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The potential of acoustical recordings as a means of monitoring breeding birds

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Abstract

Current methods of surveying bird populations in forests require expert observers with excellent hearing ability. As many monitoring requirements can be met by species presence/absence data and indices of population density, we tested the potential of audio recordings to supply such data by comparing birds heard on recordings with field observations made at the same time or at different times. Data on species presence/absence obtained from field observations and from recordings made at the same sample points and at the same time corresponded closely. Data obtained by the two methods at the same sample points but on different days did not differ more than field observations made on different days. Audio recordings show promise as a bird population monitoring technique. They can be made by people with no knowledge of birds and can be interpreted later by those expert in bird identification.

Introduction

Concern over the impacts of both habitat change and habitat loss on the breeding and wintering ranges of migratory songbird species has led to increased interest in monitoring local songbird populations. Such monitoring requires quantitative data on the status and distribution of songbird species, the collection of which is beset with many problems (Scott and Ralph 1981).

Surveys of forest bird species are particularly difficult because of the limited visibility caused by dense vegetation. During the breeding season, however, bird species exhibit two behavioural characteristics that facilitate population surveys: they are sedentary, defending territories around their nests, and they sing and make calls as key parts of their territorial defence strategy. Therefore, each breeding season provides a window in time when surveys of breeding birds are possible. The dates embracing this window vary among species and localities: in the forests of the Prairie provinces of Canada, the period of territorial defence including singing extends from the third week in May to the second week in July, approximately six weeks. All surveys of forest songbirds must be made within that short period if they are to capture the peak of singing activity for the majority of species.

Identification of birds from their songs and calls is a learned skill that requires considerable experience (Raitt 1981), and even experienced people may be limited by hearing problems (Cyr 1981). Thus, the number of people who are qualified to conduct forest bird surveys is limited, and the amount of survey work that can be accomplished by those few people in six weeks is not great. The problem is compounded by the fact that many qualified birders are amateurs or biologists who are available for breeding bird surveys only part-time, if at all.

Many different survey techniques have been developed to obtain information on bird populations using available time and resources (Ralph and Scott 1981). If data on the number of birds per unit area are essential, appropriate techniques include spot mapping of territories, fixed- and variable-width transects, and circular plots of fixed and variable radius. If such data are not absolutely required, distribution among localities and habitats can be ascertained from species presence/absence lists. Number of species is also a reasonable predictor of diversity, whereas frequency of occurrence in a series of samples is a rough index of density (Bart and Klosiewski 1989). The potential therefore exists to obtain useful information from recordings of singing and calling birds during the breeding season. Although the recordings would require interpretation by people experienced in bird vocalizations, they could be made in the field by people without specialized knowledge of the subject. This would allow scarce specialists to apply their expertise not only during the short breeding season but throughout the year.

The use of recorded vocalizations in bird studies is widespread (Kroodsma and Miller 1982). Specialized microphones developed for recording birds can be used with very compact but good quality tape recorders. The present study was aimed at testing and evaluating the performance of recording equipment by obtaining recordings of birds for laboratory use and evaluating the inventory potential of the recorded vocalizations.

Materials and methods

This study was conducted as part of a larger study of bird use of spruce (*Picea* spp.)–dominated forest stands of various ages. The locale of the study was the McLeod Working Circle of the Forest Management Area leased to Weldwood of Canada Ltd., situated south of Hinton, Alberta. For the purposes of the main study, grids of sample points were established at a series of sites in young, mature, and old spruce stands. Each grid consisted of 12 sample points 300 m apart. Bird surveys were conducted at the sample points using the variable-radius

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Table 1
Number of bird species detected by field observation and from recordings made at the same time at a young spruce stand (Y1) near Hinton, Alberta, 18 June 1991

	Sample points											
	1	2	3	4	5	6	7	8	9	Total	Mean	%
Total no. of species detected	14	14	12	10	11	12	11	10	16	110	12.2	100
No. of species observed	12	13	9	9	10	11	10	8	13	95	10.6	86
No. of species recorded	12	11	9	10	11	9	8	6	12	88	9.8	80
No. of species observed and recorded	10	11	6	9	10	7	7	4	9	73	8.1	66
No. of species observed but not recorded	2	2	3	0	0	4	3	4	4	22	2.4	20
No. of species recorded but not observed	2	1	3	1	1	1	1	2	3	15	1.7	14

Table 2
Number of bird species detected by field observation and from recordings made at the same time at a mature spruce stand (M3) near Hinton, Alberta, 15 June 1991

