Effects of Roadside Habitat and Fox Density on a Snow Track Survey for Foxes in Ohio[1]

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ABSTRACT. **Many methods have been used to survey red fox (*Vulpes vulpes*) and gray fox (*Urocyon cinereoargenteus*) populations. However, none has proven entirely satisfactory, and wild foxes remain one of the most difficult economically important wildlife species to monitor. In this study we evaluated the reliability of a snow track survey method for foxes by investigating whether the average number of road crossings per fox is influenced by changes in roadside habitat or changes in fox density. Several snow track surveys were conducted in two Ohio counties during January and February, 1984. Data on roadside habitat, relative fox densities, and fox crossings were collected. Results suggested that changes in roadside habitat could influence the average number of crossings per fox and, therefore, changes in the index could occur independent of actual population changes. We found no evidence that crossings per fox varied with fox density, but further research is needed to substantiate this finding.**

OHIO J. SCI. 91 (5): 186–190, 1991

INTRODUCTION

Many methods have been used to survey red fox and gray fox populations. However, in many cases they provide only limited information or are of unknown reliability. The scent post survey (Richards and Hine 1953, Wood 1959) has been widely used (Drake 1983), and studies have been made of its statistical properties (Hodges 1975), seasonal variation (Griffith 1976), and the efficacy of various attractants (Roughton and Bowden 1979, Turkowski et al. 1979, Roughton and Sweeny 1982). However, few studies have evaluated how well the scent post survey reveals population trends (Conner et al. 1983). Fur buyer and harvest information have also been used to assess fox abundance, but fluctuating pelt prices may significantly influence these indicators (Seagers 1944, Peterson et al. 1977). Aerial surveys of dens have been used successfully in North Dakota to estimate fox density (Sargeant et al. 1975) but are not suitable for wooded areas. Snow track surveys (Scott 1941) have been used for foxes (Linhart 1960), bobcats (*Lynx rufus*) (Karpowitz and Flinders 1979, Klepinger et al. 1979), mountain lions (*Felis concolor*) (Van Dyke et al. 1986), and lynx (*Lynx canadensis*) (Slough and Jessup 1984, Ward 1985, Stephenson 1986), but reliability of the index has not been rigorously tested. Other survey methods, like rural mail carrier, road-kill, and landowner surveys, provide some information on fox distribution, but their relationship to real populations is unknown (Sargeant et al. 1975) and they generally provide too few records to be useful as indices.

The design and efficiency of a snow track survey method for foxes in Ohio was tested by Drake (1983), and, subsequently, was implemented by the Ohio Department of Natural Resources. This method requires surveyors to drive prearranged routes and record the number of road crossings made by foxes. Because some foxes make many crossings while hunting near the road, a crossing is recorded only if it is ≥0.16 km from the last recorded crossing. Surveys are conducted on mornings following a day with sufficient melting, drifting, or new snow, to allow the surveyor to distinguish between tracks made during the previous night and older tracks.

The snow track survey, like any other population index, assumes that the proportion of the population detected (per unit of survey effort) remains constant over time. For the snow track survey, this means that the average number of road crossings recorded per fox must remain constant year after year. In the present study, we investigated whether the average number of road crossings per fox is influenced by changes in roadside habitat or changes in fox density.

MATERIALS AND METHODS

Field work was conducted from mid-January to mid-February, 1984, on a 78 km^2 area in Geauga County, and a 93 km^2 area in Licking County, OH. Farmland, woodland, and brushland covered 44%, 34%, and 12%, respectively, of the study area in Geauga County, and 62%, 12%, and 9% of the study area in Licking County.

A total of nine snow track surveys were conducted in Geauga County and seven were conducted in Licking County. There were 143 km of road in the Geauga County study area, and 128 km of road in the Licking County study area. Though it was not possible to survey every road in the two study areas on every survey attempt, all roads within each study area were surveyed at least twice.

