducted a preliminary analysis of vegetation at nest sites versus non-use sites to examine possible selection features by Bicknell's Thrush. We suspected a priori that nest site selection was based primarily on woody stem density, as nest sites seemed to be characterized by high densities of balsam fir trees. Our analysis of the data did not confirm this, however, possibly resulting in part from the small sample size. Five nests were located along human-created edges, which may have reduced the number of stems found in the circular plots. In the non-use sites we found significantly more total green cover (<50cm tall) and fern cover, reflecting the more open, glade-like appearance of non-use sites.

In 1995 we kept detailed records of net hours, number of tape recorded playbacks with and without decoys, and passive captures on all study sites (Table 7). The low number of captures per playback and the higher passive capture rate were surprising. We plan to greatly reduce the future use of playbacks for capturing Bicknell's Thrushes and to rely more heavily on passive mist netting. This will allow us to more easily apply capture-recapture models to our data.

The long-term habitat monitoring plots on Mt. Mansfield may enable an understanding of changes that occur in the habitat over time. Several studies have documented severe declines of red spruce throughout the Northeast since the early 1960's (e.g., Siccama et al. 1982, Foster and Reiners 1983, Battles et al. 1992, Miller-Weeks and Smoronk 1993), as well as heavy mortality of balsam fir (Miller-Weeks and Smoronk 1993). Most of the hypotheses proposed to account for this decline involve the effects of atmospheric deposition and include: 1) soil acidification/aluminum toxicity; 2) spruce needle damage and disease; 3) general stress from reduced photosynthetic activity and secondary metabolite production; 4) excess nitrogen deposition; 5) complex high-elevation disease from the combined effects of high ozone concentrations, acid deposition and nutrient deficiencies; and 6) organic air pollutants (Krahl-Urban et al. 1989). The possible impacts of this habitat degradation on populations of Bicknell's Thrush and other subalpine bird species are unknown. Detection and assessment of such impacts will require long-term monitoring of both vegetation and avifauna.

Future Plans

In 1996 we will initiate radio telemetry studies of Bicknell's Thrush on two Mt. Mansfield plots (MANS and NDPO). Spot mapping of Bicknell's Thrush territories will be completed on RABR, MANS, NDPO, EQUI, BELV, PLAT and a new plot to be established south of the "forehead" on Mt. Mansfield. Point count censusing protocol will include a tape recorded playback of songs and call of the Bicknell's Thrush for 2 min. followed by 3 min. of listening after the present protocol of a 10 min. count. This will result in better detection of this species on point counts. Constant effort mist netting and nest monitoring will be conducted on three Mt. Mansfield study plots (RABR, MANS, and new plot).

Acknowledgments

We are grateful to Jon Atwood of Manomet Observatory for providing indispensable help with project design, field work, data analysis, technical support, and overall encouragement. We thank Jim Chace, Dan Lambert, Jim Goetz, Ken Levenstein, Dan Lambert, Dan Froelich, Tait Johansson, Chip Darmstadt, and Steve Faccio for their field assistance in 1995. Rick Paradis of the University of Vermont, Rob Apple of the Mt. Mansfield Co., and the Green Mountain Club all provided logistical support. Trevor Lloyd-Evans independently plotted spot mapping data for each year. This project was supported financially by the U.S. Fish and Wildlife Service, the U.S. Forest Service Northeast Experimental Station, the National Fish and Wildlife Foundation, the Vermont Monitoring Cooperative, the Vermont Community Foundation, the Plumsock Fund, the Wharton Trust, and the members and trustees of the Vermont Institute of Natural Science.

Table 1. Locations and summary descriptions of Bicknell's Thrush study areas in the northeastern United States.

