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POPULATION DENSITY, VOCAL BEHAVIOR, AND RECOMMENDED SURVEY METHODS FOR BICKNELL'S THRUSH

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ABSTRACT.—We studied territorial and vocal behavior of Bicknell's Thrushes (*Catharus bicknelli*) on Mt. Mansfield, Vermont, during June to September 1992 and in June 1993 to 1995. Birds sang and called consistently throughout the day during early-mid June. Later in the season, songs were given infrequently, with vocalizations (mostly call notes) being concentrated at dawn and dusk. Spot-mapping of vocalizing males yielded breeding density estimates 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. Other less labor-intensive techniques, including fixed-width point counts and fixed-width transects, generally resulted in lower density estimates. We recommend that future presence-absence surveys for Bicknell's Thrush in the northeastern United States be concentrated from 1–20 June. Surveys from late June through mid-September should be attempted only if observers are able to be on-site before dawn or after sunset. *Received 26 Jan. 1996, accepted 8 May 1996.*

Bicknell's Thrush (*Catharus bicknelli*), recently classified as a distinct species from the Gray-cheeked Thrush (*Catharus minimus*) (Ouellet 1993, American Ornithologists' Union 1995), historically nested from the Gulf of St. Lawrence, Gaspé Peninsula, Magdalen Islands, and Nova Scotia south to the mountains of New England and New York (Wallace 1939). Recent studies have suggested that the breeding range of this bird has been reduced in both the United States and Canada (Ouellet 1993; Atwood et al. 1996; J. Marshall, pers. comm.). The breeding habitat of Bicknell's Thrush consists predominantly of dense, stunted coniferous forest dominated by balsam fir (*Abies balsamea*) and red spruce (*Picea rubens*) (Wallace 1939, Atwood et al. 1996). In the northeastern United States, this vegetation type is restricted to mountaintops higher than approximately 915 m elevation (Wallace 1939). Not only are most of these areas somewhat inaccessible geographically, but the habitat itself is difficult to work within, being characterized by nearly impenetrable, dense stands of conifers that are often located on rugged, steep slopes. These logistic challenges have hindered attempts to estimate the current population size of Bicknell's Thrush or to clarify its distributional limits in the United States.

In this study we examine territorial and vocal behavior of Bicknell's

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Thrush in the context of potential techniques that might be used in future population and distributional surveys. In particular, we compare density estimates obtained through labor-intensive spot-mapping of countervocalizing, territorial males (Kendeigh 1944, Robbins 1970, Williams 1936) with estimates derived from fixed-width line transects (Emlen 1974, Kendeigh 1944) and point counts at fixed-radius circular plots (Anderson 1970, Anderson and Shugart 1974). Additionally, we describe studies of the influence of date and time-of-day on Bicknell's Thrush vocal behavior. On the basis of these results, we recommend a standard methodology for future work aimed at assessing the distribution and population status of this poorly known songbird.

METHODS

We established an irregularly-shaped, 8.8 ha study plot on the eastern portion of Mt. Mansfield, Chittenden Co., Vermont (44°32′N, 72°49′W), at approximately 1150 m elevation. Dominant woody vegetation consisted of balsam fir interspersed with limited amounts of red spruce, white birch (*Betula papyrifera cordifolia*) and mountain ash (*Sorbus* spp.). Boundaries of the plot were determined primarily by topography and the location of two pre-existing trails (Long Trail and Amherst Trail). The eastern edge was defined by a nearly vertical cliff face covered with dense balsam fir forest; the western edge followed a major ridgeline that separated suitable Bicknell's Thrush habitat from extremely stunted (<0.5 m high), "krummholz" vegetation located immediately to the west.

Because the plot's dense vegetation and rugged topography made it extremely difficult to leave the established trail system, we did not establish a standard grid system such as usually forms the basis for spot-mapping studies (Franzreb 1981b). Instead, we used compass bearings and tape measurements to map the locations of known "vantage" points throughout the plot. Compass bearings and distance estimates were then taken from these locations for all Bicknell's Thrushes that were seen or heard; these data were later transferred to a master map of the area.

Spot-mapping was conducted on 12 dates in 1992 (11–18, 27–30 June). To validate our 1992 data and to assess changes in density between years, we also spot-mapped on 8 dates in 1993 (8–10, 16, 17, 23, 24, 29 June), 14 dates in 1994 (5–9, 14–17, 20, 22, 23, 29, 30 June), and 16 dates in 1995 (1, 5–8, 12–14, 16, 19, 20, 22, 23, 27 June). Observations made throughout the day were used to estimate the number of territorial males, here assumed to represent breeding pairs. Only the locations of stationary birds were included. Simultaneous registration of two or more vocalizing birds was used as the primary basis for discrimination between adjacent individuals (Robbins 1970). We mapped positions of both singing and calling thrushes, because our observations showed that both types of vocalization were used to indicate territorial status. Although we obtained evidence of occasional calling by females, we are confident that the great majority of calls registered in each year were given by males.

