Surveying woodland hawks with broadcasts of great horned owl vocalizations

James A. Mosher and Mark R. Fuller

Abstract Pre-recorded vocalizations of great horned owls (*Bubo virginianus*) broadcast into predominantly wooded habitat along roadside survey routes resulted in as many detections of resident red-shouldered hawks (*Buteo lineatus*) and Cooper's hawks (*Accipiter cooperii*) as broadcasts of each conspecific calls. Survey results for 3 species, expressed as average number of contacts/route, were directly related to the number of resident pairs located during systematic searches conducted on foot across the study area. Regression models based on road-transect counts were significant for predicting abundance of red-shouldered hawks, broad-winged hawks (*Buteo platypterus*), and Cooper's hawks from our study areas.

Key words abundance, road counts, survey, woodland hawks

Effective management of wildlife populations requires estimates of their density or relative abundance over space and time. Such estimates of woodland raptor populations have been difficult to obtain and are often prohibitively expensive. Raptor dispersion and behavior and the forested habitats that these species occupy limit detectability. Consequently, long-term population data at state or regional scales are available for only a few forest breeding raptor species (Robbins et al. 1986, Mosher 1989, Titus et al. 1989)

Woodland hawk responses to broadcasts of conspecific calls increase their detectability in surveys (Fuller and Mosher 1987, Rosenfield et al. 1988, Mosher et al. 1990, Kennedy and Stahlecker 1993). A limitation of this technique is that usually only the conspecific regularly responds. In preliminary tests we found that broadcasts of great horned owl (*Bubo virginianus*) vocalizations elicited responses from several woodland hawk species. However, Kimmel and Yahner (1990) found higher detection rates of northern goshawks (*Accipiter gentilis*) with conspecific calls than with great horned owl vocalizations. If surveys that use great horned owl broadcasts show a significant relationship between contacts and hawk abundance, they could provide a cost-effective estimate of relative abundance for several responsive hawk species. Our objectives were to determine if great horned owl vocalizations were effective in detecting woodland hawk species and to model the relationship between contacts and independently determined abundance.

Methods

We established unlimited-width point transects along secondary roads on study areas in Ohio, Maryland, and Minnesota. To simplify design and minimize interactions among responses to other species, 1 hawk species (red-shouldered hawk [*Buteo lineatus*] or Cooper's hawk [*Accipiter cooperii*]) was designated as the target species on each study area. These species were selected because they were of special interest to the cooperating state agencies. We alternated broadcasts no more than 5 days apart of recorded territorial vocalizations of the target species with great horned owl vocalizations in paired surveys conducted 1 April–4 July (the approximate breeding season) during 1983–1987. Transects were 7.2 km (4.5 mi) and consisted of 10 stations at 0.8-km (0.5 mi) intervals. Each study area extended to a radius of 1.6 km (1.0 mi) beyond the first and last stations and the same distance to each side of the transect, thus enclosing a study area of approximately 31.1 km^2 (12 mi^2). Mosher et al. (1990) provided details of the count protocol including sources of vocalizations. We conducted counts in weather conditions

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as prescribed for the Breeding Bird Survey (Robbins et al. 1986) beginning within 1 hour after sunrise. Observers recorded auditory and visual raptor contacts at each station for 10 minutes during the first 5 minutes of which hawk species or great horned owl vocalizations were broadcast in 6 sets of approximately 15 seconds every 45 seconds. Broadcast volume 1 m in front of the speaker was about 105 dB. Variation in volume was <5 dB based on sound-level meter readings.

From April to July, while road counts were conducted, we searched for raptor nests and adults. We made foot searches along parallel transects, variably spaced to provide overlap within the visual limits imposed by vegetation and topography, 2 or 3 times each season. We conducted additional nonsystematic searching (e.g., looking in likely habitat or in areas where hawk activity was noted) to maximize the probability of locating all resident hawks.

Field crews mapped all sites of raptor detections made during daily field activities. These maps were used to determine whether hawks not associated with known nests were likely to be residents on the study area. To be counted as a resident, ≥2 detections of the same species must have been plotted within 0.8 km (0.5 mi) and must have been ≥2.4 km (1.5 mi) from the nearest known nest of that species in the case of broad-winged (*Buteo platypterus*), sharp-shinned (*Accipiter striatus*), and Cooper's hawks, or 4.0 km (2.5 mi) in the cases of the red-shouldered hawks and red-tailed hawks (*Buteo jamaicensis*). These distances were used as general guidelines based on raptor home range, body size, and breeding density (Newton 1979:64). To minimize bias, map data were not evaluated by the individuals who conducted the road counts. When doubt existed, we chose to err on the conservative side by not counting questionable detections in our estimates of abundance. Early-season road counts appeared to include migrants of some species. Therefore, we conducted separate analyses of all counts for each species on each study area, and adjusted those survey results by eliminating counts made >2 weeks before egg-laying.