	Sample points														
	1	2	3	4	5	6	7	8	9	10	11	12	Total	Mean	%
Total no. of species detected	4	3	14	9	10	5	10	6	8	8	8	6	91	7.6	100
No. of species observed	3	3	11	8	8	5	9	5	7	7	7	4	77	6.4	85
No. of species recorded	3	2	11	7	8	5	7	6	7	8	5	5	74	6.2	81
No. of species observed and recorded	2	2	7	6	6	5	6	5	6	7	4	3	59	4.9	65
No. of species observed but not recorded	1	1	3	2	2	0	3	0	1	0	3	1	17	1.4	19
No. of species recorded but not observed	1	0	4	1	2	0	1	1	1	1	1	2	15	1.3	16

circular plot method (Reynolds et al. 1980). On two occasions, recordings were made on a site at the same time that the variable-radius plot data were taken. On three other occasions, recordings were made at variable-radius plot sample points within 1–3 days of variable-radius plot surveys. All surveys were made in the morning between one half-hour before daybreak (about 05:00 hours Rocky Mountain Daylight Saving Time) and 09:30 hours.

Equipment used for recording birds consisted of a "professional Walkman" cassette tape recorder (Sony Model No. WMD3) with accessory speakers (Sony Model No. SRS-77G) and earphones for field use and a "Longear Mini" microphone (Applied Nature Systems, Gibsonia, Pennsylvania).

At recording locations, the microphone was fastened to a stake with a heavy rubber band 1.5 m above the ground. The microphone was pointed in the direction of the next sample point in the grid to avoid bias. The operator joined the microphone and recorder with a 5-m-long extension cord and stepped back 4 or 5 m to reduce extraneous noise as much as possible. The operator then checked to see if the equipment was operating and recorded the location, date, time, and weather conditions. The equipment was allowed to run for 10 minutes. If unusual sounds occurred, such as a wind gust or a large mammal breaking brush in passing, the operator would record the source of the noise. One of us (DRF) identified and plotted locations of birds for the variable-radius plot field survey and also identified the bird vocalizations recorded on the tapes to minimize differences in identification. Recordings were made by EST.

Comparisons between recordings and the variable-radius plot field surveys were limited to data on the presence or absence of species and, for species present, whether there was one individual or more than one. We did not try to estimate the total number of birds heard on recordings taken at sites where more than one of a species was calling, because birds sometimes move between calls or are calling from locations very close together, making it difficult to determine from the tape the exact number of individuals involved. In a few cases, birds seen and included in the variable-radius plot survey did not vocalize. Such observations were not included in the lists to be compared with those obtained from the recordings.

Results

At two sets of sample points, we made recordings at the same time as observations for the variable-radius plot survey. At the young spruce site (Y1), 10–16 species (mean 12.2) were detected at each sample point when all species found by either method were combined (Table 1). Three to 15 species (mean 7.6) were found at the mature spruce site (M3) (Table 2). Those values were taken as 100%, and the numbers of species in other categories were compared with those values. Data obtained by the two methods corresponded closely. The proportions of all detected species that were noted by the field observer were 86% and 85% at the two sites, respectively (Tables 1

Table 3
Comparison of number of bird species detected by field observation and from recordings made 1–3 days apart in young (Y1), mature (M2), and old (O2) spruce stands near Hinton, Alberta, June 1991

	Study sites		
	Y1	M2	O2
Mean total no. of species detected	11.0	11.3	10.3
% of total no. of species observed	72	81	74
% of total no. of species recorded	55	66	68
% of total no. of species observed and recorded	26	47	43
% of total no. of species observed but not recorded	45	34	32
% of total no. of species recorded but not observed	27	19	26
No. of sample points	8	8	8
Date of field observations	5 June	10 June	12 June
Date of recordings	6 June	7 June	10 June

and 2), slightly larger than the 80% detected from tapes recorded at the same time. The proportions of species that were both recorded and observed at the same sample points were 66% and 65% at the two sites. The observer heard calls of some birds that were not detectable on the recordings: these amounted to 20% and 19% of total detections at the two sites. On the other hand, the recordings picked up some species not heard by the observer in the field—14% and 16% of total detections at the two sites. Although the species detected by both methods overlapped by almost two-thirds on average at each point (Tables 1 and 2), an average of one or two species picked up by each method were not detected by the other.

As might be expected, observations and recordings made on separate days were less comparable (Table 3). The number of species obtained from recordings trailed the number of species observed. The proportions of species detected at each point by both methods ranged from 26% to 47%, whereas the proportion of species detected from recordings alone ranged from 19% to 27%. These percentages were comparable with those resulting from two sets of field observations made on different days by the same observer (Table 4). It is probable that the differences in Table 3 result at least as much from the different days and times during the morning hours when the points were surveyed as from the different methods employed.