Location	USGS 7.5 Quad	Study Plot ID	Elevation (m)	Plot Size (Ha)	Impacts [a] on Study Plot	Study [b] Methods	Number of Study Years
Mt. Mansfield, VT	Mansfield	MANS	1,160 - 1,190	8.8	1,3,4	1,2,3,4,5,6	5
Mt. Mansfield, VT	Mansfield	RABR	914 - 1,070	20	3	1,2,3,4,5,6	1
Mt. Mansfield, VT	Mansfield	NDPO	885 - 1,070	20	2,3	2,3,4,5,6	1
Mt. Mansfield, VT	Mansfield	OCTA	1,070 - 1,130	6	1,2,3,4	3,4	4
Belvidere Mtn., VT	Hazens Notch	BELV	960 - 1,000	16.5	3	1,3,4,5,6	2
Mt. Equinox, VT	Manchester	EQUI	1,100 - 1,160	13.5	3,4	1,3,4,5,6	2
Plateau Mtn., NY	Hunter	PLAT	1,130 - 1,175	12.2	3	1,3,4,5,6	1
Burke, VT	Burke	BURK	915 - 985	na	1,2,3,4	1,4,6	2
Okemo Mtn., VT	Mt. Holly	OKEM	945 - 1,020	na	1,2,3,4	1,4,6	2
Haystack, VT	Wilmington	HAYS	930 - 1,040	na	3	1,4,6	2
Mt. Hunger, VT	Stow	HUNG	1,005 - 1,080	na	3	1,6	1
Shrewsbury Mtn., VT	Killington	SHREW	1,005 - 1,130	na	3	1,6	1
Camel's Hump, VT	Huntington	CAME	1,130 - 1,230	na	3	1,6	5
Mt. Kearsarge, NH	Warner	KEAR	825 - 895	na	3,4	1,6	2
Whiteface, Mtn., NY	Lake Placid	WHIT	1,250 - 1,330	na	1,3	1,6	1

[a] 1-road(s), 2-ski area, 3-foot trails, 4-communications equipment/buildings.

[b] 1-point counts, 2-spot mapping, 3-nest monitoring, 4-color banding, 5-constant effort mist netting, 6-habitat monitoring. Not all methods used during all years of study on each site.

Table 2. Bicknell's Thrush pairs/40 ha determined by spot mapping (high and low indices) and point counts (n=5 counts, radius=50m) on 3 study areas, Mt. Mansfield, Vermont.

Study Plot and Census Method	1991	1992	1993	1994	1995
MANS Spot mapping (Low)		36	50	55	45
MANS Spot mapping (High)		52	59	65	53
MANS Point Counts	51	81.5	36	25.5	25.5
RABR Spot mapping (low)					20
RABR Spot mapping (high)					21.5
NDPO Spot mapping (low)					4
NDPO Spot mapping (high)					9

Table 3. Density estimates of Bicknell's Thrush in 1995 as determined from 5 point counts (50m radius) at each site, except PLAT and WHIT which contained 10 counts.

Location	BITH/40 Ha
WHIT	76.4
MANS	61.1
PLAT	40.7
RABR	30.6
BURK	10.2
EQUI	10.2
BELV	10.2
CAME	10.2
KEAR	0
HUNG	0
HAYS	0

Table 4. Annual return rates of AHY and HY Bicknell's Thrush on Mt. Mansfield, Vermont, 1992-95. Return rate defined as the percentage of birds banded during a summer that returned in a later year. Data from two plots (MANS and OCTA).

Year	No. Captured AHY	No. Returning AHY	Return Rate (%)	No. Captured HY	No. Returning HY
MANS1992	6	4	66.7	2	0
MANS1993	19	9	47.4	2	0
MANS1994	17	7	41.2	11	0
MANS1995	26	na	na	8	na
Total	68	19	45.2	23	0
OCTA1992	3	0	0	0	0
OCTA1993	5	1	2	0	0
OCTA1994	5	2	4	0	0
OCTA1995	5	na	na	0	na
Total	18	3	23.1	0	0

Table 5. Annual and total Bicknell's Thrush AHY return rates on small, isolated peaks in Vermont, 1994 and 1995. Return rate defined as the percentage of birds banded during a summer that returned in a later year.

Study Plot	No. Captured AHY		No. Returning AHY	Return Rate (%)
	1994	1995		
BURK	2	3	1	50
EQUI	2	6	2	100
HAYS	2	2	1	50
BELV	5	6	3	60
OKEM	7	4	2	28.6
TOTAL	18	21	9	50

Table 6. Number of individual Bicknell's Thrush captured each year (by age [a] and sex).