Study areas

We conducted surveys in 9 study areas on public forest lands for which state agencies had expressed

Table 1. Number of hawk nests found, estimated number of pairs, and estimated summer resident density on each study area in Ohio, Maryland, and Minnesota, April–July 1985–1987. Conspecific vocalizations of red-shouldered hawks and Cooper's hawks were broadcast on the selected study areas, indicated by T.

Species	St. Croix	Smokey Hills	Crow Wing	Lake	White Water	Zaleski-85	Zaleski-86	Indian Springs	Pokemoke	$\bar{x}$
Broad-winged hawk										
Nests	14	11	2	4	1	0	3	4	0	4
Pairs	14	11	5	4	4	5	3	7	0	6
Pairs/km^2	0.45	0.35	0.16	0.13	0.13	0.16	0.10	0.23	0.00	0.19
Red-shouldered hawk		T	T		T	T	T			
Nests	0	4	0	0	4	2	3	0	0	1
Pairs	1	4	0	0	4	3	3	0	0	2
Pairs/km^2	0.03	0.13	0.00	0.00	0.13	0.10	0.10	0.00	0.00	0.05
Red-tailed hawk										
Nests	0	1	1	2	2	1	3	0	0	1
Pairs	0	2	1	2	2	2	2	1	0	1
Pairs/km^2	0.00	0.06	0.03	0.06	0.06	0.06	0.06	0.03	0.00	0.04
Sharp-shinned hawk										
Nests	0	0	0	0	0	0	0	0	0	0
Pairs	1	0	0	1	0	0	0	0	0	0
Pairs/km^2	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01
Cooper's hawk	T			T				T	T	
Nests	0	0	0	0	0	1	0	1	0	0
Pairs	0	0	3	0	1	2	1	2	1	1
Pairs/km^2	0.00	0.00	0.00	0.10	0.00	0.06	0.03	0.06	0.03	0.04
American kestrel										
Nests	0	0	0	1	0	0	0	0	0	0
Pairs	0	0	0	1	0	0	0	0	0	0
Pairs/km^2	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00
All hawks										
Nests	14	16	4	6	7	4	11	5	0	7.4
Pairs	16	17	10	7	11	12	10	10	1	10.0
Pairs/km^2	0.51	0.55	0.32	0.23	0.35	0.39	0.32	0.32	0.03	0.33

Table 2. Detection rates from road counts using broadcasts of great horned owl vocalizations (number of detections/number of route replications in Ohio, Maryland, and Minnesota, April–July 1985–1987). Second rows are rates adjusted to eliminate migrating hawks.

	Hawk species				
Study area	Broad-winged	Red-shouldered	Red-tailed	Sharp-shinned	Cooper's
White Water WMA	4.73	3.36	4.09	0.36	0.27
	2.88			0.17	0.25
Crow Wing Co.	1.44	0.00	0.22	0.22	0.33
	1.86			0.29	0.43
Lake Co.	1.62	0.00	0.50	0.12	0.00
	1.71			0.14	
Smokey Hills SF	1.86	2.29	0.57	0.00	0.00
	1.80				
St. Croix SF	2.11	0.22	0.00	0.78	0.11
	1.33			0.33	0.00
Zaleski SF, 1986	0.15	1.46	0.77	0.00	0.31
	0.20				0.40
Zaleski SF, 1985	1.70	2.30	0.00	0.00	0.20
	2.30				0.30
Indian Springs WMA	3.80	0.20	1.30	0.40	0.10
	4.50			0.00	0.10
Pokemoke SF	0.00	0.00	0.00	0.00	0.00

an interest in detecting raptors and their associated habitats. One Maryland study area was on the coastal plain of Maryland's eastern shore (Wicomico County) largely in the Pokemoke State Forest, and another was in the Piedmont region on the Indian Springs Wildlife Management Area (Washington County). The Pokemoke site was generally flat with sandy soils supporting river-bottom hardwood forest with mixed-plantation and natural conifer stands. The Indian Springs site was a shallow valley with agriculture on the valley floor and mixed-hardwood forest from moderate to old age on the hillsides.

Both Ohio study areas were within the Zaleski State Forest (Vinton County). These sites were characterized by nearly continuous hardwood forest with moderate relief in a complex array of ridges and steep hillsides. The road-survey routes followed the ridge tops.