We evaluated whether the average number of crossings per fox is influenced by changes in roadside habitat by comparing the number of fox crossings per km of survey route in different habitat types. Roadside habitat was classified into one of four categories: (1) crossing barriers on at least one side of the road (e.g., houses, small mesh fences, unfrozen rivers); (2) fields on both sides of the road (e.g., meadow, cropland, early successional field); (3) woods, brush, or frozen stream on one side of the road and fields on the other side; or (4) woods, brush, or frozen stream on both sides of the road. Frozen streams were classified with woods and brush because they were usually lined with trees and brush. Data were analyzed by computing a $\underline{X}^2$ test statistic under the null hypothesis that the probability of a

[1]Manuscript received 30 July 1991 and in revised form 16 October 1991 (#91-17).

crossing in each of the four habitat categories did not differ. However, because the expected values in three of the four habitat categories were less than five, the $\underline{X}^2$ statistic could not be reliably approximated by a chi-square distribution (Siegel 1956, Dixon and Massey 1969). Thus, only descriptive statistics are reported in the results.

For purposes of analysis, a road segment was defined as the length of road between two adjacent intersections. A cell was defined as an area completely bounded by road segments (Fig. 1). A stretch was defined as the portion of a road segment bounded by a single habitat type, with habitats defined as above. Thus, each road segment was a composite of one or more stretches. The location, length, and habitat type of all stretches for all segments were mapped for both study areas.

We evaluated whether the average number of crossings per fox is influenced by changes in fox density by comparing the number of fox crossings per km of survey route on road segments passing through areas of high and low fox density. Segments in high density areas (HD-segments) had one or more foxes occupying each of the two cells adjacent to a road segment; segments in low density areas (LD-segments) had one or more foxes occupying only one of the cells adjacent to a road segment, with the other cell being unoccupied (Fig. 1).

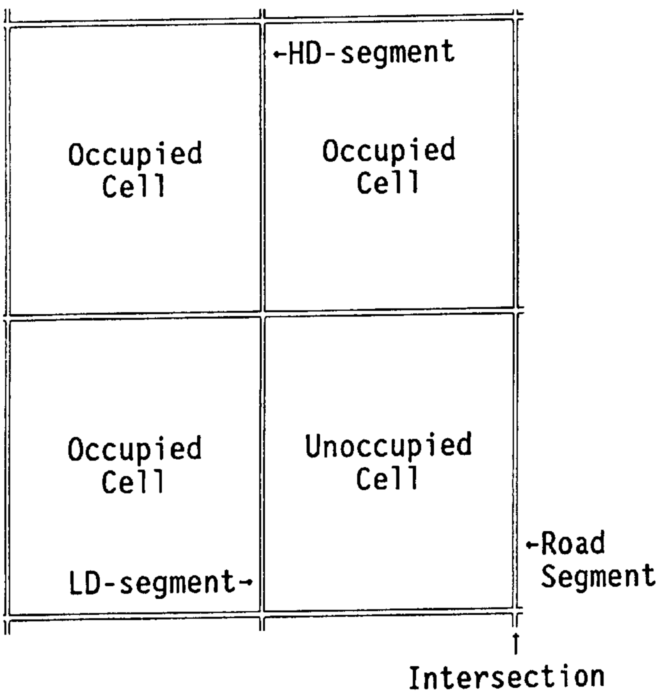

FIGURE 1. Road segments in high density (HD) and low density (LD) areas. If the average number of foxes per occupied cell equals n, and the average number of crossings per fox equals x, then HD-segments should have $2nx$ crossings and LD-segments should have nx crossings. The expected ratio of crossings on HD-segments versus LD-segments would be $(2nx) / (nx) = 2$.

Cell occupancy was determined by surveying the road segments forming the perimeter of the cell for fox crossings. If no crossings were present, the cell was entered on foot and thoroughly searched for fox tracks. If tracks were found, the cell was considered occupied. If no tracks were found, the cell was considered unoccupied. Storm (1965) reported most foxes have a daytime resting area that is used for several days, and Stanley (1985) found that foxes seldom vacated cells for more than two days. We assumed that an occupied cell contained the daytime resting area of one or more foxes and that it remained occupied for the duration of the study. Cells with crossings at the perimeter could not be immediately classified since they may have contained the daytime resting area of a fox, or may have only been visited by one. We re-examined these cells throughout the study period until they could be classified.