To assess the utility of other less labor-intensive methods for estimating breeding densities of Bicknell's Thrush, we conducted fixed-width line transects and point counts made at fixed-radius circular plots on 10 dates (11–13, 15–18, 27–29 June) in 1992. Transects and point counts, each of which required approximately 1 h to complete, were simultaneously conducted three times per day: morning (beginning approximately 1 hour after sunrise), mid-day (beginning approximately 8 h after sunrise), and evening (beginning approximately 30 min before sunset). Only spot-mapping data from 1992 were used to compare with other census techniques.

The transect line, approximately 1.1 km in total length, followed existing trails that passed through the study plot and formed its western boundary. A single observer walked slowly along the transect and recorded all Bicknell's Thrushes that were seen or heard within 30 m on either side of the trail. No recorded calls or "spishing" were used to elicit responses. The extremely stunted vegetation immediately west of the study plot's western border was deemed unsuitable for Bicknell's Thrushes; consequently, this section of the transect (0.5 km in length) was limited to a strip only 30 m wide, located entirely east of the transect line. A total of 5.1 ha were included in the area sampled by the fixed-width line transect method.

A total of seven 30-m radius circular plots ≥100 m apart were also located in the study area. The positions of these plots were determined by trail and terrain considerations and not by vegetation characteristics or observations of Bicknell's Thrushes. Boundaries of circular plots were marked with flagging tape. A single observer recorded all Bicknell's Thrushes heard or seen during a 5-min period at each plot; recorded calls or "spishing" were not used to elicit vocalization. This basic technique was modified on four dates (11, 15, 18, 27 June) to include the use of recorded playbacks as a means of eliciting Bicknell's Thrush response. After completion of a standard 5-min count, a second count of 5-min duration was conducted in which a tape recording of calls and songs was played for the initial 3 min. A total of 2.0 ha were included in the area sampled by the circular plot method.

To examine the effects of date and time-of-day on Bicknell's Thrush vocal behavior, counts of all songs and calls heard during 5-min periods were recorded at 30-min intervals on 14 dates (11–13, 15–18, 27–29 June; 6, 14, 29 July; 16 September) in 1992. The first of these counts on each date occurred approximately 20 min before sunrise; the last approximately 90 min after sunset. Vocalization counts were conducted near the "Octagon" on Mt. Mansfield (elevation approximately 950 m); 7–10 Bicknell's Thrush territories were estimated to be within hearing distance of this site.

RESULTS

Density estimates.—Spot-mapping of vocalizing males 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. The territories of 8, 11, 12, and 10 pairs were located entirely within the borders of the plot in 1992, 1993, 1994, and 1995, 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. 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.

Mean densities calculated from point counts conducted without playback elicitation were consistently lower than the maximum estimate derived from spot-mapping but were comparable to the results of spot-mapping when edge territories were excluded (Table 1). Mean values obtained

TABLE 1
DENSITY ESTIMATES FOR BREEDING BICKNELL'S THRUSHES BASED ON CIRCULAR PLOTS AND LINE TRANSECTS

Survey technique	Time of day: Morning	Mid-day	Evening
Circular plots (no playback) (N = 10)	36 ± 28.4[a] 65–97%[b]	8 ± 13.9 15–22%	32 ± 25.6 58–86%
Circular plots (with playback) (N = 4)	48 ± 23.3 87–130%	66 ± 78.2 120–178%	35 ± 19.6 64–95%
Line transects (N = 10)	23 ± 14.1 42–62%	5 ± 7.4 9–14%	18 ± 11.7 33–49%

[a] Mean density (pairs/40 ha) ± 1 SD.
[b] Mean density expressed as percent of estimates calculated from spot-mapping results (37–55 pairs/40 ha).

in the morning (36 pairs/40 ha) were slightly higher than those obtained in the evening (32 pairs/40 ha). Mean mid-day results (8 pairs/40 ha) greatly underestimated densities calculated through spot-mapping. The modal density obtained for both morning and evening point counts over the 10 days of the study was 20 pairs/40 ha. Bicknell's Thrushes were not detected within any of the circular study plots during 10% of morning counts, 70% of mid-day counts, and 20% of evening counts.