Whereas species occurrence at individual sample points could differ substantially depending on the method used (Tables 1 and 2), there was considerable agreement in the species list compiled from a series of sample points surveyed in the same forest stand (Table 5). The nine points sampled on Site Y1 (30-year-old spruce) differed on only two species, whereas the total number of species was the same (22). In the mature spruce stand (Site M3), the recordings failed to detect four species that the observer heard in the field and detected one species that was not observed.

The number of individuals of each species at each sample point from sites Y1 and M3 was categorized as 0, 1, or >1. Densities determined by observation and from recordings were compared using the sign test (Steel and Torrie 1960). No significant differences ($p < 0.05$) in density ranking were found. Therefore, bird species may be assigned to those three density categories as accurately from recordings as from field observations.

Discussion

There are several reasons why species and numbers of birds detected by observation and from recordings taken at the same time differed somewhat. First, the observer sometimes saw a bird before it called or sang and would thus listen closely for that particular species. Secondly, whereas the Longear Mini microphone can be expected to register sound from an oval-shaped area with the long axis in the direction in which it is pointed (Wickstrom 1982), the human observer probably receives sound more equally from all directions. Thus, it is possible for the recording equipment to miss birds heard by the observer if they were calling from behind the microphone or at right angles to its direction of orientation. On the other hand, the recording could register bird vocalizations from the direction in which the microphone was aimed that were out of the hearing range of the observer.

An example of the effect of microphone directionality can be seen in Table 5: the most serious difference between the observed and recorded list of species is the absence of the Northern Waterthrush *Seiurus noveboracensis* from the recordings on Site M3, where the observer detected that species at three sample points. The Northern Waterthrush songs came from the direction of a creek that parallels the sample grid. The orientation of the microphone forward along the line of travel meant that the instrument was pointed at right angles to the waterthrushes. However, at one of the same sample points, the microphone detected a Western Wood-Pewee *Contopus sordidulus* that was not detected by the field observer. It therefore appears that the human ear and the Longear Mini microphone are registering sound from a somewhat different volume of space and thus may occasionally be expected to detect different birds from a given sample point.

Other factors possibly influencing bird detection include the effect of forest structure on relative ability of the human ear and the microphone to register sounds. The species list from the young spruce stand (Y1) was similar for both survey methods (Table 5); in comparison, five discrepancies occurred in the lists for the mature spruce stand (M3), where the volume of tree trunks and foliage was greater and differently distributed in space, particularly vertically.

Observations and recordings taken on different days at the same sample points (Table 3) showed much less overlap in species than data collected concurrently. Such differences are to be expected, because not all birds will

Table 4
Comparison of number of bird species recorded in a young spruce stand (Y1) near Hinton, Alberta, by the same observer on different days, June 1991

	Sample points														
	1	2	3	4	5	6	7	8	9	10	11	12	Total	Mean	%
Total no. of species detected on both dates	13	13	11	19	16	14	13	14	12	17	12	15	168	14.0	100
No. of species observed on 5 June	4	7	5	11	8	10	8	10	9	11	8	10	101	8.4	60
No. of species observed on 18 June	12	8	9	16	13	10	9	10	11	10	8	13	129	10.8	77
No. of species observed on both days	3	3	3	8	5	6	4	6	8	4	4	8	62	5.2	37
No. of species observed on 5 June but not on 18 June	1	4	2	3	3	4	4	4	1	7	4	2	39	3.3	23
No. of species observed on 18 June but not on 5 June	9	6	6	7	8	4	5	4	3	6	4	5	67	5.6	40

Table 5
Frequency of occurrence of bird species detected by field observation and from recordings made at the same time in young (Y1) and mature (M3) spruce stands near Hinton, Alberta, June 1991