Because habitats in occupied cells in both high and low density areas were similar (Stanley 1985), we assumed that the average number of fox per occupied cell did not differ between high and low density areas. Under this assumption, the fox density around HD-segments would be expected to be approximately twice that around LD-segments. Thus, if the average number of crossings per fox is not influenced by fox density, the number of fox crossings per km along HD-segments would be expected to be approximately twice that along LD-segments (Fig. 1). Point estimates of the ratio of mean fox crossings per km (± SE) along HD-segments versus LD-segments are reported.

RESULTS

Fox crossings rarely occurred on habitat type (1) stretches, occurred at intermediate frequencies on type (2) and type (3) stretches, and were markedly more common on type (4) stretches (Table 1). These results suggest that roadside habitat influences the frequency of fox crossings, and indicate crossings per fox might decline if roadside habitat becomes less attractive or increase if habitat becomes more attractive. We evaluated this issue further by categorizing each road segment by the most attractive stretch it contained where, based on the above results, stretch types (1) through (4) were considered successively more attractive. Thus, for example, category 1 segments contained only type (1) stretches, and category 2 segments contained at least one type (2) stretch but no type (3) or type (4) stretches. Crossings per km, for both counties combined, in segment categories 1 through 4 were 0.0, 0.05, 0.07, and 0.12, respectively. More crossings per km occurred on segments containing at least one attractive stretch and, in general, increased as the attractiveness of the stretch increased.

In Geauga County there were 19 occupied cells ($\bar{x}$ = 314 ha) and 11 unoccupied cells ($\bar{x}$ = 260 ha), and there were 17 HD-segments and 22 LD-segments. We surveyed 431 stretches for fox crossings. In Licking County there were 13 occupied cells ($\bar{x}$ = 466 ha) and 19 unoccupied cells ($\bar{x}$ = 271 ha), and there were 17 HD-segments and 25 LD-segments. We surveyed 472 stretches for fox crossings. In both study areas combined we recorded 66 fox crossings on 48 different stretches.

The ratio of crossings per km on HD-segments versus LD-segments was 4.3 in Geauga County and 1.7 in Licking County (Table 2). These values, when compared to the expected value 2.0, suggest that crossings per fox does not decrease at higher densities but that it may increase. Some uncertainty still exists, however, because standard errors are large. In part, this is because roadside habitat influences the frequency of fox crossings. We standardized habitat influence by recalculating the ratio for each of the four stretch types. Habitat type (1) stretches were excluded because they had virtually no crossings. The results for the other stretch types generally confirm the results for entire segments (Table 3); stretches with foxes on both sides tended to have twice as many, or more, crossings per km as stretches with foxes present on only one side, though considerable variability is evident.

DISCUSSION

Our data suggest that change in roadside habitat is the most important source of bias likely to affect the snow track survey. In areas where development or other activities reduce woody or brushy roadside cover, the survey is likely to indicate a decrease in fox levels independent of actual levels. On the other hand, reversion of roadsides from fields to brushy or woody cover may indicate an increase in fox levels independent of actual levels. In Geauga and Licking counties, 81% and 74%, respectively, of the roadside was developed. Considering the number of cells known to be occupied and that we drove a total of 751 km on surveys, it was striking that only 66 fox crossings were recorded. Thus, in areas with developed roadsides, the survey detects only a small fraction of the foxes present.

Our investigation of how changes in fox density will affect crossings per fox was less conclusive. Because foxes avoid conspecifics holding adjacent territories, and because they tend to expand their territories to include areas vacated by adjacent foxes (Sargeant 1972), we expected crossings per fox to be fewer at higher densities. This would have resulted in a ratio less than 2.0. Our ratios (Tables 2 and 3), however, were generally ≥ 2.0, indicating no effect or a possible increase rather than decrease in

TABLE 1

Mean road crossings per km by foxes in different roadside habitat types [a].