Use of playback recordings increased the density estimates obtained through point counts, but, in general, the results were still less than the maximum estimate derived through spot-mapping (Table 1). Morning and evening counts resulted in mean density estimates of 48 pairs/40 ha and 35 pairs/40 ha, respectively. Because of a single count in which playback recordings stimulated an unusually large number of territorial interactions, the mean density estimate based on mid-day counts (66 pairs/40 ha) exceeded the maximum estimate based on spot-mapping. Using playback elicitation, the modal densities obtained on morning and evening counts throughout the study period were 40 pairs/40 ha and 20 pairs/40 ha, respectively. All point counts (morning, mid-day, and evening) that made use of playback recordings successfully detected at least one Bicknell's Thrush on each of the four days surveyed using this technique.

Line transects produced the lowest density estimates (Table 1). Results based on morning transects (23 pairs/40 ha) were higher than those obtained in the evening (18 pairs/40 ha). Transect data collected at mid-day underestimated (5 pairs/40 ha) actual densities as calculated through spot-mapping. Bicknell's Thrushes were not detected on 10% of morning transects, 50% of mid-day transects, and 10% of evening transects.

Vocal behavior.—At the time of our preliminary visit to Mt. Mansfield on 2 June 1992, Bicknell's Thrushes sang and called frequently throughout the day, although no quantitative data were collected. According to Green Mountain Club summit caretakers stationed on the mountain, singing Bicknell's Thrushes had been evident for at least one week prior to this date. In 1993, 1994, and 1995 several individuals were heard calling sporadically during the mornings of our initial site visits that ranged from 25 to 27 May. During mid-June (11–18 June) 1992, Bicknell's Thrushes called and sang consistently throughout the day, with only 18% of the total vocalizations (N = 7998) being restricted to the first and last 2-h periods of the day (Fig. 1). On 15 June, under full moon conditions, Bicknell's Thrushes were silent from 03:00 until the first song was given at 03:57. Of 238 5-min counts conducted during mid-June between 04:30 and 21:30, we failed to record any Bicknell's Thrush vocalizations in only 25 (10.5%) instances.

By late June (27–29 June) the frequency and consistency of Bicknell's Thrush vocalizations declined sharply, and songs, in particular, were given only rarely (Fig. 1). Of the total vocalizations (N = 807) recorded on these dates, 28% occurred during the first and last 2-h periods of the day. We failed to record a single Bicknell's Thrush vocalization during 60 (58.8%) of 102 5-min counts made during late June.

There appeared to be some resurgence in Bicknell's Thrush vocal activity, including both songs and calls, during July (6, 14, 29 July). Of the total vocalizations (N = 1650) detected on these dates, 31% were given during the first and last 2-h periods of the day (Fig. 1). We failed to record a single Bicknell's Thrush vocalization during 51 (50.0%) of 102 5-min counts made during July.

No vocalization samples were obtained during August. On 16 September, Bicknell's Thrushes called inconsistently, and gave no songs during the sampling periods (Fig. 1). Of the total vocalizations (N = 537) recorded on this date, 20% were given during the first and last 2-h periods of the day. We failed to record any Bicknell's Thrush vocalizations during 15 (51.7%) of 29 5-min counts on 16 September.

DISCUSSION

Surveys for Bicknell's Thrush, aimed at determining presence or absence, or at estimating population size, are hindered by significant logistic challenges. In the United States, known breeding habitat occurs almost exclusively on mountaintops of more than approximately 915 m elevation (Wallace 1939; Atwood et al. 1996). Of over 500 such high elevation sites in New York, Vermont, New Hampshire, Maine and Massachusetts that potentially support Bicknell's Thrush, most are accessible only by hiking, and many lack any established trail system. In addition to its