Sex	Unknown			Male			Female		
Age	HY	SY	AHY	SY	AHY	ASY	SY	AHY	ASY
MANS 1992	2	0	0	1	2	0	1	2	0
MANS 1993	2	0	0	1	11	2	0	4	1
MANS 1994	11	0	1	0	4	7	0	2	3
MANS 1995	10	1	2	3	4	8	3	4	2
OCTA 1992	0	0	0	0	3	0	1	2	0
OCTA 1993	0	1	0	0	3	0	0	1	0
OCTA 1994	1	0	0	1	2	0	0	0	1
OCTA 1995	1	0	0	0	1	2	0	2	0
BELV 1994	0	0	0	0	3	0	0	2	0
BELV 1995	0	0	0	2	0	2	1	0	1
BURK 1994	0	0	0	0	2	0	0	0	0
BURK 1995	0	0	0	1	0	1	1	0	0
EQUI 1994	0	0	0	0	2	0	0	0	0
EQUI 1995	0	0	1	2	0	2	0	0	1
HAYS 1994	0	0	0	0	1	0	0	1	0
HAYS 1995	0	0	0	0	1	1	0	0	0
OKEM 1994	0	1	0	2	2	0	0	2	0
OKEM 1995	0	0	0	1	0	2	1	0	0
NDPO 1995	0	0	0	1	2	0	0	1	0
PLAT 1995	1	1	1	2	4	3	0	1	2
RABR 1995	3	1	0	3	1	5	0	0	2

[a] HY= juvenile, SY= second year, AHY= after hatch year, ASY= after second year.

Table 7. Number of mist net hours (one 12m net hr = 1 hr.), tape broadcasts with and without decoys and capture success of each method during 1995.

All Study Areas Combined	Month						Total
	5	6	7	8	9	10	
No. broadcasts with decoy	35.0	143.0	2				198.0
No. captures with broadcast/decoy	3.0	23.0	1.0				27.0
% capture success	8.6	16.1	5.0				13.6
No. broadcasts only	8.0	9	12.0		1.0		111.0
No. captures w/ broadcast only	3.0	8.0					11.0
% capture success	37.5	8.9					9.9
Total net hours	33.6	1501.9	1442.1	2558.3	1799.3	660.4	7995.6
No. of passive captures	2.0	61.0	35.0	3.0	11.0		112.0
No. passive captures / 100 hours	6.0	4.1	2.4	0.1	0.6		1.4

Table 8. Success rate and cause of failures of Bicknell's Thrush nests monitored during this study and by Wallace (1939) on Mt. Mansfield, Vermont. Nest stages that were completed by at least one egg or chick were considered successful. Four nests of unknown status that were not occupied during this study are not included. Wallace's data are presented in parentheses.

Nesting Stage	Success	Depredated	Abandoned	Failed / Cause Unknown	Success (%)
Egg Laying	9(13)	1(0)	0(0)	1(0)	82(100)
Incubation	6(8)	1(4)	2(1)	0(1)	67(62)
Nestling	3(4)	2(3)	0(0)	1(1)	50(63)
Final	3(4)	4(7)	2(1)	2(2)	27(31)

Table 9. Clutch sizes, number of eggs hatched, number of fledglings, and chronologies of active nests monitored on Mt. Mansfield, Vermont during this study and by Wallace (1939). W = Wallace (1939); nests in this study indicated by I.D. number, study plot, year. Julian dates given.