Of 5 study areas in Minnesota, the Superior National Forest site was within the boreal forest with flat relief and covered largely by mature mixed conifer forest intermixed with stands of paper birch (*Betula papyrifera*) and aspen (*Populus sp*). About 40% of the area had been logged. The second site, in Crow Wing and Cass Counties, was flat marshland, dominated by birch–aspen forest. The sites on St. Croix State Forest (Pine County) and Smokey Hills State Forest (Becker County) were similar to Crow Wing and Cass counties but included a few conifer plantations and tamarack (*Larix laricina*) swamp and marsh. Lastly, the site on White Water Wildlife Management Area was flat, eroded stream bottom with steep gradients leading up to tableland. Vegetation was more open than any of the other sites, providing better visibility.

Results and discussion

Densities of pairs by species ranged from 0.0 to 0.45 pair/km^2 (Table 1), with a mean for all species and study areas of 0.33 pairs/km^2. In the Pokemoke State Forest there was almost no hawk activity. Exceptionally high densities of broad-winged hawks occurred on the St. Croix and Smokey Hills study areas. Only the broad-winged hawk was found on the St. Croix site. None of our data, including habitat structure and composition (e.g., Mosher et al. 1986), explained these disparities in nest density. Rosenfield (1984) reported a similarly high density of broad-winged hawks in Wisconsin.

Table 3. Linear regression models ($y = b_0 + b_1x$) for predicting number of pairs (y) of hawks based on detection rate (x) from road counts using great horned owl broadcasts, 1985–1987.

Hawk species[a]	b_0 (SE)	b_1 (SE)	r^2	P	SE_{est}
Broad-winged hawk	1.67 (0.74)	1.21 (0.31)	0.76	0.0111	1.17
Red-shouldered hawk	0.21 (0.26)	1.33 (0.16)	0.91	0.0001	0.59
Red-tailed hawk	1.12 (0.21)	0.26 (0.23)	0.15	0.3084 ns	0.86
Sharp-shinned hawk	0.10 (0.21)	0.85 (0.99)	0.10	0.4186 ns	0.44
Cooper's hawk	0.43 (0.36)	4.15 (1.53)	0.51	0.0303	0.79

[a] $n = 9$ study areas for all species except broad-winged hawks for which $n = 7$.

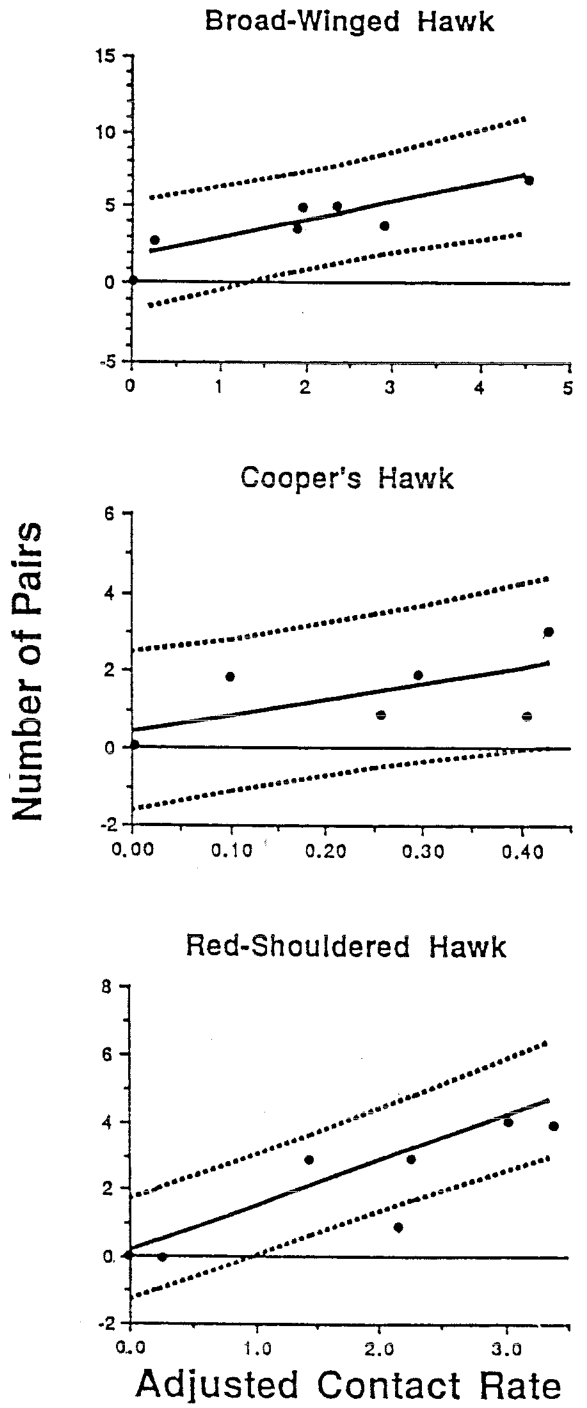

Fig. 1. Prediction intervals (95% confidence intervals around predicted values) for estimating number of pairs of hawks based on detection rate from roadside point transects when broadcasting great horned owl vocalizations. Multiple 0,0 values occur for Cooper's and red-shouldered hawks.