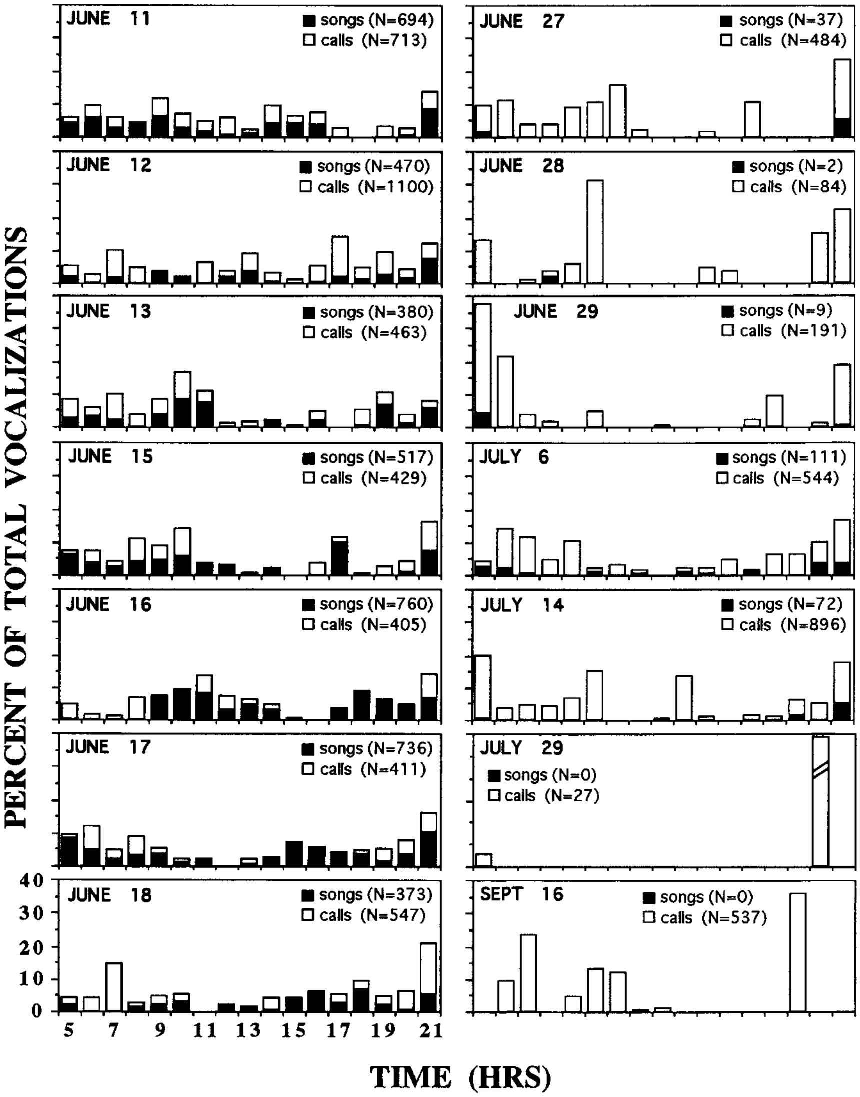

FIG. 1. Daily and seasonal variation in Bicknell's Thrush vocalizations. Axes of all graphs on same scale as shown for 18 June.

frequent occurrence on difficult-to-access peaks, Bicknell's Thrush nesting habitat, which generally consists of nearly impenetrable thickets of stunted coniferous forest located on steep, rugged terrain, is very difficult to work within. Wallace (1939) commented that "only a freak ornithologist would think of leaving the trails [on Mt. Mansfield] for more than a few feet [due to] the discouragingly dense tangles" of vegetation. Furthermore, the time period in which surveys for Bicknell's Thrush may be effectively conducted is constrained by potentially harsh, high-elevation weather conditions coupled with a brief breeding season. For example, Davenport (1903) described Mt. Mansfield's weather during June 1902 as being "in whole or part rainy . . . with high winds often making it impossible to keep one's footing in the open on the summit."

As a result of our study and data included in Wallace's (1939) classic life history work, we recommend the following protocol for conducting presence-absence surveys for Bicknell's Thrush. Sites in New England and New York should ideally be visited between 1–20 June, during which time songs and calls are consistently given throughout the day. In northern parts of the species' Canadian breeding range, surveys should be conducted several days later than this (Ouellet, pers. comm.). Although Bicknell's Thrush may be present on its United States breeding grounds as early as 17 May (Rimmer and McFarland, unpubl. data), the possibility of northward-bound migrants cannot be excluded until early June (Wallace 1939). Because vocal activity becomes more sporadic later in the season, especially during the middle portion of the day, surveys conducted from late June through mid-September should be attempted only if the observer is able to be present on site at dawn or dusk, and is familiar with the call notes and song of Bicknell's Thrushes. Especially during this time period, we recommend use of playback recordings of songs and calls as a means of eliciting vocal response.

Our vocalization studies failed to show any strong effects of varying weather conditions on singing or calling behavior. Bicknell's Thrushes vocalized consistently in all but the most severe weather during early and mid June. We thus found no evidence to support Wallace's (1939) assertion that "this mist-loving bird has acquired a well-founded reputation for singing more in damp or rainy weather than on clear, sunshiny days." We do, however, recommend that field observers avoid conditions of strong winds (>15–20 knots), moderate to heavy precipitation, and cold temperatures, especially in combination. Under such conditions, Bicknell's Thrush vocalize less frequently, and vocalizations are more difficult to detect.