Nest	Egg Period			Nestling Period			% Success
Nest	No. Eggs	Initiation Date	Incubation Period	No. Hatch	No. Fledge	Nestling period	
W1	3	169	171-?	0	0	---	0
W2	4	161	163-177	1	0	---	0
W3(a)	3	174	176	0	0	---	0
W4	4	162	164-178	4	0	---	0
W5	4	167	169-182	3	3	± 12 days	75
W6	4	before 173	---	0	0	---	0
W7	3	164	±166-179	3	0	---	0
W8	4	164	±166-179	2	2	9 and 10 days	
W9	3	before 176		0	0	---	0
W10	4	176	---	0	0	---	0
W13	3	169	±171-184	3	0	---	0
W14	3	192	194-206	3	3	---	100
W15	3	175	±177-190	3	3	10 days	100
Mean	3.4	170.3	13.1 days	1.7	0.9	10.5 days	
± SD	0.5	8.9	0.64	1.6	1.3	0.4	
1MANS92	3	167	169-181	2	2	181-192	67
1MANS93	4	165	168-179	4	0	---	0
1MANS94	4	165	---	0	0	---	0
2MANS94	4	165	---	0	0	---	0
1MANS95	3	178	180-192	3	0	---	0
2MANS95	3	182	184-198	3	0	---	0
1OCTA95	NA	168	170-182	2	1	182-194	50
1RABR95	3	162	164-174	3	2	174-184	67
2RABR95	NA	178	---	0	0		0
3RABR95	NA	188	---	0	0		0
Mean	3.4	171.8	11.8 days	1.7	0.5	11 days	
± SD	0.5	8.8	1.5	1.6	0.7	1.41	

Table 10. Bicknell's Thrush nest placement and concealment (n = 13) on Mt. Mansfield, Vermont. Nest heights for this study and Wallace (1939) compared. Wallace did not record other pertinent measurements for comparison.

Parameter	Range	Mean	± SD
Nest height (m)	1 - 2.85	1.51	0.58
Nest height (Wallace 1939)	0.9 - 3.7	2.1	0.87
Nest plant height (m)	1.8 - 3.39	2.46	0.51
Nest plant DBH (cm)	1 - 7.9	4.0	1.9
Concealment:			
west side	0 - 100	71.4	25.4
east side	40-100	68.8	22.2
south side	10 - 100	65	32.9
north side	5 - 100	59.2	30.7
above	50 - 100	85.3	16.9
No. of nest support branches	1 - 5	2.5	1.0
Diameter. of nest support branches (cm)	0.3 - 1.5	0.8	0.4
Nest distance from main stem (cm)	0 - 25	2.0	7.0
Nest distance from outer foliage of plant (cm)	28 - 110	50.8	24.8

Table 11. Comparison of microhabitat variables ($x \pm SD$) at Bicknell's Thrush nest sites (n = 13) with random non-use sites (n = 13) on Mt. Mansfield, Vermont, 1992-95.

Parameter	Nest Site	Random Site	P
5m radius woody stem density < 2.5 cm diameter at 10 cm height:			
Dead	7.15 ± 6.66	4.77 ± 11.59	
Balsam Fir	59.62 ± 39.33	52.38 ± 35.94	
Red Spruce	0.15 ± 0.55	0.10 ± 0.30	
White Birch	15.10 ± 13.1	10.23 ± 9.45	
Mt. Ash	0.62 ± 1.12	0.08 ± 0.30	
Mt. Shadbush	0.92 ± 3.04	0	
Mt. Maple	0	0.20 ± 0.60	
Mt. Holly	12.54 ± 26.24	18.31 ± 22.96	
Pin Cherry	0	0.10 ± 0.30	
Meadowsweet	0	2.10 ± 7.50	
5m radius woody stem density >2.5 cm diameter at 10 cm height:			
Dead	6.31 ± 7.80	4.70 ± 6.32	
Balsam Fir	117.54 ± 204.33	43.80 ± 37.42	
Red Spruce	0.40 ± 0.80	0.23 ± 0.44	
White Birch	12.80 ± 10.01	11.10 ± 13.33	
Mt. Ash	0.69 ± 1.40	0.38 ± 1.0	
Mt. Shadbush	1.10 ± 3.90	0	
Mt. Holly	1.23 ± 4.15	0.62 ± 1.33	
Pin Cherry	0	0.20 ± 0.60	
11.3m radius tree density >8-23 cm DBH:			
Balsam Fir	21.40 ± 14.22	20.62 ± 13.0	
Red Spruce	0.69 ± 1.44	0.31 ± 0.48	
White Birch	0.46 ± 1.13	1.69 ± 2.56	
Mt. Ash	0.23 ± 0.60	0	
Dead (>12-23)	13.62 ± 8.90	12.62 ± 8.42	
11.3m radius tree density >23-38 cm DBH:			
Balsam Fir	1.23 ± 2.52	2.15 ± 3.02	
Red Spruce	0	0.08 ± 0.30	
White Birch	0.15 ± 0.55	0.31 ± 0.63	
Dead	1.15 ± 1.41	2.92 ± 2.02	
5m radius ground cover[a] (%):			
Total	4.9 ± 1.2	5.5 ± 0.5	0.052
Shrubs	2.5 ± 1.1	2.5 ± 1.1	
Forbs	2.2 ± 0.7	2.2 ± 0.9	
Ferns	1.6 ± 0.8	2.3 ± 1.5	0.047
Grass/sedge	1.08 ± 0.3	1.08 ± 0.3	
Leaf litter	2.9 ± 1.2	2.5 ± 1.1	
Downed Logs (>12cm dia)	1.5 ± 0.5	1.4 ± 0.5	
Bare ground	1.4 ± 0.7	1.2 ± 0.4	
Litter depth (cm)	4.0 ± 1.2	2.9 ± 1.6	