Roadside habitat type	Geauga County No. stretches	Geauga County Total length (km)	Geauga County Mean crossings per km	Licking County No. stretches	Licking County Total length (km)	Licking County Mean crossings per km
(1) houses, other barriers	243	115.5	0.00	258	95.0	0.01
(2) fields, both sides of road	59	11.9	0.17	88	16.3	0.07
(3) woods, brush, stream one side of road	59	7.9	0.28	66	8.5	0.10
(4) woods, brush, stream both sides of road	70	7.6	0.48	60	8.3	0.23

[a]All standard errors of mean crossings per km (assuming a simple random sample of stretches) were less than 0.02.

TABLE 2

Mean road crossings per km (± SE) by foxes on HD-segments and LD-segments, and the ratio of fox crossings per km along HD-segments versus LD-segments [a].

Segment type	Geauga County No. segments	Geauga County Total length (km)	Geauga County Mean crossings per km	Licking County No. segments	Licking County Total length (km)	Licking County Mean crossings per km
HD-segment	17	29.2	0.177 (0.03)	17	29.2	0.073 (0.02)
LD-segment	22	40.8	0.041 (0.02)	25	45.0	0.042 (0.02)
Ratio	-	-	4.32 (1.8)	-	-	1.74 (0.8)

[a]HD-segment = foxes present on both sides of road segment; LD-segment = foxes present on only one side of road segment.

TABLE 3

Mean road crossings per km by foxes in different habitat types along HD-segments and LD-segments, and the ratio of fox crossings per km along HD-segments, versus LD-segments [a].

	Geauga County			Licking County		
	Segment type			Segment type		
Habitat type	HD	LD	Ratio	HD	LD	Ratio
Fields on both sides of road	0.30	0.16	1.9	0.12	0.06	2.0
Woods or brush or stream on one side of road	0.79	0.07	11.3	0.17	0.15	1.1
Woods, brush, or stream on both sides of road	1.22	0.30	4.1	0.12	0.06	2.0

[a]HD-segment = foxes present in cells on both sides of road segment; LD-segment = foxes present in a cell on only one side of road segment.

crossings per fox. One explanation may be that at higher densities foxes mark territorial boundaries with greater frequency, resulting in more road crossings per fox. An alternative explanation is that densities in our areas were too low for a density effect to be evident. Both counties had been trapped shortly before our study, and in Geauga and Licking counties, 37% and 59%, respectively, of the cells were unoccupied. Because habitat maps of cell interiors showed that most unoccupied cells were similar to occupied cells and were probably capable of supporting a fox (Stanley 1985), it is likely that our areas were well below carrying capacity. Thus, despite our results, it is still possible that the index will fail at relatively high fox densities.

Like many other methods, the snow track survey is difficult to evaluate rigorously. We believe it is a potentially useful technique that could be used to survey several species simultaneously (e.g., canids, felids, and cervids). However, our data indicate that in areas where roadside habitat changes rapidly over time, survey results are likely to be biased. This is especially true where preferred crossing sites are being destroyed, for example, by construction of houses. Thus, use of the snow track survey may be limited to public lands or other areas protected from development.

Determination of the relationship between crossings per fox and fox density is an important and complex problem that still needs to be resolved. Our data indicated crossings per fox remain constant or even increase as fox density increases, but were too variable to ascribe any degree of certainty. It is likely that crossings per fox does vary somewhat with density. However, whether this variation is great enough to invalidate the survey is unknown. This issue warrants further research and must be evaluated for any species for which the survey is to be used.

ACKNOWLEDGEMENTS. We gratefully acknowledge the Ohio Department of Natural Resources, Division of Wildlife for their aid and support in this project. D. G. Hill and D. M. Smith are acknowledged for their advice and assistance throughout the study, and S. J. Turner for his assistance in the field. C. M. Bunck, P. F. P. Henry, J. D. Nichols, A. B. Sargeant, and two anonymous reviewers provided helpful comments on earlier drafts of the manuscript.

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