Although Wallace (1939) suggested that Bicknell's Thrush begins its southward, fall migration in mid to late September, the extent of postbreeding dispersal prior to the onset of actual migration is unknown. At the present time, we tentatively suggest that records obtained in late August and early-mid September in areas of suitable breeding habitat probably represent birds on breeding or natal sites. However, such observations may also include wandering individuals, and therefore may be of less value as documentation of breeding distribution than records obtained earlier in the summer.

We believe that surveys directed toward actual population censuses of Bicknell's Thrushes throughout their breeding range are impractical, given the extensive areas which must be visited and the difficulties associated with field work on these sites. Instead, we recommend that future population estimates be based on (a) calculation, using satellite or aerial photography, of the extent of suitable habitat, and (b) density estimates obtained from representative sites selected throughout the species' breeding range. We further recommend that a standardized monitoring program be established on a subset of northeastern United States peaks for detection of population trends. This scheme should include sites located throughout the species' range, characterized by varying amounts of subalpine spruce-fir habitat and with differing degrees of isolation from other high elevation areas.

Line transects and point counts both underestimated the densities of Bicknell's Thrushes as compared with the maximum density estimate calculated from spot-mapping of territorial males. Point counts conducted in the morning and evening without playback elicitation yielded results that best approximated the minimum density estimate obtained through spot-mapping. Point counts that made use of playback recordings frequently resulted in inflated density estimates relative to the minimum value obtained through spot-mapping. Our results indicated that fixed-width line transects were the least effective method of estimating the breeding density of Bicknell's Thrushes.

Because we were attempting to evaluate techniques that could provide consistent results even when used by relatively inexperienced observers, we rejected the variable-width transect and variable-width circular plot survey methods that have generally been superior to fixed-width techniques (DeSante 1981; Edwards et al. 1981; Franzreb 1981a, b). Variable-width methods require observers to estimate distances to unseen, vocalizing birds; we found the volume of Bicknell's Thrush vocalizations to be so variable that even trained observers were sometimes unable to estimate accurately distances beyond approximately 30 m. We believe that unlimited distance point counts (e.g., Blondel et al. 1981) provide the most feasible means to obtain abundance indices and assess population trends of Bicknell's Thrushes on a rangewide basis. These types of count eliminate difficulties of distance estimation, are much less labor intensive than spot mapping, and are well suited for use in a single habitat type over multiple years (Blondel et al. 1981).

Based on our field experience with Bicknell's Thrushes, we believe that use of tape recorded playbacks may increase the efficiency of detecting the species, when present, and may lead to more accurate counts, as suggested for other species by Marion et al. (1981) and Falls (1981). We recommend that future censuses of Bicknell's Thrushes be conducted as standardized series of unlimited distance point counts. Counts at each point should include an initial 5- or 10-min period of listening, followed by a 1-min taped broadcast of songs and calls and an additional 4-min listening period. Thrushes detected during both portions of each point count should be tallied separately, to compare the relative efficiency of both methods and to allow comparability with other censuses that may not employ tapes.

The density estimates we calculated from spot-mapping data on Mt. Mansfield in 1992 to 1995 were higher than those reported from two other similar studies of this species in New Hampshire. Morse (1979) recorded Bicknell's Thrush densities of 22 pairs/40 ha on Mt. Osceola, while Sabo (1980) estimated only 4 pairs/40 ha on Mt. Moosilaukee. However, our data may not be strictly comparable to those of other studies due to differences in sampling frequency and technique (Rimmer, unpubl. data), seasonal timing of censuses (Morse 1979), plot size (Morse 1979, Sabo 1980), and elevational and habitat gradients over which sampling occurred (Morse 1979; Sabo 1980; Rimmer and McFarland, unpubl. data). We believe that our spot-mapping data, from which two independent observers calculated similar numbers of territories in 1992–1995, closely approximated actual Bicknell's Thrush densities on the study plot. Marchant (1981) reported that edge-effects in spot-mapping studies tended to inflate density estimates by incorrectly including 10–27% of "edge clusters" that do not strictly belong to the plot. Discounting 27% of partial territories in this study results in maximum estimates of 48 pairs/40 ha in 1992, 57 pairs/40 ha in 1993, 62 pairs/40 ha in 1994, and 55 pairs/40 ha in 1995. We believe these to be more accurate than our minimum values calculated by excluding all partial territories.

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 and may reflect unusually high densities on Mt. Mansfield, which we believe supports >250 pairs. Further study of Bicknell's Thrush territorial behavior, based on observation of color-banded or radio-marked birds, is clearly warranted, as are studies of possible geographic differences in breeding density and habitat selection.

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