Species	Site Y1		Site M3	
	Observed	From recordings	Observed	From recordings
Common Snipe *Gallinago gallinago*	2	1	0	0
Northern Flicker *Colaptes auratus*	3	1	0	0
Three-toed Woodpecker *Picoides tridactylus* or Black-backed Woodpecker *Picoides arcticus*	0	0	1	0
Yellow-bellied Flycatcher *Empidonax flaviventris*	1	1	1	0
Alder Flycatcher *Empidonax alnorum*	0	1	0	0
Western Wood-Pewee *Contopus sordidulus*	0	0	0	1
Olive-sided Flycatcher *Contopus borealis*	1	1	3	4
Gray Jay *Perisoreus canadensis*	4	6	5	5
Common Raven *Corvus corax*	2	1	0	0
Boreal Chickadee *Parus hudsonicus*	2	1	3	2
Red-breasted Nuthatch *Sitta canadensis*	0	0	1	1
American Robin *Turdus migratorius*	5	7	1	2
Varied Thrush *Ixoreus naevius*	6	6	9	10
Hermit Thrush *Catharus guttatus*	7	6	1	1
Swainson's Thrush *Catharus ustulatus*	6	7	4	6
Golden-crowned Kinglet *Regulus satrapa*	0	0	7	7
Ruby-crowned Kinglet *Regulus calendula*	5	5	10	12
Cedar Waxwing *Bombycilla cedrorum*	1	0	0	0
Warbling Vireo *Vireo gilvus*	8	6	1	0
Orange-crowned Warbler *Vermivora celata*	7	8	0	0
Yellow-rumped Warbler *Dendroica coronata*	9	7	11	9
Northern Waterthrush *Seiurus noveboracensis*	1	1	3	0
Pine Siskin *Carduelis pinus*	4	3	7	4
White-winged Crossbill *Loxia leucoptera*	0	0	1	1
Dark-eyed Junco *Junco hyemalis*	6	1	5	1
Chipping Sparrow *Spizella passerina*	7	3	1	1
White-throated Sparrow *Zonotrichia albicollis*	8	5	0	0
Unidentified	2	2	1	4
Total no. of species	22	22	20	17
Mean frequency	4.41	3.64	3.80	4.18
Total no. of sample points	9	9	12	12
Mean % frequency	49	40	32	35

be active and singing during a particular 10-minute period (Robbins 1981). Differences in the species detected by the two methods on different days were similar to those found in data collected by the same observer on two different days, suggesting that both observations and recordings provide similar time-period samples of singing birds. Results of both methods are greatly enhanced by repeated samples from the same points or elsewhere within the same habitat type.

In the analysis presented above, any species that did not call or sing but was seen by the observer was excluded. Some species are nearly silent and would be detected only by incidental visual observations in a survey of forest birds: on one occasion, as we were recording and observing at a sample point, a Northern Goshawk *Accipiter gentilis* floated down through the early-morning gloom within the forest, alighted briefly on the forest floor nearby, looked us over, and then flew off without making a sound. Of course, inclusion of such sightings in the data depends on the ability of the observer to identify birds by their appearance. The usefulness of sound recordings stems from the fact that they can be obtained in the field by people with little knowledge of birds.

The recording equipment employed gave excellent results and was largely trouble free. Useful recordings could not be obtained if there was any appreciable wind: winds stronger than Beaufort scale force 3 (12.9–19.3 km/h) created marginal conditions for recording. The same is true for the human ear, although observers can sometimes identify faint sounds by concentrating or changing their position, enabling them to conduct surveys in somewhat stronger wind conditions than would be suitable for making recordings. The human ear had a definite advantage over the microphone during rain. Most forest birds will sing on wet mornings provided the rain is light and temperatures are not unusually cold for the season. Observers can concentrate on sounds and detect bird calls through the noise of dripping water and the patter of raindrops, but such discrimination was not possible from recordings. The noise of dripping water effectively blocked out other sounds.

Although we were working in a forest area 10–20 km from a town and the associated highway and railway line, the amount of human-caused noise recorded on a calm morning was surprising. A gravel secondary road passing through the study area was used by logging trucks, forestry workers, oilfield workers, and others going to work very early in the morning. Each vehicle was within hearing for 2–4 minutes even when recording was being done 1–2 km from the nearest portion of the road. The utility of recordings as a means of monitoring bird populations would be limited in proximity to towns, busy transportation corridors, and industrial sites. Occasional, unexpected human-caused noise may be compensated for by stopping the recorder until the noise ends, then recording for that additional length of time.

Conclusions

In summary, this study shows that it is possible to use audio recordings to sample the presence of bird species, their frequency of occurrence at sample points, and their density in the categories of 0, 1, and >1. A 10-minute time sample taken from a recording gives data comparable to those from a similar field observation period. Repeated samples within the same habitat will build up a species list similar to that obtained through field observation by an experienced field observer.

The principal difference in the methods is that the field observer can estimate distance to singing birds and thereby obtain estimates of density per unit area. To date, it is not possible to estimate densities per unit area from recording data. However, work with song detection thresholds for various bird species in different habitats (Emlen and DeJong 1981) suggests that greater knowledge of those thresholds and of the "polar pattern" of microphones might make such estimates possible.

It may also be possible to distinguish among individual birds of a species from recordings by computerized spectrographic analysis, as discussed by Falls (1982), enabling complete counts of individuals heard. Combined with knowledge of the attenuation of the sound waves produced by bird calls and songs in different habitats, this technique could permit density per unit area estimates comparable with those from field observations. Recorded tapes have the distinct advantage of permitting the interpreter to replay and listen to a call or song as often as required to identify the species involved, whereas the field observer gets only one chance. In an era when large numbers of data are required to monitor songbird distribution and status, this preliminary study suggests that survey methodology involving recordings can play a useful role.

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