[a] Index of percent coverage: 1=0-4, 2=5-24, 3=25-49, 4=50-74, 5=75-94, 6=95-100. Index values were compared with a Wilcoxon rank-sum test; all other comparisons made with a two-sample t-test.

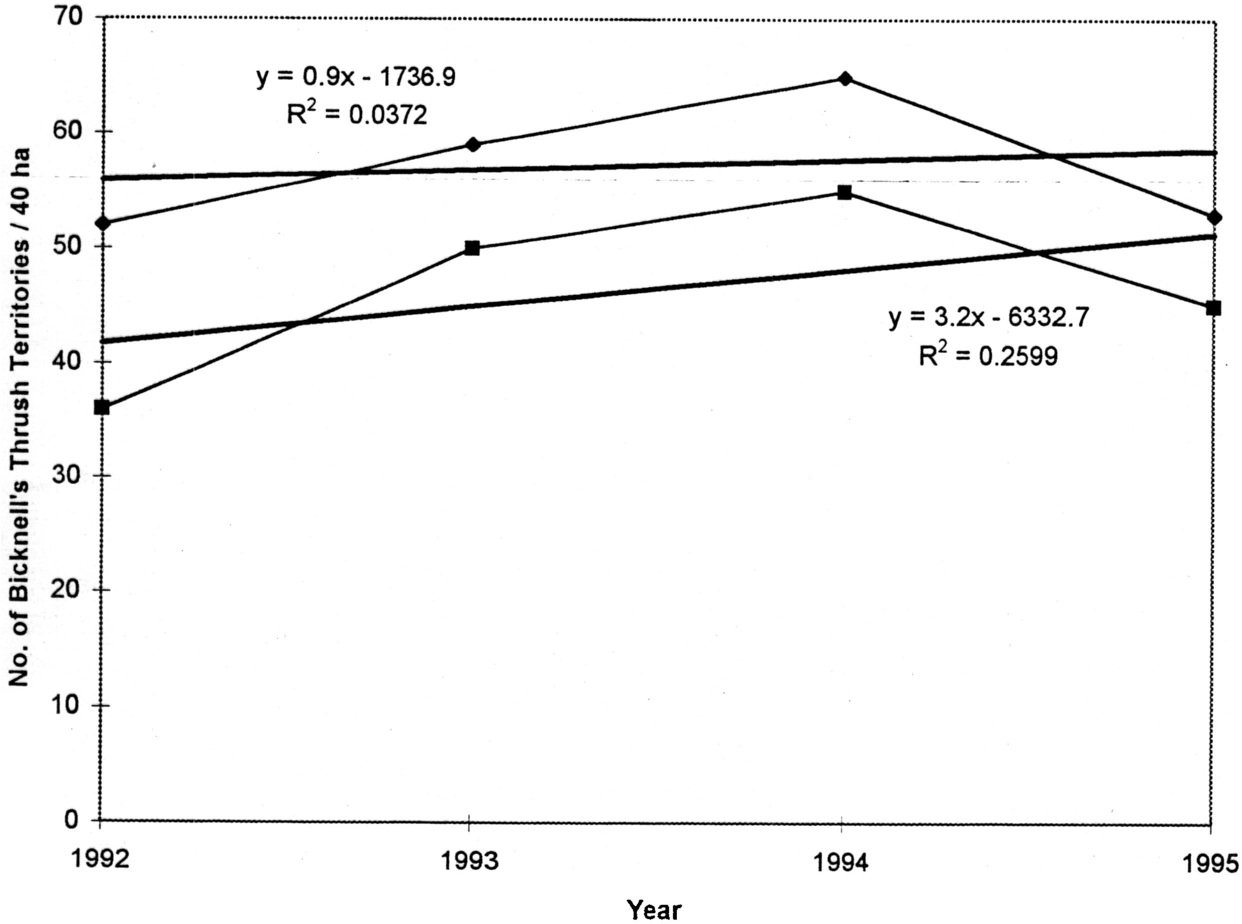

Figure 1. High and low density indices determined from spot mapping of Bicknell's Thrush on MANS study plot, Mt. Mansfield, VT.