Six hawk species responded to great horned owl vocalizations (Table 2). Although contact rates for great horned owl broadcasts were not significantly different from those for red-shouldered and Cooper's hawks, the great horned owl broadcasts provided the added advantage of contacting several hawk species on a single survey. Further, results from a previous study indicated that interspecific responses to hawk vocalizations were rare (Mosher et al. 1990).

We found significant relationships between contacts associated with broadcasts of great horned owl vocalizations and numbers of summer-resident pairs (nests found plus pairs not associated with nests found) of broad-winged, red-shouldered, and Cooper's hawks (Table 3). There was a significant relationship for broad-winged hawks only when the 2 high-density study areas were omitted as outliers. We do not know why detections were lower in these 2 highest-density areas. The regressions did not provide significant results for adjusted counts and numbers of nests found (except for red-shouldered hawks), for unadjusted counts (which include migrants) and pairs, or for unadjusted counts and nests. These results suggest that to obtain an estimate of the number of hawks in an area during the breeding season, it is important to account for non-nesting birds or for pairs for which nests are not found and to schedule surveys to avoid counting migrating birds early in the season.

Using prediction intervals (Neter et al. 1985), we can estimate a new parameter, number of hawk pairs, based on the contacts counted on the area. Prediction intervals are wider than the usual confidence intervals because a confidence interval, in this case, would estimate the mean number of hawks in the area whereas a prediction interval estimates the actual number of hawks, not a mean. The standard error of the estimates and width of the prediction intervals depend on the variability in the contact rate and the number of replications of the transect. The 95% prediction intervals (Fig. 1) are wide, probably due in part to a small sample of study sites from diverse geographic areas. However, the significant relationships between road counts and estimated pairs of hawks suggest that counts based on broadcast detections have a biological basis and that this survey method may be broadly applicable to some species.

Management implications

This technique can be used to enhance detection of woodland hawks during breeding season surveys. The specific application depends on study objectives as discussed below.

1. To determine the presence or absence of ≥1 hawk species on an area, we recommend broadcasts from point-count stations along

roads throughout the area of interest. The sampling strategy (e.g., random starting point, stratified) will depend on additional objectives, such as relating raptor presence to habitat types (Fuller and Mosher 1987). Intensity of sampling depends on the availability of personnel, time, and ease of travel. Broadcasts carry about 1.0 km (0.63 mi) in western Maryland forests (Mosher et al. 1990). Thus we suggest that broadcast stations be spaced about 0.5 km (0.32 mi) apart for very intensive surveys and >1.0 km apart if time or personnel are limited for sampling larger areas. We recommend repeated counts (6-8), 5-10 days apart during the breeding season because woodland hawk breeding chronology varies among pairs and species and because they have relatively low contact rates and probabilities of detection (Geissler and Fuller 1986, Mosher et al. 1990, Iverson and Fuller 1986). Presence of raptors can be difficult to determine if only 1 or 2 counts are conducted at a point.

2. Probability of detecting each hawk species and the number of areas around point-count sites occupied by the hawks can be estimated (Geissler and Fuller 1986) by repeating a series of standardized point counts with the broadcasts of great horned owl vocalizations. The results are estimates of area occupied, a refined measure of frequency (Verner 1985) and not estimates of species abundance. Results from this survey method and analytical techniques can be used to compare study areas or periods because the analyses account for differences in detection (e.g., among study areas, habitats, periods, species).
3. To obtain counts that can be used to provide relative abundance estimates (Verner 1985) we recommend great horned owl broadcasts, applied in a standardized protocol (e.g., Mosher et al. 1990). Results of regression analyses suggest that for broad-winged hawks, red-shouldered hawks, and Cooper's hawks, there is a relationship between contact rates and numbers of pairs around the transect.
4. Broadcasts applied in a standardized protocol also can be used to estimate densities. Our data indicate some counts can be related to numbers of pairs. Interpretation and use of this relationship is dependent on knowledge of the hawk breeding chronology, habitat relationships, and on information obtained during surveys (e.g., spot-mapping).

Additional trials with road counts and estimates of pairs will be useful in testing how applicable this model is to other study areas, habitats, pair densities, and species. We encourage biologists to gather road-count data and to estimate numbers of pairs on the same area for exploring the usefulness of the regression model for estimating density. Additional data are needed for the rarer and less detectable species, a range of breeding bird densities (e.g., high density of broad-winged hawks), habitats, and geographic areas.

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