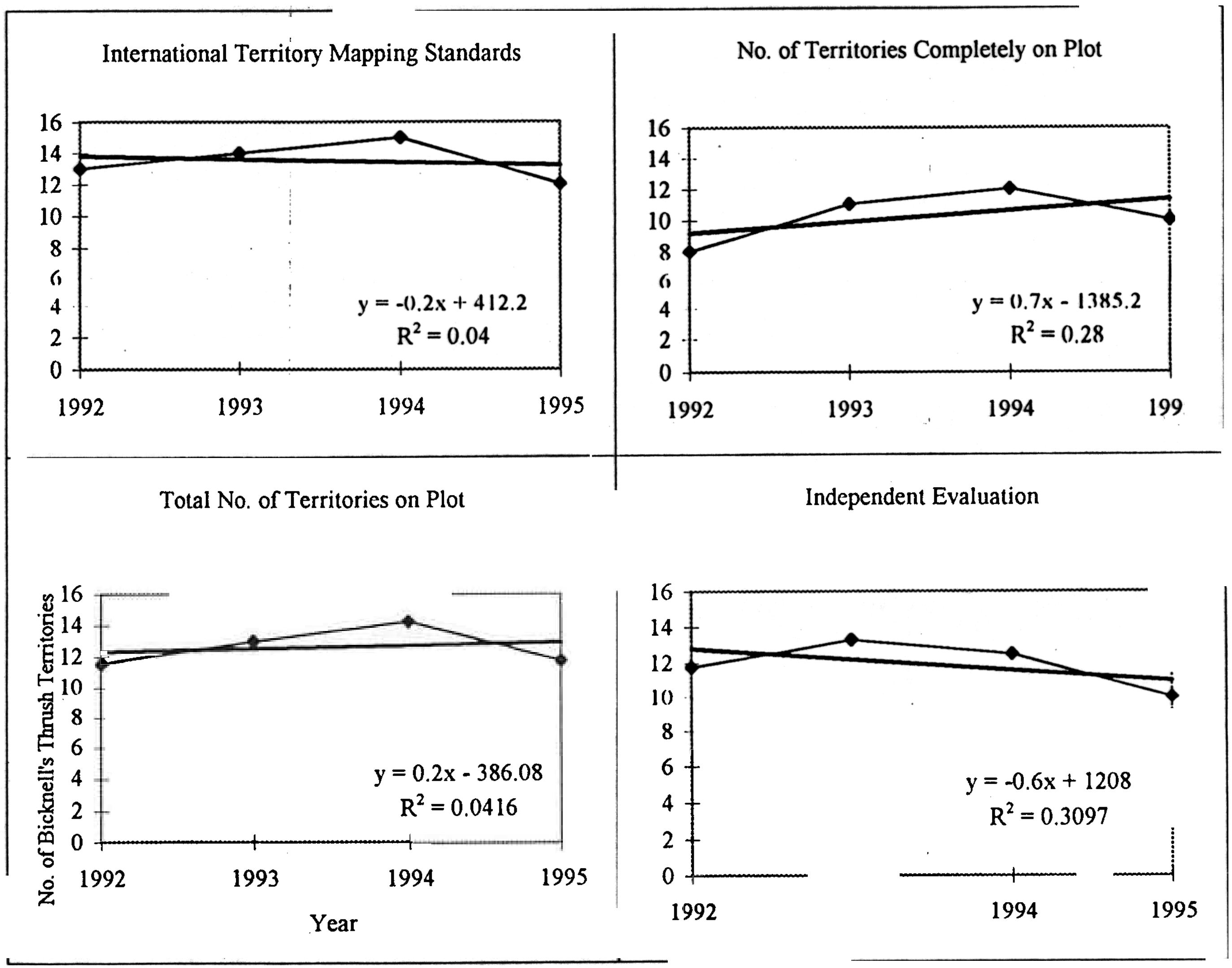

Figure 2. Density indices determined using four different analyses methods of spot mapping data from MANS study plot, Mt. Mansfield, VT

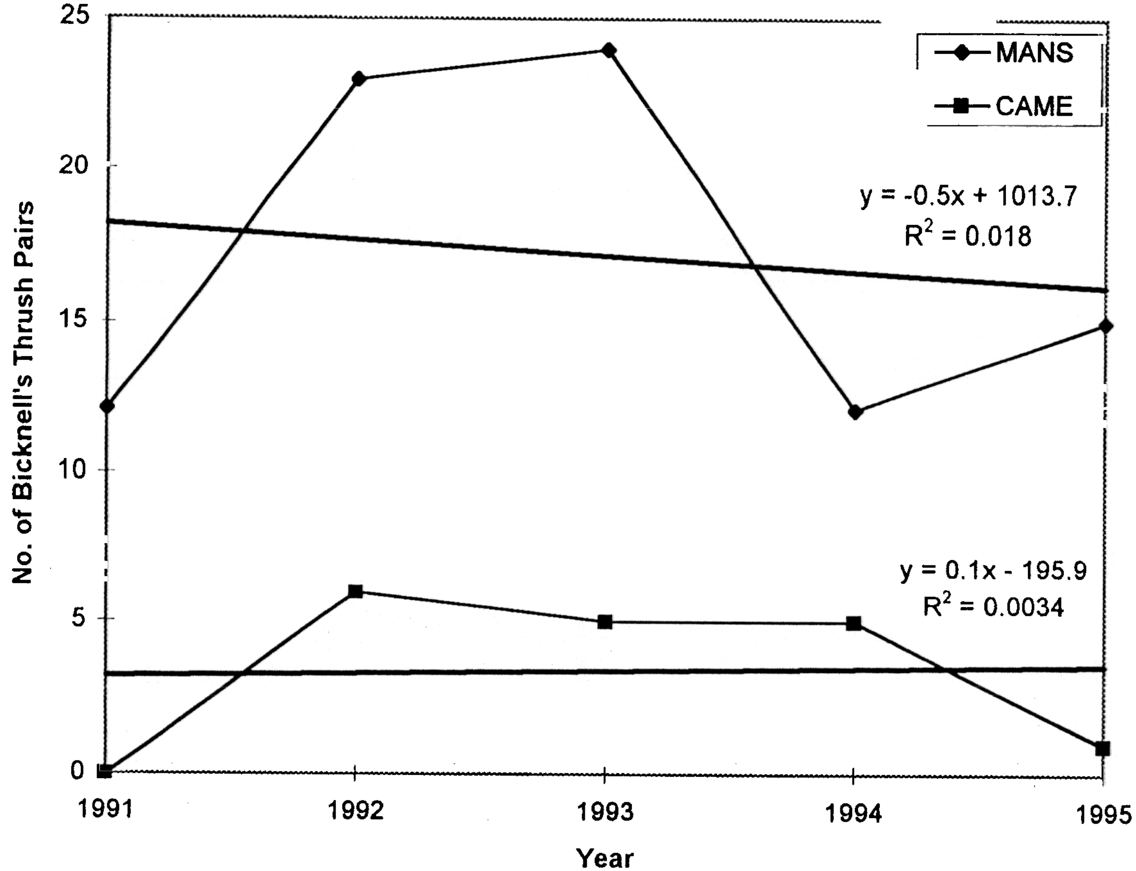

Figure 3. Number of Bicknell's Thrush pairs detected on unlimited distance point counts on Mt. Mansfield and Camel's Hump, Vermont (n = 5 counts at each site)

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